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Tini a Tangaroa

Characterisation and CPUE analyses for the FLA 2 fishery to 2024, with species composition for all flatfish fishstocks

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PLAIN LANGUAGE SUMMARY

The FLA 2 Quota Management Area extends southwards from the central east coast of the North Island around to the Taranaki coast. The main flatfish fishery within this area has been in Hawke Bay, but there are smaller fisheries in Wellington Harbour, off the Kapiti coast, and in the north Taranaki Bight.

Flatfish stocks comprise a group of eight flatfish species. Recent changes in reporting regulations mean that comprehensive catch reporting for these individual species has been in place since late 2021. The distribution of the different species was examined at a countrywide level, as well as at a detailed level within the FLA 2 area.

The FLA 1 fishery is dominated by yellow-bellied flounder, while New Zealand sole and sand flounder are the main species caught in FLA 2, and lemon sole is the main species caught in FLA 3. FLA 7 currently has the most diverse catch composition, although sand flounder and New Zealand sole appeared to dominate the FLA 7 catch historically.

In FLA 2, monitoring of stock abundance previously used a combined flatfish catch-per-unit-effort-series from flatfish target bottom trawl fishing. However, a decline in flatfish target fishing required a re-evaluation of the monitoring approach.

Catch-per-unit-effort-series beginning in 2008 were adopted for combined flatfish, New Zealand sole, and sand flounder in Hawke Bay. These stocks were assessed as being as likely as not to be at or above the management target.

EXECUTIVE SUMMARY

Starr, P.J.[1]**; Middleton, D.A.J.**[2]**; Large, K.**[3]**; Neubauer, P.**[3] **(2025). Characterisation and CPUE analyses for the FLA 2 fishery to 2024, with species composition for all flatfish fishstocks.**

New Zealand Fisheries Assessment Report 2025/51**. 368 p.**

The flatfish population in FLA 2 was last characterised using data up to the 2016 fishing year. Since then, the annual Total Allowable Commercial Catch (TACC) was reduced from 750 t to 150 t and annual aggregate flatfish catches dropped from 150 t to 250 t to near or below 50 t. In 2016, a bottom trawl (BT) target flatfish (FLA) catch-per-unit-effort (CPUE) series for combined FLA species in Hawke Bay was adopted as the abundance monitoring series. However, recent catch and effort data indicated that this series was no longer usable because only a single vessel participated in this fishery in 2023–24. A full review of the FLA 2 fishery was commissioned by Fisheries New Zealand for 2025, based on data up to the end of the 2023–24 fishing year, in order to update the understanding of this Quota Management Area (QMA).

This document provides a full characterisation of the FLA 2 commercial fishery on both sides of the North Island, including the spatial distribution of the catch and effort associated with the capture of FLA and an evaluation of the species composition of the catch, taking account of the September 2021 regulatory change that ensured full reporting of the catch by species. The historical species composition of the FLA 2 catch was inferred from the reporting practises of a subset of individual fishers who reported their catch as disaggregated species.

The Inshore Working Group (INSWG) agreed to use a CPUE series which included FLA bycatch in the BT target red gurnard (GUR) fishery, in addition to the target FLA fishery, because the target FLA CPUE series had been compromised through the loss of effort. Furthermore, the INSWG agreed to move from a daily BT series beginning in 1990 to a tow-by-tow, event-based, series beginning in 2007–08 because the shorter series included more complete species catch reporting as well as depth information associated with each event which could be used as an explanatory covariate. Three event-based series were accepted by the INSWG for monitoring FLA 2: combined FLA, NZ sole (ESO), and sand flounder (SFL). Two other species-specific series were not accepted because the data were too sparse for the series to be reliable monitoring tools: lemon sole (LSO), and yellow belly flounder (YBF).

Five near shore water quality series (dissolved oxygen mg^{-1}, nitrogen gm^{-3}, suspended solids gm^{-3}, total phosperous gm^{-3}, and water temperature deg C), monitored from 16 Hawke Bay stations over the period 2005 to early 2025, were matched with the CPUE series developed from this project. Not all stations were monitored over this period, with the most comprehensive coverage beginning in 2013. No significant correlations were found between the accepted FLA 2 CPUE series and any of the five water quality series.

A range of CPUE series were investigated as sensitivity analyses. These included daily resolution models extending back to 1990 with both FLA and FLA/GUR targeting, models that implemented the stepwise inclusion of covariates instead of the full suite of covariates, and series which split the effort of long-term participating vessels in order to test for learning over time. In addition, two trial CPUE series directed at the LSO and SFL fishing in the South Taranaki Bight section of FLA 2 were unsuccessfully attempted.

The three CPUE series accepted by the INSWG for FLA 2 abundance monitoring were evaluated against agreed B_{MSY}-compatible proxies (FLA 2: geometric mean CPUE from 2007–08 to 2023–24;

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ESO 2: geometric mean CPUE from 2014–15 to 2023–24; SFL 2: geometric mean CPUE from 2011–12 to 2017–18). All three series were evaluated to be ‘About as Likely as Not (40–60%) to be at or above the target’, ‘Unlikely (<40%) to be below the Soft Limit’ and ‘Very Unlikely (<10%) to be below the Hard Limit’. Only the combined species FLA 2 series was evaluated against the overfishing target (at ‘Very Unlikely (<10%) to be Overfished’) because the historical species-specific catches are unknown.

This analysis of species composition was extended to the other NZ FLA QMAs in order to contrast with the FLA 2 results and to provide a baseline for these QMAs. Flatfish catches have reduced in all areas, although the FLA 1 catch has been stable for the last decade.

The FLA 1 fishery is dominated by yellow-bellied flounder, with a minor catch of sand flounder. Other species were reported historically, but are less apparent in the full catch reporting since 2021. New Zealand sole and sand flounder are the main species caught in FLA 2, although all flatfish species are reported to some extent. The proportion of lemon sole in the FLA 2 catch is related to the depths at which the gurnard target fishery operates in Hawke Bay. Lemon sole is the main species caught in FLA 3, with New Zealand sole and sand flounder also important and all species represented in the catch. In FLA 7, sand flounder and New Zealand sole appeared to dominate the FLA 7 catch historically, but the current fishery includes a mix of sand flounder, yellow-bellied flounder, lemon sole, and New Zealand sole, with turbot and brill also caught.

Greenback flounder was recorded in both the shallow flatfish fisheries, and in deepwater fisheries around the Auckland Islands, highlighting the possibility that it may comprise two similar species that are yet to be described separately.

1. INTRODUCTION

Flatfish (FLA) were introduced to the Quota Management System (QMS) on 01 October 1986. Each of the FLA QMS stocks includes eight flatfish species: black flounder (BFL; *Rhombosolea retiaria*), brill (BRI; *Colistium guntheri*), greenback flounder (GFL; *Rhombosolea tapirina*), lemon sole (LSO; *Pelotretis flavilatus*), New Zealand sole (ESO; *Peltorhamphus novaezeelandiae*), sand flounder (SFL; *Rhombosolea plebeia*), turbot (TUR; *Colistium nudipinnis*), and yellowbelly flounder (YBF; *Rhombosolea leporina*).

The FLA 2 Quota Management Area (QMA) includes both Fisheries Management Area 2 (FMA 2) off the southern east and south coasts of the North Island, and FMA 8 on the lower west coast (Figure 1). Other than small initial increases, associated with the quota appeals process, the Total Allowable Commercial Catch for FLA 2 had been constant since QMS introduction, but was reduced to 150 t from 1 October 2021 on the basis that the previous TACC of 726 t had never been reached and there was uncertainty whether catches at that higher TACC would be sustainable. Allowances for customary and recreational fisheries, and other fishing-related mortality, were made at the same time (Table 1).

Commercial catches peaked at 600 t to 800 t in the early 1980s, and exceeded 400 t per annum during the mid-1990s, but have otherwise been less than 300 t per annum (Figure 2). Catches have steadily declined since 2010, and have been less than 100 t since 2019. Catches in 2023 were just over 30 t but were closer to 60 t in 2024 (Table B.1).

Only 0.61 t of flatfish was estimated to have been caught by recreational fishers in FLA 2 in the 2023 fishing year (Heinemann & Gray 2024).

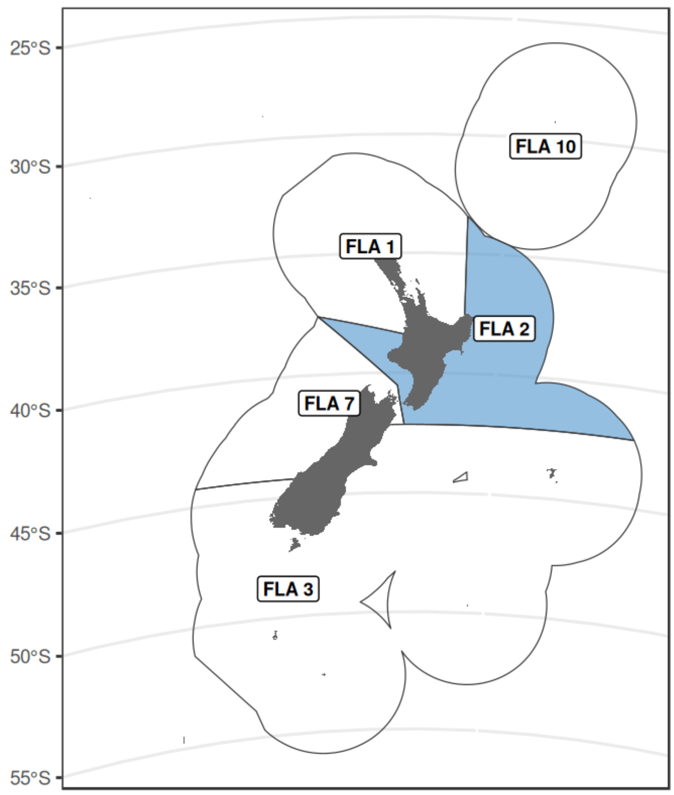

Figure 1: Quota Management Areas for flatfish with FLA 2 highlighted.

Table 1: Total Allowable Catch (TAC), Total Allowable Commercial Catch (TACC), and allowances (all tonnes) for FLA 2, as at 1 October 2025.

			Allowances		
Stock	TAC	TACC	Customary	Recreational	Other mortality
FLA 2	178	150	10	10	8

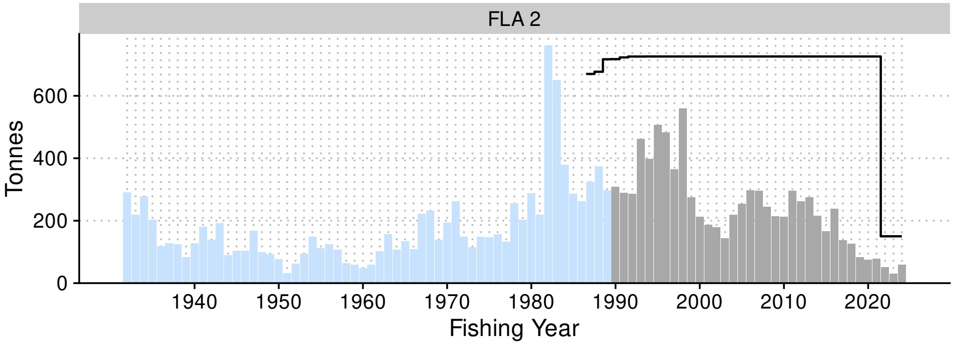

Figure 2: Total Allowable Commercial Catch (TACC; black line) and Monthly Harvest Return/Quota Management Report annual totals (bars) for FLA 2 from 1990 to 2024. Catches prior to 1990 are shown in blue using the information compiled in the Fisheries Assessment Plenary Report (Fisheries New Zealand 2024). Tabulated data are provided in Table B.1.

The FLA 2 fishery was last characterised by Schofield et al. (2018b), using data to the 2016 fishing year. A daily resolution catch-per-unit-effort (CPUE) based abundance series for combined flatfish species in Hawke Bay beginning in 1990 was adopted as the primary abundance monitoring series, with mean CPUE from 1990 to 2013 considered to be a B_{MSY}-compatible proxy and taken as a target reference point. The series was updated with data to the 2017 fishing year (Schofield et al. 2018a), at which point the stock was assessed as being About as Likely as Not to be at or above the target.

Fishing event resolution CPUE analyses, beginning in 2008, were also carried out by Schofield et al. (2018a) for sand flounder and New Zealand sole using a subset of data from vessels that consistently reported catch by species. The resulting series were considered to be reasonably consistent with the combined species series but were not used to assess stock status for these species.

2. METHODS

Extracts (report logs 13159, 17044) 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 standard New Zealand fishing year which runs from 1 October to 30 September. Fishing years are labelled using the later calendar year; thus, for example, 1990 refers to the fishing year 1 October 1989 to 30 September 1990.

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

2.1 Terminology

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

For species managed under the Quota Management System (QMS) we use the term **removals** to refer to the known mortality of fish; 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*. In this report, trip-based allocation was used for all stocks and methods.

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

2.4 Conversion factors

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

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

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

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

Table 2: Destination codes used in reporting of landings and disposals, with introduction date for codes that were not defined in the original Fisheries (Reporting) Regulations 1990. The inclusion of the landing/disposal in subsequent MHR returns is indicated in circulars issued under the Fisheries (Reporting) Regulations 2017. Only categories that are legally retainable, and considered final, are included in the catches and removals for a stock. LFR = Licensed Fish Receiver.

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

2.5 Characterisation dataset

A fishery characterisation dataset was prepared by identifying all trips with landings or estimated catches from FLA 2 and extracting the associated catch and effort data for fishing events within the FLA 2 Quota Management Area (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).

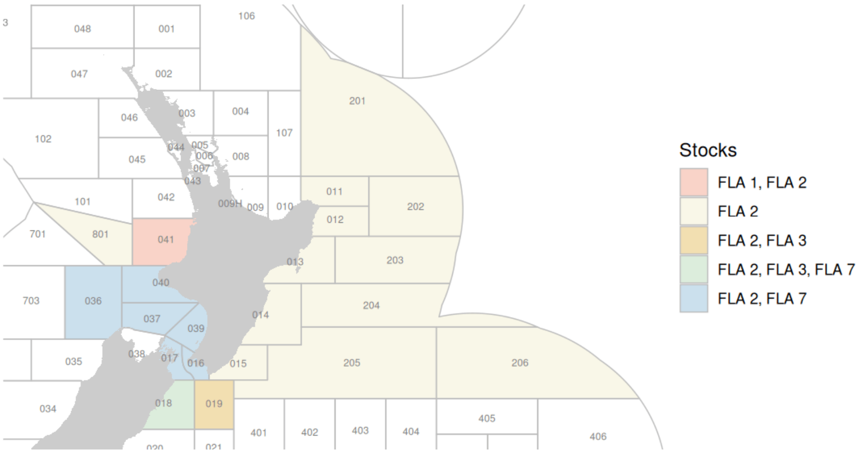

Figure 3: Statistical Areas that intersect the FLA 2 Quota Management Area.

2.6 CPUE methods

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

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

All fishing events matching the series definition were extracted, whether or not FLA 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.

3. FISHERY CHARACTERISATION

Landings to FLA 2 were almost entirely made to Licensed Fish Receivers (destination code 'L'; Figure 4), with negligible landings made to all other destination codes. There was also good agreement between the catches and the QMR/MHR annual totals (Figure 4). Almost all landings were made in the GUTted state, with minor amounts landed as GREen or DREssed (Figure 5). There was no evidence of changes in the FLA conversion factors beginning with the 1989–90 fishing year (Figure 6). Almost all landings can be allocated to fishing events across the entire data set, with only small amounts not attributable during the 1990s (Figure 7). The estimated catches tracked the landings reasonably well, although estimated catches only accounted for about 75–80% of the landings in most years (Figure 8).

The sequence of reporting forms is typical of a predominantly trawl inshore fishery: almost all landings and most records were made using the daily CELR forms up to 2007–08 when the majority of the fleet switched to the tow-by-tow fishing event TCER form (Figure 9). Beginning with the 2019–20 fishing year, the fleet transitioned to the event-based electronic reporting (ERS). Minor amounts of reporting were made by the set net fleet on the NCELR and ERS-netting forms (Figure 9). Consistent with the form type reporting shown in Figure 9, the FLA 2 fishery has been predominantly a bottom trawl (BT) fishery, with some set net (SN) landings which have largely disappeared since the late 2010s (Figure 10). Other capture methods in FLA 2 are negligible. Historically, the FLA 2 BT fishery has primarily targeted FLA and GUR, with only minor amounts of effort directed at other species (Figure 11). The FLA 2 SN fishery has been almost entirely targeted at FLA. The important observations to be taken from Figure 11 are the disappearance of the target BT FLA fishery beginning in 2022–23 and the virtual disappearance of the FLA 2 SN fishery since 2018–19.

The catch rank of the FLA species varies with the target species, with a rank of one or two for most BT FLA target tows, but a much lower rank for GUR target tows, ranging from rank three to five for the TCER forms and rank five to seven (or eight) for the ERS reports (Figure 12). These low catch report rankings have implications in the reporting of GUR target tows, because tows with a rank of greater than eight will not be comparable to the TCER reported tows and greater than five will not be comparable to the CELR daily forms. There appears to be reasonable evidence that the new ERS reporting by event or by record is consistent with reporting on the previous event-based TCER paper forms in terms of number of events or records per day of fishing (Figure 13).

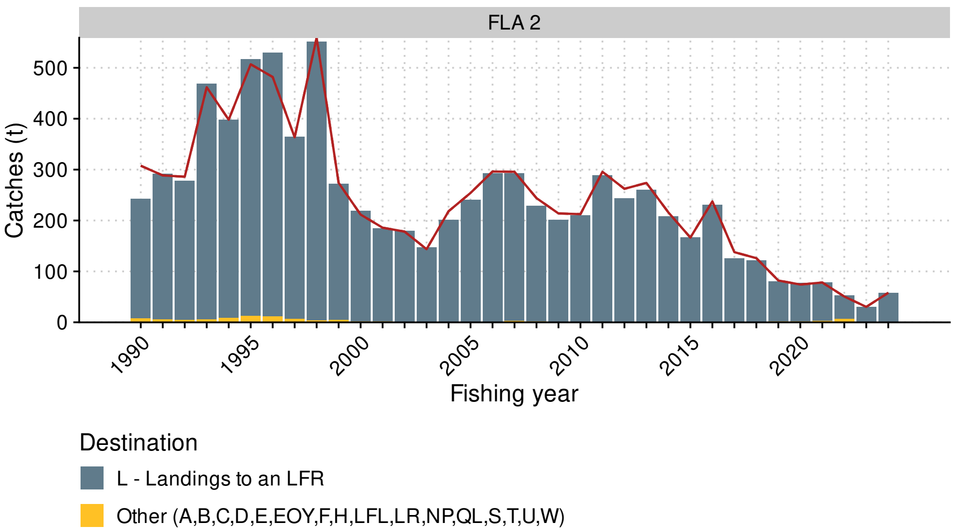

Figure 4: Catches of flatfish by destination (bars), compared with Monthly Harvest Return / Quota Management Report (MHR/QMR) annual totals (line), for Quota Management Area FLA 2. Destination codes are defined in Table 2 and tabulated catches are given in Appendix B.

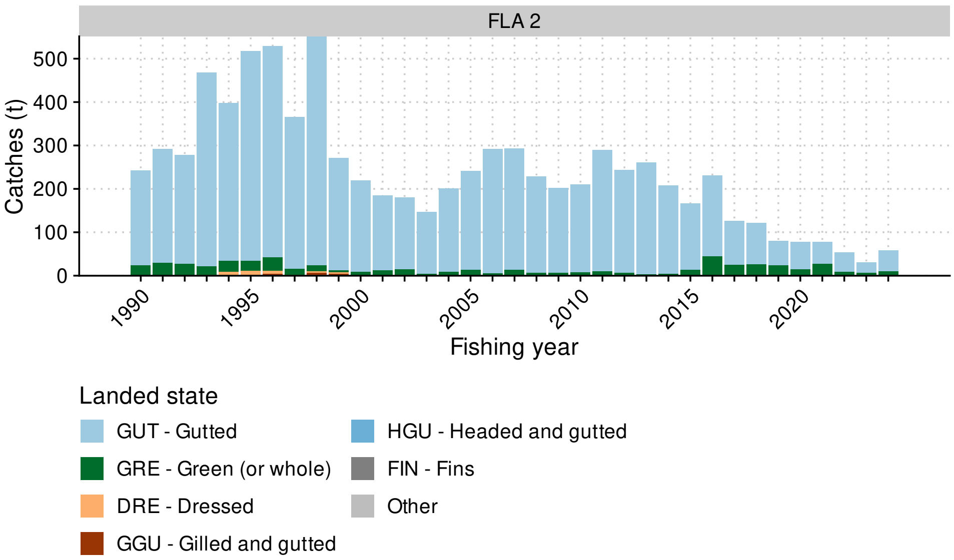

Figure 5: Product state of flatfish landings from Quota Management Area FLA 2. Catches are tabulated in Appendix B.

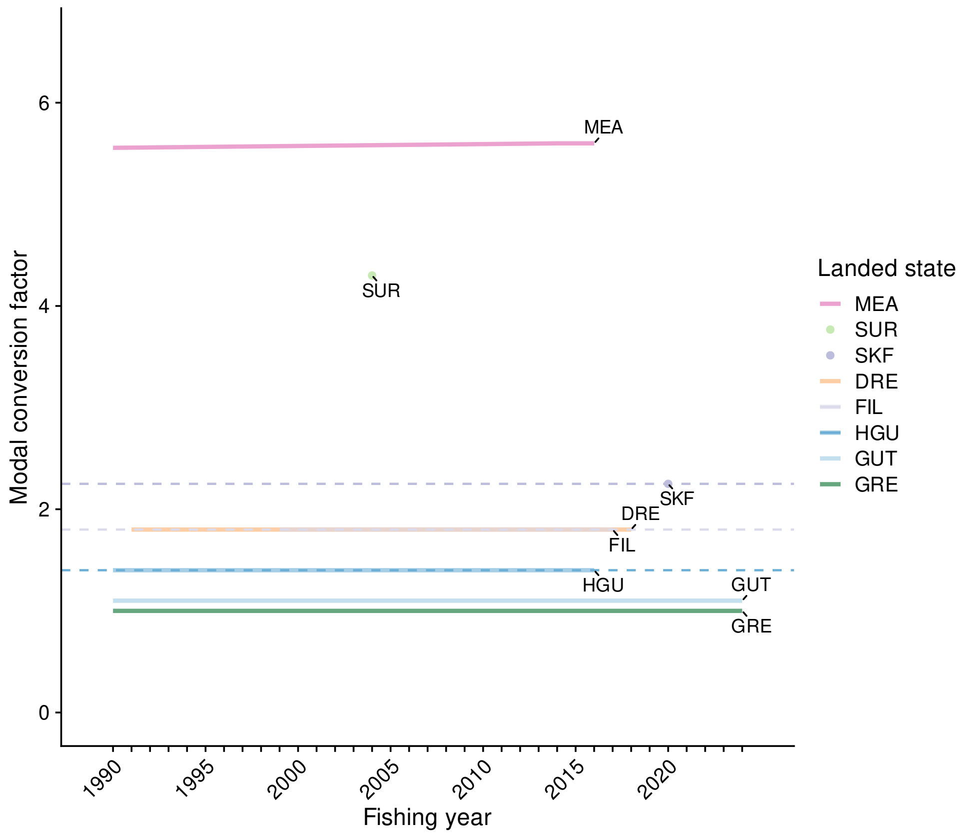

Figure 6: The modal annual conversion factor reported for the product states used in FLA 2 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table B.5, and landed state codes are defined in the glossary Table D.1.

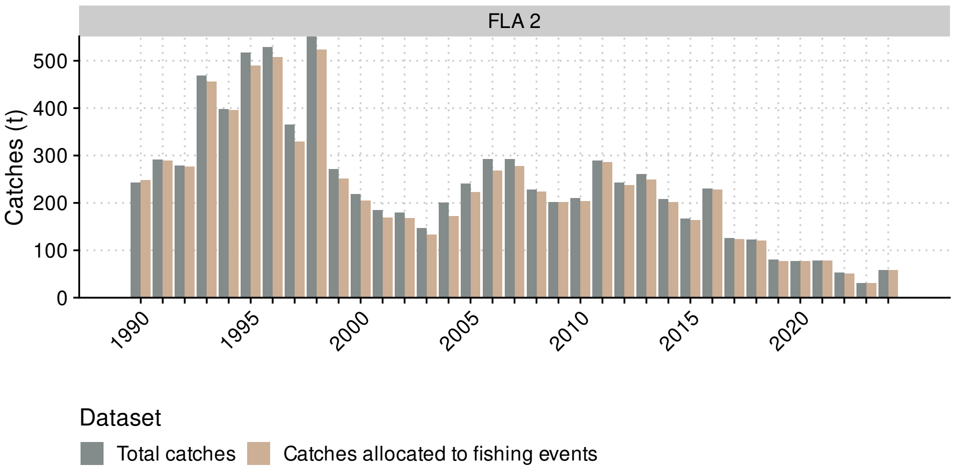

Figure 7: Total catches (t) of flatfish from FLA 2 in comparison with catches allocated to fishing events in the characterisation dataset.

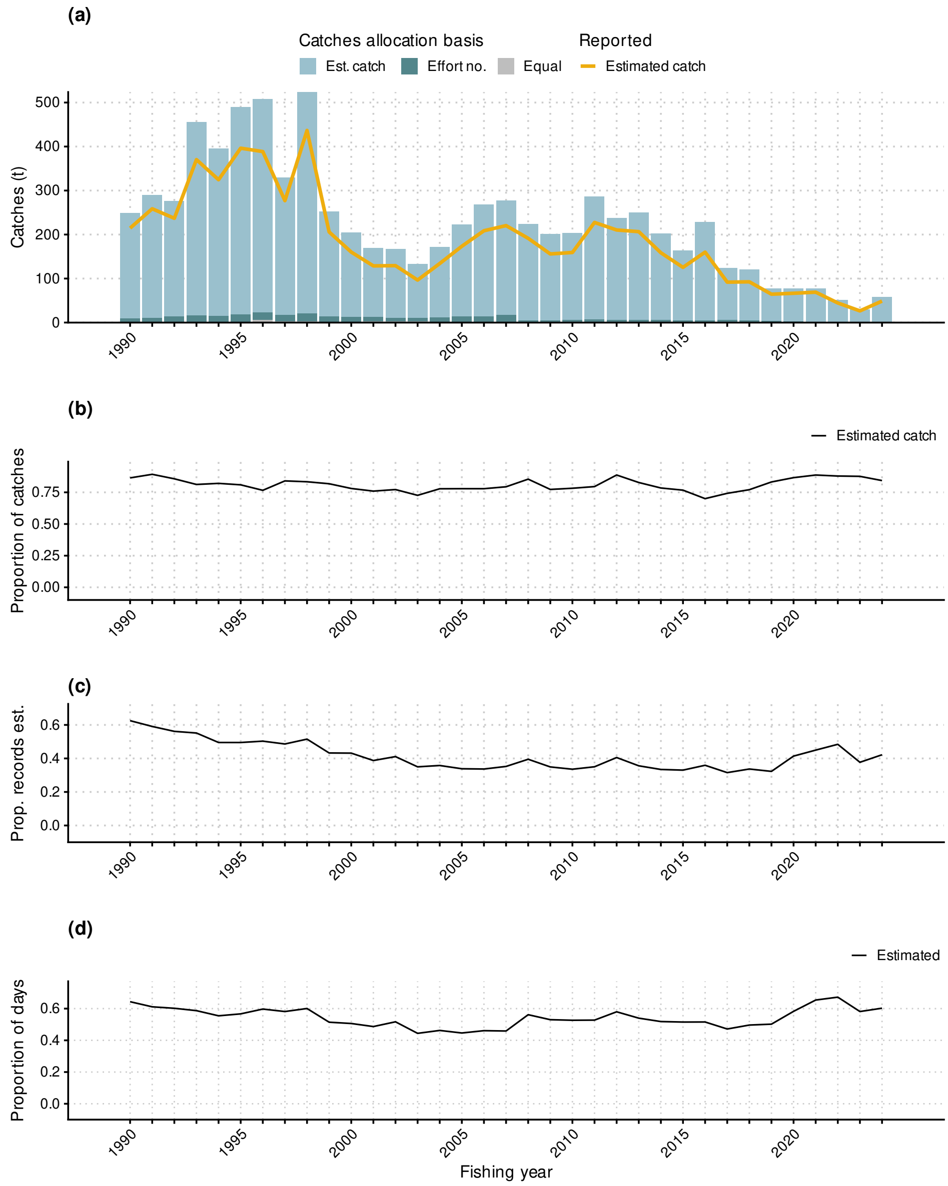

Figure 8: (a) bars: flatfish catches allocated to fishing events in the FLA 2 QMA with allocation method indicated by fill colour (see Section 2.3); line: total estimated catch of FLA; (b) the proportion of FLA 2 catches included in estimated catch data; (c) the proportion of fishing event records with an estimated catch of FLA; (d) the proportion of vessel-days fished with a reported catch of FLA.

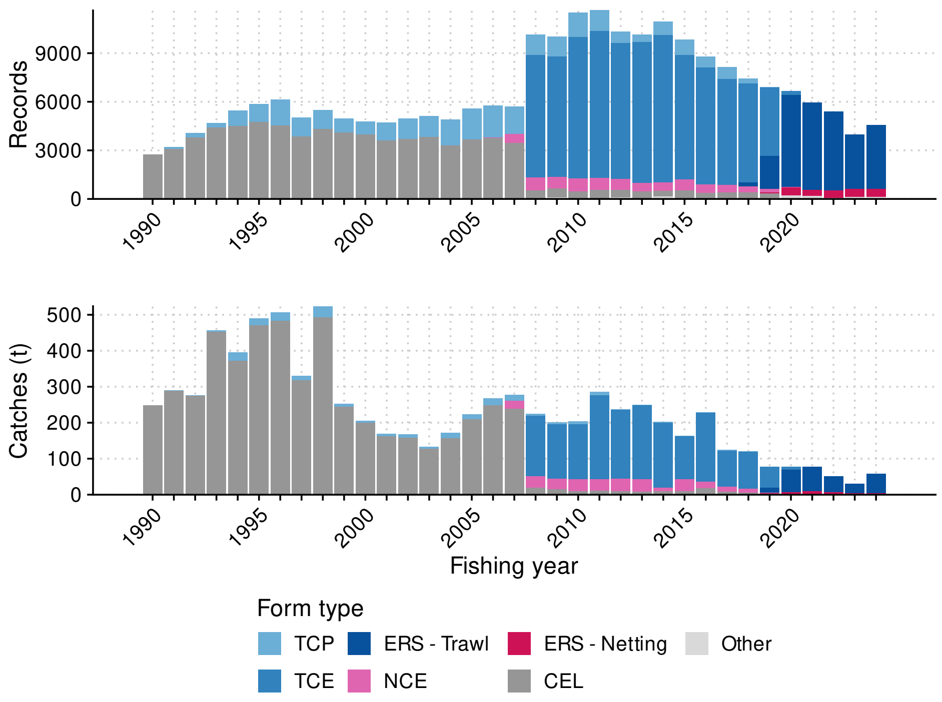

Figure 9: Reporting forms used on trips catching flatfish within the FLA 2 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Lining, ERS - Other Lining, ERS - Potting, ERS - Seining, LCE, LTC,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

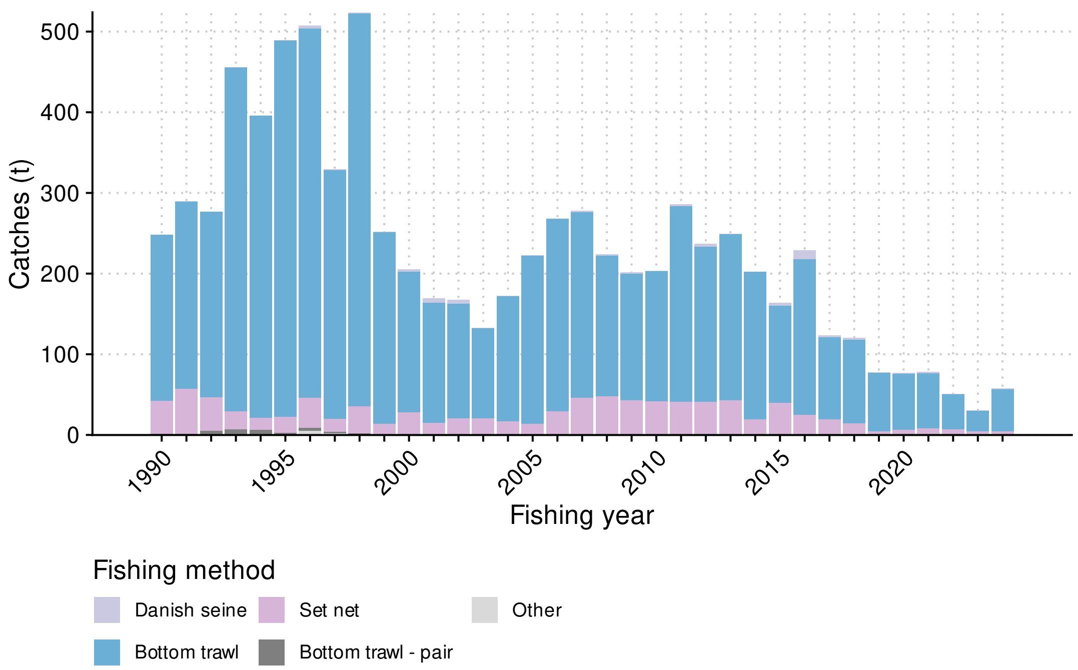

Figure 10: Catches of flatfish by fishing method, for events within the FLA 2 Quota Management Area. Methods grouped as Other include: BLL, BS, CP, CRP, D, DL, DV, FN, FP, HL, L, MW, PL, PRB, PS, PSH, RLP, RN, SLL, T. Tabulated results are provided in Appendix B, and a list of the main fishing method codes is included in the glossary Table D.3.

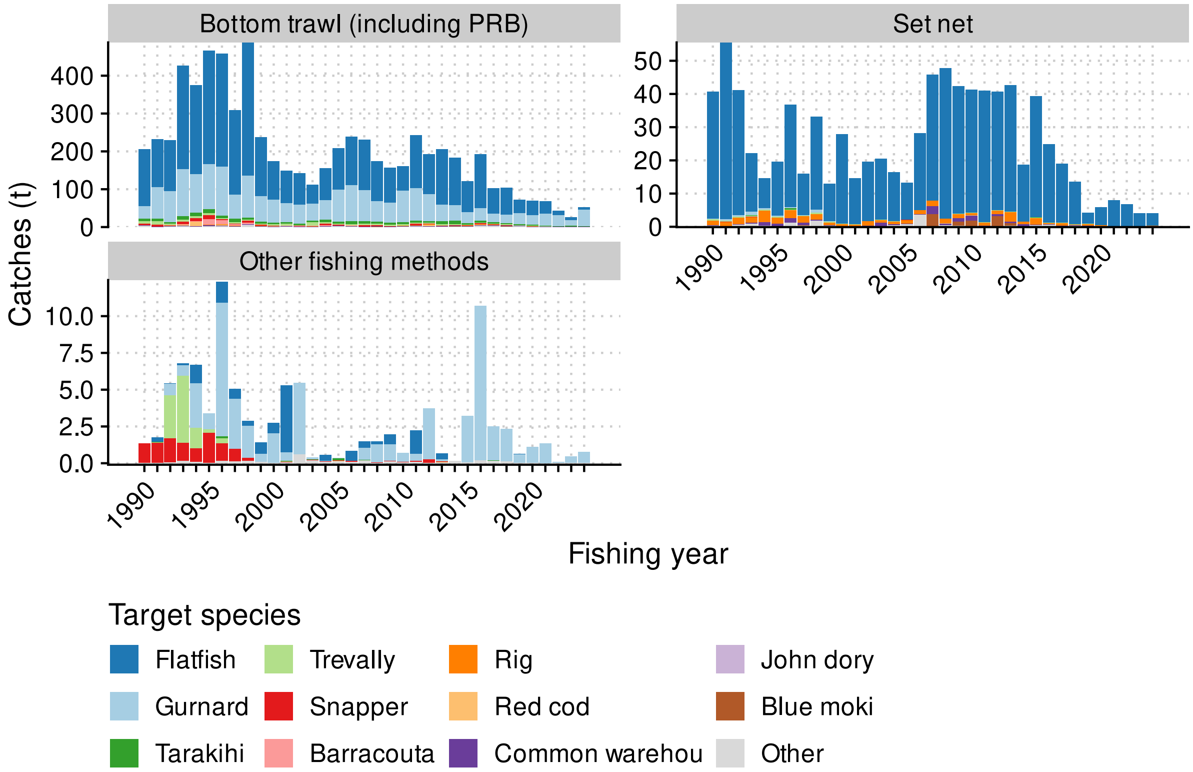

Figure 11: Catches of flatfish by fishing method and declared target species, for events within the FLA 2 Quota Management Area. Precision bottom trawl (PRB) catches are included with conventional bottom trawl (BT) catches. Fishing methods grouped as Other include: BLL, BPT, BS, CP, CRP, D, DL, DS, DV, FN, FP, HL, L, MW-PRM, PL, PS, PSH, RLP, RN, SLL, T. Species grouped as Other include target species with less than 1% of the flatfish catch within the FLA 2 Quota Management Area in a fishing year.

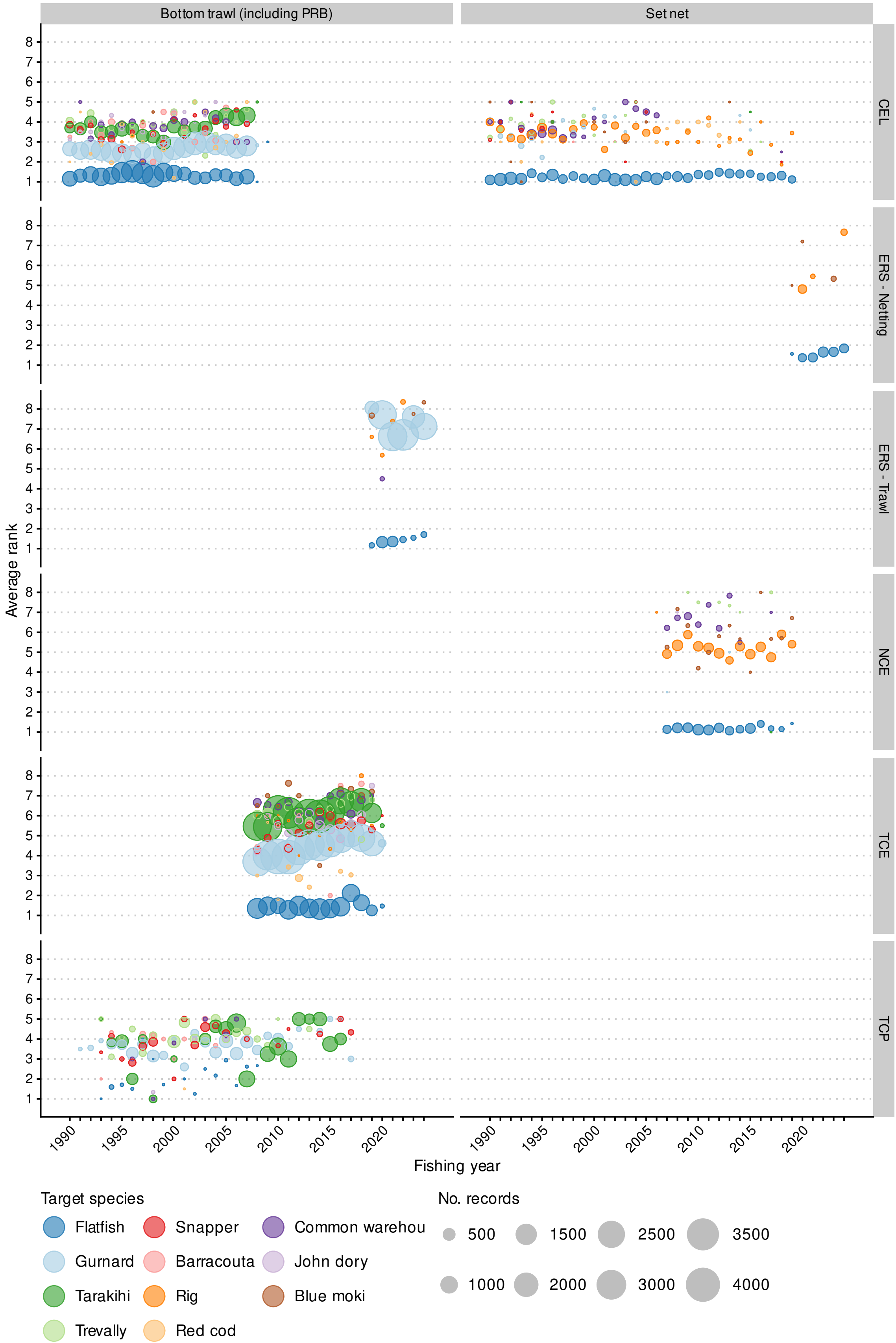

Figure 12: Average rank of flatfish in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the FLA 2 Quota Management Area. The area of the circles scales with the number of records.

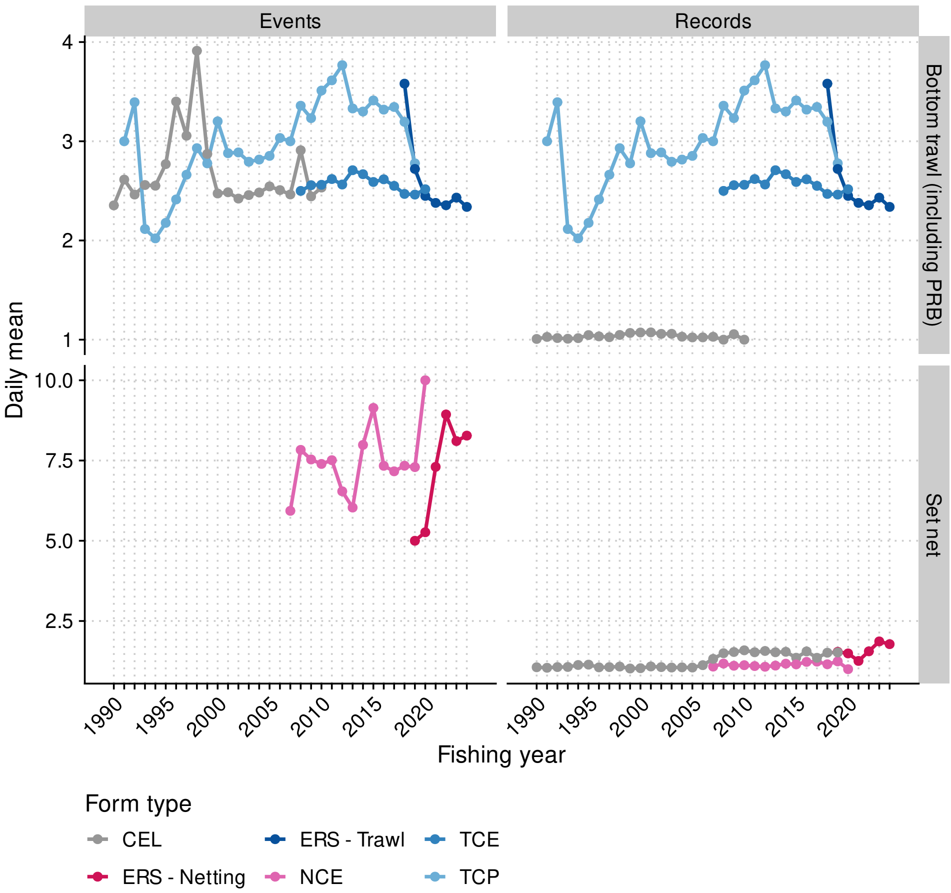

Figure 13: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the FLA 2 QMA on trips landing catch from FLA 2. Data are included for years where a form was used on at least five vessel-days. CELR form types are undefined in set net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

3.1 The bottom trawl (including PRB) fishery

Figure 14 indicates that spatial reporting of FLA 2 bottom trawl (BT) catches was almost non-existent before the introduction of the event-based TCER forms in 2007–08. Once that shift occurred, however, nearly all BT catches were reported with spatial information and comprehensive spatial reporting has continued under electronic reporting.

While the observed spatial distribution of the FLA 2 BT catches has been widespread over the entire period of spatial reporting of catches (Figure 15), detailed spatial reporting of catches indicates that FLA 2 catches were primarily taken in Hawke Bay, with the highest catches near the mouth of the Ngaruroro River just south of Napier. Spatial reporting of BT FLA catches by target fishery shows that the target BT FLA fishery was almost entirely concentrated in southern Hawke Bay while, even though the BT target GUR fishery was more widespread, the catch hotspots were at the same locations as for the BT target FLA fishery (Figure 16). FLA 2 catches when fishing for other BT target species tended to be more widespread, with FLA catches on the Kapiti coast occurring when targeting for tarakihi, trevally, rig and John Dory.

There is evidence from the spatial data that the FLA 2 BT fishery has contracted since 2008–2010 (the first 3-year period with consistent spatial information), with the number of spatial cells dropping in each three-year period plotted in Figure 17. When BT FLA 2 catches are summarised by Statistical Area, the two main Hawke Bay Statistical Areas (013 and 014) predominate, with the Kapiti Statistical Area (039) a distant third (Figure 18). Figure 19 shows clearly that while the BT target FLA catches have considerably diminished since 2021–22, BT target GUR catches of FLA have remained fairly consistent in the same years.

There appears to be little seasonality in the BT catches of FLA, regardless of the target species (Figure 20).

The depth range of BT captured FLA varies by target species, with the BT target FLA tows clustered less than 30 m (Figure 21). The depth range of FLA captures for other BT target species reflect the depth range of each target species, with the BT GUR target captures of FLA being somewhat deeper (extending to deeper than 50 m) than for the BT FLA target tows. There is some evidence in the data that BT FLA 2 tows targeted at FLA have become more shallow since the mid-2000s, with tows beginning with the 2006–2008 time block being more concentrated near 10 m when previously BT FLA target tows were more concentrated between 30 and 40 m (Figure 22). However, this is likely to be an artefact of reporting, with most of the reported BT depths before 2007–08 coming from the deepwater TCEPR forms which were used by larger vessels unable to get as close to shore. There does not appear to be a similar time trend among the other BT target species such as GUR and TAR.

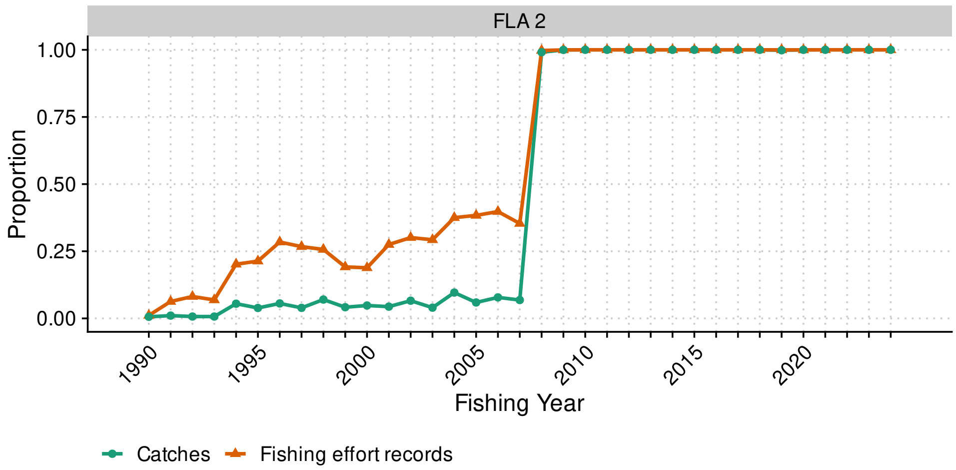

Figure 14: The proportion of records and catches reported with a latitude/longitude for the FLA 2 bottom trawl (including PRB) fishery.

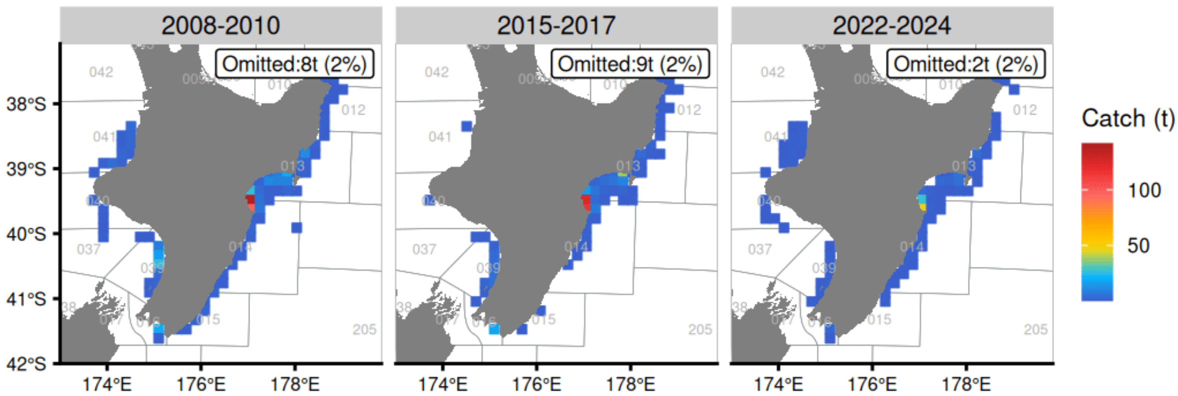

Figure 15: Catches (t) for the FLA 2 bottom trawl (including PRB) fishery, for 3-year periods within the era during which at least 60% of catch was reported with spatial information. These plots use a 16 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

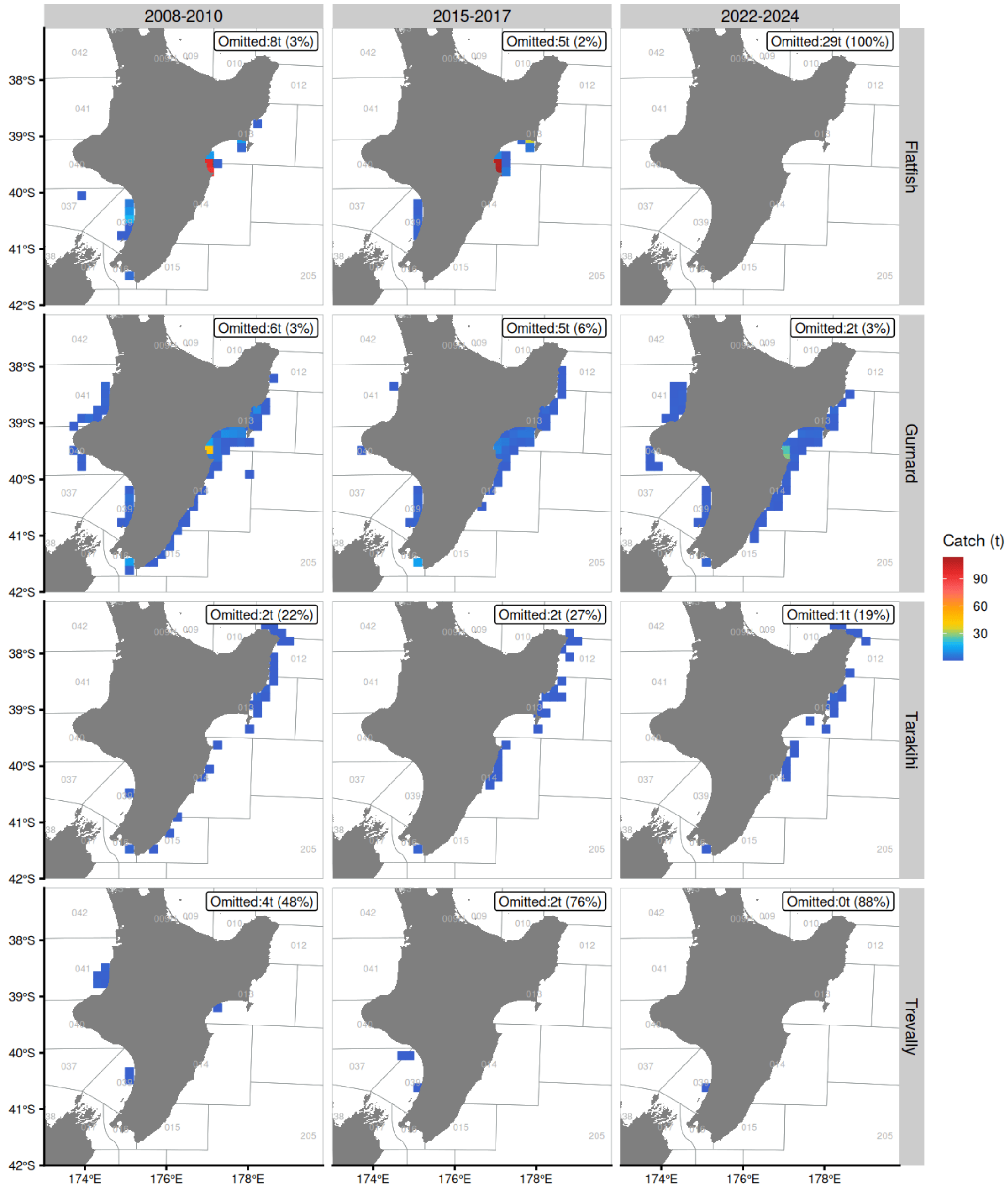

Figure 16: Catches of flatfish from the bottom trawl (including PRB) fishery by key target species. These plots use a 16 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

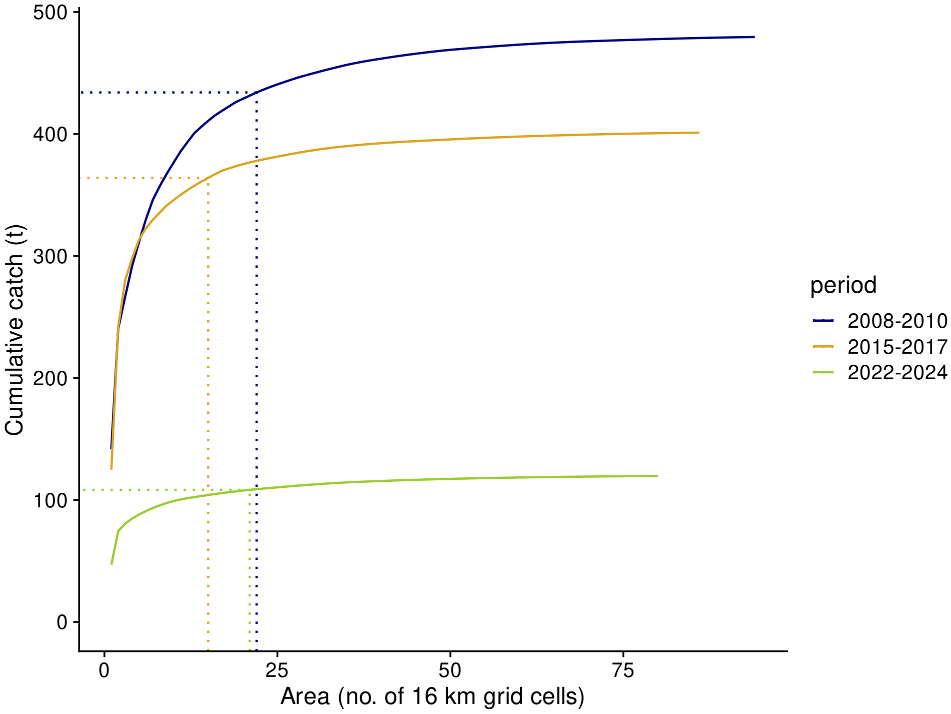

Figure 17: Cumulative FLA 2 catch by area (grid cells) for the bottom trawl (including PRB) fishery, aggregated for the first, middle, and last 3-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 3-year period of reporting.

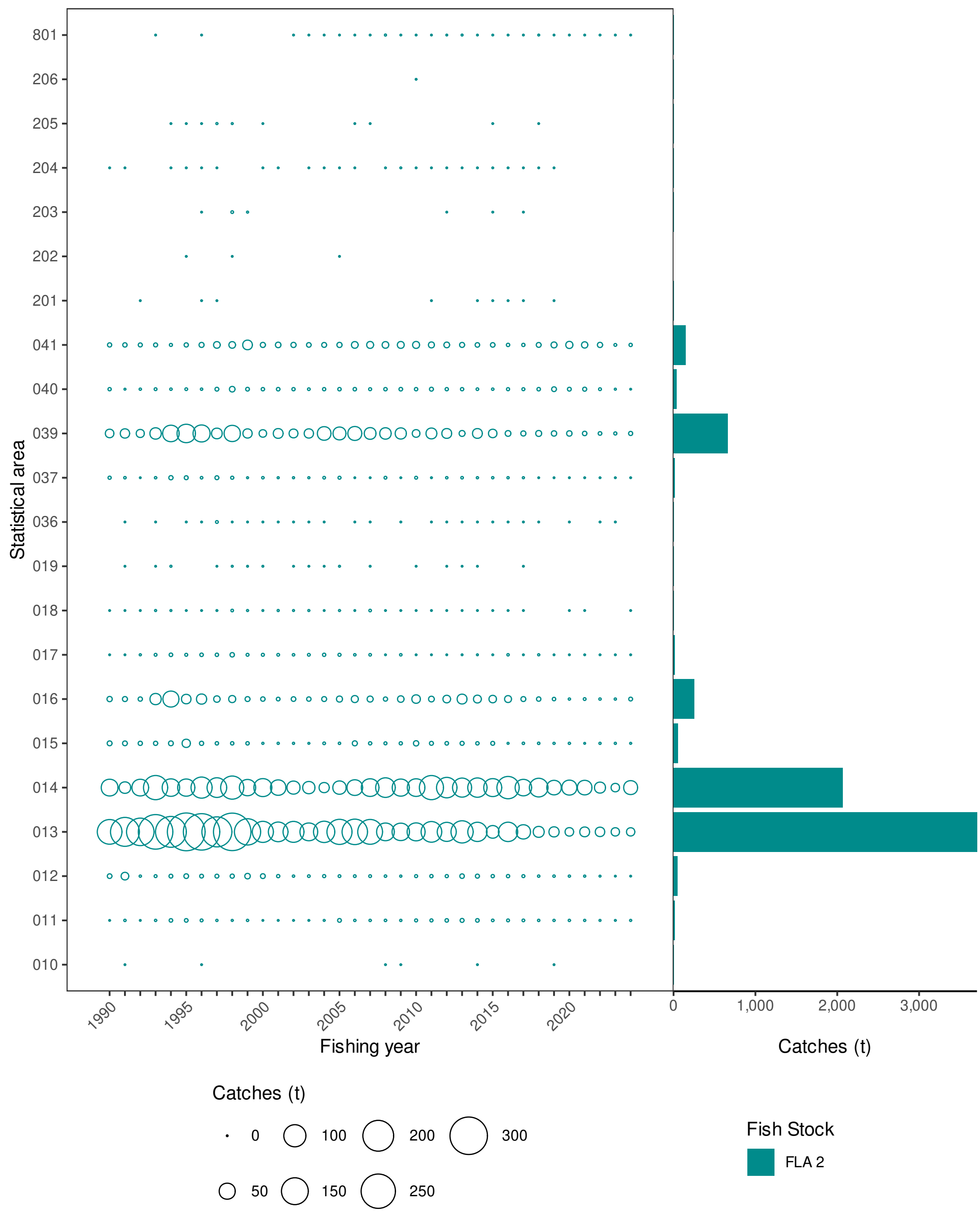

Figure 18: Annual FLA 2 catches (t) by statistical area for the bottom trawl (including PRB) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of FLA 2 for each statistical area.

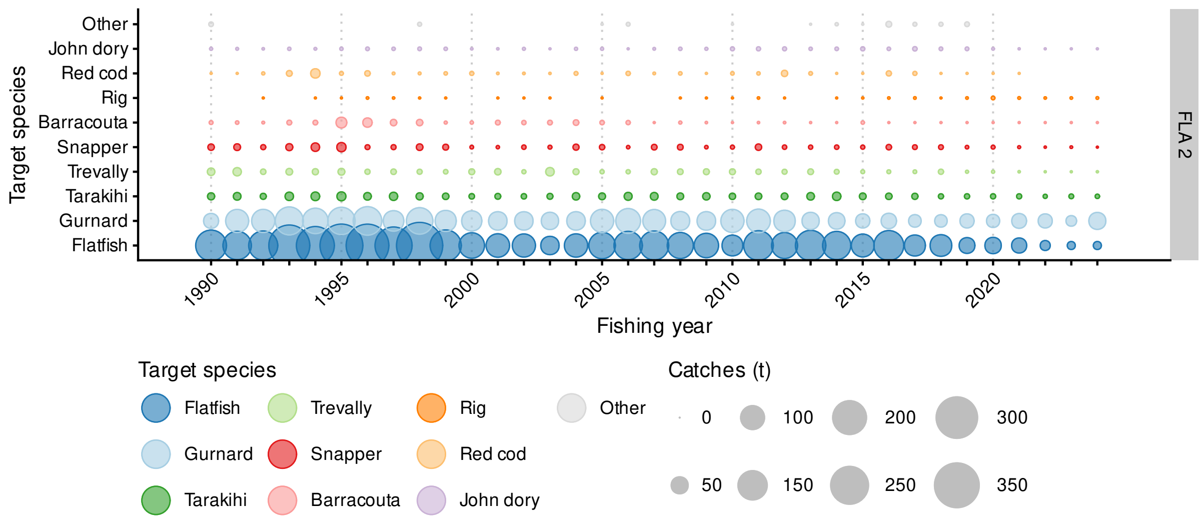

Figure 19: Flatfish catches by fishing year and target species for the bottom trawl (including PRB) fishery. The area of the circle scales with the yearly catches.

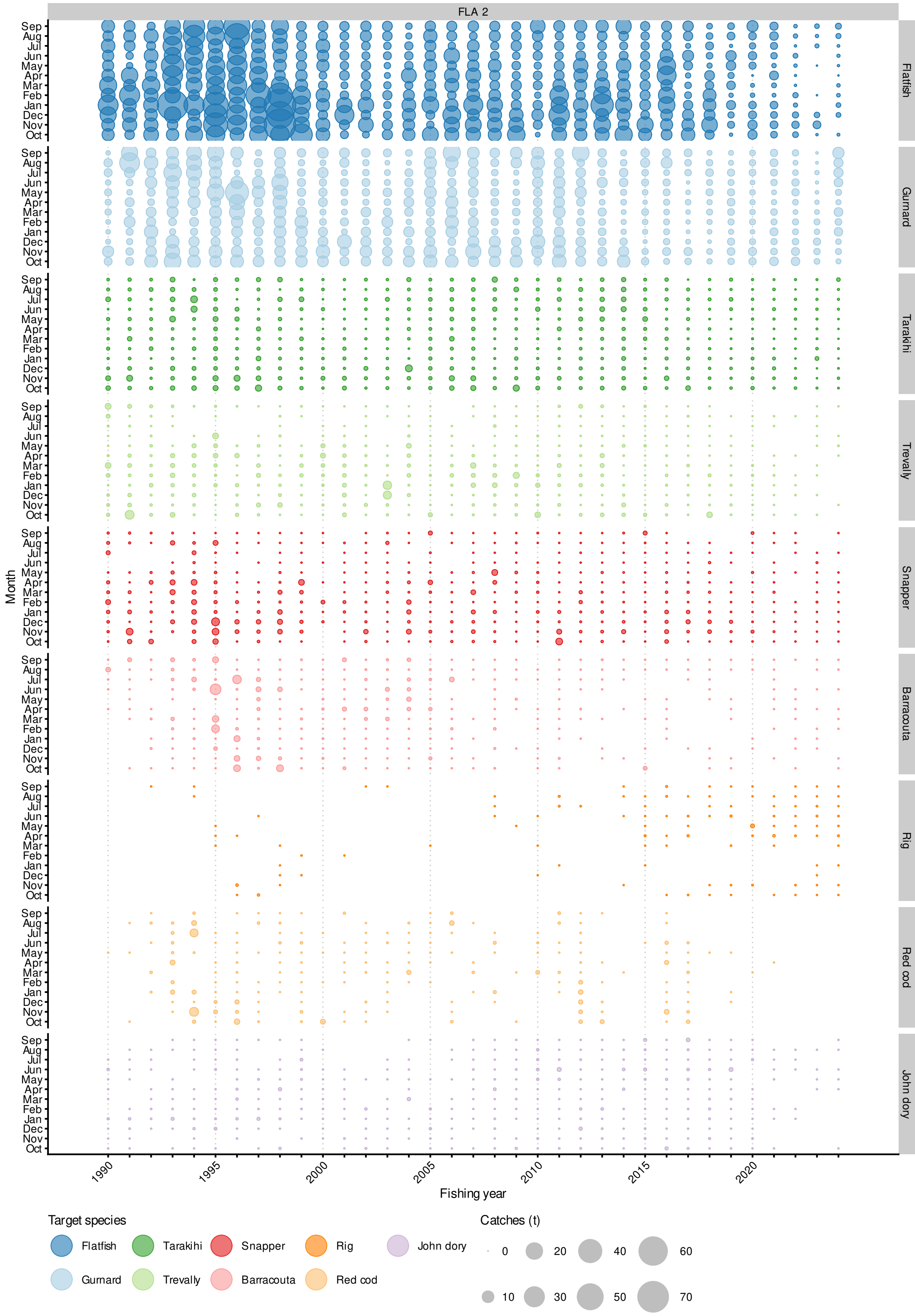

Figure 20: Seasonal distribution of FLA 2 catches by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly catches.

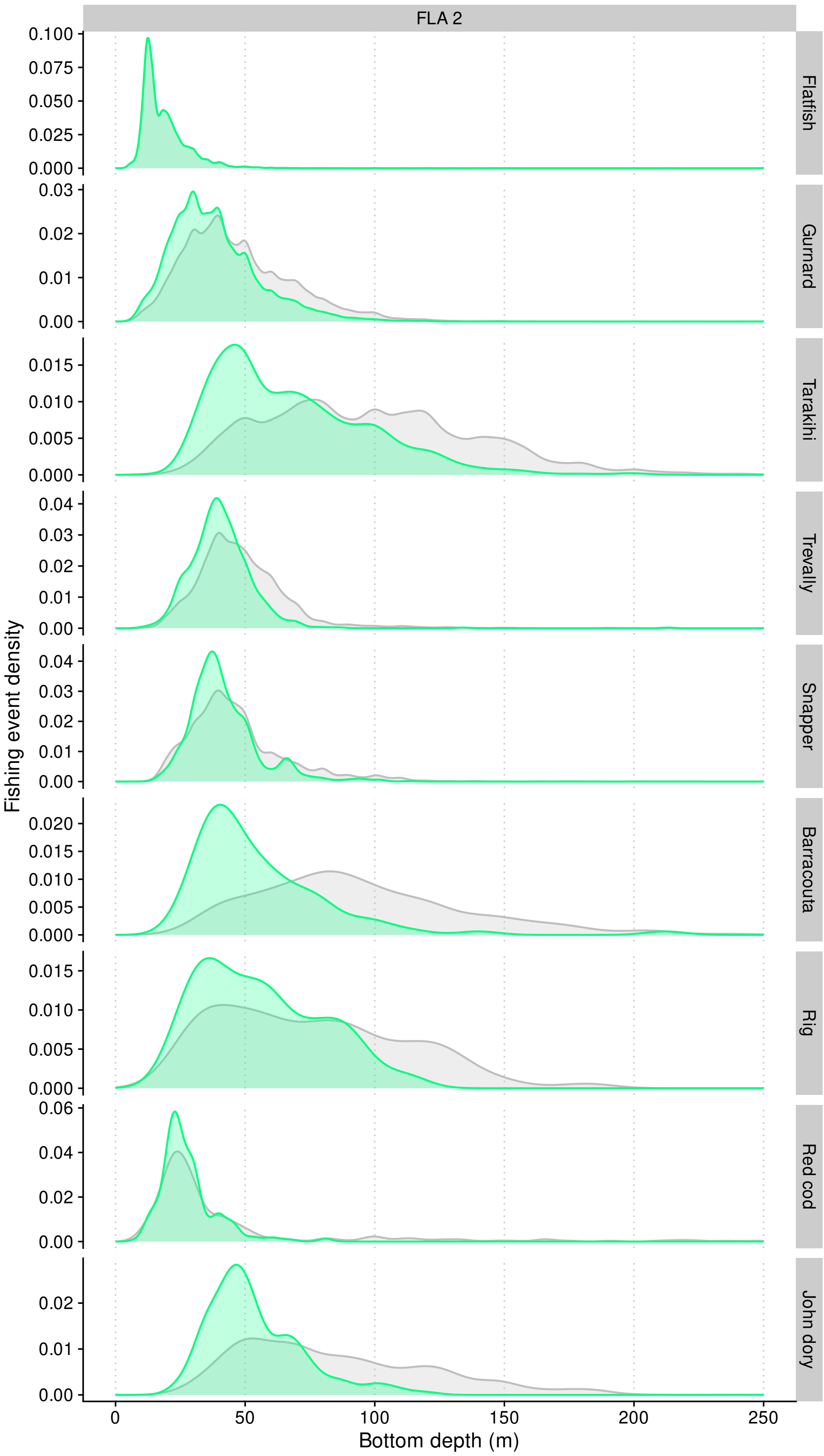

Figure 21: distribution by target species for trips landing FLA 2 from the bottom trawl (including PRB) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, green fill = positive effort (i.e., estimated catch > 0).

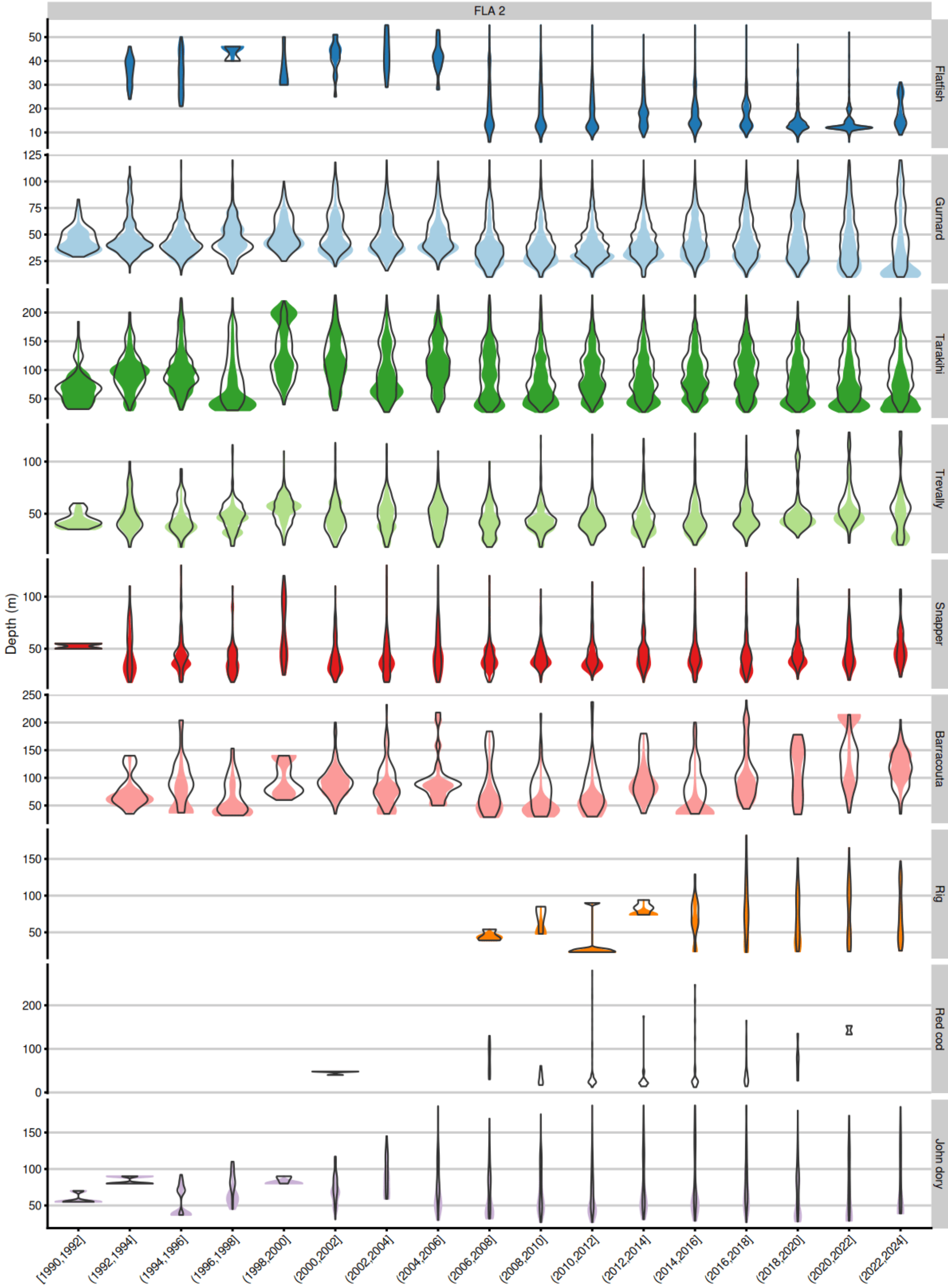

Figure 22: Catch-weighted (coloured) and unweighted (unfilled) effort depth distribution by target species for trips landing FLA 2 from the bottom trawl (including PRB) fishery.

3.2 The set net fishery

Figure 23 indicates that spatial reporting of FLA 2 set net (SN) catches was non-existent before the introduction of the event-based NCELR forms in 2006–07. Once that shift occurred, however, spatial reporting was still incomplete, probably because exemptions from using the NCELR form were allowed for vessels less than 6 m in overall length. These vessels continued to use the CELR form, a daily event form which did not require spatial reporting. Once the introduction of electronic reporting was made in 2019–20, there was 100% spatial reporting in the FLA 2 set net fishery (Figure 23).

As for the FLA 2 BT fishery, there is evidence from the spatial data that the FLA 2 SN fishery has contracted in size since 2008-2010, with the number of spatial cells dropping in each three-year period plotted in Figure 24. The diminution of the set net fishery on the west coast of the North Island is likely to be due to regulations implemented for the protection of Maui dolphins, with that fishery disappearing north of Cape Egmont in recent years. On the east coast, the remnant SN fishery has coalesced into Hawke Bay. FLA catches by SN were mostly targeted at FLA, although the target rig SN fishery also captured some FLA on both coasts.

When SN FLA 2 catches are summarised by Statistical Area, the two main Hawke Bay Statistical Areas (013 and 014) are clearly important, but Area 016 (eastern Cook Strait) is second in terms of accumulated SN FLA catch and the Kapiti Statistical Area (039) is also important (Figure 25). Figure 26 shows that all target FLA catches by SN have diminished since 2019–20.

There appears to be little seasonality in the SN catches of FLA, regardless of the target species, although it is difficult to determine monthly patterns in the sparse SN catches of FLA 2 (Figure 27).

The depths at which set net fishing events occur are not reported to MPI. While it is feasible to obtain an approximate estimate of the depth from the reported position, this was not done for this report.

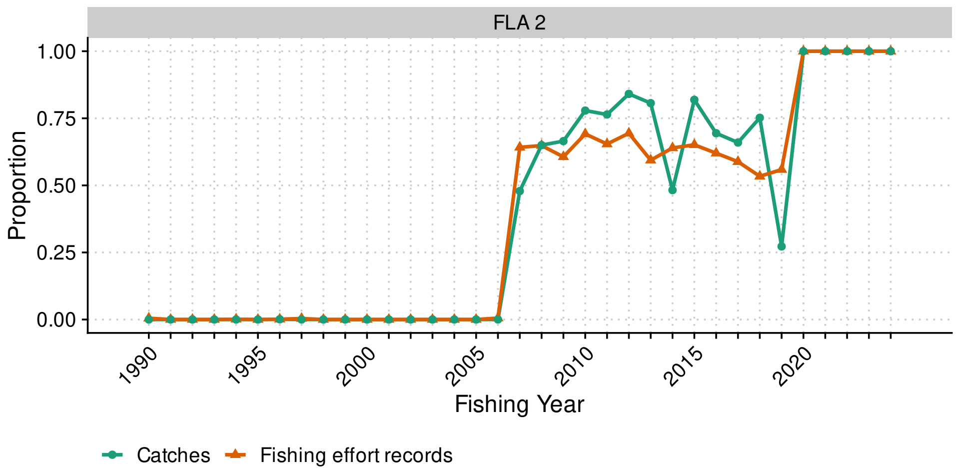

Figure 23: The proportion of records and catches reported with a latitude/longitude for the FLA 2 set net fishery.

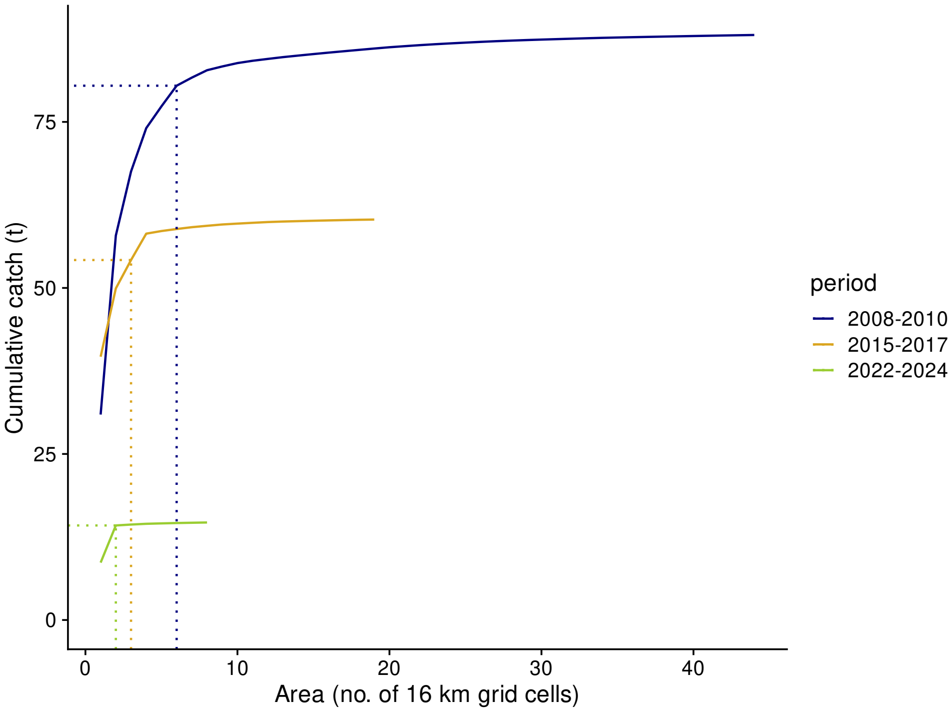

Figure 24: Cumulative FLA 2 catch by area (grid cells) for the set net fishery, aggregated for the first, middle, and last 3-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 3-year period of reporting.

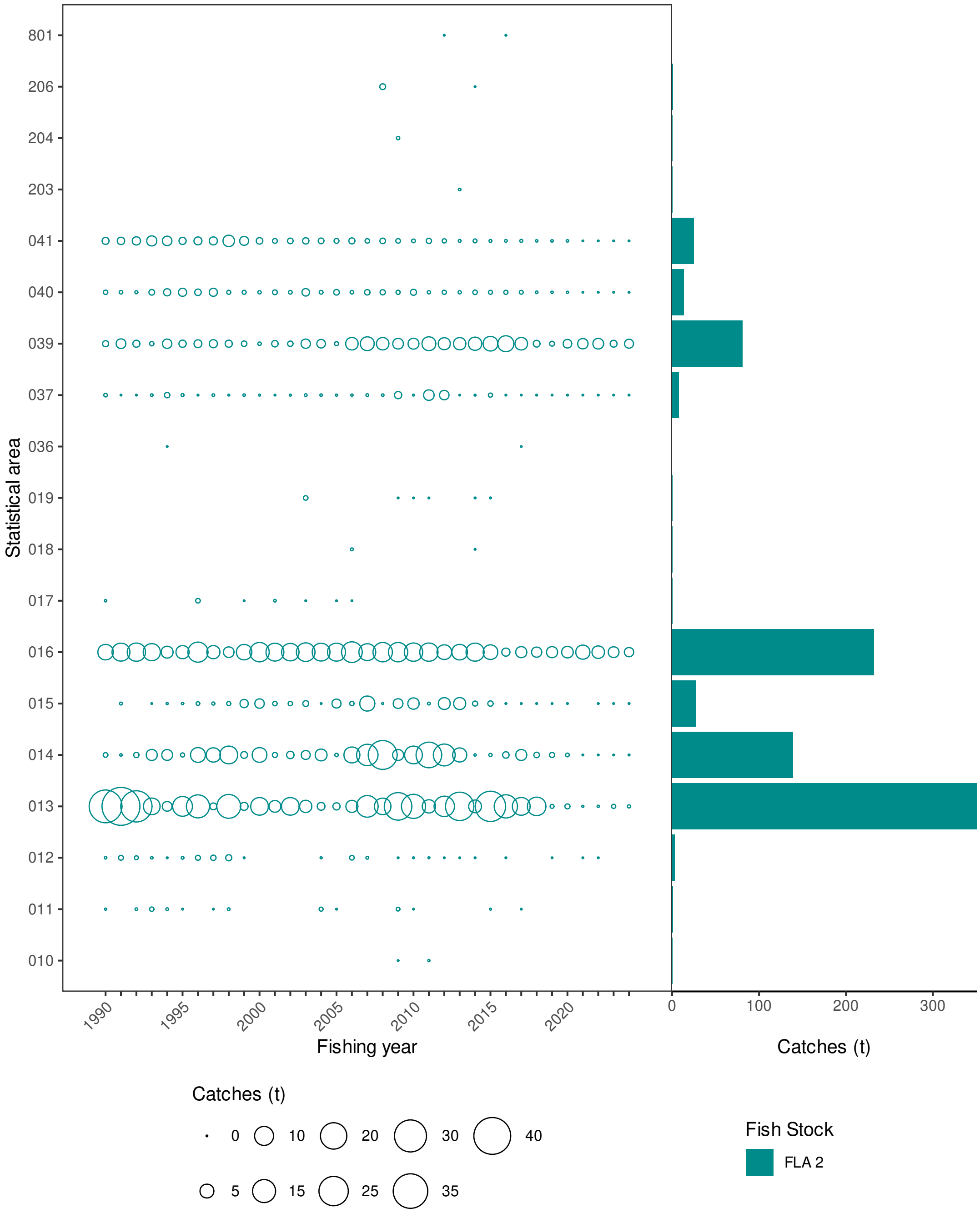

Figure 25: Annual FLA 2 catches (t) by statistical area for the set net fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of FLA 2 for each statistical area.

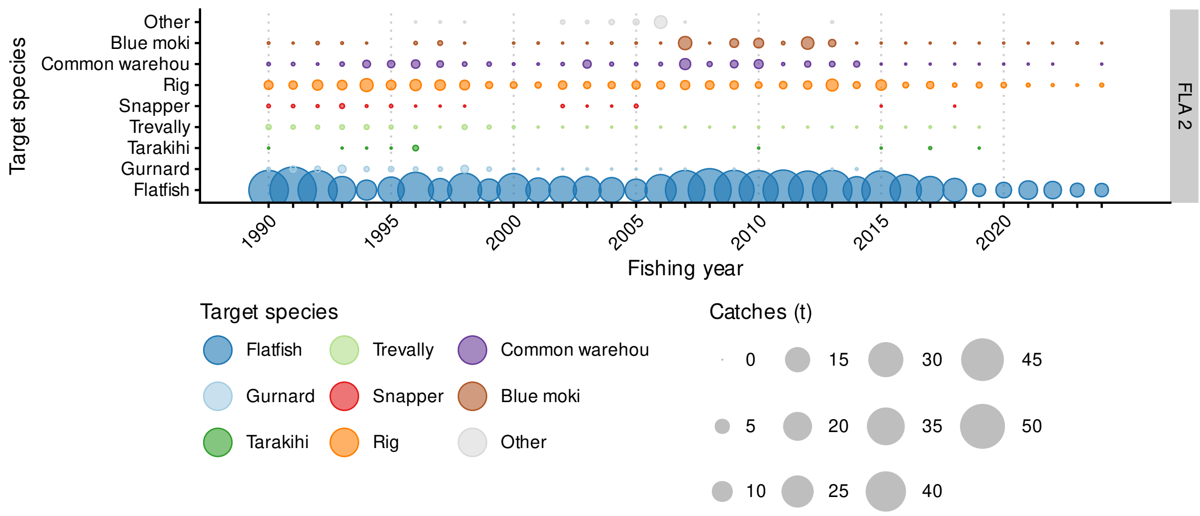

Figure 26: Flatfish catches by fishing year and target species for the set net fishery. The area of the circle scales with the yearly catches.

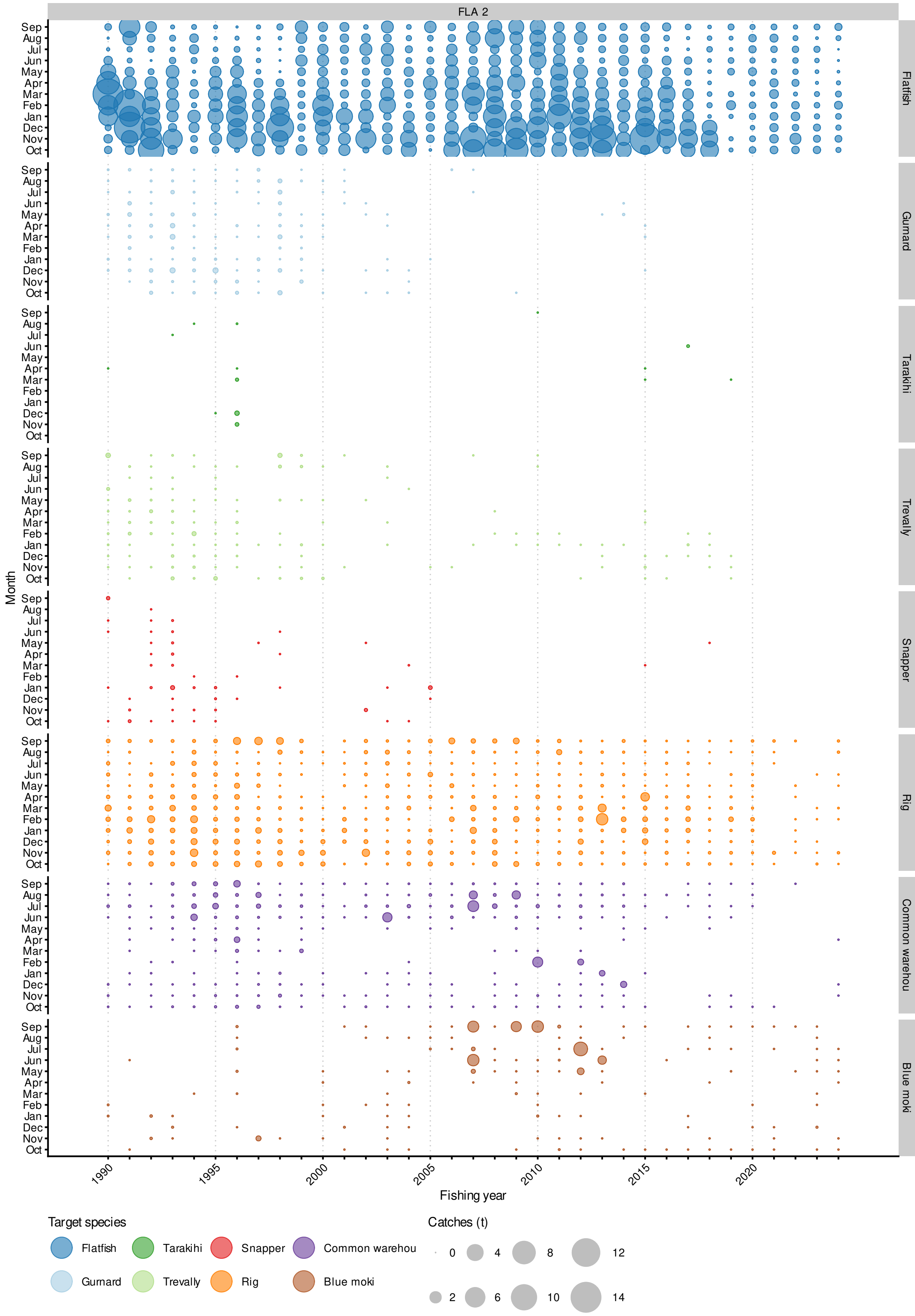

Figure 27: Seasonal distribution of FLA 2 catches by month and fishing year for the set net target fisheries. The area of the circle scales with the monthly catches.

3.3 Species-specific reporting

In common with other QMS stocks that encompass multiple species (such as hapuka and bass), reporting of flatfish has not always had the species-level data that is desirable for stock assessment purposes.

The *Fisheries (Reporting) Regulations 1990* (and the subsequent *Fisheries (Reporting) Regulations 2001*) indicated that the code FLA should be used for the flatfish fishstocks, but indicated that the individual species codes (i.e., *not* the FLA code) should be used whenever a species code was required. However, this distinction was not enforced and the October 2004 *Catch Effort Data Quality Specifications and Standards* explicitly recognised FLA as a valid species code for use on catch effort forms. This interpretation persisted in the initial implementation of the Electronic Reporting System (ERS) with instructions up to and including the *Fisheries (E-logbook Users Instructions and Codes) Circular 2019* identifying FLA as a valid species code.

However, species-level flatfish reporting was addressed in the *Fisheries (E-logbook Users Instructions and Codes) Circular 2021* which removed FLA as a valid species code. The individual flatfish species codes are now required to be used in all reporting, other than Monthly Harvest Returns. Thus, from September 2021, estimated catch and target species reporting must use species codes rather than FLA, and landings must be recorded to pseudo-fishstocks, such as SFL 1 or LSO 3, rather than FLA 1 or FLA 3.

3.3.1 Reporting practice

The use of the species-specific codes for reporting flatfish catches has varied over time, and between QMAs (Figure 28). The change in the number of events in 2008 is attributable to the introduction of the TCER form; this has limited impact in FLA 1 where the flatfish fisheries used small vessels (less than 6 m) and continued to report on the CELR form.

The impact of the 1 September 2021 change is clearly apparent, with all flatfish catch in all areas using the species-specific codes in reporting both estimated catches, and landings. Prior to this, if the species-specific codes were used, this was usually in estimated catch reporting, although a small number of records—with the highest proportion occurring in FLA 2—came from trips where the species codes were used in landings data.

Figure 28 addresses whether, *given the opportunity to report flatfish catches at the finest scale possible, did fishers do this?* It therefore includes only those fishing effort records where flatfish was included in the estimated catch. Furthermore, we only consider the species codes to have been used for the estimated catch or landings if these were used comprehensively, with no use of the FLA group code.

3.3.2 Assigning catch by species

Flatfish catches, at the fishing event level, can be assigned to the individual species in the following situations:

- if species codes are used exclusively (i.e., no use of the FLA code) for the estimated catch reported for an event, then the proportions by species can be applied to the total FLA catches for an event (noting that the catches are scaled to landings); and
- if species codes were used (exclusively) only in the landings for a trip, but only one species was reported, then all event-level catches from the trip can be assumed to be the species landed. (If a trip-level analysis were conducted, then landings data with mixed species could be used in that case).

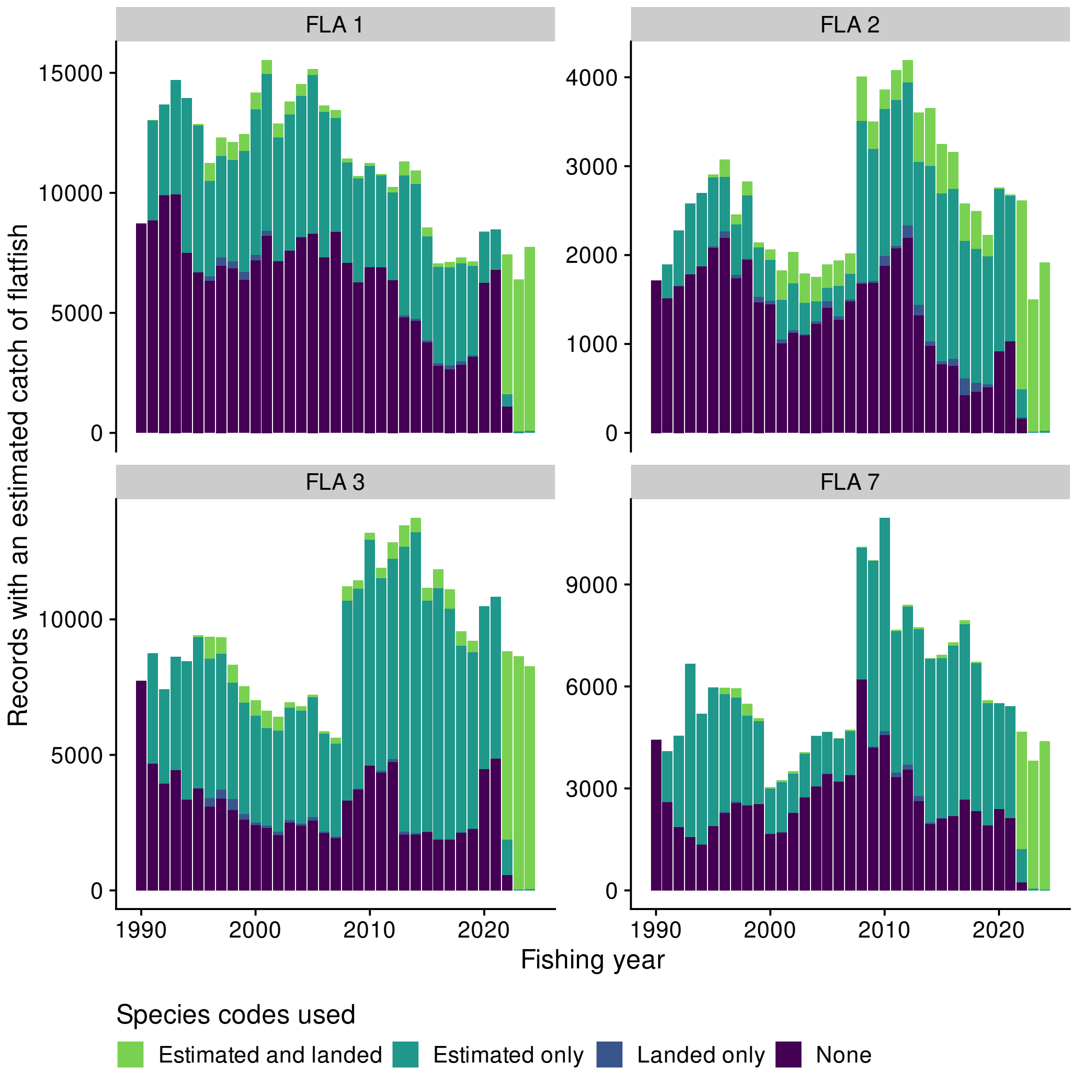

Figure 28: Fishing effort records where there was an estimated catch of flatfish classified according to the use of the species-specific codes in reporting. Species-specific codes could be used for estimated catch reporting (at the fishing event level, here labelled 'Estimated only'), the reporting of landings (from the trip on which an event occurred, labelled 'Landed only'), for both estimated and landed catch data (from the event and its associated trip, labelled 'Estimated and landed'), or for neither (i.e., where the generic FLA code was used for both estimated and landed catches, labelled 'None').

Before 2019, species resolution reporting was undertaken for around half of the FLA 1 catch, with steady increases in the proportion of catch identified to species in FLA 2 and FLA 3 (Figure 29). In FLA 7, the proportion of catch identified to species increased rapidly during the early 1990s, but then gradually decreased to the mid-2000s, before increasing again. In all four QMAs, the introduction of electronic reporting in 2019 resulted in a drop in the proportion of the catch that was reported to species level. Although the circulars allowed species specific reporting, it may have been discouraged by the implementation in ERS software. However, this issue has largely been resolved by the 2021 circular, which reinstated mandatory species reporting, resulting in the great majority of the catch reported to species level during 2022 to 2024.

Reporting to species level accounts for a greater proportion of the total flatfish catch when flatfish are targeted, particularly in FLA 1 and FLA 3 (Figures 30 to 33). The proportion reported to species level varies by method and by QMA, with SN having a higher proportion of the catch reported to species level in FLA 1 (Figure 34) while BT appears to have the highest proportion of catch reported at the species level in FLA 2 (Figure 35), FLA 3 (Figure 36) and FLA 7 (Figure 37). Note that SN also has a consistently high proportion of catch reported to species level in FLA 3 (Figure 36).

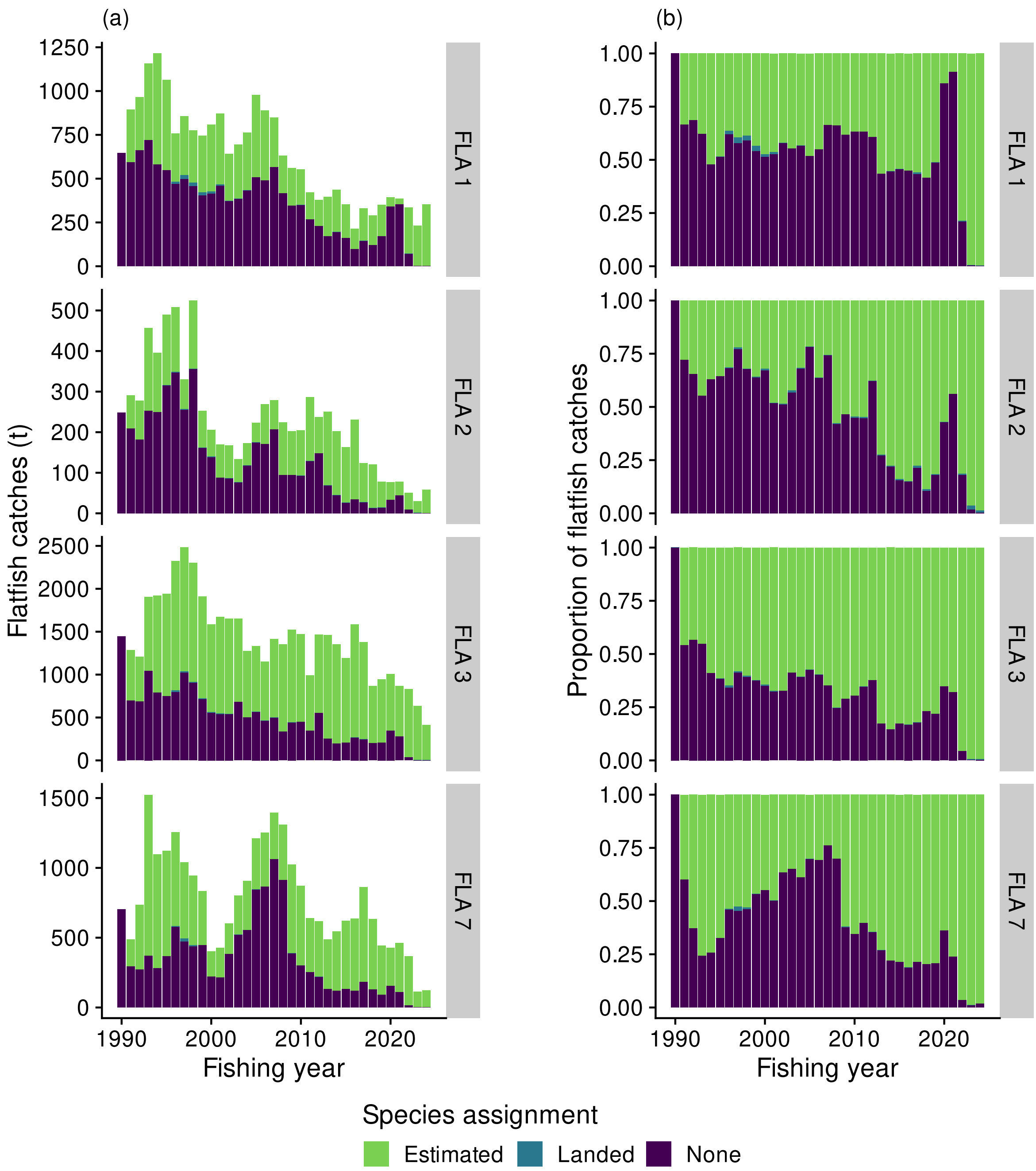

Figure 29: Quantity (a) and proportion (b) of fishing event-level flatfish catches that are assignable to species, by fishstock and year and categorised by assignment method (estimated catch data or landings data).

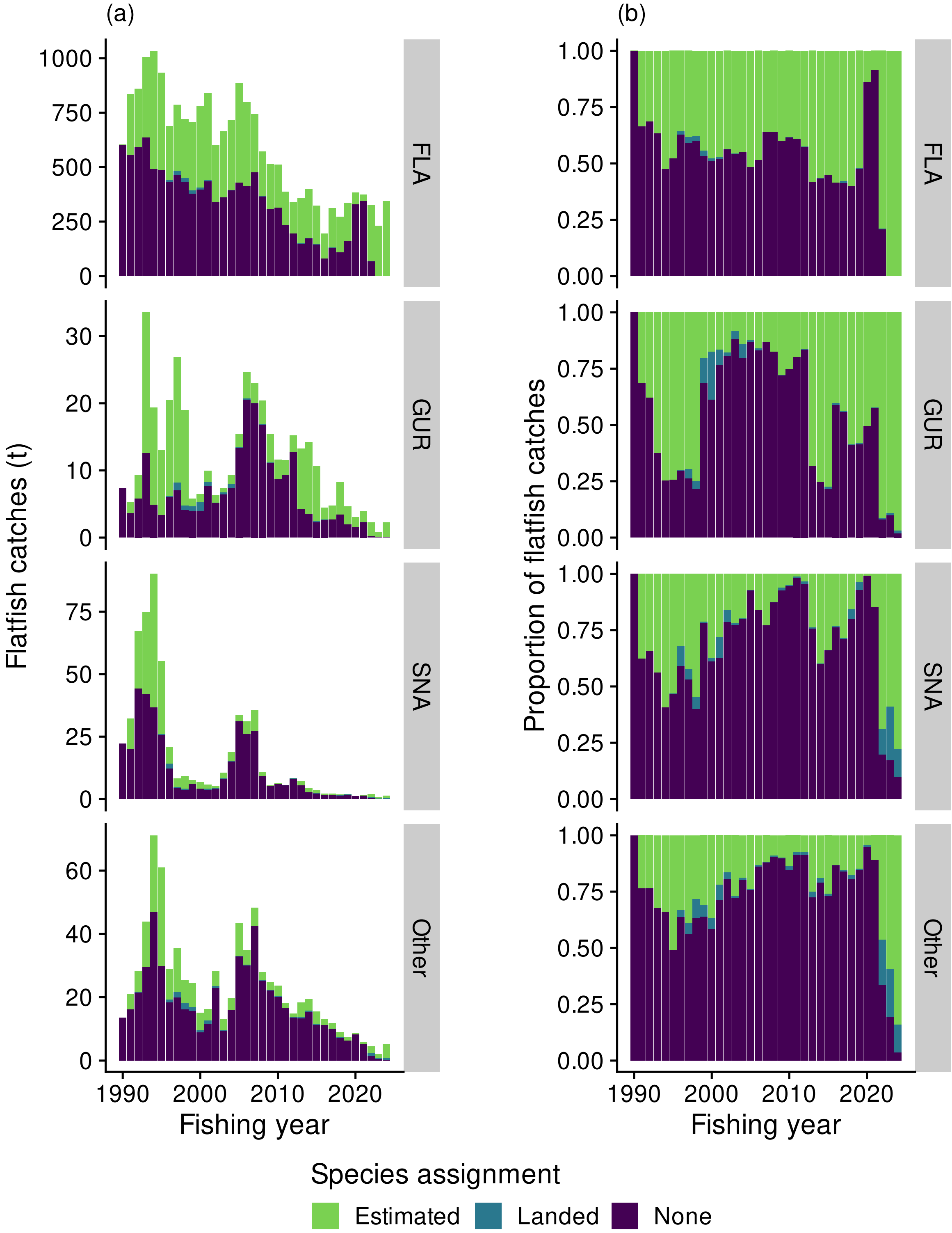

Figure 30: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 1 that are assignable to species by target species and year, categorised by assignment method (estimated catch data or landings data). All flatfish species targets are coded as FLA target, and target species other than the top three by flatfish catch weight are grouped as Other.

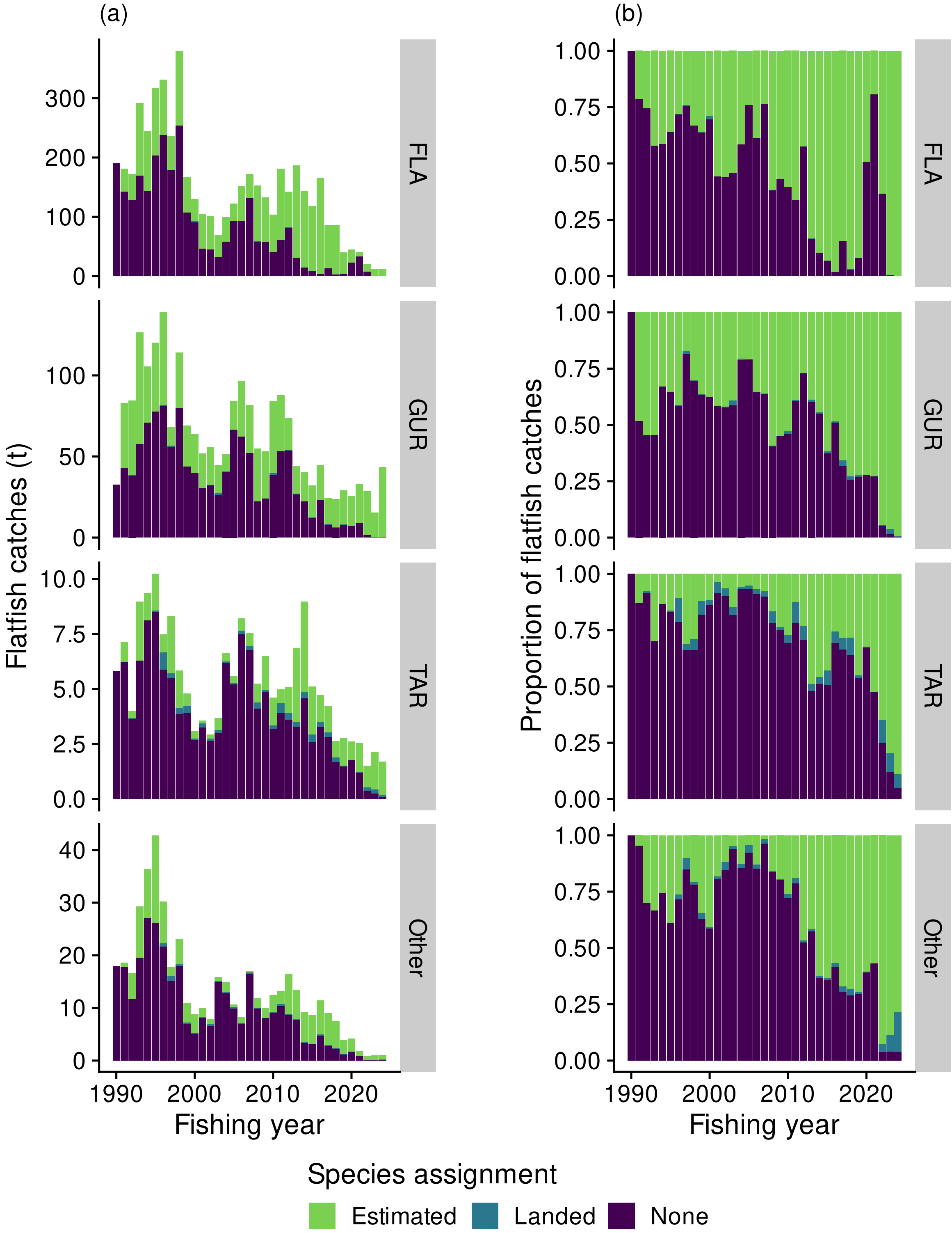

Figure 31: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 2 that are assignable to species by target species and year, categorised by assignment method (estimated catch data or landings data). All flatfish species targets are coded as FLA target, and target species other than the top three by flatfish catch weight are grouped as Other.

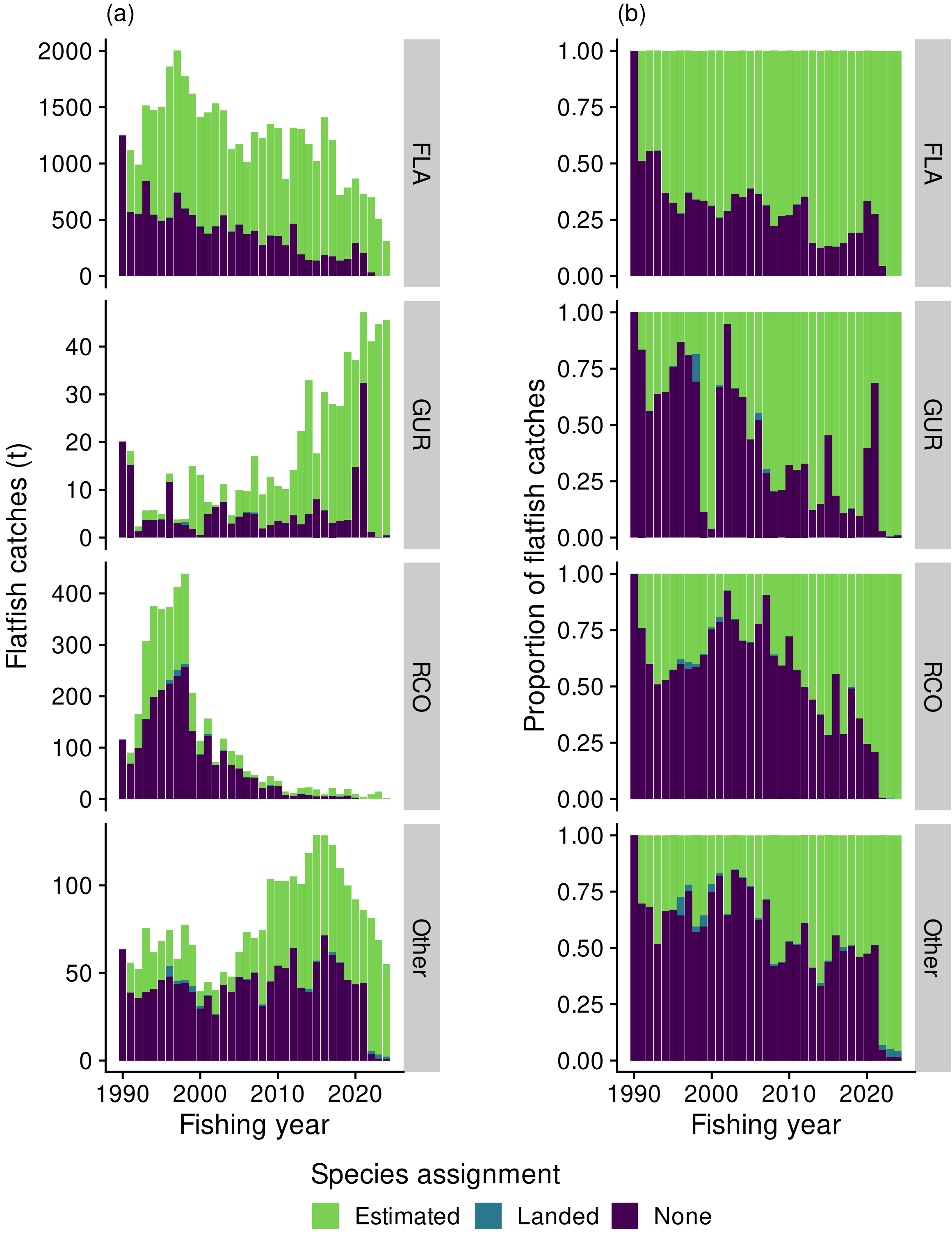

Figure 32: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 3 that are assignable to species by target species and year, categorised by assignment method (estimated catch data or landings data). All flatfish species targets are coded as FLA target, and target species other than the top three by flatfish catch weight are grouped as Other.

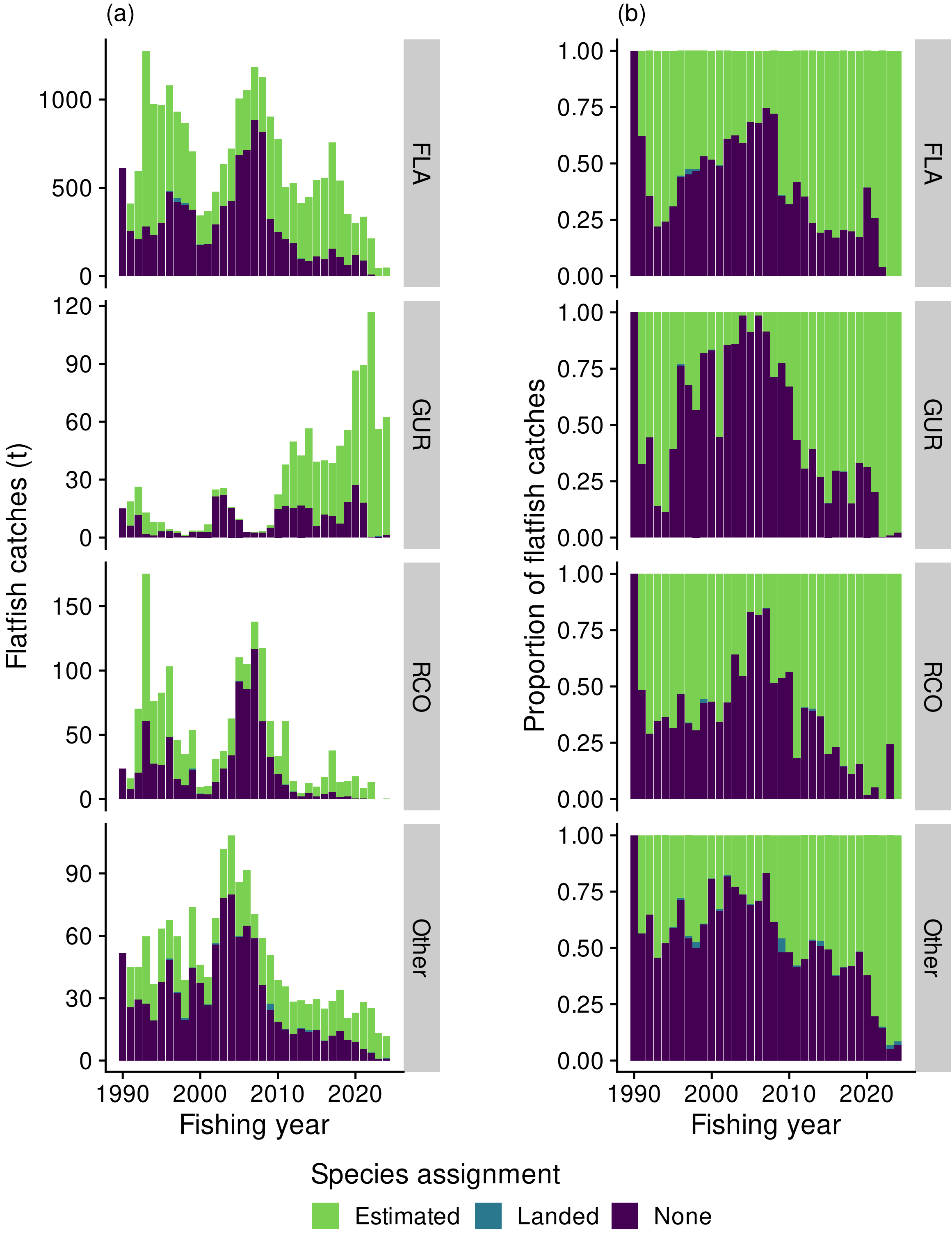

Figure 33: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 7 that are assignable to species by target species and year, categorised by assignment method (estimated catch data or landings data). All flatfish species targets are coded as FLA target, and target species other than the top three by flatfish catch weight are grouped as Other.

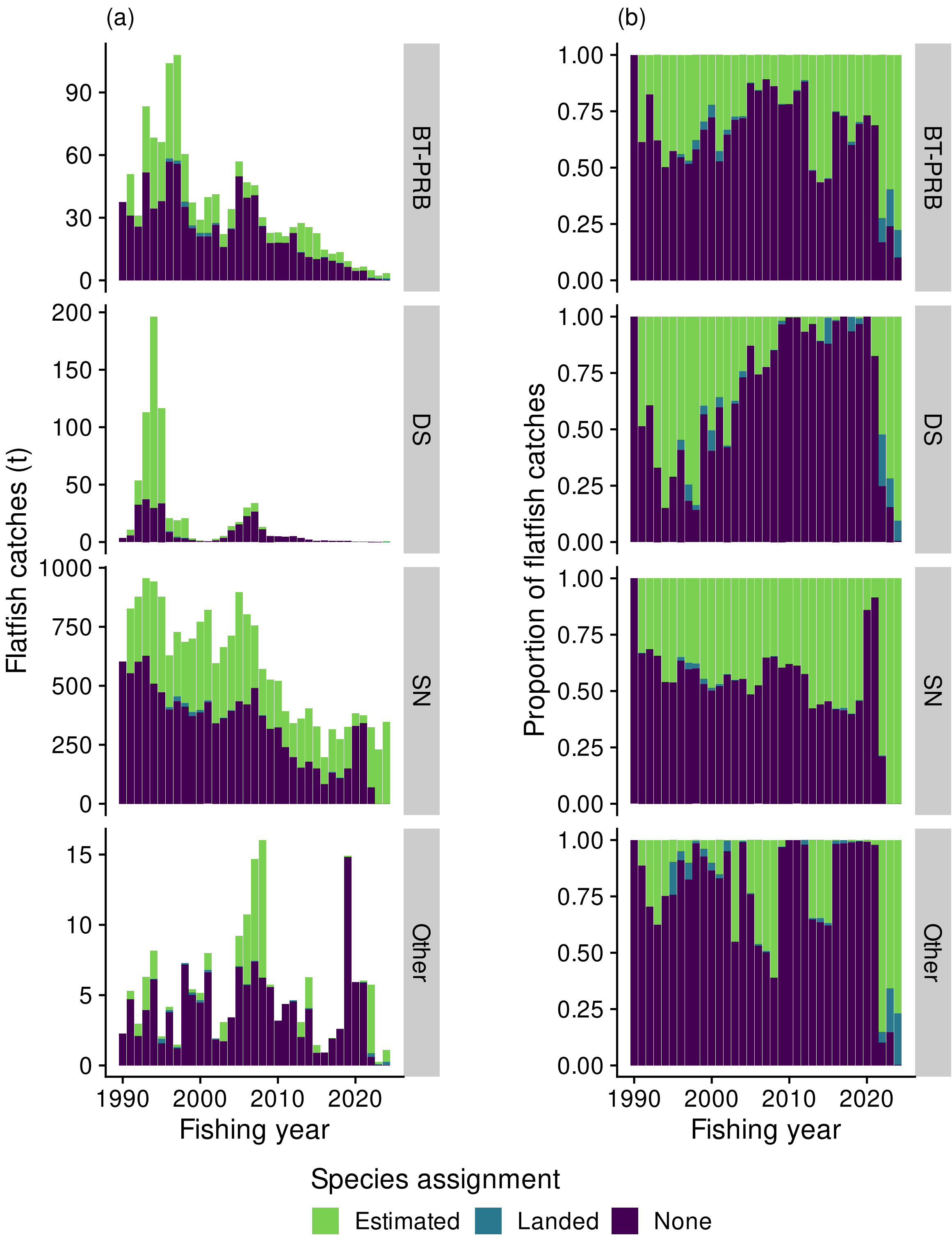

Figure 34: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 1 that are assignable to species by fishing method and year, categorised by assignment method (estimated catch data or landings data). Methods other than the top three by flatfish catch weight are grouped as Other.

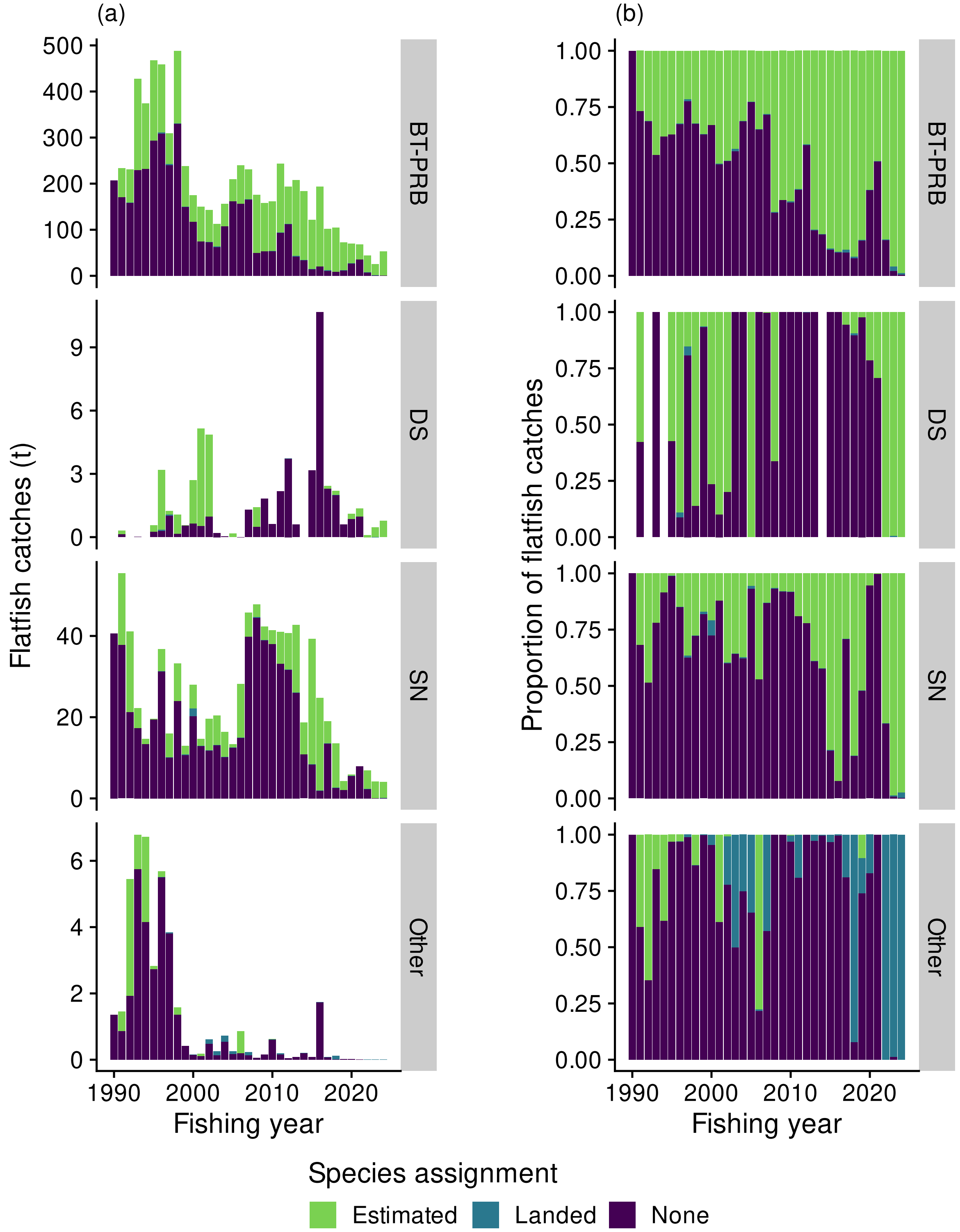

Figure 35: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 2 that are assignable to species by fishing method and year, categorised by assignment method (estimated catch data or landings data). Methods other than the top three by flatfish catch weight are grouped as Other.

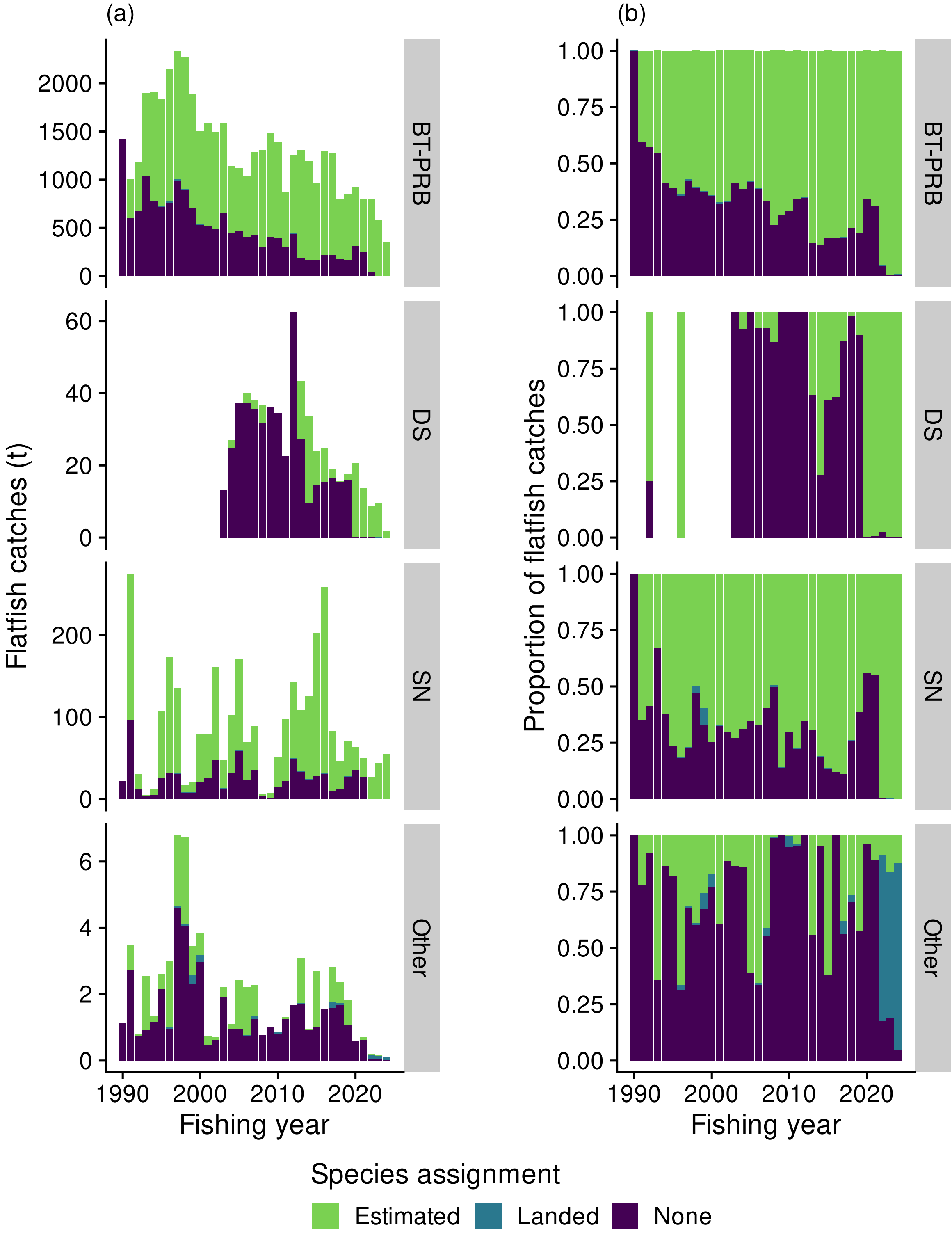

Figure 36: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 3 that are assignable to species by fishing method and year, categorised by assignment method (estimated catch data or landings data). Methods other than the top three by flatfish catch weight are grouped as Other.

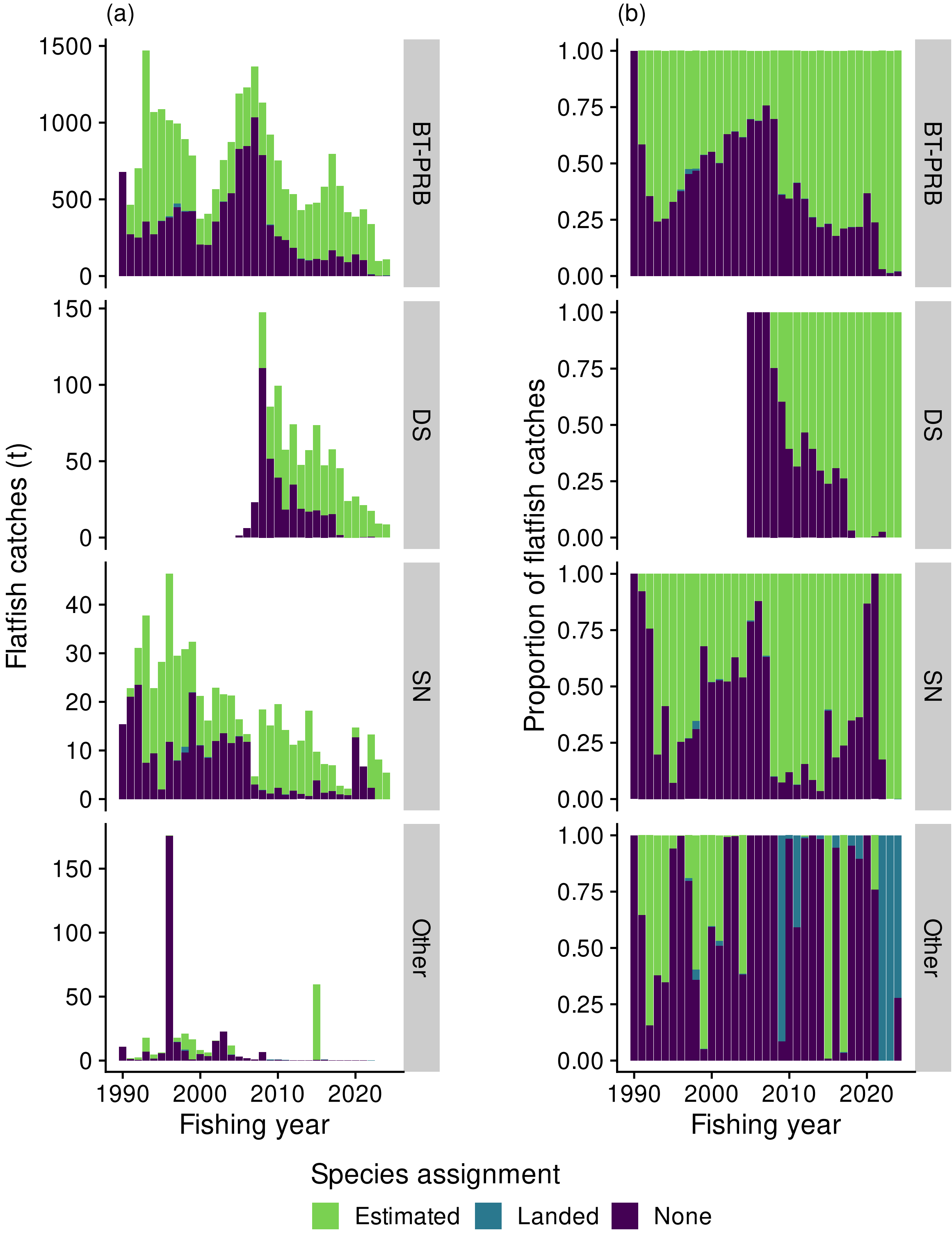

Figure 37: Quantity (a) and proportion (b) of fishing event-level flatfish catches in FLA 7 that are assignable to species by fishing method and year, categorised by assignment method (estimated catch data or landings data). Methods other than the top three by flatfish catch weight are grouped as Other.

3.3.3 Species mix

The amount of FLA catch that can be apportioned by event at the species level was variable, and sometimes relatively low, before the introduction of the 2001 circular. Typically, between 50 and 75% of the catch used the generic FLA code in FLA 1, FLA 2 and FLA 7 before 2007–08 (Figure 38). This will cause uncertainty in the eventual species determination for these early years in these three QMAs. There seems to be more apportionment potential in FLA 3, beginning with the mid-1990s, because the generic FLA code was used in less than 50% of the catch (Figure 38). Likely trends in species catch by QMA become more apparent when the species proportions are recalculated without including the generic FLA code (Figure 39). YBF predominated in FLA 1 along with a drop in the relative SFL catch in FLA 1 over the same period. FLA 2 showed reasonably similar levels of catch for ESO and SFL, combined with increased catches of LSO (a species found at deeper depths) from about 2010 (Figure 39). LSO and ESO predominated in the catch for FLA 3 while LSO was hardly reported from the WCSI (FLA 7) catches. At the same time in FLA 7, there appeared to be a consistent level of TUR catches and an increasing catch of YBF (Figure 39).

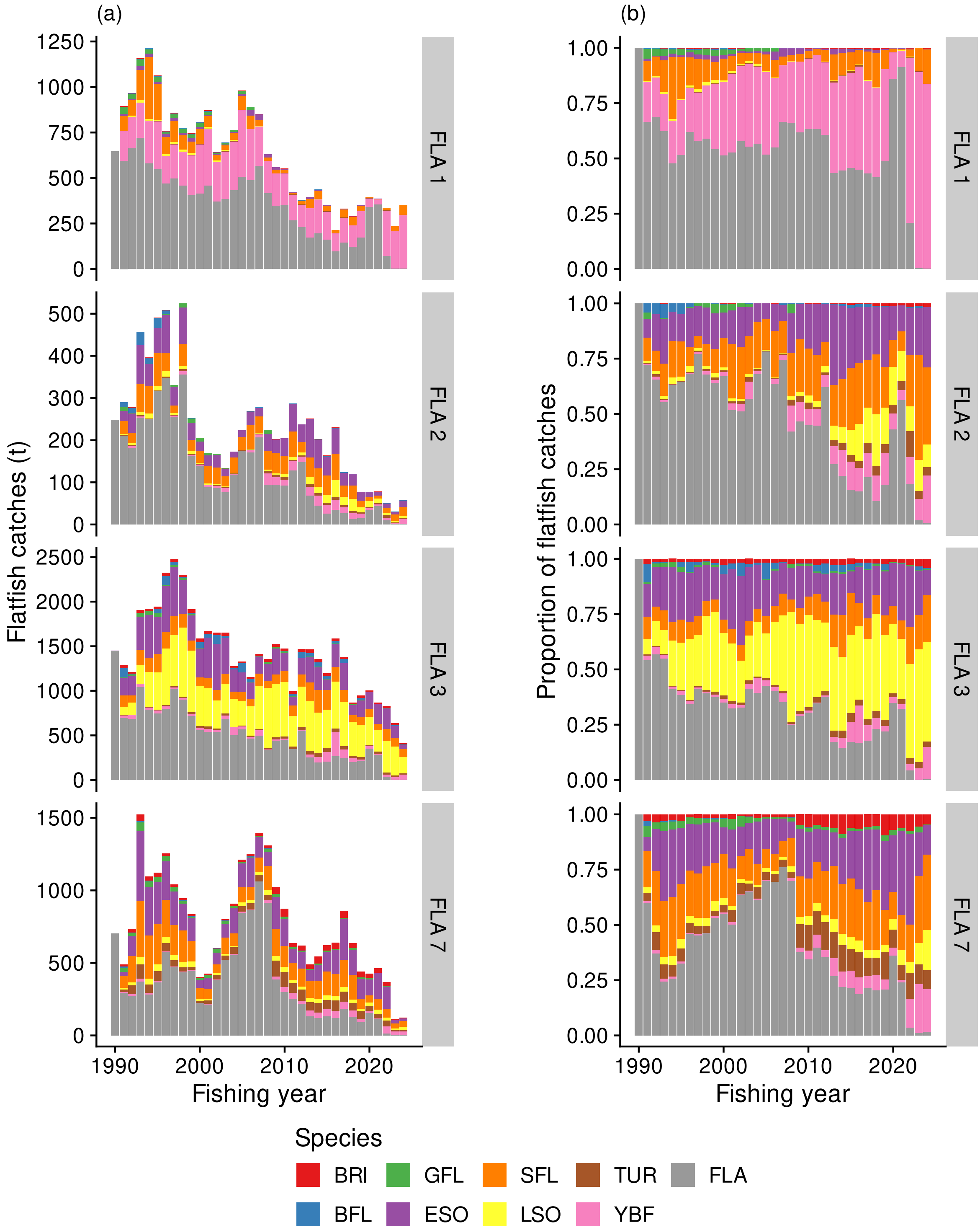

Figure 38: The (a) quantity and (b) proportion of flatfish catches by QMA, split by species where this can be done at the event level.

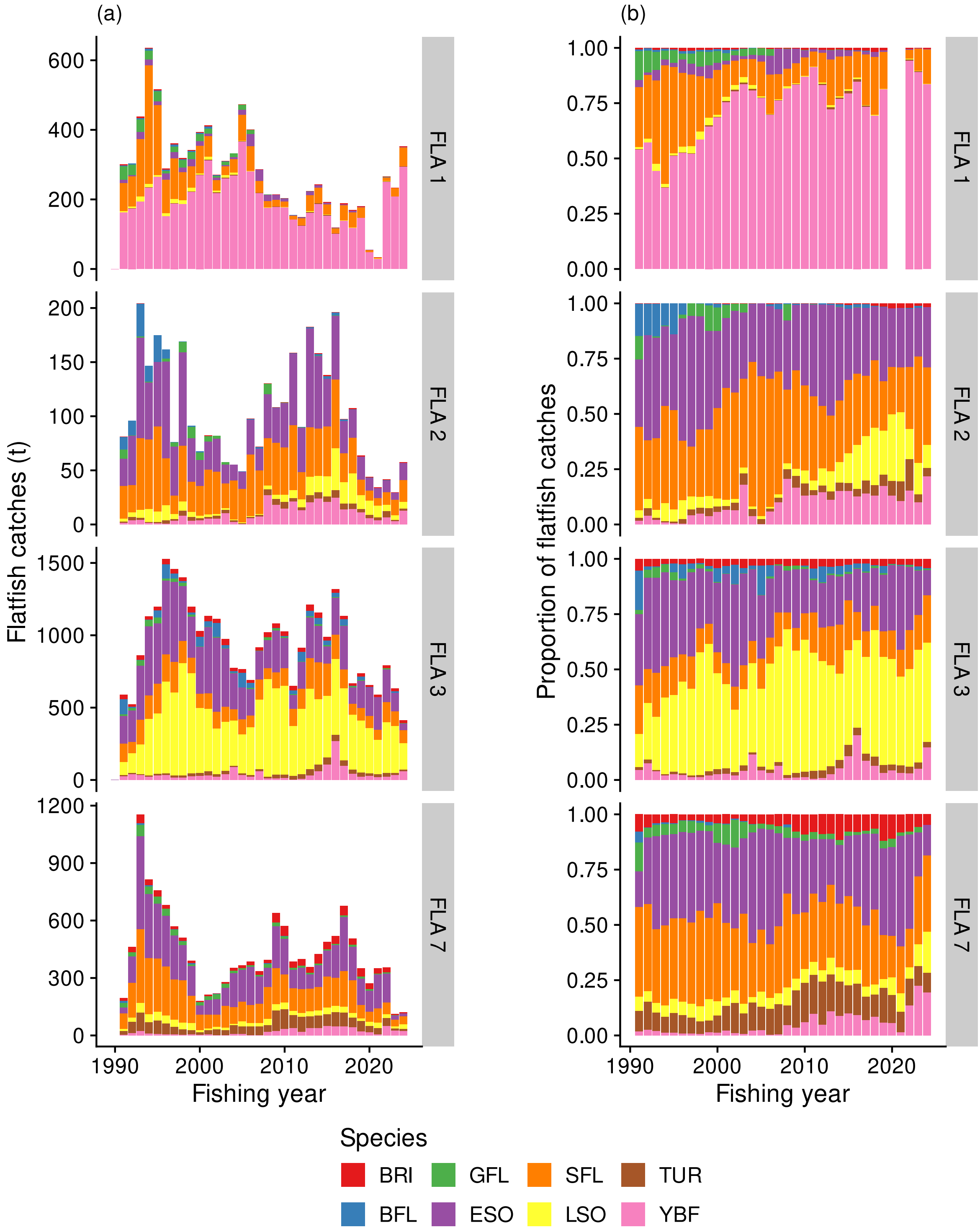

Figure 39: The (a) quantity and (b) proportion of flatfish catches by species and QMA, for the portion of the catch where catches can be assigned by species at the event-level. Only years where at least 20% of the catch can be assigned by species are plotted as proportions.

3.3.4 Species distributions

Comparative distributions of catches by species show that most species (BRI, ESO, LSO, SFL, TUR, and YBF) are found ubiquitously around the two main NZ islands (Figure 40), although there appear to be differences in relative catch levels with BRI, ESO, LSO, SFL and TUR being more prevalent off both coasts of the South Island than off the North Island. YBF appears to have a slightly more northerly distribution, with good catches off the North Island and off the top half of the South Island (Figure 40). Both GFL and BFL appear to be mainly southern species, with very few catches seen off the North Island (Figure 40).

Distributional spatial maps for the catch of each of the eight statutory flatfish species, were produced for two time periods (2007–2021 and 2022–2024), before and after full species reporting was implemented. These indicated that there has been little change in the spatial distribution for any of the eight species, once allowance has been made for the difference in the time span represented by the two reporting periods (15 years and 3 years) and the effect of the 3 vessel/3 permit holder reporting limitation (Figure 41, Figure 42, Figure 43, Figure 44, Figure 45, Figure 46, Figure 47, Figure 48).

Two species (YBF and BFL) have depth distributions that are consistently more shallow than any of the other eight FLA species in all four FLA QMAs (Figure 49). Several of the other species (SFL, ESO, BRI) have broader depth distributions that cover a wider range of depths, also in all four QMAs, while TUR and LSO appear to have deeper depth distributions than the other flatfish species, again in all four QMAs (Figure 49). The only species with a mixed depth signal among the four QMAs is GFL, which shows a deep depth distribution in FLA 2 and FLA 3, while it is among the shallow species in FLA 7. Examination of the spatial distribution map for GFL (Figure 44) shows this species being caught around the Auckland Islands, located south of the South Island, while the FLA 7 catches are in the shallow waters of Tasman Bay/Golden Bay where they are fished with other flatfish species. The multi-modal spatial depth distribution for this species in two very dissimilar locations leads to speculation that these may be the expressions of two inadvertently lumped (i.e., cryptic) species.

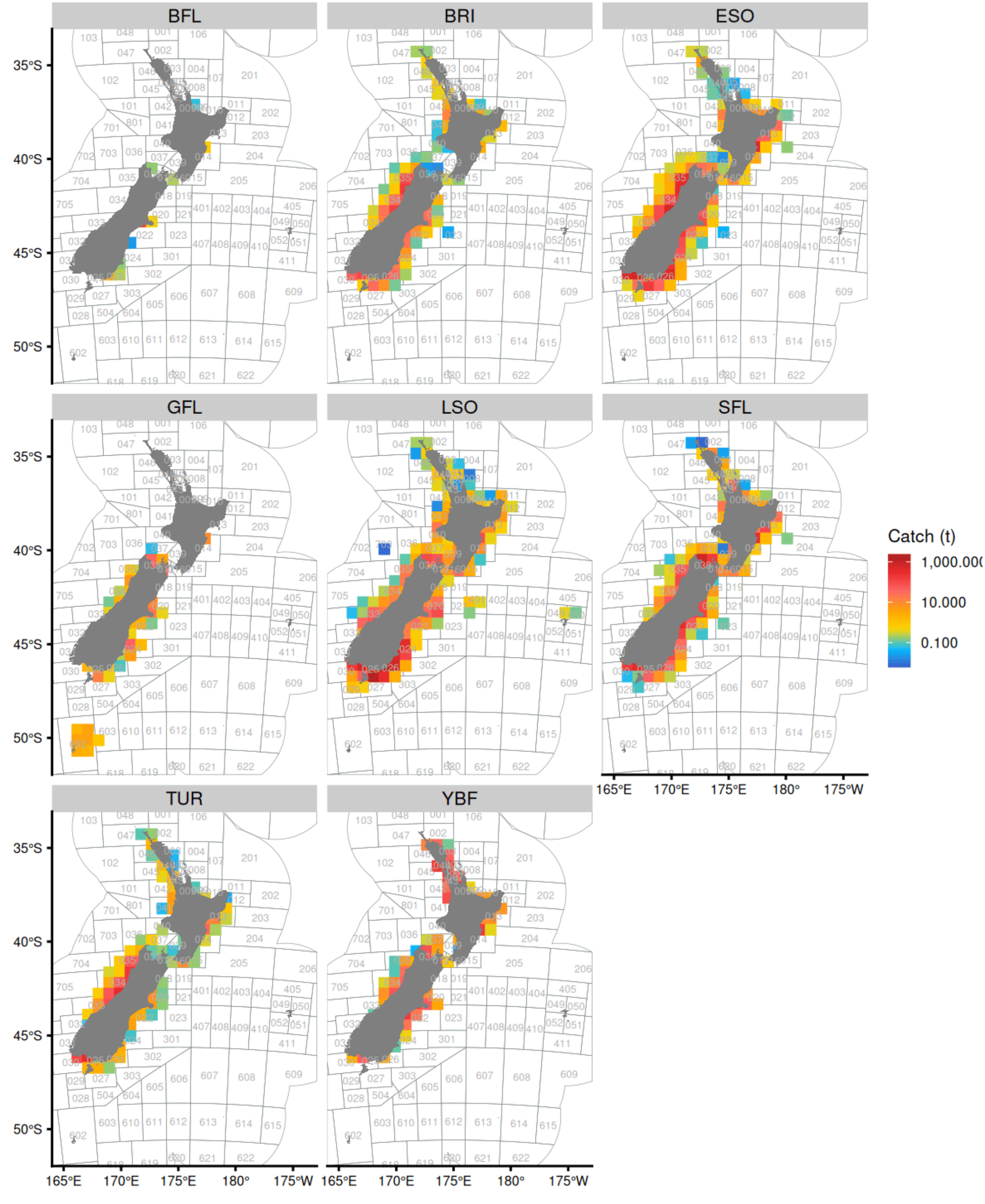

Figure 40: Comparative distribution of NZ-wide flatfish catches (t), expressed logarithmically, for the eight statutory flatfish species. Catches have been summed by 64 km grids, over the period 2007–2024, with each grid having at least 3 vessels and 3 permit holders.

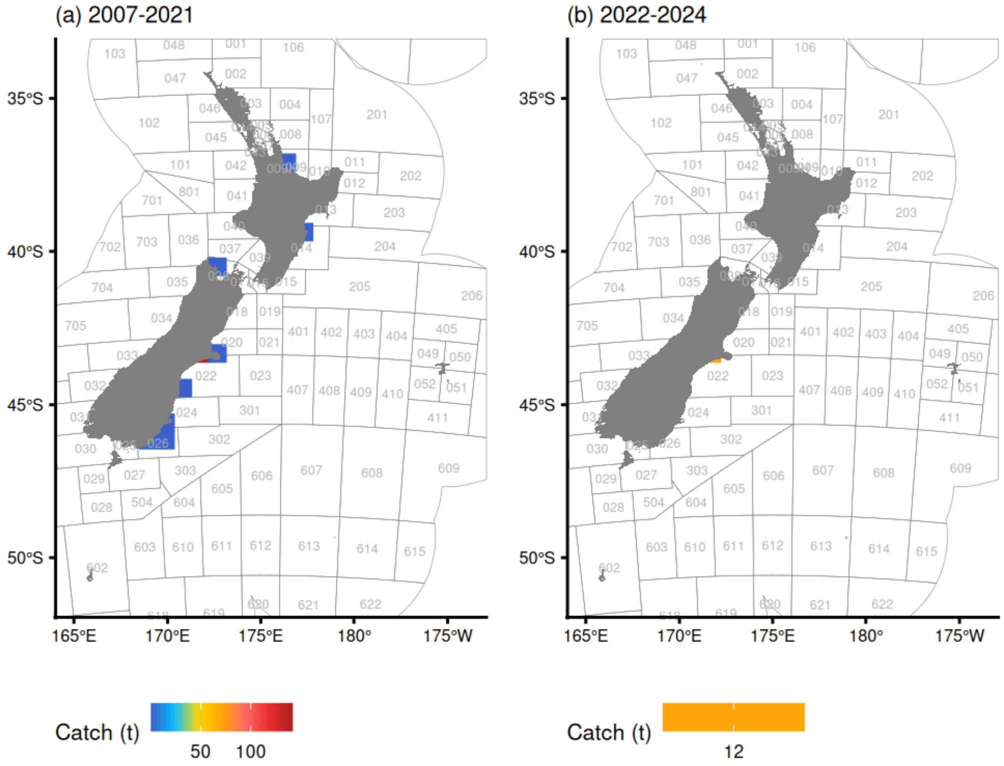

Figure 41: Distribution of BFL catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

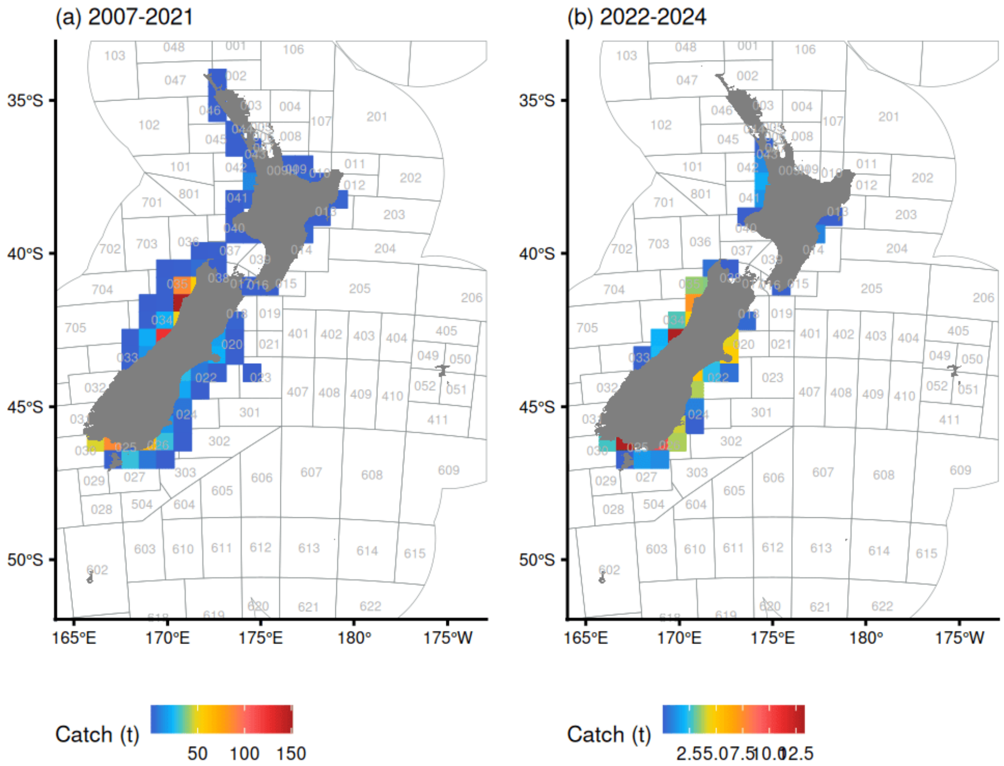

Figure 42: Distribution of BRI catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

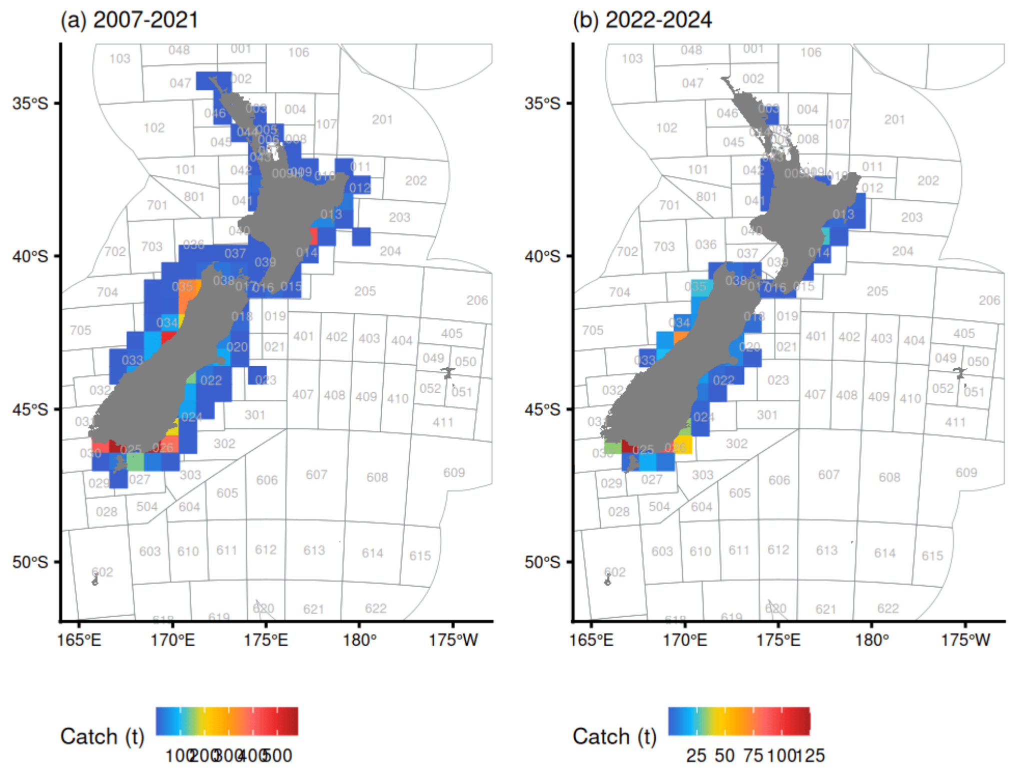

Figure 43: Distribution of ESO catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

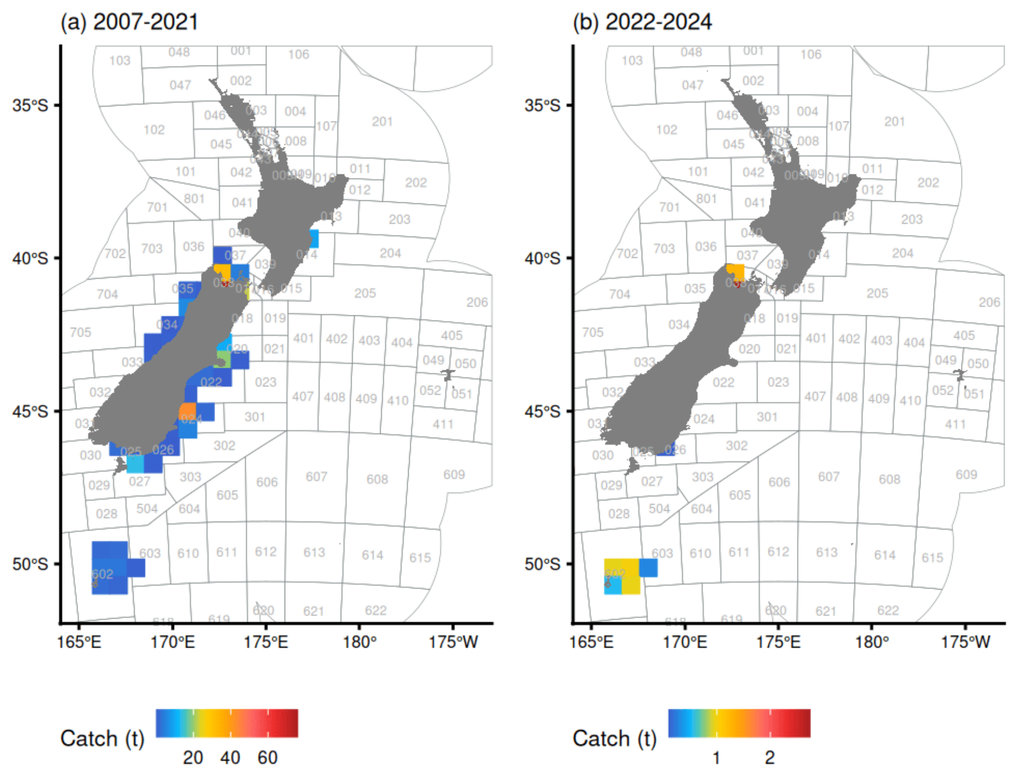

Figure 44: Distribution of GFL catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

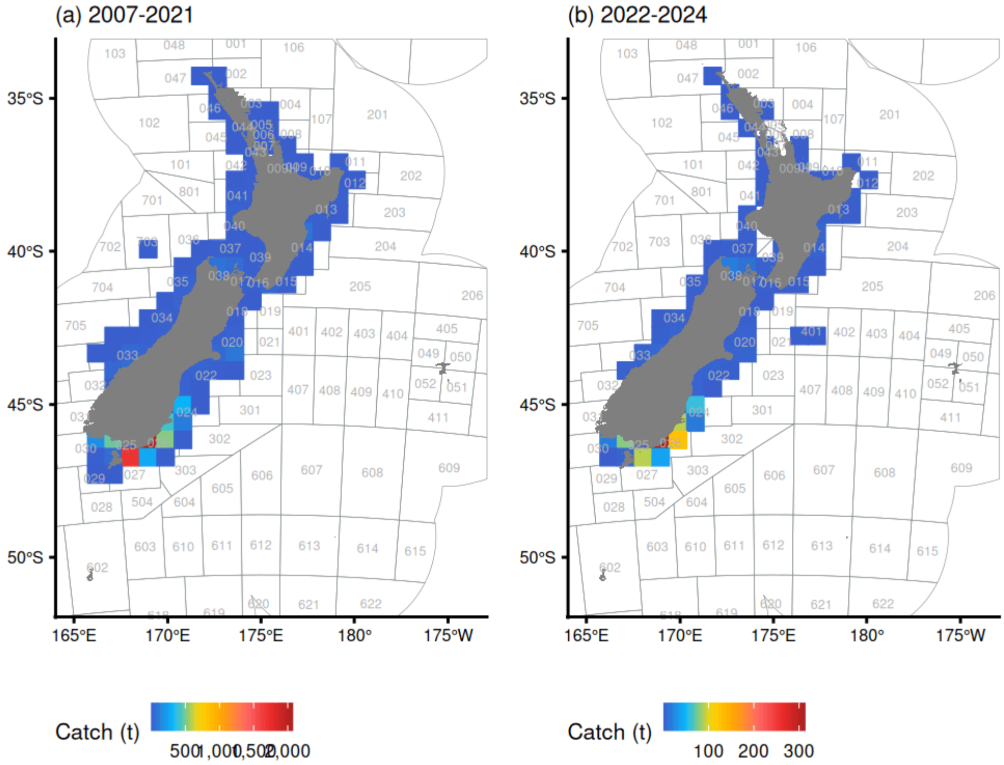

Figure 45: Distribution of LSO catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

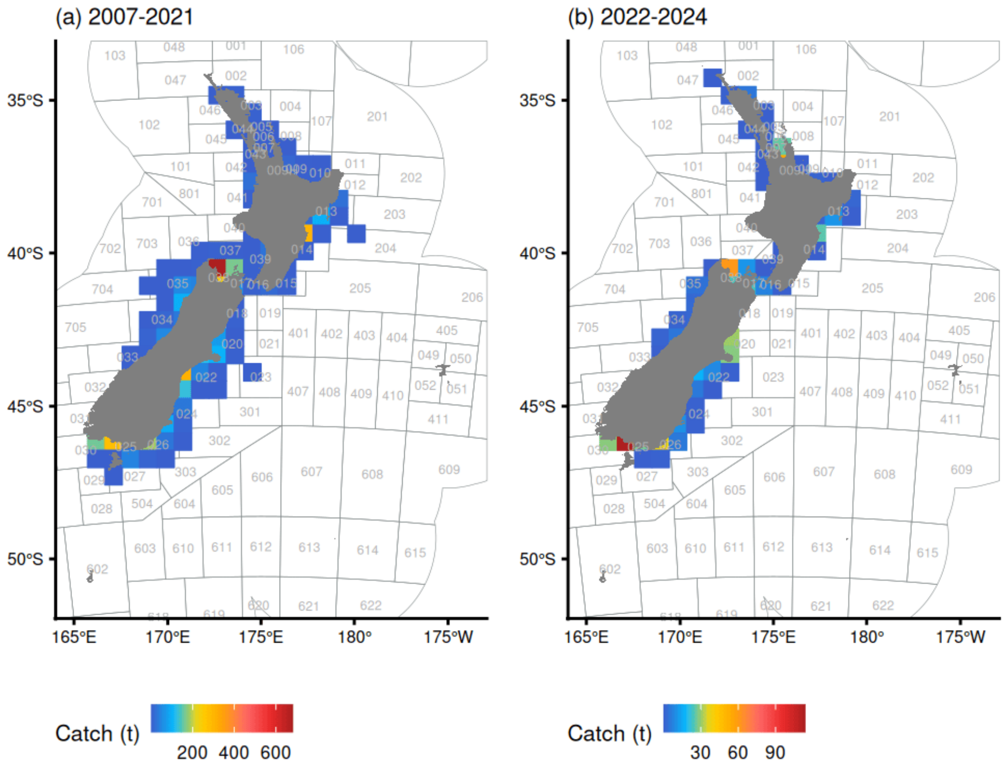

Figure 46: Distribution of SFL catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

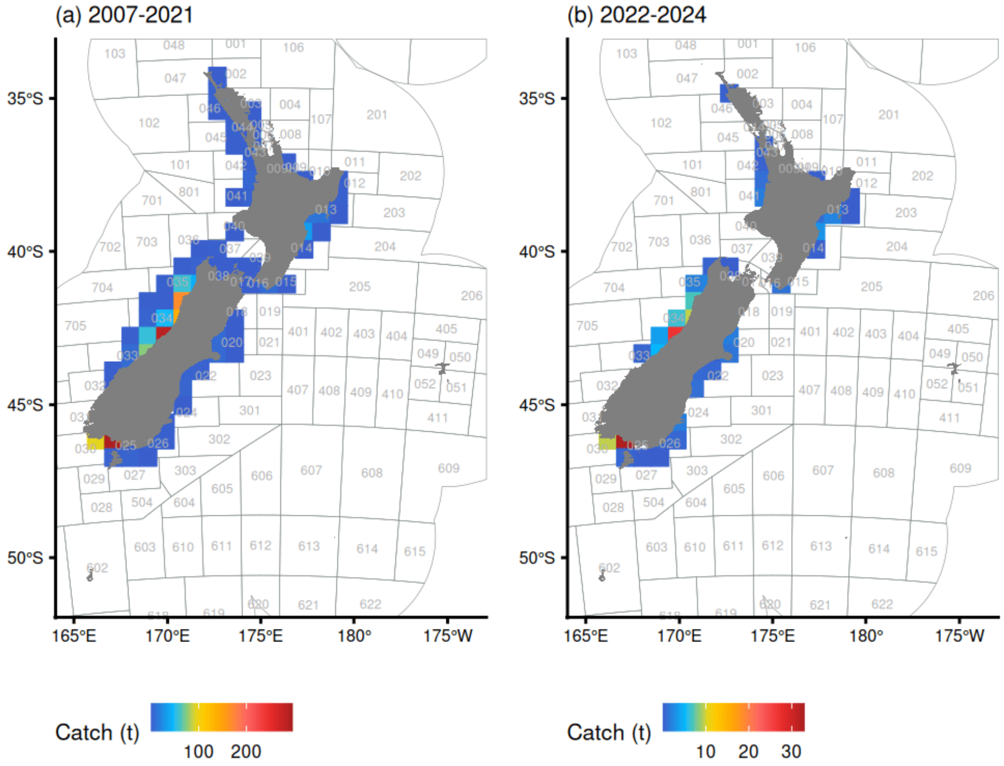

Figure 47: Distribution of TUR catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

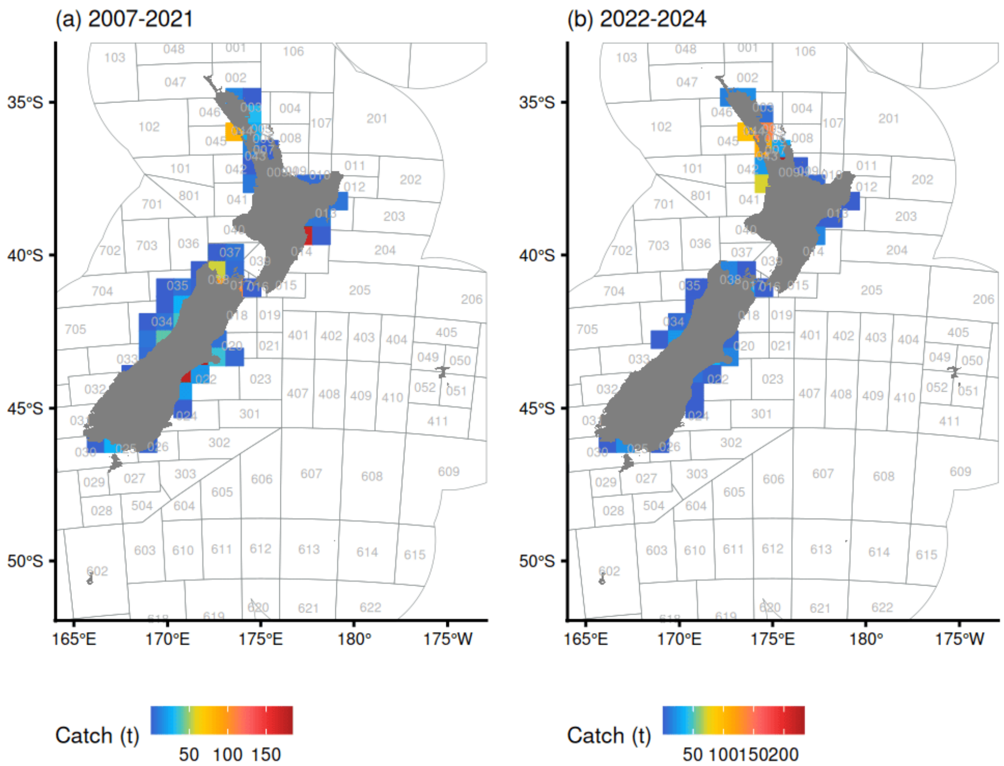

Figure 48: Distribution of YBF catches (t). Catches have been summed by 64 km grids, over the two indicated periods, with each grid having at least 3 vessels and 3 permit holders.

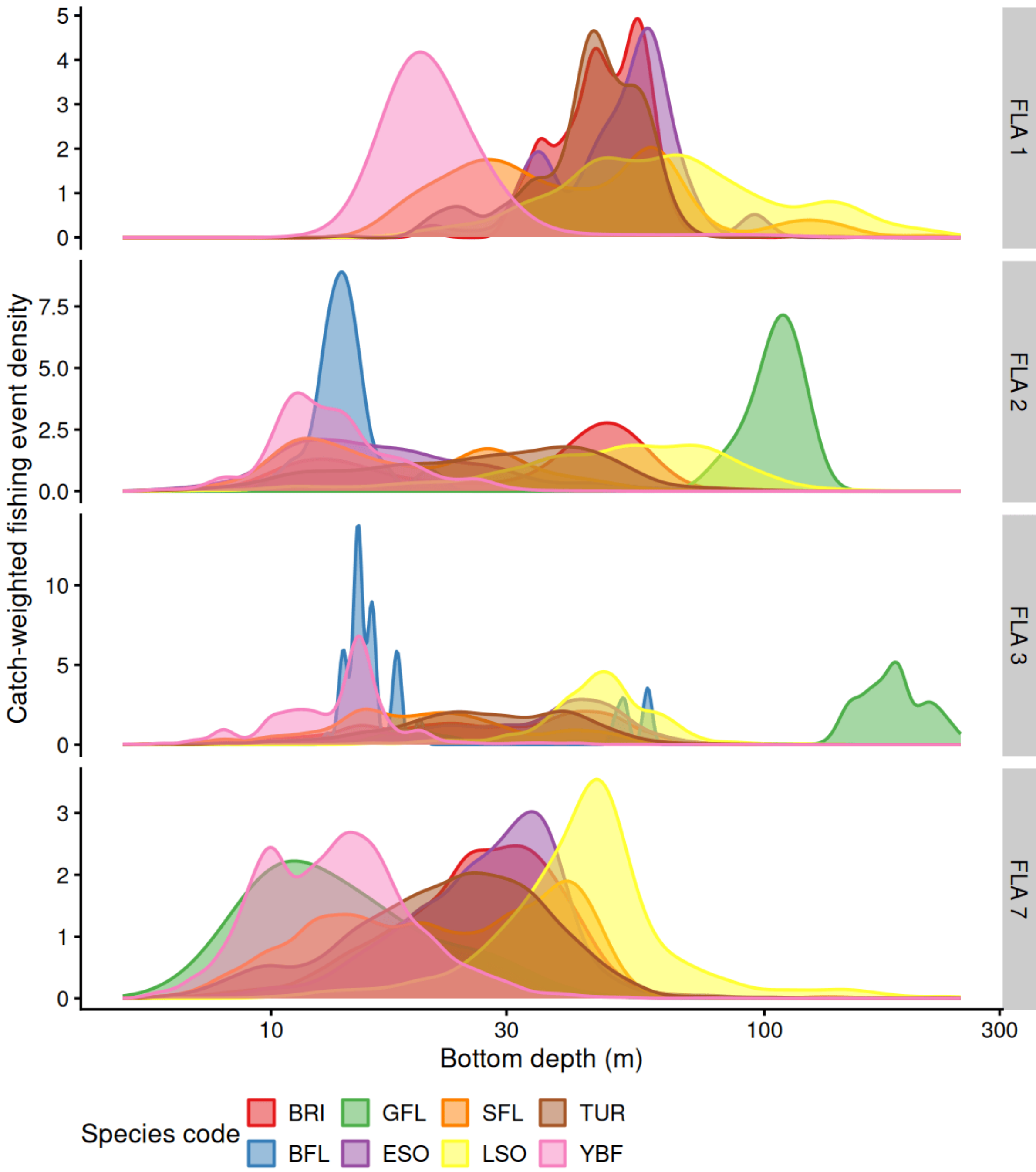

Figure 49: Density of log-transformed catch-weighted events plotted over the tow starting depth for each of the eight FLA statutory species. Catches by species have been aggregated beginning with the 2020–21 fishing year.

3.4 Species composition in FLA 2

Historical species-specific reporting in FLA 2 is hampered by the relatively small number of events that can be used to separate out species catch before 2007–08 (Figure 38). Consequently, the species splits before 2007–08 should be interpreted with considerable caution. Similarly, the plots in Figure 50 should be interpreted cautiously because of the large amount of data partitioning required when dividing small amounts of data among a number of categories.

In general, SFL is the main species captured when BT vessels target FLA in FLA 2 while increasing amounts of LSO are associated with GUR targeting by BT vessels. Presumably this increase in LSO catch by the BT GUR fishery reflects an increasingly deeper tow distribution for this fishery over time. Unsurprisingly, because it is an even deeper fishery, the BT TAR target fishery has an even greater incidence of LSO in its catches (Figure 50).

Maps of the fine scale distribution of FLA catches by species in Hawke Bay, and other parts of FLA 2, were examined, but are not included here due to data confidentiality considerations. These indicated that seven of the eight statutory flatfish species are caught in Hawke Bay, with only GFL not represented. Of the species with representation, ESO, LSO and SFL appear to be caught throughout Hawke Bay, and extend north past Mahia and south past Cape Kidnappers. However, all seven species show relatively high catches in the southern part of Hawke Bay, in the vicinity of the mouths of the Ngaruroro and Tukituki Rivers.

Examination of the fine scale distributions of flatfish catches by species along the South Taranaki Bight and Wellington harbour sections of FLA 2 indicates that six of the eight statutory flatfish species are caught in that region, with BRI and GFL not represented. Of the six species with representation, only LSO and possibly SFL appear to be caught in significant amounts.

Examination of the fine scale distributions of flatfish catches by species in the North Taranaki Bight section of FLA 2 indicates that seven of the eight statutory flatfish species are caught in that region, but in very low amounts (GFL is not represented). Of the species with representation, LSO, TUR, BRI and ESO are present in approximately equal amounts, with offshore catches showing in very small amounts for LSO and TUR.

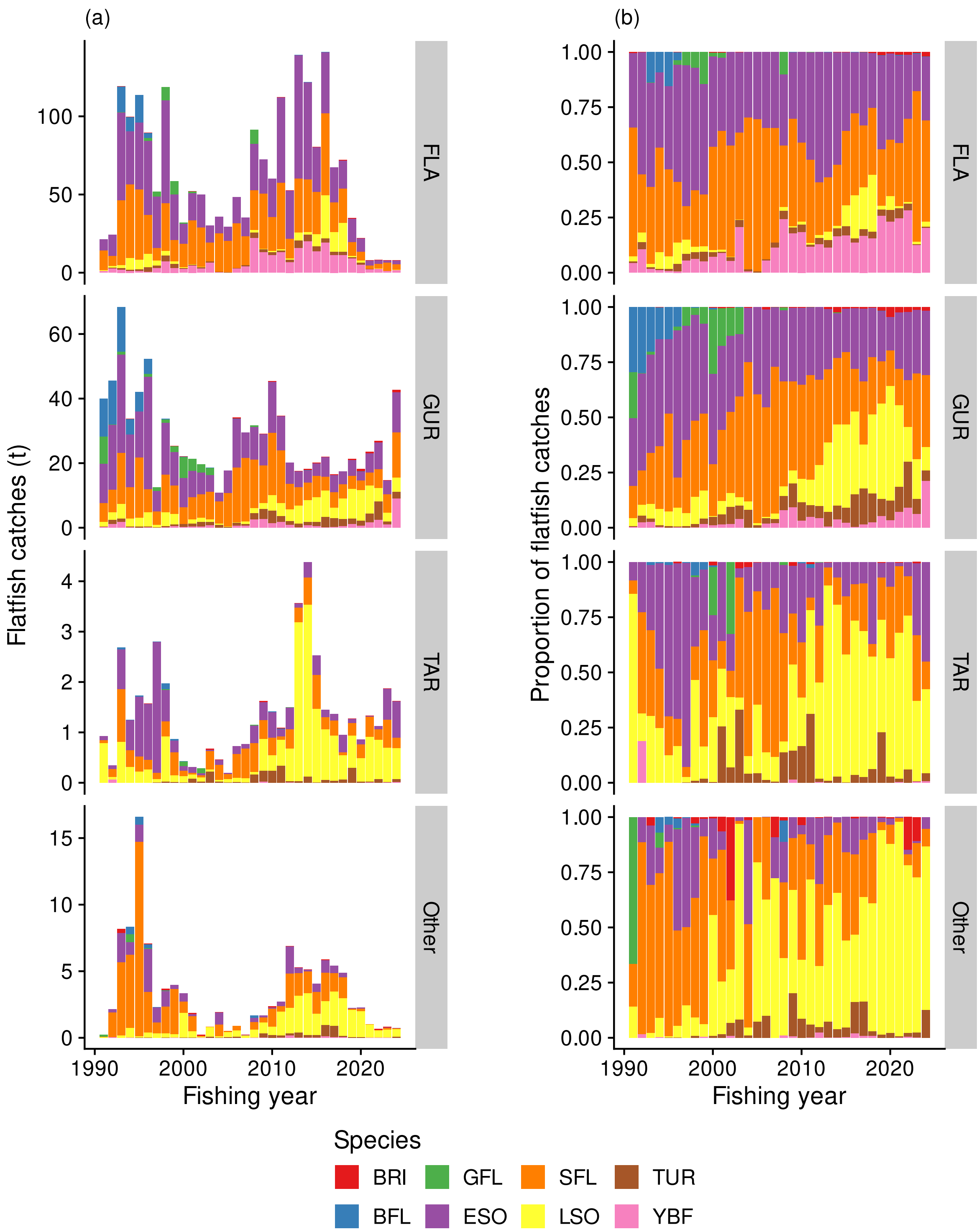

Figure 50: The (a) quantity and (b) proportion of flatfish catches by species and target species in the FLA 2 bottom trawl fishery, for the portion of the catch where catches can be assigned by species at the event-level. Only years where at least 20% of the catch has been assigned by species are plotted as proportions.

4. CATCH-PER-UNIT-EFFORT

4.1 Introduction

In 2017, Schofield et al. (2018b) generated a standardised CPUE series for FLA 2 based on the bottom trawl (BT) fishery targeting FLA in Statistical Areas 013 and 014, and using the combined flatfish catch (FLA). This series formed the basis for a partial quantitative stock assessment which was used to determine the status of the total FLA 2 vulnerable Fishstock. Species specific CPUE series were also generated for New Zealand sole and sand flounder, but these were not used to set reference points.

This report documents an update of Schofield et al. (2018b), including revisions to the previously agreed combined species reference series. As well, species-specific CPUE series, using event resolution data from flatfish and gurnard target effort in Statistical Areas 013 and 014 were also developed for New Zealand sole, sand flounder, yellowbelly flounder, and lemon sole. However, the Inshore Working Group (INSWG) only accepted the New Zealand sole and sand flounder series as being adequate to monitor abundance for these species. Species specific CPUE series were also investigated for sand flounder and lemon sole in the South Taranaki Bight (Statistical Area 039), but catches in this area were too sparse and adequate CPUE models could not be fitted.

A Delta (Hurdle) Generalised Linear modelling approach was used for all CPUE analyses, which combined a binomial model of presence/absence (occurrence) and a model of positive catches. Several error distributions were available for the positive catch models, including lognormal, Weibull and gamma, with each model using the error distribution that best fit the observed data. Hurdle models were simulation tested and found to be generally unbiased as long as both the occurrence and positive catch components were included in the model (Langley 2019).

The three CPUE series (Table 3) accepted by the INSWG to represent abundance trends in FLA 2 are documented in the main body of this report, with diagnostic plots and tables, as well as plots and a table of the component models for each analysis. Thirteen supporting sensitivity analyses can be found in Appendix C - Additional CPUE analyses. Full diagnostics are also presented for these latter analyses.

Past procedure used in these types of general linear models has been to offer each explanatory variable to the model in a stepwise manner, with the model sequentially accepting the variable that explained the greatest amount of deviance followed by the variable explaining the secondmost amount of deviance, and so on, until an improvement threshold (usually 1%) of additional deviance improvement was reached, after which no further variables were offered (e.g., Schofield et al. 2018b). This report has adopted a different approach by using all the available variables without selecting variables on the basis of explanatory power. This shift was suggested by P. Neubauer (pers.comm.), who questioned the assumption that the stepwise approach selected the best model when fishing year was forced into the model. Appendix C - Additional CPUE analyses has a number of analyses presented which have used the previous ‘stepwise’ model variable selection procedure in order to test the sensitivity of these models to the different procedures used for variable selection.

Table 3: Summary of models constructed for CPUE standardisation. The primary models are highlighted in darker grey and supporting diagnostics are included below. Diagnostics for secondary models, highlighted in lighter grey, are included in Appendix C. The other models listed were evaluated but are not reported in detail.

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
Hawke Bay FLA BT-FLA day	daily	allockg	All selected	4	4	Weibull
Hawke Bay FLA BT-FLA event	event	allockg_top8	All selected	4	4	gamma
Hawke Bay FLA BT-MIX event	event	allockg_top8	All selected	4	4	Weibull
Hawke Bay FLA BT-MIX event (stepwise)	event	allockg_top8	Stepwise	4	4	Weibull
Hawke Bay FLA BT-MIX event (no effort allocation)	event	allockg_top8	Stepwise	4	4	Weibull
Hawke Bay FLA BT-GUR event	event	allockg_top8	All selected	4	4	Weibull
Hawke Bay FLA BT-FLA day (2018 analysis update)	daily	allockg	All selected	7	5	gamma
Hawke Bay FLA BT-MIX day	daily	allockg	All selected	6	5	Weibull
Hawke Bay ESO BT-FLA event	event	ESO	All selected	4	4	lognormal
Hawke Bay SFL BT-FLA event	event	SFL	All selected	4	4	lognormal
Hawke Bay ESO BT-MIX event	event	ESO	All selected	4	4	lognormal
Hawke Bay SFL BT-MIX event	event	SFL	All selected	4	4	lognormal
Hawke Bay LSO BT-MIX event	event	LSO	All selected	4	4	lognormal
Hawke Bay YBF BT-MIX event	event	YBF	All selected	4	4	lognormal
Hawke Bay ESO BT-MIX event (full covariates)	event	ESO	All selected	4	4	lognormal
Hawke Bay ESO BT-MIX event (trawl speed)	event	ESO	All selected	4	4	lognormal
Hawke Bay ESO BT-MIX event (full covariates, stepwise)	event	ESO	Stepwise	4	4	lognormal
South Taranaki SFL BT-MIX event	event	SFL	All selected	4	2	lognormal
South Taranaki LSO BT-MIX event	event	LSO	All selected	4	2	lognormal
Hawke Bay LSO BT-MIX2 event	event	LSO	All selected	4	4	lognormal
Hawke Bay FLA BT-MIX event (split long vessels)	event	allockg_top8	All selected	4	4	Weibull
Hawke Bay ESO BT-MIX event (split long vessels)	event	ESO	All selected	4	4	lognormal
Hawke Bay SFL BT-MIX event (split long vessels)	event	SFL	All selected	4	4	lognormal

4.2 Hawke Bay FLA BT-MIX event

This series grew from an initial intent to update the series developed by Schofield et al. (2018b). However, it soon became apparent that the diminution of the target FLA BT fishery in FLA 2 precluded creating a simple update to the original series. This was because of the recent reduction of BT FLA target fishing (documented in Section 3.1) which resulted in only one vessel remaining in this fishery for the 2023–24 fishing year, based on the original vessel selection criteria used by Schofield et al. (2018b). Unfortunately, loosening the vessel selection criteria did not solve the problem because there had been insufficient vessels fishing these species. However, as noted in Section 3.1, the target GUR fishery bycatch of FLA had not been diminished very much, so it was proposed to revise this series to include the FLA bycatch in the target GUR fishery. This change was based on the observation that the depth range used by this fishery extended only a bit deeper than the BT target FLA fishery (Figure 21) and that the spatial distribution of the Hawke Bay FLA catches by the BT target GUR fishery was similar to that observed for the BT target FLA fishery (Figure 16).

Consequently, this series is based on the catch of FLA in bottom trawl events targeted at FLA or GUR (Table 4). The INSWG decided to only use tow-by-tow data because it was felt that the shift away from FLA targeting and its replacement with GUR targeting over time also required information about the fishing depth to help the model tease out the targeting behaviour of the vessels. As previously indicated, this analysis is confined to the two Hawke Bay Statistical Areas (013, 014), although Area 014 extends southward from Hawke Bay and both areas cover a wide depth range. The core fleet was defined by having fished at least four trips in each of four years, retaining 98% of the catch and reducing the fleet from about 50 vessels to 29 vessels (Figure 51). The pattern of vessel participation in this fishery was characterised by a mix of continuity, with some vessels entering and exiting the fishery over the 17 years in the analysis while there was a reasonable number of vessels that remained the fishery for at least 12 years or more (Figure 52). The final groomed dataset represented 71% (2023) to 100% (2011, 2016, 2018) of the annual ungroomed catch (Table 5). The total annual catch of FLA in the defined fishery ranged from 195 t (in 2011) to 15 t (in 2023) over the 17 years in the data set and was characterised by a slightly decreasing occurrence of FLA in the catch, ranging from 71% (in 2008) to 55% (in 2019) and 56% (in 2024) (Table 6). Nearly all landings were allocated to effort data using estimated catch proportions, with minor amounts of landings distributed proportionately to effort (Figure 53).

The binomial (occurrence) model explained 23% of the deviance when using all the offered explanatory variables (Table 7). The primary variable causing this shift was the vessel variable, but other variables were consistent with this shift (Figure 55). The overall impact of the standardisation model was to change the slightly decreasing trend in the unstandardised occurrence model to a slightly increasing trend in the standardised model (Figure 54). The primary variable causing this shift was the vessel variable, but other variables were consistent with this shift (Figure 55). CDI plots for the occurrence model are provided for each covariate offered to the model: vessel (Figure 56), statistical area (Figure 57), month (Figure 58), target species (Figure 59), fishing duration (Figure 60), bottom depth (Figure 61), and effort height (Figure 62). The vessel CDI plot indicated that there was a shift away from vessels that had a high probability of catching FLA, probably an expression of the shift away from target fishing for FLA and the rise of GUR targeting (Figure 56). This effect can also be seen in the target species covariate, with a strong shift away from FLA to GUR (Figure 59), and the bottom depth covariate, reflecting a similar shift in preferred depth (Figure 61).

The positive catch Weibull model explained 57% of the deviance when using all the explanatory variables (Table 8). The model showed good conformity to the Weibull distribution, even in the tails (except at the very upper end of the distribution: Figure 63). Both the gamma and the lognormal distributions showed reasonable fits to the positive catch data but both were inferior to the Weibull model (Figure 64). The unstandardised and the standardised series both showed a variable but decreasing overall trend, with the standardised series having a slightly less steep trend overall and an upturn in the two final years (Figure 65). The primary variable causing this shift was the target species variable, but other variables were consistent with this shift (Figure 66). CDI plots for the Weibull model are provided for each variable offered to the model: vessel (Figure 67), statistical area (Figure 68), month (Figure 69), target species (Figure 70), fishing duration (Figure 71), bottom depth (Figure 72), and effort height (Figure 73). The upturn in the final two years can be seen in the target species covariate, which is adjusting for the strong shift away from FLA targeting to GUR targeting (Figure 70). Other covariates consistent with this shift included fishing duration (Figure 71) and bottom depth (Figure 72). The vessel covariate appeared to go the other way with an expected decrease in relative CPUE, but its impact was insufficient to change the overall trend in the final years (Figure 67). The other covariates had little impact on the standardisation model (see Figure 66). Implied residual plots for target species on the total annual CPUE trend showed good conformity for GUR but a departure from the annual trend for FLA after the mid-2010s (Figure 74). The conformity with the overall annual CPUE trend was reasonable for the two statistical areas (013 and 014), but only Statistical Area 014 showed the strong increase in the final two years, with 013 just showing an increase in 2024 (Figure 75).

There was almost no contrast in the binomial model (except for the mildly increasing trend), so the combined model is primarily like the Weibull positive catch model, including the upturn in the final two years (Figure 76, Figure 77). Indices, bounds and standard errors for each series are presented in Table 9.

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 Hawke Bay FLA BT-MIX event CPUE series.

Series	Hawke Bay FLA BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	allockg_top8 ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3) + ns(effort_height, 3)
Stepwise selection	No
Positive catch distribution	Weibull

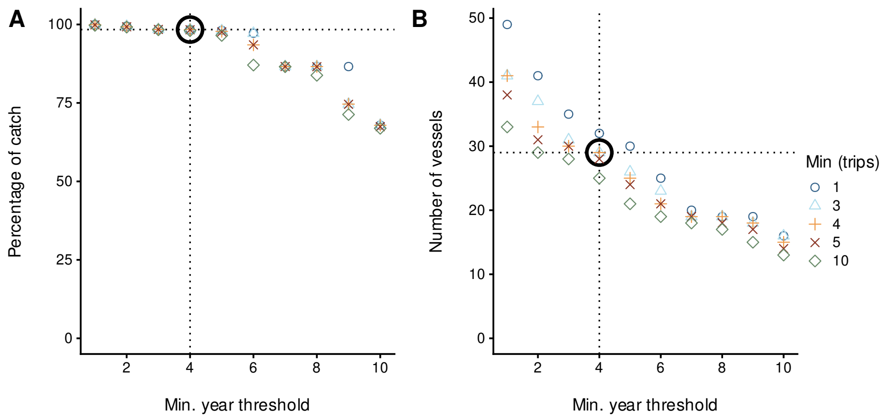

Figure 51: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

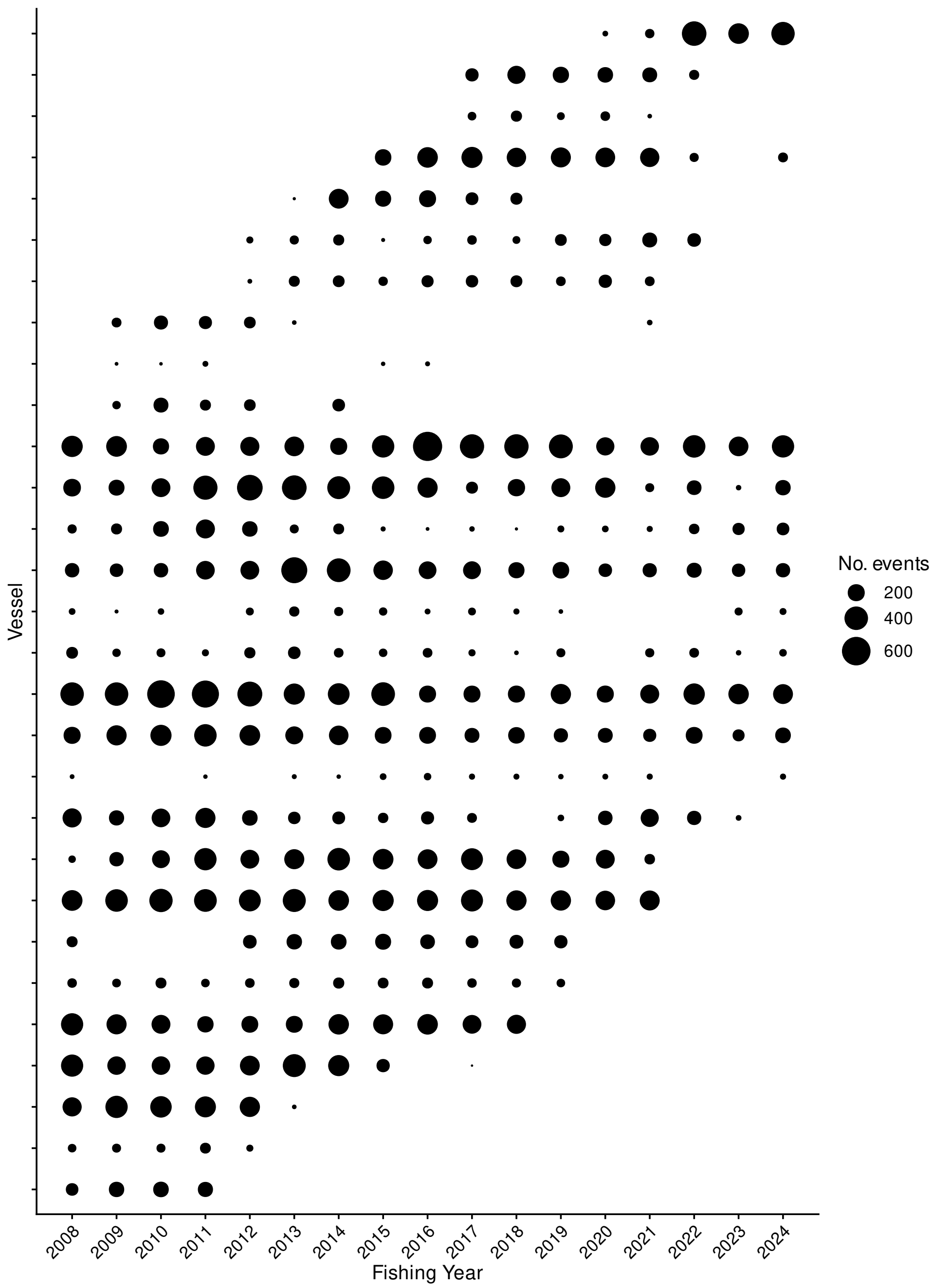

Figure 52: Number of events by fishing year for core vessels in the Hawke Bay FLA BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 5: Summary of the Hawke Bay FLA BT-MIX 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	132 (100%) n: 3836	113 (100%) n: 3542	119 (100%) n: 4050	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4248	90 (100%) n: 3637	166 (100%) n: 3539
Positive fishing duration	132 (100%) n: 3834	113 (100%) n: 3539	118 (100%) n: 4048	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4247	90 (100%) n: 3636	166 (100%) n: 3539
Fishing duration less than 6 h	132 (100%) n: 3813	113 (99%) n: 3515	118 (99%) n: 4033	195 (100%) n: 4365	148 (99%) n: 3966	169 (99%) n: 3713	141 (98%) n: 4223	90 (100%) n: 3625	166 (100%) n: 3516
Bottom depth < 150m	132 (100%) n: 3810	113 (99%) n: 3514	118 (99%) n: 4030	195 (100%) n: 4362	148 (99%) n: 3963	169 (99%) n: 3713	141 (98%) n: 4221	90 (100%) n: 3622	166 (100%) n: 3515
Trawl opening < 10m	131 (99%) n: 3802	112 (99%) n: 3504	118 (99%) n: 4030	195 (100%) n: 4357	148 (99%) n: 3963	169 (99%) n: 3710	141 (98%) n: 4212	90 (100%) n: 3618	166 (100%) n: 3515
Core fleet selection	121 (92%) n: 3282	111 (98%) n: 3307	117 (99%) n: 3935	195 (100%) n: 4330	148 (98%) n: 3945	168 (99%) n: 3690	132 (92%) n: 3962	84 (93%) n: 3468	166 (100%) n: 3510

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2800	53 (100%) n: 2513	55 (100%) n: 2190	36 (100%) n: 2438	22 (100%) n: 1523	47 (100%) n: 1886
Positive fishing duration	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2793	53 (100%) n: 2507	55 (100%) n: 2186	36 (100%) n: 2437	22 (100%) n: 1521	47 (100%) n: 1884
Fishing duration less than 6 h	85 (99%) n: 3097	87 (100%) n: 3054	55 (99%) n: 2752	52 (99%) n: 2458	55 (99%) n: 2153	35 (99%) n: 2415	21 (99%) n: 1482	47 (100%) n: 1859
Bottom depth < 150m	85 (99%) n: 3097	87 (100%) n: 3053	55 (99%) n: 2749	52 (99%) n: 2457	55 (99%) n: 2151	35 (99%) n: 2407	21 (99%) n: 1478	47 (100%) n: 1853
Trawl opening < 10m	84 (99%) n: 3092	87 (100%) n: 3052	54 (98%) n: 2735	51 (97%) n: 2438	55 (99%) n: 2151	32 (90%) n: 2192	15 (71%) n: 1259	45 (95%) n: 1735
Core fleet selection	84 (99%) n: 3080	87 (100%) n: 3045	54 (98%) n: 2699	51 (97%) n: 2419	55 (99%) n: 2150	32 (89%) n: 2115	15 (71%) n: 1259	45 (95%) n: 1735

Table 6: Summary of the Hawke Bay FLA BT-MIX 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	19	907	3 282	10 909.67	121.44	70.87
2009	20	976	3 307	11 398.92	110.86	65.62
2010	20	1 087	3 935	13 682.43	117.22	65.41
2011	20	1 092	4 330	15 160.38	194.90	65.98
2012	21	1 072	3 945	13 663.73	147.73	64.23
2013	21	907	3 690	12 705.20	168.40	64.09
2014	20	999	3 962	13 785.72	132.22	61.33
2015	21	928	3 468	12 170.10	84.31	61.56
2016	20	1 019	3 510	12 206.58	165.66	69.34
2017	22	924	3 080	10 780.47	84.15	64.42
2018	20	871	3 045	10 804.97	86.86	63.91
2019	19	720	2 699	10 256.27	54.23	55.24
2020	16	635	2 419	9 527.27	51.30	56.88
2021	18	625	2 150	7 822.68	54.79	64.98
2022	12	570	2 115	7 741.13	31.85	60.09
2023	10	320	1 259	4 892.80	15.23	58.94
2024	11	418	1 735	6 184.00	44.61	56.14

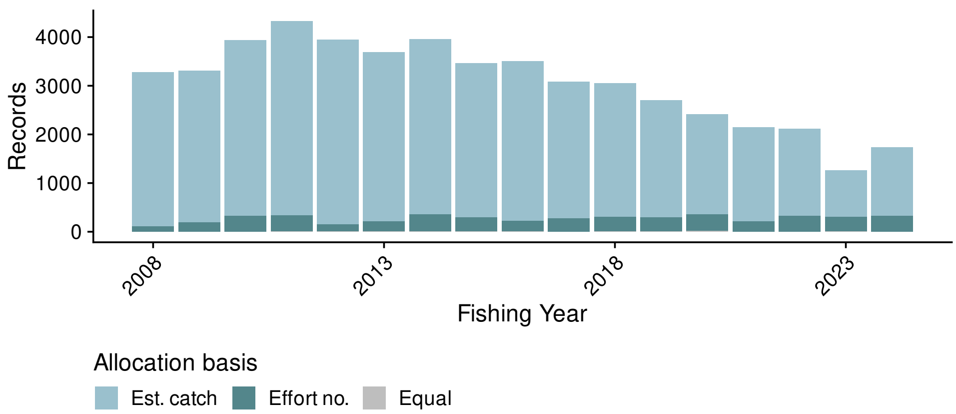

Figure 53: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table 7: Summary table for occurrence of positive catch in the Hawke Bay FLA BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	68 127.40	0.00	0.00	*
fyear	16	67 800.86	0.53	0.53	*
vessel_key	28	57 649.72	15.51	14.98	*
stat_area	1	57 640.08	15.53	0.02	*
month	11	57 372.65	15.95	0.42	*
target_species	1	55 543.03	18.64	2.69	*
ns(log(fishing_duration), 3)	3	55 486.12	18.73	0.09	*
ns(bottom_depth, 3)	3	52 992.32	22.40	3.67	*
ns(effort_height, 3)	3	52 919.05	22.52	0.12	*

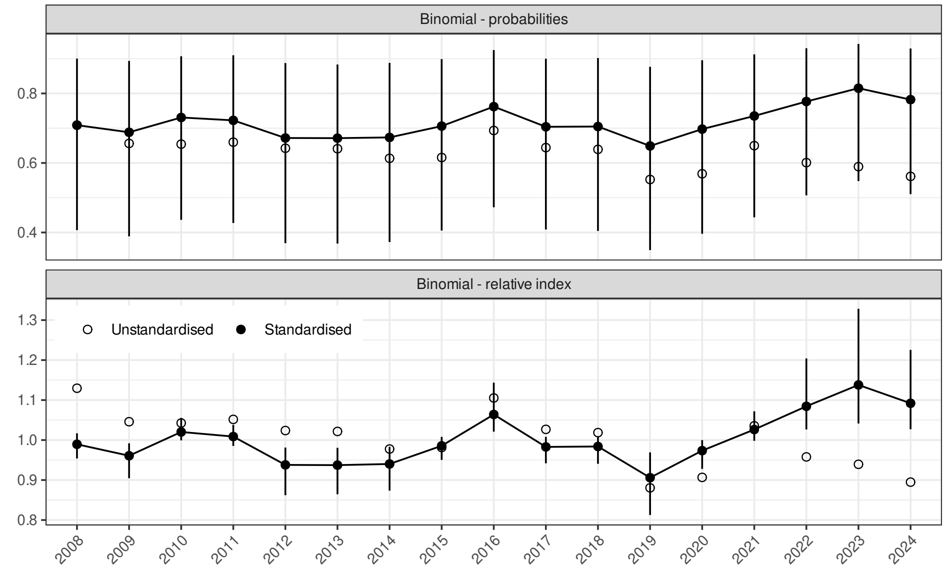

Figure 54: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay FLA BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

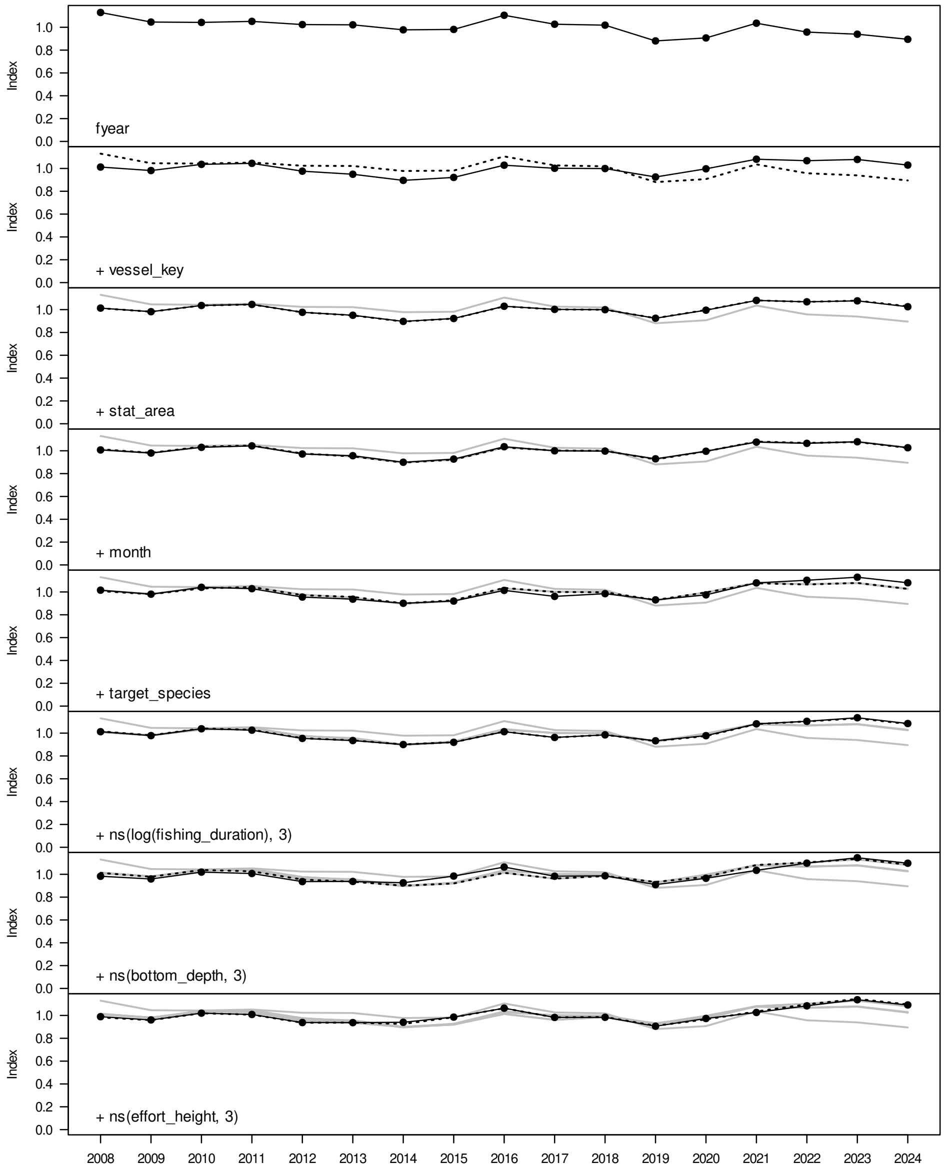

Figure 55: Step plot for occurrence of catch in the Hawke Bay FLA BT-MIX event dataset.

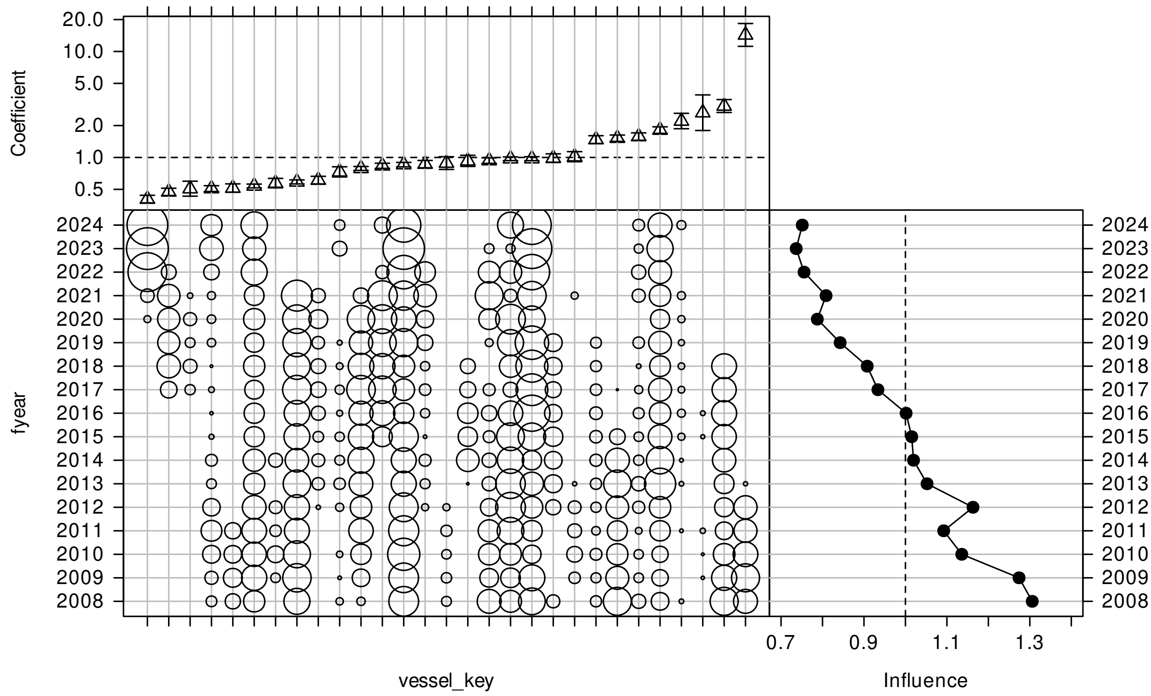

Figure 56: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

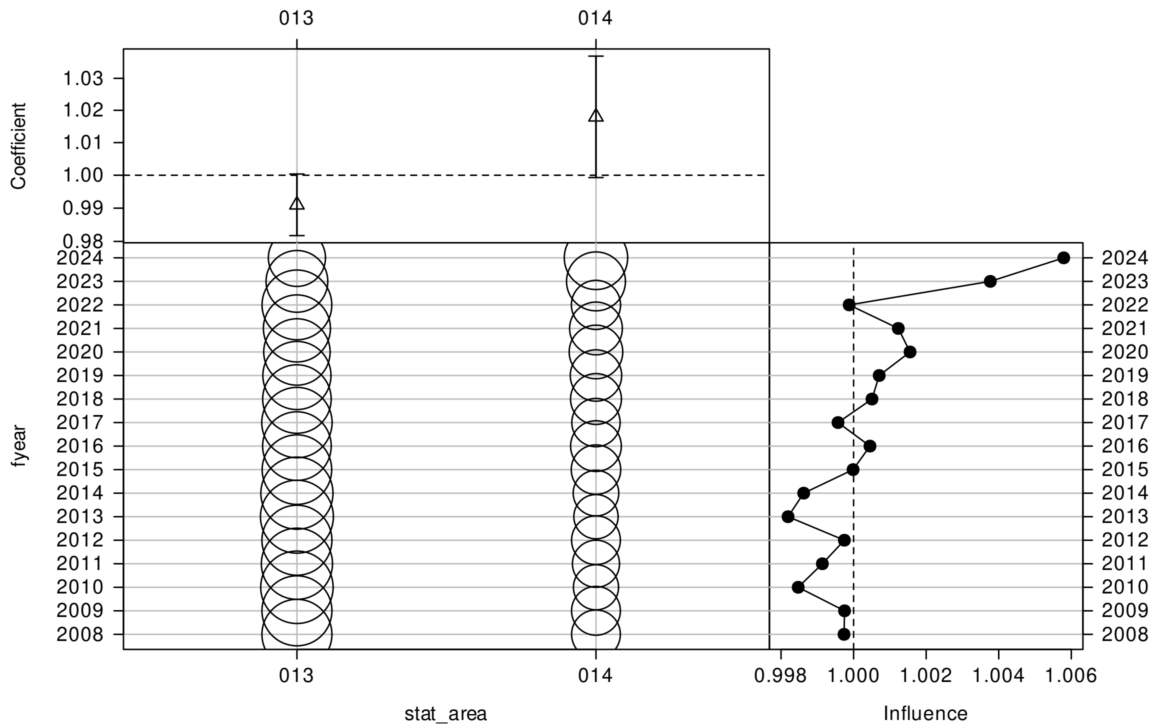

Figure 57: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

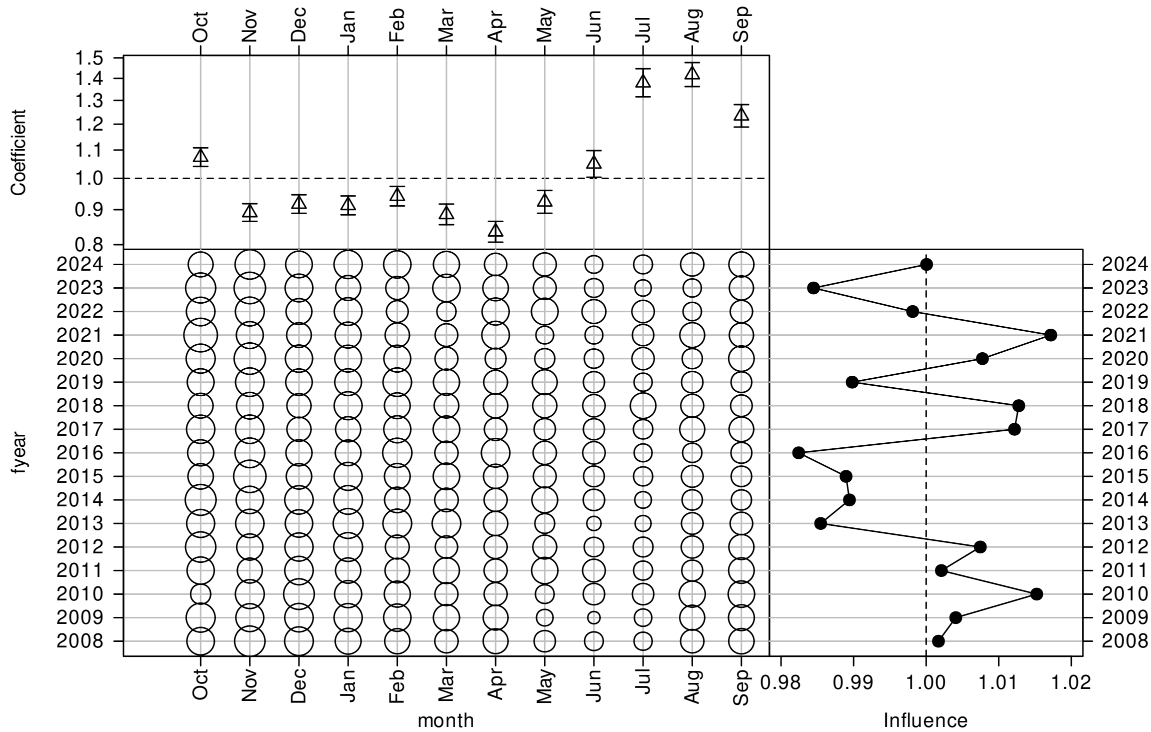

Figure 58: CDI plot for month for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

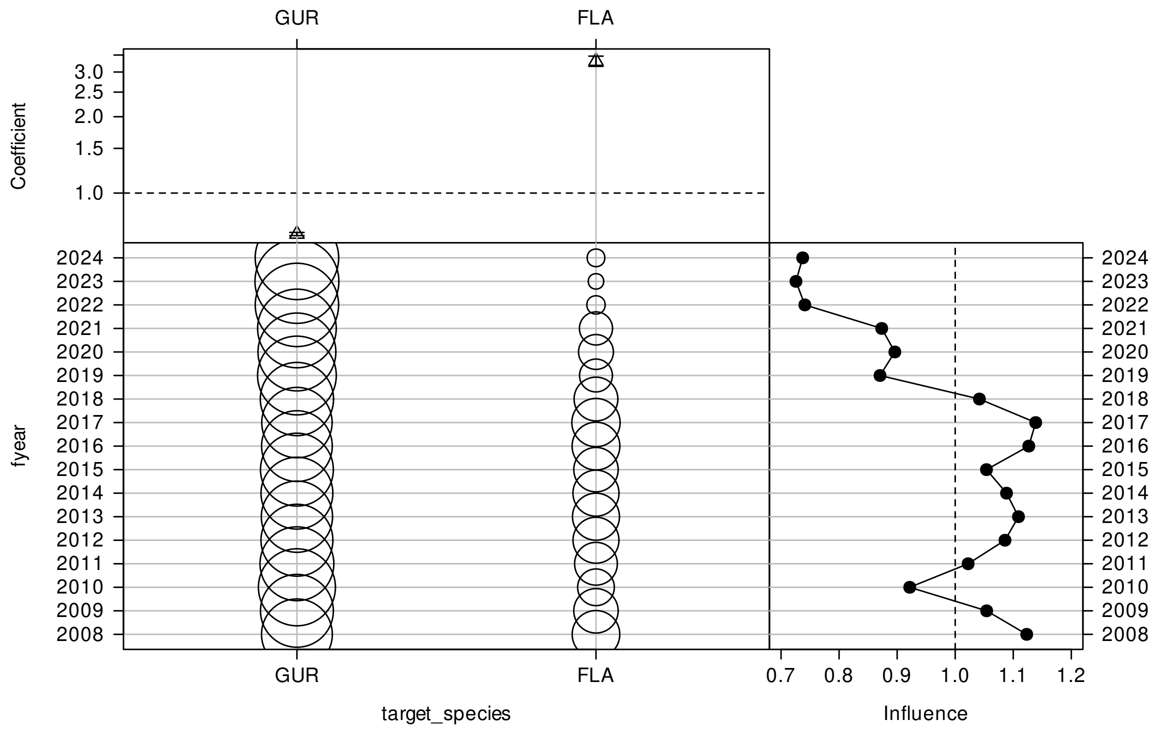

Figure 59: CDI plot for target species for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

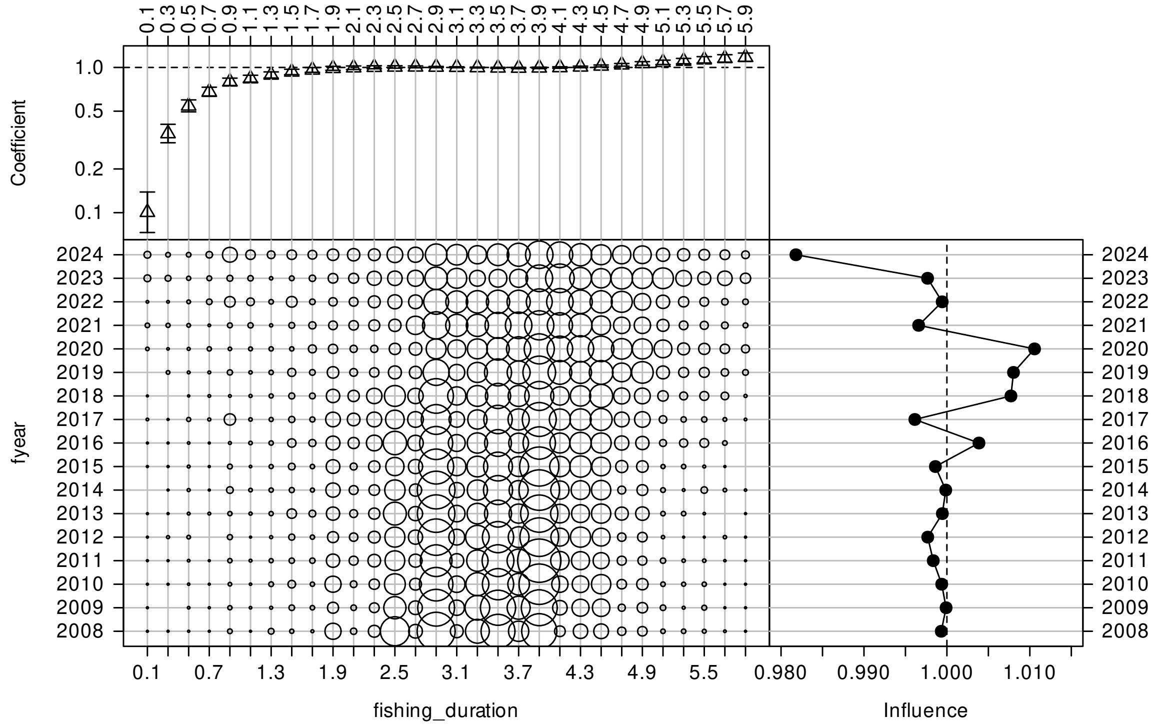

Figure 60: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

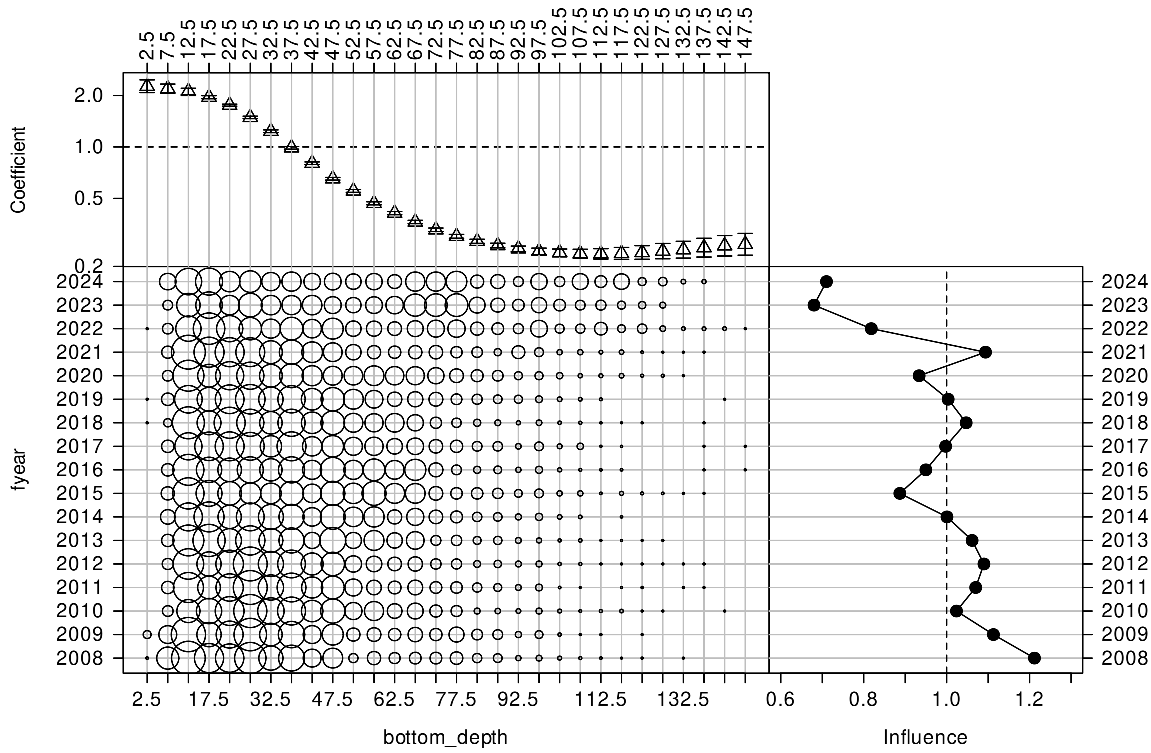

Figure 61: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

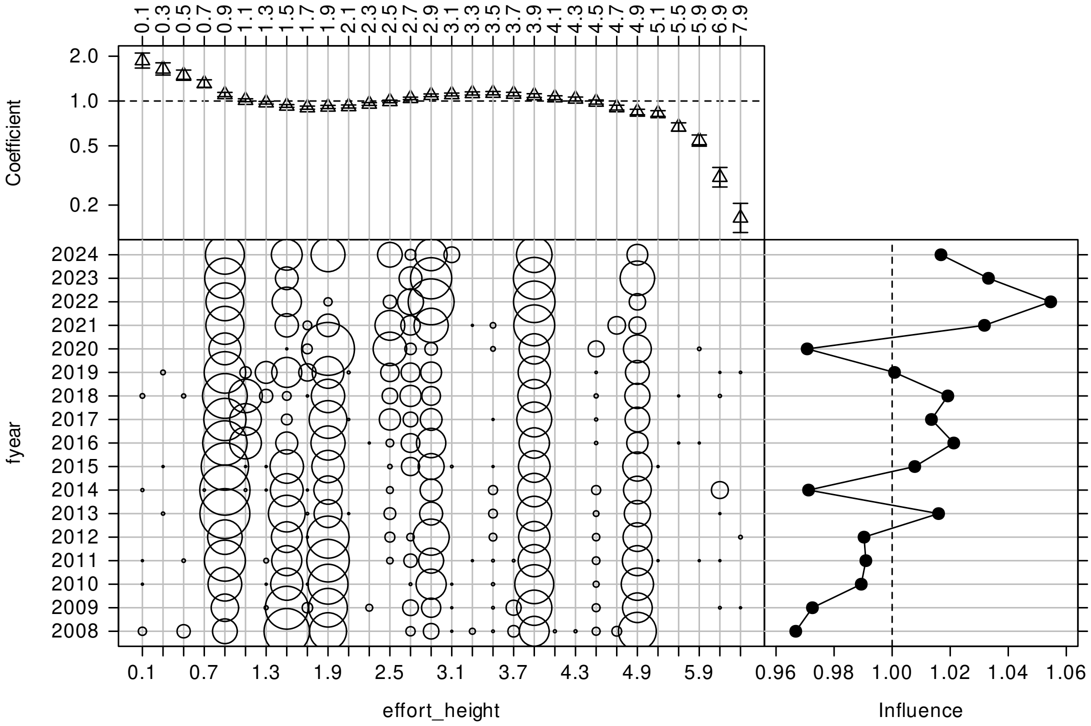

Figure 62: CDI plot for effort height (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

Table 8: Summary table for the Weibull model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	315 750.9	0.00	0.00	*
fyear	16	314 387.9	3.96	3.96	*
vessel_key	28	305 356.4	29.73	25.77	*
stat_area	1	304 550.0	32.02	2.29	*
month	11	304 295.7	32.80	0.78	*
target_species	1	300 534.1	43.48	10.67	*
ns(log(fishing_duration), 3)	3	300 396.1	43.89	0.41	*
ns(bottom_depth, 3)	3	295 834.8	56.84	12.95	*
ns(effort_height, 3)	3	295 780.5	57.01	0.17	*

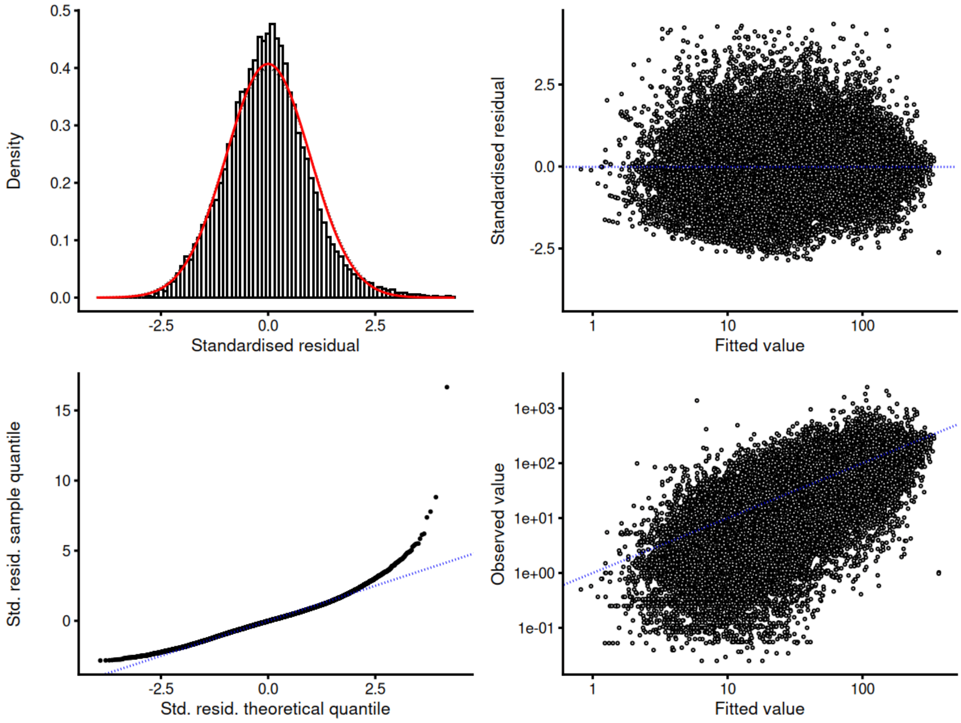

Figure 63: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-MIX event dataset.

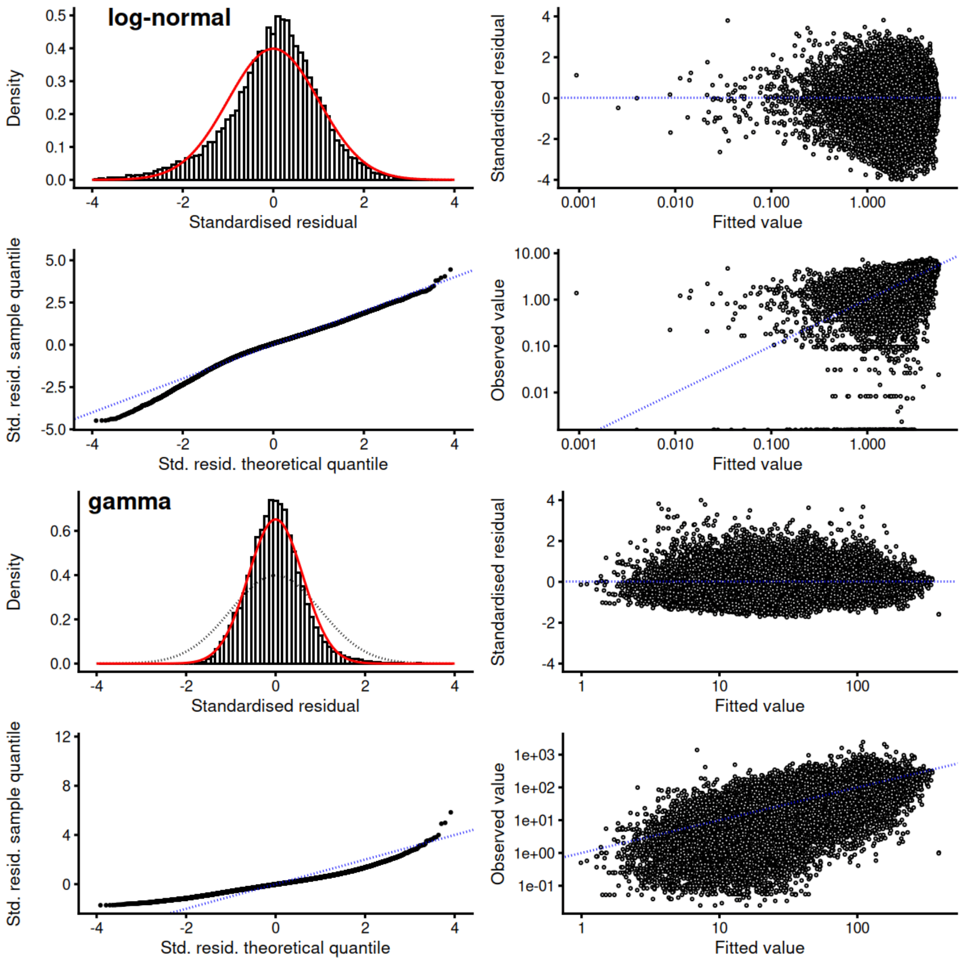

Figure 64: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-MIX event dataset.

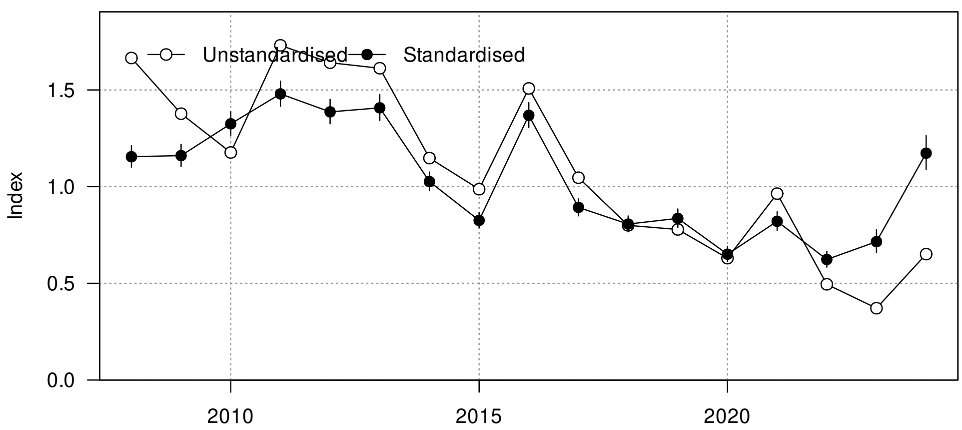

Figure 65: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-MIX event dataset.

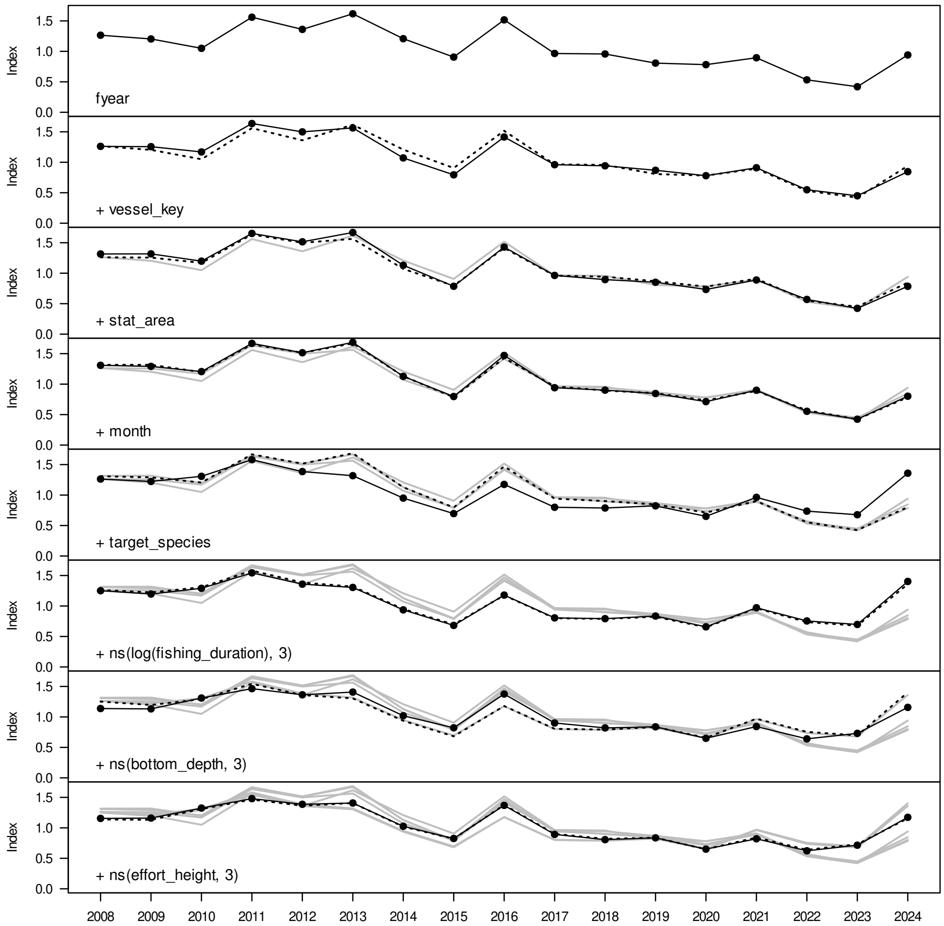

Figure 66: Changes to the Hawke Bay FLA BT-MIX event positive catch index as terms are successively entered into the Weibull model.

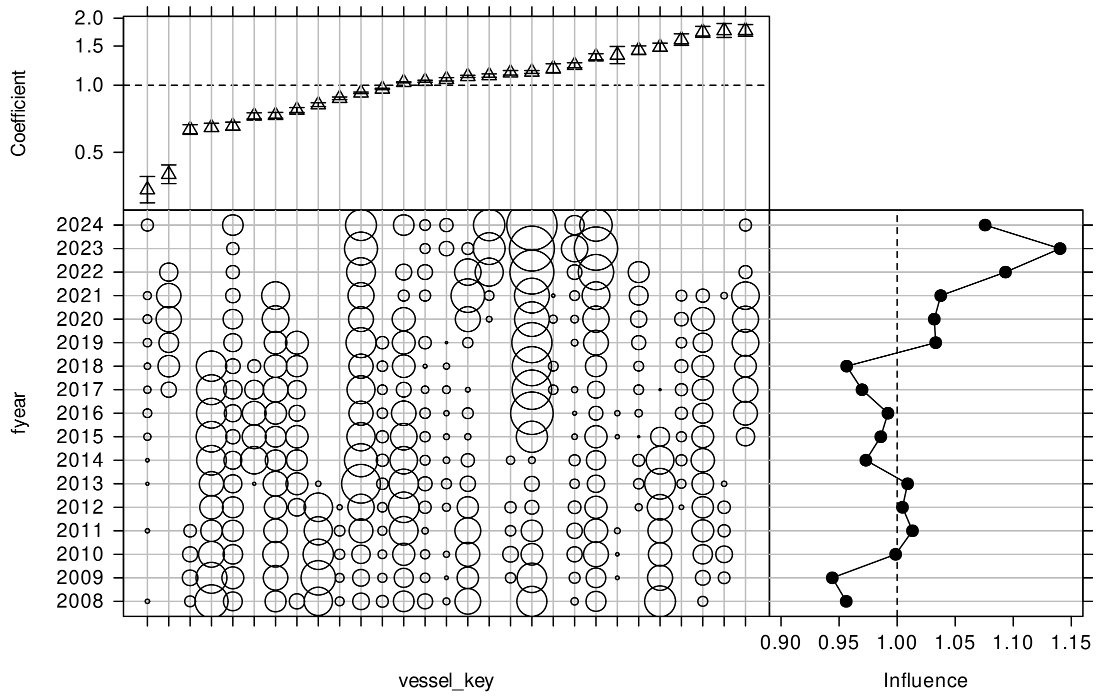

Figure 67: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

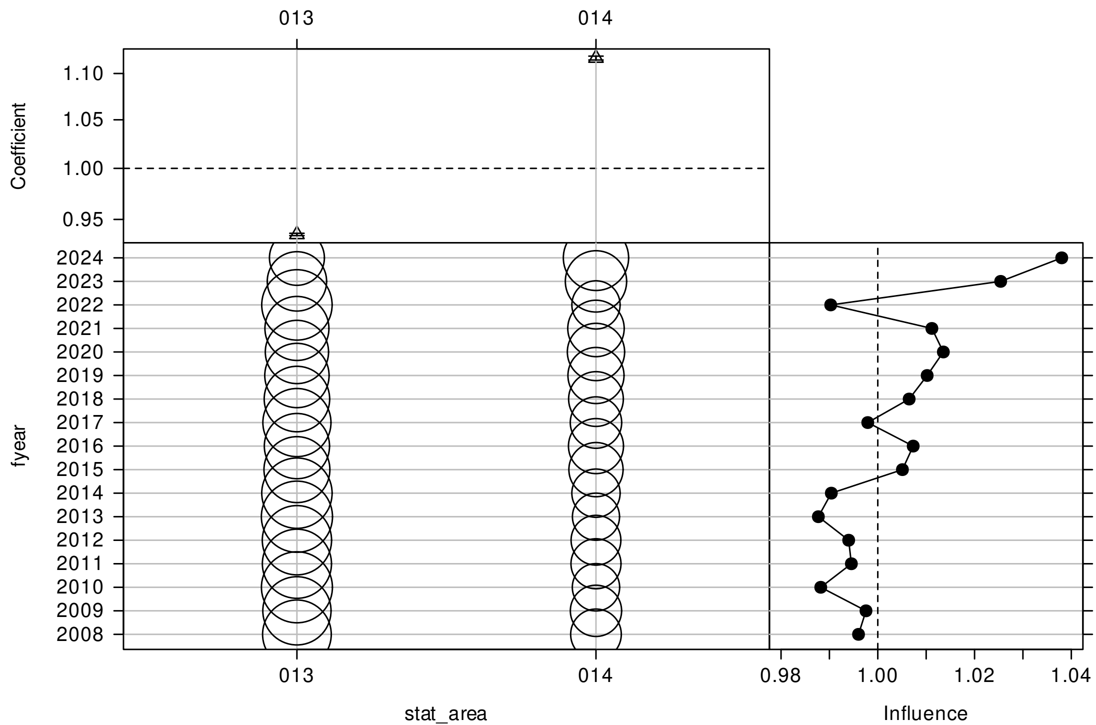

Figure 68: CDI plot for statistical area for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

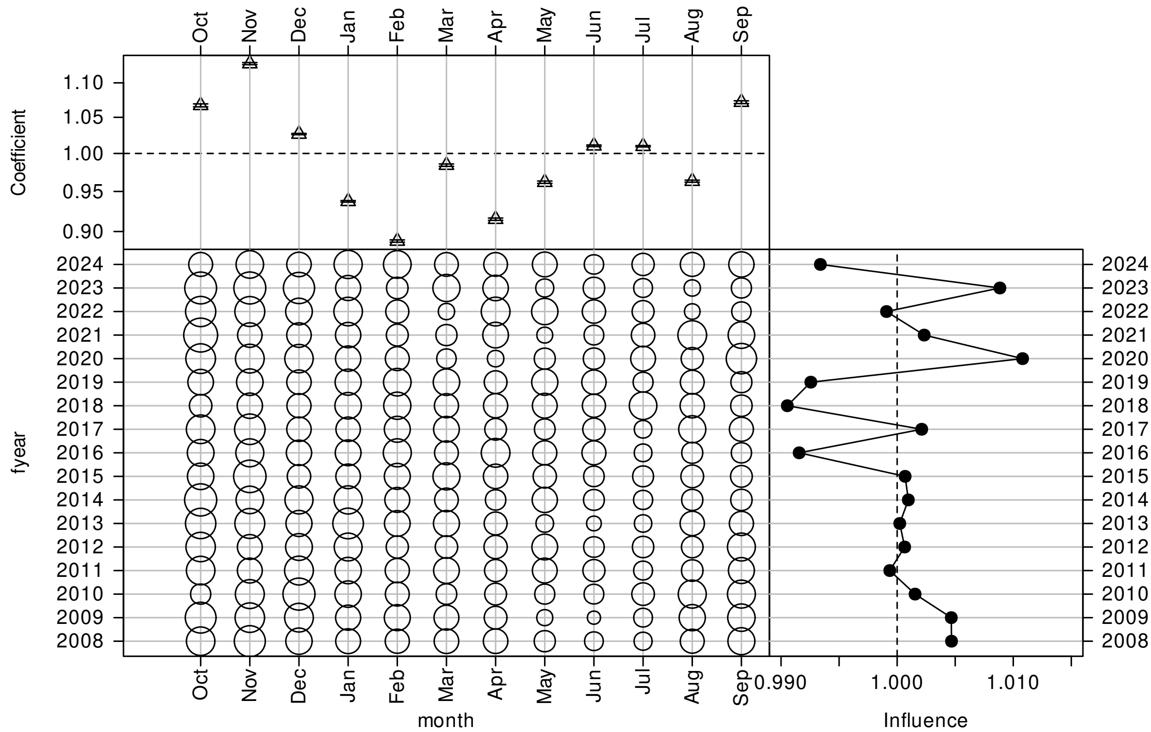

Figure 69: CDI plot for month for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

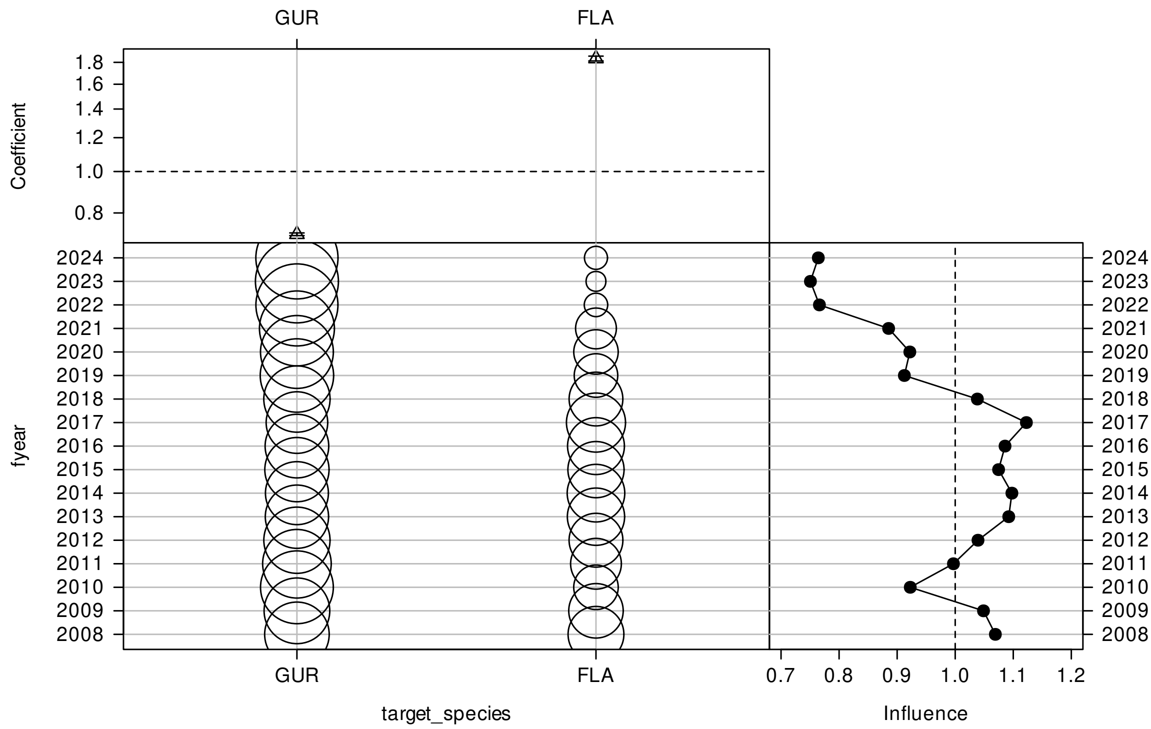

Figure 70: CDI plot for target species for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

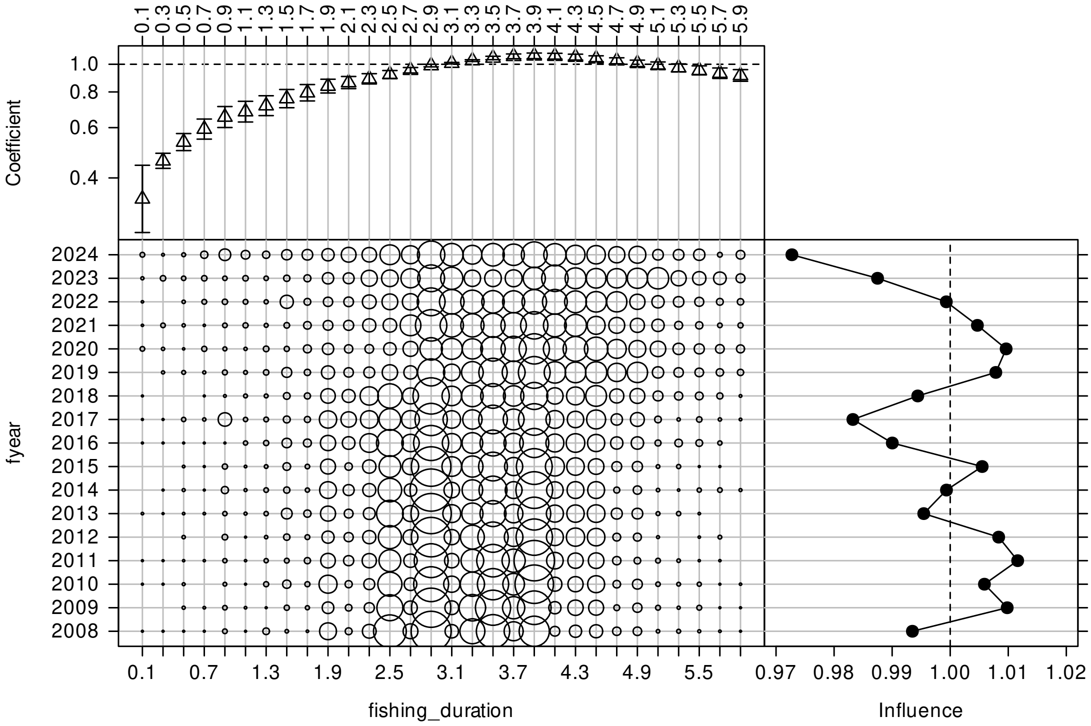

Figure 71: CDI plot for fishing duration (h) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

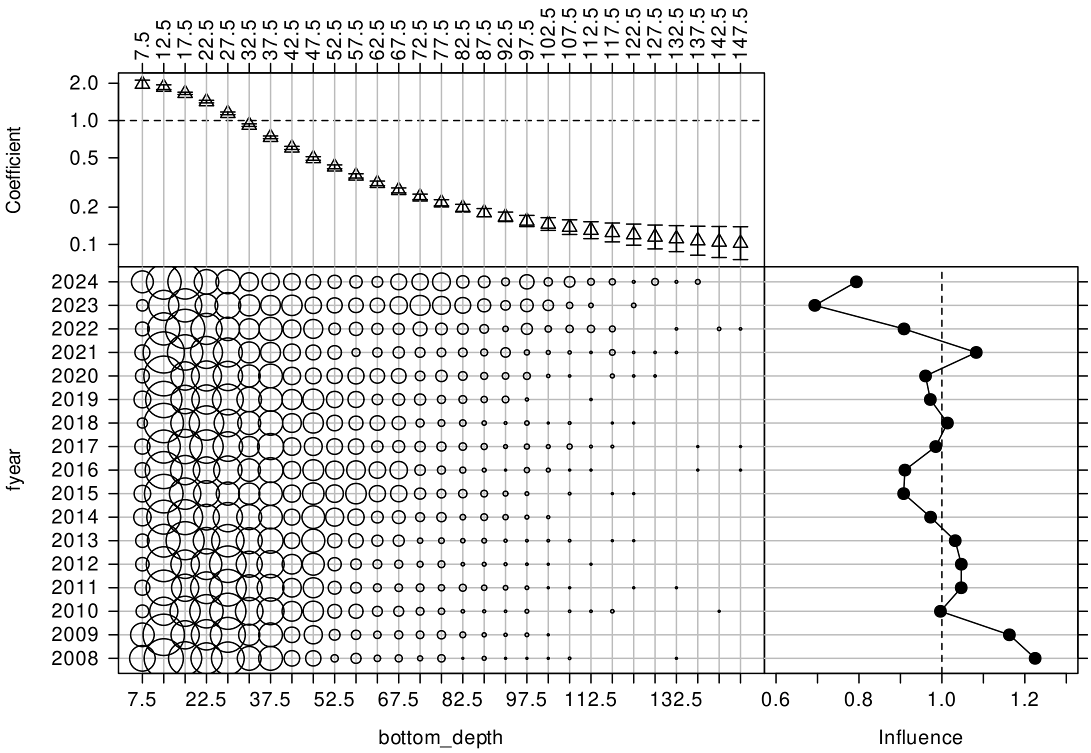

Figure 72: CDI plot for bottom depth (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

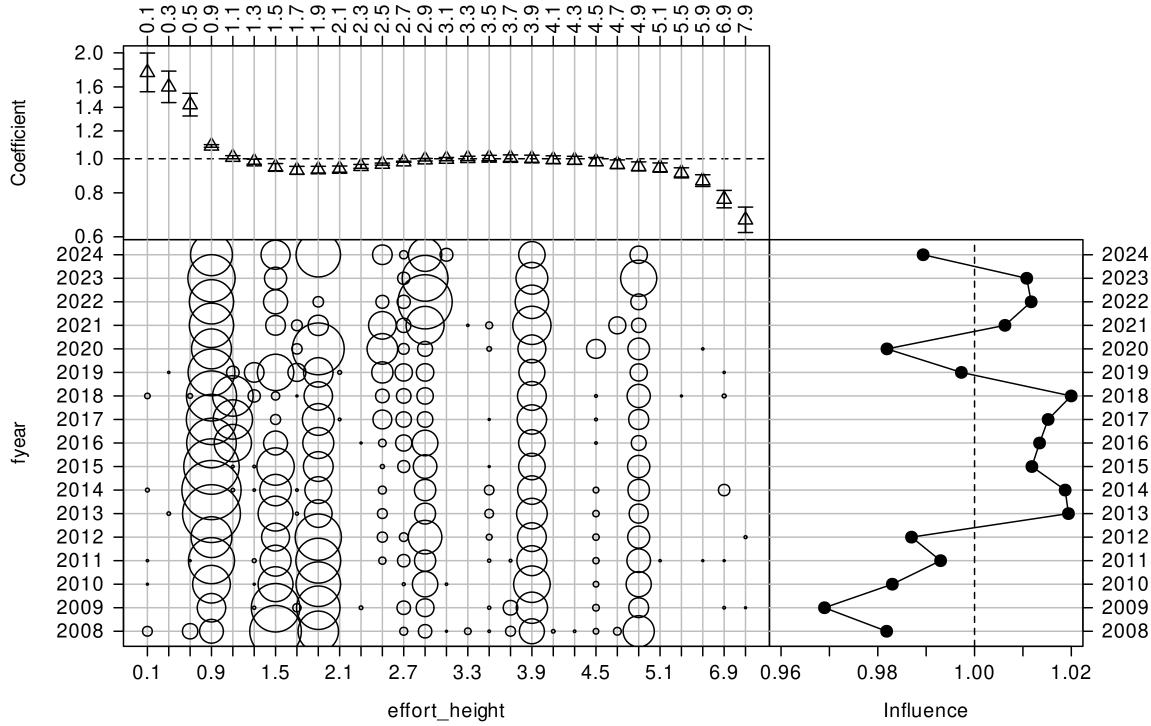

Figure 73: CDI plot for effort height (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event catch-per-unit-effort dataset.

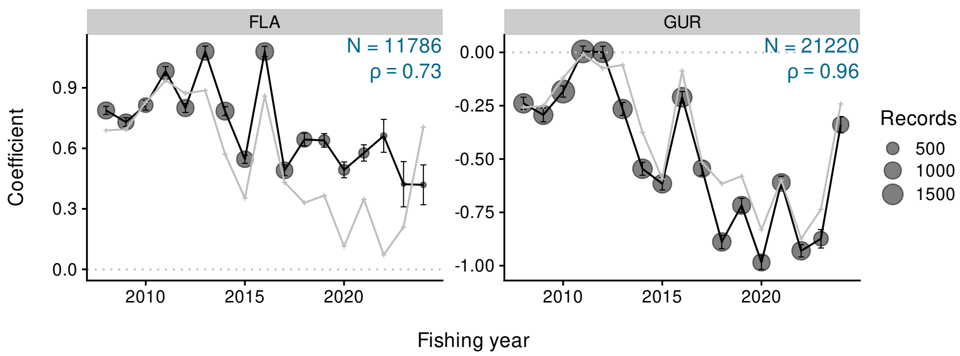

Figure 74: Residual implied coefficients for target-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least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

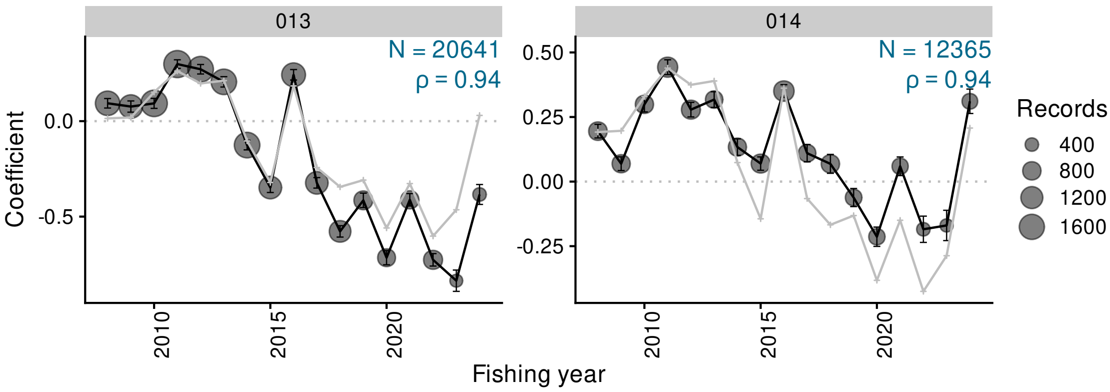

Figure 75: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 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.

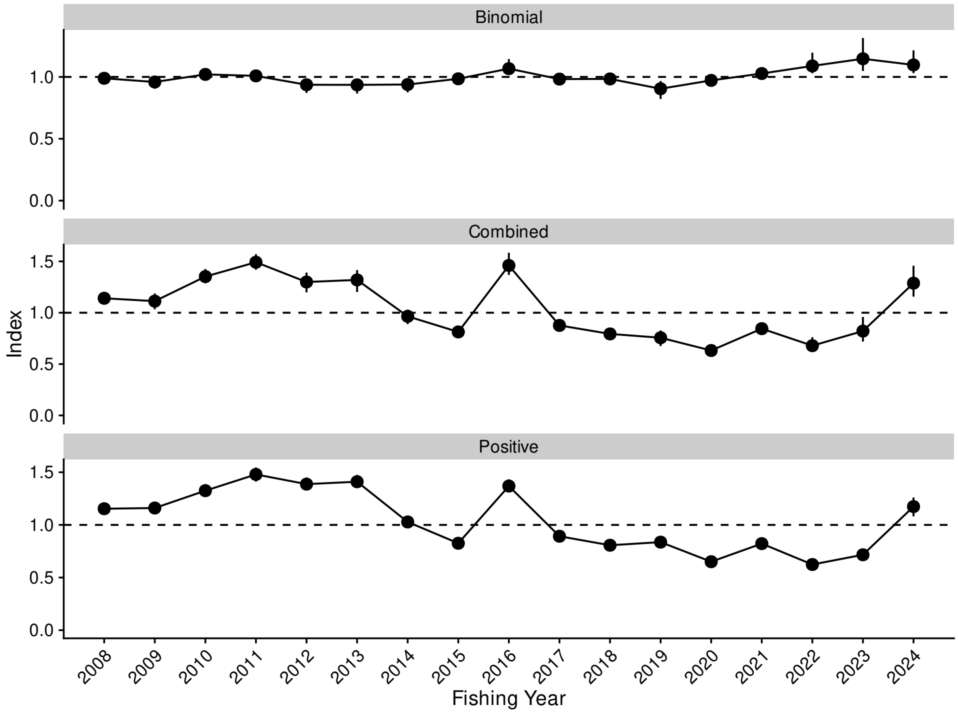

Figure 76: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-MIX event dataset.

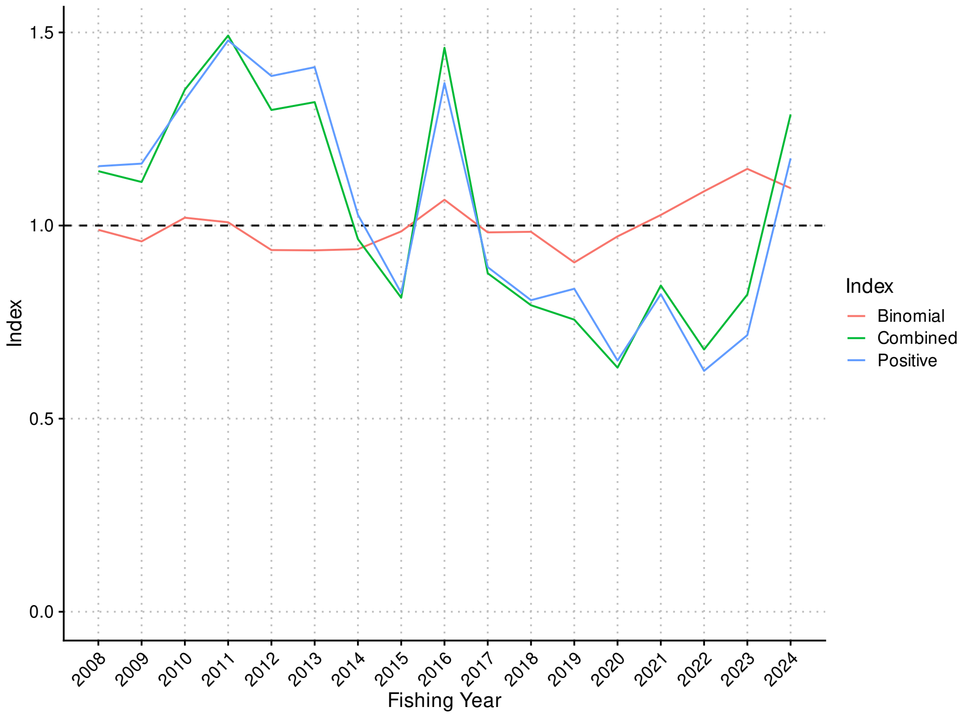

Figure 77: Standardised indices for the Hawke Bay FLA BT-MIX event dataset.

Table 9: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay FLA BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.989	0.017	0.949	1.017	1.141	0.032	1.080	1.203	1.154	0.027	1.101	1.207
2009	0.959	0.022	0.905	0.991	1.113	0.039	1.033	1.187	1.160	0.030	1.104	1.220
2010	1.020	0.014	0.998	1.052	1.352	0.036	1.286	1.426	1.325	0.030	1.268	1.387
2011	1.008	0.012	0.986	1.035	1.492	0.039	1.419	1.570	1.479	0.034	1.412	1.545
2012	0.937	0.028	0.870	0.978	1.299	0.049	1.198	1.391	1.387	0.031	1.331	1.451
2013	0.936	0.029	0.866	0.980	1.320	0.054	1.202	1.415	1.410	0.032	1.350	1.475
2014	0.939	0.027	0.875	0.980	0.965	0.036	0.889	1.030	1.028	0.023	0.984	1.075
2015	0.985	0.016	0.946	1.007	0.813	0.023	0.767	0.856	0.826	0.020	0.787	0.864
2016	1.067	0.031	1.022	1.145	1.460	0.055	1.368	1.584	1.369	0.031	1.311	1.434
2017	0.982	0.016	0.944	1.006	0.876	0.025	0.829	0.926	0.892	0.022	0.853	0.939
2018	0.984	0.015	0.949	1.009	0.794	0.024	0.744	0.840	0.807	0.021	0.766	0.849
2019	0.904	0.037	0.822	0.967	0.756	0.039	0.675	0.827	0.836	0.023	0.793	0.884
2020	0.972	0.018	0.927	1.000	0.632	0.023	0.586	0.676	0.650	0.019	0.614	0.690
2021	1.027	0.019	0.999	1.074	0.845	0.029	0.789	0.902	0.822	0.025	0.774	0.871
2022	1.089	0.042	1.029	1.195	0.679	0.037	0.618	0.762	0.624	0.021	0.585	0.666
2023	1.147	0.068	1.048	1.315	0.821	0.061	0.719	0.959	0.716	0.029	0.659	0.774
2024	1.097	0.047	1.030	1.215	1.288	0.077	1.157	1.458	1.174	0.046	1.081	1.260

4.3 Hawke Bay ESO BT-MIX event

This series is based on the Hawke Bay FLA BT-MIX event series (Section 4.2), using nearly the same model criteria except that the dependent variable is the species-specific ESO catches (see Section 3.1) instead of the combined FLA species code (Table 10). Two minor differences relative to the Hawke Bay FLA BT-MIX event series were implemented: the effort_height covariate was omitted (having had no impact on the Hawke Bay FLA BT-MIX event series – see Figure 55 and Figure 66) and the lognormal distribution was used for the positive catch model instead of the Weibull. Because this series was event-based, it began with the 2007–08 fishing year and benefitted from the somewhat better species discrimination data available from the 2007–08 fishing year (see Figure 50).

As for the Hawke Bay FLA BT-MIX event series, the core fleet was defined by having fished at least four trips in each of four years, retaining 98% of the catch and reducing the fleet from about 40 vessels to 20 vessels (Figure 78). The pattern of vessel participation in this fishery was characterised by a mix of continuity, with some vessels entering and exiting the fishery over the 17 years in the analysis while there was a reasonable number of vessels that remained the fishery for at least 12 years or more (Figure 79). The final groomed dataset represented 91% (2015, 2023, 2024) to 100% (2012, 2013, 2016) of the annual ungroomed catch (Table 11). The total annual catch of ESO in the defined fishery ranged from 82 t (in 2013) to 5 t (in 2023) over the 17 years in the data set and was characterised by a slightly decreasing trend in ESO occurrence in the catch, ranging from 80% (in 2008) to 46% (in 2018) to 51% (in 2023) (Table 12). Almost all landings were allocated to the effort data using estimated catch proportions, with very minor amounts of landings distributed proportionately to effort (Figure 80).

The binomial (occurrence) model explained 37% of the deviance when using all the offered explanatory variables (Table 13). The overall impact of the standardisation model was to change the slightly decreasing trend in the unstandardised occurrence model to a standardised model which decreased steadily to 2018, followed by an increasing trend to the end of the series (Figure 81). The primary variable causing this shift was the vessel variable, and to a lesser extent the target species variable (Figure 82). CDI plots for the occurrence model are provided for each covariate offered to the model: vessel (Figure 83), statistical area (Figure 84), month (Figure 85), target species (Figure 86), fishing duration (Figure 87), and bottom depth (Figure 88). The vessel CDI plot indicated that there was a shift away from vessels that had a high probability of catching ESO, probably an expression of the shift away from target fishing for FLA and the rise of GUR targeting (Figure 83). This effect was also apparent in the target species covariate, with a strong shift away from FLA to GUR (Figure 86), and possibly as well in the final years of the bottom depth covariate, reflecting a similar shift in preferred depth (Figure 88).

The lognormal model explained 38% of the deviance when using all the explanatory variables (Table 14). The model showed good conformity to the lognormal distribution (Figure 89), except at the very lower end of the distribution. Both the gamma and the Weibull distributions also showed reasonable fits to the positive catch data (Figure 90). The unstandardised and the standardised series both showed a variable flat trend up to 2016, followed by a decreasing trend to 2023 with an upturn in the final year (Figure 91). There appears to be very little standardisation effect in this model, with all series following very similar trends as each variable successively enters the model (Figure 92). CDI plots for the lognormal model are provided for each variable offered to the model: vessel (Figure 93), statistical area (Figure 94), month (Figure 95), target species (Figure 96), fishing duration (Figure 97), and bottom depth (Figure 98). The upturn in the final year is present in both the unstandardised and standardised series and is augmented by the target species covariate, which is presumably adjusting for the strong shift away from FLA targeting to GUR targeting (Figure 96). The impact of the remaining covariates on the standardisation model tended to be small, resulting in a standardised series that was similar to the unstandardised series (see Figure 92). Implied residual plots for target species on the total annual CPUE trend showed good conformity for both target species categories, with each category showing an upturn in the final model year (Figure 99). The conformity with the overall annual CPUE trend was also reasonable for the two Statistical Areas (013 and 014), with both Statistical Areas showing the upturn in the final model year (Figure 100).

There was a divergence between the binomial and lognormal models, with the occurrence model increasing after 2016 while the positive catch model decreased over the same time period (Figure 101, Figure 102). Consequently, the combined model is an average between these two series and more closely resembles the positive catch model. Indices, bounds and standard errors for each series are presented in Table 15.

Table 10: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay ESO BT-MIX event CPUE series.

Series	Hawke Bay ESO BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	ESO ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

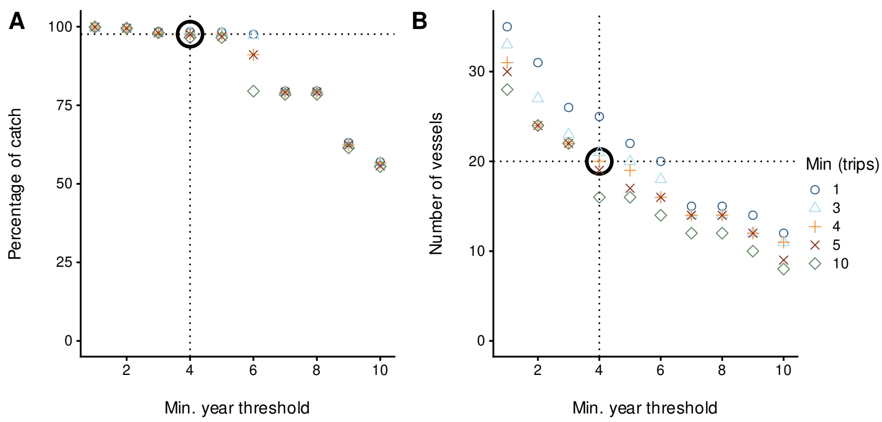

Figure 78: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay ESO BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

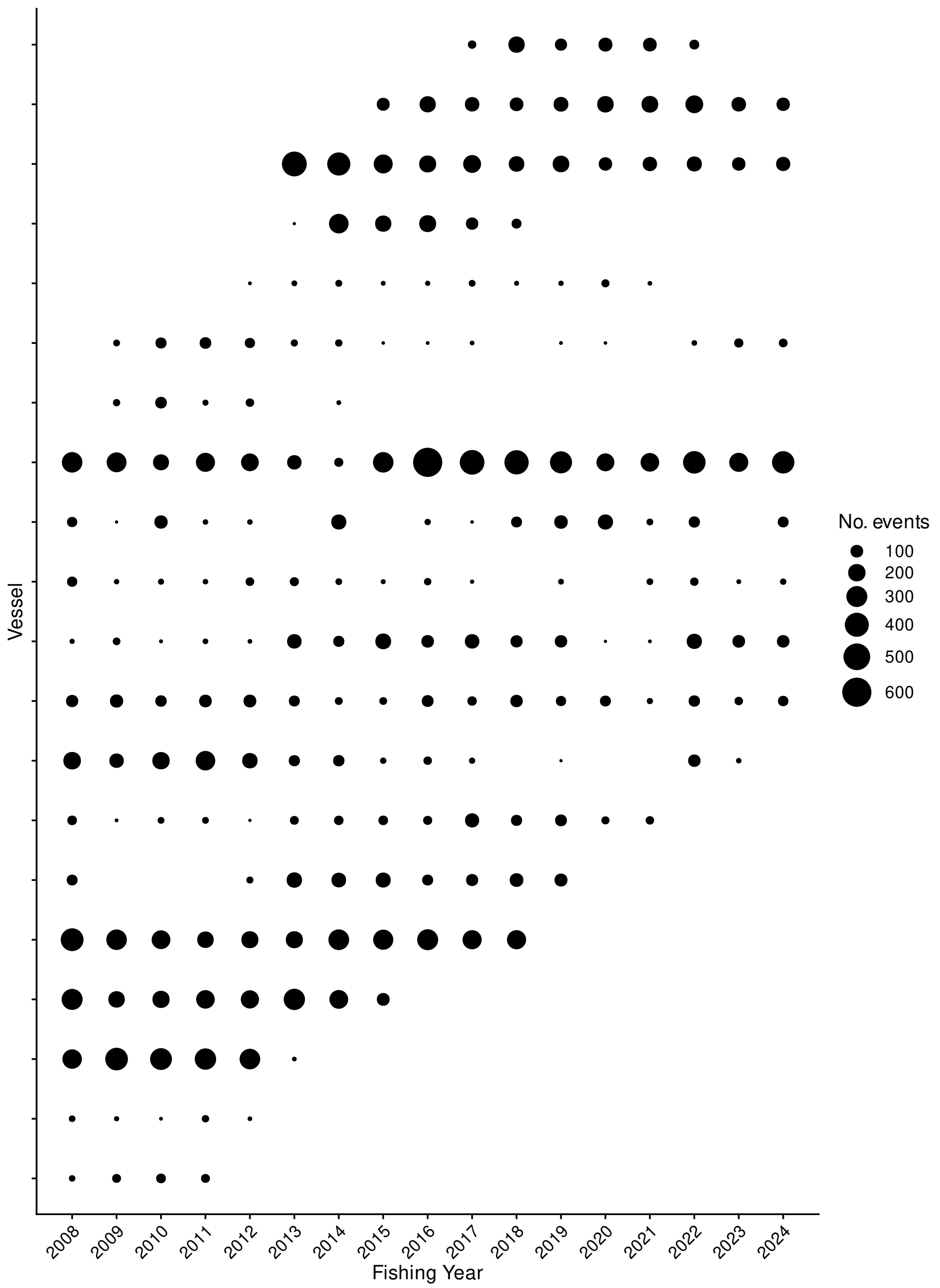

Figure 79: Number of events by fishing year for core vessels in the Hawke Bay ESO BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 11: Summary of the Hawke Bay ESO BT-MIX 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	39 (100%) n: 2087	30 (100%) n: 1515	37 (100%) n: 1601	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Positive fishing duration	39 (100%) n: 2087	30 (100%) n: 1513	37 (100%) n: 1599	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Fishing duration less than 6 h	39 (100%) n: 2077	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1664	37 (100%) n: 1387	82 (100%) n: 1669	63 (98%) n: 2068	30 (100%) n: 1779	44 (100%) n: 1864
Bottom depth < 150m	39 (100%) n: 2076	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1662	37 (100%) n: 1387	82 (100%) n: 1669	63 (97%) n: 2066	30 (100%) n: 1777	44 (100%) n: 1864
Core fleet selection	37 (95%) n: 1801	29 (99%) n: 1490	37 (99%) n: 1579	64 (99%) n: 1566	37 (100%) n: 1378	82 (100%) n: 1647	60 (92%) n: 1817	28 (91%) n: 1624	44 (100%) n: 1863

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1277	11 (100%) n: 946	9 (100%) n: 809	10 (100%) n: 1519	5.4 (100%) n: 885	14 (100%) n: 1093
Positive fishing duration	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1273	11 (99%) n: 943	9 (100%) n: 808	10 (100%) n: 1518	5.4 (100%) n: 884	14 (100%) n: 1093
Fishing duration less than 6 h	27 (99%) n: 1722	21 (99%) n: 1699	20 (100%) n: 1260	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1505	5.4 (100%) n: 871	14 (100%) n: 1085
Bottom depth < 150m	27 (99%) n: 1722	21 (99%) n: 1698	20 (100%) n: 1258	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1501	5.4 (100%) n: 870	14 (100%) n: 1081
Core fleet selection	26 (96%) n: 1617	20 (95%) n: 1627	20 (99%) n: 1248	11 (99%) n: 931	9 (99%) n: 788	9.9 (96%) n: 1220	5 (91%) n: 707	13 (91%) n: 882

Table 12: Summary of the Hawke Bay ESO BT-MIX 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	13	656	1 801	5 686.15	37.38	80.18
2009	14	675	1 490	4 852.32	29.18	78.86
2010	14	683	1 579	5 200.67	36.71	70.93
2011	14	700	1 566	5 152.73	63.82	77.20
2012	15	622	1 378	4 437.47	37.15	70.32
2013	14	567	1 647	5 098.95	81.58	69.52
2014	15	649	1 817	5 762.42	59.80	73.25
2015	14	662	1 624	5 245.20	27.65	58.31
2016	14	711	1 863	5 865.78	43.90	48.09
2017	15	644	1 617	5 121.83	26.49	51.21
2018	12	623	1 627	5 268.70	20.46	45.54
2019	13	462	1 248	4 522.53	19.51	57.93
2020	10	382	931	3 413.22	10.99	52.31
2021	10	368	788	2 635.32	8.99	66.12
2022	10	452	1 220	4 317.17	9.89	58.77
2023	8	242	707	2 533.05	4.96	51.06
2024	8	332	882	2 918.95	13.11	64.85

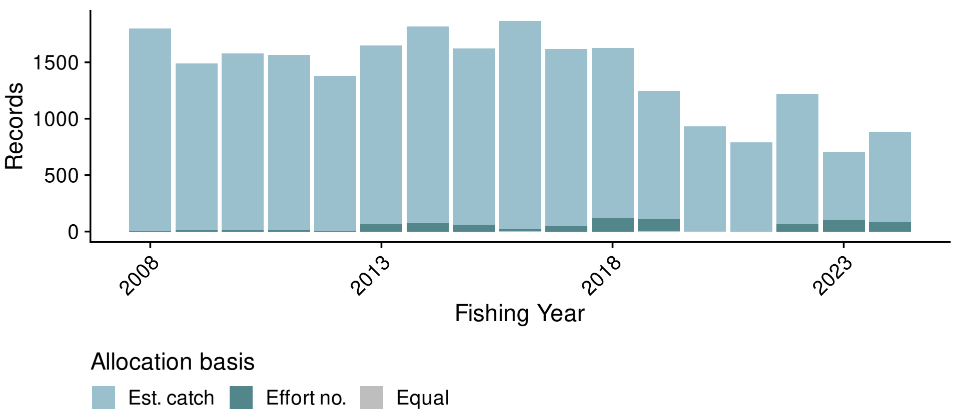

Figure 80: The allocation approach used for attributing catches to records in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table 13: Summary table for occurrence of positive catch in the Hawke Bay ESO BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	31 126.75	0.00	0.00	*
fyear	16	29 804.05	4.35	4.35	*
vessel_key	19	20 463.95	34.48	30.13	*
stat_area	1	20 462.79	34.49	0.01	*
month	11	20 352.70	34.92	0.42	*
target_species	1	20 085.53	35.78	0.86	*
ns(log(fishing_duration), 3)	3	20 082.00	35.81	0.03	*
ns(bottom_depth, 3)	3	19 580.54	37.44	1.63	*

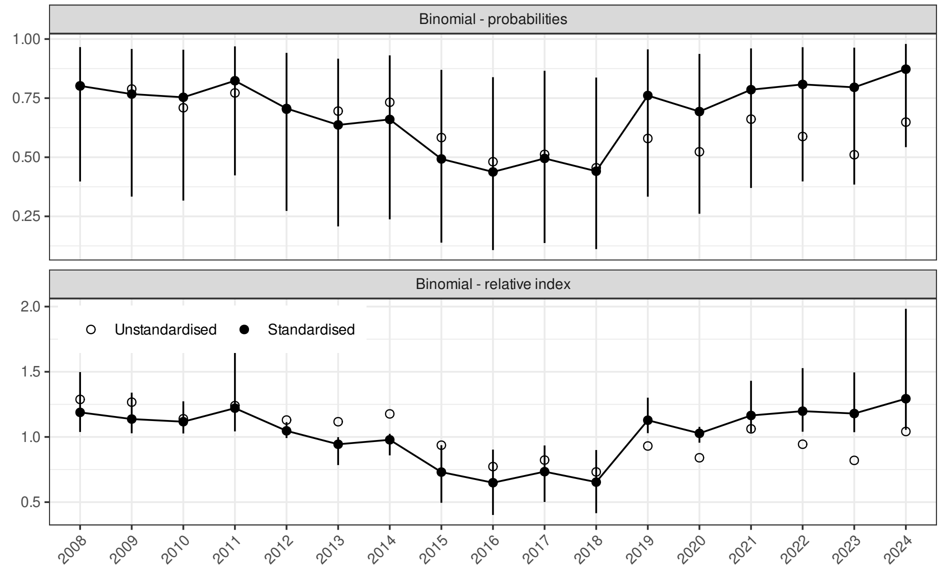

Figure 81: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay ESO BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

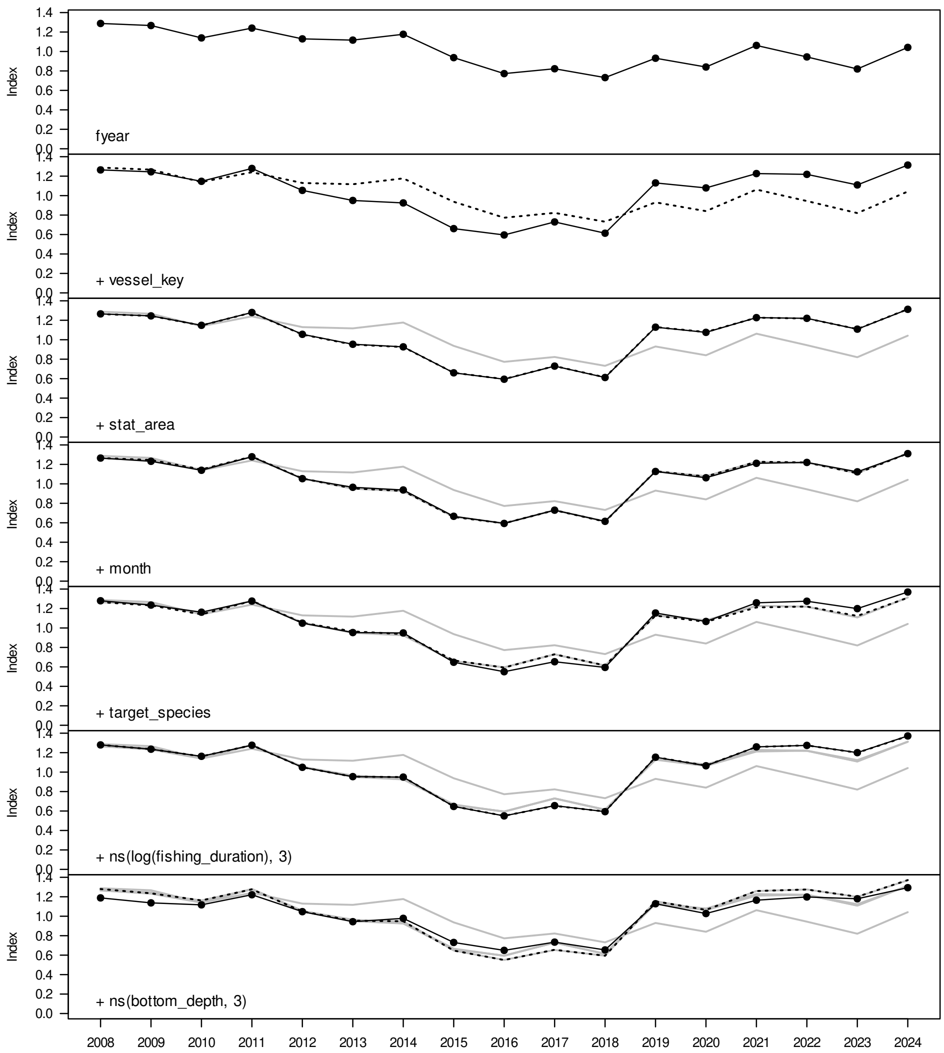

Figure 82: Step plot for occurrence of catch in the Hawke Bay ESO BT-MIX event dataset.

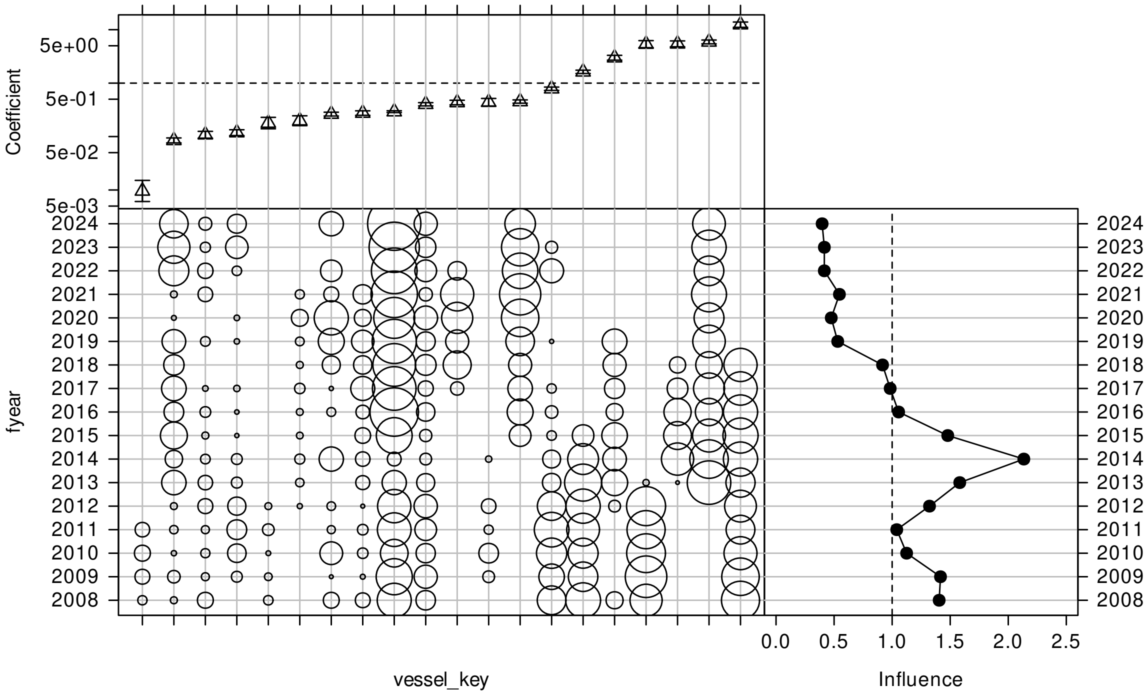

Figure 83: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

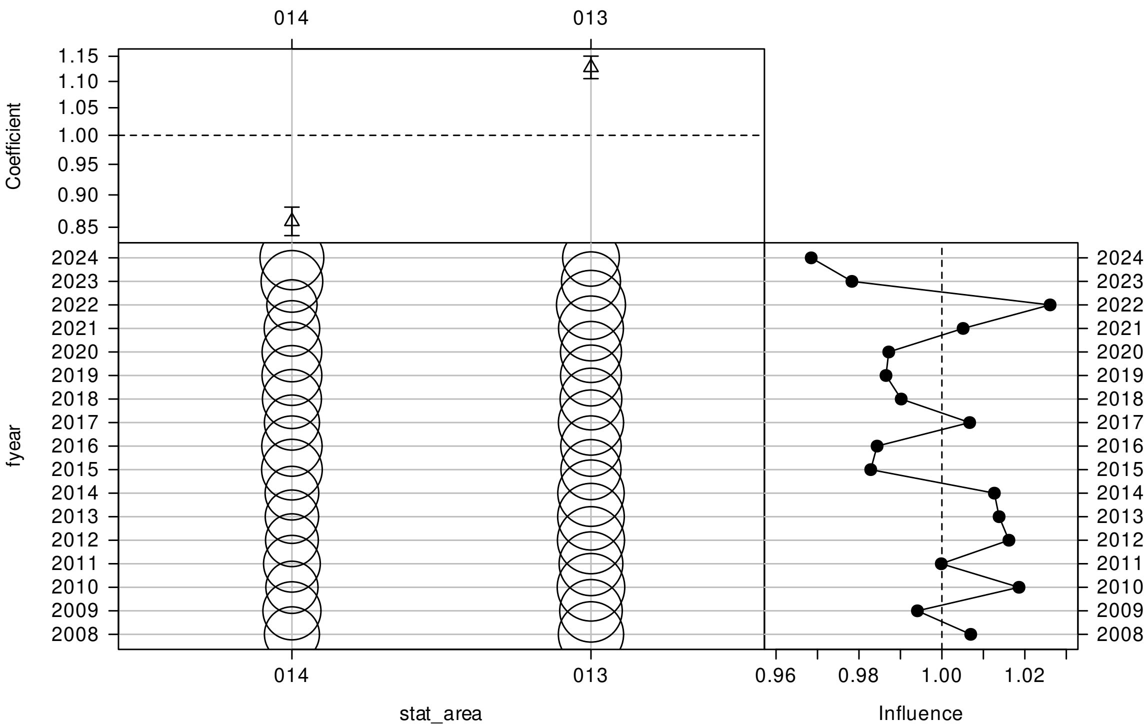

Figure 84: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

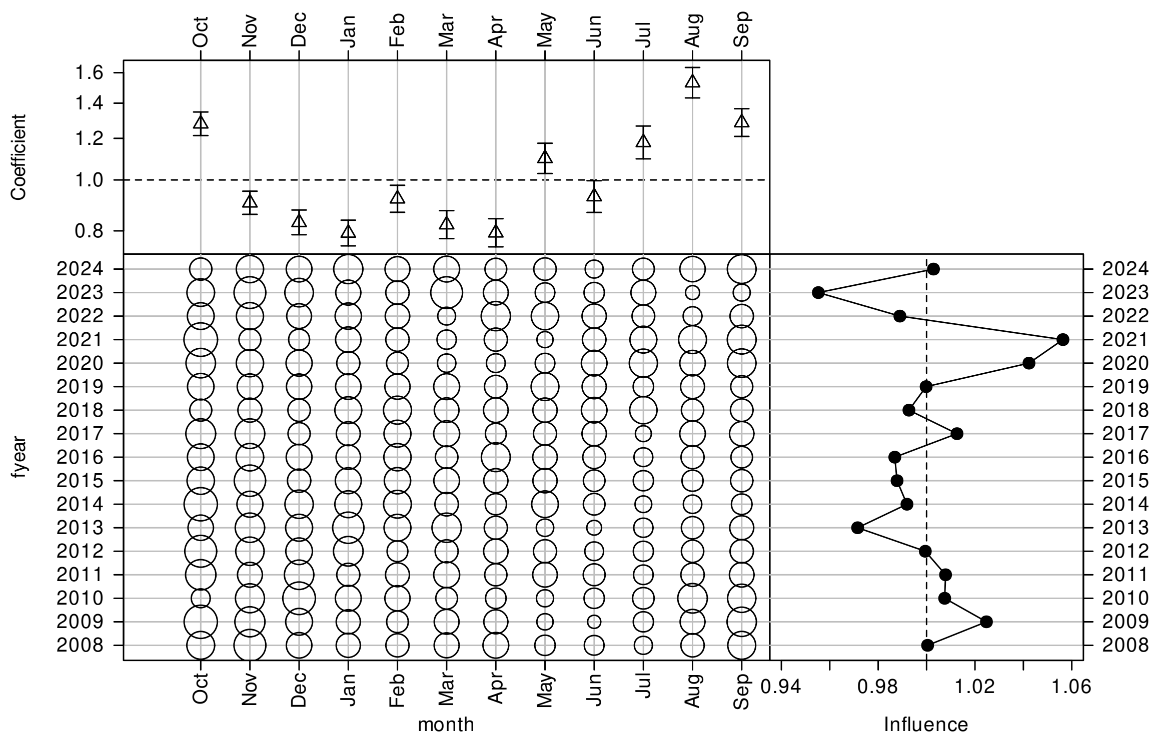

Figure 85: CDI plot for month for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

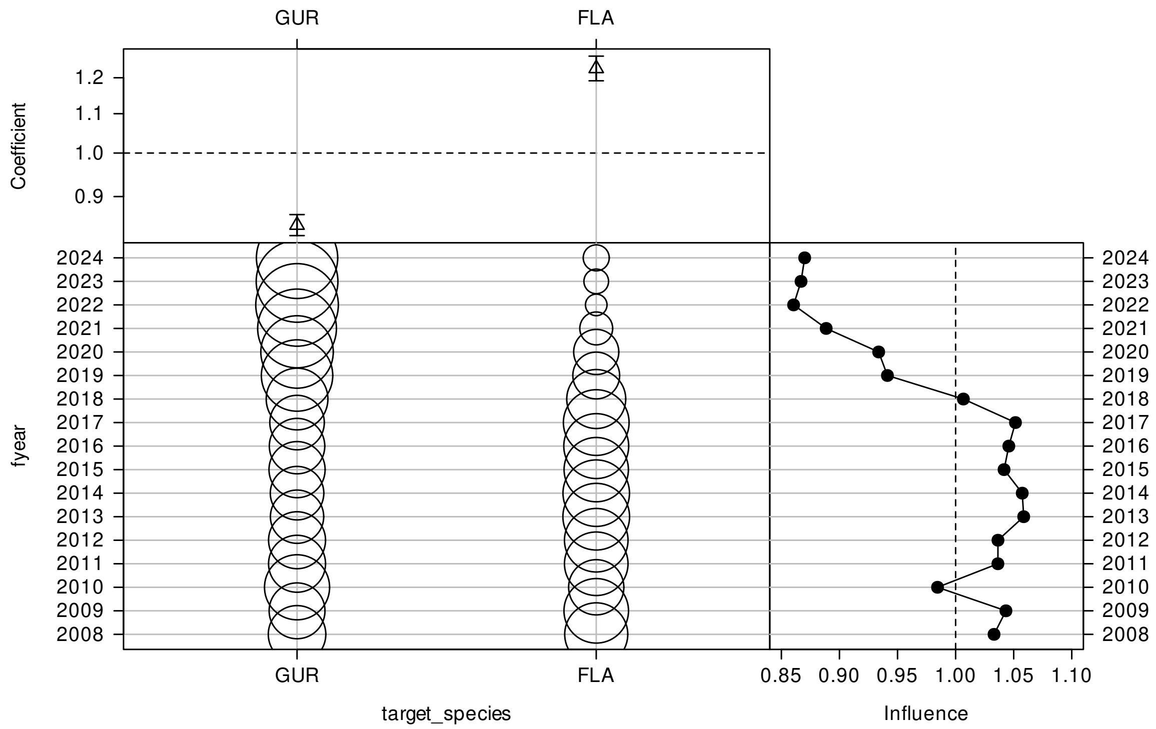

Figure 86: CDI plot for target species for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

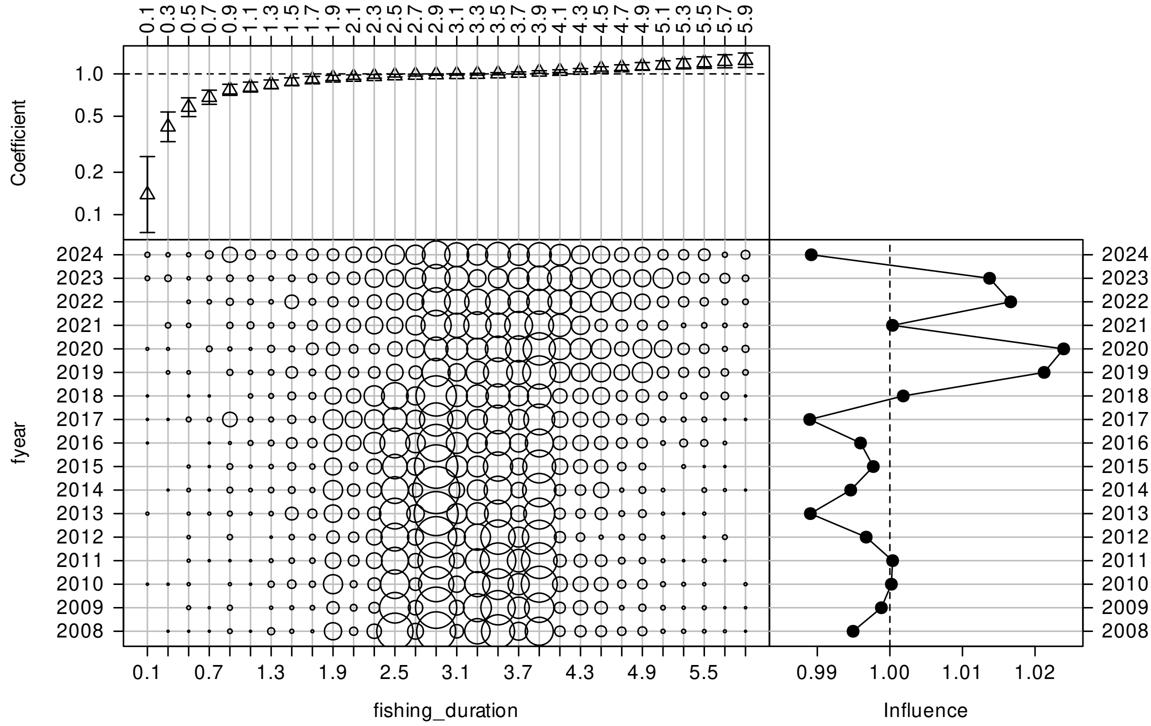

Figure 87: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

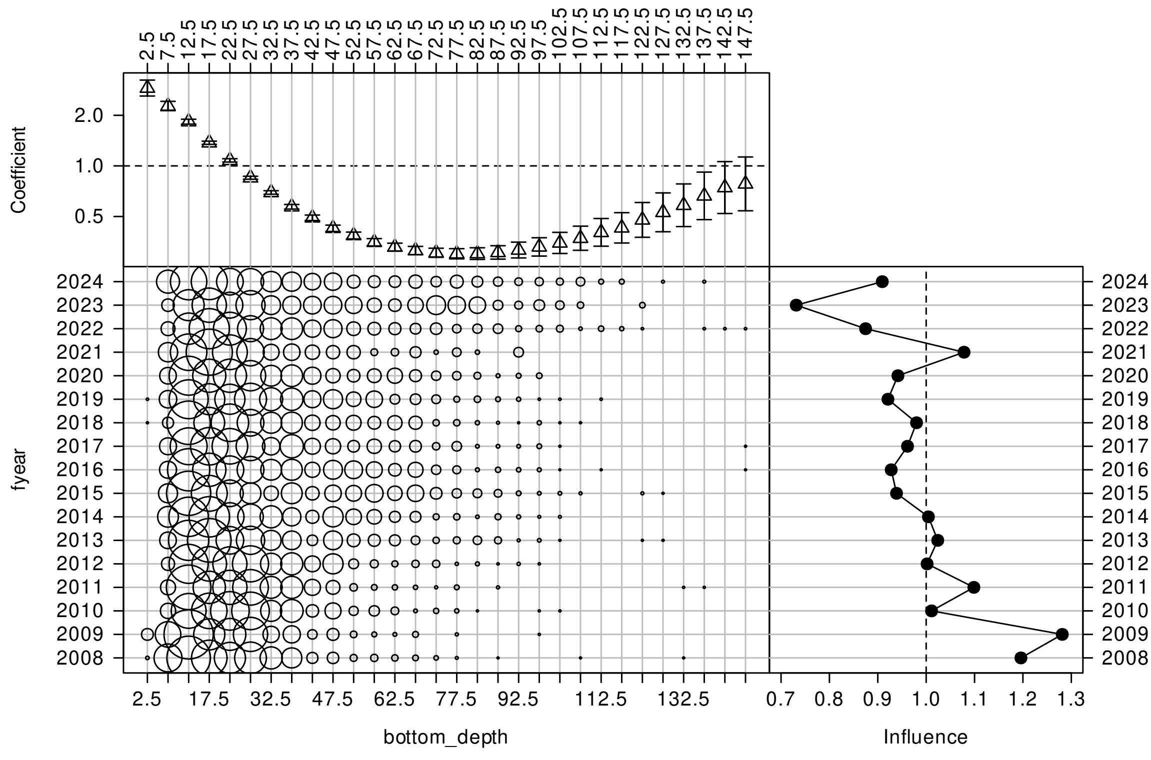

Figure 88: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

Table 14: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	49 777.72	0.00	0.00	*
fyear	16	47 694.27	13.00	13.00	*
vessel_key	19	45 395.94	25.41	12.41	*
stat_area	1	44 866.30	27.98	2.57	*
month	11	44 754.79	28.61	0.63	*
target_species	1	43 605.97	33.82	5.21	*
ns(log(fishing_duration), 3)	3	43 442.22	34.55	0.74	*
ns(bottom_depth, 3)	3	42 690.40	37.74	3.19	*

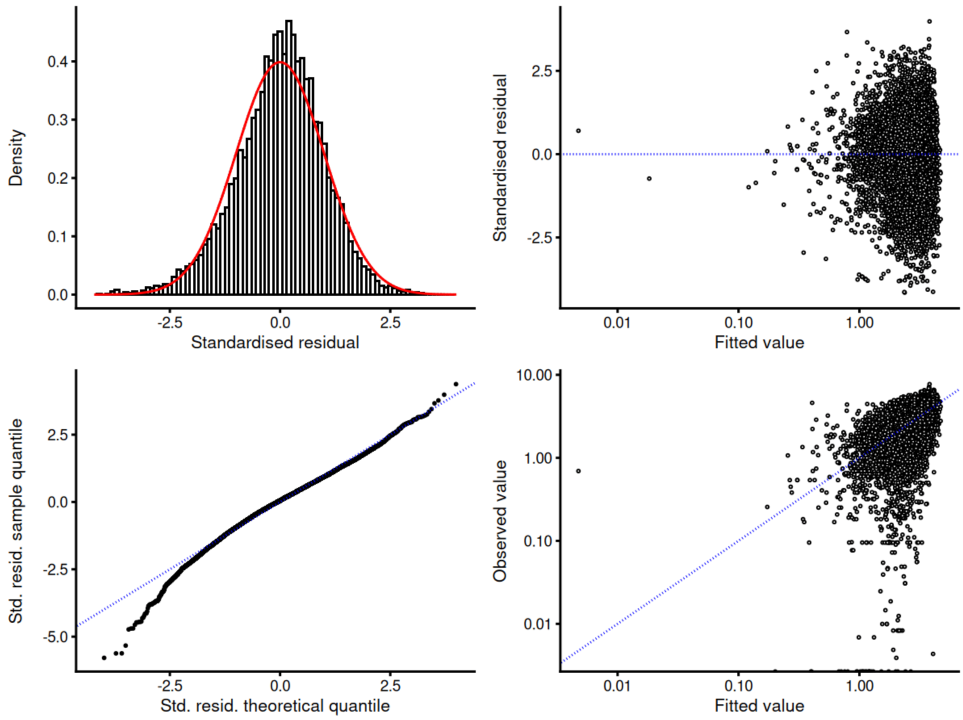

Figure 89: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay ESO BT-MIX event dataset.

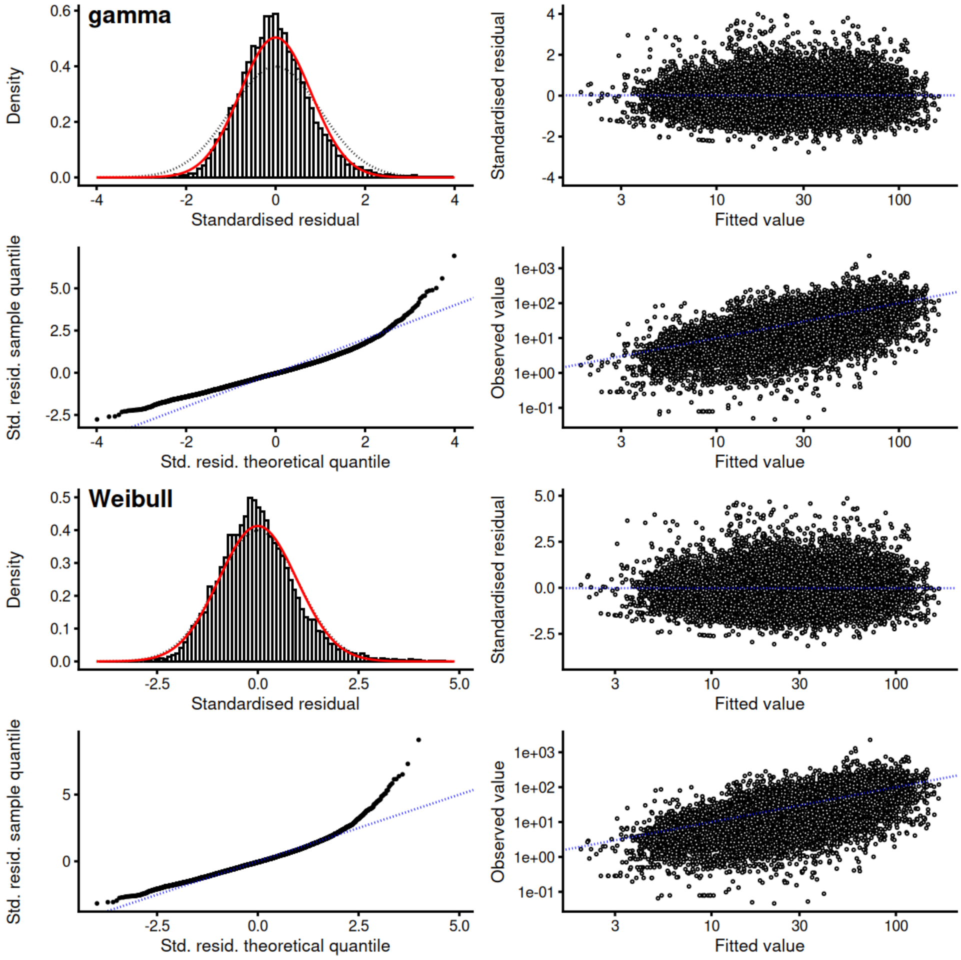

Figure 90: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay ESO BT-MIX event dataset.

Figure 91: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay ESO BT-MIX event dataset.

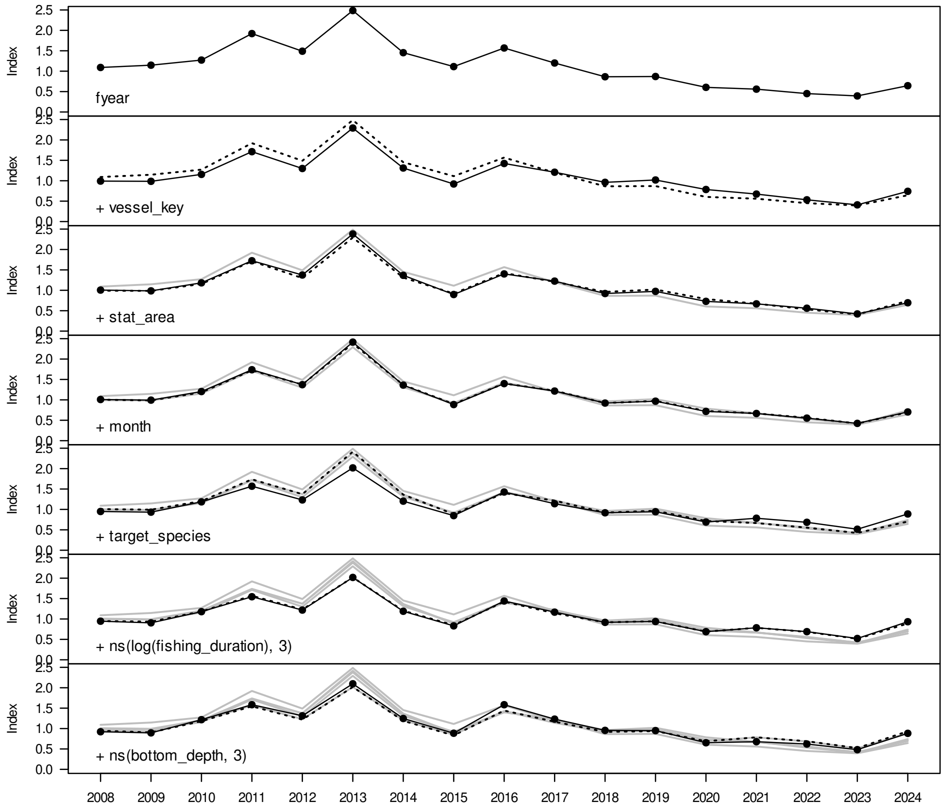

Figure 92: Changes to the Hawke Bay ESO BT-MIX event positive catch index as terms are successively entered into the lognormal model.

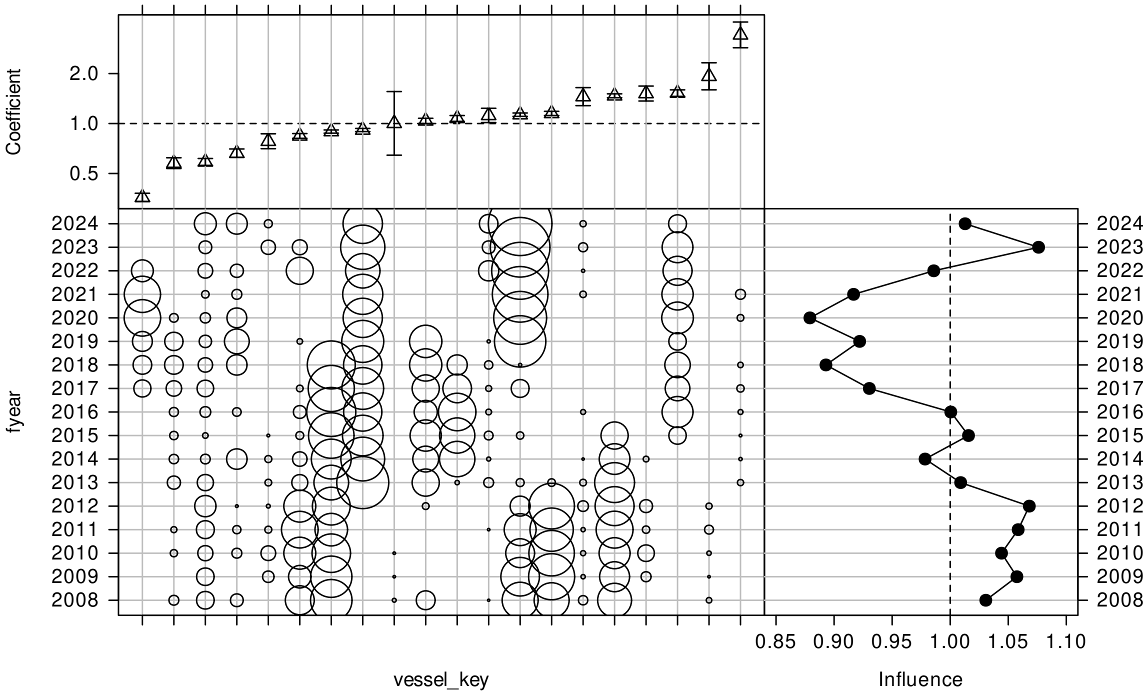

Figure 93: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

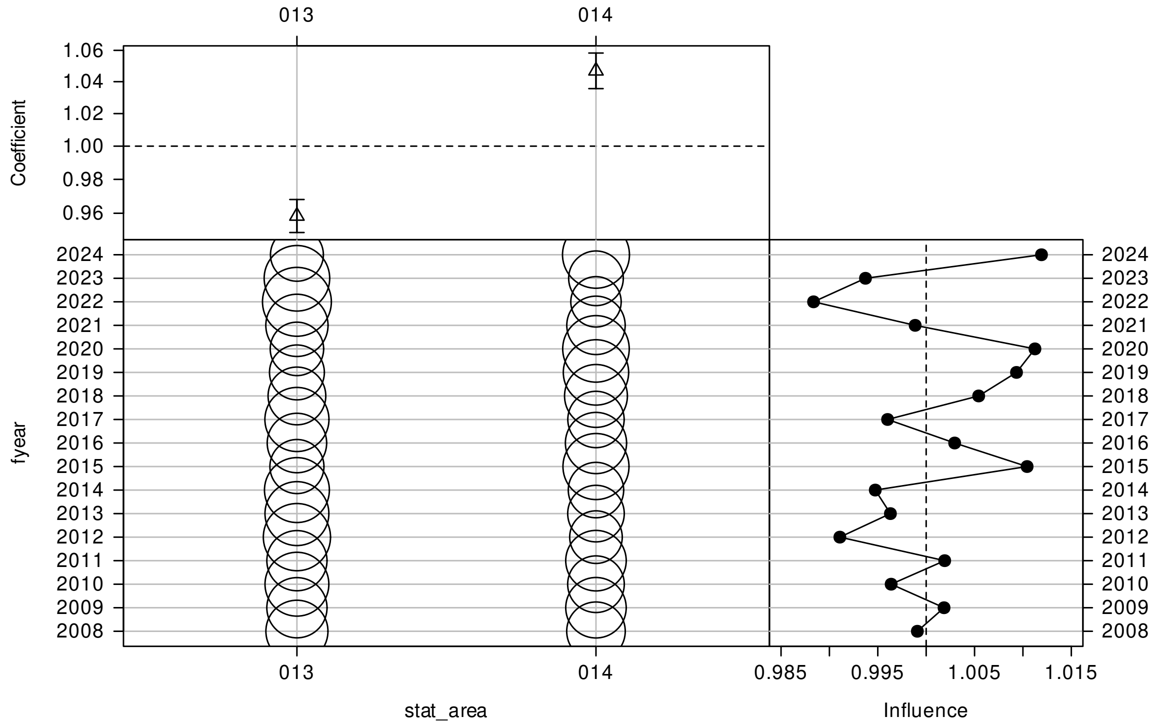

Figure 94: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

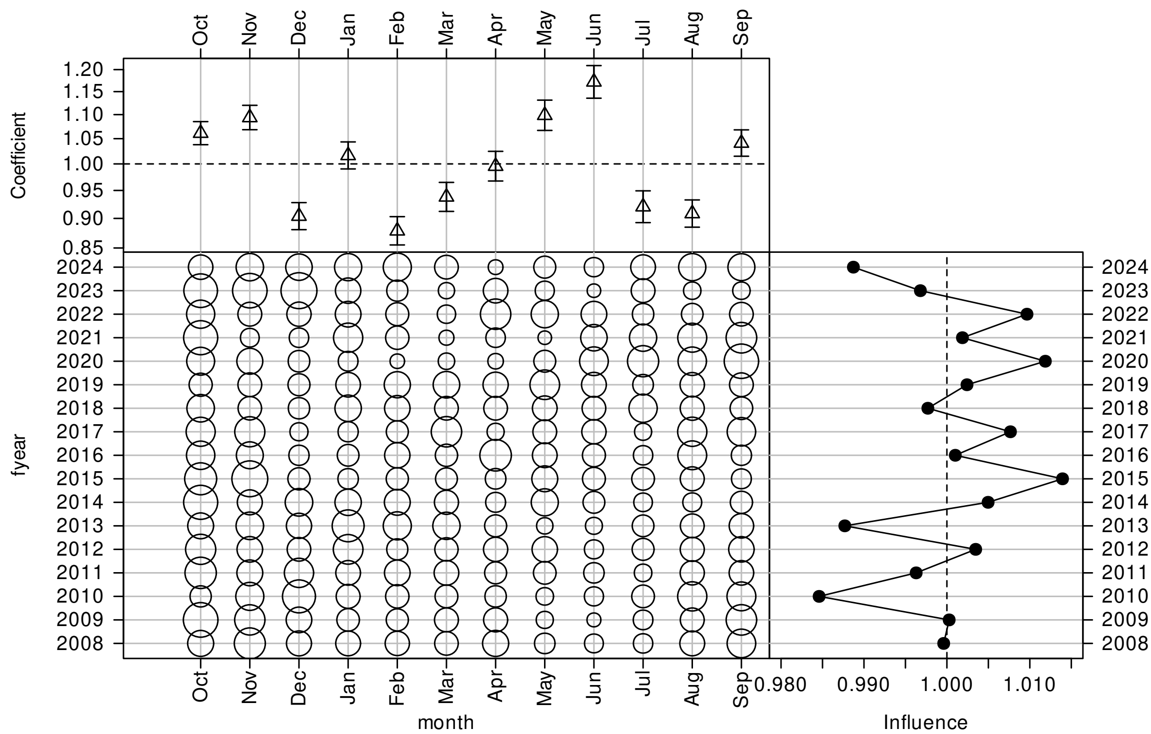

Figure 95: CDI plot for month for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

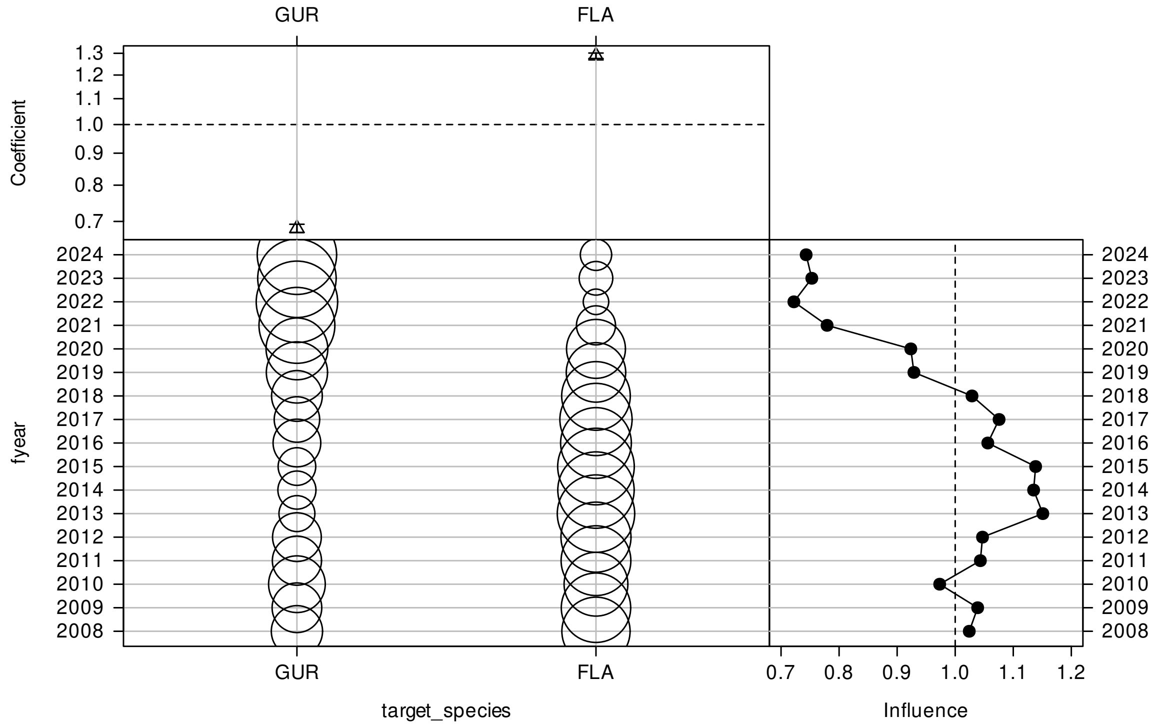

Figure 96: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

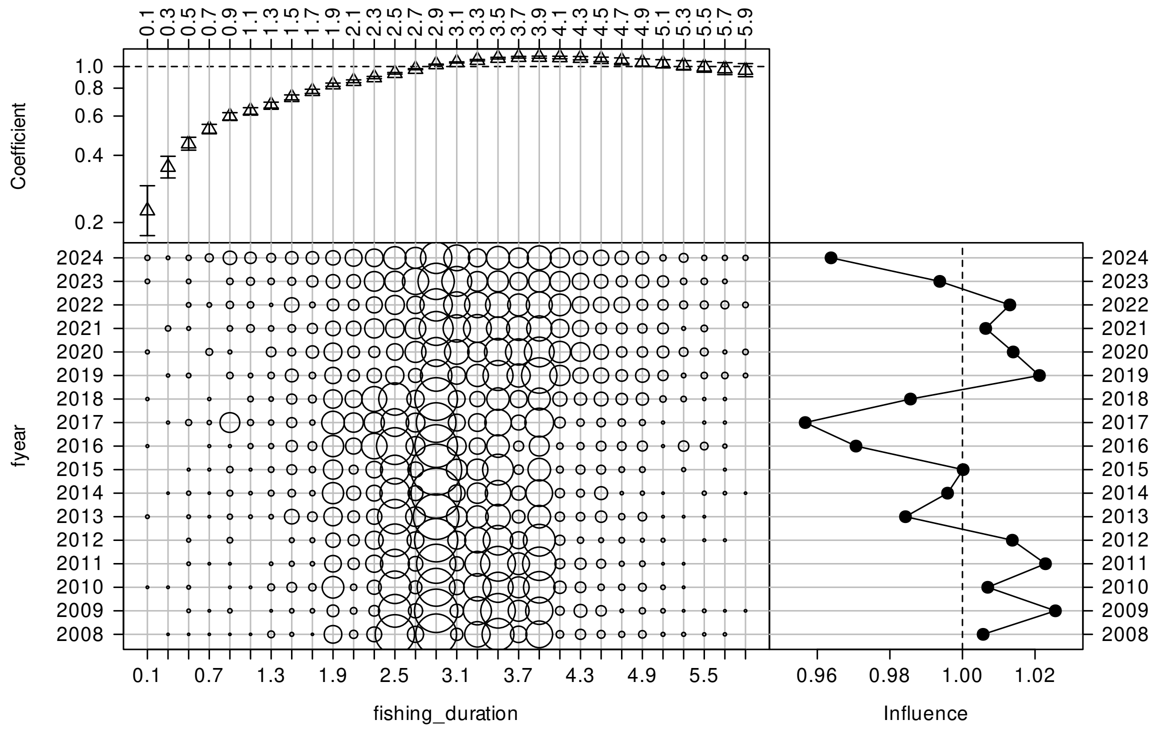

Figure 97: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

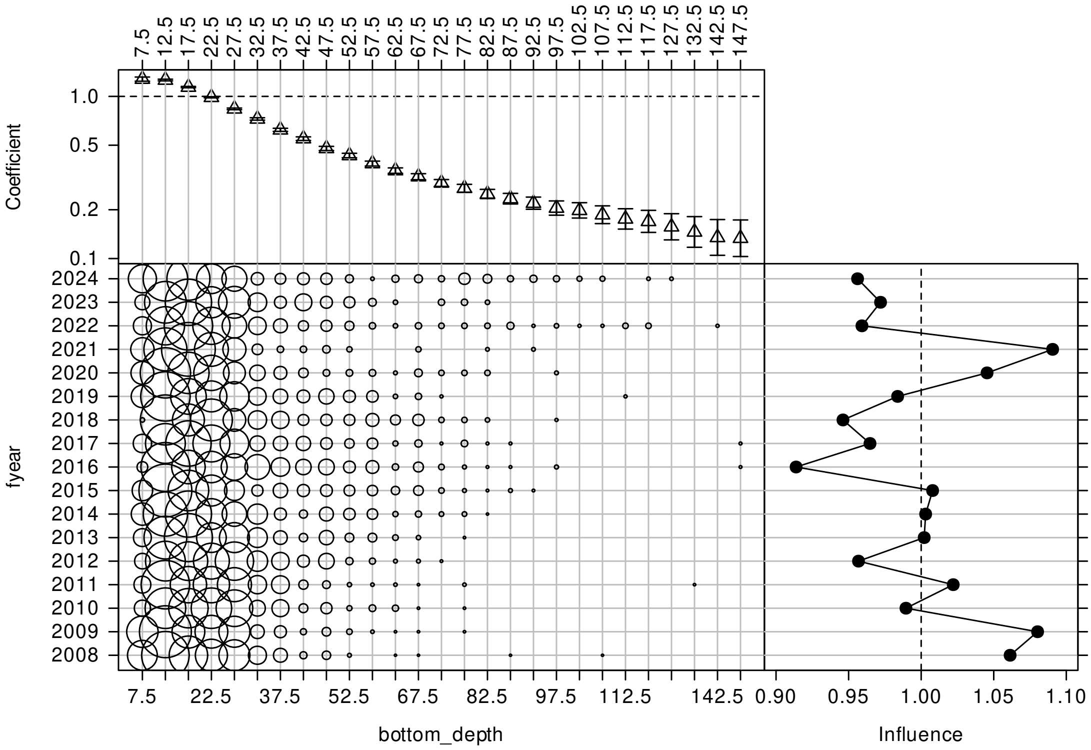

Figure 98: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event catch-per-unit-effort dataset.

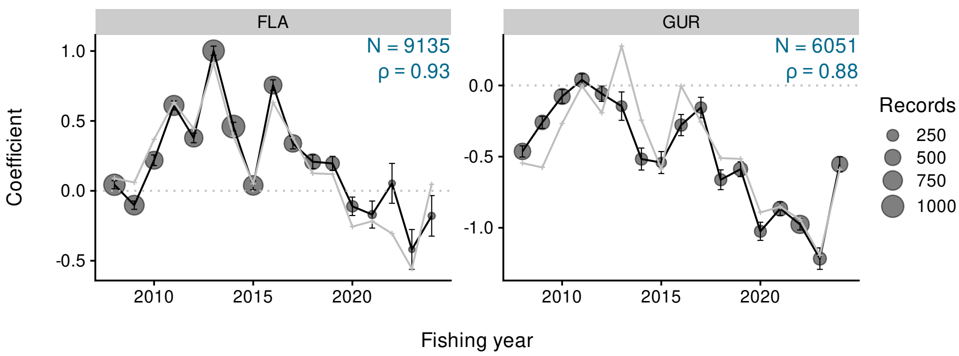

Figure 99: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay ESO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

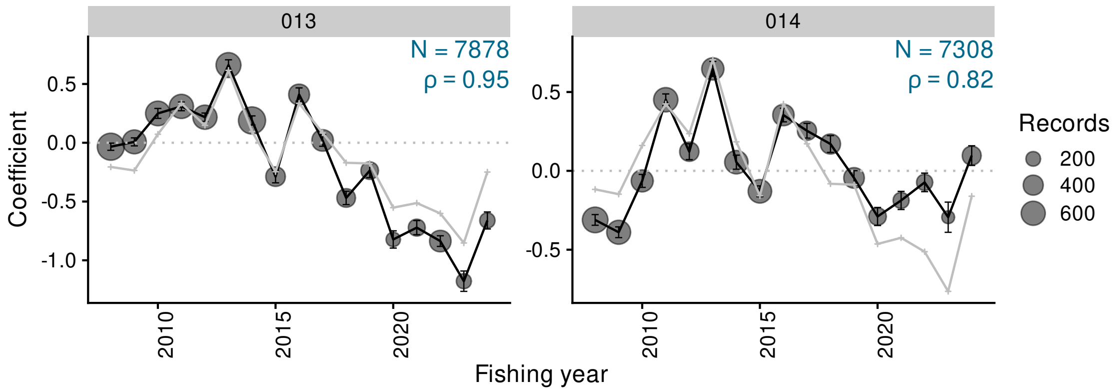

Figure 100: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay ESO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 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.

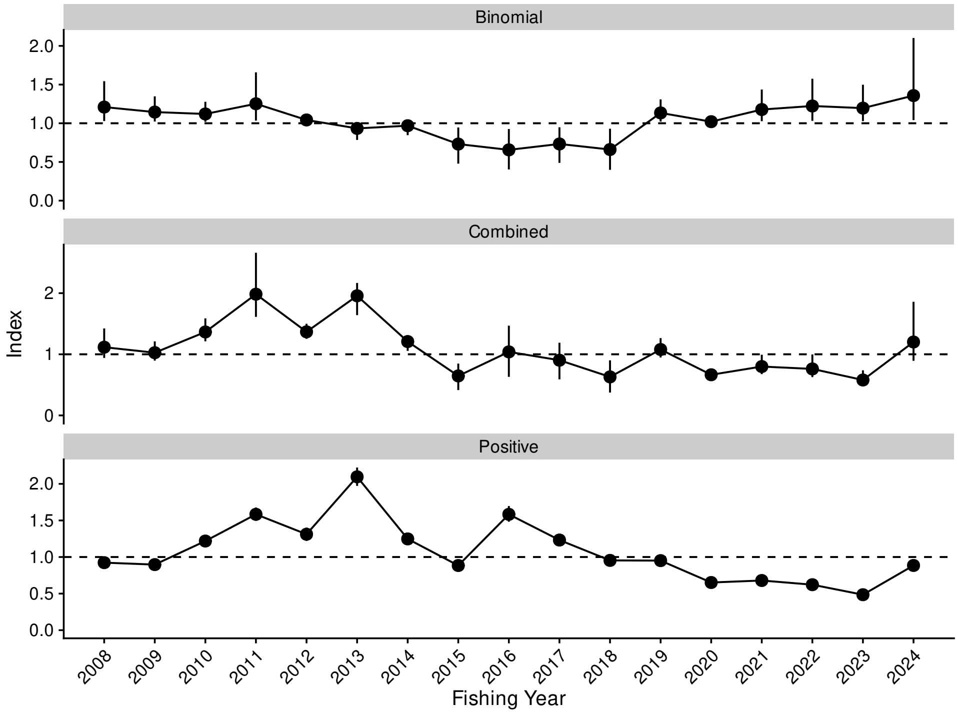

Figure 101: Standardised indices and 95% confidence intervals for the Hawke Bay ESO BT-MIX event dataset.

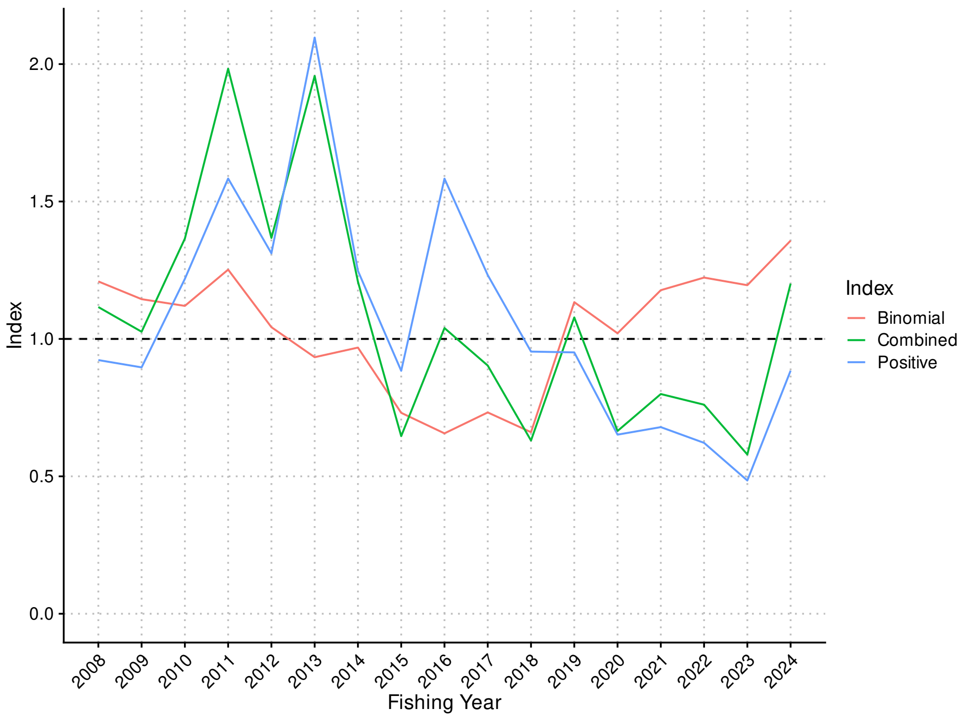

Figure 102: Standardised indices for the Hawke Bay ESO BT-MIX event dataset.

Table 15: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay ESO BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.209	0.131	1.029	1.544	1.116	0.123	0.940	1.423	0.923	0.026	0.875	0.976
2009	1.145	0.083	1.022	1.348	1.026	0.080	0.896	1.211	0.896	0.028	0.846	0.955
2010	1.120	0.066	1.019	1.277	1.365	0.096	1.212	1.587	1.219	0.038	1.147	1.297
2011	1.252	0.159	1.034	1.658	1.983	0.268	1.612	2.661	1.584	0.047	1.495	1.678
2012	1.043	0.033	0.989	1.119	1.367	0.063	1.253	1.500	1.311	0.046	1.221	1.403
2013	0.933	0.055	0.785	1.001	1.957	0.134	1.640	2.167	2.097	0.064	1.973	2.223
2014	0.968	0.044	0.846	1.019	1.208	0.065	1.056	1.312	1.248	0.034	1.180	1.315
2015	0.731	0.119	0.478	0.946	0.646	0.111	0.415	0.848	0.884	0.030	0.827	0.944
2016	0.656	0.133	0.403	0.926	1.039	0.214	0.631	1.468	1.583	0.055	1.482	1.697
2017	0.733	0.117	0.488	0.948	0.903	0.153	0.590	1.189	1.232	0.041	1.159	1.320
2018	0.661	0.135	0.398	0.929	0.630	0.135	0.374	0.901	0.954	0.033	0.889	1.020
2019	1.134	0.073	1.023	1.308	1.078	0.081	0.948	1.264	0.951	0.034	0.886	1.021
2020	1.020	0.033	0.954	1.083	0.665	0.035	0.595	0.733	0.652	0.030	0.595	0.711
2021	1.177	0.104	1.027	1.436	0.799	0.081	0.676	0.993	0.679	0.031	0.621	0.742
2022	1.223	0.139	1.031	1.575	0.761	0.095	0.626	0.998	0.622	0.024	0.577	0.670
2023	1.195	0.120	1.028	1.498	0.579	0.066	0.479	0.738	0.485	0.025	0.438	0.537
2024	1.358	0.271	1.041	2.102	1.201	0.246	0.893	1.859	0.885	0.036	0.818	0.961

4.4 Hawke Bay SFL BT-MIX event

This series is based on the Hawke Bay FLA BT-MIX event series (Section 4.2), using nearly the same model criteria except that the dependent variable is the species-specific SFL catches (see Section 3.1) instead of the combined FLA species code (Table 16). Two minor differences relative to the Hawke Bay FLA BT-MIX event series were implemented: the effort_height covariate was omitted (having had no impact on the Hawke Bay FLA BT-MIX event series – see Figure 55 and Figure 66) and the lognormal distribution was used for the positive catch model instead of the Weibull. Because this series was event-based, it began with the 2007–08 fishing year and benefitted from the somewhat better species discrimination data available from the 2007–08 fishing year (see Figure 50).

As for the Hawke Bay FLA BT-MIX event series, the core fleet was defined by having fished at least four trips in each of four years, retaining 97% of the catch and reducing the fleet from about 40 vessels to 20 vessels (Figure 103). The pattern of vessel participation in this fishery was characterised by a mix of continuity, with some vessels entering and exiting the fishery over the 17 years in the analysis while there was a reasonable number of vessels that remained the fishery for at least 12 years or more (Figure 104). The final groomed dataset represented 87% (2008) to 100% (2009, 2010, 2012, 2016, 2019-2021) of the annual ungroomed catch (Table 17). The total annual catch of SFL in the defined fishery ranged from 49 t (in 2011) to 6 t (in 2021) over the 17 years in the data set and was characterised by an occurrence series that had no occurrence trend, ranging from a high of 69% (in 2009) to a low of 47% (in 2012) to the second-highest in the series 68% in 2024 (Table 18). Almost all landings were allocated to the effort data using estimated catch proportions, with very minor amounts of landings distributed proportionately to effort (Figure 105).

The binomial (occurrence) model explained 17% of the deviance when using all the offered explanatory variables (Table 19). The overall impact of the standardisation model was to change the flat trend in the unstandardised occurrence model to a standardised model which decreased sharply between 2011 and 2012 which was followed by a gradual increasing trend to the end of the series (Figure 106). The most notable shifts away from the unstandardised series were caused by the vessel variable, which dropped the index values in 2013 and 2014 and raised them in 2019–2020 (Figure 107). CDI plots for the occurrence model are provided for each covariate offered to the model: vessel (Figure 108), statistical area (Figure 109), month (Figure 110), target species (Figure 111), fishing duration (Figure 112), and bottom depth (Figure 113). The target species covariate lifted the final four index years without changing the trend. The vessel CDI plot indicated that there was a shift towards vessels with higher probability of catching SFL in 2013–2014 and in 2022–2024 (Figure 108). However, while the 2013–2014 shift resulted in the series drop seen in Figure 107, the 2022–2024 shift did not cause much change in the series. The strong shift away from targeting FLA to target fishing for GUR resulted in a drop in the influence for this covariate beginning in 2019 (Figure 111), which in turn caused an increase in the standardised CPUE (Figure 107). The bottom depth covariate, reflecting a shift in preferred depth, also showed a drop in influence (Figure 113) which resulted in minor shifts in the standardised CPUE series (Figure 107). The final standardised series is very similar to the unstandardised series, with the drop from 2011 to 2012 and the final upturn in 2024 present in all series.

The lognormal model explained 38% of the deviance when using all the explanatory variables (Table 20). The model showed good conformity to the lognormal distribution, except at the very lower end of the distribution: Figure 114. Neither the gamma nor the Weibull distributions showed fits to the positive catch data that were as good as the lognormal (Figure 115). The unstandardised and the standardised series both showed a flat trend from 2008 to 2011, followed by a decreasing trend to 2022 which upturned for 2023 and 2024 (Figure 116). There appears to be very little standardisation effect in this model, particularly for the eight years beginning with 201, with all series following very similar trends as each variable successively enters the model (Figure 117). CDI plots for the lognormal model are provided for each variable offered to the model: vessel (Figure 118), statistical area (Figure 119), month (Figure 120), target species (Figure 121), fishing duration (Figure 122), and bottom depth (Figure 123). The upturn in the two final years is present in the unstandardised series and is augmented by the target species covariate, which is adjusting for the strong shift away from FLA targeting to GUR targeting (Figure 121). The impact of the remaining covariates on the standardisation model tended to be small, resulting in a standardised series that is similar to the unstandardised series (see Figure 117). Implied residual plots for target species relative to the total annual CPUE trend showed good conformity for the GUR target species, but with the FLA target species trend rising one year earlier (2021) and then dropping in 2024 but still remaining at a high level (Figure 124). The conformity with the overall annual CPUE trend was good for Statistical Area 014 and for 2023 in Area 013, but Area 013 did not show much increase in 2024 relative to 2023 (Figure 125).

There was little contrast in the binomial model, so the combined model looks primarily like the lognormal positive catch model, dropping to less than 50% of the series mean in 2022, but returning to the series mean by 2024 (Figure 126, Figure 127). Indices, bounds and standard errors for each series are presented in Table 21.

Table 16: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay SFL BT-MIX event CPUE series.

Series	Hawke Bay SFL BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	SFL ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

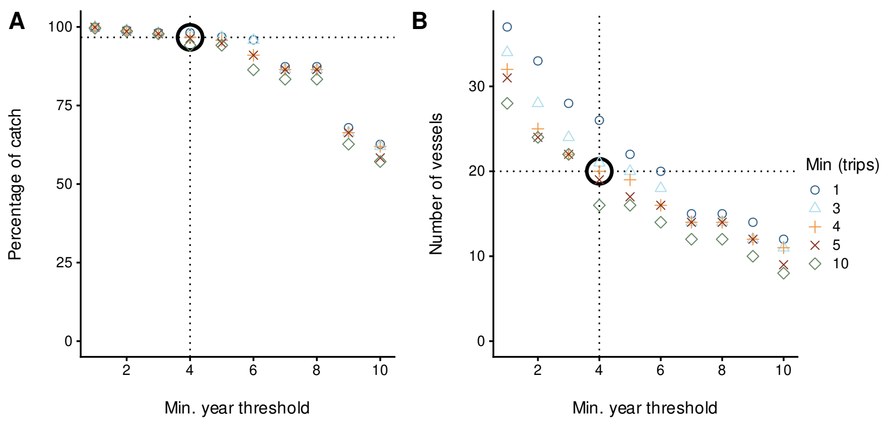

Figure 103: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay SFL BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

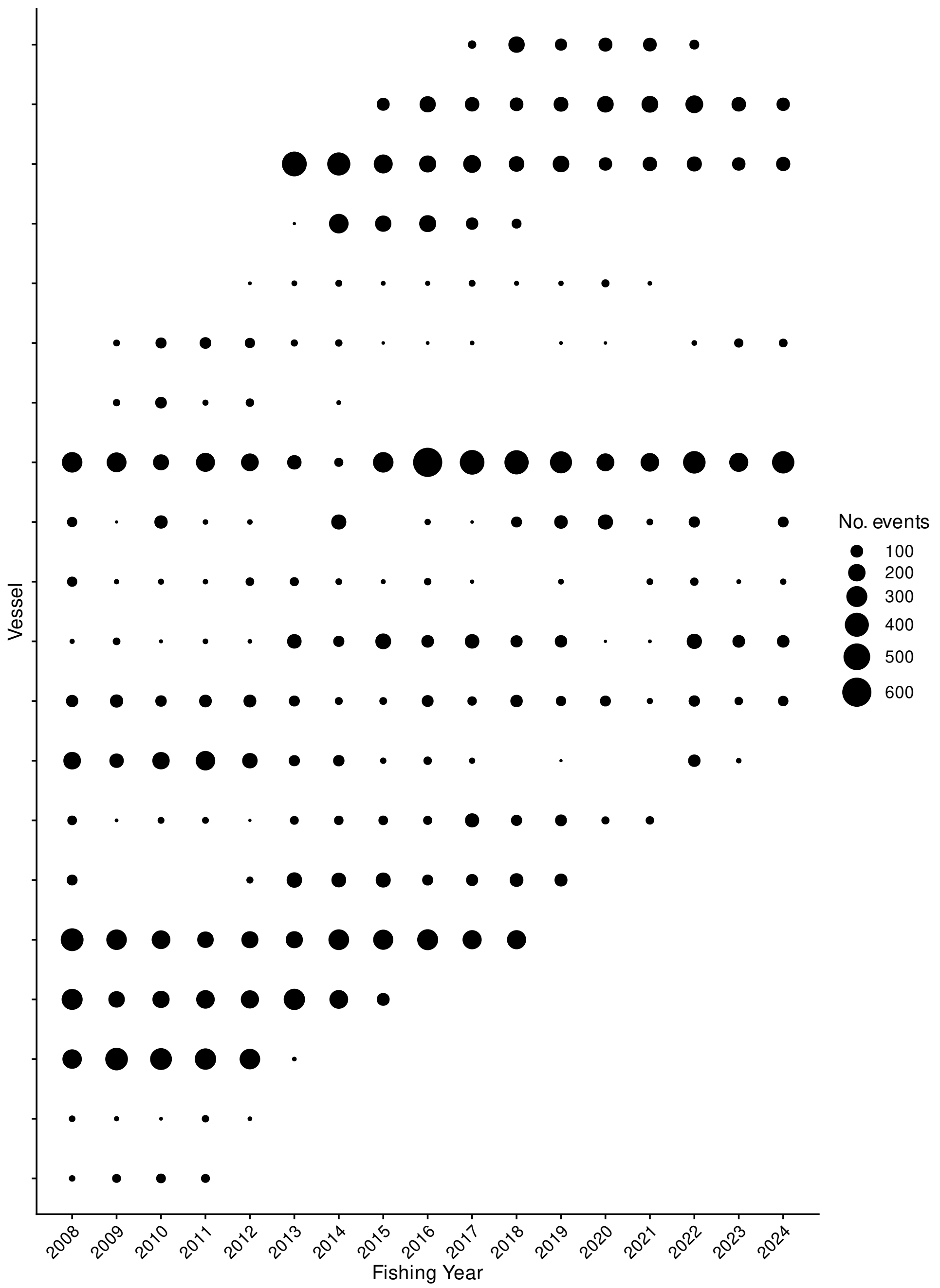

Figure 104: Number of events by fishing year for core vessels in the Hawke Bay SFL BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 17: Summary of the Hawke Bay SFL BT-MIX 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	36 (100%) n: 2087	45 (100%) n: 1515	34 (100%) n: 1601	52 (100%) n: 1669	19 (100%) n: 1390	38 (100%) n: 1673	31 (100%) n: 2086	25 (100%) n: 1782	55 (100%) n: 1867
Positive fishing duration	36 (100%) n: 2087	45 (100%) n: 1513	34 (100%) n: 1599	52 (100%) n: 1669	19 (100%) n: 1390	38 (100%) n: 1673	31 (100%) n: 2086	25 (100%) n: 1782	55 (100%) n: 1867
Fishing duration less than 6 h	36 (100%) n: 2077	45 (100%) n: 1506	34 (100%) n: 1595	52 (100%) n: 1664	19 (100%) n: 1387	38 (100%) n: 1669	31 (98%) n: 2068	25 (100%) n: 1779	55 (99%) n: 1864
Bottom depth < 150m	36 (100%) n: 2076	45 (100%) n: 1506	34 (100%) n: 1595	52 (99%) n: 1662	19 (100%) n: 1387	38 (100%) n: 1669	31 (98%) n: 2066	25 (100%) n: 1777	55 (99%) n: 1864
Core fleet selection	31 (87%) n: 1801	45 (99%) n: 1490	34 (99%) n: 1579	49 (94%) n: 1566	18 (99%) n: 1378	37 (98%) n: 1647	29 (93%) n: 1817	23 (94%) n: 1624	55 (99%) n: 1863

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	23 (100%) n: 1740	26 (100%) n: 1710	13 (100%) n: 1277	8.1 (100%) n: 946	5.9 (100%) n: 809	8.7 (100%) n: 1519	11 (100%) n: 885	17 (100%) n: 1093
Positive fishing duration	23 (100%) n: 1740	26 (100%) n: 1710	13 (100%) n: 1273	8 (99%) n: 943	5.9 (100%) n: 808	8.7 (100%) n: 1518	11 (100%) n: 884	17 (100%) n: 1093
Fishing duration less than 6 h	23 (99%) n: 1722	26 (100%) n: 1699	13 (99%) n: 1260	8 (99%) n: 933	5.9 (99%) n: 802	8.5 (98%) n: 1505	11 (99%) n: 871	17 (100%) n: 1085
Bottom depth < 150m	23 (99%) n: 1722	26 (100%) n: 1698	13 (99%) n: 1258	8 (99%) n: 933	5.9 (99%) n: 802	8.5 (98%) n: 1501	11 (99%) n: 870	17 (100%) n: 1081
Core fleet selection	22 (97%) n: 1617	25 (98%) n: 1627	13 (99%) n: 1248	8 (99%) n: 931	5.8 (99%) n: 788	7.8 (90%) n: 1220	11 (96%) n: 707	17 (97%) n: 882

Table 18: Summary of the Hawke Bay SFL BT-MIX 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	13	656	1 801	5 686.15	31.24	58.52
2009	14	675	1 490	4 852.32	44.71	68.79
2010	14	683	1 579	5 200.67	34.07	59.78
2011	14	700	1 566	5 152.73	49.23	65.01
2012	15	622	1 378	4 437.47	18.48	46.66
2013	14	567	1 647	5 098.95	37.22	56.16
2014	15	649	1 817	5 762.42	29.29	56.58
2015	14	662	1 624	5 245.20	23.48	57.94
2016	14	711	1 863	5 865.78	54.86	64.63
2017	15	644	1 617	5 121.83	22.07	55.53
2018	12	623	1 627	5 268.70	25.10	56.24
2019	13	462	1 248	4 522.53	12.57	54.89
2020	10	382	931	3 413.22	8.00	53.17
2021	10	368	788	2 635.32	5.85	57.11
2022	10	452	1 220	4 317.17	7.81	57.21
2023	8	242	707	2 533.05	10.55	53.04
2024	8	332	882	2 918.95	16.78	68.25

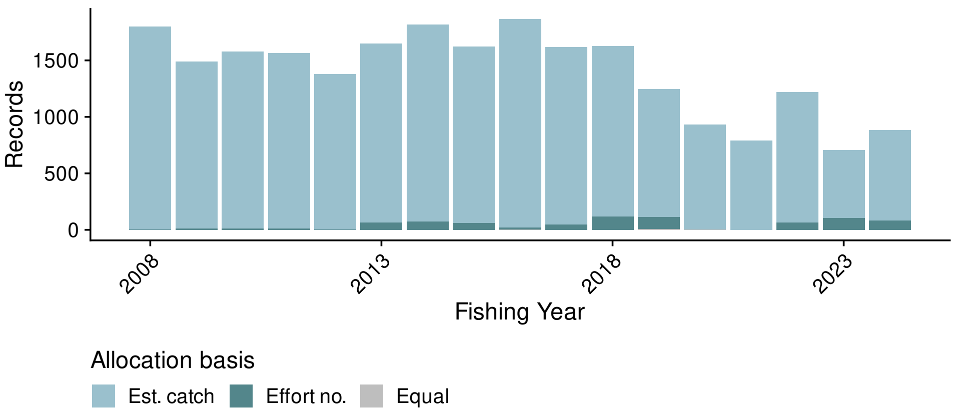

Figure 105: The allocation approach used for attributing catches to records in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table 19: Summary table for occurrence of positive catch in the Hawke Bay SFL BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	32 294.01	0.00	0.00	*
fyear	16	32 043.54	0.87	0.87	*
vessel_key	19	28 712.87	11.31	10.43	*
stat_area	1	28 532.90	11.87	0.56	*
month	11	28 314.19	12.62	0.75	*
target_species	1	27 682.09	14.58	1.96	*
ns(log(fishing_duration), 3)	3	27 675.50	14.62	0.04	*
ns(bottom_depth, 3)	3	27 072.86	16.50	1.88	*

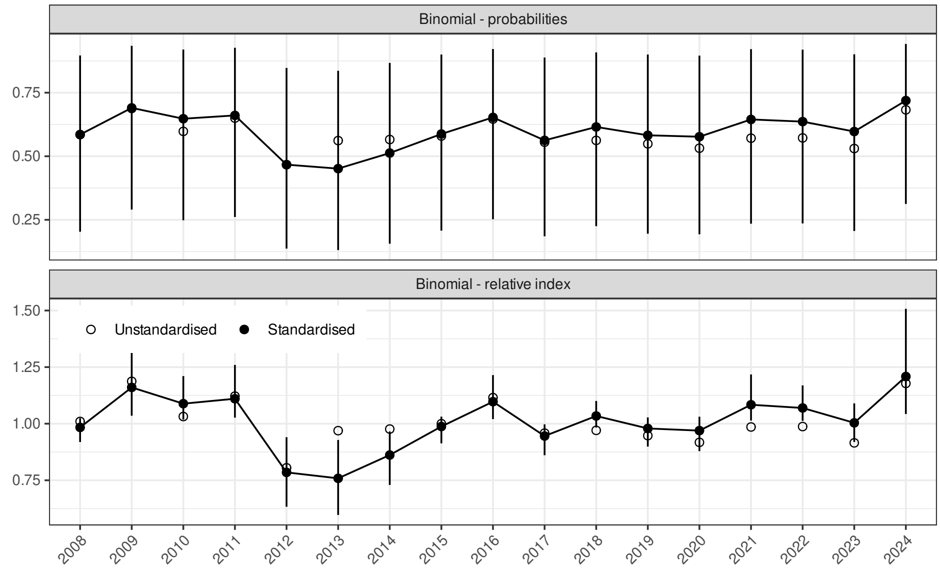

Figure 106: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay SFL BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

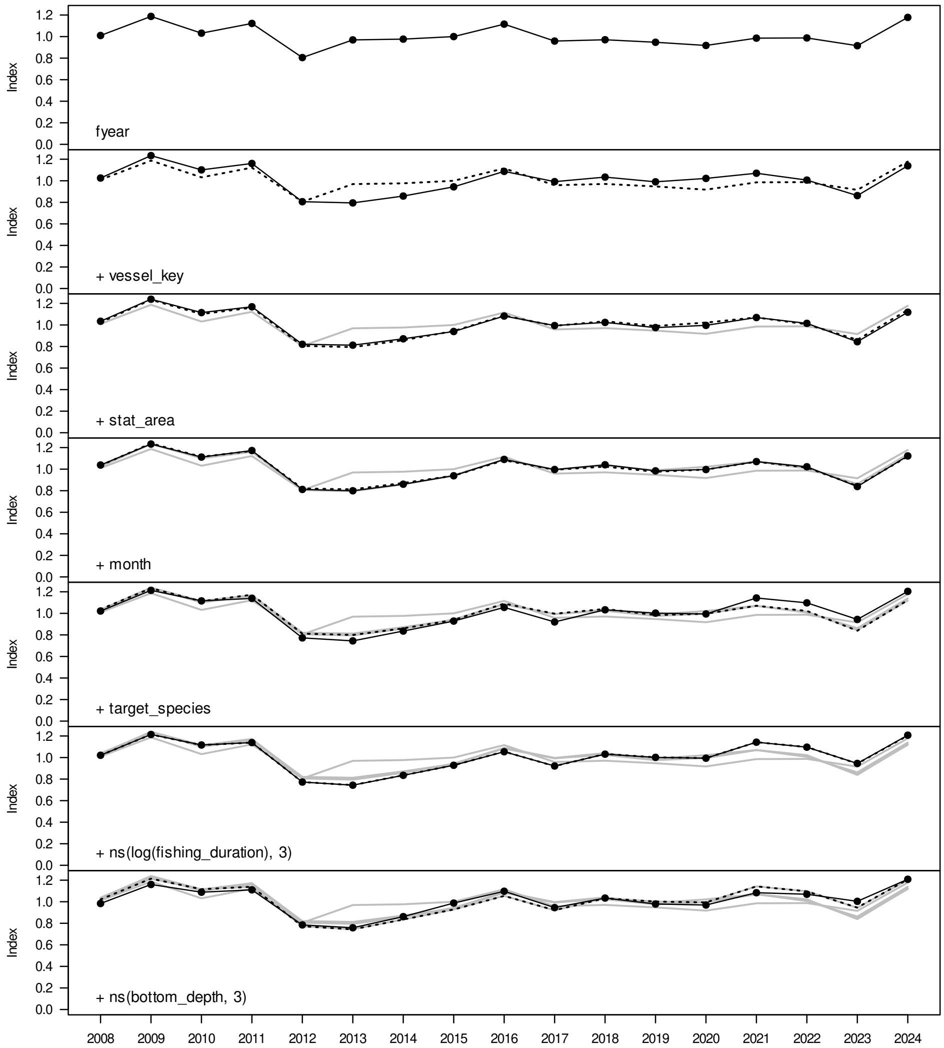

Figure 107: Step plot for occurrence of catch in the Hawke Bay SFL BT-MIX event dataset.

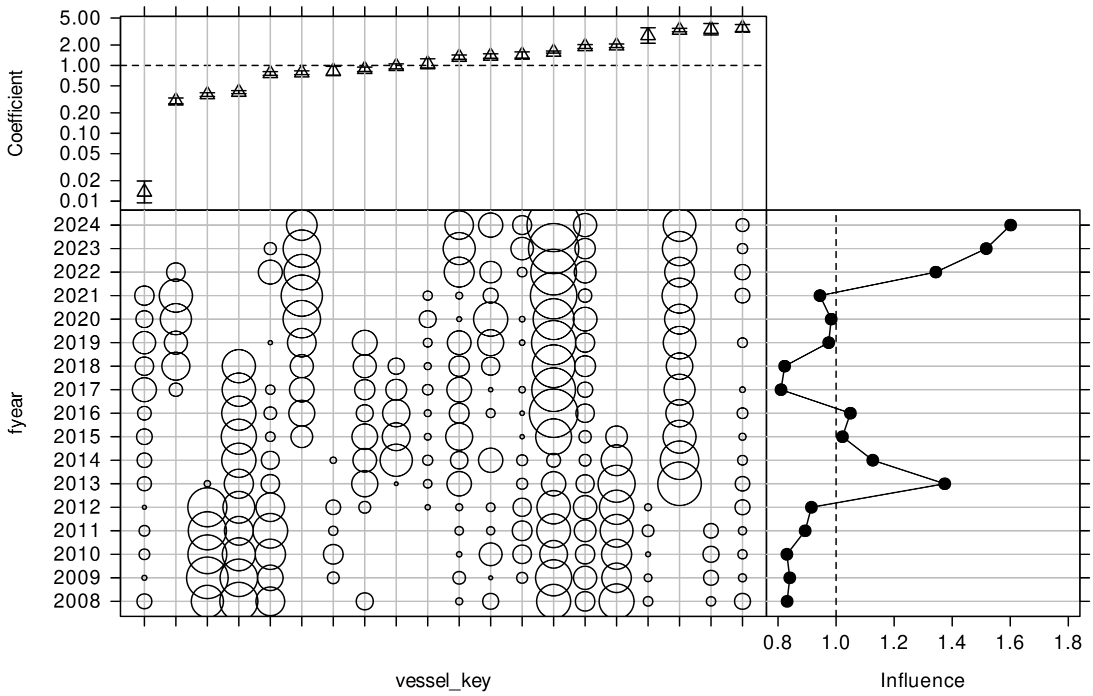

Figure 108: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

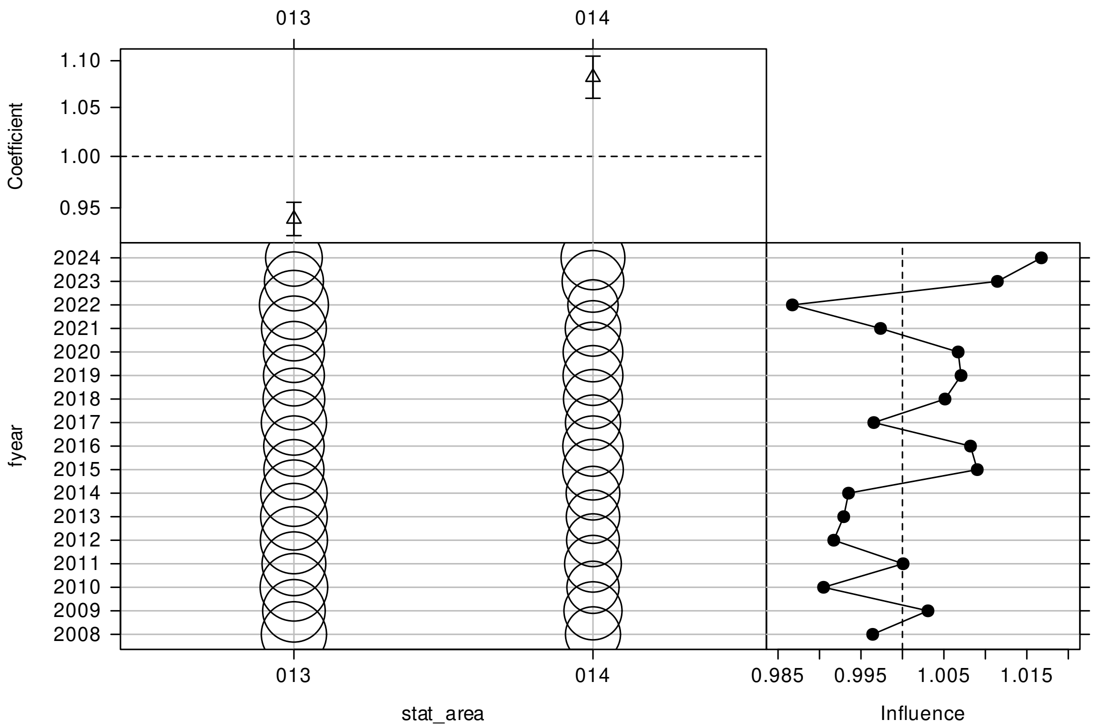

Figure 109: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

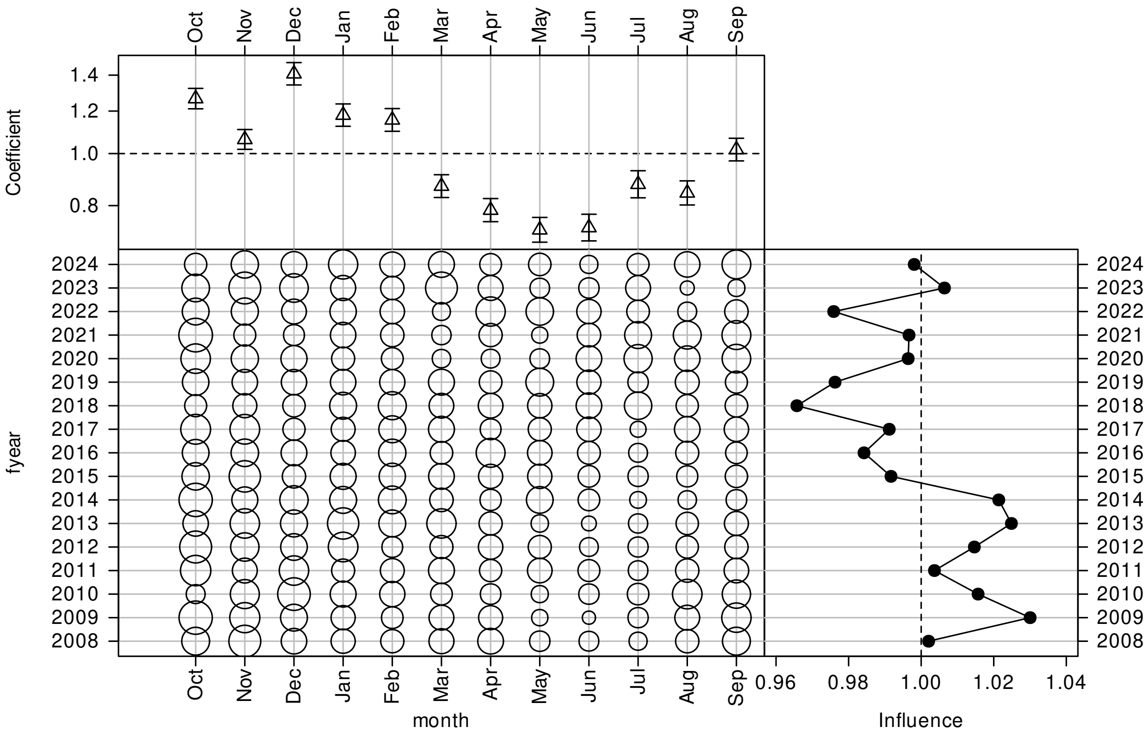

Figure 110: CDI plot for month for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

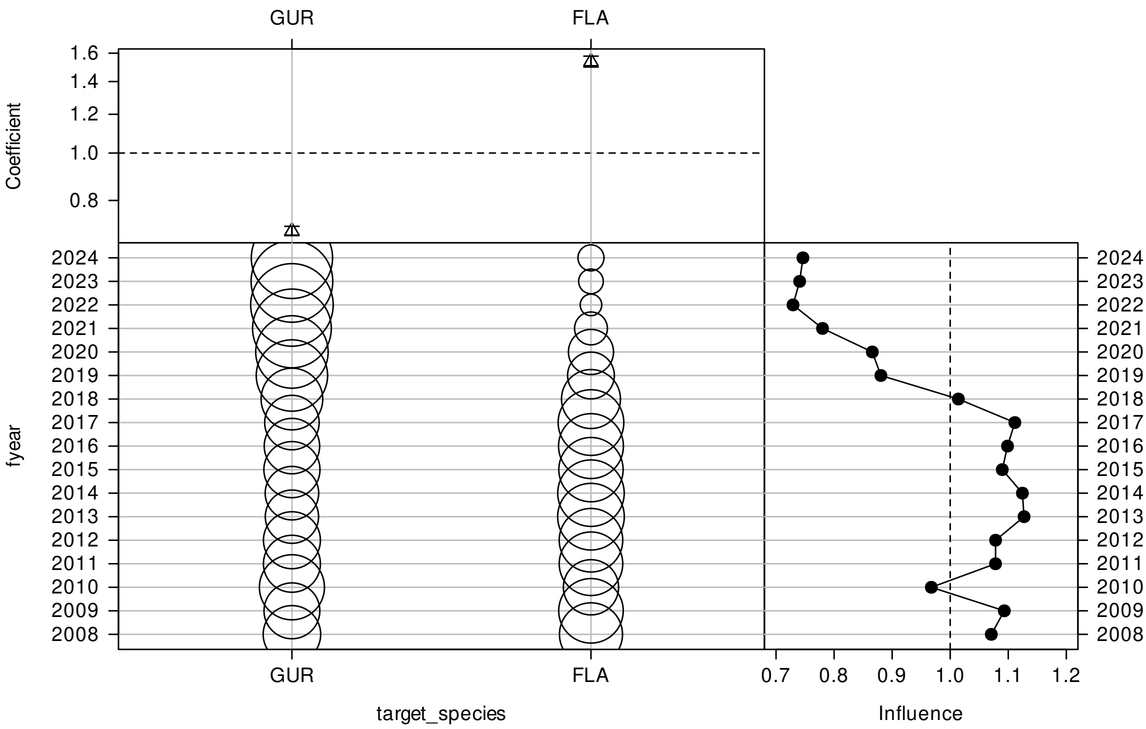

Figure 111: CDI plot for target species for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

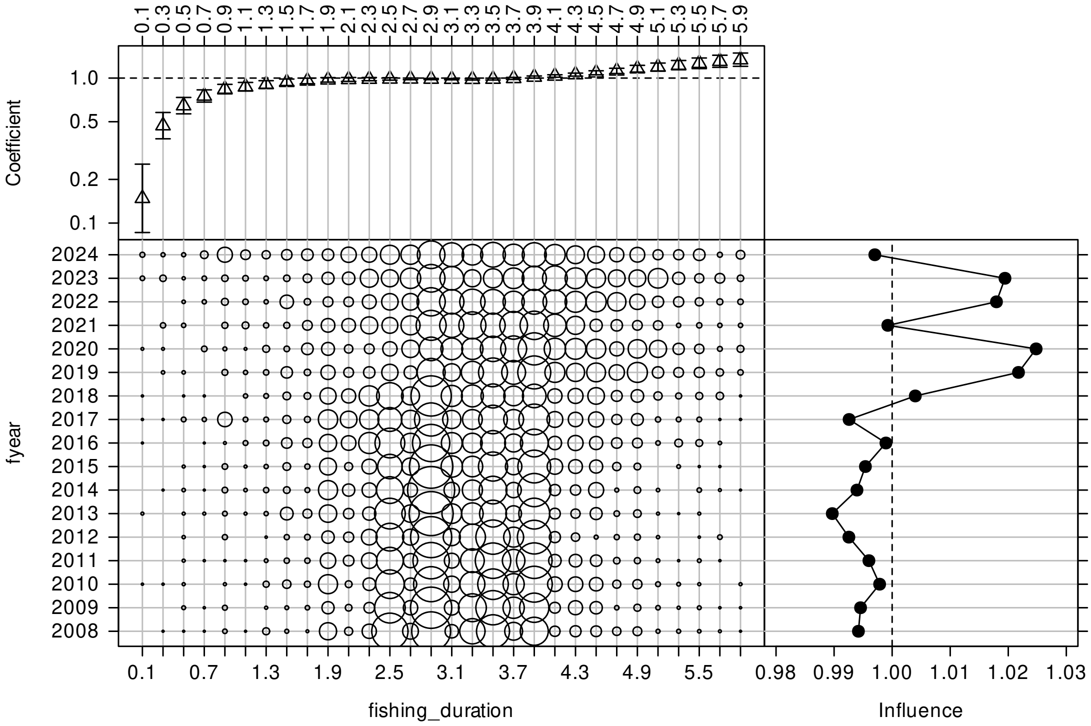

Figure 112: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

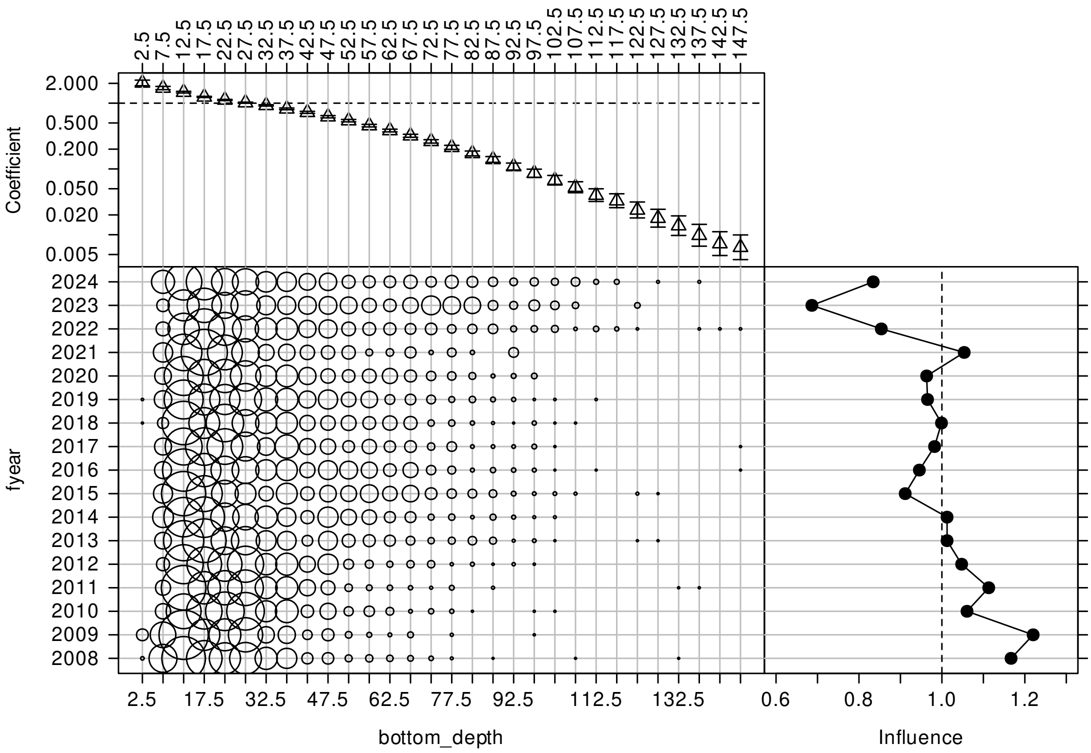

Figure 113: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

Table 20: **Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.**

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	48 312.68	0.00	0.00	*
fyear	16	46 826.29	10.35	10.35	*
vessel_key	19	45 303.10	19.87	9.52	*
stat_area	1	43 707.79	28.57	8.70	*
month	11	43 544.64	29.52	0.95	*
target_species	1	42 589.56	34.21	4.69	*
ns(log(fishing_duration), 3)	3	42 512.17	34.60	0.39	*
ns(bottom_depth, 3)	3	41 777.20	37.99	3.40	*

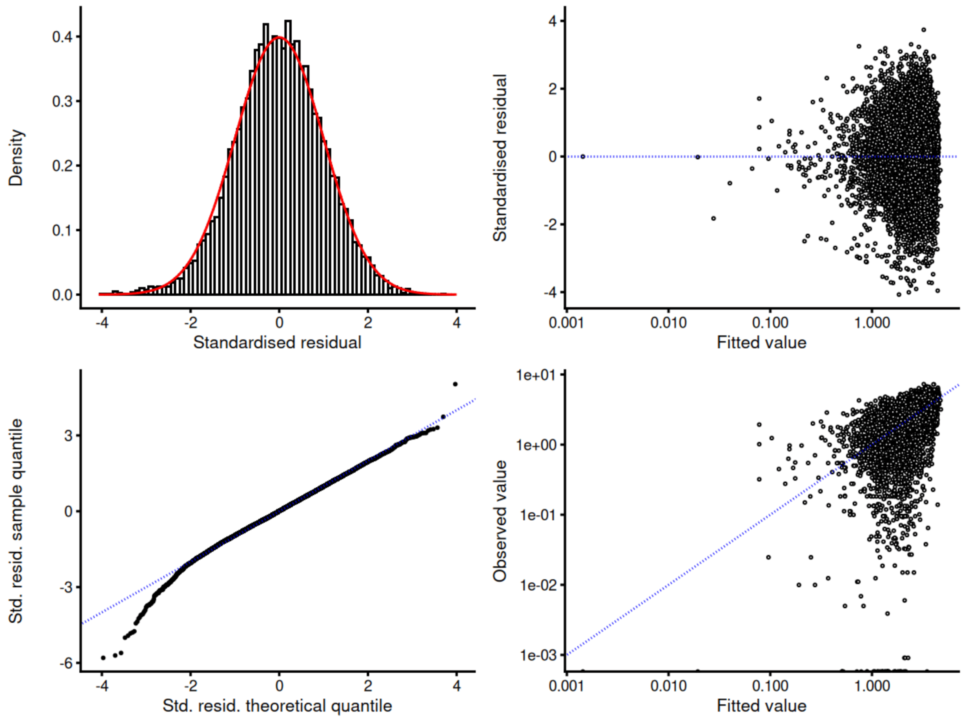

Figure 114: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay SFL BT-MIX event dataset.

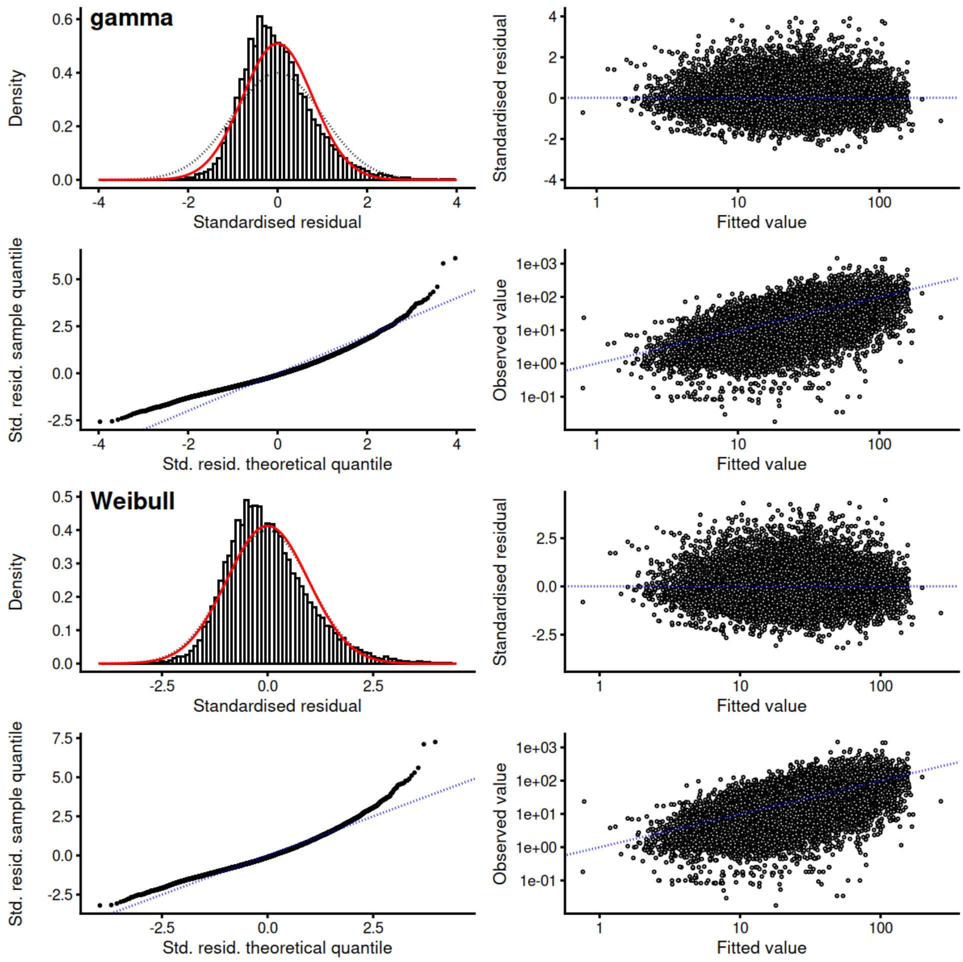

Figure 115: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay SFL BT-MIX event dataset.

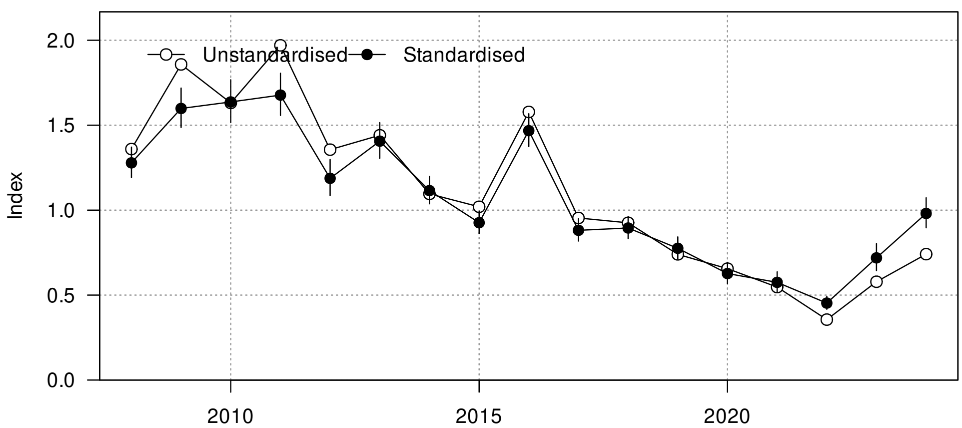

Figure 116: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay SFL BT-MIX event dataset.

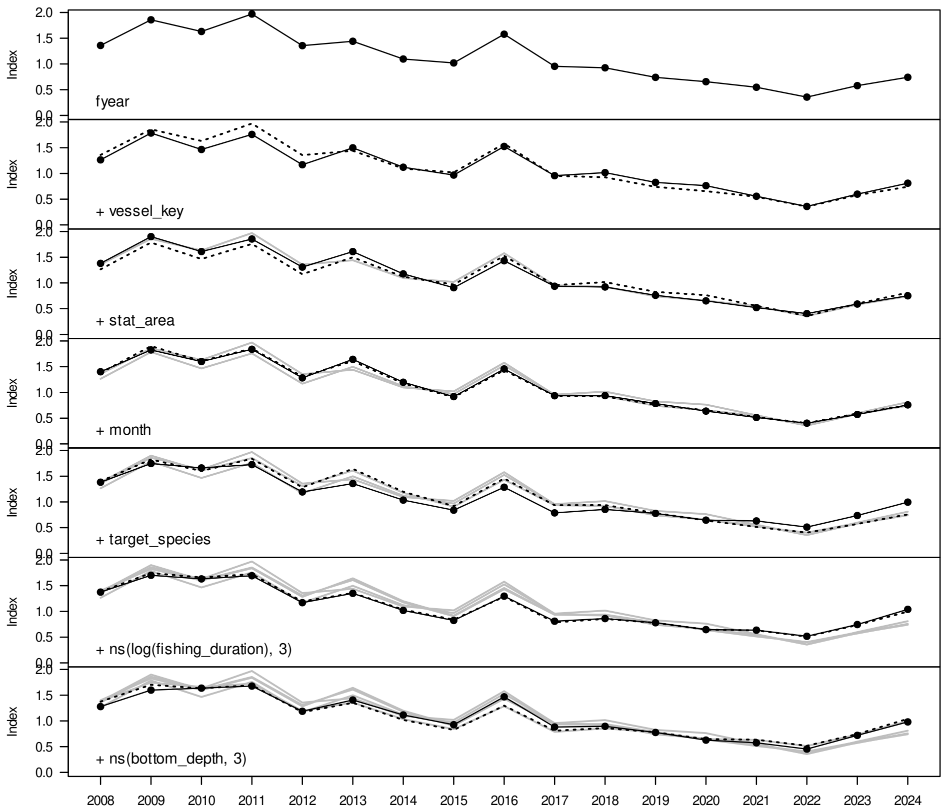

Figure 117: Changes to the Hawke Bay SFL BT-MIX event positive catch index as terms are successively entered into the lognormal model.

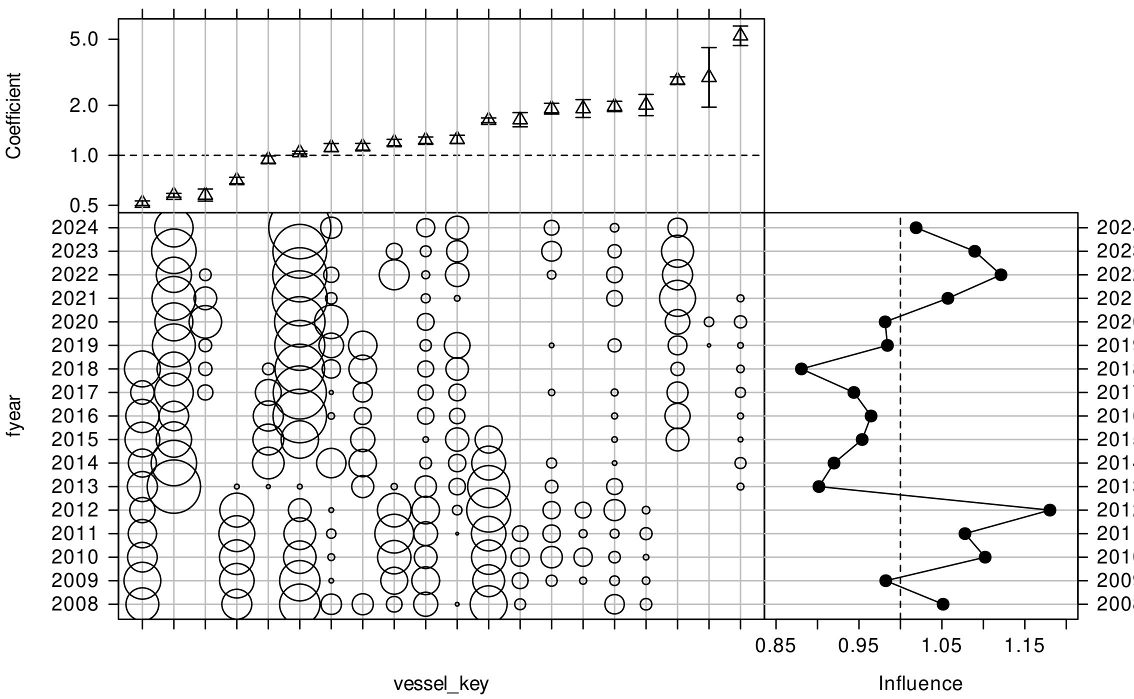

Figure 118: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

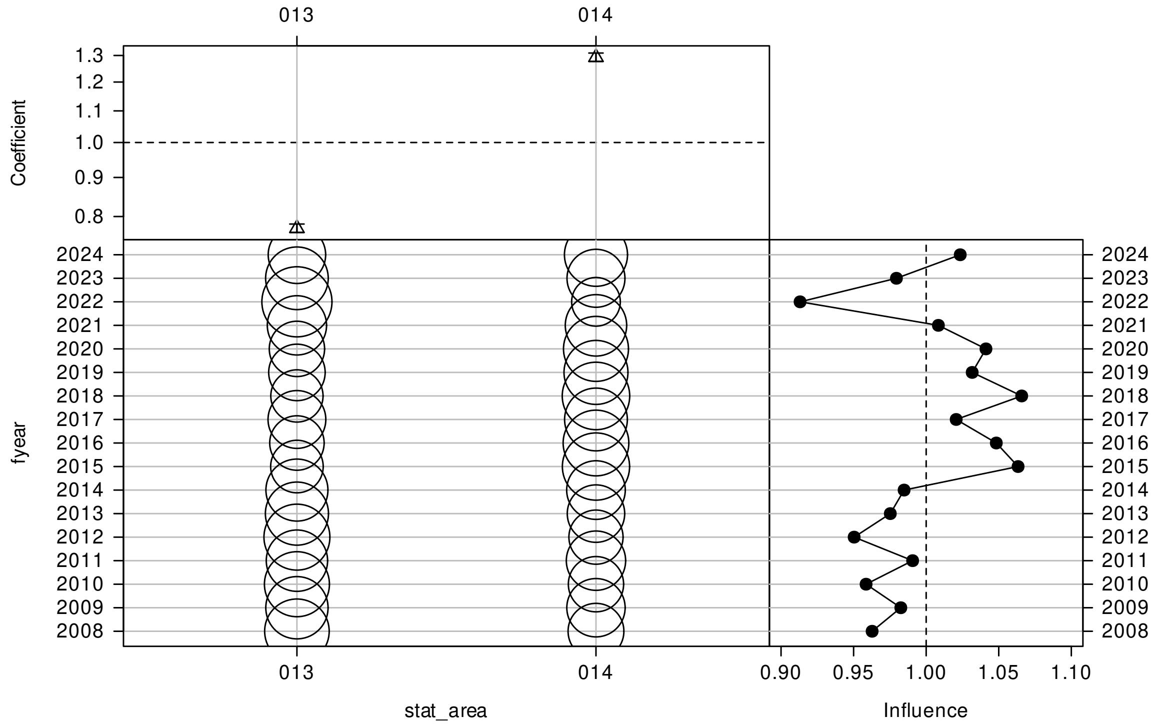

Figure 119: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

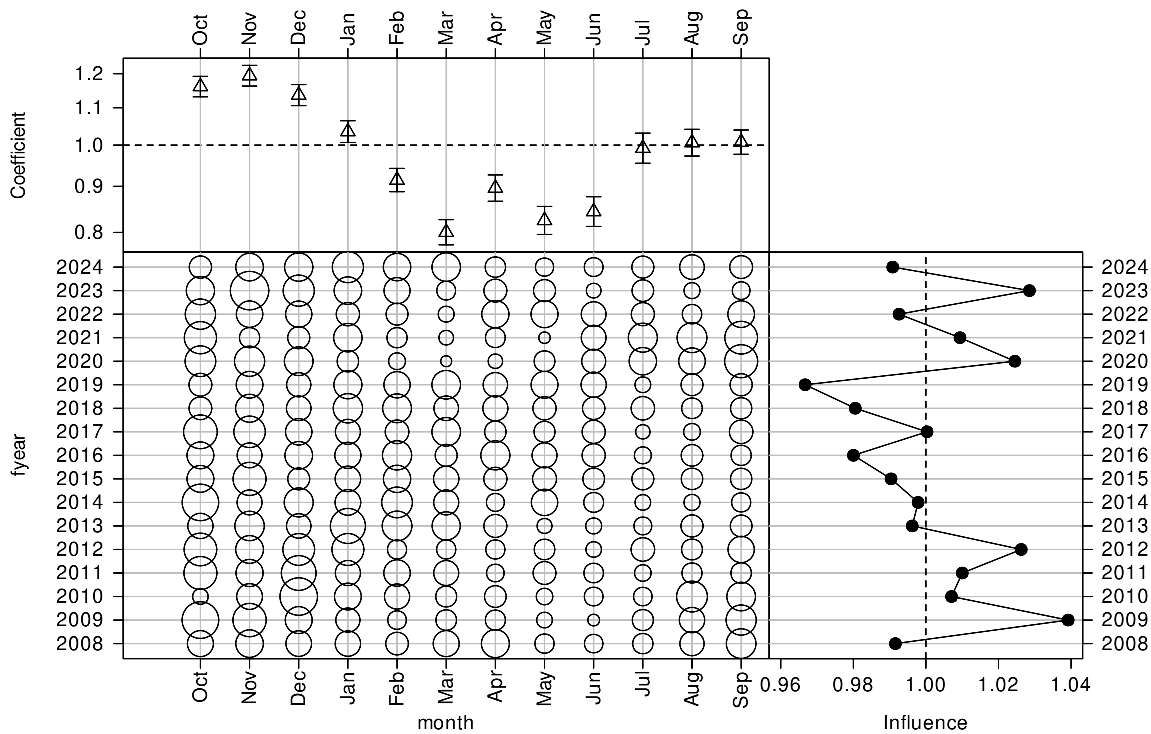

Figure 120: CDI plot for month for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

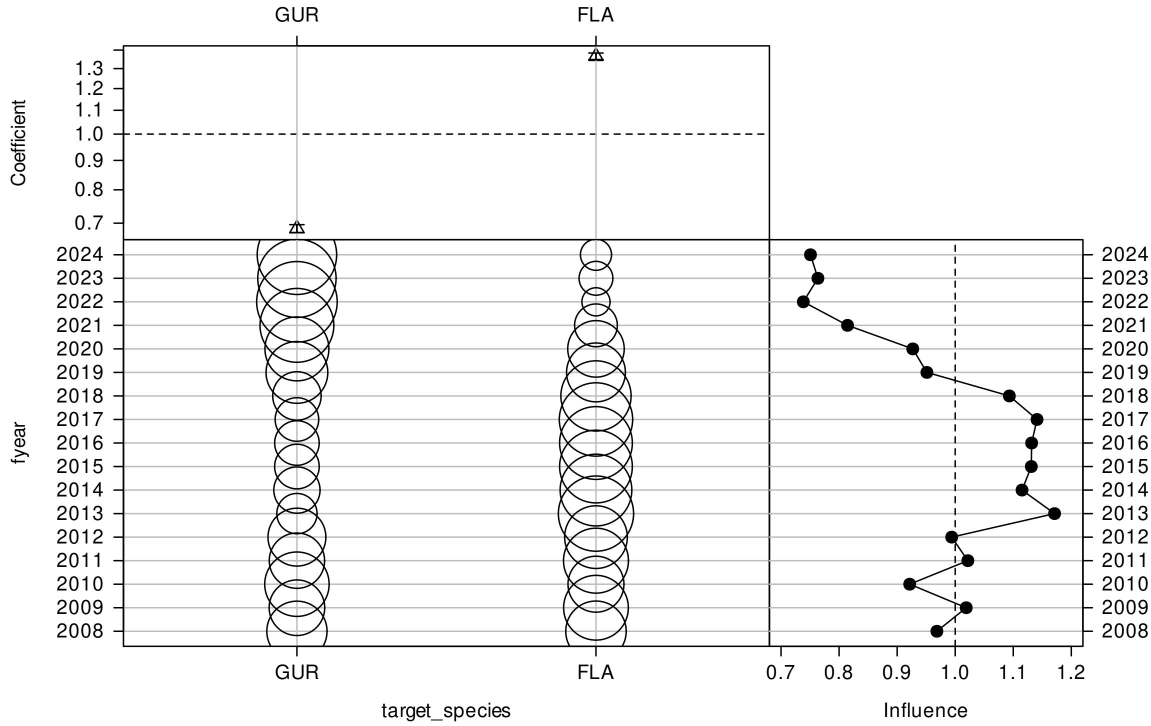

Figure 121: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

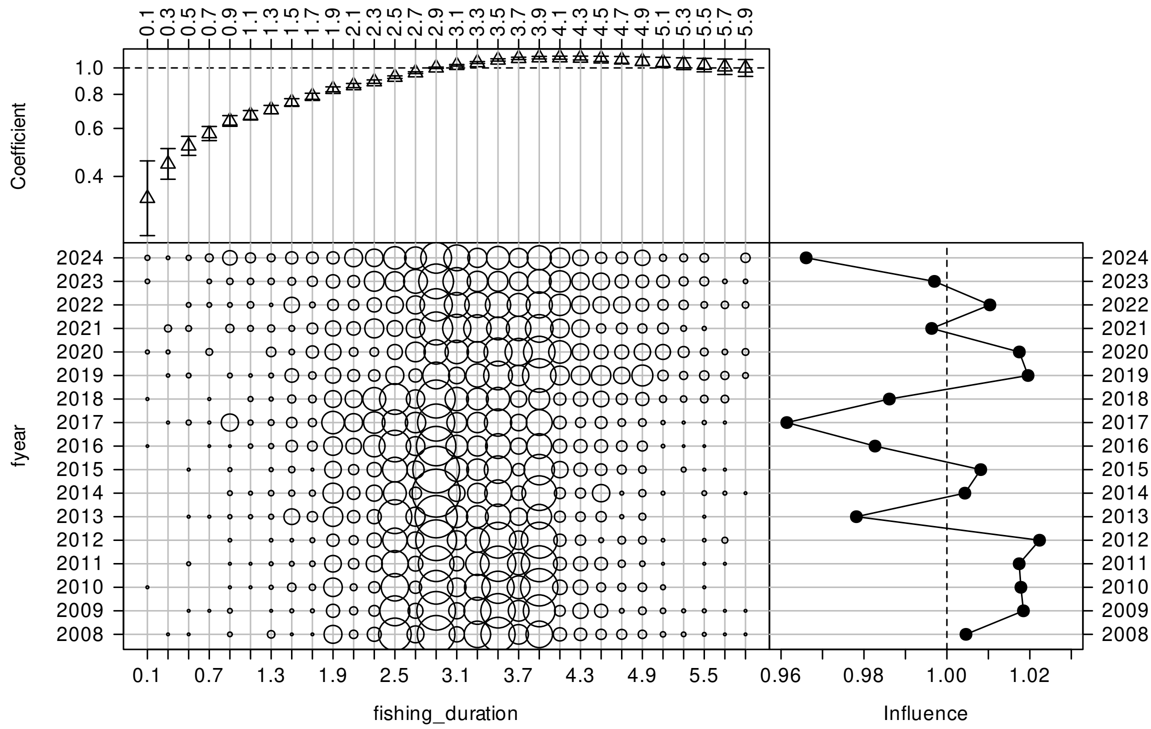

Figure 122: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

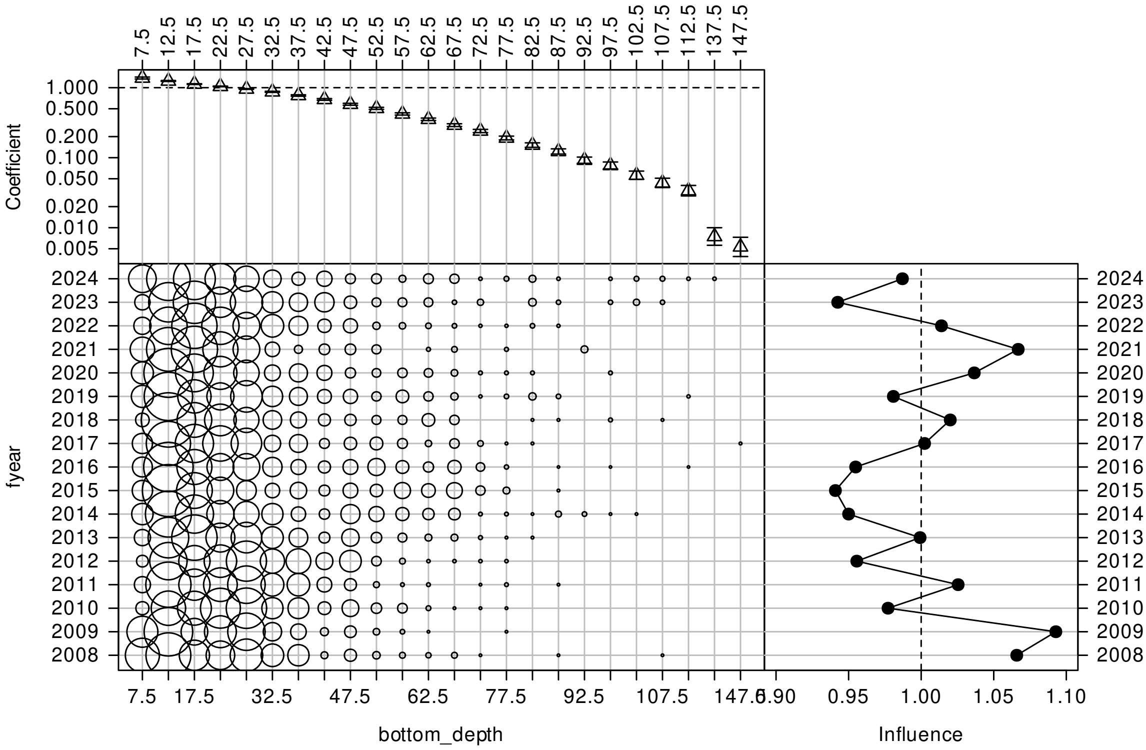

Figure 123: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event catch-per-unit-effort dataset.

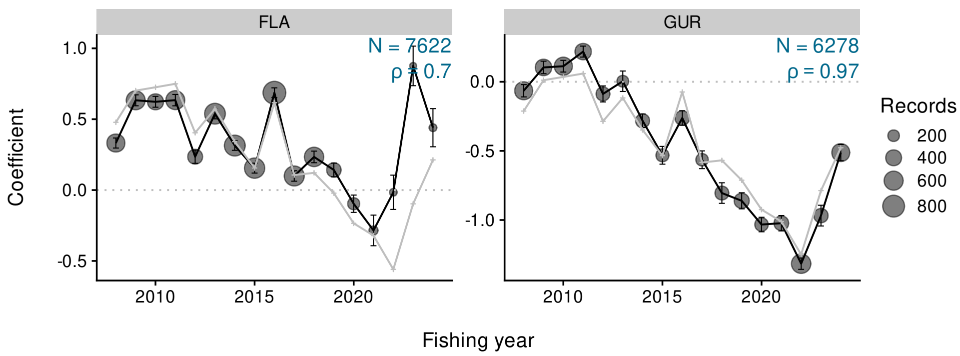

Figure 124: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay SFL BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

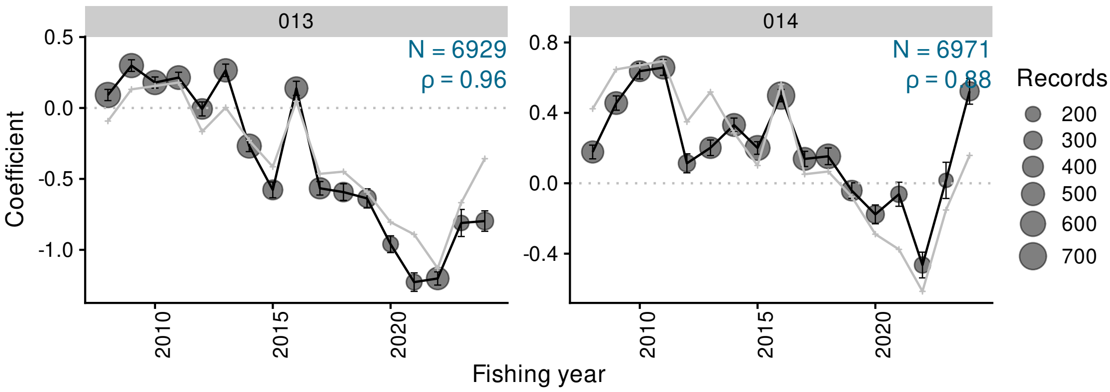

Figure 125: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay SFL BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 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.

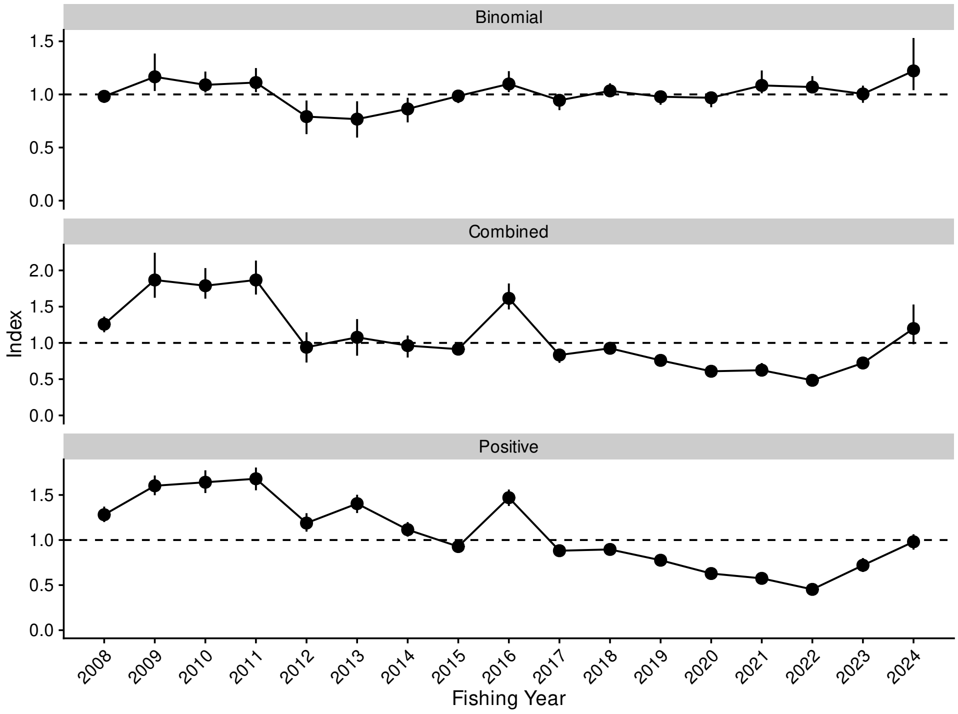

Figure 126: Standardised indices and 95% confidence intervals for the Hawke Bay SFL BT-MIX event dataset.

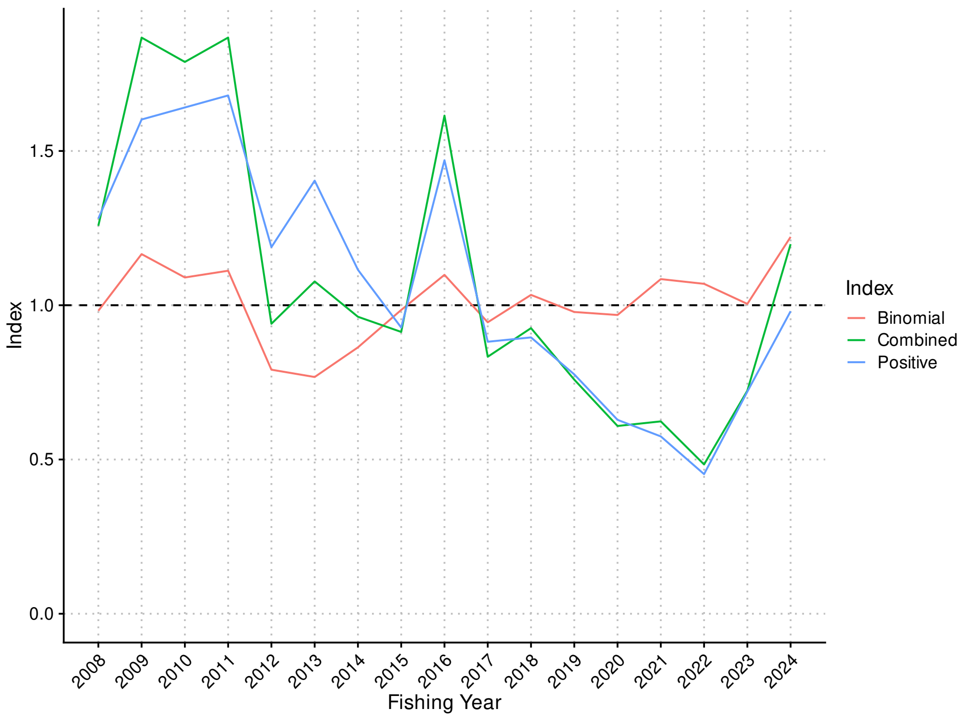

Figure 127: Standardised indices for the Hawke Bay SFL BT-MIX event dataset.

Table 21: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay SFL BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.982	0.026	0.921	1.023	1.258	0.055	1.147	1.363	1.281	0.044	1.199	1.371
2009	1.166	0.090	1.032	1.385	1.867	0.158	1.622	2.243	1.602	0.056	1.497	1.716
2010	1.090	0.050	1.018	1.215	1.789	0.108	1.610	2.032	1.641	0.064	1.521	1.774
2011	1.112	0.058	1.022	1.248	1.868	0.120	1.667	2.135	1.680	0.064	1.552	1.804
2012	0.791	0.081	0.626	0.943	0.940	0.106	0.730	1.147	1.188	0.052	1.093	1.298
2013	0.767	0.087	0.594	0.936	1.077	0.129	0.823	1.328	1.404	0.052	1.299	1.502
2014	0.863	0.059	0.737	0.968	0.963	0.077	0.798	1.102	1.115	0.041	1.038	1.199
2015	0.985	0.029	0.918	1.031	0.913	0.041	0.832	0.993	0.928	0.034	0.861	0.994
2016	1.099	0.050	1.021	1.219	1.615	0.091	1.461	1.820	1.470	0.047	1.377	1.560
2017	0.945	0.037	0.852	0.998	0.833	0.050	0.725	0.920	0.882	0.034	0.816	0.949
2018	1.034	0.030	0.986	1.104	0.926	0.042	0.847	1.014	0.896	0.032	0.835	0.959
2019	0.978	0.033	0.902	1.033	0.759	0.042	0.675	0.838	0.776	0.034	0.712	0.845
2020	0.968	0.037	0.879	1.023	0.609	0.039	0.536	0.687	0.629	0.032	0.569	0.694
2021	1.085	0.055	1.011	1.226	0.624	0.045	0.548	0.723	0.575	0.029	0.518	0.630
2022	1.069	0.041	1.011	1.172	0.484	0.027	0.436	0.540	0.453	0.019	0.418	0.491
2023	1.004	0.041	0.921	1.083	0.723	0.045	0.635	0.812	0.720	0.039	0.646	0.800
2024	1.221	0.125	1.040	1.531	1.198	0.140	0.981	1.529	0.980	0.043	0.893	1.064

5. ENVIRONMENTAL DATA

In order to investigate the use of environmental covariates in the standardisation of catch rates, we sourced water quality monitoring data from Hawke Bay. Examining trends in these data could then be used to develop hypotheses about environmental influences on flatfish abundance based on relationships that emerge from the standardisation modelling.

5.1 Water quality data

Prior to 2006, marine water quality information in Hawke Bay was limited to one-off studies. A pilot study by the Hawke's Bay Regional Council (HBRC) prompted routine, State of the Environment (SOE) monitoring of sentinel coastal sites that were collectively representative of various coastal environments and adjacent types within Hawke Bay. Routine sampling at these near shore water quality (NSWQ) sites has continued from November 2006 to the present day at the following key locations: Ocean Beach, Awatoto, Marine Parade, Westshore and Whirinaki (Figure 128). Additional sites in the north-east were added and sampled from 2012: Wairoa, Nuhaka, Mahia, and Waikoko. Since then other sites have been added, some for specific sampling projects with collection extending over a few years.

Near shore water quality samples are taken within 7–10 m water depth and 500–1000 m from shore, and where the water is considered fully mixed, i.e., no freshwater layer stratification (especially after flood events). A sonde with calibrated probes is deployed during sampling to collect chlorophyll-a, turbidity, conductivity, temperature, dissolved oxygen and pH measurements; with a Secchi disk used to determine water clarity. Water samples are also collected for additional lab analysis. Collected data is processed by HBRC to National Environment Monitoring Standard (NEMS).

In December 2012, HBRC deployed the Hawke's Bay Water Quality Information (HAWQi) buoy 5 km off the coast of Whirinaki at Tongaio Bluff (Figure 128). This records continuous data about water temperature, salinity, clarity and weather information in the near shore marine environment (Hawke's Bay Regional Council 2025). Data from the coastal monitoring buoy is transmitted to HBRC via telemetry and is available on the HBRC website.

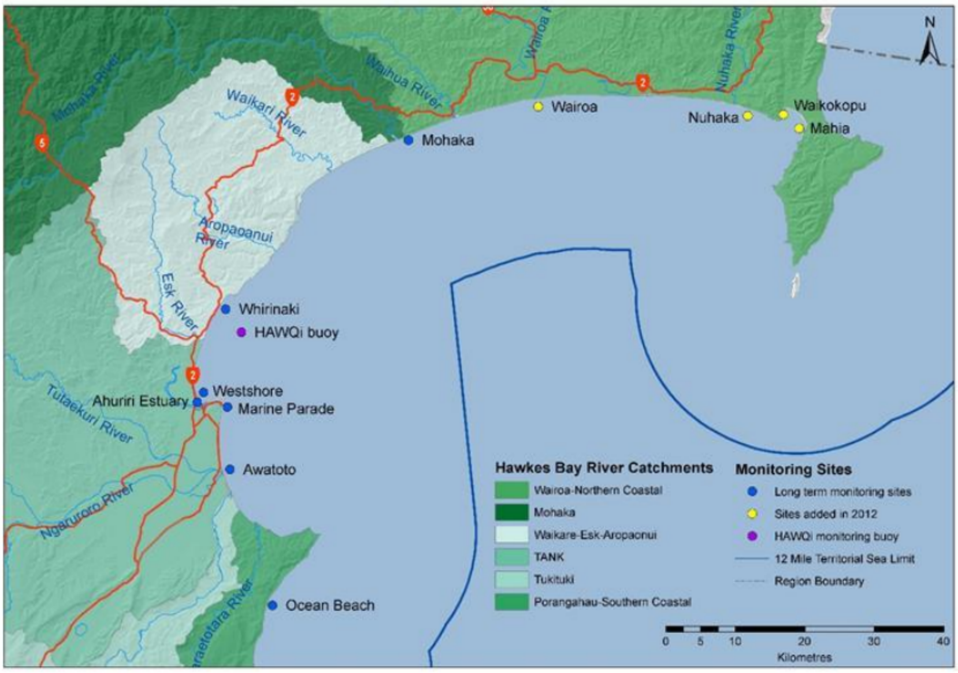

Figure 128: Coastal water quality monitoring sites within Hawke Bay routinely measured (every 6 weeks) by Hawke's Bay Regional Council. From (Haggit & Wade 2016).

Servicing of the HAWQi buoy is completed every 2 years, where the buoy is broken down in order to calibrate instruments, implement any necessary upgrades or replacements, and check the integrity of the buoy. During this servicing cycle, the Cawthron Institute collects and processes HAWQi data and provides updated files to HBRC spanning the previous two years. These files contain a comprehensive data set which replaces the existing telemetry data, and is then run through HBRC's "autocoder" script to quality-code the data in line with the NEMS.

Hawke's Bay Regional Council's Water Quality and Ecology Team supplied two data extracts, one for the SOE NSWQ sites and one for the HAWQi buoy. Data were provided in spreadsheets, with one sheet per measurement type, and with site coordinates, date, time, measurement units, and quality code provided for each record. Data were filtered to exclude records with quality codes indicating data records of poor or unknown quality, and keeping records with good or fair quality (considered acceptable quality for scientific analysis). SOE NSWQ data was supplied for sixteen sampling sites (Figure 129), including discrete samples collected at a site adjacent to the HAWQi bouy.

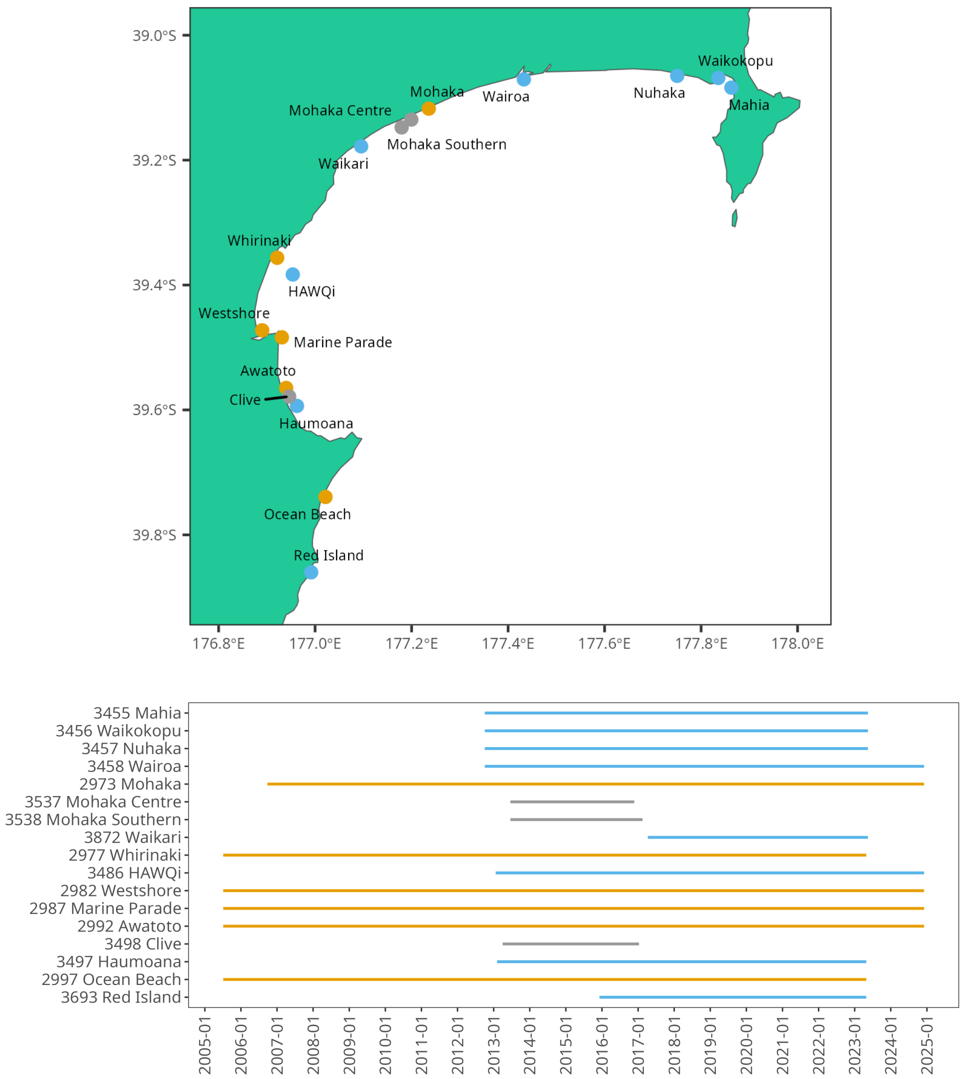

Figure 129: Location (top) and date ranges (bottom), by site for State of the Environment near shore water quality sampling stations included in the data extract received from Hawke's Bay Regional Council: yellow – the six initial key sites sampled from 2006; blue – sampling sites added since 2013; and, grey – sampling sites for short-duration (1–3 years) data collection.

5.2 Water quality data analysis

Daily means of the HAWQi buoy water quality measurements show that water temperature and salinity are the most consistently recorded measurements, with data collected for turbidity, chlorophyll-a and dissolved oxygen being discontinuous for much of the period from 2013 to 2025. For all measurements, data were not available for extended periods of months, and years in some cases (Figure 130). The majority of these data gaps were explained by malfunctioning sensors, transmission errors, or when the buoy was removed for servicing. Others were explained by instruments not being equipped with all sensors, e.g., early deployments of dissolved oxygen at 0.5 m and at times at 15 m (HBRC, pers. comm. 2025). Due to these inconsistencies, these data were not used in any further analysis.

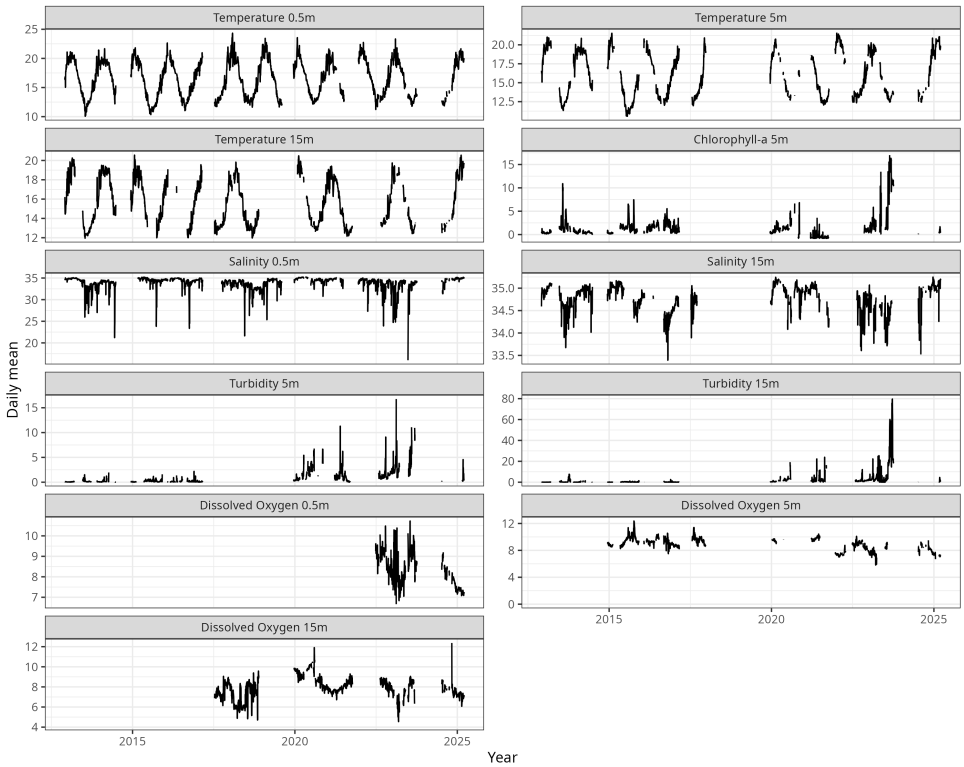

Figure 130: Daily means of continuously sampled water quality data collected from the HAWQi buoy, by measurement type.

Annual means for each SOE near shore water discrete quality measurement (dissolved oxygen mg^{-1}, nitrogen gm^{-3}, suspended solids gm^{-3}, total phosperous gm^{-3}, and water temperature deg C) were plotted for each sampling site (station) (Figure 131). To better assess any spatial variation in the measurements, these data were also plotted by station location groups, from north-east to south-east: North-east (Mahia, Waikokopu, Nuhaka, Wairoa); Central-north (Mohaka, Waikari, Mohaka Centre, Mohaka South); West (Whirinaki, Westshore, Marine, Parade, HAWQi); South-west (Awatoto, Haumoana, Clive); and, South (Ocean Beach, Red Island) (Figure 132).

Across location groups, there is some indication of trends for some measurements, such as increasing temperature and decreasing total phosphorus, as well as increasing dissolved oxygen for West stations (Figure 132). However, any patterns are highly variable between years. When the candidate CPUE series are overlaid with the SOE near shore water quality measurements (annual means) it is not clear that there is any correspondence between the water quality measurements and the CPUE standardisation (Figure 133 – Figure 135). The Working Group decided that in light of these results further analysis using environmental data to inform abundance trends was not warranted.

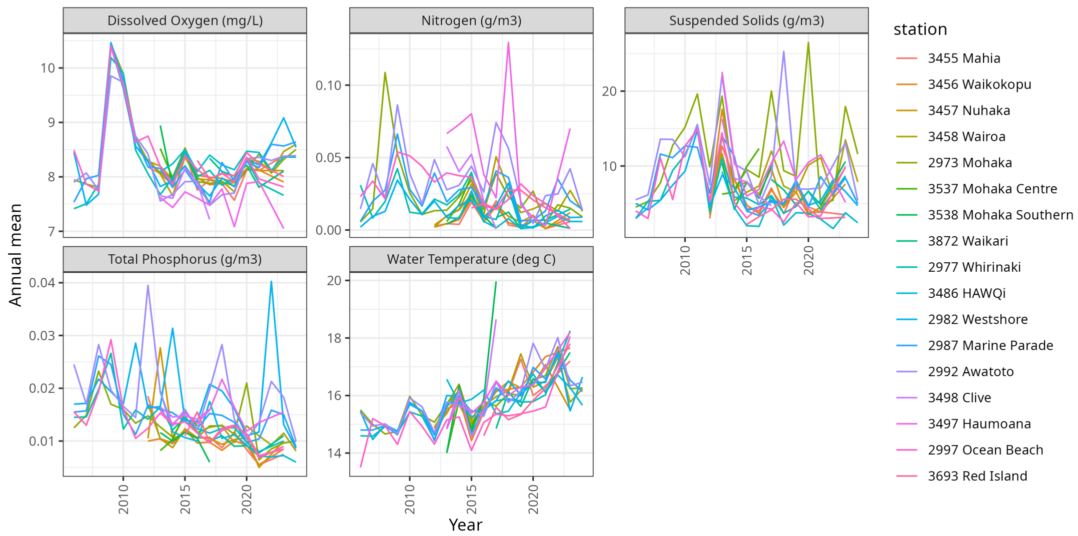

Figure 131: State of the Environment near shore water quality sampling data: annual means by measurement type and by sampling site.

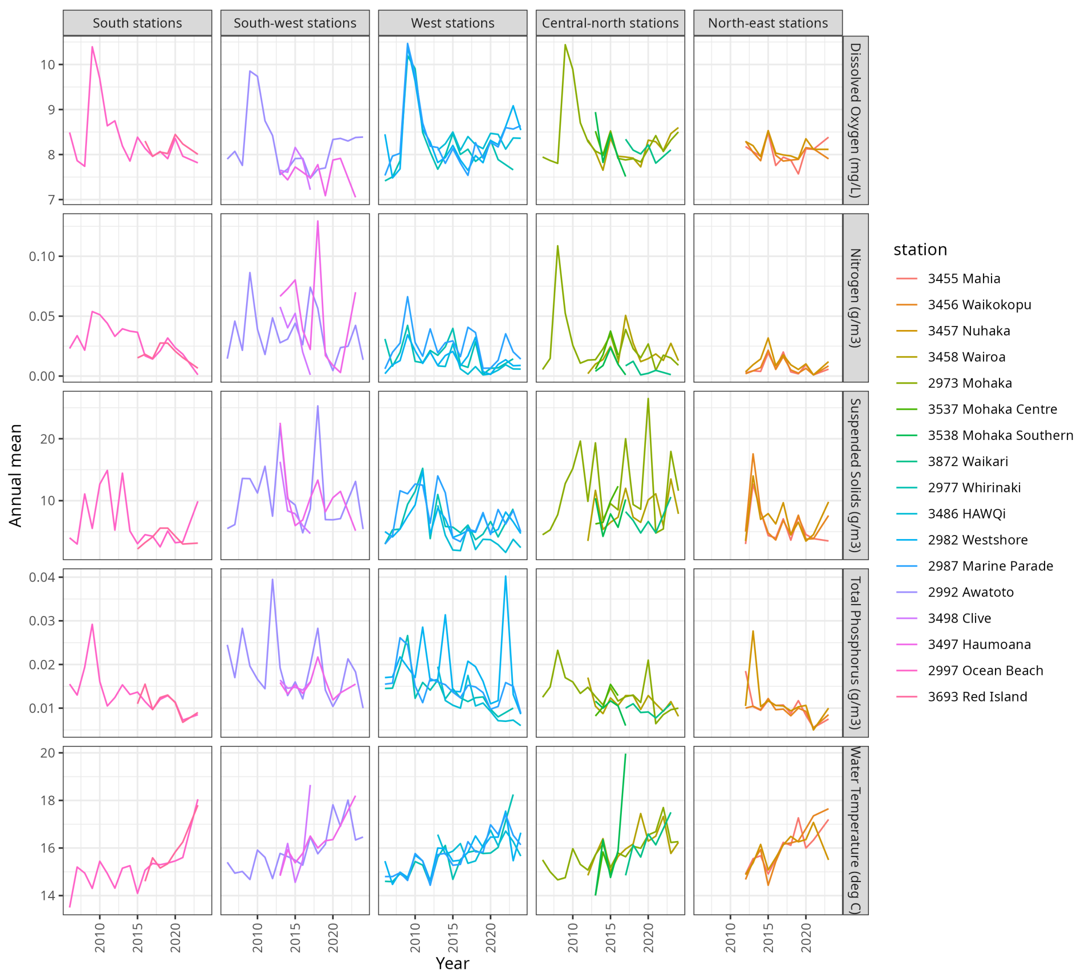

Figure 132: State of the Environment near shore water quality sampling data: annual means by measurement type and sampling site, and by location groups: North-east (Mahia, Waikokopu, Nuhaka, Wairoa); Central-north (Mohaka, Waikari, Mohaka Centre, Mohaka South); West (Whirinaki, Westshore, Marine, Parade, HAWQi); South-west (Awatoto, Haumoana, Clive); and South (Ocean Beach, Red Island).

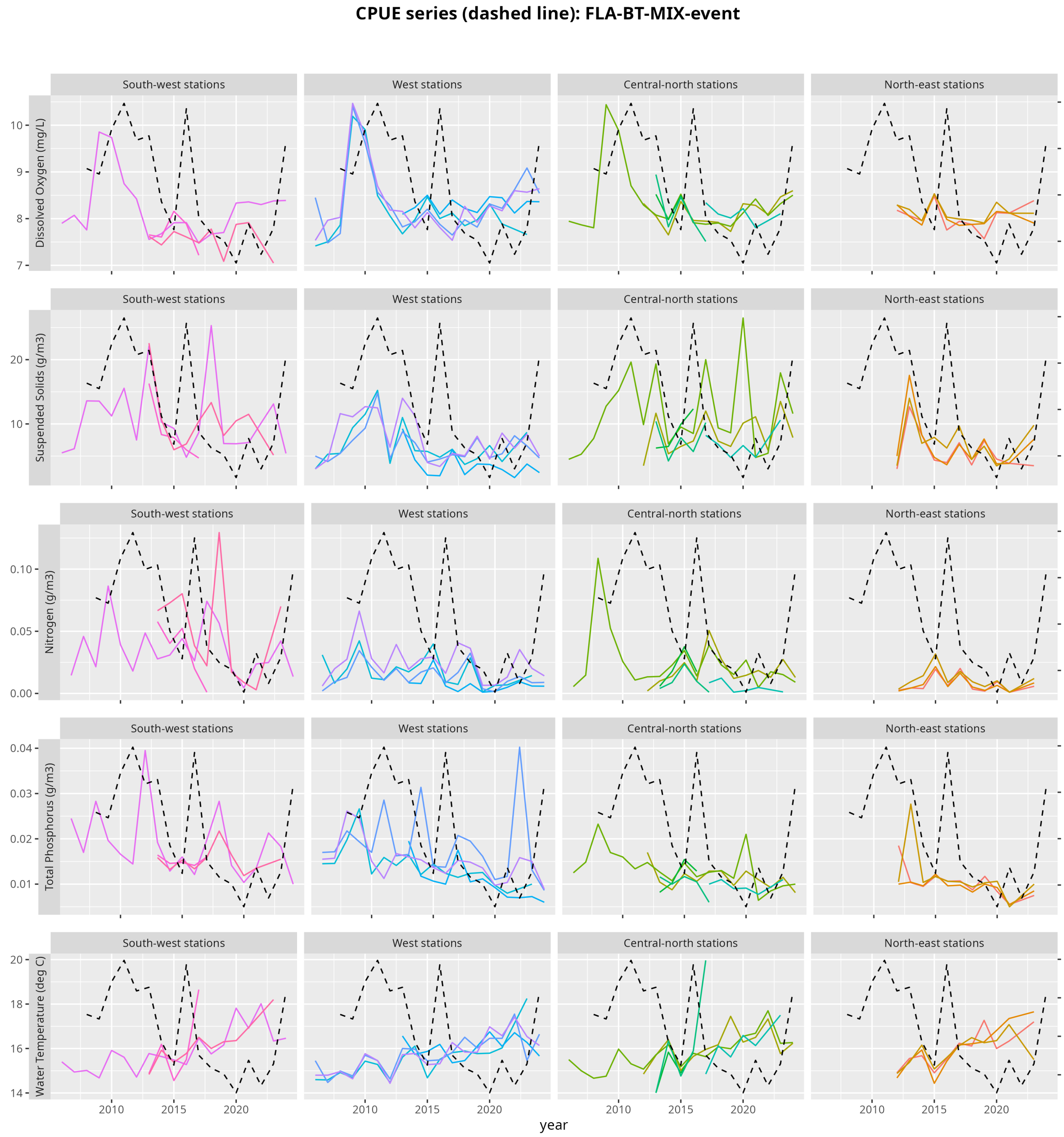

Figure 133: Hawke Bay FLA BT-MIX event standardised CPUE series overlaid on SOE nearshore water quality data measurements (yearly means), by location groups: North-east (Mahia, Waikokopu, Nuhaka, Wairoa); Central-north (Mohaka, Waikari, Mohaka Centre, Mohaka South); West (Whirinaki, Westshore, Marine, Parade, HAWQi); South-west (Awatoto, Haumoana, Clive).

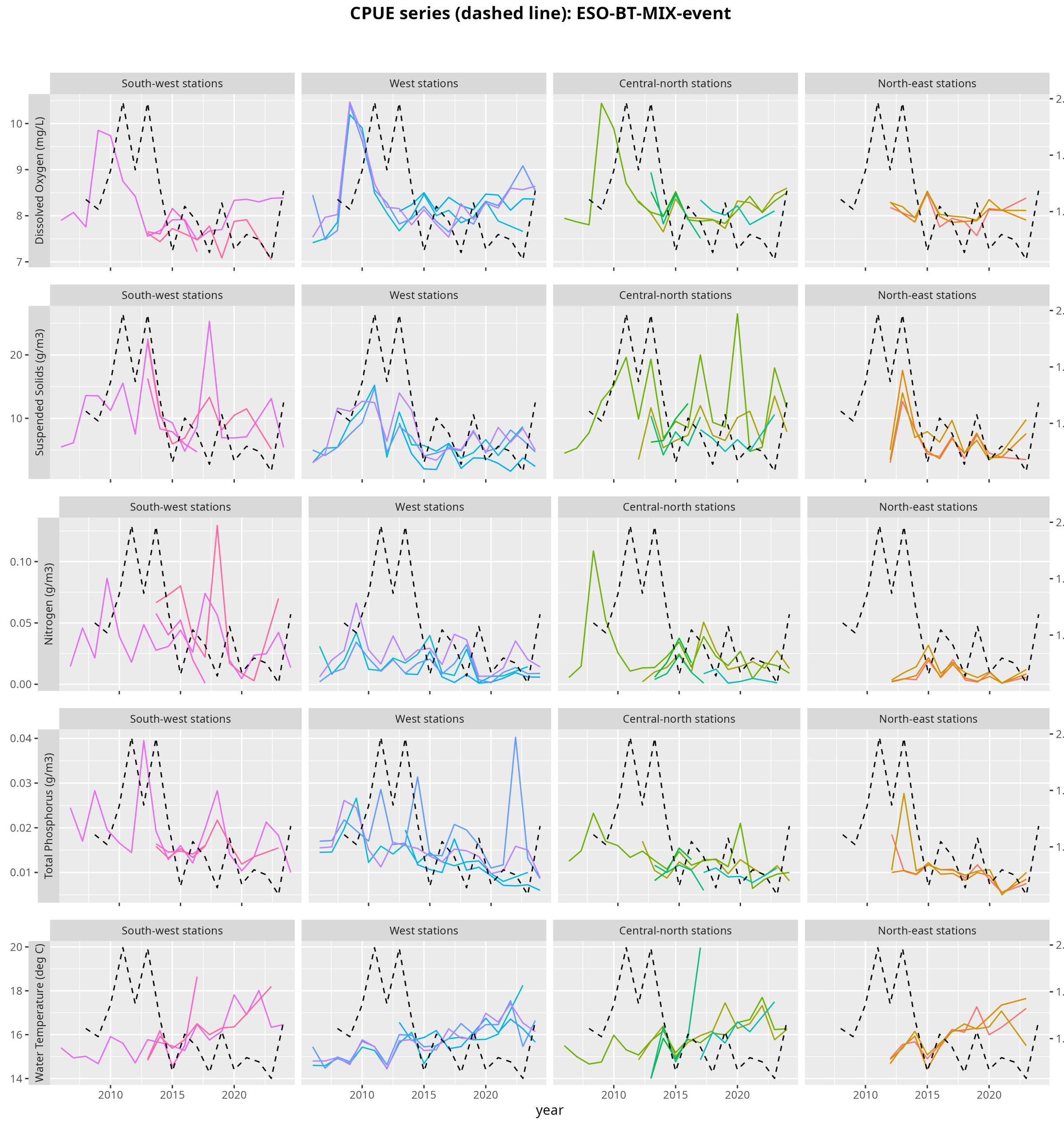

Figure 134: Hawke Bay ESO BT-MIX event standardised CPUE series overlaid on SOE nearshore water quality data measurements (yearly means), by location groups: North-east (Mahia, Waikokopu, Nuhaka, Wairoa); Central-north (Mohaka, Waikari, Mohaka Centre, Mohaka South); West (Whirinaki, Westshore, Marine, Parade, HAWQi); South-west (Awatoto, Haumoana, Clive).

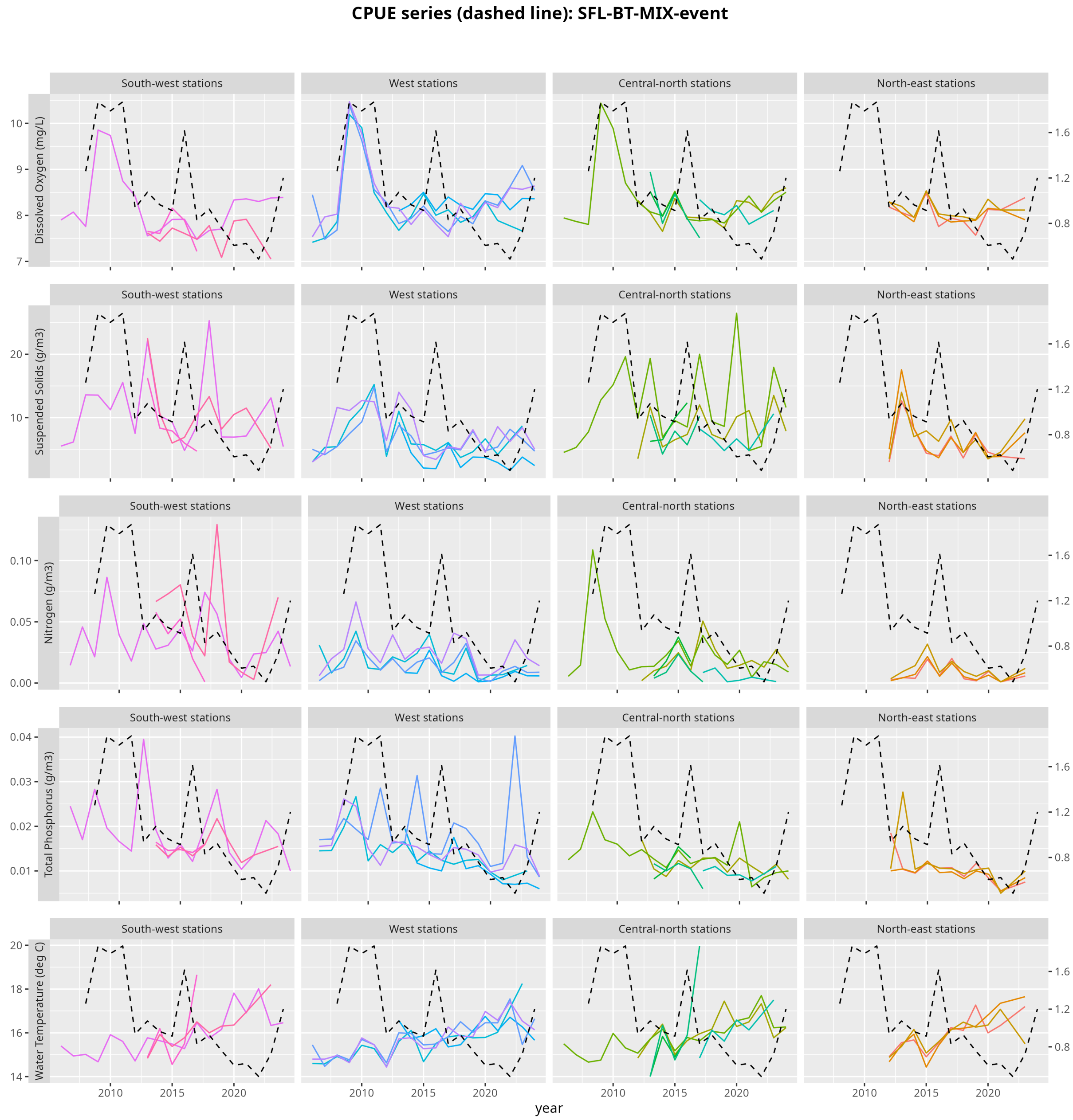

Figure 135: Hawke Bay SFL BT-MIX event standardised CPUE series overlaid on SOE nearshore water quality data measurements (yearly means), by location groups: North-east (Mahia, Waikokopu, Nuhaka, Wairoa); Central-north (Mohaka, Waikari, Mohaka Centre, Mohaka South); West (Whirinaki, Westshore, Marine, Parade, HAWQi); South-west (Awatoto, Haumoana, Clive).

6. DISCUSSION

6.1 Evaluation of daily effort models for FLA 2

An initial intention for this project was to update the series accepted by the INSWG for monitoring FLA 2 abundance in 2017 and 2018, by using the same selection criteria as were used by Schofield et al. (2018b) and Schofield et al. (2018a). These were daily-effort pseudo-CELR analyses that were preferred because they allowed the series to extend from the initiation of the data collection period in October 1989.

Figure 136 compares the original Schofield et al. (2018b) CPUE series that was accepted by the INSWG in 2018 with the equivalent analysis prepared for this project. While this comparison indicates that the original series has been appropriately repeated, the extension of the series was not accepted by the 2025 INSWG for tracking FLA 2 abundance for two reasons:

1. the loss of vessels in recent years, attributed to a greatly reduced FLA market, (down to a single vessel in 2024 and two vessels in both 2022 and 2023; Table C.20); and

2. evidence in the event-based analyses that there have been structural changes in the fishery, particularly in the depths being fished over time.

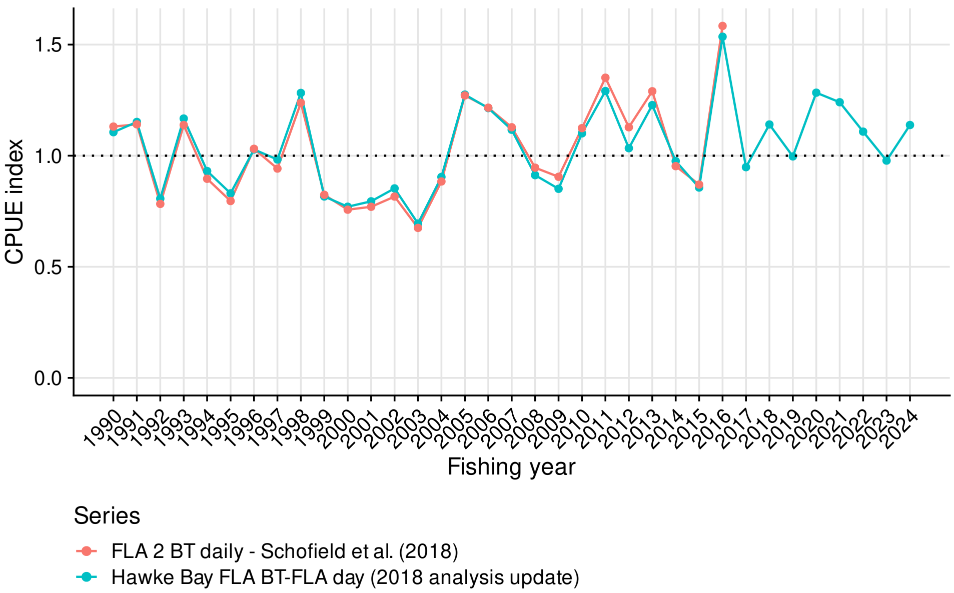

Figure 136: Comparison of the FLA 2 (Hawke Bay - Statistical Areas 013 and 014) BT daily index with data to the 2016 fishing year (Schofield et al. 2018b), with the updated index using data to the 2024 fishing year.

Relaxing the core fleet selection criteria did not result in a more acceptable FLA target daily series. However, expanding the target species selection criteria to include gurnard (GUR) improved vessel participation in the analyses. Figure 137 compares the updated 2018 BT CPUE daily series (Appendix C.4) with two alternative daily series: a series with relaxed core fleet selection (Appendix C.1) and a series which includes effort targeted at GUR as well as at FLA (Appendix C.5). Neither of these additional series were acceptable to the INSWG, which was especially concerned with the very strong upturn shown for 2024 by the Hawke Bay FLA BT-MIX day series, an increase that was unlikely to indicate an abundance increase. The INSWG was wary of accepting the daily series targeted at GUR and FLA because it was limited to the top 5 species caught daily, which would reduce the representativeness of the GUR contribution to the model because FLA bycatch in target GUR BT tows was often not in the top 5 species in the daily catch (see Figure 12)

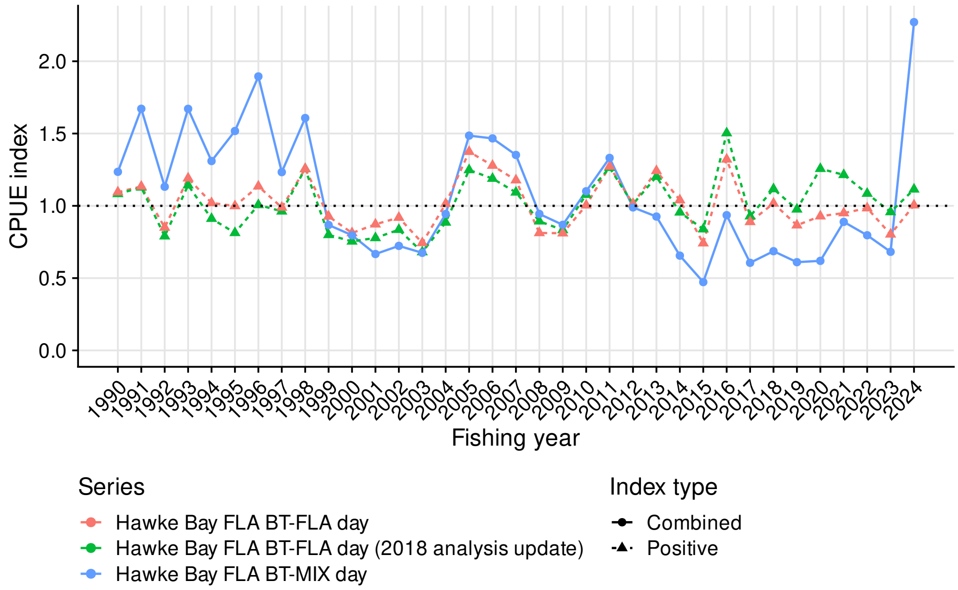

Figure 137: Comparison of the FLA 2 (Hawke Bay) BT daily series: the updated index using data to the 2024 fishing year, a model with relaxed core fleet selection, and a model that includes gurnard target effort in addition to flatfish target fishing.

The INSWG agreed to move to an event-based model with combined FLA and GUR target effort. This was done because the TCER paper form requested the top 8 species on a tow-by-tow (event) basis rather than the top 5 for a whole day of fishing. As well, the event-based data recorded the depth fished, which would allow the model to use depth as an explanatory variable, an option that was not available on the daily CELR forms. Figure 138 compares the BT CPUE daily series targeted at FLA with a relaxed core fleet selection (Appendix C.1) with three event-based series with varying target species definitions. These are an event-based series targeted at FLA only (a positive catch series without documentation), a series targeted at GUR only (also not documented) and the MIX (FLA and GUR target species) target series that was accepted by the INSWG (Section 4.2) for monitoring the aggregate FLA catch. Note that both the MIX target and the GUR target series show a relatively strong increase in the final (2024) fishing year.

When the target FLA daily series is compared directly with the combined target FLA/GUR tow-by-tow series, both series show a strong increase in the final (2024) fishing year, but the increase in the daily series, with only FLA target effort, is relatively much larger (Figure 139). This was another consideration that led to the acceptance of the combined FLA/GUR target series over a series that just used FLA target effort.

6.2 Development of species-specific flatfish models for FLA 2

The INSWG also considered developing species-specific flatfish CPUE series for FLA 2, given the analyses presented in Section 3.3. Event-based CPUE series equivalent to the Hawke Bay FLA BT-MIX event series were developed for New Zealand sole (ESO – Section 4.3), sand flounder (SFL – Section 4.4), lemon sole (LSO – Appendix C.6) and yellow-belly flounder (YBF – Appendix C.7). Figure 140 compares these four event-based series with the combined target FLA/GUR BT CPUE series based on the aggregate FLA catch.

It was suggested that the strong between-year variation seen in the LSO event-based CPUE series was due to the intermittent presence of LSO at depths favourable to GUR fishing. It was suggested that adding TAR target effort to the LSO FLA/GUR target species event-based model might reduce the between year variable in the LSO series. However, the addition of this target species to the model (not

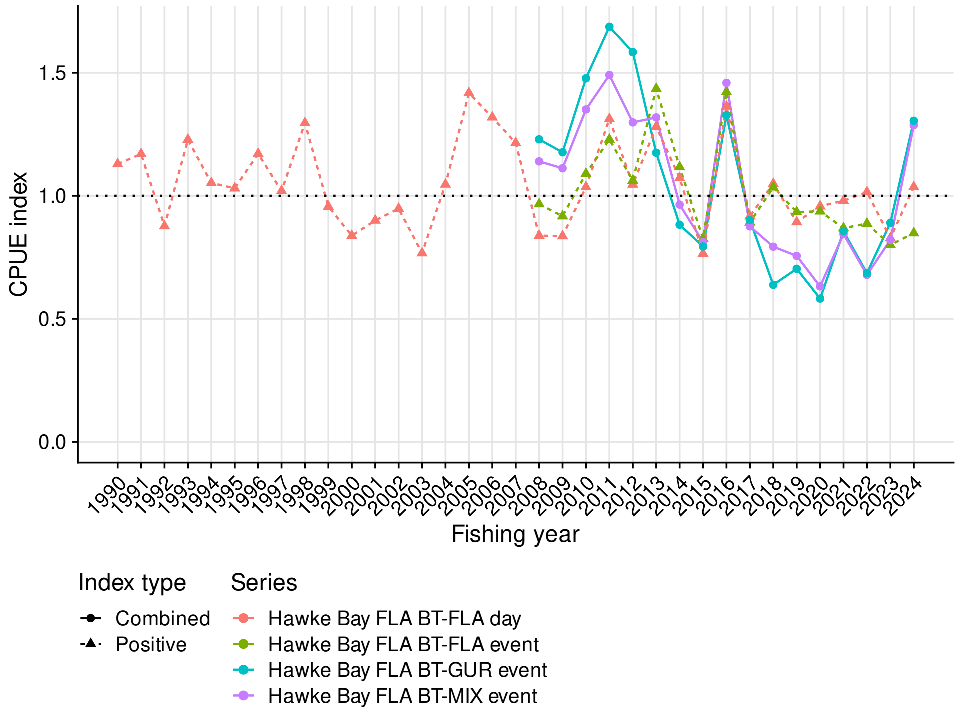

Figure 138: Comparison of the relaxed core fleet FLA 2 (Hawke Bay) BT daily series with three event resolution series based on aggregate FLA catches and varying target species definitions.

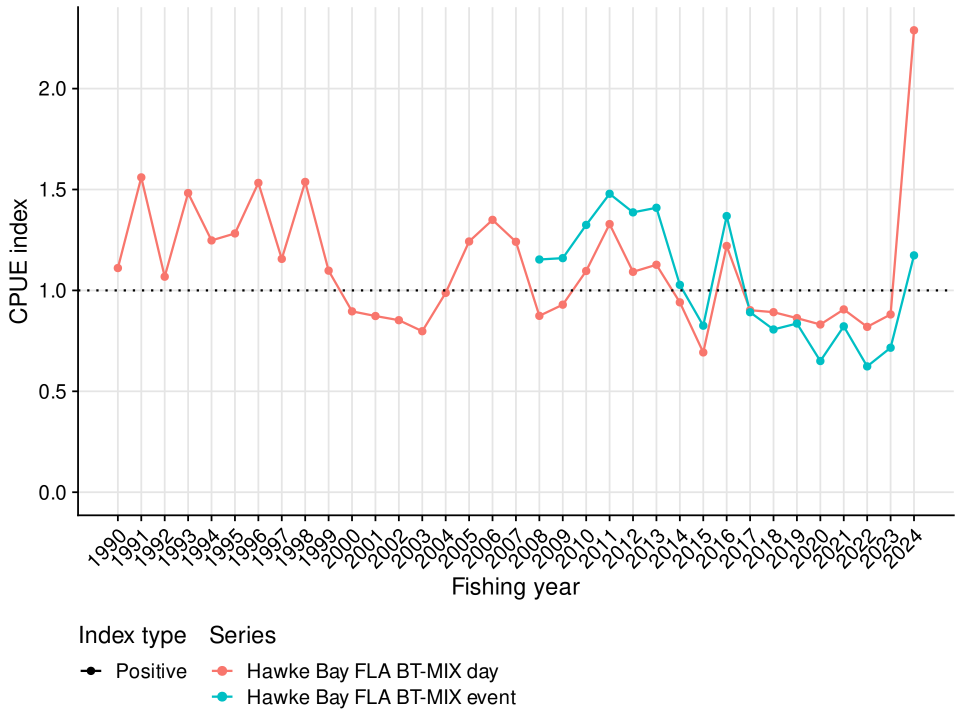

Figure 139: Comparison of the relaxed core fleet FLA 2 (Hawke Bay) BT daily series with the event-based MIX model (positive catch) using aggregate FLA catches.

documented) did not materially alter the series trend (Figure 141). Consequently, the INSWG did not accept either series for LSO abundance monitoring due to the very high index values estimated by this series over the period 2015 to 2018.

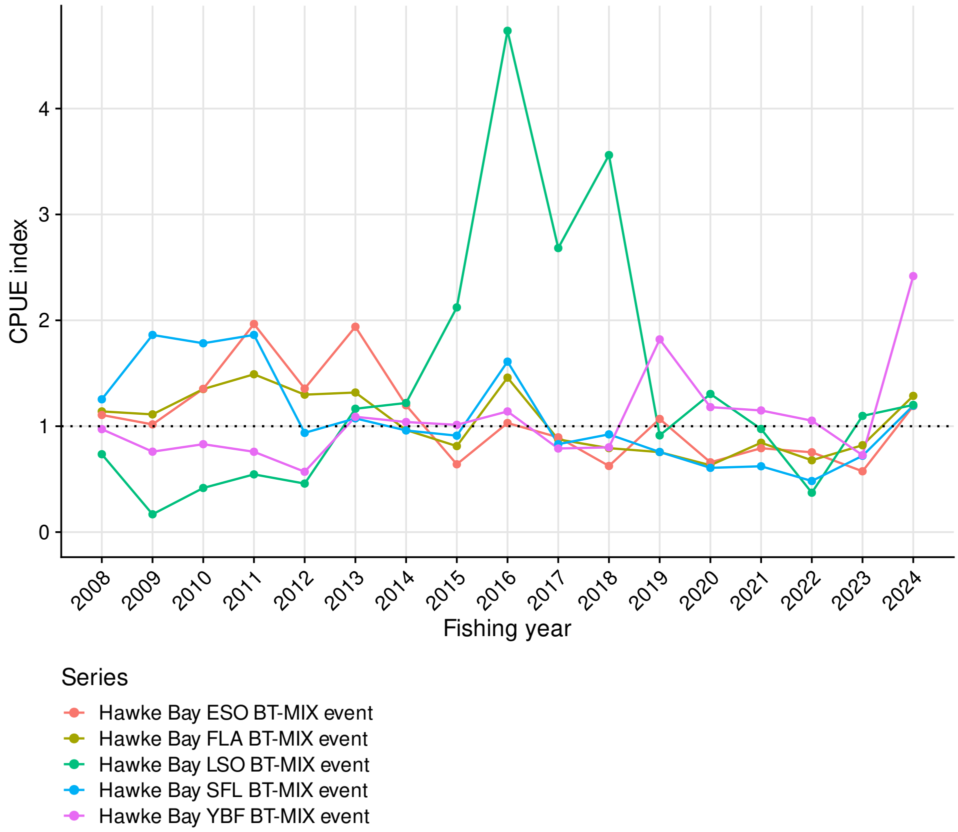

Figure 140: Comparison of the Hawke Bay event resolution series for aggregate FLA catch with four species-specific series.

The INSWG also did not accept the YBF event-based FLA/GUR target species model due to the small amount of data in many of the model years and the relatively low incidence of this species in the data set, leading to a lack of reliability for the overall series (Table C.37).

6.3 Final models adopted by the Plenary

The INSWG and the Plenary accepted the Hawke Bay FLA BT-MIX event series for monitoring the aggregate FLA population in FLA 2. Figure 142 compares the event-based combined target FLA/GUR BT CPUE series based on the aggregate flatfish (FLA) catch with the BT daily series targeted at FLA only. This series is more variable than the daily series derived from the FLA target fishery, possibly due to the fact that the inclusion of GUR target effort resulted in a more diverse range of flatfish species in the catch, in particular more lemon sole (LSO).

The INSWG and the Plenary also accepted the species-specific monitoring series for New Zealand sole and sand flounder but rejected the equivalent series for lemon sole and yellow-belly flounder. Figure 143 compares the event-based combined target FLA/GUR BT CPUE series based on the aggregate FLA catch with the two event-based species (ESO and SFL) specific series accepted for monitoring the abundance of the respective species. The INSWG noted the overall agreement among all three series, which showed a declining trend beginning near 2010 and which continued to nearly the end of each series before all three series showed a sharp jump in 2024.

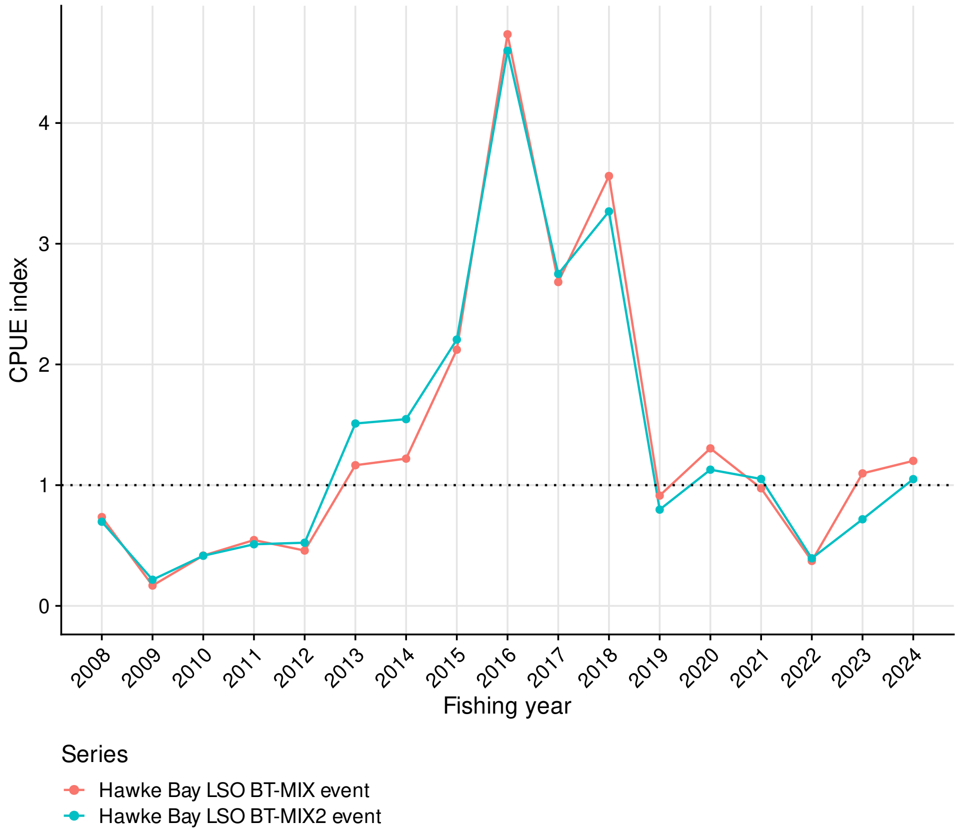

Figure 141: Comparison of the event resolution series for Hawke Bay lemon sole with and without tarakihi target effort.

6.4 Evaluating the stock status of FLA 2, ESO 2 and SFL 2

In 2014, the INSWG adopted mean CPUE from the bottom trawl flatfish target series based on the combined species catch in Statistical Areas 013 and 014 (Hawke Bay) for the period 1989–90 to 2012–13 as a B_{MSY}-compatible proxy for FLA 2. In 2025, this target was updated to the geometric mean CPUE from 2007–08 to 2023–24 using the Hawke Bay FLA BT-MIX event series (Figure 143).

B_{MSY}-compatible proxy targets were also set for New Zealand sole (geometric mean CPUE from 2014–15 to 2023–24 in the Hawke Bay ESO BT-MIX event series) and sand flounder (geometric mean CPUE from 2011–12 to 2017–18 in the Hawke Bay SFL BT-MIX event series) in Hawke Bay (Figure 143).

Although the predominant flatfish species monitored by the CPUE series in FLA 2 are highly productive species (for which a management target of 30% B_0 might apply), it was recommended that these targets should be considered as proxies for 40% B_0 targets. A higher target biomass was appropriate because management of flatfish as a species complex creates challenges where individual species are naturally variable, may not vary in synchrony and also because the interval between assessments may be too long. The INSWG accepted the default Harvest Strategy Standard definitions that the soft and hard limits would be one half and one quarter the target, respectively.

Application of the B_{MSY}-compatible proxy target for FLA 2 resulted in an evaluation of ‘About as Likely as Not (40–60%) to be at or above the target’. The stock was also evaluated to be ‘Unlikely (<40%) to be below the Soft Limit’ and ‘Very Unlikely (<10%) to be below the Hard Limit’. The stock was evaluated to be ‘Very Unlikely (<10%) to be Overfished’ (Figure 144).

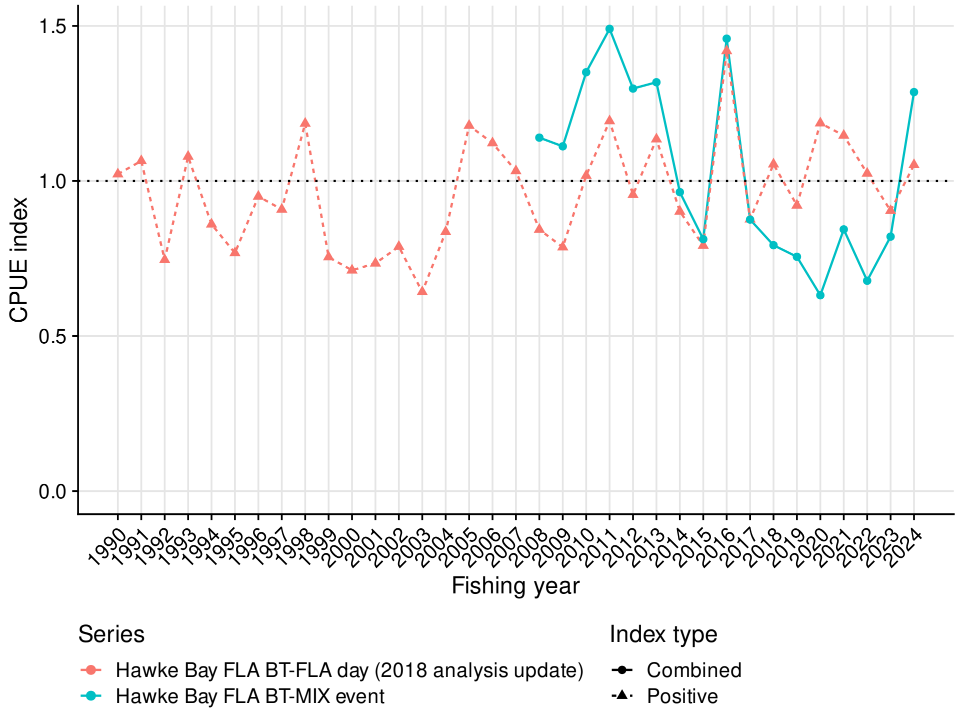

Figure 142: Comparison of the FLA 2 (Hawke Bay) BT daily series that updates the accepted 2018 analysis with the event-based combined target FLA/GUR BT CPUE series based on the aggregate flatfish (FLA) catch.

Application of the B_{MSY}-compatible proxy target for ESO 2 resulted in an evaluation of 'About as Likely as Not (40–60%) to be at or above the target'. ESO 2 was also evaluated to be 'Unlikely (<40%) to be below the Soft Limit' and 'Very Unlikely (<10%) to be below the Hard Limit'. The stock was evaluated to be 'Unknown' with regard to overfishing because total ESO catches during the reference period are not known (Figure 145).

Application of the B_{MSY}-compatible proxy target for SFL 2 resulted in an evaluation of 'About as Likely as Not (40–60%) to be at or above the target'. SFL 2 was also evaluated to be 'Unlikely (<40%) to be below the Soft Limit' and 'Very Unlikely (<10%) to be below the Hard Limit'. The stock was evaluated to be 'Unknown' with regard to overfishing because total SFL catches during the reference period are not known (Figure 146).

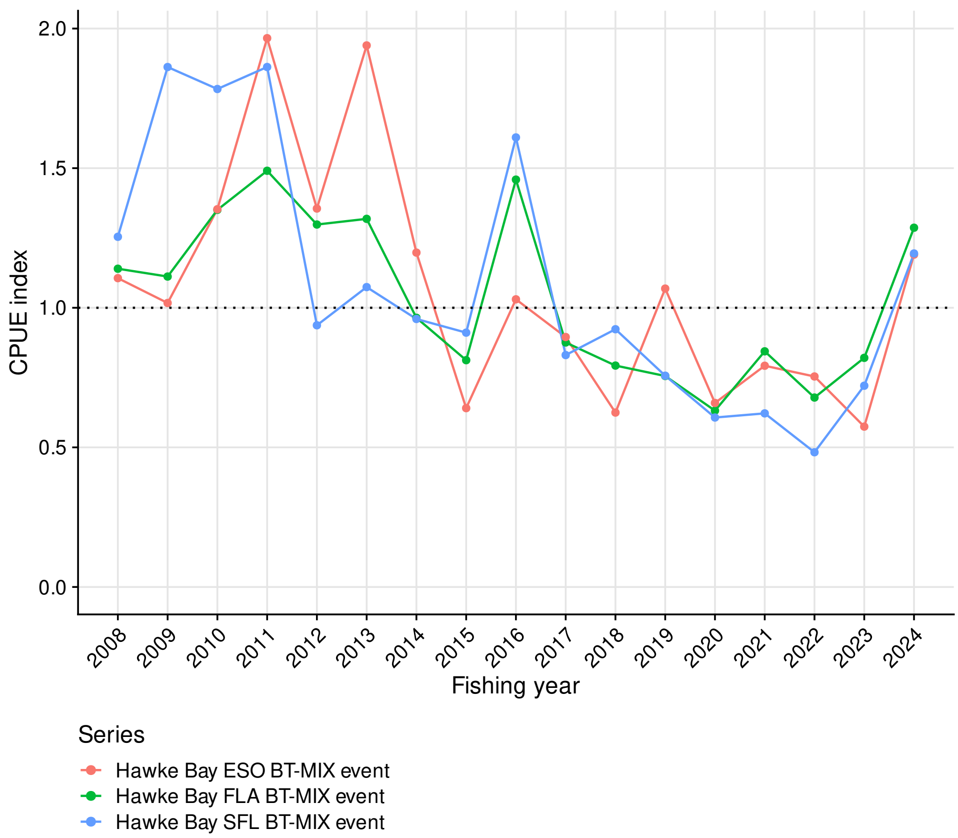

Figure 143: Comparison of the Hawke Bay event resolution series for aggregate FLA catch with the two species-specific series accepted by the INSWG for monitoring abundance.

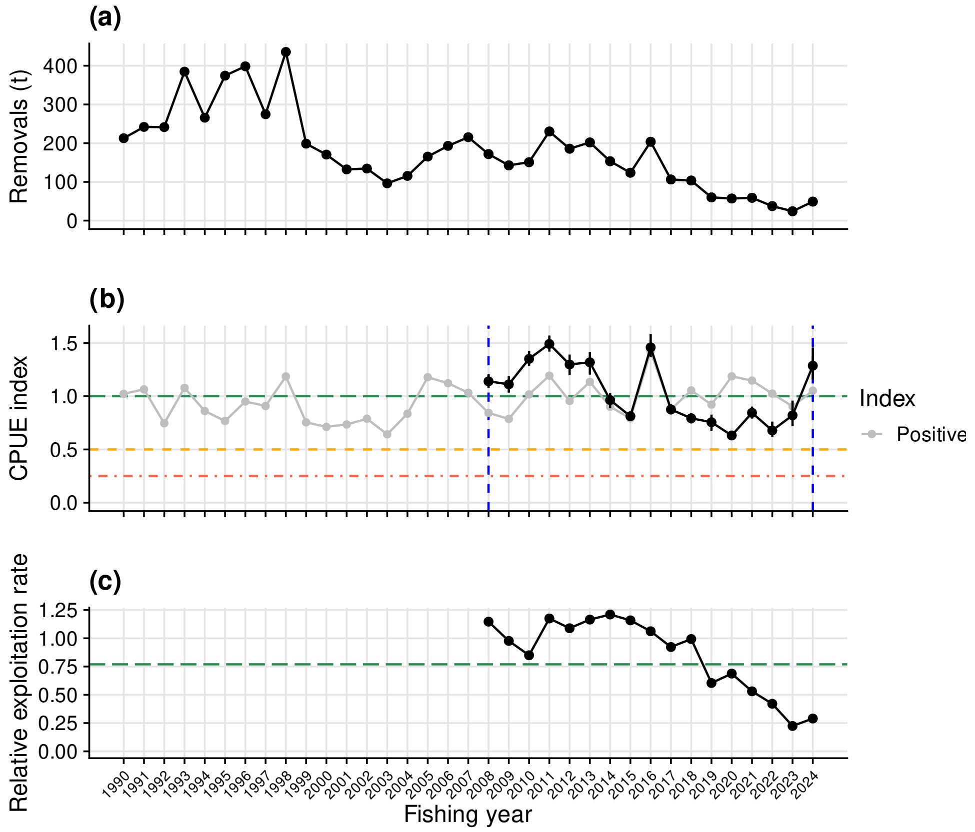

Figure 144: Commercial removals (a) and stock status (b) of FLA 2 relative to the reference period (2008–2024, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green long-dashed line. The hard and soft limits are represented by horizontal dot-dashed red and dashed orange lines, respectively. The relative exploitation rate (c) considers only commercial removals. In (b), the grey line shows an update of the previous daily resolution index for bottom trawl effort targeting flatfish.

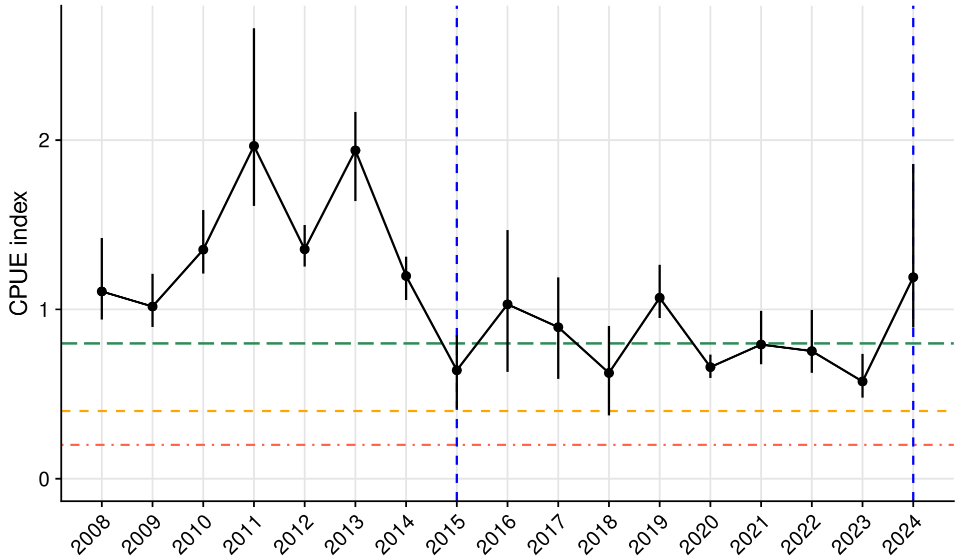

Figure 145: Stock status of ESO in FLA 2 relative to the reference period (2015–2024, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green long-dashed line. The hard and soft limits are represented by horizontal dot-dashed red and dashed orange lines, respectively.

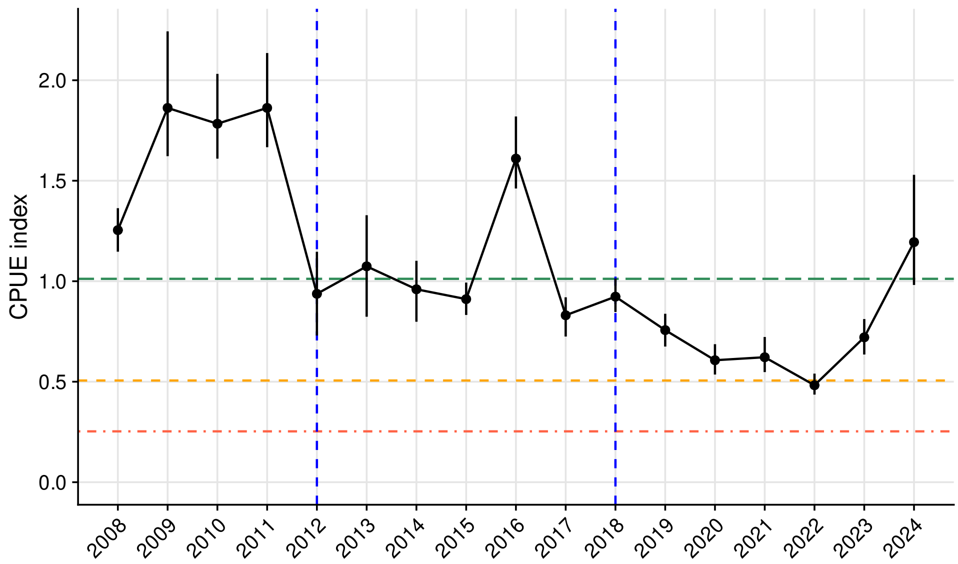

Figure 146: Stock status of SFL in FLA 2 relative to the reference period (2012–2018, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green long-dashed line. The hard and soft limits are represented by horizontal dot-dashed red and dashed orange lines, respectively.

7. ACKNOWLEDGEMENTS

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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
LADTI	Flag	Invalid landing destination
LAFLA	Fix	Correct landings using a flatfish species code to FLA
LASEC	Fix	Landings to Crown or experimental stock codes
LADMR	Drop	Mandatory returns (e.g. sub-MLS)
LADTH	Drop	Retained (non-final) landings
LADTT	Flag	Vessel received transhipments
LASCI	Flag	Landings to invalid state code
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

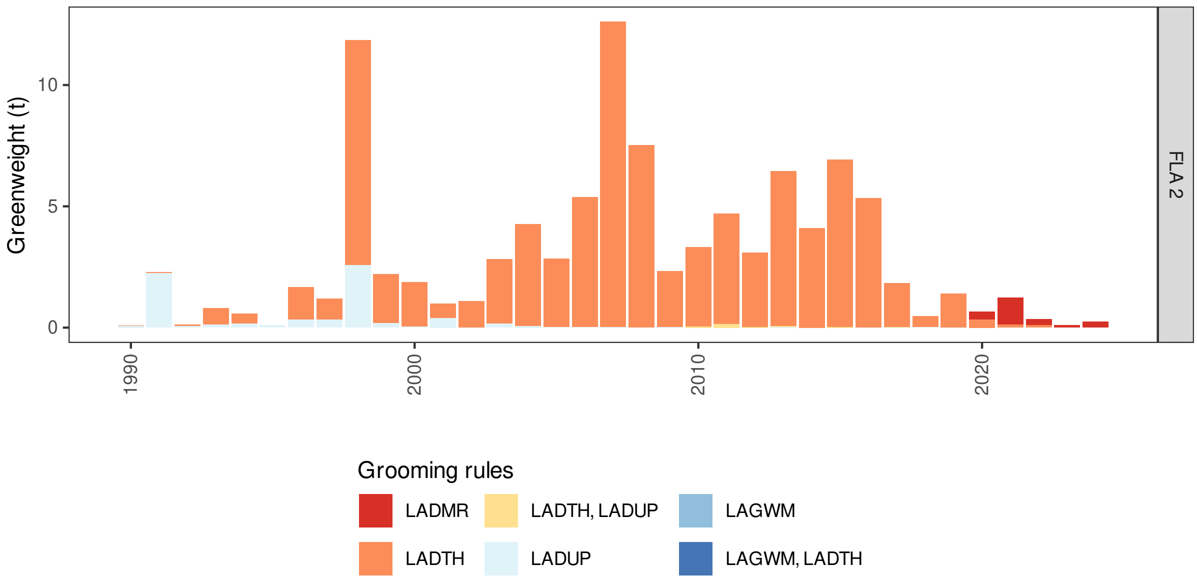

Figure A.1: The quantity of landings dropped, with the relevant grooming rules (Table A.1) indicated, by stock and fishing year.

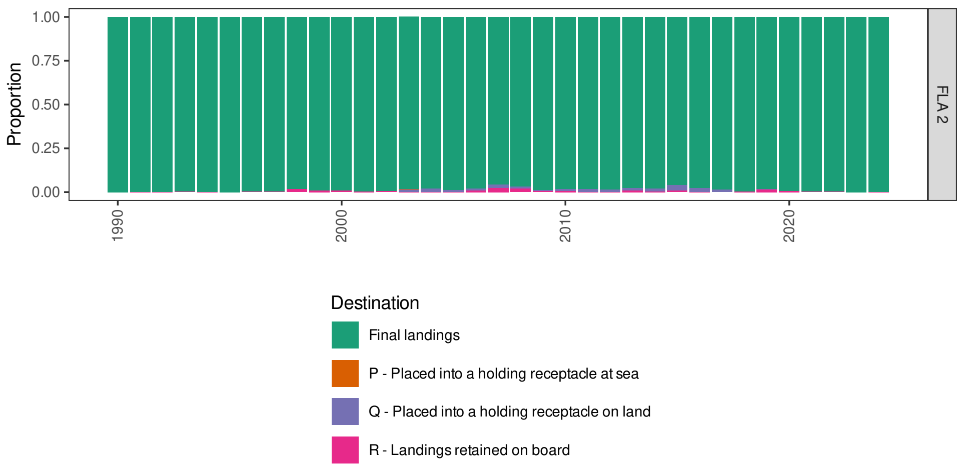

Figure A.2: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

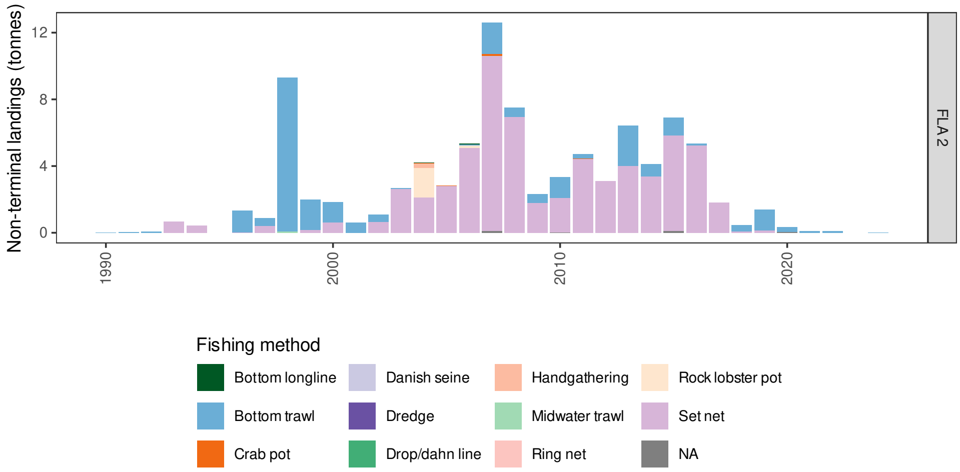

Figure A.3: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

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
FLA 2	1996	2	25 679.50	254.3695
FLA 2	1997	3	383 805.00	669.2670
FLA 2	1999	1	14 654.00	146.5400
FLA 2	2000	1	5 740.00	57.4000
FLA 2	2007	3	8 910.00	89.1000
FLA 2	2008	1	4 466.00	44.6600
FLA 2	2011	3	7 392.00	73.9200
FLA 2	2014	2	5 010.06	50.1006
FLA 2	2024	1	233.20	2.3320

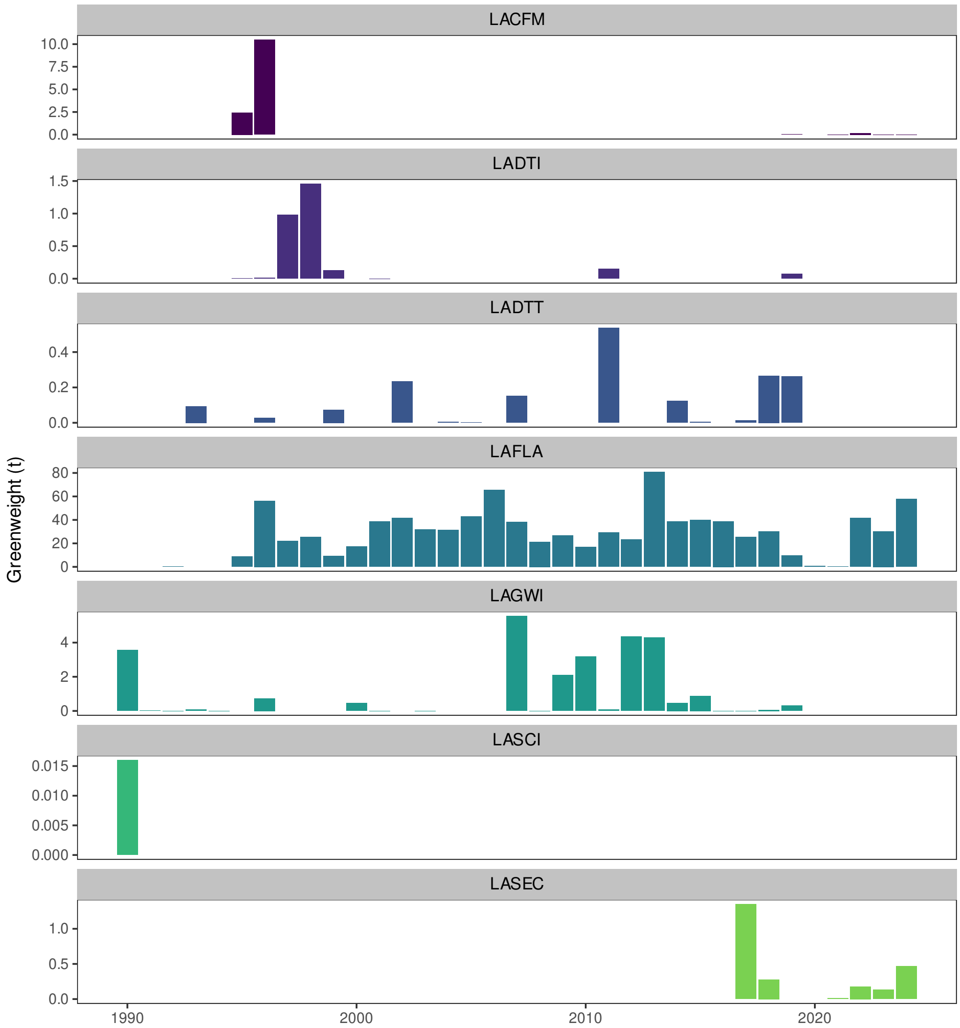

Figure A.4: **The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.**

A.2 Effort

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

Rule	Effect	Description
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
FESAF	Flag	Flag non RLP events using RL statistical area codes
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
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
ESTGT	Fix	Create estimated catch records for events with a total catch weight only

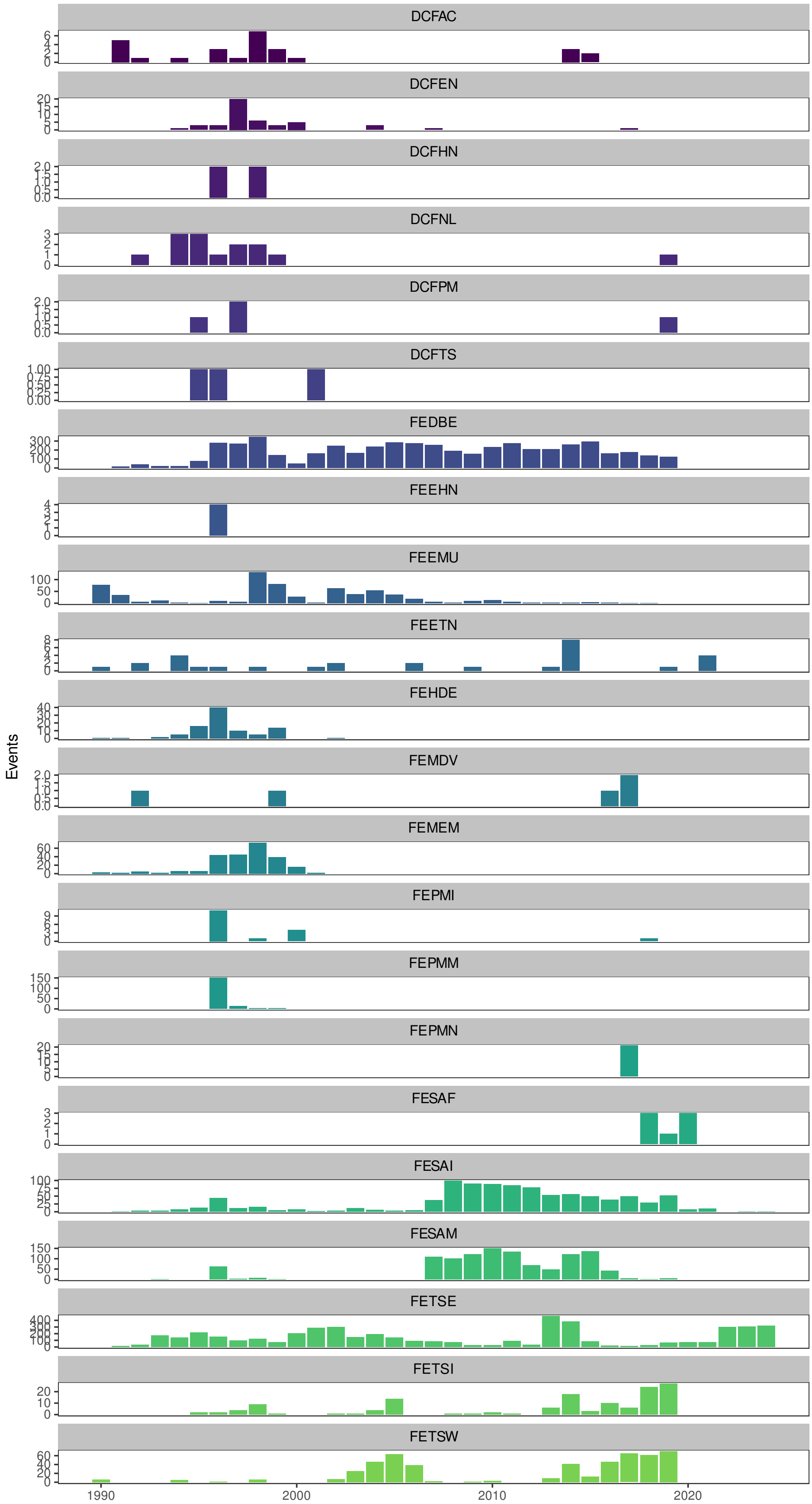

Figure A.5: The number of fishing events flagged or fixed by the grooming rules (Table A.3). Note that some events may be affected by multiple rules.

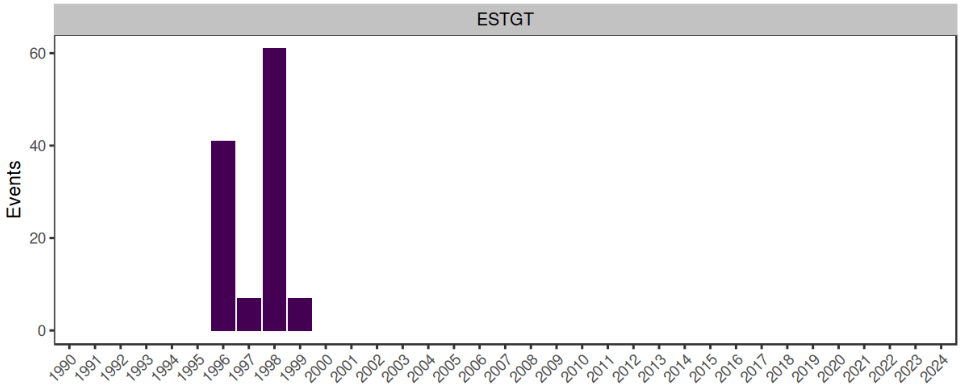

Figure A.6: The number of fishing events where the estimated catch of flatfish was flagged or fixed by the grooming rules (Table A.4). Note that some events may be affected by multiple rules.

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 FLA 2 from 1990 to 2024.

Fishing year	FLA 2	
	TACC	MHR/QMR
1990	717.40	307.62
1991	722.90	288.58
1992	725.70	285.98
1993	725.70	461.85
1994	725.90	397.99
1995	725.90	506.92
1996	725.90	481.95
1997	725.90	363.44
1998	725.90	558.94
1999	725.90	274.01
2000	725.90	211.64
2001	725.90	185.89
2002	725.90	178.21
2003	725.90	143.66
2004	725.90	218.15
2005	725.90	254.14
2006	725.90	296.18
2007	725.90	295.73
2008	725.90	243.97
2009	725.90	213.86
2010	725.90	212.51
2011	725.90	295.71
2012	725.90	262.25
2013	725.90	273.85
2014	725.90	215.88
2015	725.90	166.42
2016	725.90	237.64
2017	725.90	137.82
2018	725.90	126.01
2019	725.90	82.10
2020	725.90	74.22
2021	725.90	78.18
2022	150.00	50.67
2023	150.00	30.30
2024	150.00	57.96

Table B.2: Annual FLA 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 flatfish was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches			Target catches	
			Total (t)	BT-PRB (%)	SN (%)	tonnes	%
1990	307.62	242.48	248.34	83.10	16.36	190.14	76.56
1991	288.58	291.55	289.75	80.27	19.12	181.43	62.62
1992	285.98	278.42	276.50	83.18	14.85	172.01	62.21
1993	461.85	468.83	455.93	93.64	4.87	292.12	64.07
1994	397.99	398.13	395.44	94.60	3.71	244.52	61.83
1995	506.92	516.99	489.60	95.30	4.01	317.02	64.75
1996	481.95	529.30	507.30	90.32	7.25	331.42	65.33
1997	363.44	365.09	329.64	93.61	4.85	236.13	71.63
1998	558.94	551.42	523.77	93.11	6.33	380.18	72.58
1999	274.01	271.51	251.69	94.27	5.16	167.59	66.59
2000	211.64	219.08	205.20	85.05	13.61	129.99	63.35
2001	185.89	185.04	169.50	88.20	8.67	104.39	61.58
2002	178.21	179.70	167.51	85.02	11.72	101.14	60.38
2003	143.66	146.80	132.93	84.32	15.38	68.74	51.71
2004	218.15	201.03	172.36	90.16	9.51	99.62	57.80
2005	254.14	240.99	222.58	93.85	5.99	121.99	54.81
2006	296.18	292.41	267.91	89.17	10.51	151.50	56.55
2007	295.73	292.49	277.53	82.96	16.50	172.12	62.02
2008	243.97	228.47	224.12	78.03	21.31	152.52	68.05
2009	213.86	201.78	201.67	78.04	20.99	132.53	65.72
2010	212.51	209.98	203.53	79.33	20.33	103.22	50.71
2011	295.71	289.35	286.00	84.89	14.32	180.77	63.21
2012	262.25	243.18	237.21	81.29	17.13	142.15	59.93
2013	273.85	260.47	249.56	82.63	17.10	186.31	74.65
2014	215.88	207.94	202.19	90.67	9.25	143.49	70.97
2015	166.42	166.54	163.44	74.00	24.03	117.74	72.04
2016	237.63	230.37	228.54	84.47	10.85	166.09	72.67
2017	137.82	125.90	123.73	82.62	15.36	85.30	68.94
2018	126.01	122.21	120.05	86.77	11.30	85.07	70.86
2019	82.10	80.66	77.46	93.71	5.49	39.91	51.52
2020	74.22	77.33	76.84	90.98	7.57	44.72	58.20
2021	78.18	78.02	77.85	88.11	10.15	40.68	52.25
2022	50.67	53.29	50.64	86.29	13.51	19.84	39.17
2023	30.30	30.38	30.24	84.79	13.67	11.84	39.14
2024	57.96	57.88	57.82	91.68	6.99	11.63	20.11

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

Fishing year	L	Other	Total
1990	234.79	7.69	242.48
1991	286.61	4.94	291.55
1992	273.90	4.52	278.42
1993	463.46	5.37	468.83
1994	389.95	8.19	398.13
1995	505.08	11.90	516.99
1996	517.60	11.69	529.30
1997	358.83	6.26	365.09
1998	547.54	3.88	551.42
1999	266.62	4.90	271.51
2000	217.11	1.97	219.08
2001	183.63	1.41	185.04
2002	179.59	0.12	179.70
2003	146.68	0.12	146.80
2004	200.64	0.38	201.03
2005	240.86	0.14	240.99
2006	291.49	0.92	292.41
2007	289.78	2.71	292.49
2008	227.43	1.04	228.47
2009	201.16	0.63	201.78
2010	209.56	0.42	209.98
2011	288.96	0.39	289.35
2012	243.05	0.13	243.18
2013	260.27	0.20	260.47
2014	207.50	0.43	207.94
2015	166.39	0.15	166.54
2016	230.33	0.04	230.37
2017	125.57	0.34	125.90
2018	121.88	0.34	122.21
2019	79.42	1.25	80.66
2020	75.62	1.71	77.33
2021	75.26	2.76	78.02
2022	46.85	6.43	53.29
2023	30.32	0.07	30.38
2024	57.75	0.13	57.88

Table B.4: Annual catches (t) by landed state of flatfish from the FLA 2 Quota Management Area. DRE = Dressed, FIN = Fins, GGU = Gilled and gutted, GRE = Green (or whole), GUT = Gutted, HGU = Headed and gutted. A complete list of product state codes is provided in Table D.1. – : no observations. Records where the landed state was missing were excluded.

Fishing year	GUT	GRE	DRE	GGU	HGU	FIN	Other	Total
1990	218.33	23.77	-	-	0.33	-	0.03	242.46
1991	261.86	28.55	0.98	-	0.17	-	-	291.55
1992	251.09	26.90	0.18	-	0.25	-	-	278.42
1993	447.72	18.89	1.67	-	0.55	-	-	468.83
1994	364.02	25.09	8.91	-	0.12	-	-	398.13
1995	483.53	22.39	9.78	0.07	1.05	-	-	516.82
1996	487.83	30.39	7.15	2.63	1.20	-	-	529.20
1997	349.41	13.73	1.12	0.46	0.24	-	-	364.96
1998	528.14	12.93	3.32	6.72	0.05	-	-	551.16
1999	259.35	4.22	3.84	1.92	2.15	-	0.02	271.51
2000	210.70	8.17	0.16	-	0.04	-	-	219.08
2001	173.17	11.83	0.04	-	-	-	-	185.04
2002	164.87	12.85	0.81	0.72	0.13	0.33	-	179.70
2003	142.52	3.71	0.35	-	0.22	-	0.00	146.80
2004	191.80	9.08	0.03	-	0.11	-	0.00	201.03
2005	227.21	13.61	0.17	-	-	-	-	240.99
2006	287.69	4.72	0.01	-	-	-	-	292.41
2007	279.06	13.34	0.07	-	0.02	-	0.00	292.49
2008	222.41	6.04	0.02	-	-	-	-	228.47
2009	195.08	6.66	0.00	-	0.01	-	0.03	201.78
2010	202.38	6.99	0.09	-	0.52	-	-	209.98
2011	279.78	9.37	0.17	-	0.02	-	-	289.35
2012	236.66	6.33	0.20	-	-	-	-	243.18
2013	257.02	3.41	0.04	-	-	-	-	260.47
2014	203.55	4.38	0.00	-	-	-	0.00	207.94
2015	153.35	13.18	0.00	-	0.01	-	0.00	166.54
2016	185.45	44.84	-	-	0.08	-	0.00	230.37
2017	100.96	24.88	0.06	-	-	-	0.00	125.90
2018	96.51	25.66	0.04	-	-	-	-	122.21
2019	57.16	23.51	-	-	-	-	-	80.66
2020	62.80	14.53	-	-	-	-	0.00	77.33
2021	51.31	26.71	-	-	-	-	-	78.02
2022	44.67	8.61	-	-	-	-	-	53.29
2023	23.51	6.87	-	-	-	-	-	30.38
2024	48.12	9.76	-	-	-	-	-	57.88

Table B.5: Annual modal conversion factor reported for product state codes of flatfish from the FLA 2 Quota Management Areas. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HGU = Headed and gutted, MEA = Fish meal, SKF = Fillets: skin-off, SUR = Surimi. – : no observations.

Fishing year	GRE	GUT	HGU	MEA	DRE	FIL	SUR	SKF
1990	1.00	1.10	1.40	5.56	-	-	-	-
1991	1.00	1.10	1.40	-	1.80	-	-	-
1992	1.00	1.10	1.40	-	1.80	-	-	-
1993	1.00	1.10	1.40	-	1.80	-	-	-
1994	1.00	1.10	1.40	-	1.80	-	-	-
1995	1.00	1.10	1.40	-	1.80	-	-	-
1996	1.00	1.10	1.40	-	1.80	-	-	-
1997	1.00	1.10	1.40	-	1.80	-	-	-
1998	1.00	1.10	1.40	-	1.80	-	-	-
1999	1.00	1.10	1.40	-	1.80	1.80	-	-
2000	1.00	1.10	1.40	-	1.80	-	-	-
2001	1.00	1.10	-	-	1.80	-	-	-
2002	1.00	1.10	1.40	-	1.80	-	-	-
2003	1.00	1.10	1.40	-	1.80	1.80	-	-
2004	1.00	1.10	1.40	-	1.80	-	4.30	-
2005	1.00	1.10	-	-	1.80	-	-	-
2006	1.00	1.10	-	-	1.80	-	-	-
2007	1.00	1.10	1.40	-	1.80	1.80	-	-
2008	1.00	1.10	-	-	1.80	-	-	-
2009	1.00	1.10	1.40	-	1.80	1.80	-	-
2010	1.00	1.10	1.40	-	1.80	-	-	-
2011	1.00	1.10	1.40	-	1.80	-	-	-
2012	1.00	1.10	-	-	1.80	-	-	-
2013	1.00	1.10	-	-	1.80	-	-	-
2014	1.00	1.10	-	5.60	1.80	-	-	-
2015	1.00	1.10	1.40	5.60	1.80	-	-	-
2016	1.00	1.10	1.40	5.60	-	-	-	-
2017	1.00	1.10	-	-	1.80	1.80	-	-
2018	1.00	1.10	-	-	1.80	-	-	-
2019	1.00	1.10	-	-	-	-	-	-
2020	1.00	1.10	-	-	-	-	-	2.25
2021	1.00	1.10	-	-	-	-	-	-
2022	1.00	1.10	-	-	-	-	-	-
2023	1.00	1.10	-	-	-	-	-	-
2024	1.00	1.10	-	-	-	-	-	-

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

	Records (N)								Allocated catches (t)							
Fishing year	CEL	TCP	Other	NCE	TCE	ERS - Trawl	ERS - Netting	Total	CEL	TCP	Other	NCE	TCE	ERS - Trawl	ERS - Netting	Total
1990	2744	-	-	-	-	-	-	2744	248.34	-	-	-	-	-	-	248.34
1991	3116	93	-	-	-	-	-	3209	289.49	0.26	-	-	-	-	-	289.75
1992	3797	260	-	-	-	-	-	4057	275.54	0.96	-	-	-	-	-	276.50
1993	4414	261	-	-	-	-	-	4675	453.10	2.84	-	-	-	-	-	455.93
1994	4519	934	-	-	-	-	-	5453	372.78	22.66	-	-	-	-	-	395.44
1995	4774	1088	-	-	-	-	-	5862	471.24	18.36	-	-	-	-	-	489.60
1996	4546	1578	2	-	-	-	-	6126	484.10	23.20	0.00	-	-	-	-	507.30
1997	3863	1170	2	-	-	-	-	5035	318.41	11.20	0.02	-	-	-	-	329.64
1998	4332	1161	-	-	-	-	-	5493	493.85	29.92	-	-	-	-	-	523.77
1999	4108	851	-	-	-	-	-	4959	244.66	7.04	-	-	-	-	-	251.69
2000	4011	773	-	-	-	-	-	4784	200.80	4.40	-	-	-	-	-	205.20
2001	3615	1084	-	-	-	-	-	4699	162.93	6.57	-	-	-	-	-	169.50
2002	3707	1256	6	-	-	-	-	4969	157.65	9.40	0.46	-	-	-	-	167.51
2003	3828	1294	-	-	-	-	-	5122	128.46	4.47	-	-	-	-	-	132.93
2004	3304	1600	-	-	-	-	-	4904	157.38	14.98	-	-	-	-	-	172.36
2005	3691	1899	1	-	-	-	-	5591	210.07	12.51	0.00	-	-	-	-	222.58
2006	3774	1982	-	4	-	-	-	5760	249.17	18.74	-	0.00	-	-	-	267.91
2007	3459	1722	-	528	-	-	-	5709	239.68	15.82	-	22.03	-	-	-	277.53
2008	535	1247	7	789	7576	-	-	10154	19.71	4.56	0.00	31.04	168.81	-	-	224.12
2009	601	1208	79	685	7436	-	-	10009	16.09	4.76	0.04	28.14	152.64	-	-	201.67
2010	466	1510	19	776	8726	-	-	11497	9.80	8.28	0.00	32.23	153.23	-	-	203.53
2011	560	1265	18	713	9083	-	-	11639	11.85	8.73	0.03	31.31	234.08	-	-	286.00
2012	494	681	73	672	8405	-	-	10325	10.20	1.26	0.01	34.17	191.57	-	-	237.21
2013	430	433	37	509	8740	-	-	10149	8.87	0.72	0.02	34.42	205.52	-	-	249.56
2014	355	832	137	522	9097	-	-	10943	9.77	1.73	0.12	8.96	181.61	-	-	202.19
2015	486	937	41	670	7706	-	-	9840	10.31	1.09	0.01	32.16	119.87	-	-	163.44
2016	372	678	3	509	7236	-	-	8798	18.26	1.16	0.00	17.22	191.90	-	-	228.54
2017	391	726	25	437	6564	-	-	8143	8.93	1.40	0.01	12.54	100.85	-	-	123.73
2018	407	278	12	355	6144	225	-	7421	5.58	0.18	0.11	10.20	102.98	1.00	-	120.05
2019	290	25	52	236	4224	2033	40	6900	3.17	0.00	0.55	0.89	57.72	14.86	0.26	77.46
2020	-	-	198	7	236	5700	523	6664	-	-	1.11	0.00	7.55	62.38	5.81	76.84
2021	-	-	193	-	-	5414	353	5960	-	-	1.36	-	-	68.59	7.90	77.85
2022	-	-	47	-	-	4885	476	5408	-	-	0.10	-	-	43.70	6.84	50.64
2023	-	-	105	-	-	3373	509	3987	-	-	0.46	-	-	25.64	4.14	30.24
2024	-	-	106	-	-	3926	516	4548	-	-	0.77	-	-	53.01	4.04	57.82

Table B.7: Allocated catches (t) of flatfish in FLA 2 by method of capture and fishing year. A complete list of fishing method codes is provided in Table D.3. – : no observations.

Fishing year	BPT	BT	SN	DS	Other	Total
1990	1.34	206.37	40.62	-	0.01	248.34
1991	1.43	232.59	55.41	0.31	0.01	289.75
1992	5.27	229.99	41.06	-	0.17	276.50
1993	6.23	426.96	22.19	0.00	0.54	455.93
1994	6.60	374.07	14.65	-	0.11	395.44
1995	2.75	466.61	19.62	0.57	0.05	489.60
1996	4.32	458.18	36.76	3.15	4.89	507.30
1997	2.21	308.58	16.00	1.13	1.72	329.64
1998	1.15	487.71	33.17	0.99	0.76	523.77
1999	0.01	237.27	13.00	0.56	0.86	251.69
2000	0.00	174.52	27.93	2.71	0.04	205.20
2001	0.07	149.50	14.70	5.13	0.10	169.50
2002	-	142.41	19.64	4.86	0.61	167.51
2003	-	112.08	20.44	0.16	0.24	132.93
2004	0.40	155.41	16.39	0.02	0.14	172.36
2005	-	208.90	13.34	0.17	0.18	222.58
2006	0.00	238.90	28.15	0.00	0.85	267.91
2007	0.02	230.24	45.78	1.29	0.19	277.53
2008	0.00	174.89	47.76	1.42	0.05	224.12
2009	-	157.37	42.33	1.82	0.15	201.67
2010	0.01	161.46	41.38	0.62	0.06	203.53
2011	-	242.79	40.97	2.16	0.09	286.00
2012	-	192.83	40.63	3.72	0.03	237.21
2013	-	206.22	42.68	0.59	0.07	249.56
2014	-	183.33	18.71	-	0.15	202.19
2015	-	120.94	39.28	3.16	0.06	163.44
2016	-	193.04	24.80	10.67	0.02	228.54
2017	-	102.13	19.01	2.43	0.16	123.73
2018	-	103.71	13.56	2.20	0.58	120.05
2019	-	72.45	4.25	0.61	0.15	77.46
2020	-	69.86	5.81	1.09	0.07	76.84
2021	-	68.39	7.90	1.36	0.20	77.85
2022	-	43.64	6.84	0.10	0.05	50.64
2023	-	25.59	4.14	0.46	0.06	30.24
2024	-	52.95	4.04	0.77	0.06	57.82

APPENDIX C: ADDITIONAL CPUE SERIES

C.1 Hawke Bay FLA BT-FLA day

This series is an alternative to the long-term series created by by Schofield et al. (2018b) which was accepted by the INSWG in 2018 for monitoring FLA 2 abundance. This series is also a daily-effort pseudo-CELR analysis in order to extend the series back in time to the initiation of the data collection period in October 1989 and it relaxes the vessel selection criteria to four trips in only four years, the same criteria used for the event-based CPUE analyses. However, it cannot be accepted either because the relaxed vessel selection criteria still result in a single vessel in 2024 and two vessels in both 2022 and 2023 (Table C.3)).

Table C.1: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-FLA day CPUE series.

Series	Hawke Bay FLA BT-FLA day
QMS stock	FLA 2
Reporting forms	CEL, ERS - Trawl, TCE, TCP
Fishing methods	BT
Target species	FLA
Statistical Areas	013, 014
Period	1989-10-01, 2024-09-30
Resolution	Day
Core fleet years	4
Core fleet trips	4
Default model	allockg ~ fyear + vessel_key + stat_area + month + ns(log(fishing_duration), 3) + ns(effort_height, 3) + ns(effort_num, 3)
Stepwise selection	No
Positive catch distribution	Weibull

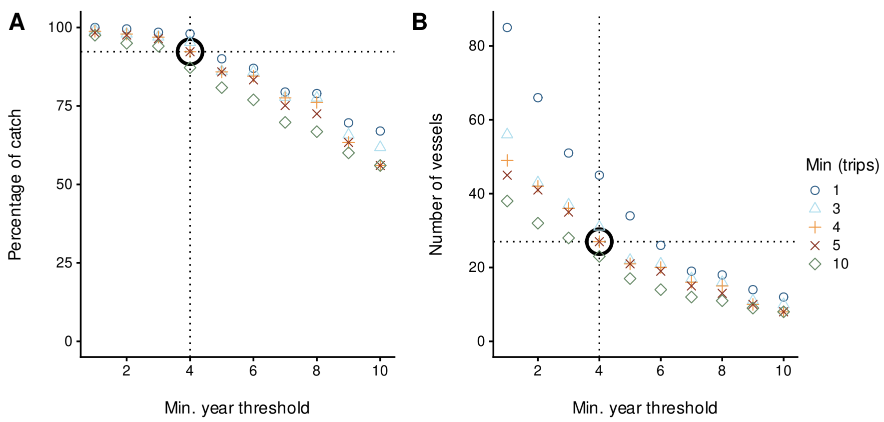

Figure C.1: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-FLA day CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated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

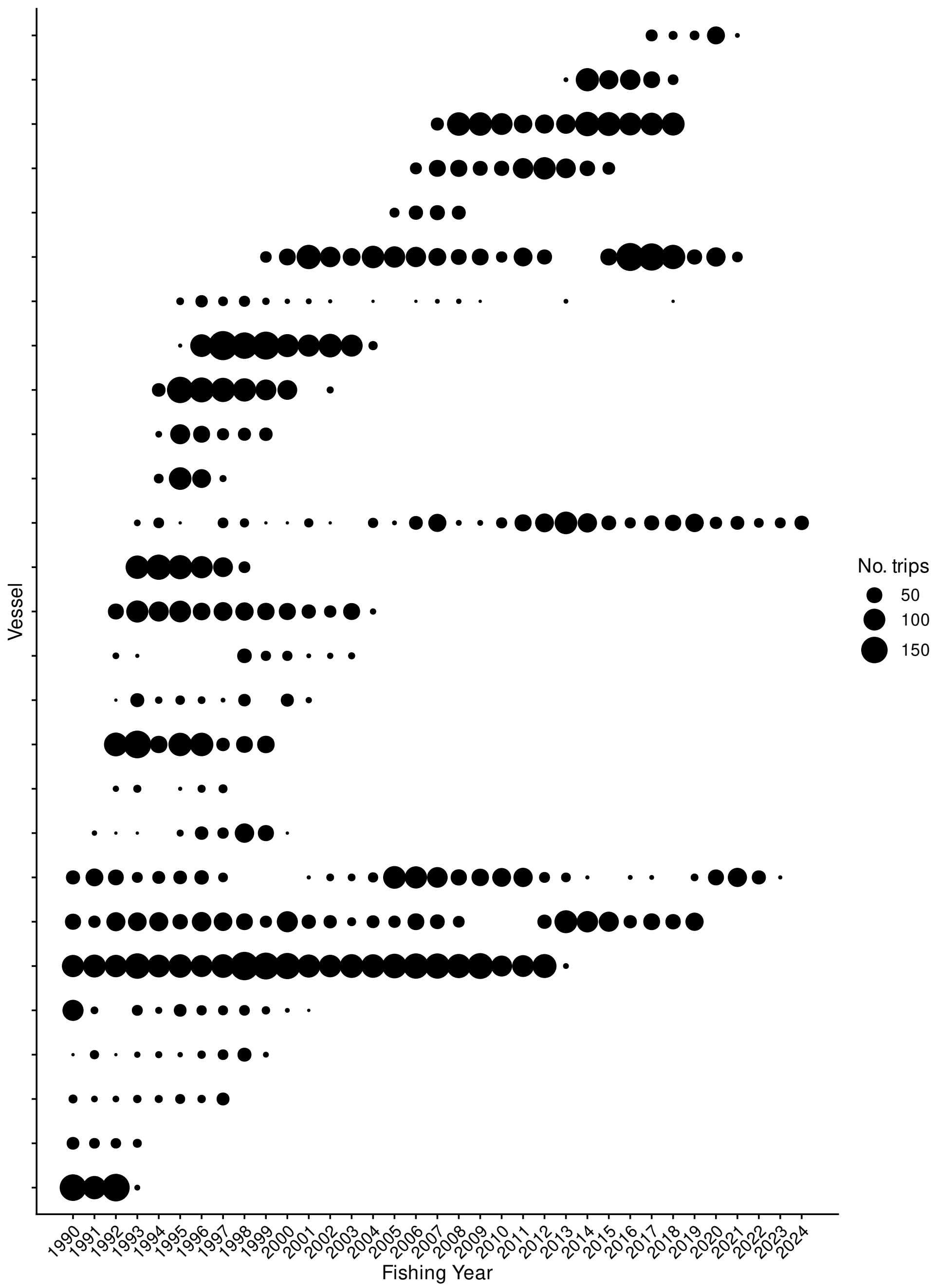

Figure C.2: Number of trips by fishing year for core vessels in the Hawke Bay FLA BT-FLA day series. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

Table C.2: Summary of the Hawke Bay FLA BT-FLA day 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. Catch data for years with less than three vessels are omitted (indicated by x). (Continued on next page)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	143 (100%) n: 647	116 (100%) n: 485	127 (100%) n: 711	253 (100%) n: 946	152 (100%) n: 774	261 (100%) n: 1219	265 (100%) n: 1383	216 (100%) n: 1382	331 (100%) n: 1436
Positive fishing duration	142 (99%) n: 642	115 (99%) n: 481	127 (100%) n: 711	253 (100%) n: 945	152 (100%) n: 773	259 (100%) n: 1216	261 (98%) n: 1367	211 (98%) n: 1349	324 (98%) n: 1410
Fishing duration less than 20 h	142 (99%) n: 642	115 (99%) n: 479	123 (96%) n: 708	243 (96%) n: 938	151 (99%) n: 771	251 (96%) n: 1199	259 (98%) n: 1361	210 (97%) n: 1342	316 (95%) n: 1378
Less than 7 tows	141 (99%) n: 637	115 (99%) n: 472	123 (96%) n: 708	240 (95%) n: 934	148 (97%) n: 765	248 (95%) n: 1193	258 (97%) n: 1353	207 (96%) n: 1332	310 (94%) n: 1369
Headline height less than 10 m	141 (99%) n: 637	115 (99%) n: 472	122 (96%) n: 705	240 (95%) n: 932	145 (95%) n: 754	245 (94%) n: 1186	255 (96%) n: 1329	204 (95%) n: 1315	304 (92%) n: 1348
Core fleet selection	120 (84%) n: 513	100 (86%) n: 414	107 (84%) n: 647	231 (91%) n: 863	135 (88%) n: 711	234 (90%) n: 1147	242 (91%) n: 1287	187 (87%) n: 1209	252 (76%) n: 1171

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	146 (100%) n: 1028	95 (100%) n: 778	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Positive fishing duration	142 (97%) n: 1008	94 (99%) n: 772	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Fishing duration less than 20 h	139 (95%) n: 996	94 (99%) n: 772	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (99%) n: 371	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Less than 7 tows	139 (95%) n: 994	94 (99%) n: 771	82 (100%) n: 524	71 (100%) n: 482	47 (97%) n: 401	66 (99%) n: 371	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Headline height less than 10 m	137 (94%) n: 982	94 (99%) n: 771	82 (100%) n: 524	71 (100%) n: 480	47 (97%) n: 396	65 (99%) n: 366	90 (100%) n: 411	110 (97%) n: 528	120 (100%) n: 609
Core fleet selection	112 (76%) n: 813	85 (89%) n: 680	73 (89%) n: 491	65 (91%) n: 461	46 (95%) n: 393	59 (89%) n: 343	87 (96%) n: 398	109 (97%) n: 522	115 (95%) n: 596

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	90 (100%) n: 558	74 (100%) n: 478	60 (100%) n: 373	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Positive fishing duration	90 (100%) n: 557	74 (100%) n: 478	60 (100%) n: 371	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Fishing duration less than 20 h	90 (100%) n: 556	74 (100%) n: 477	60 (100%) n: 371	129 (100%) n: 551	96 (100%) n: 590	139 (100%) n: 524	113 (100%) n: 676	75 (100%) n: 522	141 (100%) n: 489
Less than 7 tows	90 (100%) n: 556	74 (100%) n: 477	60 (100%) n: 371	129 (100%) n: 551	96 (100%) n: 590	139 (100%) n: 524	113 (100%) n: 676	75 (100%) n: 522	141 (100%) n: 489
Headline height less than 10 m	89 (99%) n: 553	74 (100%) n: 476	60 (100%) n: 371	129 (100%) n: 551	96 (100%) n: 590	139 (100%) n: 523	113 (100%) n: 676	75 (100%) n: 521	141 (100%) n: 489
Core fleet selection	89 (99%) n: 552	71 (95%) n: 463	60 (100%) n: 371	126 (97%) n: 544	95 (99%) n: 584	134 (96%) n: 518	106 (93%) n: 591	68 (91%) n: 469	114 (81%) n: 462

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	67 (100%) n: 497	72 (100%) n: 411	36 (100%) n: 258	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Positive fishing duration	67 (100%) n: 497	72 (100%) n: 411	36 (100%) n: 256	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Fishing duration less than 20 h	67 (100%) n: 496	72 (100%) n: 410	36 (100%) n: 255	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Less than 7 tows	67 (100%) n: 496	72 (100%) n: 410	36 (100%) n: 255	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Headline height less than 10 m	67 (99%) n: 495	72 (100%) n: 410	36 (99%) n: 253	38 (98%) n: 241	33 (100%) n: 191	x (99%) n: 62	x (44%) n: 24	x (73%) n: 42
Core fleet selection	62 (91%) n: 486	71 (98%) n: 404	35 (96%) n: 250	38 (98%) n: 241	33 (100%) n: 190	x (99%) n: 62	x (44%) n: 24	x (73%) n: 42

Table C.3: Summary of the Hawke Bay FLA BT-FLA day dataset after core fleet selection. 'Records' indicates the number of rows (days) in the dataset, and 'Records caught' indicates the percentage of days with catches of flatfish. Catch and effort data for years with less than three vessels are omitted (indicated by x).

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	8	486	513	3 301.92	120.00	99.22
1991	9	377	414	2 735.00	99.92	100.00
1992	13	609	647	4 420.48	106.52	99.23
1993	16	735	863	6 627.30	231.07	99.65
1994	14	614	711	5 119.97	134.57	98.03
1995	18	971	1 147	9 149.85	233.94	98.26
1996	17	1 007	1 287	9 680.28	242.17	98.52
1997	18	891	1 209	8 677.87	187.07	94.62
1998	15	928	1 171	8 155.93	251.74	91.20
1999	14	724	813	5 615.30	111.58	92.87
2000	12	610	680	4 476.35	84.73	97.79
2001	11	454	491	3 504.42	72.84	98.17
2002	10	403	461	3 033.40	65.32	99.57
2003	7	377	393	2 612.47	46.10	99.49
2004	8	317	343	2 338.92	59.17	99.71
2005	6	384	398	2 598.60	86.65	100.00
2006	8	489	522	3 087.22	108.67	99.81
2007	9	539	596	3 423.63	114.73	99.33
2008	9	476	552	3 445.98	88.85	97.28
2009	7	429	463	2 808.58	70.93	98.92
2010	6	358	371	2 098.38	60.18	96.23
2011	6	467	544	3 333.57	125.91	91.91
2012	7	483	584	3 595.78	94.80	88.18
2013	8	407	518	3 363.77	133.95	94.02
2014	6	464	591	3 608.82	105.87	96.28
2015	6	413	469	2 831.43	68.02	98.29
2016	6	426	462	3 023.20	114.09	99.13
2017	7	458	486	2 872.92	61.58	94.44
2018	7	374	404	2 306.58	70.93	96.29
2019	5	211	250	1 365.93	34.70	98.40
2020	4	223	241	1 350.82	37.72	90.04
2021	4	137	190	1 068.08	32.77	98.42
2022	2	x	62	x	x	98.39
2023	2	x	24	x	x	91.67
2024	1	x	42	x	x	97.62

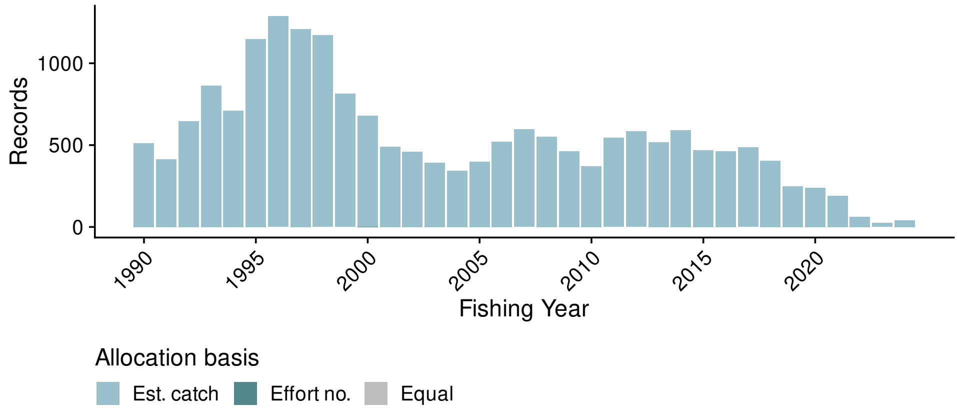

Figure C.3: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

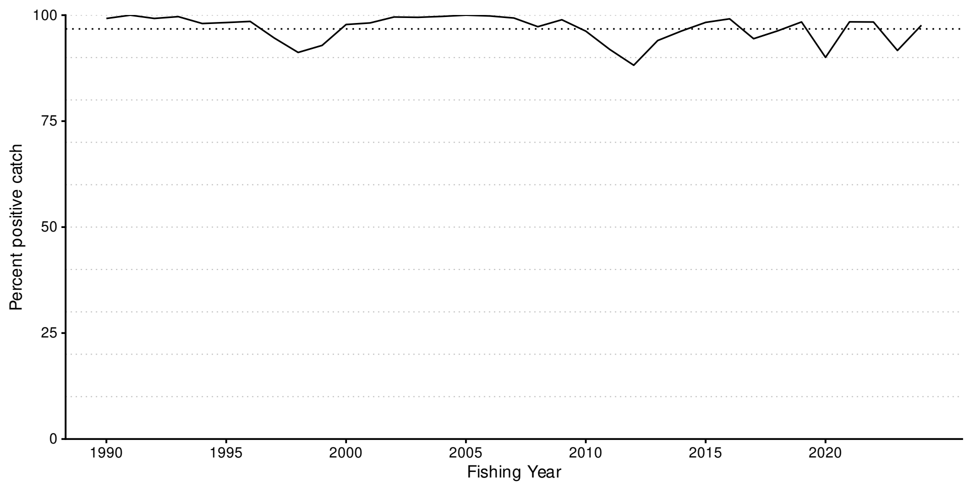

Figure C.4: Percentage of positive catch records in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

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

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	228 171.2	0.00	0.00	*
fyear	34	227 112.9	3.51	3.51	*
vessel_key	26	225 182.2	9.68	6.17	*
stat_area	1	224 878.4	10.63	0.95	*
month	11	223 940.5	13.62	2.99	*
ns(log(fishing_duration), 3)	3	220 601.4	24.03	10.41	*
ns(effort_height, 3)	3	220 570.2	24.15	0.12	*
ns(effort_num, 3)	3	219 502.5	27.49	3.34	*

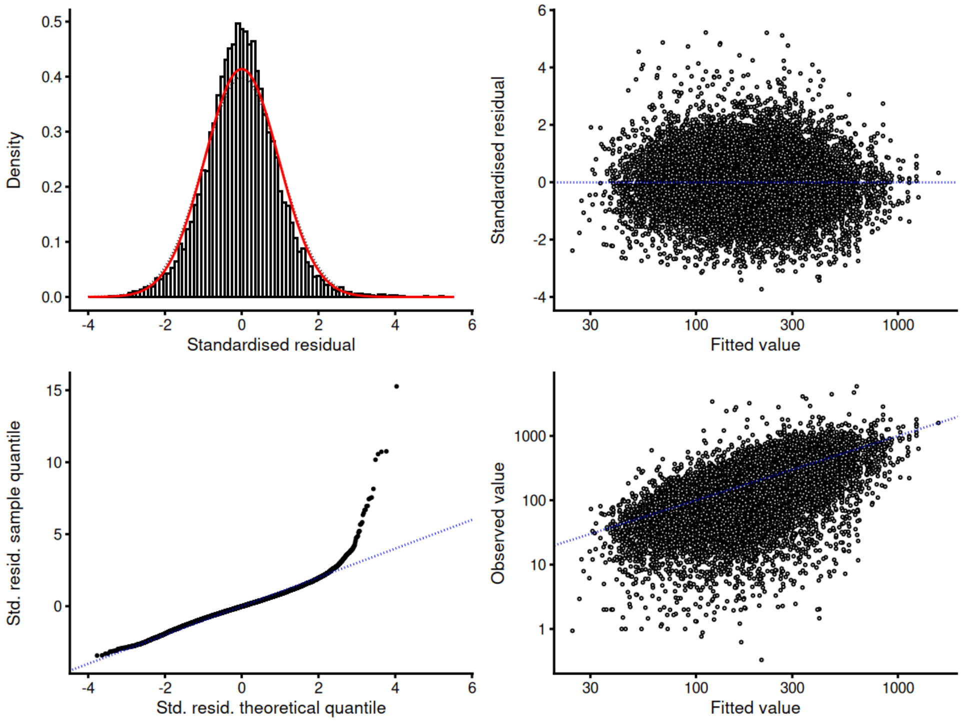

Figure C.5: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-FLA day dataset.

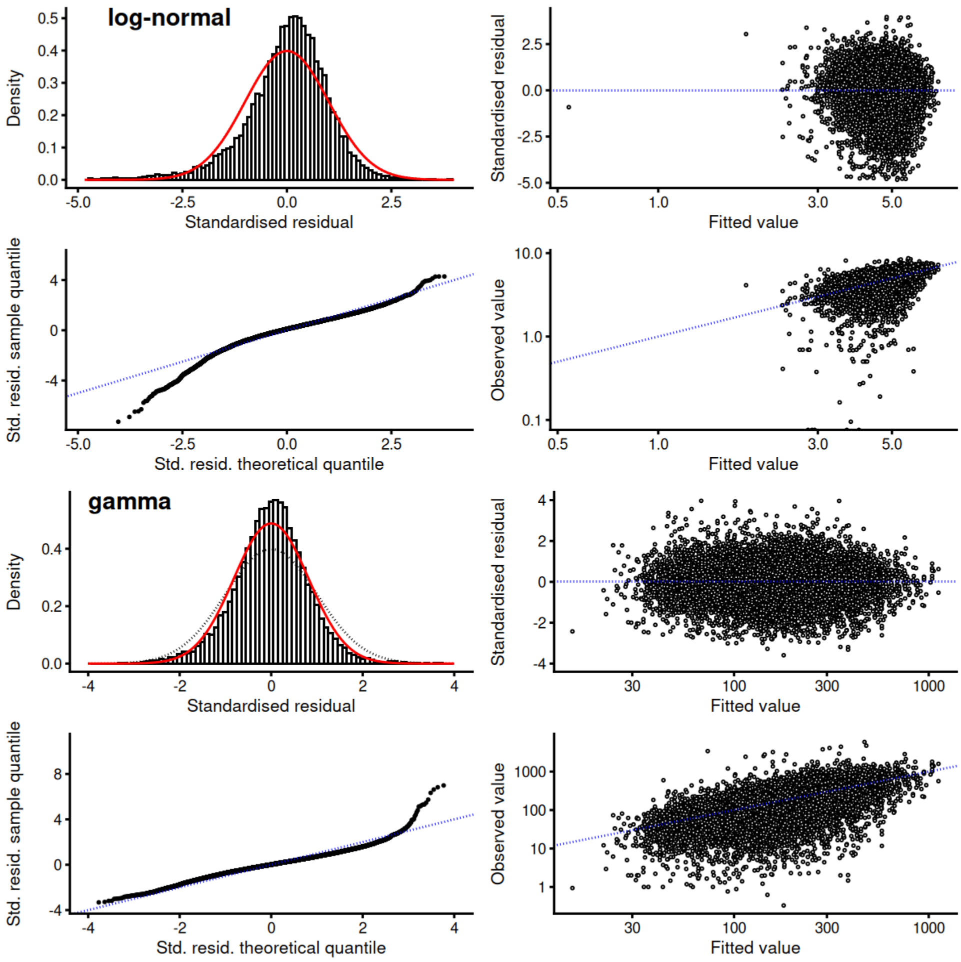

Figure C.6: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-FLA day dataset.

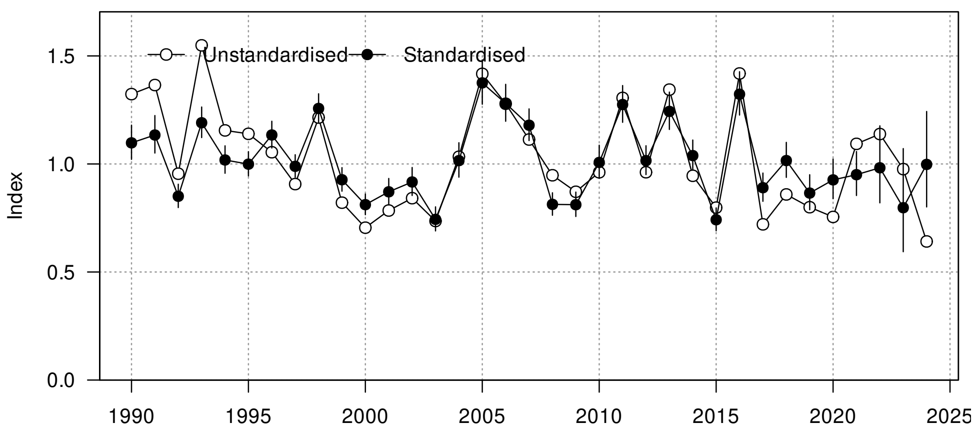

Figure C.7: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-FLA day dataset.

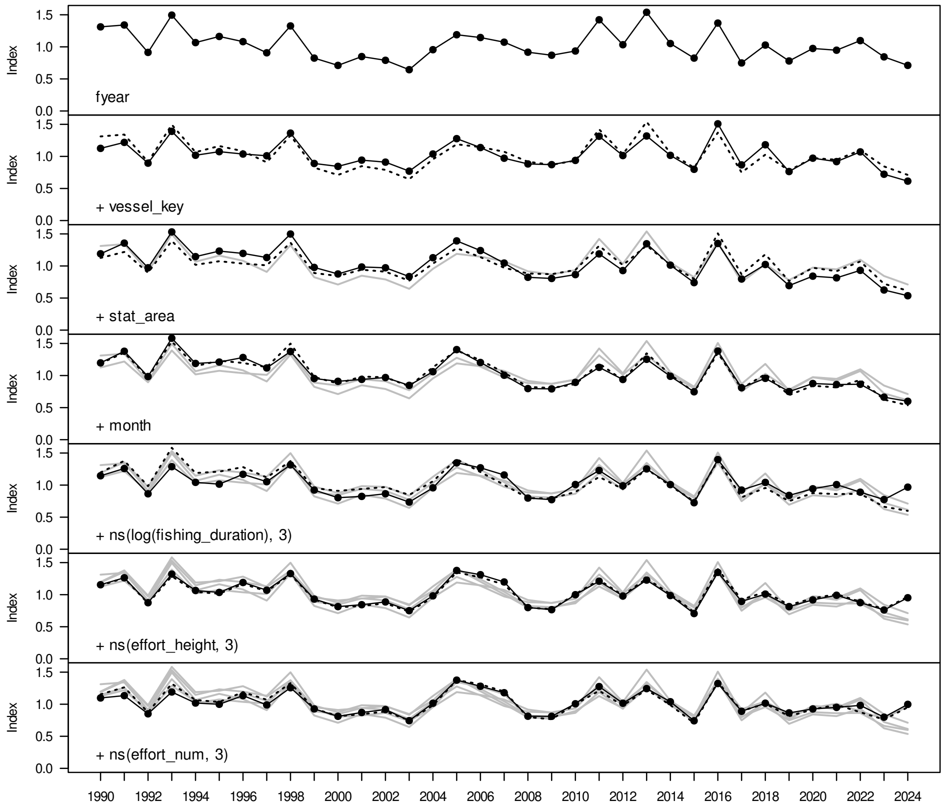

Figure C.8: Changes to the Hawke Bay FLA BT-FLA day positive catch index as terms are successively entered into the Weibull model.

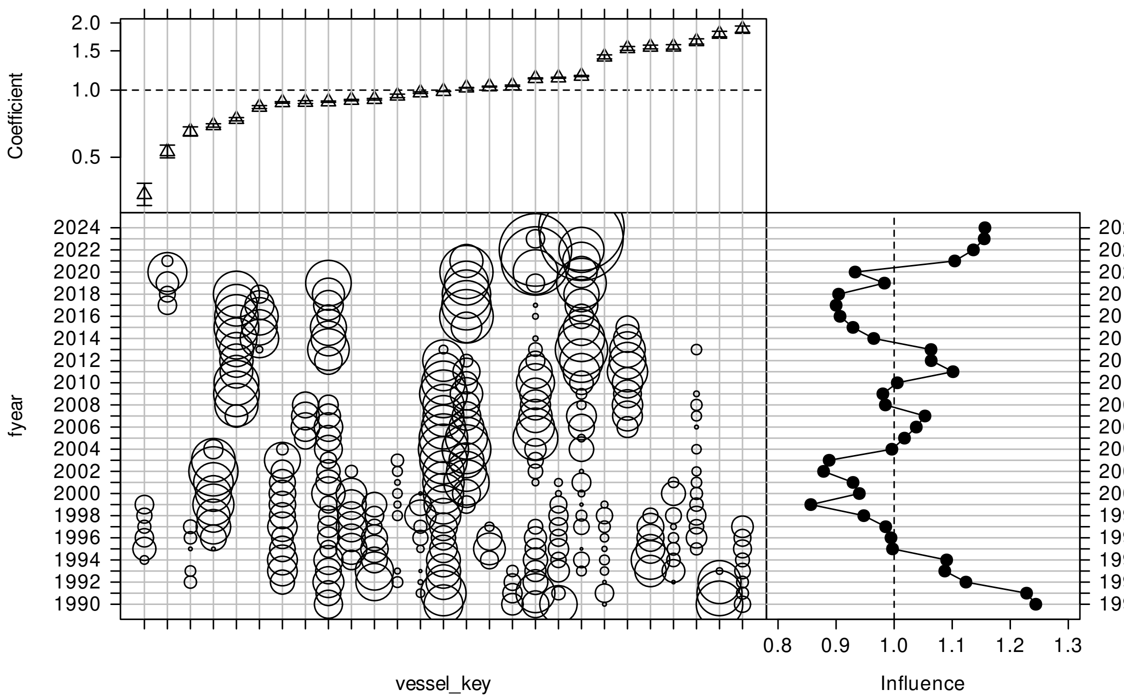

Figure C.9: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

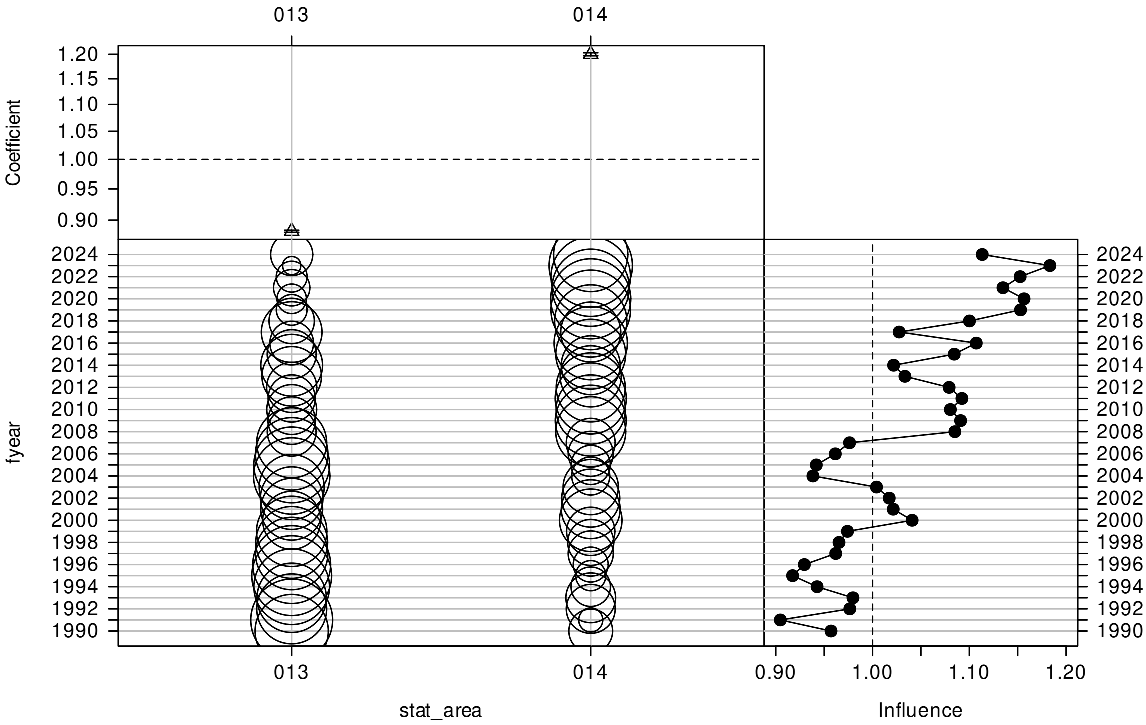

Figure C.10: CDI plot for statistical area for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

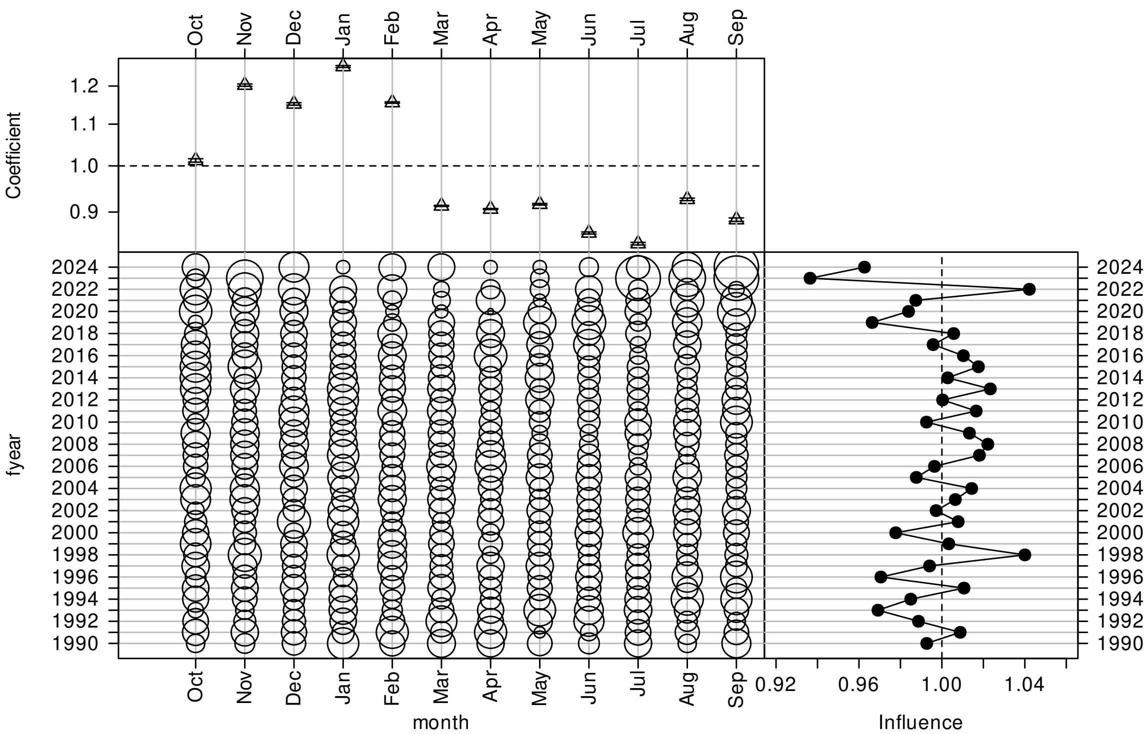

Figure C.11: CDI plot for month for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

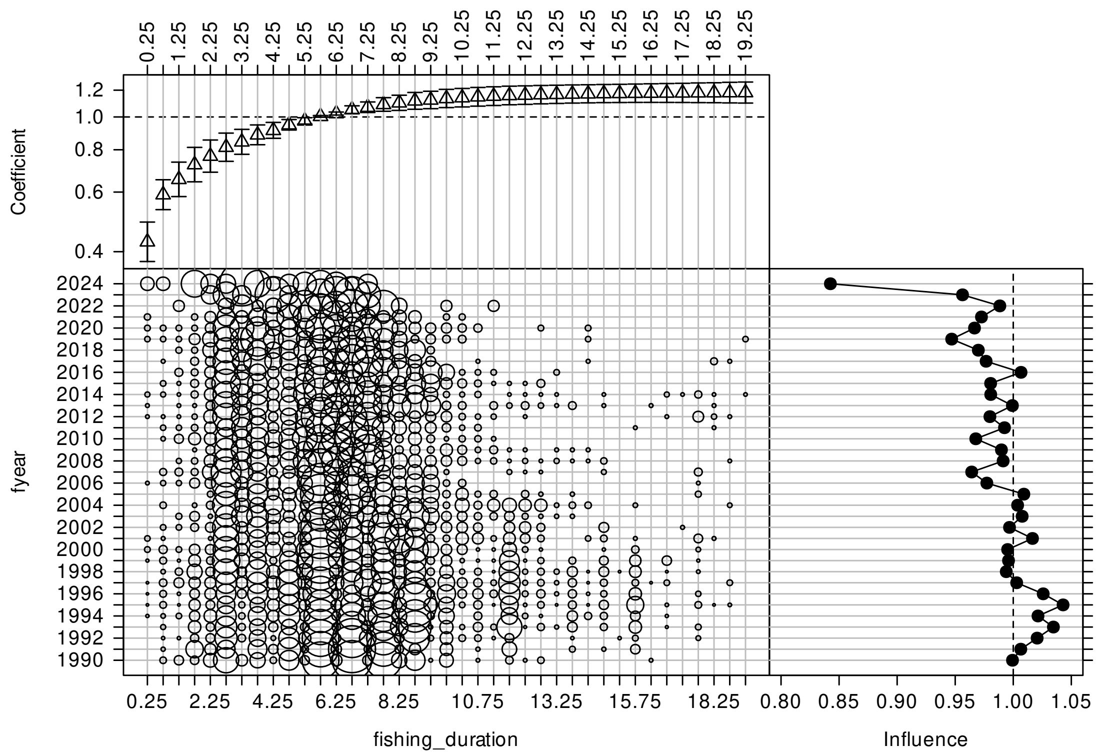

Figure C.12: CDI plot for fishing duration (h) for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

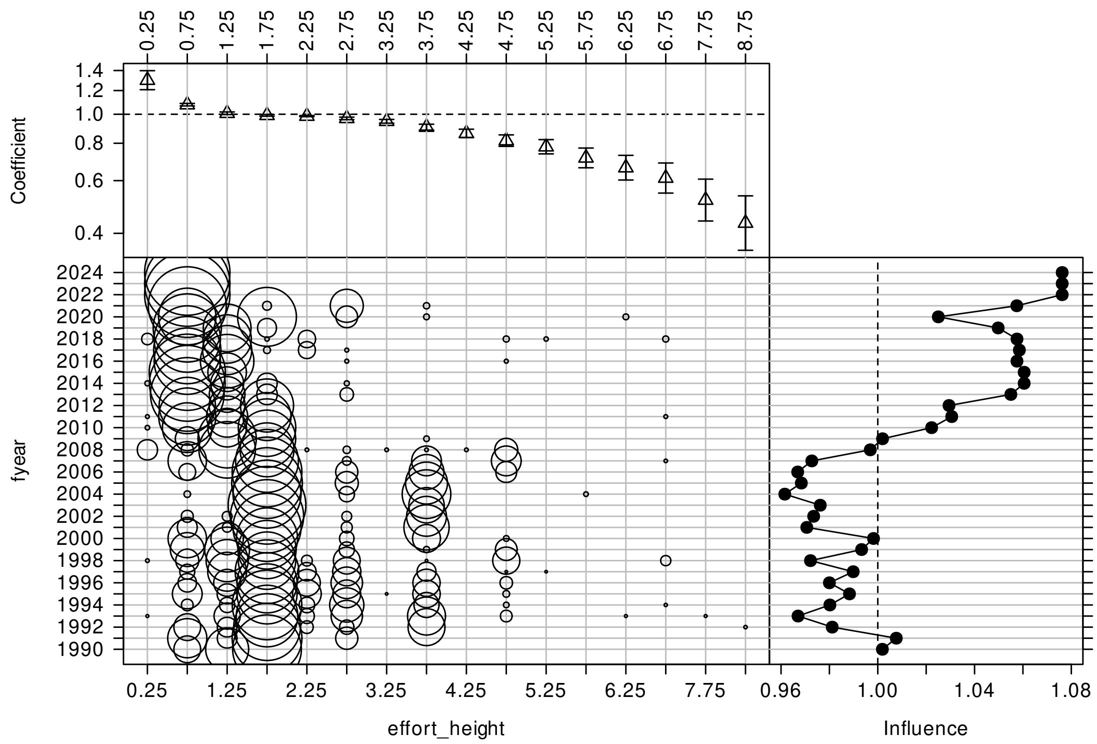

Figure C.13: CDI plot for effort height (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

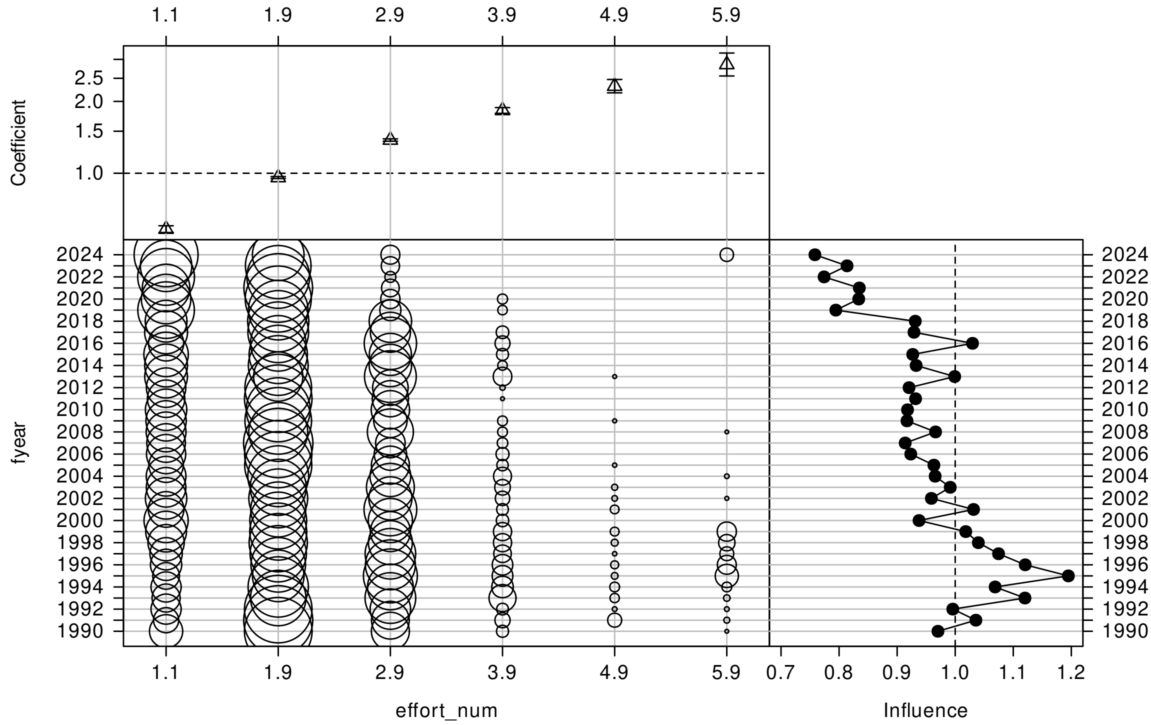

Figure C.14: CDI plot for effort num for the Weibull model of positive catches in the Hawke Bay FLA BT-FLA day catch-per-unit-effort dataset.

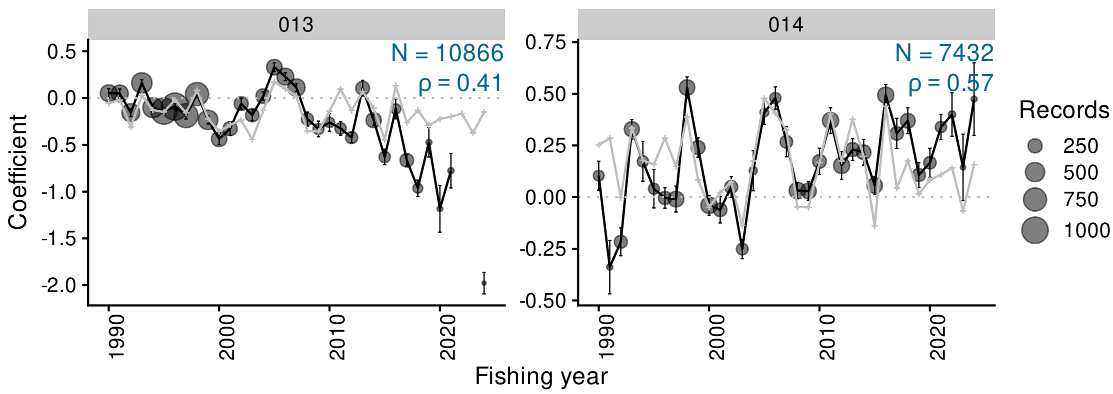

Figure C.15: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-FLA day dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 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.

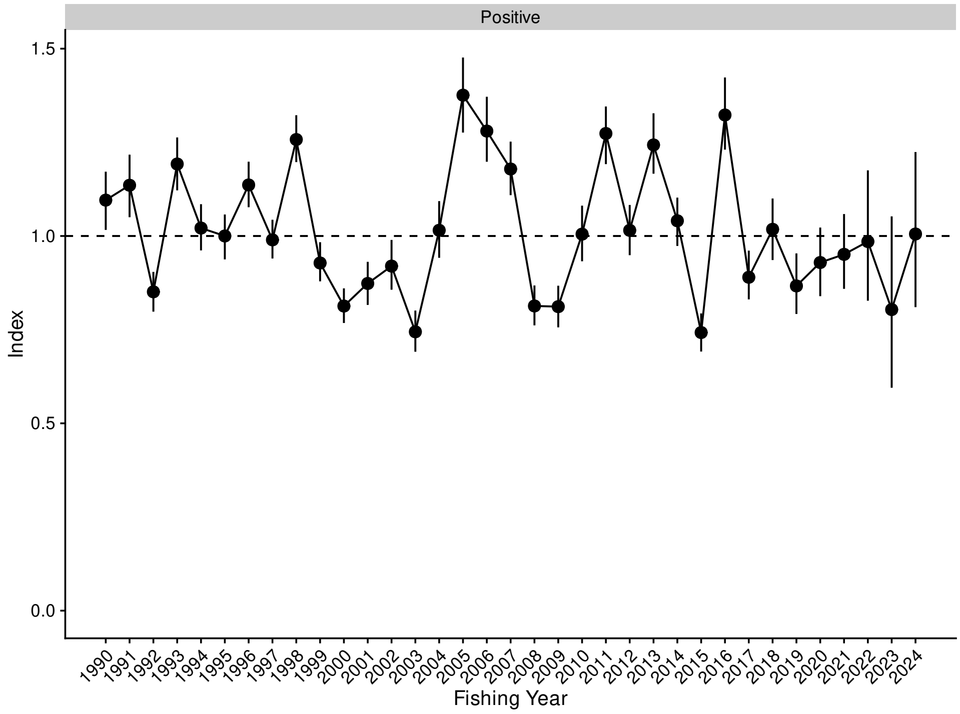

Figure C.16: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-FLA day dataset.

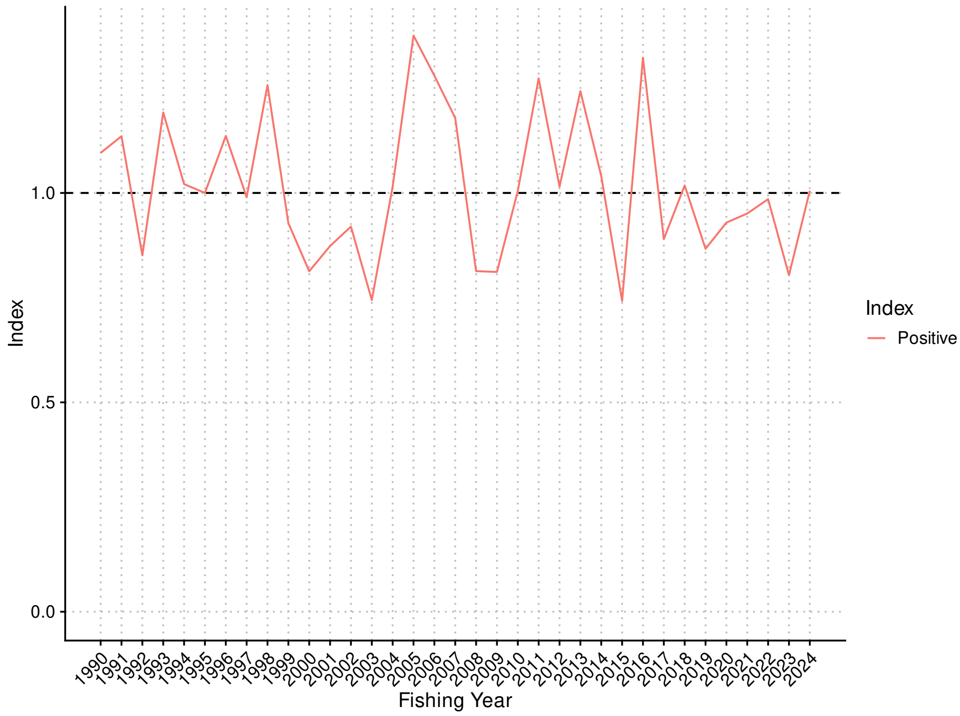

Figure C.17: Standardised indices for the Hawke Bay FLA BT-FLA day dataset.

Table C.5: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for the Hawke Bay FLA BT-FLA day series.

	Positive			
Fishing year	index	SE	LCI	UCI
1990	1.096	0.040	1.016	1.172
1991	1.135	0.043	1.050	1.217
1992	0.851	0.027	0.798	0.904
1993	1.192	0.036	1.122	1.263
1994	1.021	0.031	0.962	1.085
1995	1.000	0.031	0.938	1.057
1996	1.136	0.031	1.077	1.198
1997	0.990	0.026	0.940	1.043
1998	1.257	0.032	1.197	1.322
1999	0.928	0.027	0.879	0.983
2000	0.813	0.024	0.768	0.860
2001	0.873	0.029	0.816	0.931
2002	0.920	0.034	0.857	0.990
2003	0.744	0.028	0.691	0.801
2004	1.015	0.039	0.942	1.093
2005	1.376	0.051	1.276	1.476
2006	1.280	0.044	1.198	1.372
2007	1.179	0.036	1.109	1.252
2008	0.813	0.027	0.761	0.868
2009	0.811	0.028	0.756	0.867
2010	1.005	0.038	0.932	1.081
2011	1.274	0.039	1.192	1.346
2012	1.015	0.034	0.949	1.083
2013	1.243	0.041	1.166	1.328
2014	1.041	0.033	0.973	1.102
2015	0.742	0.026	0.692	0.793
2016	1.323	0.049	1.230	1.423
2017	0.890	0.033	0.831	0.961
2018	1.018	0.042	0.936	1.100
2019	0.867	0.041	0.792	0.954
2020	0.929	0.047	0.839	1.023
2021	0.951	0.051	0.859	1.059
2022	0.985	0.089	0.827	1.175
2023	0.804	0.117	0.595	1.052
2024	1.005	0.106	0.810	1.224

C.2 Hawke Bay FLA BT-MIX event (stepwise)

This CPUE analysis is presented as a sensitivity analysis to the procedure adopted for this report of accepting all the explanatory variables without going through a stepwise selection of variables with a cutoff at 1% of additional deviance (see discussion in the final paragraph of Section 4.1). This model uses the same criteria as specified for the Hawke Bay FLA BT-MIX event model (Section 4.2) except that a stepwise selection procedure was specified which was stopped using the 1% improvement rule (compare Table C.6 with Table 4).

Figure C.37 compares the event-based combined target FLA/GUR BT CPUE series based on the aggregate flatfish (FLA) catch which accepted all explanatory variables without undergoing a selection procedure (as documented in Section 4.2) with an analysis using the same data set and model criteria but with the explanatory variables selected in a stepwise manner, beginning with the variable which explained the greatest amount of model deviance and stopping the selection procedure when the improvement in explained deviance dropped below 1% (documented in Appendix C.2). The INSWG noted that these two series were very similar, indicating that both procedures resulted in similar models with equivalent conclusions.

Table C.6: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-MIX event (stepwise) CPUE series.

Series	Hawke Bay FLA BT-MIX event (stepwise)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	allockg_top8 ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3) + ns(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

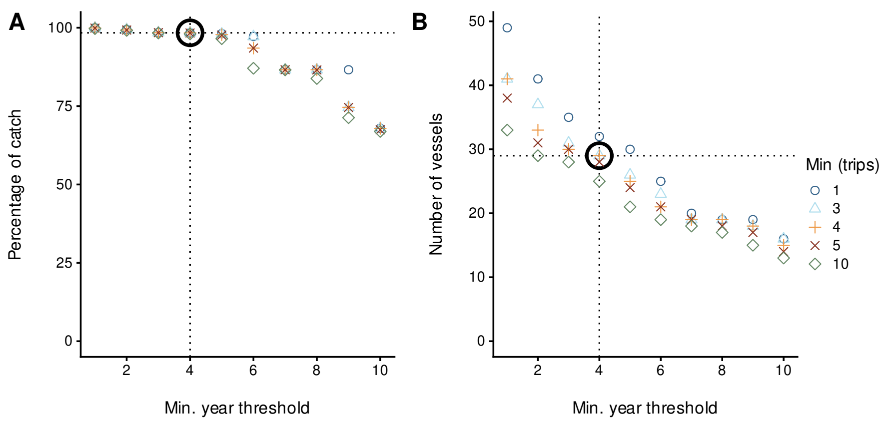

Figure C.18: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-MIX event (stepwise) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

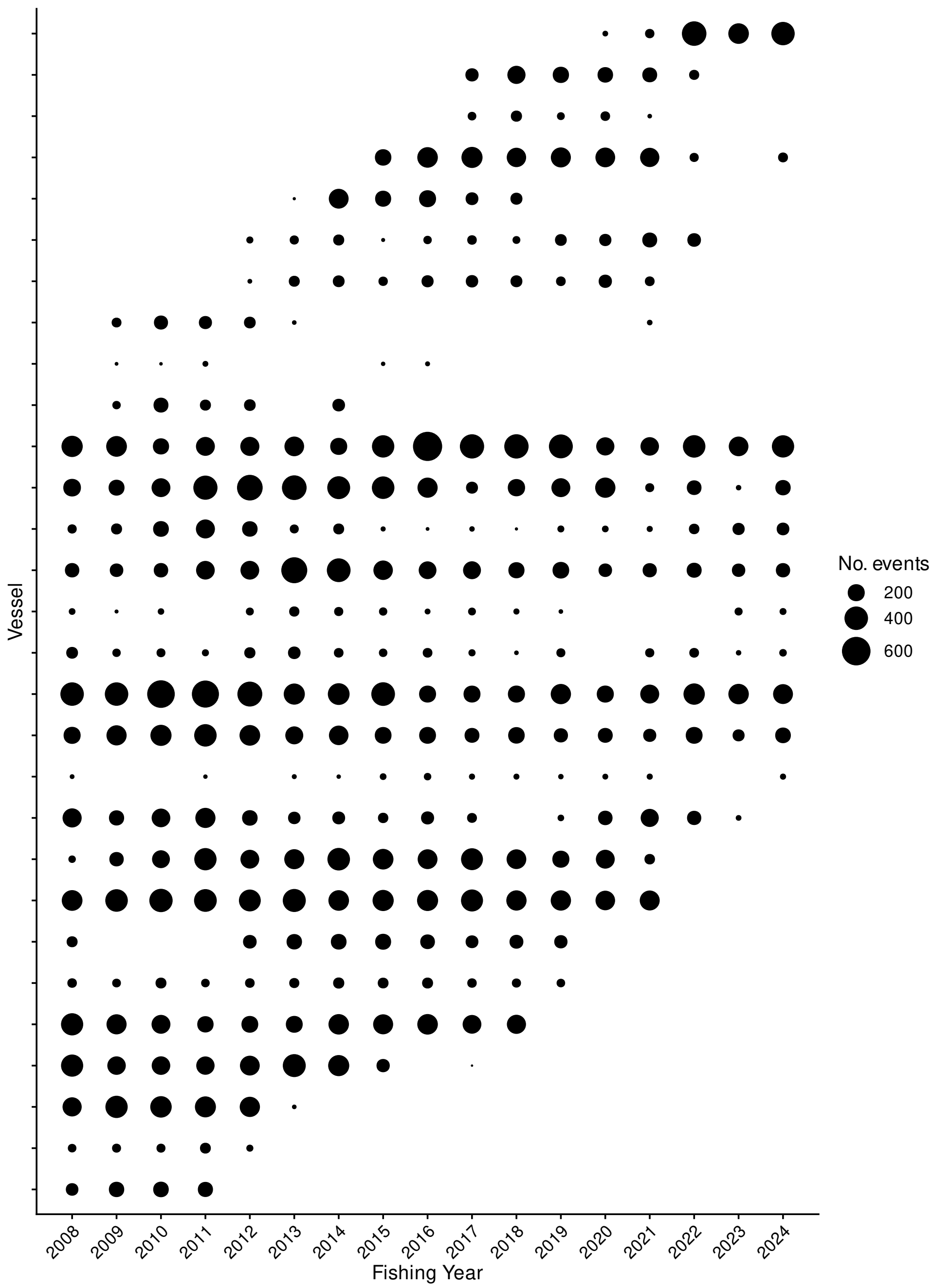

Figure C.19: Number of events by fishing year for core vessels in the Hawke Bay FLA BT-MIX event (stepwise) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.7: Summary of the Hawke Bay FLA BT-MIX event (stepwise) 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	132 (100%) n: 3836	113 (100%) n: 3542	119 (100%) n: 4050	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4248	90 (100%) n: 3637	166 (100%) n: 3539
Positive fishing duration	132 (100%) n: 3834	113 (100%) n: 3539	118 (100%) n: 4048	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4247	90 (100%) n: 3636	166 (100%) n: 3539
Fishing duration less than 6 h	132 (100%) n: 3813	113 (99%) n: 3515	118 (99%) n: 4033	195 (100%) n: 4365	148 (99%) n: 3966	169 (99%) n: 3713	141 (98%) n: 4223	90 (100%) n: 3625	166 (100%) n: 3516
Bottom depth < 150m	132 (100%) n: 3810	113 (99%) n: 3514	118 (99%) n: 4030	195 (100%) n: 4362	148 (99%) n: 3963	169 (99%) n: 3713	141 (98%) n: 4221	90 (100%) n: 3622	166 (100%) n: 3515
Trawl opening < 10m	131 (99%) n: 3802	112 (99%) n: 3504	118 (99%) n: 4030	195 (100%) n: 4357	148 (99%) n: 3963	169 (99%) n: 3710	141 (98%) n: 4212	90 (100%) n: 3618	166 (100%) n: 3515
Core fleet selection	121 (92%) n: 3282	111 (98%) n: 3307	117 (99%) n: 3935	195 (100%) n: 4330	148 (98%) n: 3945	168 (99%) n: 3690	132 (92%) n: 3962	84 (93%) n: 3468	166 (100%) n: 3510

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2800	53 (100%) n: 2513	55 (100%) n: 2190	36 (100%) n: 2438	22 (100%) n: 1523	47 (100%) n: 1886
Positive fishing duration	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2793	53 (100%) n: 2507	55 (100%) n: 2186	36 (100%) n: 2437	22 (100%) n: 1521	47 (100%) n: 1884
Fishing duration less than 6 h	85 (99%) n: 3097	87 (100%) n: 3054	55 (99%) n: 2752	52 (99%) n: 2458	55 (99%) n: 2153	35 (99%) n: 2415	21 (99%) n: 1482	47 (100%) n: 1859
Bottom depth < 150m	85 (99%) n: 3097	87 (100%) n: 3053	55 (99%) n: 2749	52 (99%) n: 2457	55 (99%) n: 2151	35 (99%) n: 2407	21 (99%) n: 1478	47 (100%) n: 1853
Trawl opening < 10m	84 (99%) n: 3092	87 (100%) n: 3052	54 (98%) n: 2735	51 (97%) n: 2438	55 (99%) n: 2151	32 (90%) n: 2192	15 (71%) n: 1259	45 (95%) n: 1735
Core fleet selection	84 (99%) n: 3080	87 (100%) n: 3045	54 (98%) n: 2699	51 (97%) n: 2419	55 (99%) n: 2150	32 (89%) n: 2115	15 (71%) n: 1259	45 (95%) n: 1735

Table C.8: Summary of the Hawke Bay FLA BT-MIX event (stepwise) 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	19	907	3 282	10 909.67	121.44	70.87
2009	20	976	3 307	11 398.92	110.86	65.62
2010	20	1 087	3 935	13 682.43	117.22	65.41
2011	20	1 092	4 330	15 160.38	194.90	65.98
2012	21	1 072	3 945	13 663.73	147.73	64.23
2013	21	907	3 690	12 705.20	168.40	64.09
2014	20	999	3 962	13 785.72	132.22	61.33
2015	21	928	3 468	12 170.10	84.31	61.56
2016	20	1 019	3 510	12 206.58	165.66	69.34
2017	22	924	3 080	10 780.47	84.15	64.42
2018	20	871	3 045	10 804.97	86.86	63.91
2019	19	720	2 699	10 256.27	54.23	55.24
2020	16	635	2 419	9 527.27	51.30	56.88
2021	18	625	2 150	7 822.68	54.79	64.98
2022	12	570	2 115	7 741.13	31.85	60.09
2023	10	320	1 259	4 892.80	15.23	58.94
2024	11	418	1 735	6 184.00	44.61	56.14

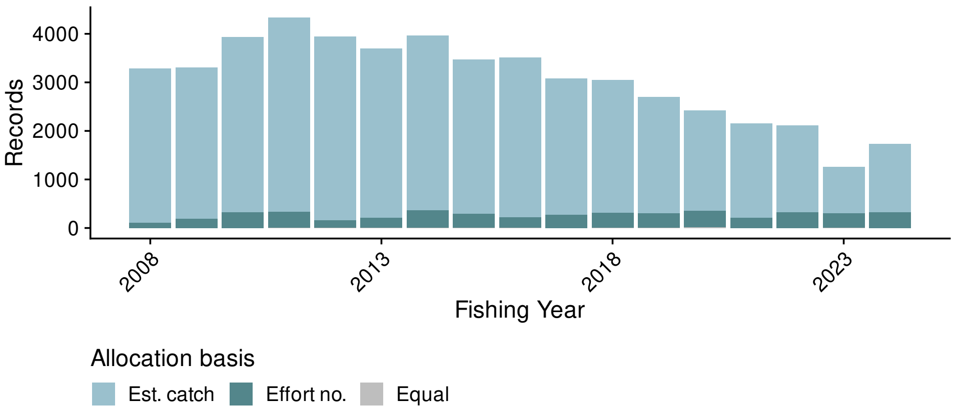

Figure C.20: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.9: Summary of stepwise selection for occurrence of positive catch in the Hawke Bay FLA BT-MIX event (stepwise) 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	15	67 801	0.5	0.5	*
+ ns(bottom_depth, 3)	3	56 303	17.4	16.9	*
+ vessel_key	28	54 065	20.8	3.4	*
+ target_species	1	53 251	22.0	1.2	*
+ month	11	53 055	22.3	0.3	
+ ns(effort_height, 3)	3	52 979	22.4	0.1	
+ ns(log(fishing_duration), 3)	3	52 918	22.5	0.1	

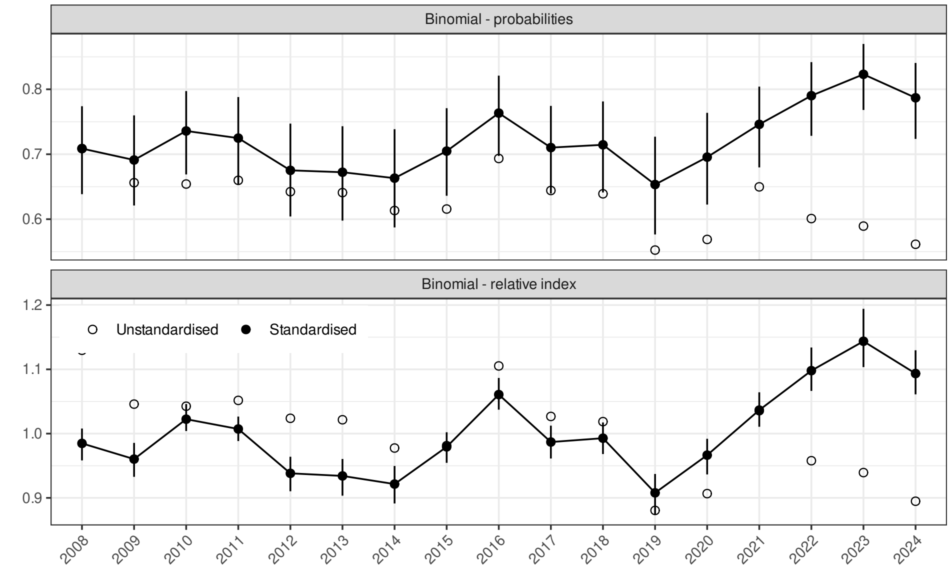

Figure C.21: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay FLA BT-MIX event (stepwise) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

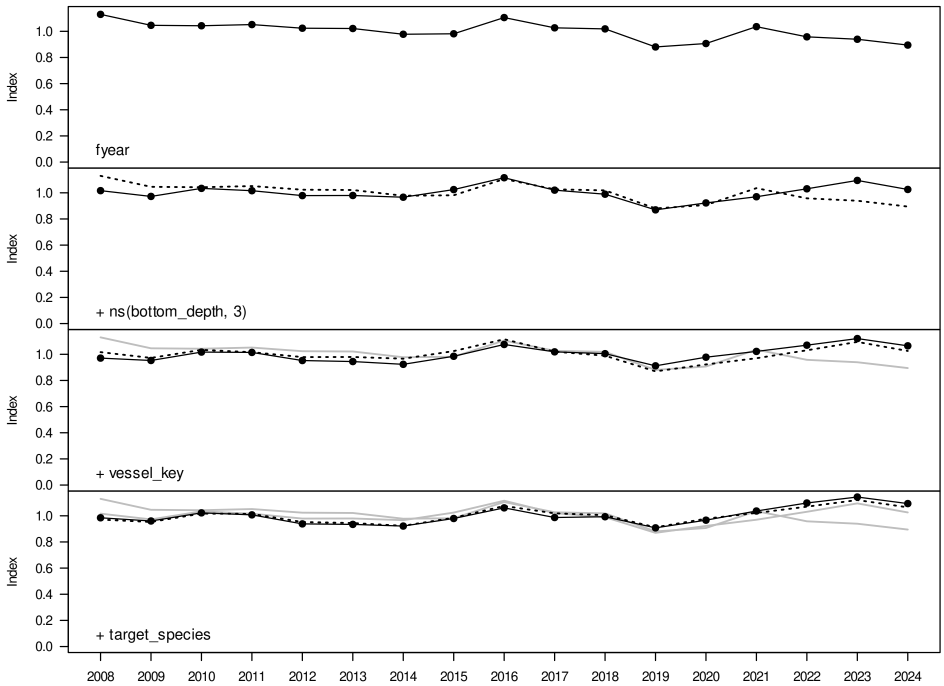

Figure C.22: Step plot for occurrence of catch in the Hawke Bay FLA BT-MIX event (stepwise) dataset.

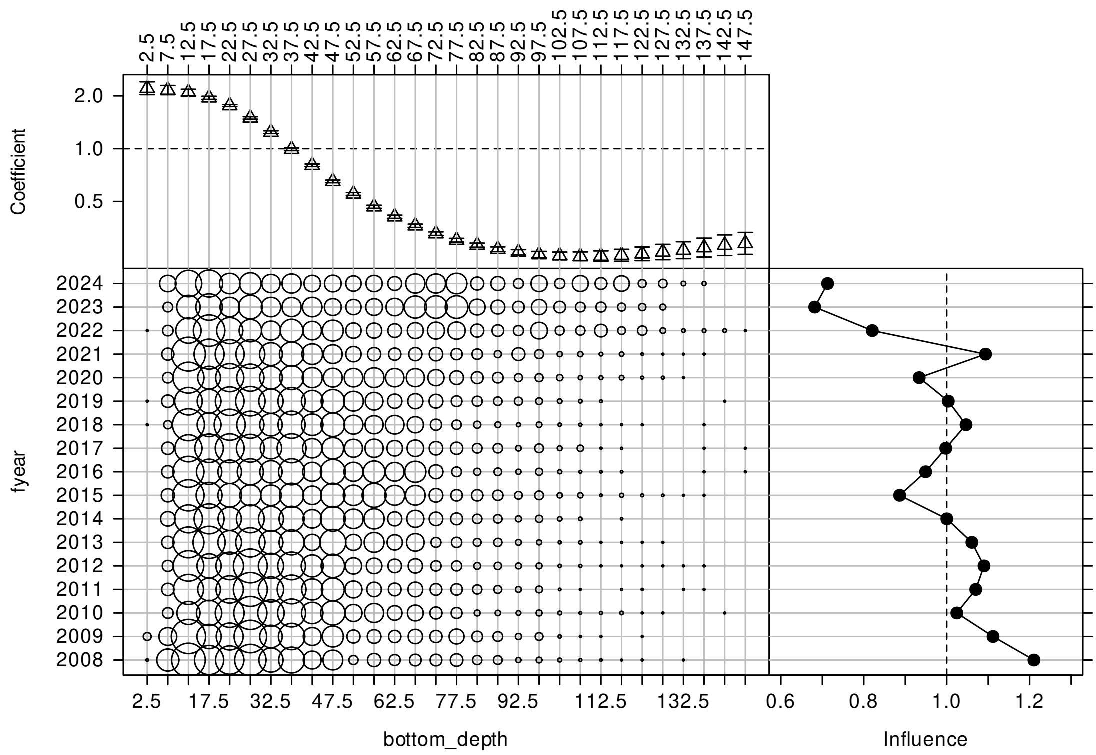

Figure C.23: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

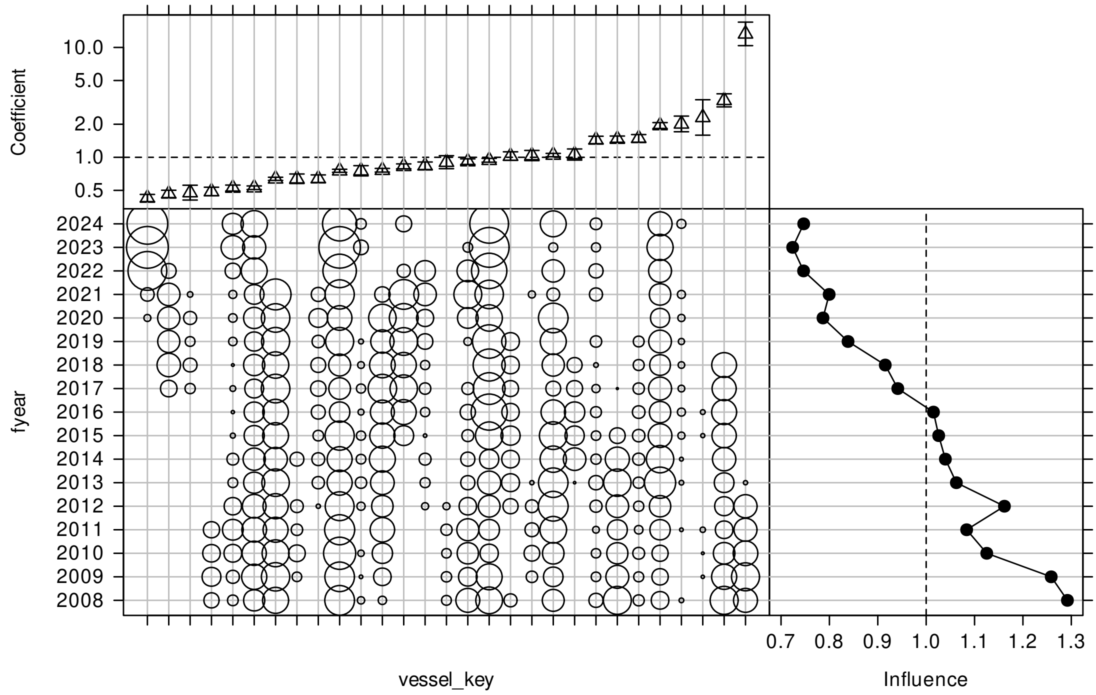

Figure C.24: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

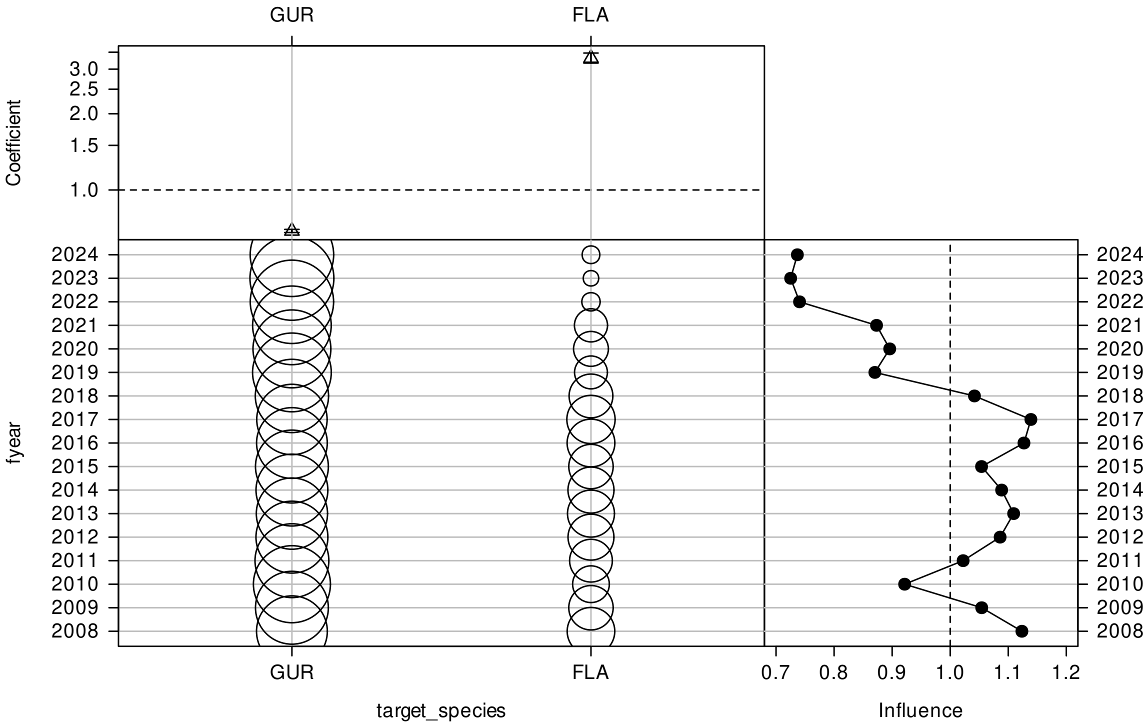

Figure C.25: CDI plot for target species for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

Table C.10: Summary of stepwise selection for the Weibull model for positive catches in the Hawke Bay FLA BT-MIX event (stepwise) 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	18	314 388	3.7	3.7	*
+ ns(bottom_depth, 3)	3	300 996	39.5	35.7	*
+ vessel_key	28	298 339	46.7	7.2	*
+ target_species	1	296 212	52.4	5.7	*
+ ns(log(fishing_duration), 3)	3	296 054	52.8	0.4	
+ month	11	295 939	53.2	0.4	
+ stat_area	1	295 835	53.5	0.3	
+ ns(effort_height, 3)	3	295 781	53.6	0.2	

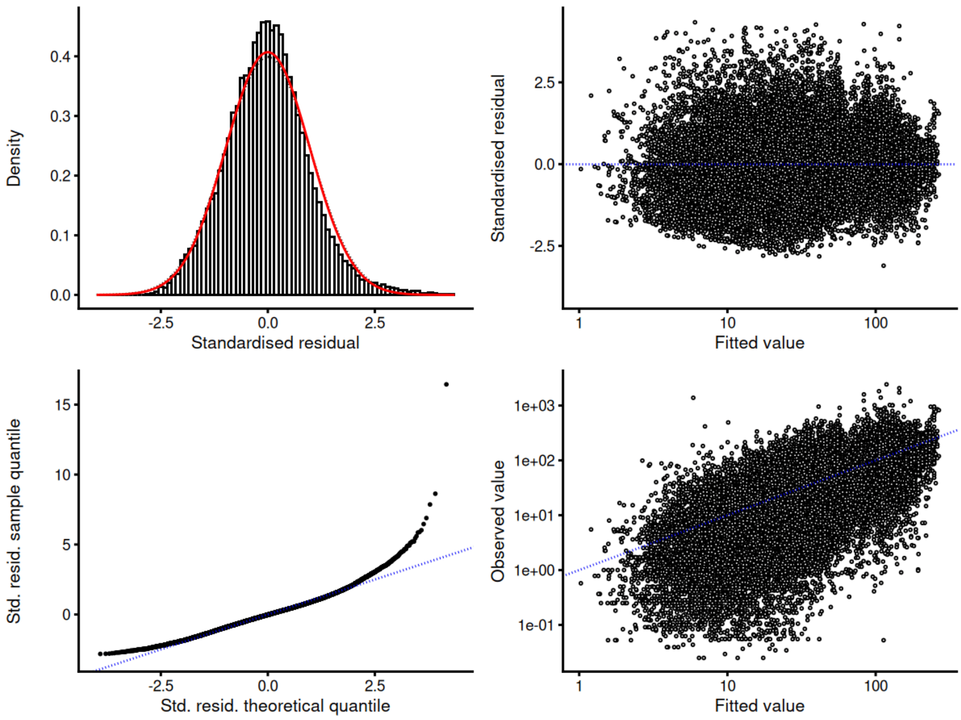

Figure C.26: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-MIX event (stepwise) dataset.

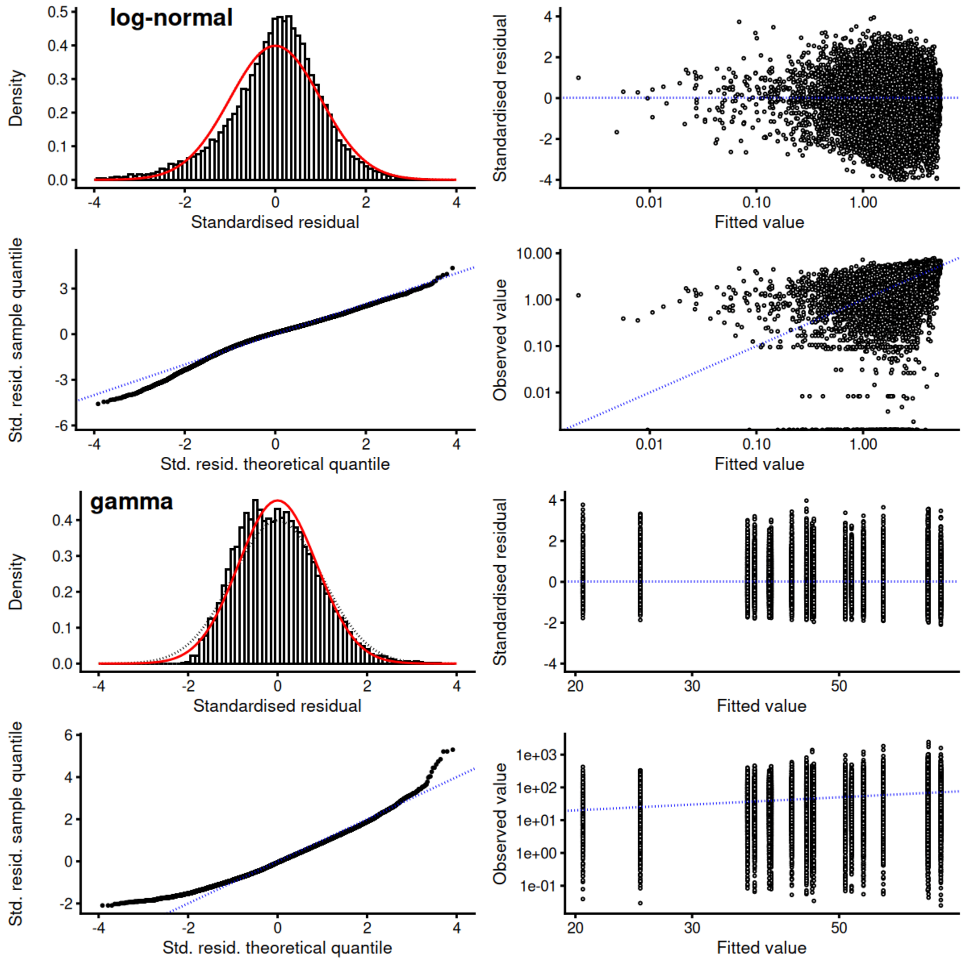

Figure C.27: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-MIX event (stepwise) dataset.

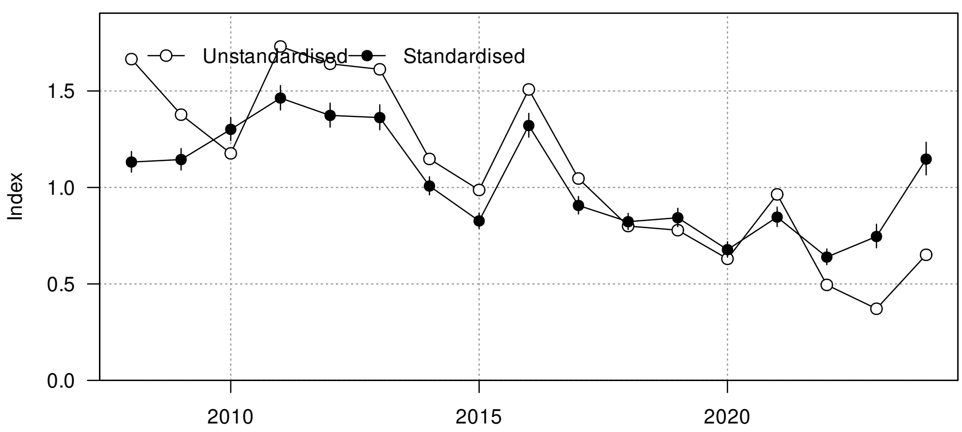

Figure C.28: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-MIX event (stepwise) dataset.

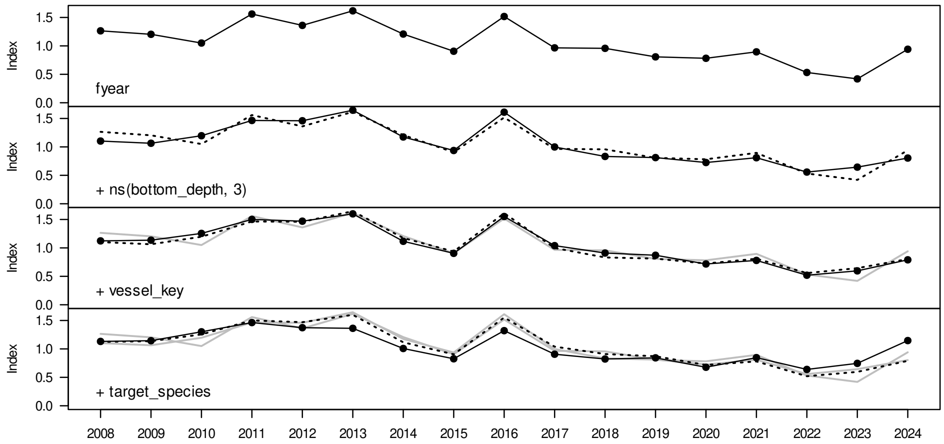

Figure C.29: Changes to the Hawke Bay FLA BT-MIX event (stepwise) positive catch index as terms are successively entered into the Weibull model.

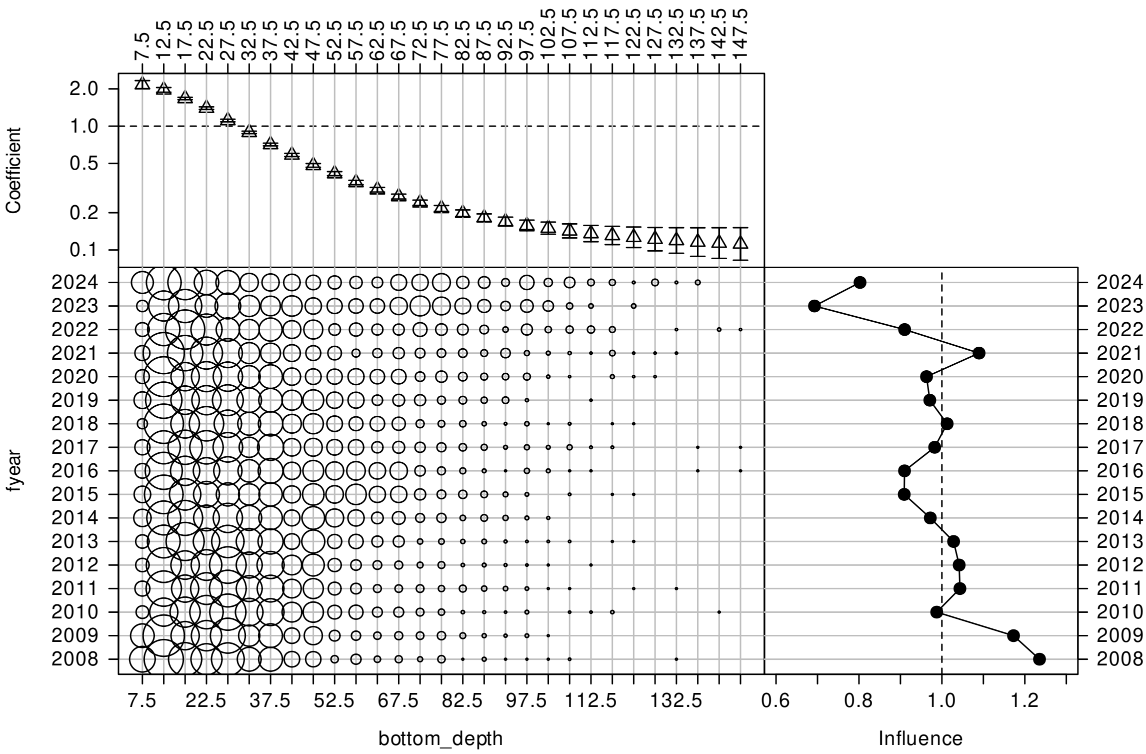

Figure C.30: CDI plot for bottom depth (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

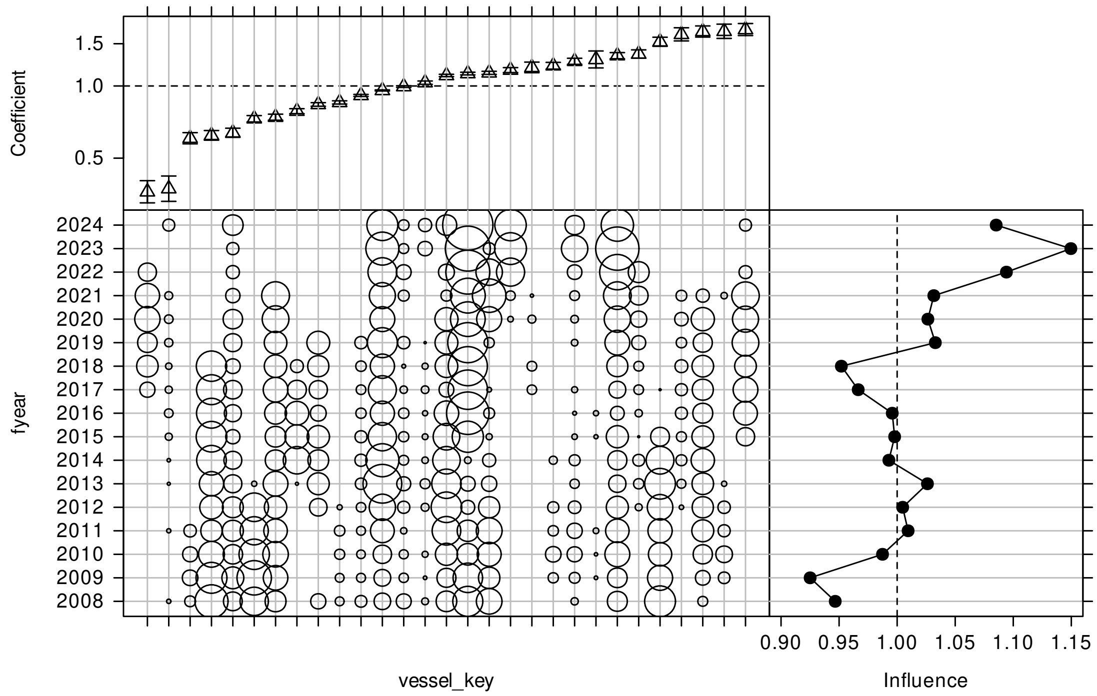

Figure C.31: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

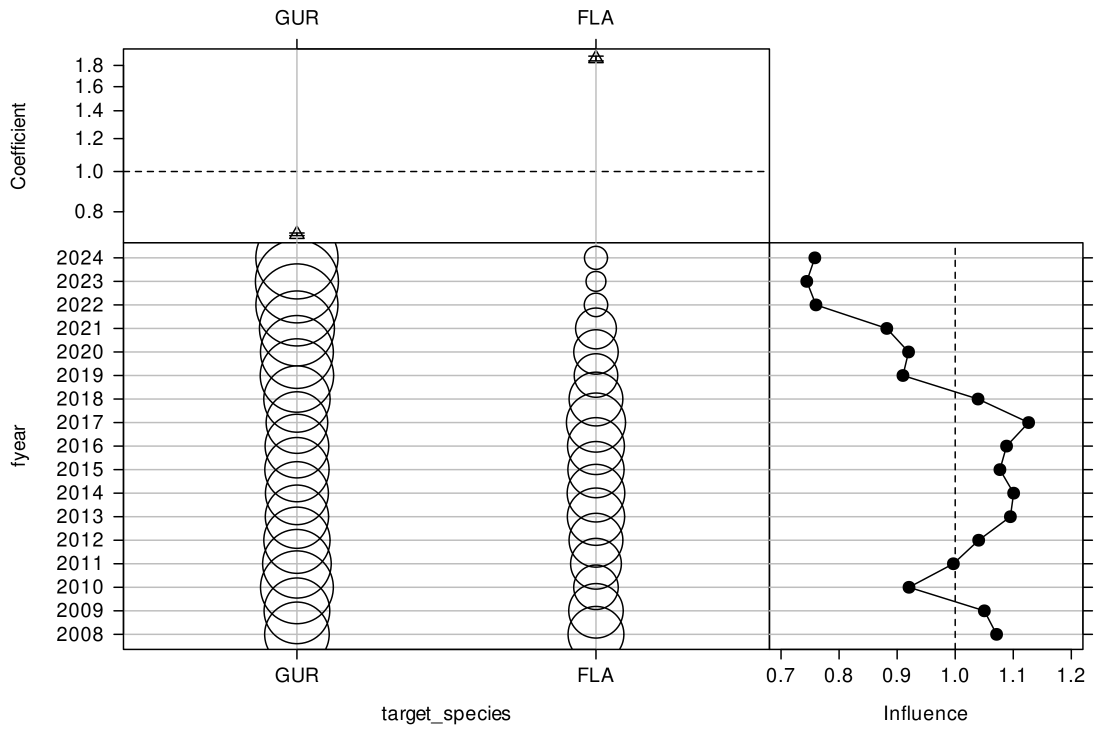

Figure C.32: CDI plot for target species for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (stepwise) catch-per-unit-effort dataset.

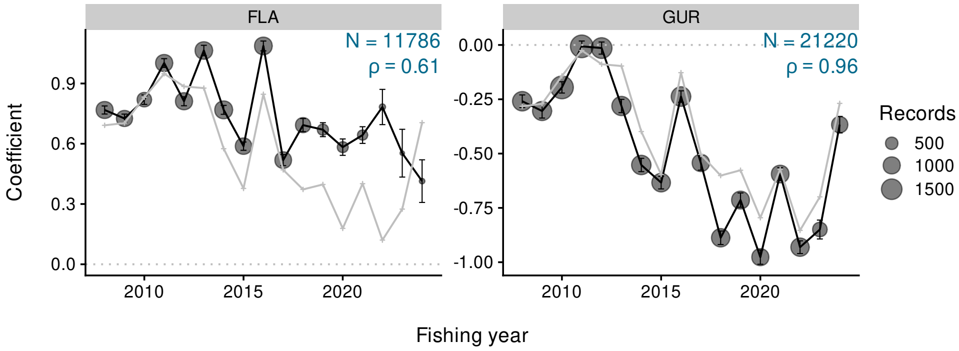

Figure C.33: Residual implied coefficients for target-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (stepwise) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

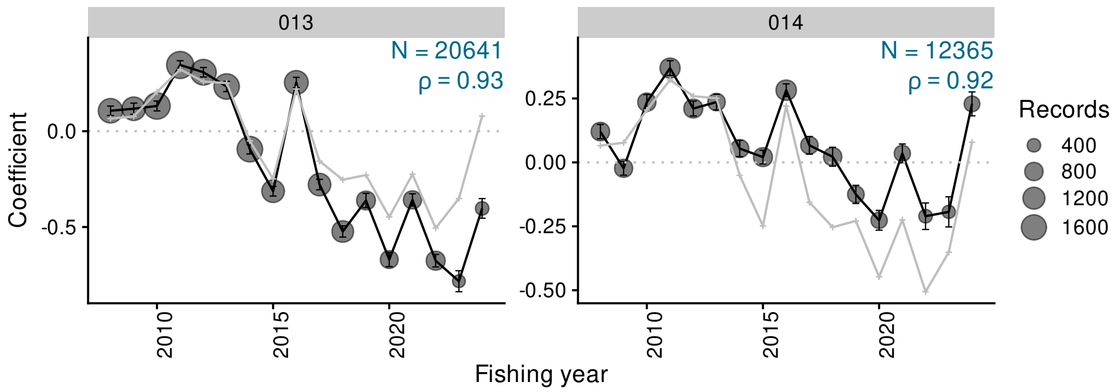

Figure C.34: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (stepwise) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are 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.

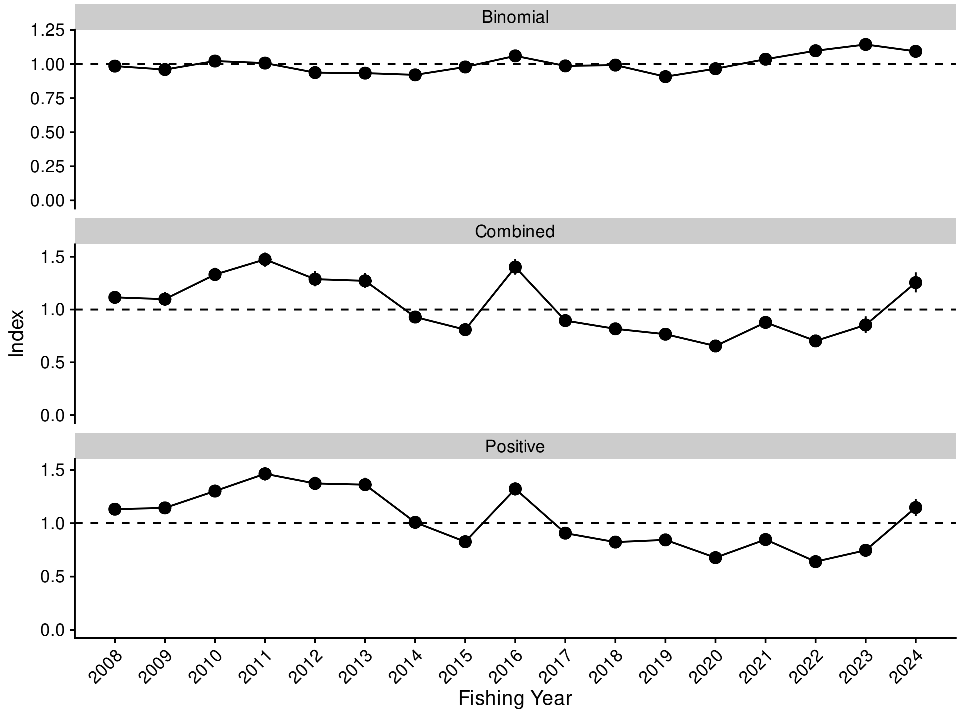

Figure C.35: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-MIX event (stepwise) dataset.

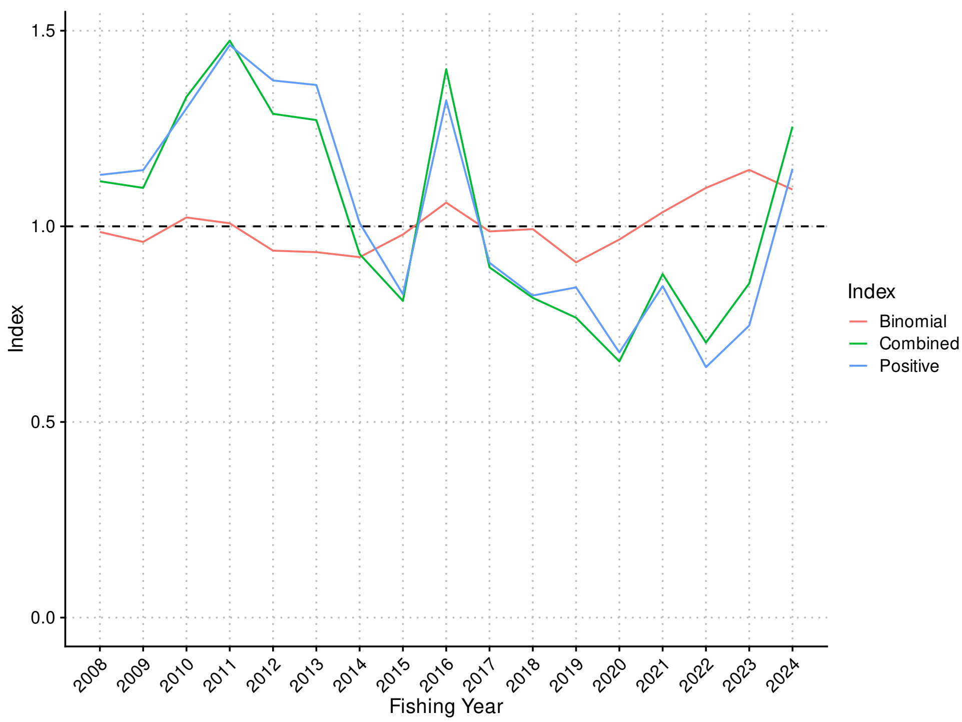

Figure C.36: Standardised indices for the Hawke Bay FLA BT-MIX event (stepwise) dataset.

Table C.11: **Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay FLA BT-MIX event (stepwise) series.**

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.986	0.013	0.960	1.011	1.115	0.030	1.056	1.173	1.132	0.027	1.079	1.184
2009	0.960	0.014	0.933	0.987	1.098	0.033	1.036	1.165	1.144	0.028	1.088	1.199
2010	1.023	0.011	1.003	1.045	1.331	0.032	1.269	1.396	1.301	0.030	1.244	1.362
2011	1.008	0.011	0.986	1.027	1.475	0.034	1.406	1.540	1.463	0.032	1.400	1.524
2012	0.938	0.013	0.911	0.962	1.288	0.036	1.220	1.362	1.373	0.031	1.316	1.436
2013	0.934	0.014	0.906	0.961	1.272	0.035	1.207	1.345	1.361	0.032	1.302	1.427
2014	0.921	0.015	0.892	0.949	0.929	0.026	0.880	0.983	1.008	0.023	0.965	1.056
2015	0.979	0.012	0.954	1.002	0.810	0.021	0.769	0.852	0.827	0.019	0.789	0.863
2016	1.061	0.012	1.038	1.086	1.402	0.038	1.330	1.478	1.322	0.031	1.260	1.383
2017	0.987	0.012	0.962	1.009	0.895	0.025	0.848	0.947	0.907	0.023	0.865	0.953
2018	0.993	0.013	0.968	1.017	0.817	0.023	0.771	0.863	0.823	0.021	0.783	0.866
2019	0.908	0.017	0.872	0.940	0.766	0.027	0.714	0.819	0.844	0.025	0.797	0.894
2020	0.966	0.014	0.936	0.992	0.655	0.022	0.614	0.702	0.678	0.021	0.640	0.721
2021	1.036	0.014	1.012	1.065	0.878	0.027	0.825	0.931	0.847	0.024	0.800	0.896
2022	1.098	0.017	1.066	1.134	0.703	0.024	0.659	0.753	0.640	0.020	0.604	0.682
2023	1.144	0.024	1.100	1.194	0.854	0.040	0.780	0.935	0.746	0.031	0.686	0.807
2024	1.094	0.018	1.062	1.133	1.255	0.048	1.162	1.352	1.147	0.040	1.070	1.227

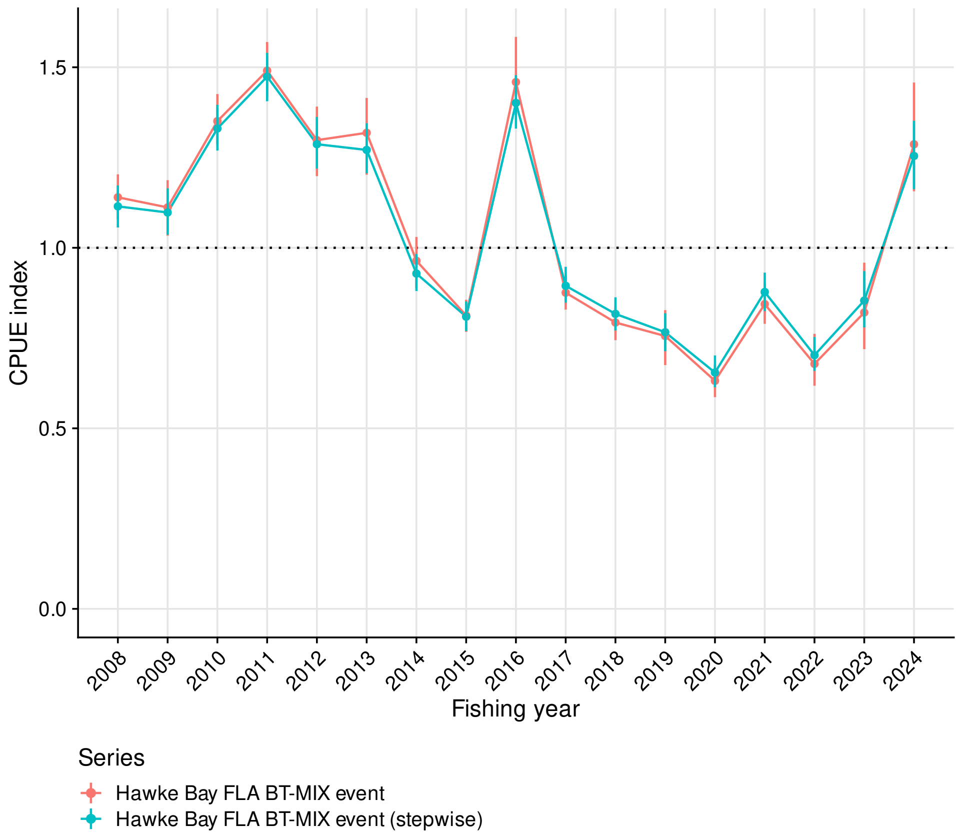

Figure C.37: **Comparison of the event resolution series for aggregate flatfish (FLA) catches in Hawke Bay with and without stepwise selection.**

C.3 Hawke Bay FLA BT-MIX event (no effort allocation)

This analysis is based on the same model criteria which were used for the Hawke Bay FLA BT-MIX event model (Section 4.2), except that it drops the additional data preparation step for trips which did not return an estimated catch record. In this instance, the allocation of landings to the effort, either proportionately or equally across all records (see Section 2.3), is not done. The effect of this change in data preparation procedure can be seen by comparing Figure C.40 with Figure 53. A comparison of resulting combined series from each of these two models indicates that the impact of dropping this additional data preparation step was minimal (Figure C.57).

Figure C.57 compares the event-based combined target FLA/GUR BT CPUE series based on the aggregate flatfish (FLA) catch with the same model where the data preparation step for trips without estimated catches allocate catch proportionately or equally to the effort records is omitted (described in Section 2.3). This model is documented in Appendix C.3 and Figure C.57 indicates that the impact of dropping the additional data preparation step was small.

Table C.12: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-MIX event (no effort allocation) CPUE series.

Series	Hawke Bay FLA BT-MIX event (no effort allocation)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	allockg_top8 ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3) + ns(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

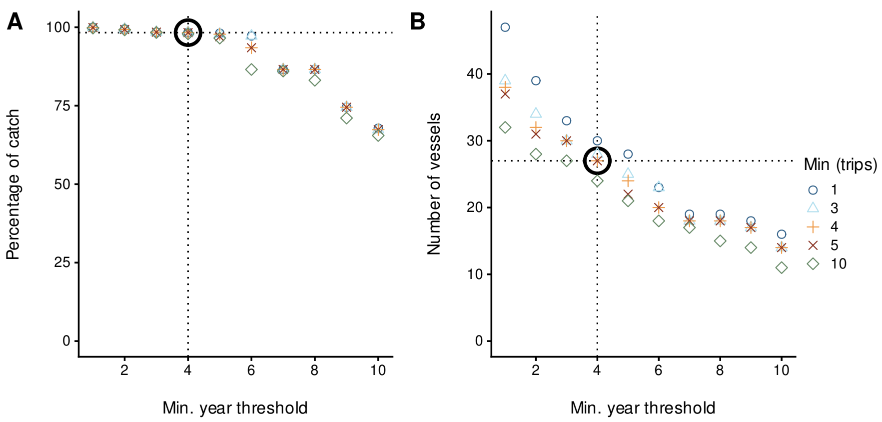

Figure C.38: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-MIX event (no effort allocation) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

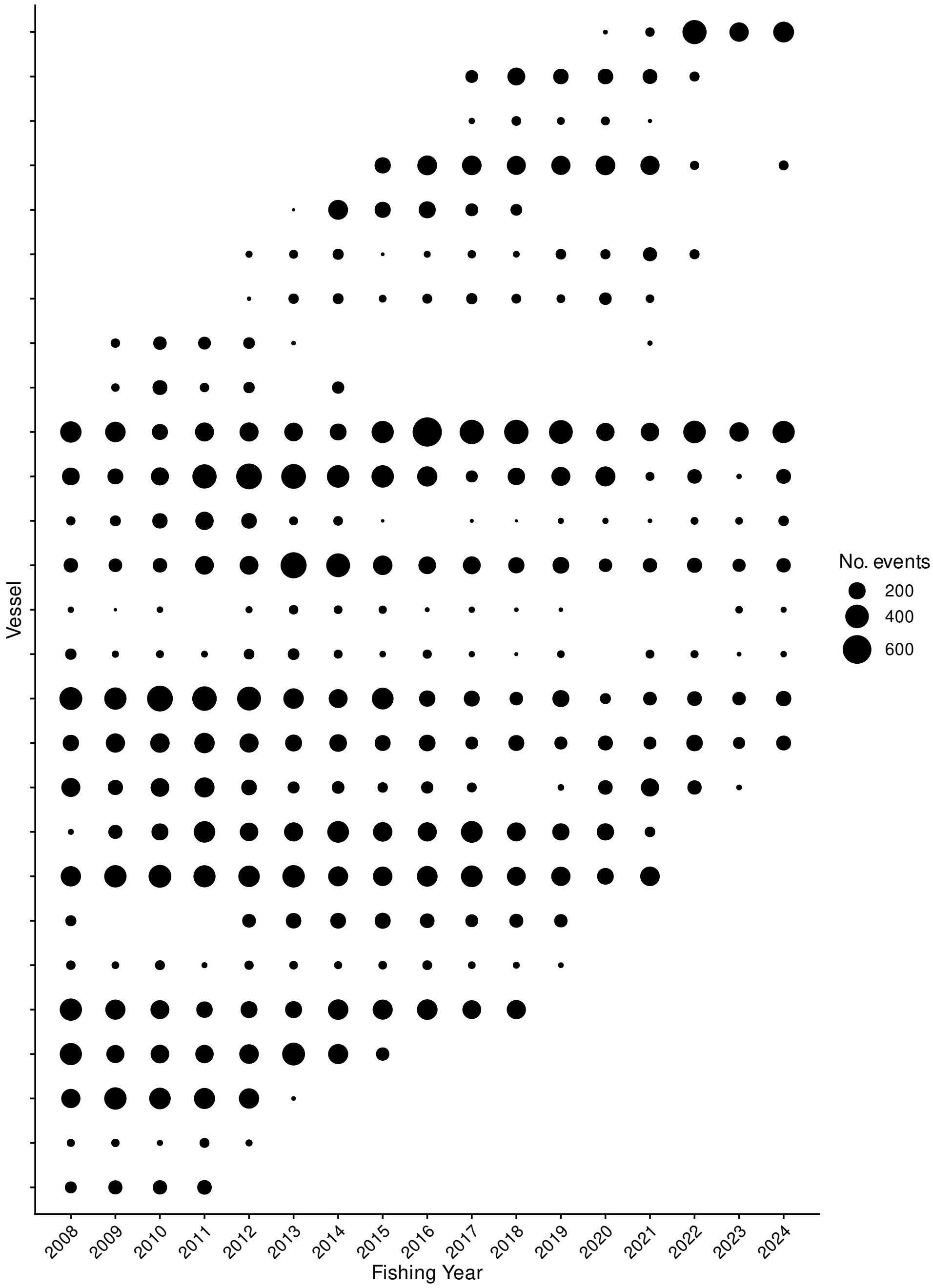

Figure C.39: Number of events by fishing year for core vessels in the Hawke Bay FLA BT-MIX event (no effort allocation) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.13: Summary of the Hawke Bay FLA BT-MIX event (no effort allocation) dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. **(Continued on next page)**

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	132 (100%) n: 3836	113 (100%) n: 3542	119 (100%) n: 4050	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4248	90 (100%) n: 3637	166 (100%) n: 3539
Positive fishing duration	132 (100%) n: 3834	113 (100%) n: 3539	118 (100%) n: 4048	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4247	90 (100%) n: 3636	166 (100%) n: 3539
Fishing duration less than 6 h	132 (100%) n: 3813	113 (99%) n: 3515	118 (99%) n: 4033	195 (100%) n: 4365	148 (99%) n: 3966	169 (99%) n: 3713	141 (98%) n: 4223	90 (100%) n: 3625	166 (100%) n: 3516
Bottom depth < 150m	132 (100%) n: 3810	113 (99%) n: 3514	118 (99%) n: 4030	195 (100%) n: 4362	148 (99%) n: 3963	169 (99%) n: 3713	141 (98%) n: 4221	90 (100%) n: 3622	166 (100%) n: 3515
Trawl opening < 10m	131 (99%) n: 3802	112 (99%) n: 3504	118 (99%) n: 4030	195 (100%) n: 4357	148 (99%) n: 3963	169 (99%) n: 3710	141 (98%) n: 4212	90 (100%) n: 3618	166 (100%) n: 3515
No effort allocation	131 (99%) n: 3654	112 (99%) n: 3290	117 (98%) n: 3701	193 (99%) n: 4019	148 (98%) n: 3803	168 (99%) n: 3498	140 (98%) n: 3853	90 (99%) n: 3325	165 (99%) n: 3293
Core fleet selection	121 (91%) n: 3165	111 (98%) n: 3117	116 (98%) n: 3610	192 (98%) n: 3971	147 (98%) n: 3790	168 (99%) n: 3468	132 (92%) n: 3598	84 (93%) n: 3158	165 (99%) n: 3274

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2800	53 (100%) n: 2513	55 (100%) n: 2190	36 (100%) n: 2438	22 (100%) n: 1523	47 (100%) n: 1886
Positive fishing duration	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2793	53 (100%) n: 2507	55 (100%) n: 2186	36 (100%) n: 2437	22 (100%) n: 1521	47 (100%) n: 1884
Fishing duration less than 6 h	85 (99%) n: 3097	87 (100%) n: 3054	55 (99%) n: 2752	52 (99%) n: 2458	55 (99%) n: 2153	35 (99%) n: 2415	21 (99%) n: 1482	47 (100%) n: 1859
Bottom depth < 150m	85 (99%) n: 3097	87 (100%) n: 3053	55 (99%) n: 2749	52 (99%) n: 2457	55 (99%) n: 2151	35 (99%) n: 2407	21 (99%) n: 1478	47 (100%) n: 1853
Trawl opening < 10m	84 (99%) n: 3092	87 (100%) n: 3052	54 (98%) n: 2735	51 (97%) n: 2438	55 (99%) n: 2151	32 (90%) n: 2192	15 (71%) n: 1259	45 (95%) n: 1735
No effort allocation	84 (98%) n: 2811	86 (99%) n: 2740	53 (96%) n: 2398	50 (95%) n: 2065	54 (98%) n: 1937	31 (88%) n: 1857	15 (68%) n: 954	44 (94%) n: 1416
Core fleet selection	84 (98%) n: 2801	86 (99%) n: 2730	53 (96%) n: 2398	50 (95%) n: 2062	54 (98%) n: 1922	31 (87%) n: 1786	15 (68%) n: 954	44 (94%) n: 1416

Table C.14: **Summary of the Hawke Bay FLA BT-MIX event (no effort allocation) 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 flatfish.**

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	18	873	3 165	10 489.80	121.02	69.92
2009	19	922	3 117	10 730.37	110.59	63.55
2010	19	1 000	3 610	12 549.63	116.35	62.30
2011	18	1 012	3 971	13 883.08	192.37	63.03
2012	21	1 025	3 790	13 110.67	147.30	62.77
2013	20	839	3 468	11 893.95	167.79	62.02
2014	19	912	3 598	12 432.22	131.61	57.53
2015	19	846	3 158	11 017.58	83.71	58.17
2016	17	939	3 274	11 306.72	164.76	67.38
2017	20	847	2 801	9 700.87	83.62	61.05
2018	19	795	2 730	9 523.40	86.47	60.00
2019	18	639	2 398	9 053.12	53.41	49.62
2020	15	562	2 062	8 023.20	50.23	49.56
2021	17	575	1 922	6 866.51	54.13	61.19
2022	12	504	1 786	6 379.47	31.14	52.74
2023	10	257	954	3 531.62	14.58	45.81
2024	10	362	1 416	4 848.48	44.00	46.26

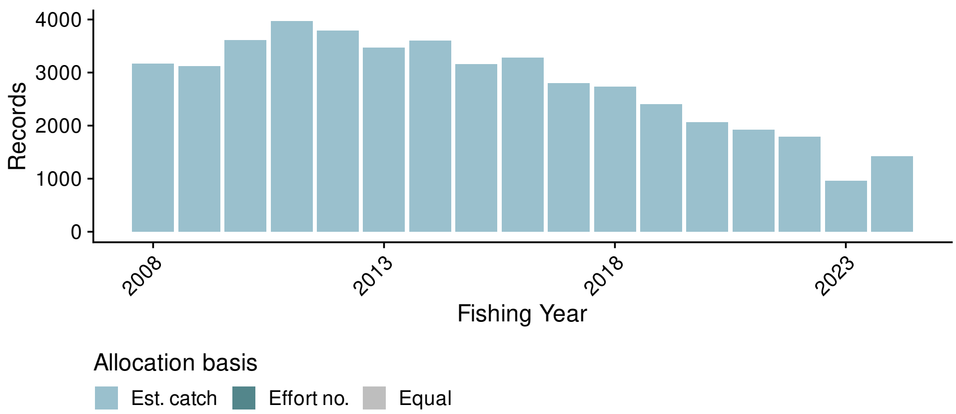

Figure C.40: **The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).**

Table C.15: **Summary of stepwise selection for occurrence of positive catch in the Hawke Bay FLA BT-MIX event (no effort allocation) 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	15	62 864	1.1	1.1	*
+ ns(bottom_depth, 3)	3	46 867	26.3	25.2	*
+ vessel_key	26	43 942	31.0	4.7	*
+ target_species	1	43 147	32.2	1.3	*
+ month	11	42 919	32.6	0.4	
+ ns(effort_height, 3)	3	42 834	32.8	0.1	
+ ns(log(fishing_duration), 3)	3	42 763	32.9	0.1	
+ stat_area	1	42 763	32.9	0.0	

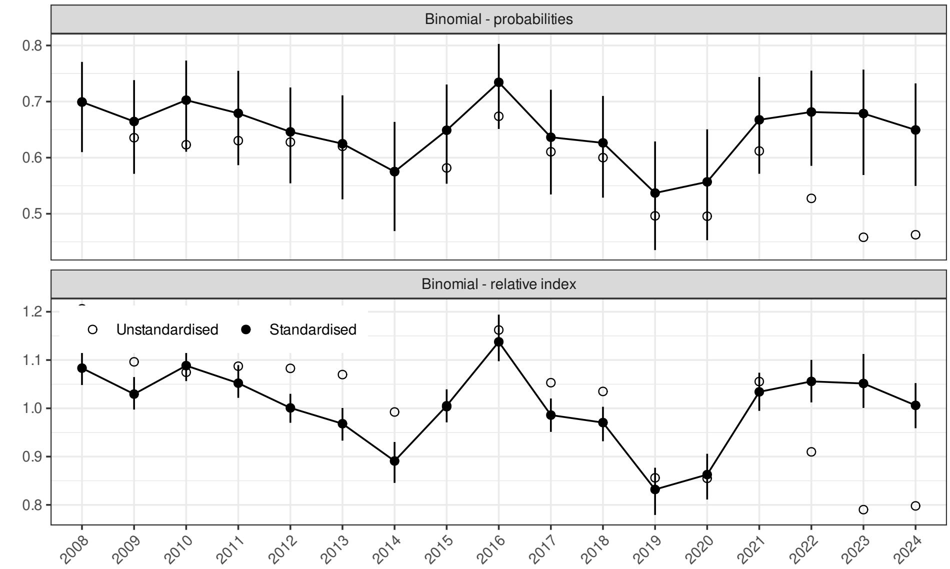

Figure C.41: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay FLA BT-MIX event (no effort allocation) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

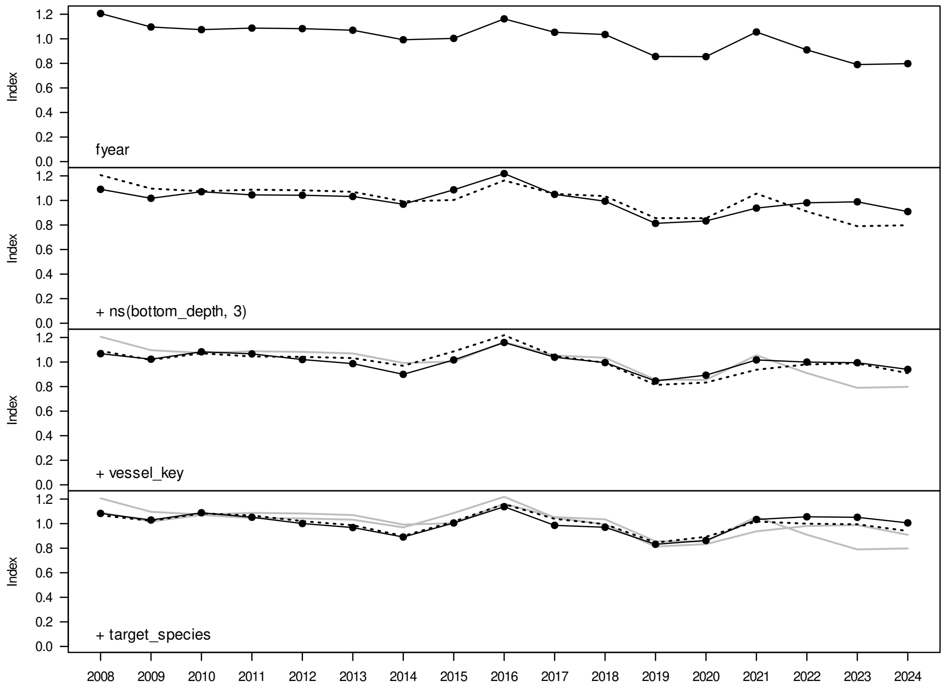

Figure C.42: Step plot for occurrence of catch in the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

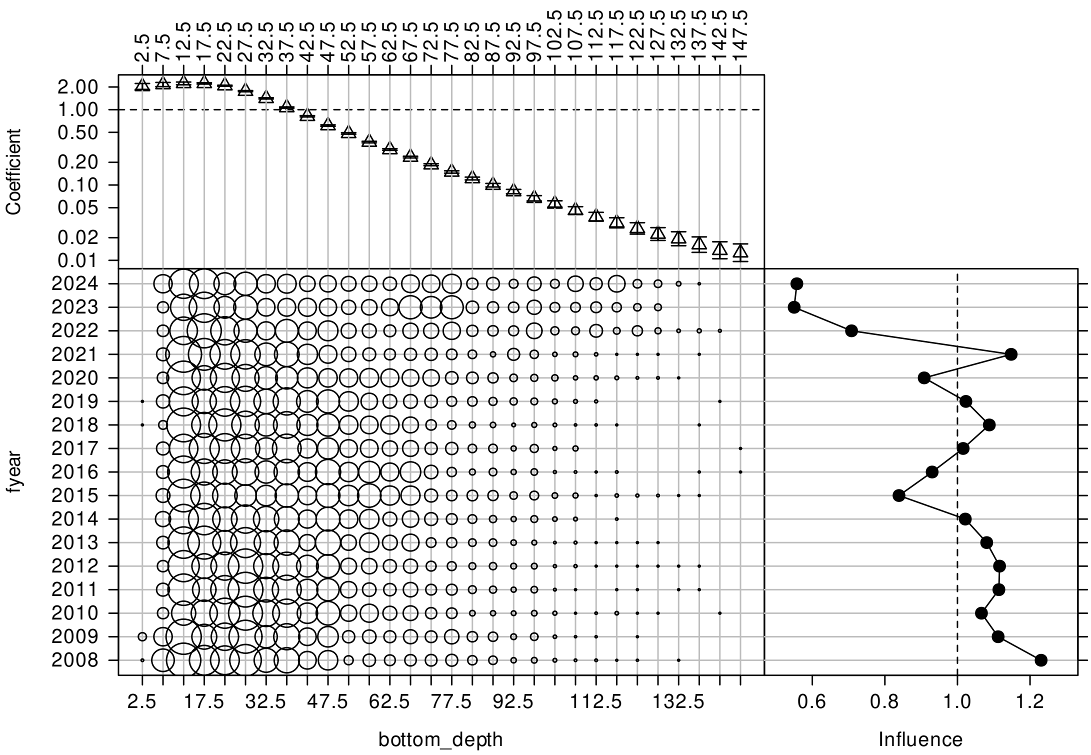

Figure C.43: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

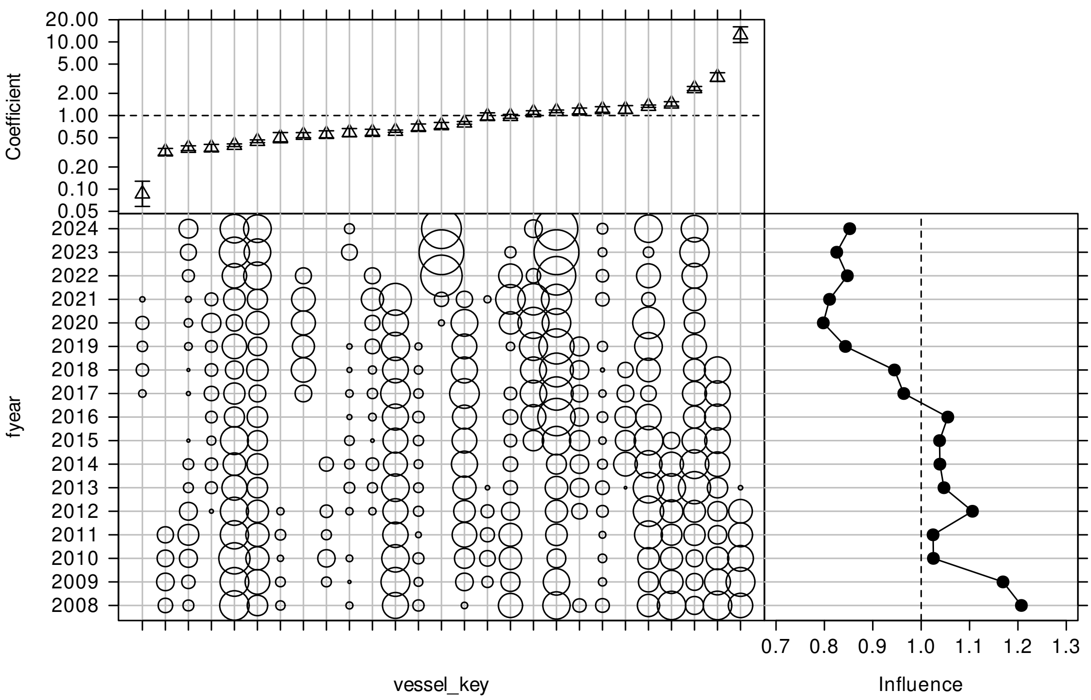

Figure C.44: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

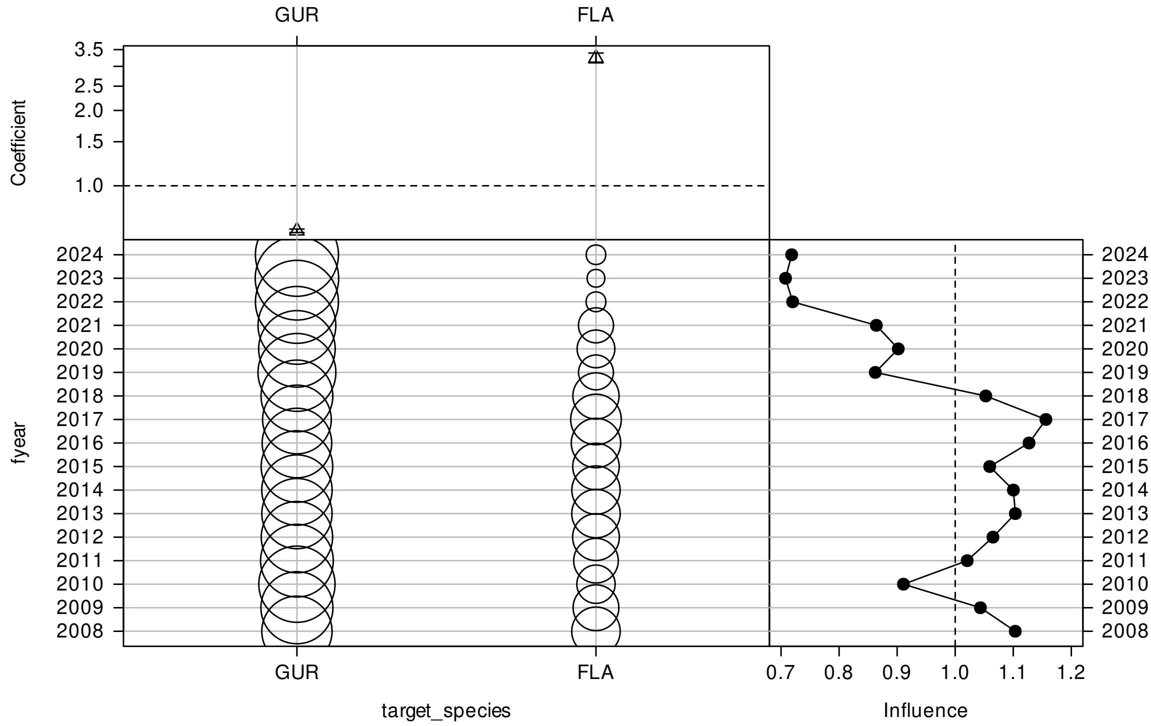

Figure C.45: CDI plot for target species for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

Table C.16: Summary of stepwise selection for the Weibull model for positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) 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	18	284 481	3.0	3.0	*
+ target_species	1	275 788	31.3	28.3	*
+ vessel_key	26	273 124	40.1	8.8	*
+ ns(bottom_depth, 3)	3	270 533	48.6	8.4	*
+ month	11	270 331	49.3	0.7	
+ ns(log(fishing_duration), 3)	3	270 155	49.9	0.6	
+ stat_area	1	270 036	50.3	0.4	
+ ns(effort_height, 3)	3	269 945	50.6	0.3	

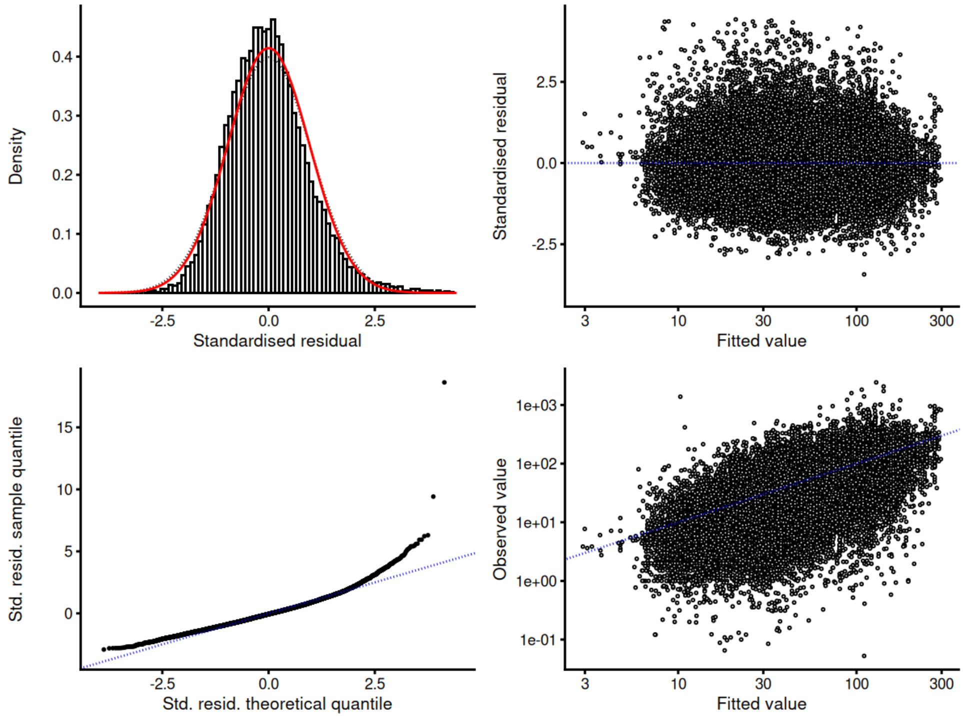

Figure C.46: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

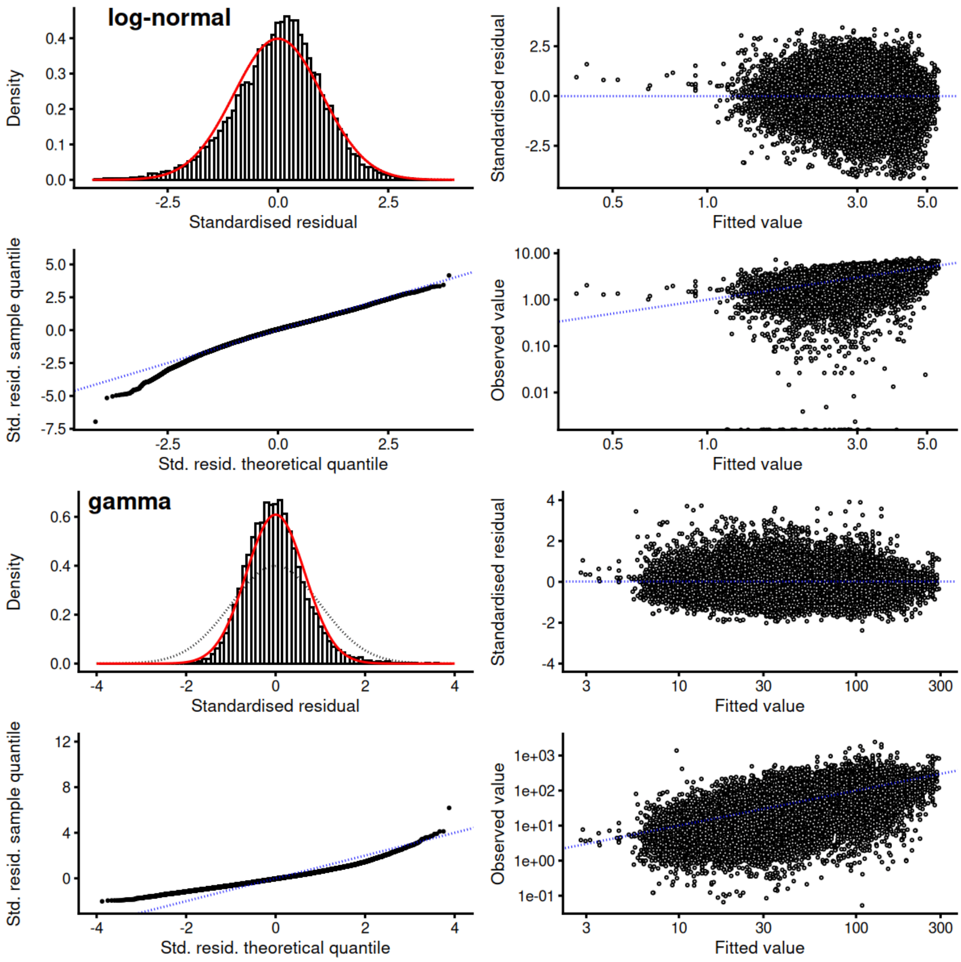

Figure C.47: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

Figure C.48: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

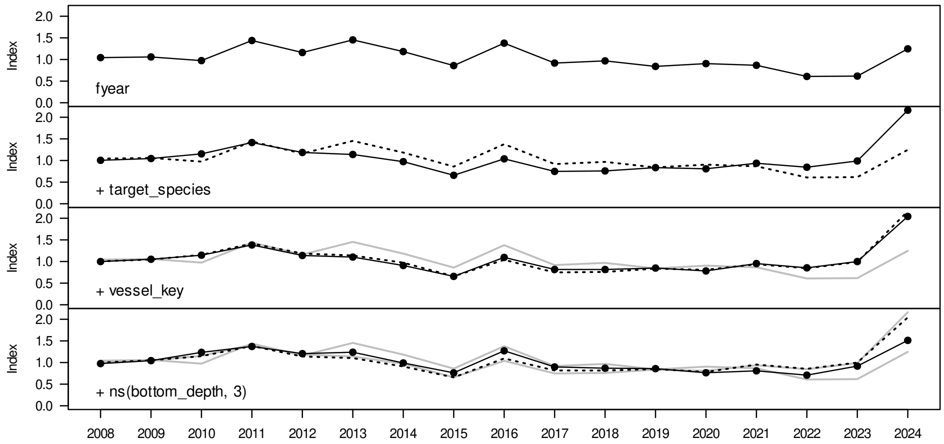

Figure C.49: Changes to the Hawke Bay FLA BT-MIX event (no effort allocation) positive catch index as terms are successively entered into the Weibull model.

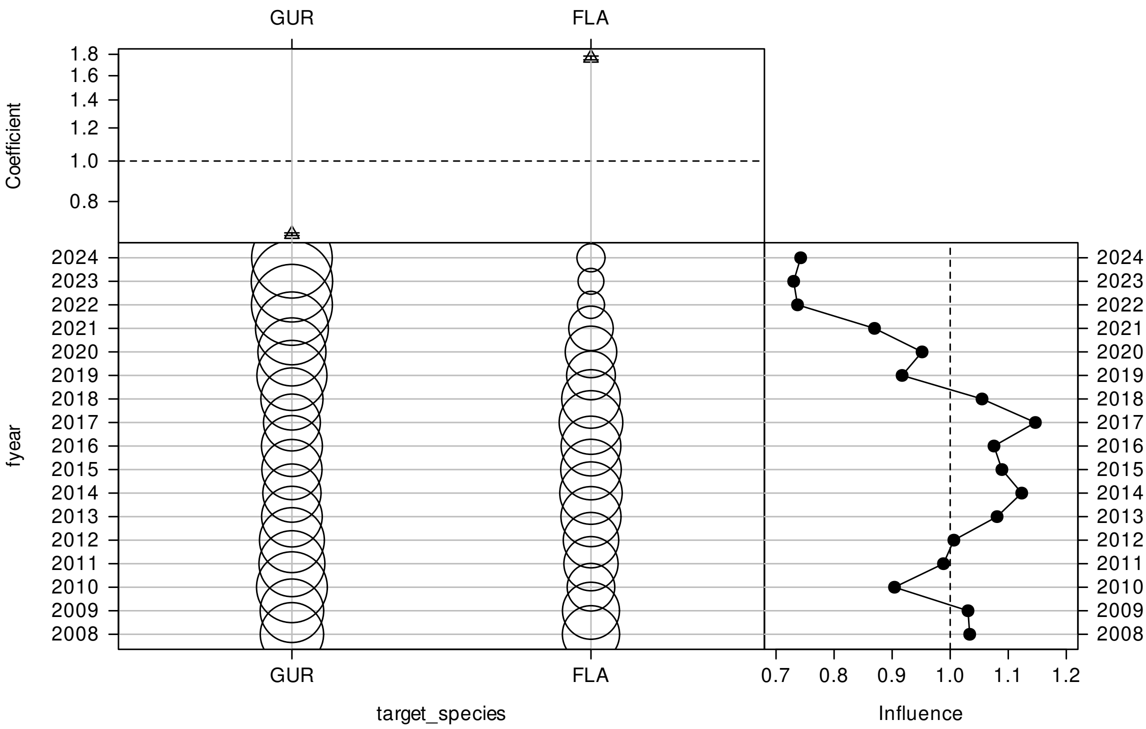

Figure C.50: CDI plot for target species for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

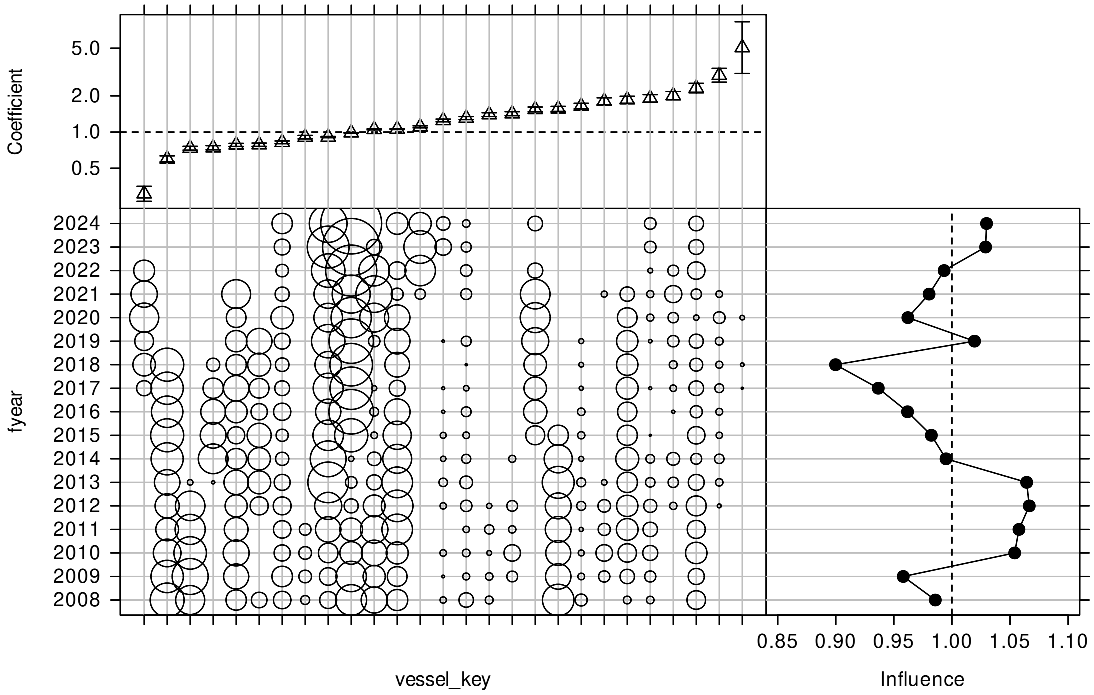

Figure C.51: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

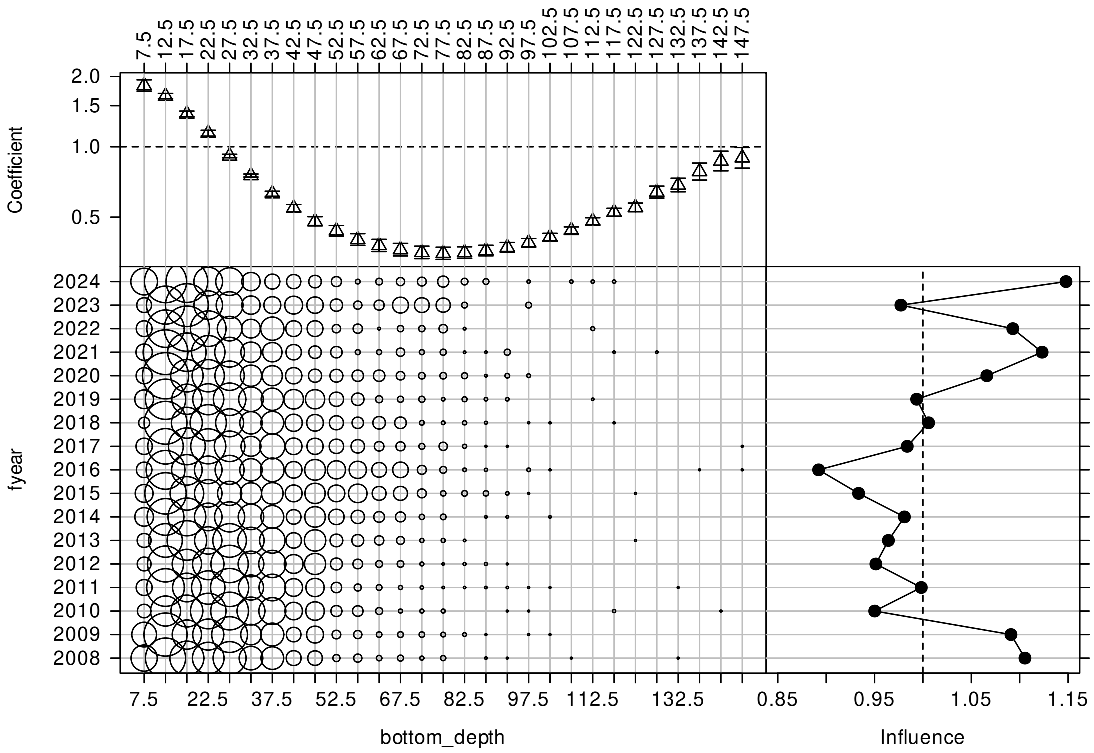

Figure C.52: CDI plot for bottom depth (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (no effort allocation) catch-per-unit-effort dataset.

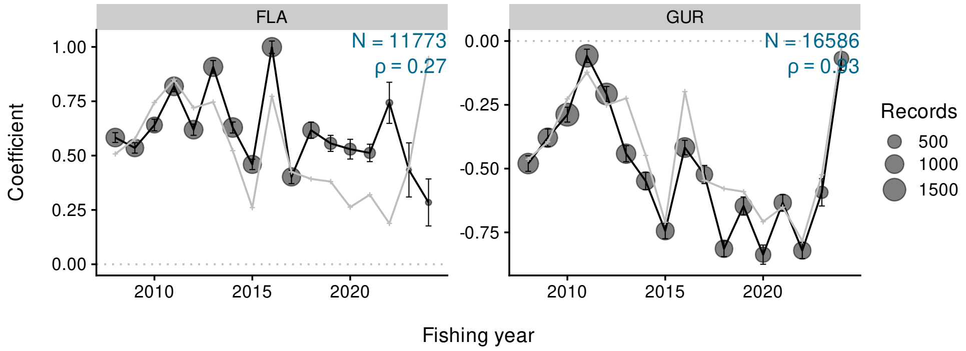

Figure C.53: Residual implied coefficients for target-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (no effort allocation) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

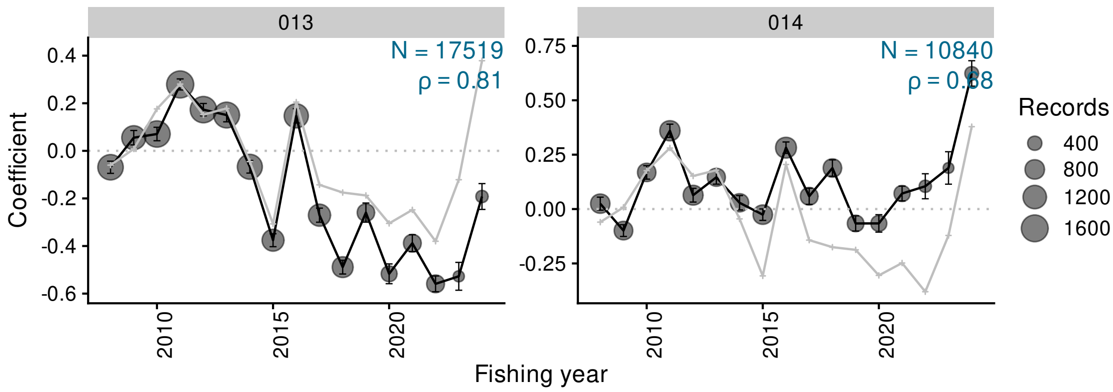

Figure C.54: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (no effort allocation) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when 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.

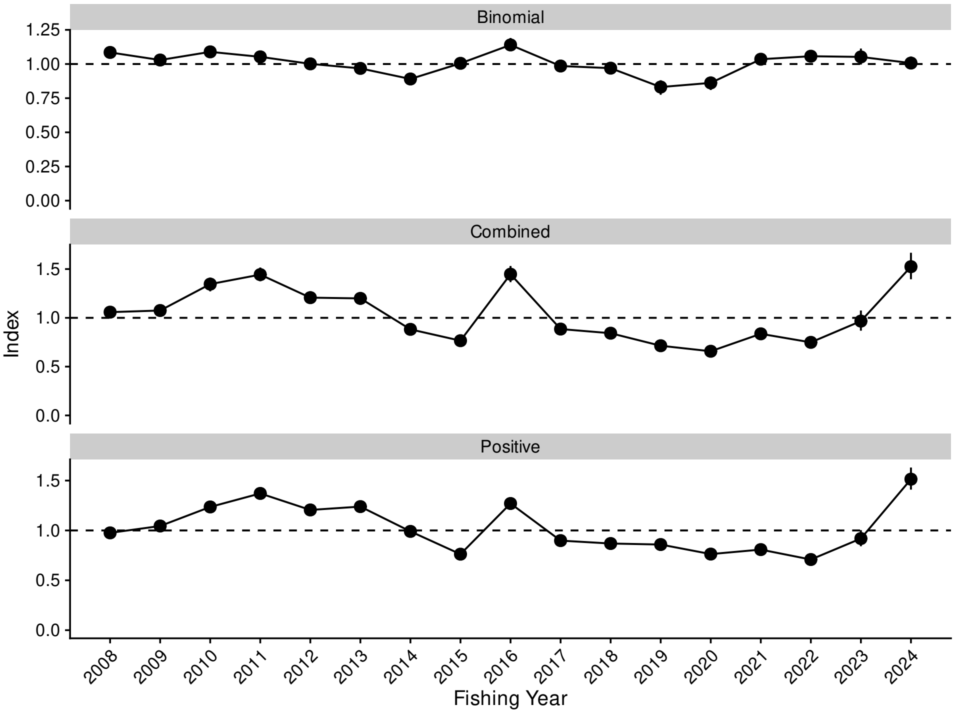

Figure C.55: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

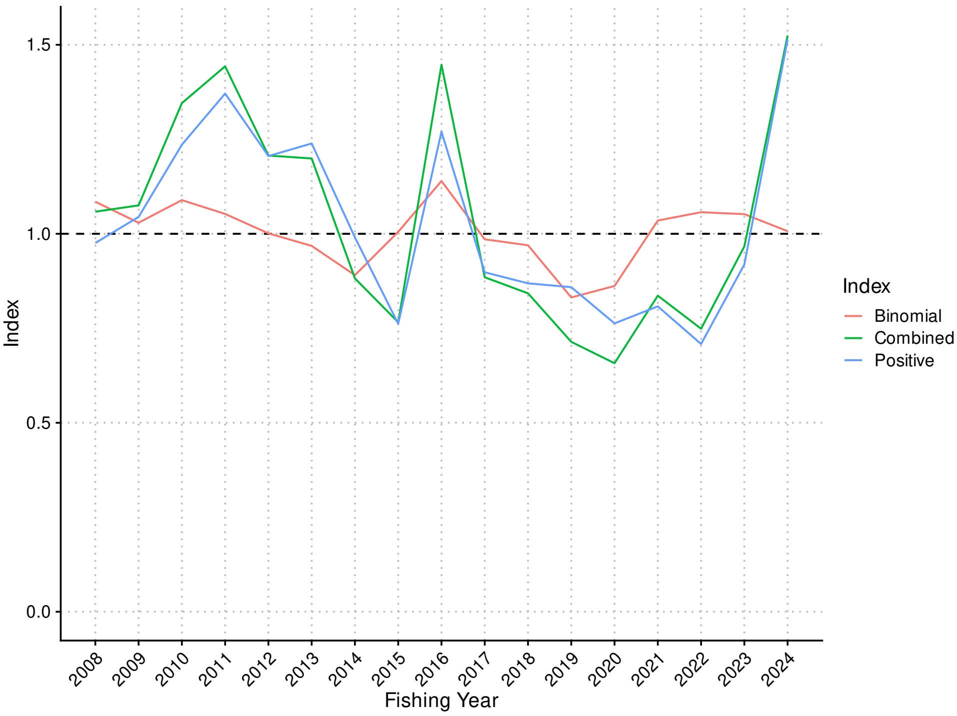

Figure C.56: Standardised indices for the Hawke Bay FLA BT-MIX event (no effort allocation) dataset.

Table C.17: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay FLA BT-MIX event (no effort allocation) series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.085	0.020	1.051	1.129	1.058	0.029	1.006	1.120	0.976	0.021	0.937	1.017
2009	1.029	0.018	0.994	1.063	1.075	0.030	1.015	1.132	1.045	0.022	1.001	1.088
2010	1.089	0.018	1.057	1.128	1.346	0.036	1.272	1.413	1.236	0.026	1.185	1.287
2011	1.053	0.016	1.023	1.087	1.443	0.036	1.375	1.516	1.371	0.028	1.314	1.424
2012	1.001	0.015	0.972	1.030	1.207	0.032	1.145	1.272	1.206	0.026	1.157	1.258
2013	0.968	0.018	0.930	1.000	1.199	0.034	1.134	1.265	1.239	0.026	1.187	1.291
2014	0.891	0.021	0.847	0.928	0.882	0.029	0.823	0.935	0.990	0.021	0.949	1.033
2015	1.005	0.018	0.970	1.039	0.766	0.021	0.724	0.807	0.762	0.017	0.729	0.796
2016	1.140	0.024	1.097	1.191	1.447	0.042	1.366	1.532	1.270	0.026	1.220	1.322
2017	0.985	0.018	0.952	1.021	0.885	0.025	0.835	0.932	0.898	0.021	0.858	0.940
2018	0.970	0.019	0.929	1.002	0.842	0.024	0.794	0.890	0.869	0.021	0.830	0.913
2019	0.832	0.027	0.775	0.881	0.714	0.029	0.657	0.772	0.859	0.023	0.815	0.904
2020	0.862	0.025	0.810	0.909	0.658	0.027	0.607	0.712	0.763	0.023	0.720	0.810
2021	1.035	0.019	1.000	1.074	0.836	0.028	0.785	0.896	0.808	0.023	0.766	0.858
2022	1.057	0.021	1.019	1.100	0.749	0.028	0.694	0.805	0.708	0.023	0.666	0.755
2023	1.052	0.030	0.996	1.113	0.966	0.053	0.868	1.075	0.919	0.041	0.842	1.003
2024	1.007	0.024	0.961	1.055	1.524	0.069	1.396	1.667	1.514	0.057	1.409	1.631

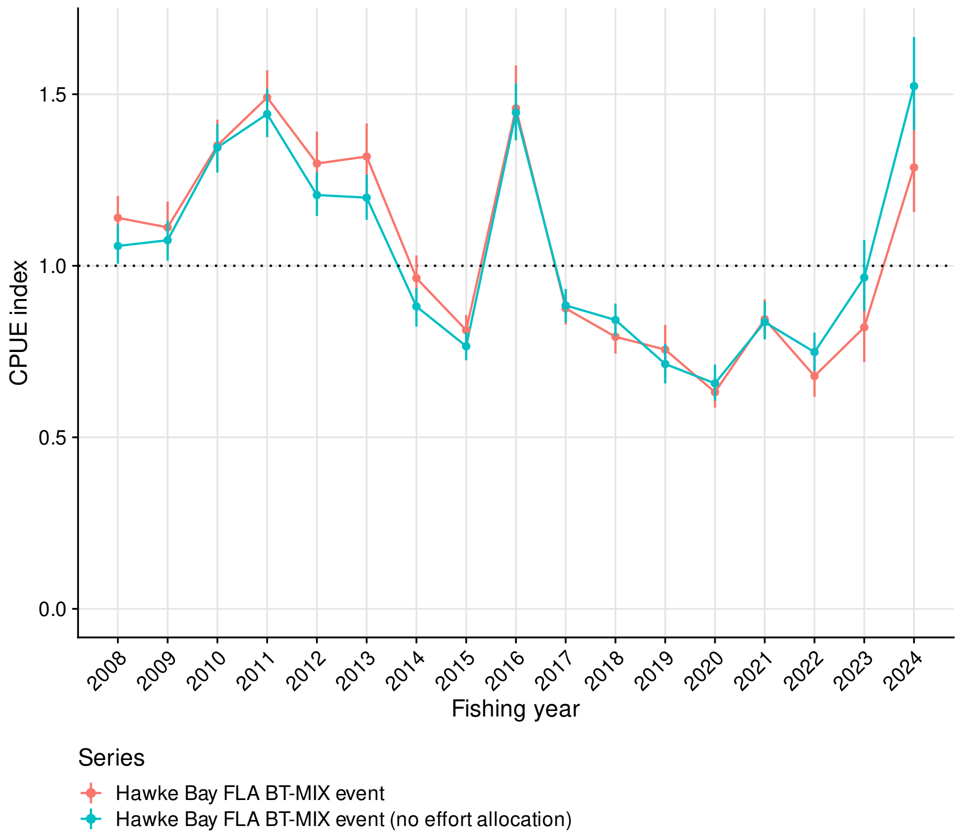

Figure C.57: Comparison of the event resolution series for aggregate flatfish (FLA) catches in Hawke Bay with and without the additional data preparation step for trips without estimated catches allocate catch proportionately or equally to the effort records.

C.4 Hawke Bay FLA BT-FLA day (2018 analysis update)

This series is an update of the series accepted by the INSWG for monitoring FLA 2 abundance, using the same selection criteria as were used by Schofield et al. (2018b). It is a daily-effort pseudo-CELR analysis in order to extend the series back in time to the initiation of the data collection period in October 1989. This series was abandoned by the INSWG for two reasons: 1) the loss of vessels in recent years due to the collapse of the FLA market (it is down to a single vessel in 2024 and two vessels in both 2022 and 2023 (Table C.20)); and 2) evidence in the event-based analyses that there have been structural changes in the fishery, particularly in the depths being fished over time.

Table C.18: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-FLA day (2018 analysis update) CPUE series.

Series	Hawke Bay FLA BT-FLA day (2018 analysis update)
QMS stock	FLA 2
Reporting forms	CEL, ERS - Trawl, TCE, TCP
Fishing methods	BT
Target species	FLA
Statistical Areas	013, 014
Period	1989-10-01, 2024-09-30
Resolution	Day
Core fleet years	7
Core fleet trips	5
Default model	allockg ~ fyear + vessel_key + poly(log(fishing_duration), 3) + month
Stepwise selection	No
Positive catch distribution	Gamma

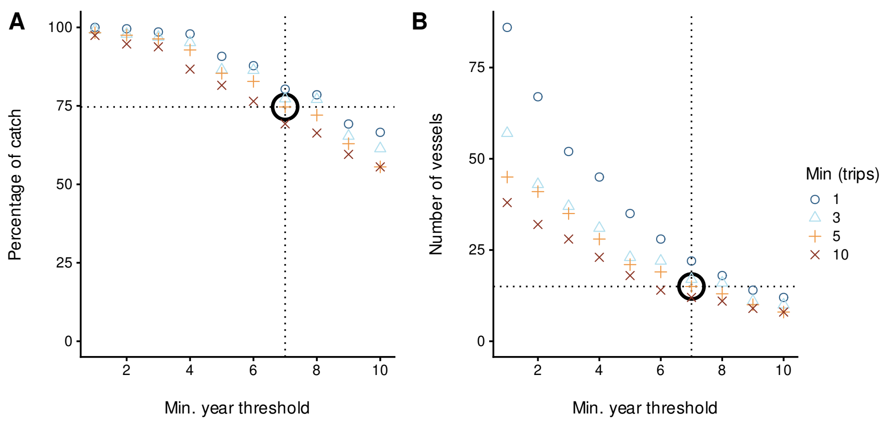

Figure C.58: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-FLA day (2018 analysis update) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

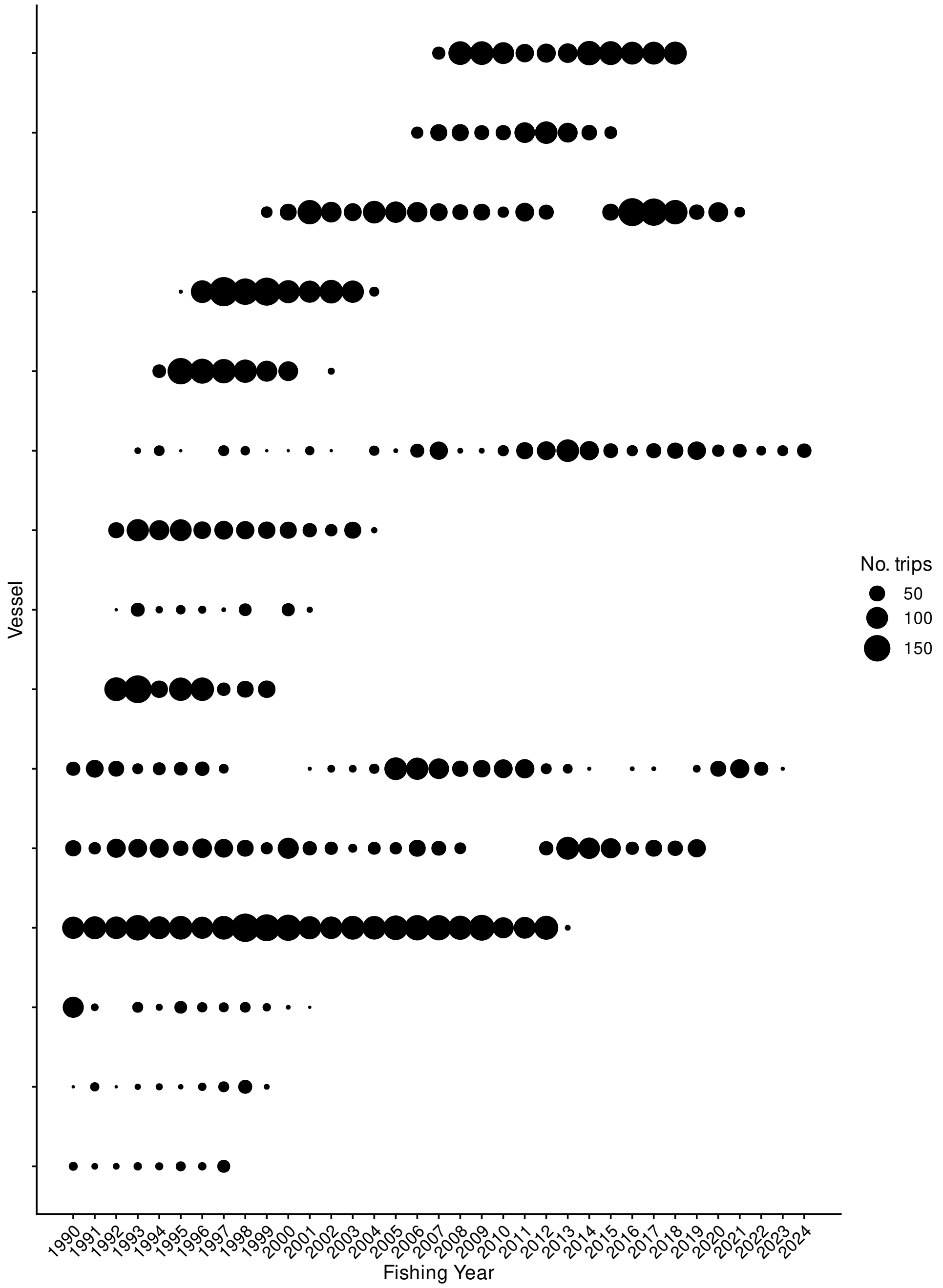

Figure C.59: Number of trips by fishing year for core vessels in the Hawke Bay FLA BT-FLA day (2018 analysis update) series. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

Table C.19: Summary of the Hawke Bay FLA BT-FLA day (2018 analysis update) 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. Catch data for years with less than three vessels are omitted (indicated by x). (Continued on next page)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	143 (100%) n: 647	116 (100%) n: 485	127 (100%) n: 711	253 (100%) n: 946	152 (100%) n: 774	261 (100%) n: 1219	265 (100%) n: 1383	216 (100%) n: 1382	331 (100%) n: 1436
Positive fishing duration	142 (99%) n: 642	115 (99%) n: 481	127 (100%) n: 711	253 (100%) n: 945	152 (100%) n: 773	259 (100%) n: 1216	261 (98%) n: 1367	211 (98%) n: 1349	324 (98%) n: 1410
Fishing duration less than 24 h	142 (99%) n: 642	115 (99%) n: 479	127 (100%) n: 711	243 (96%) n: 938	151 (99%) n: 772	256 (98%) n: 1210	259 (98%) n: 1363	211 (98%) n: 1345	318 (96%) n: 1386
Less than 7 tows	141 (99%) n: 637	115 (99%) n: 472	125 (98%) n: 710	240 (95%) n: 934	149 (98%) n: 766	254 (97%) n: 1204	258 (97%) n: 1355	209 (97%) n: 1335	312 (94%) n: 1376
Core fleet selection	68 (48%) n: 329	62 (53%) n: 274	63 (50%) n: 435	189 (74%) n: 709	97 (64%) n: 532	152 (58%) n: 752	156 (59%) n: 854	150 (70%) n: 937	186 (56%) n: 818

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	146 (100%) n: 1028	95 (100%) n: 778	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Positive fishing duration	142 (97%) n: 1008	94 (99%) n: 772	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Fishing duration less than 24 h	142 (97%) n: 1001	94 (99%) n: 772	82 (100%) n: 524	71 (100%) n: 482	48 (100%) n: 402	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Less than 7 tows	141 (96%) n: 999	94 (99%) n: 771	82 (100%) n: 524	71 (100%) n: 482	47 (97%) n: 401	66 (100%) n: 372	90 (100%) n: 411	112 (100%) n: 533	120 (100%) n: 611
Core fleet selection	92 (63%) n: 658	79 (83%) n: 645	69 (85%) n: 474	65 (90%) n: 449	46 (96%) n: 387	58 (88%) n: 344	76 (85%) n: 372	95 (85%) n: 468	96 (80%) n: 527

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	90 (100%) n: 558	74 (100%) n: 478	60 (100%) n: 373	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Positive fishing duration	90 (100%) n: 557	74 (100%) n: 478	60 (100%) n: 371	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Fishing duration less than 24 h	90 (100%) n: 557	74 (100%) n: 478	60 (100%) n: 371	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Less than 7 tows	90 (100%) n: 557	74 (100%) n: 478	60 (100%) n: 371	129 (100%) n: 552	96 (100%) n: 591	139 (100%) n: 524	114 (100%) n: 677	75 (100%) n: 522	141 (100%) n: 489
Core fleet selection	81 (90%) n: 498	69 (93%) n: 463	60 (100%) n: 371	126 (97%) n: 545	95 (99%) n: 585	130 (93%) n: 509	88 (78%) n: 477	62 (83%) n: 390	96 (68%) n: 374

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	67 (100%) n: 497	72 (100%) n: 411	36 (100%) n: 258	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Positive fishing duration	67 (100%) n: 497	72 (100%) n: 411	36 (100%) n: 256	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Fishing duration less than 24 h	67 (100%) n: 496	72 (100%) n: 411	36 (100%) n: 255	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Less than 7 tows	67 (100%) n: 496	72 (100%) n: 411	36 (100%) n: 255	38 (100%) n: 247	33 (100%) n: 191	x (100%) n: 63	x (100%) n: 33	x (100%) n: 46
Core fleet selection	53 (78%) n: 403	67 (92%) n: 368	35 (96%) n: 234	38 (98%) n: 181	33 (100%) n: 187	x (99%) n: 62	x (44%) n: 24	x (73%) n: 42

Table C.20: Summary of the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset after core fleet selection. 'Records' indicates the number of rows (days) in the dataset, and 'Records caught' indicates the percentage of days with catches of flatfish. Catch and effort data for years with less than three vessels are omitted (indicated by x).

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	6	303	329	2 127.67	67.95	99.09
1991	6	237	274	1 790.00	61.97	100.00
1992	8	412	435	2 955.63	63.09	99.31
1993	10	588	709	5 573.30	188.64	99.86
1994	11	455	532	3 880.58	97.26	98.31
1995	12	639	752	6 241.60	151.51	98.27
1996	11	699	854	6 062.57	155.82	98.95
1997	12	724	937	6 309.37	150.03	97.44
1998	10	728	818	4 941.27	186.38	97.31
1999	10	610	658	4 128.30	91.69	99.24
2000	9	586	645	4 146.10	78.69	99.69
2001	9	446	474	3 260.92	69.36	99.79
2002	8	396	449	2 906.40	64.57	100.00
2003	6	373	387	2 588.55	46.17	100.00
2004	7	320	344	2 337.15	57.90	99.71
2005	5	366	372	2 358.85	76.47	100.00
2006	6	451	468	2 693.13	95.47	99.79
2007	7	493	527	2 907.72	96.41	99.43
2008	7	436	498	3 051.27	80.89	96.99
2009	6	430	463	2 810.18	68.82	98.92
2010	6	358	371	2 098.38	60.18	96.23
2011	6	468	545	3 356.48	126.04	91.93
2012	7	484	585	3 615.95	94.80	88.03
2013	6	401	509	3 248.57	129.51	93.91
2014	5	350	477	2 814.37	88.43	95.39
2015	5	337	390	2 389.68	61.96	97.95
2016	5	339	374	2 553.70	96.04	98.93
2017	5	375	403	2 367.23	52.60	95.78
2018	4	339	368	2 102.25	66.54	97.83
2019	4	195	234	1 325.48	34.60	98.72
2020	3	162	181	1 142.20	37.58	98.34
2021	3	134	187	1 054.10	32.72	98.40
2022	2	x	62	x	x	98.39
2023	2	x	24	x	x	91.67
2024	1	x	42	x	x	97.62

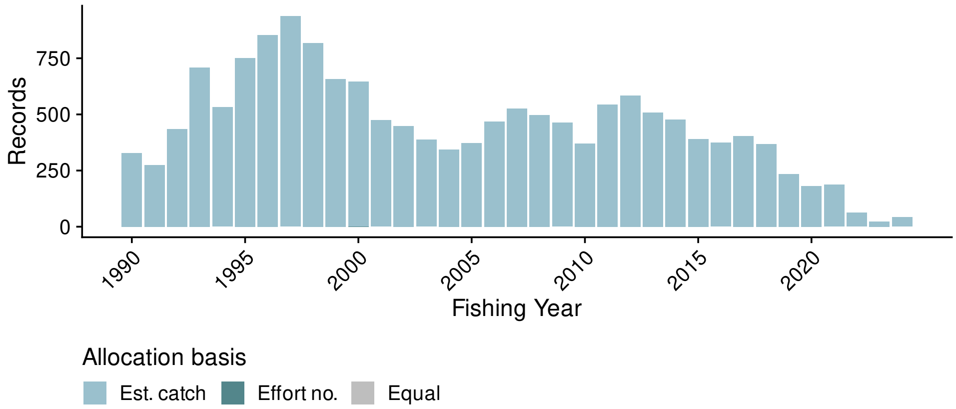

Figure C.60: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-FLA day (2018 analysis update) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

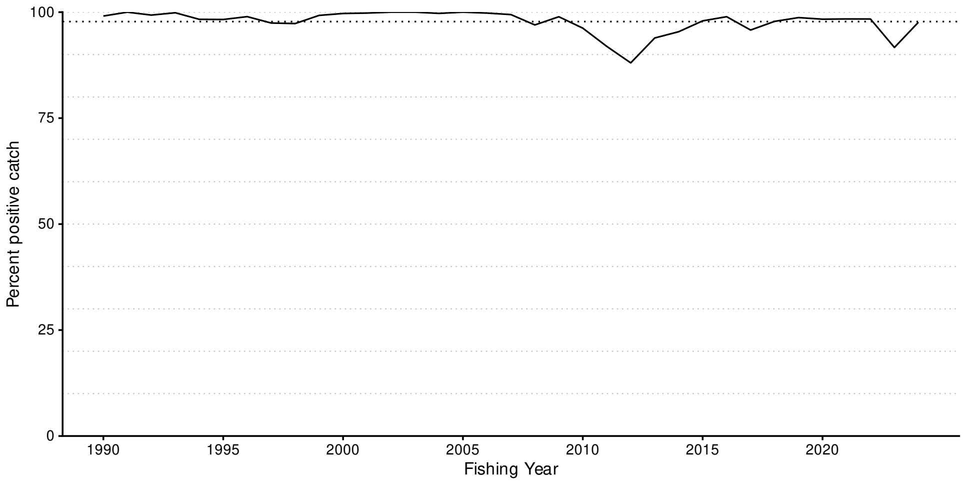

Figure C.61: Percentage of positive catch records in the Hawke Bay FLA BT-FLA day (2018 analysis update) catch-per-unit-effort dataset.

Table C.21: Summary table for the gamma model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	190 094.3	0.00	0.00	*
fyear	34	189 092.7	6.02	6.02	*
vessel_key	14	187 810.5	12.94	6.93	*
poly(log(fishing_duration), 3)	3	184 327.3	29.18	16.24	*
month	11	183 542.5	32.52	3.34	*

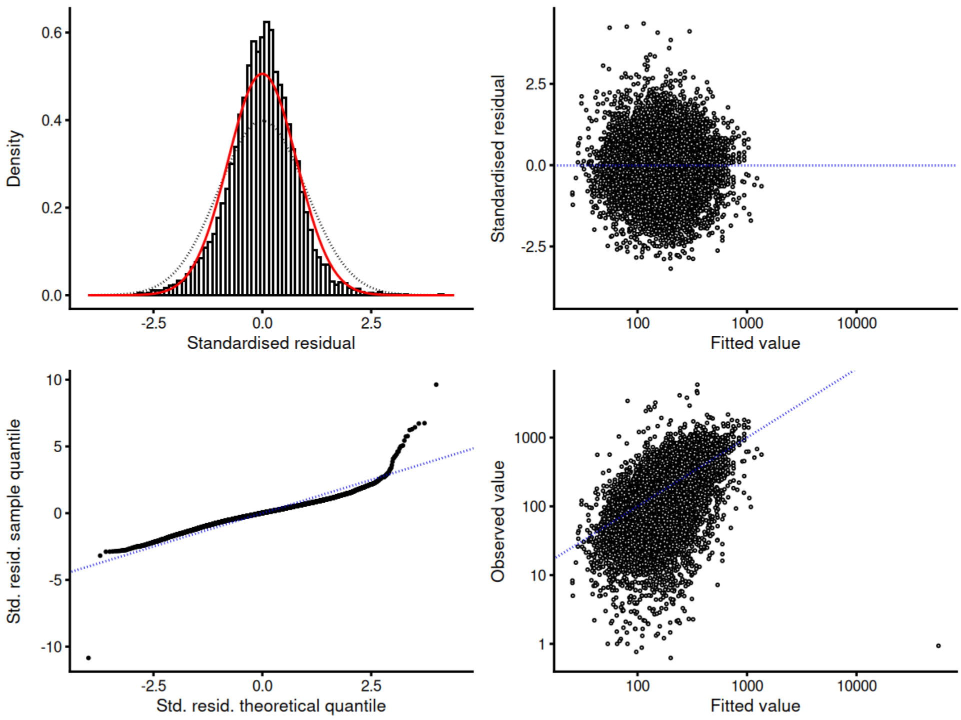

Figure C.62: Diagnostic plots for the selected gamma model for positive catches in the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset.

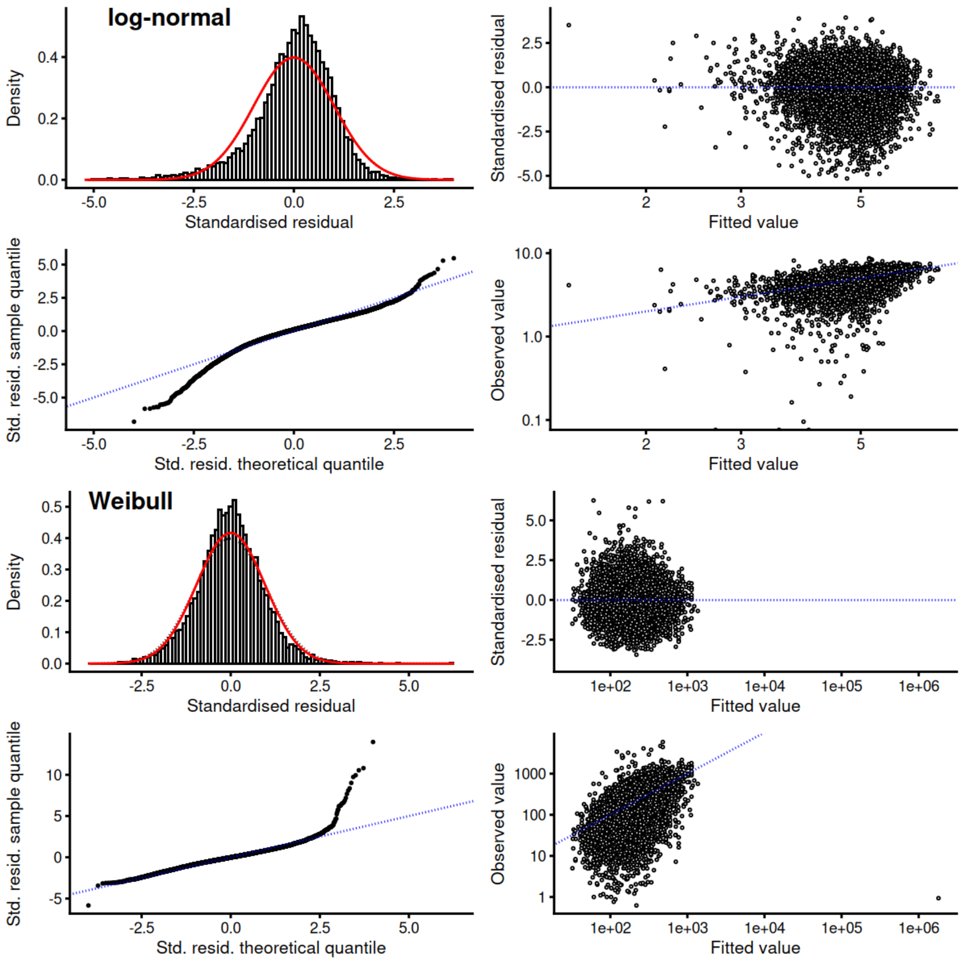

Figure C.63: Diagnostic plots for the alternative log-normal and Weibull models considered for positive catches in the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset.

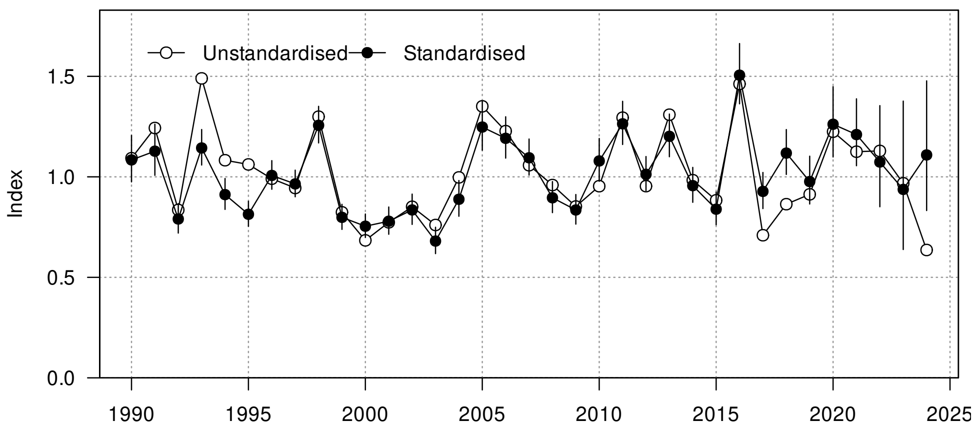

Figure C.64: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the gamma model for the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset.

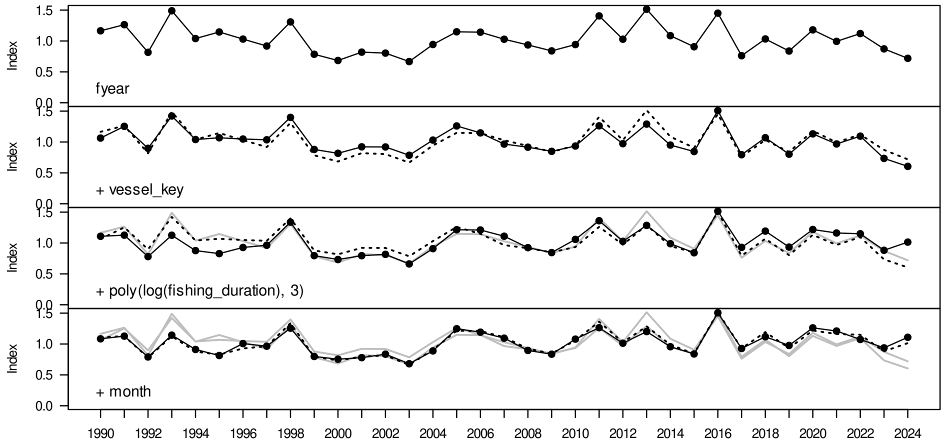

Figure C.65: Changes to the Hawke Bay FLA BT-FLA day (2018 analysis update) positive catch index as terms are successively entered into the gamma model.

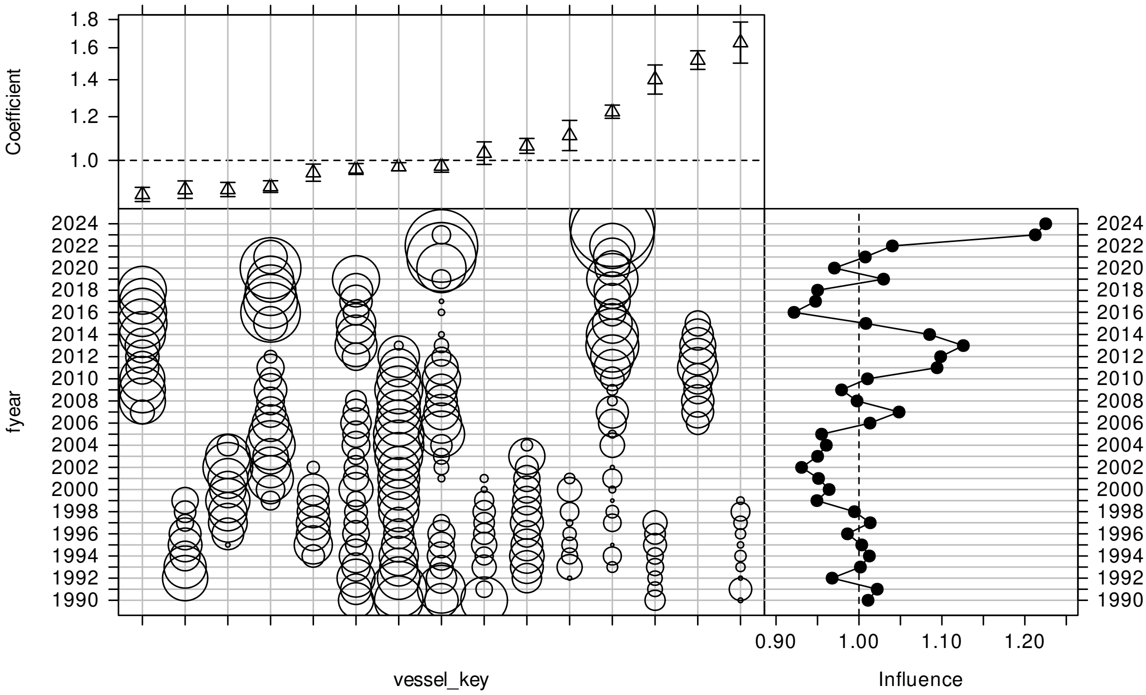

Figure C.66: CDI plot for vessel key for the gamma model of positive catches in the Hawke Bay FLA BT-FLA day (2018 analysis update) catch-per-unit-effort dataset.

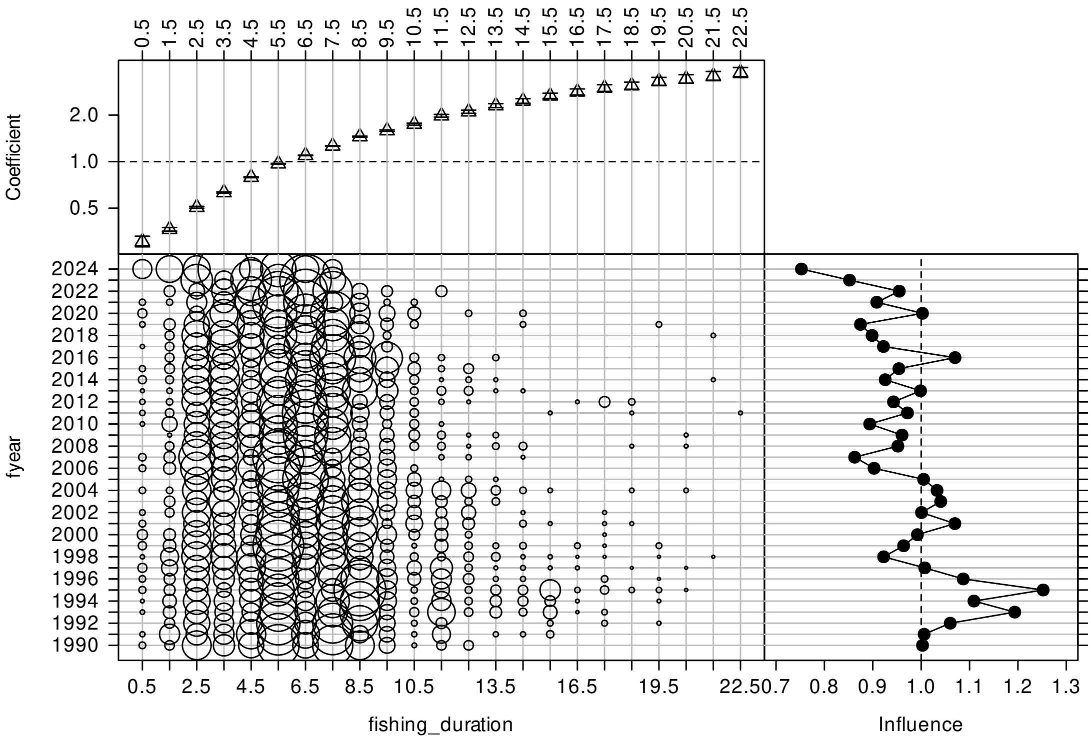

Figure C.67: CDI plot for poly fishing duration (h) for the gamma model of positive catches in the Hawke Bay FLA BT-FLA day (2018 analysis update) catch-per-unit-effort dataset.

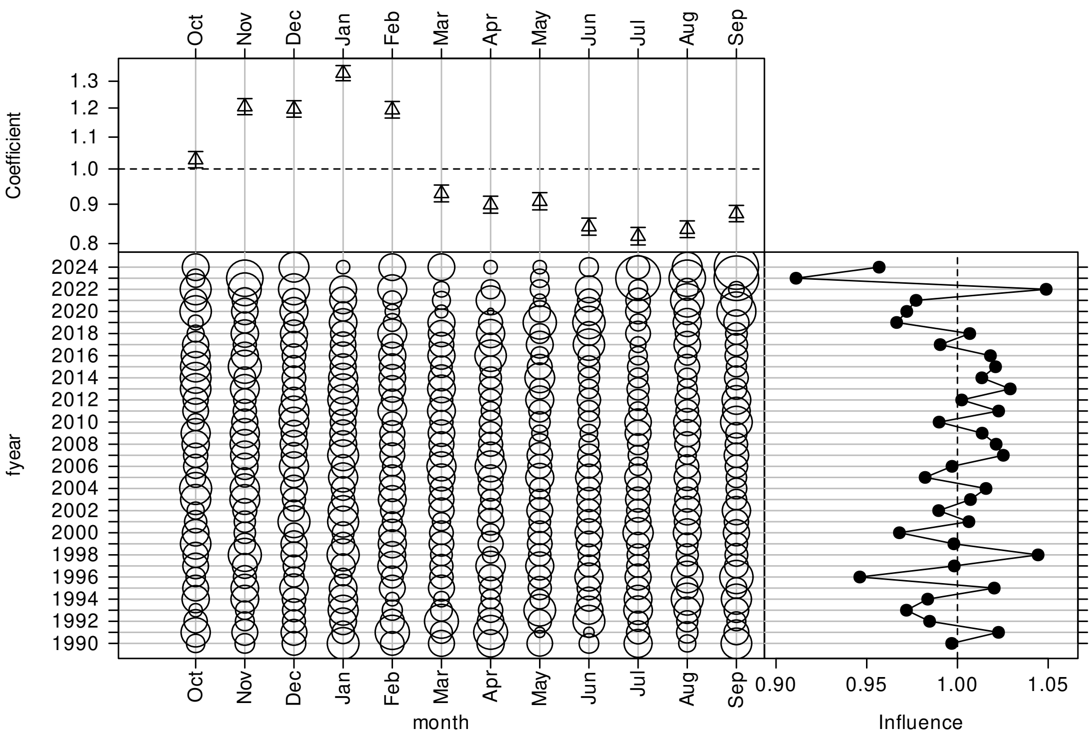

Figure C.68: CDI plot for month for the gamma model of positive catches in the Hawke Bay FLA BT-FLA day (2018 analysis update) catch-per-unit-effort dataset.

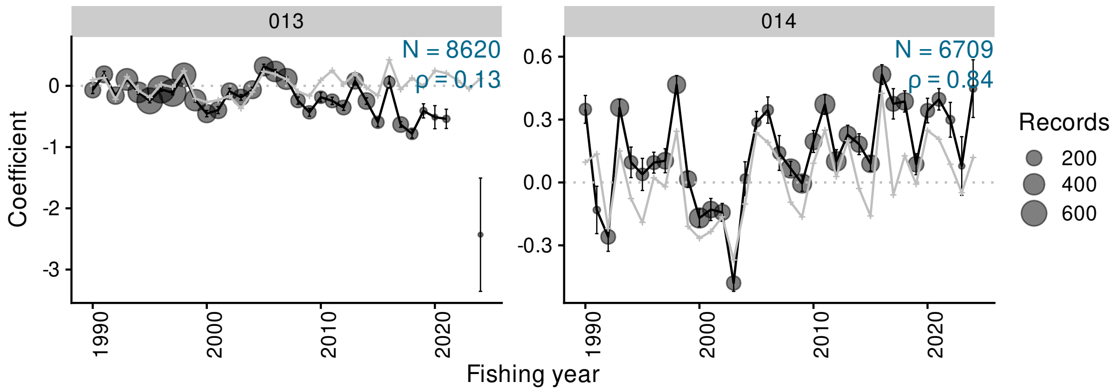

Figure C.69: Residual implied coefficients for area-year in the gamma positive catch model for the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when 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.

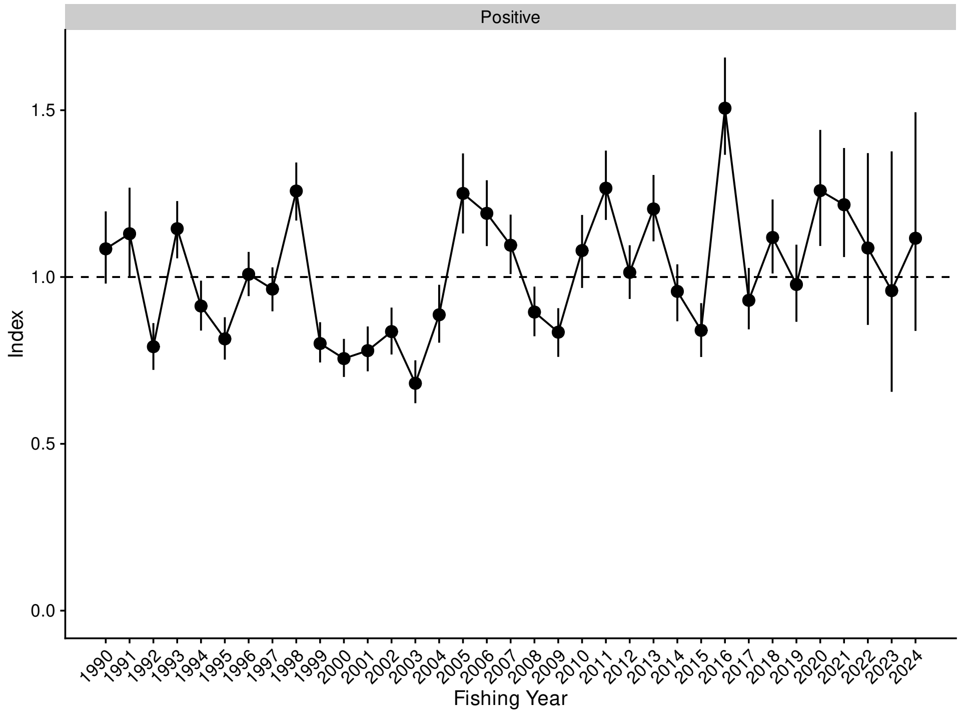

Figure C.70: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset.

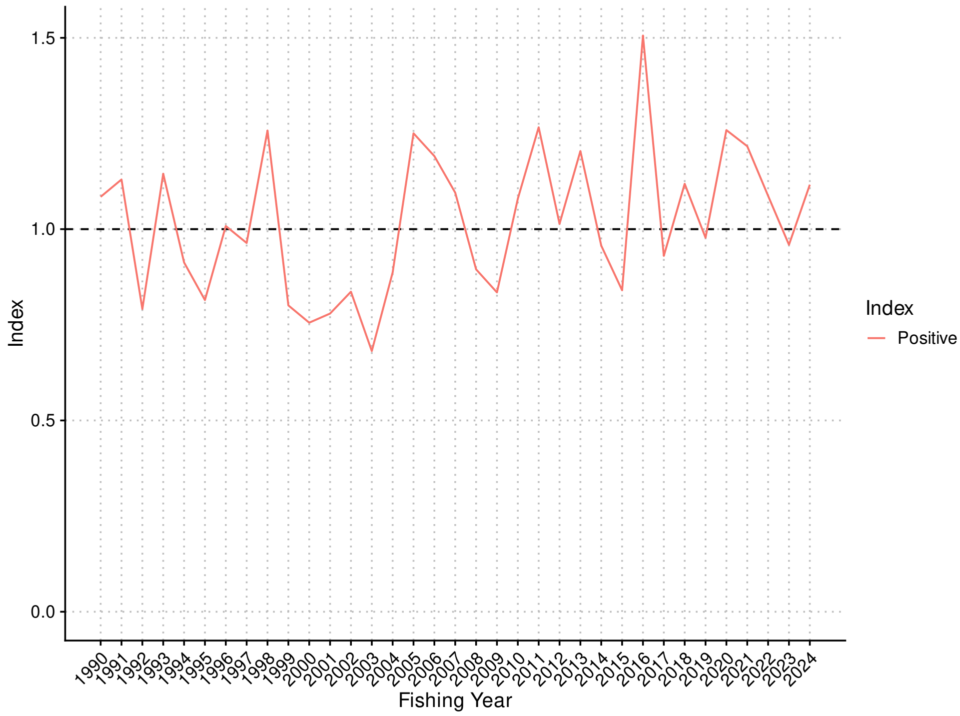

Figure C.71: Standardised indices for the Hawke Bay FLA BT-FLA day (2018 analysis update) dataset.

Table C.22: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for the Hawke Bay FLA BT-FLA day (2018 analysis update) series.

	Positive			
Fishing year	index	SE	LCI	UCI
1990	1.084	0.055	0.980	1.197
1991	1.130	0.068	1.002	1.268
1992	0.791	0.036	0.722	0.862
1993	1.145	0.044	1.056	1.228
1994	0.913	0.038	0.839	0.989
1995	0.815	0.032	0.752	0.879
1996	1.008	0.034	0.943	1.075
1997	0.964	0.034	0.897	1.029
1998	1.258	0.044	1.169	1.343
1999	0.801	0.031	0.744	0.865
2000	0.756	0.029	0.701	0.815
2001	0.779	0.034	0.717	0.852
2002	0.836	0.036	0.768	0.908
2003	0.681	0.033	0.622	0.750
2004	0.887	0.044	0.803	0.977
2005	1.251	0.061	1.131	1.371
2006	1.191	0.050	1.093	1.290
2007	1.095	0.045	1.009	1.187
2008	0.895	0.038	0.822	0.971
2009	0.835	0.037	0.761	0.907
2010	1.079	0.056	0.967	1.186
2011	1.266	0.053	1.171	1.379
2012	1.014	0.041	0.934	1.095
2013	1.204	0.051	1.107	1.306
2014	0.957	0.044	0.867	1.038
2015	0.840	0.041	0.760	0.922
2016	1.506	0.074	1.366	1.658
2017	0.930	0.047	0.843	1.027
2018	1.119	0.057	1.011	1.232
2019	0.978	0.059	0.866	1.097
2020	1.259	0.089	1.093	1.441
2021	1.217	0.083	1.060	1.387
2022	1.087	0.131	0.856	1.371
2023	0.959	0.184	0.656	1.377
2024	1.116	0.167	0.839	1.494

C.5 Hawke Bay FLA BT-MIX day

This series was prepared to be intermediate between the event-based series which necessarily began with the introduction of the TCER tow-by-tow forms in the 2007–08 fishing year and a longer time series reaching back to the 1989–90 fishing year through the use of pseudo-CELR data preparation procedure. The bridging with the event-based analysis was achieved by adding GUR as a target species category and setting the vessel selection criteria to five trips in at least six years. This analysis also used the Weibull distribution for the positive catch model and accepted all the explanatory variables for use in the final model. Because this analysis was based on the CELR data, only the top five species in a day of fishing were used to determine records with positive FLA catch instead of the eight species in the event-based analysis. This series accepted more vessels than the series based only on FLA target fishing, with nine vessels observed in both 2023 and 2024 (Table C.25). However, FLA catches were still 26 t in 2022, only 11 t in 2023 and 40 t in 2024.

Table C.23: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-MIX day CPUE series.

Series	Hawke Bay FLA BT-MIX day
QMS stock	FLA 2
Reporting forms	CEL, ERS - Trawl, TCE, TCP
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	1989-10-01, 2024-09-30
Resolution	Day
Core fleet years	6
Core fleet trips	5
Default model	allockg ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(effort_height, 3) + ns(effort_num, 3)
Stepwise selection	No
Positive catch distribution	Weibull

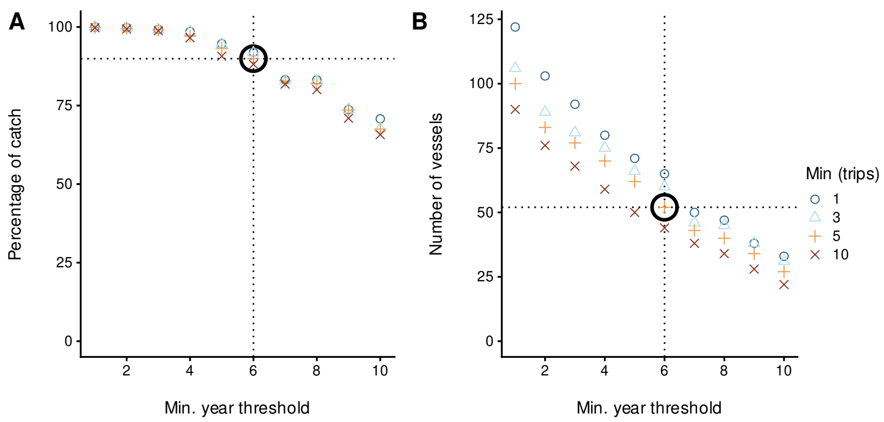

Figure C.72: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-MIX day CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

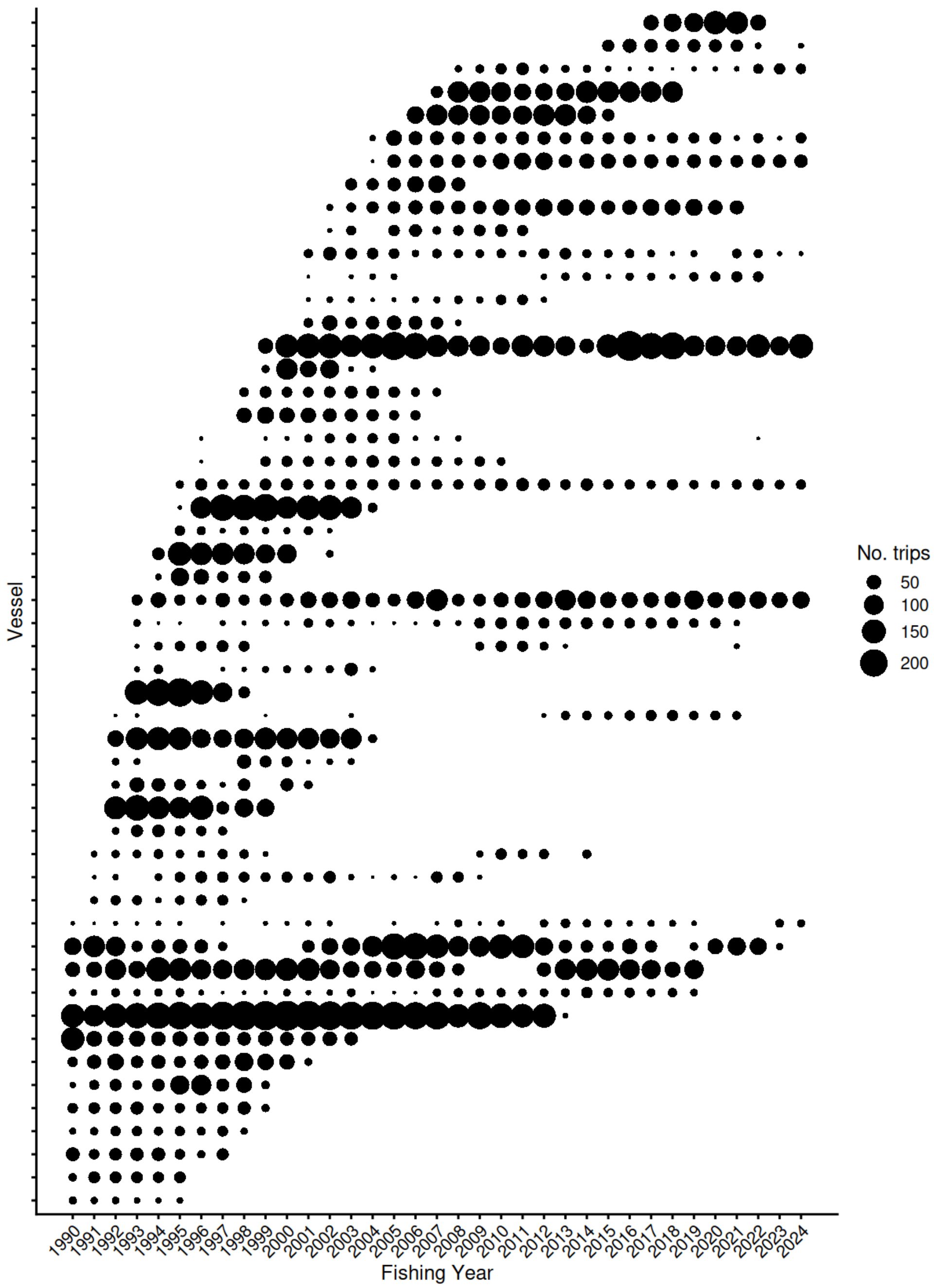

Figure C.73: Number of trips by fishing year for core vessels in the Hawke Bay FLA BT-MIX day series. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

Table C.24: Summary of the Hawke Bay FLA BT-MIX day 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	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	167 (100%) n: 1243	189 (100%) n: 1346	200 (100%) n: 2052	357 (100%) n: 2234	241 (100%) n: 2255	346 (100%) n: 2426	354 (100%) n: 2411	254 (100%) n: 2268	388 (100%) n: 2411
Positive fishing duration	166 (99%) n: 1236	187 (99%) n: 1334	200 (100%) n: 2050	357 (100%) n: 2233	241 (100%) n: 2252	345 (100%) n: 2418	348 (98%) n: 2381	249 (98%) n: 2228	380 (98%) n: 2373
Fishing duration less than 20 h	166 (99%) n: 1235	184 (97%) n: 1323	195 (97%) n: 2040	345 (97%) n: 2221	238 (99%) n: 2245	334 (97%) n: 2387	345 (97%) n: 2356	247 (97%) n: 2213	372 (96%) n: 2334
Less than 7 tows	165 (99%) n: 1229	183 (97%) n: 1315	195 (97%) n: 2040	342 (96%) n: 2217	236 (98%) n: 2236	329 (95%) n: 2366	342 (96%) n: 2315	244 (96%) n: 2202	366 (94%) n: 2324
Headline height less than 10 m	165 (99%) n: 1228	183 (97%) n: 1306	194 (97%) n: 2021	341 (96%) n: 2196	232 (96%) n: 2209	326 (94%) n: 2342	336 (95%) n: 2276	241 (95%) n: 2171	357 (92%) n: 2259
Core fleet selection	86 (51%) n: 677	106 (56%) n: 783	115 (58%) n: 1283	307 (86%) n: 1670	208 (86%) n: 1872	291 (84%) n: 2023	311 (88%) n: 2087	222 (87%) n: 1983	322 (83%) n: 2059

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	186 (100%) n: 2276	145 (100%) n: 2250	119 (100%) n: 2028	114 (100%) n: 2295	81 (100%) n: 2043	100 (100%) n: 1640	156 (100%) n: 1903	172 (100%) n: 1820	179 (100%) n: 1985
Positive fishing duration	182 (98%) n: 2231	144 (99%) n: 2223	119 (100%) n: 2028	114 (100%) n: 2295	81 (100%) n: 2043	100 (100%) n: 1640	156 (100%) n: 1903	172 (100%) n: 1820	179 (100%) n: 1985
Fishing duration less than 20 h	179 (96%) n: 2195	142 (98%) n: 2207	118 (99%) n: 2021	114 (100%) n: 2285	81 (100%) n: 2030	100 (99%) n: 1631	155 (99%) n: 1888	172 (100%) n: 1814	179 (100%) n: 1979
Less than 7 tows	178 (96%) n: 2189	142 (98%) n: 2205	117 (99%) n: 2018	114 (100%) n: 2283	80 (98%) n: 2029	99 (99%) n: 1628	155 (99%) n: 1886	172 (100%) n: 1814	179 (100%) n: 1978
Headline height less than 10 m	176 (95%) n: 2155	142 (97%) n: 2176	117 (98%) n: 1992	113 (99%) n: 2265	79 (97%) n: 1992	99 (99%) n: 1599	153 (98%) n: 1846	169 (98%) n: 1804	178 (100%) n: 1960
Core fleet selection	159 (85%) n: 1944	131 (90%) n: 1991	113 (95%) n: 1883	109 (96%) n: 2169	79 (97%) n: 1987	99 (98%) n: 1588	152 (97%) n: 1773	168 (97%) n: 1758	177 (99%) n: 1870

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	128 (100%) n: 1712	107 (100%) n: 1588	106 (100%) n: 1821	188 (100%) n: 1889	139 (100%) n: 1745	161 (100%) n: 1538	136 (100%) n: 1858	84 (100%) n: 1571	159 (100%) n: 1556
Positive fishing duration	128 (100%) n: 1711	107 (100%) n: 1588	106 (100%) n: 1819	188 (100%) n: 1889	139 (100%) n: 1745	161 (100%) n: 1538	136 (100%) n: 1858	84 (100%) n: 1570	159 (100%) n: 1556
Fishing duration less than 20 h	128 (100%) n: 1701	106 (100%) n: 1583	106 (100%) n: 1812	188 (100%) n: 1881	139 (100%) n: 1740	161 (100%) n: 1534	135 (100%) n: 1853	84 (100%) n: 1567	159 (100%) n: 1546
Less than 7 tows	128 (100%) n: 1701	106 (100%) n: 1583	106 (100%) n: 1812	188 (100%) n: 1881	139 (100%) n: 1740	161 (100%) n: 1534	135 (100%) n: 1853	84 (100%) n: 1567	159 (100%) n: 1546
Headline height less than 10 m	128 (99%) n: 1698	106 (99%) n: 1578	106 (100%) n: 1812	188 (100%) n: 1879	139 (100%) n: 1740	161 (100%) n: 1531	135 (100%) n: 1848	84 (100%) n: 1565	159 (100%) n: 1546
Core fleet selection	127 (99%) n: 1615	104 (98%) n: 1502	105 (99%) n: 1745	186 (99%) n: 1822	139 (100%) n: 1721	160 (100%) n: 1518	109 (80%) n: 1588	72 (85%) n: 1380	140 (88%) n: 1408

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	79 (100%) n: 1451	82 (100%) n: 1426	48 (100%) n: 1317	46 (100%) n: 1179	48 (100%) n: 1075	29 (100%) n: 1116	16 (100%) n: 678	42 (100%) n: 859
Positive fishing duration	79 (100%) n: 1451	82 (100%) n: 1426	48 (100%) n: 1315	46 (100%) n: 1179	48 (100%) n: 1074	29 (100%) n: 1116	16 (100%) n: 678	42 (100%) n: 859
Fishing duration less than 20 h	79 (100%) n: 1440	82 (100%) n: 1422	48 (100%) n: 1302	46 (100%) n: 1170	48 (100%) n: 1067	29 (100%) n: 1113	16 (100%) n: 674	42 (100%) n: 857
Less than 7 tows	79 (100%) n: 1440	82 (100%) n: 1422	48 (100%) n: 1302	46 (100%) n: 1170	48 (100%) n: 1067	29 (100%) n: 1113	16 (100%) n: 674	42 (100%) n: 854
Headline height less than 10 m	78 (99%) n: 1438	82 (100%) n: 1421	48 (99%) n: 1296	45 (98%) n: 1162	48 (100%) n: 1067	27 (93%) n: 1022	11 (69%) n: 585	40 (95%) n: 805
Core fleet selection	71 (90%) n: 1315	80 (98%) n: 1330	48 (99%) n: 1264	45 (98%) n: 1119	48 (99%) n: 1035	26 (91%) n: 814	11 (68%) n: 456	40 (95%) n: 626

Table C.25: **Summary of the Hawke Bay FLA BT-MIX day dataset after core fleet selection. 'Records' indicates the number of rows (days) in the dataset, and 'Records caught' indicates the percentage of days with catches of flatfish.**

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	13	556	677	4 690.17	85.55	82.13
1991	16	565	783	5 974.22	105.78	77.91
1992	22	951	1 283	10 633.03	115.39	74.59
1993	26	1 164	1 670	14 549.55	306.92	82.57
1994	27	1 362	1 872	15 817.28	207.72	77.19
1995	29	1 582	2 023	16 779.80	291.15	83.24
1996	27	1 501	2 087	17 182.45	311.34	83.80
1997	28	1 317	1 983	15 617.50	221.55	79.02
1998	27	1 411	2 059	15 851.85	322.12	78.87
1999	28	1 361	1 944	15 950.92	158.52	66.31
2000	23	1 389	1 991	16 449.07	131.46	68.46
2001	27	1 298	1 883	15 699.68	112.87	61.55
2002	27	1 357	2 169	18 015.30	109.46	59.06
2003	27	1 199	1 987	17 154.40	79.06	53.50
2004	25	963	1 588	13 848.53	98.92	59.95
2005	23	1 119	1 773	15 813.20	151.79	67.91
2006	22	1 171	1 758	13 971.72	167.77	67.86
2007	23	1 205	1 870	14 656.10	176.53	65.08
2008	23	985	1 615	13 010.48	126.68	63.96
2009	21	968	1 502	12 326.68	104.10	55.19
2010	20	1 052	1 745	14 754.88	105.01	50.37
2011	18	1 039	1 822	15 791.88	186.24	54.06
2012	21	1 029	1 721	14 347.12	138.89	53.86
2013	19	868	1 518	13 034.00	160.38	51.78
2014	18	833	1 588	13 575.35	108.72	43.70
2015	18	790	1 380	11 894.80	71.95	43.55
2016	17	864	1 408	11 767.85	140.08	47.66
2017	18	811	1 315	10 712.39	70.61	44.33
2018	17	789	1 330	10 492.72	80.14	47.37
2019	17	675	1 264	10 373.47	47.60	38.13
2020	13	599	1 119	9 386.22	44.86	36.37
2021	15	604	1 035	8 007.78	47.95	49.86
2022	12	504	814	6 147.78	26.16	49.39
2023	9	265	456	3 728.57	11.21	32.46
2024	9	357	626	4 624.27	39.87	46.33

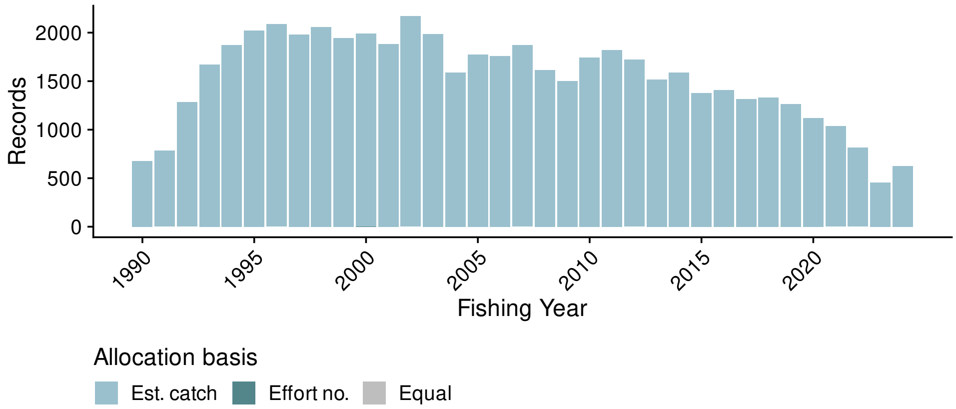

Figure C.74: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.26: Summary table for occurrence of positive catch in the Hawke Bay FLA BT-MIX day series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	71 376.30	0.00	0.00	*
fyear	34	66 926.01	6.33	6.33	*
vessel_key	51	43 027.04	39.96	33.63	*
stat_area	1	43 025.30	39.96	0.01	*
month	11	42 598.88	40.59	0.63	*
target_species	1	39 091.76	45.51	4.92	*
ns(log(fishing_duration), 3)	3	39 081.55	45.53	0.02	*
ns(effort_height, 3)	3	39 039.91	45.60	0.07	*
ns(effort_num, 3)	3	38 928.88	45.76	0.16	*

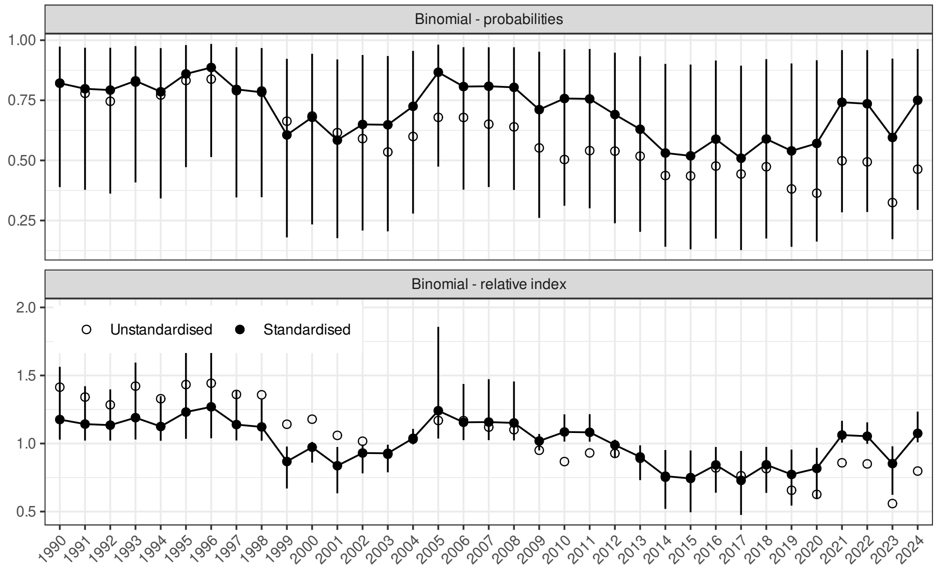

Figure C.75: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay FLA BT-MIX day dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

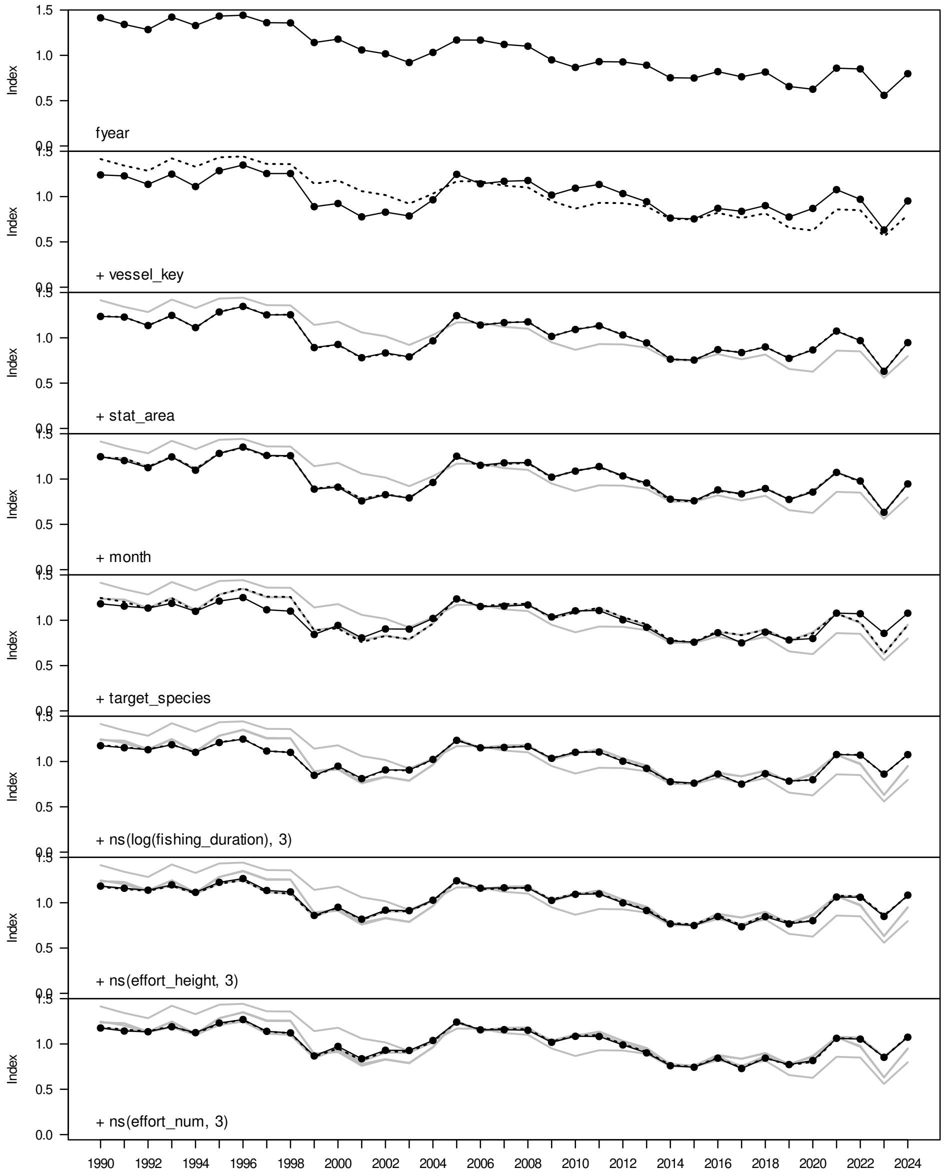

Figure C.76: Step plot for occurrence of catch in the Hawke Bay FLA BT-MIX day dataset.

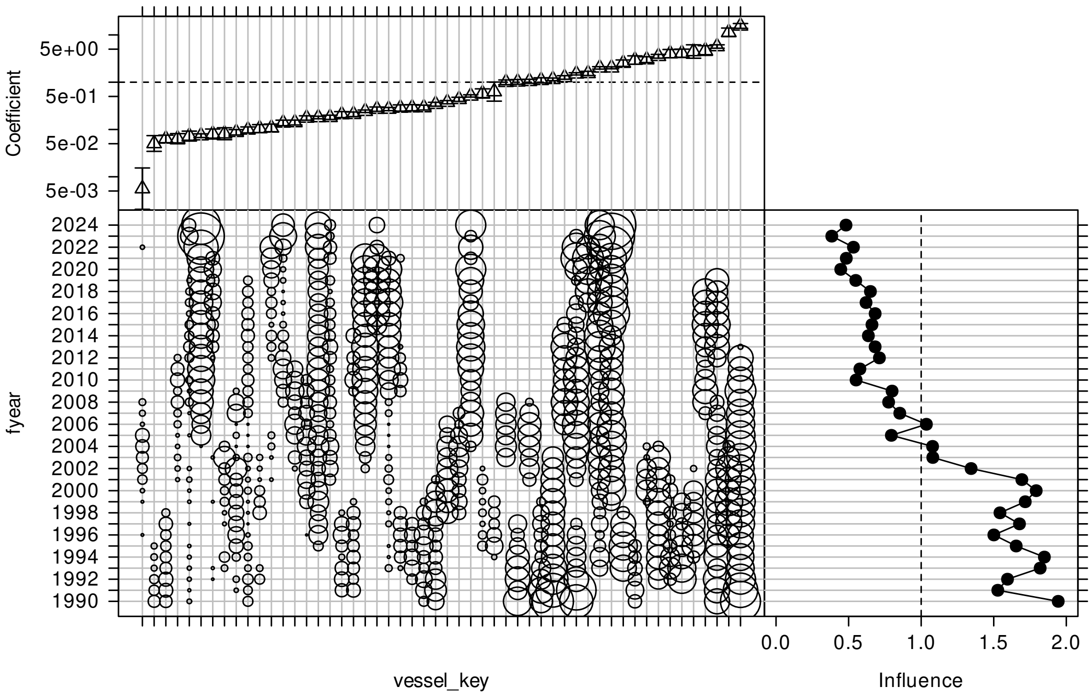

Figure C.77: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

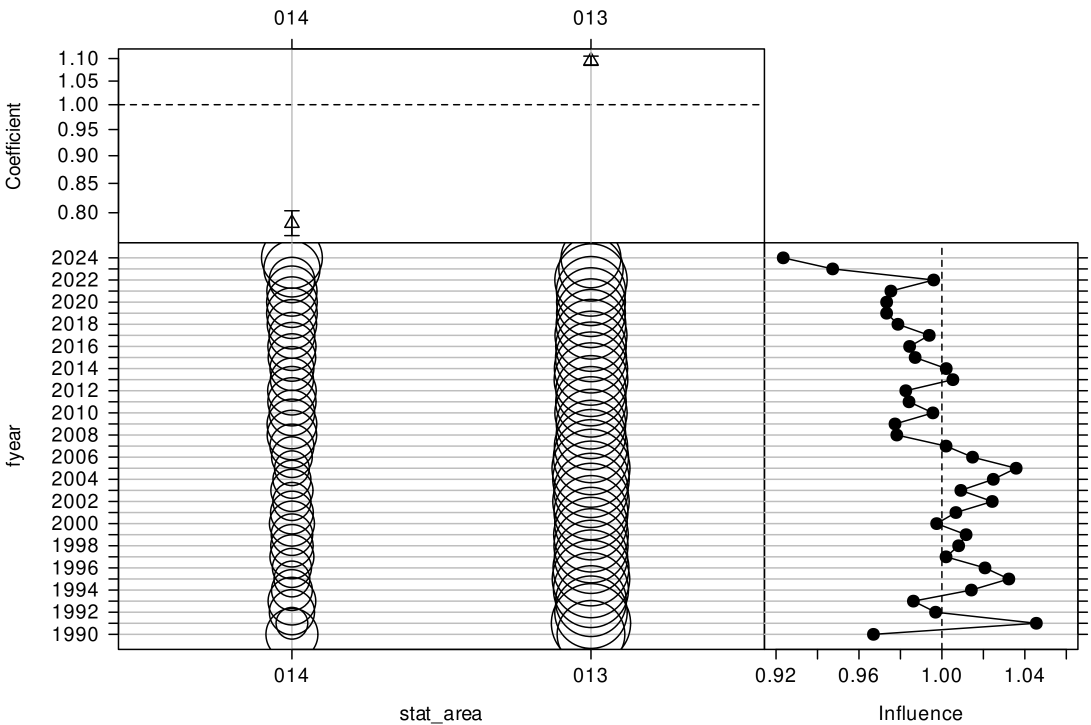

Figure C.78: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

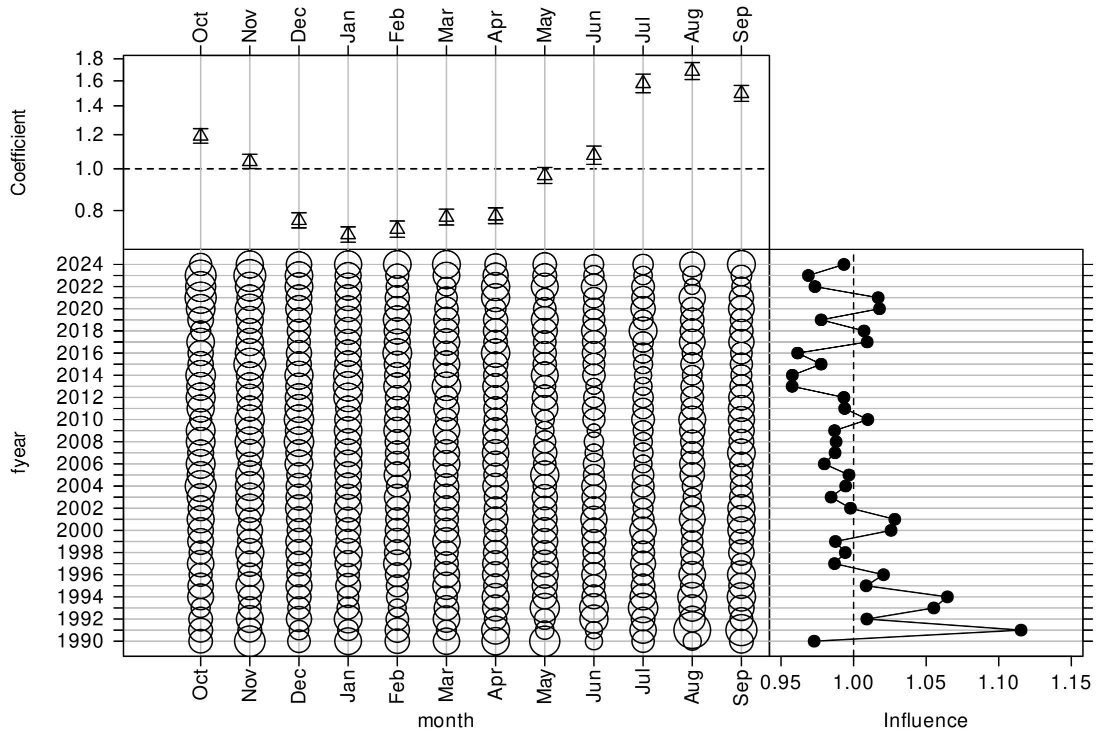

Figure C.79: CDI plot for month for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

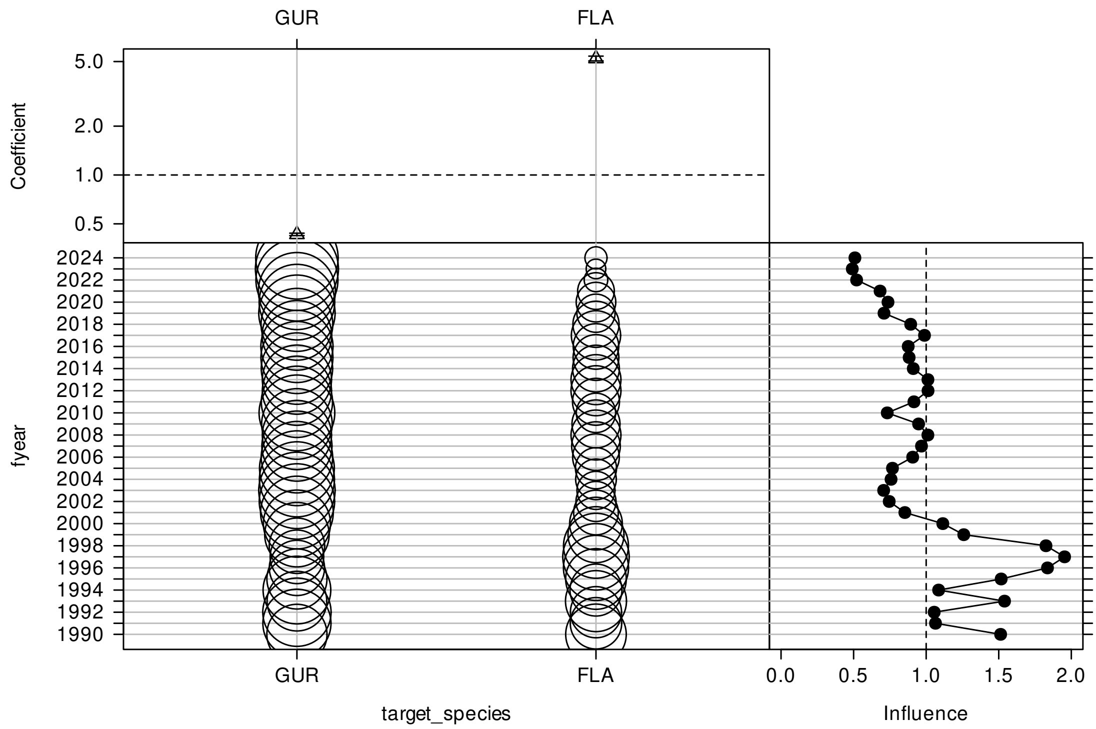

Figure C.80: CDI plot for target species for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

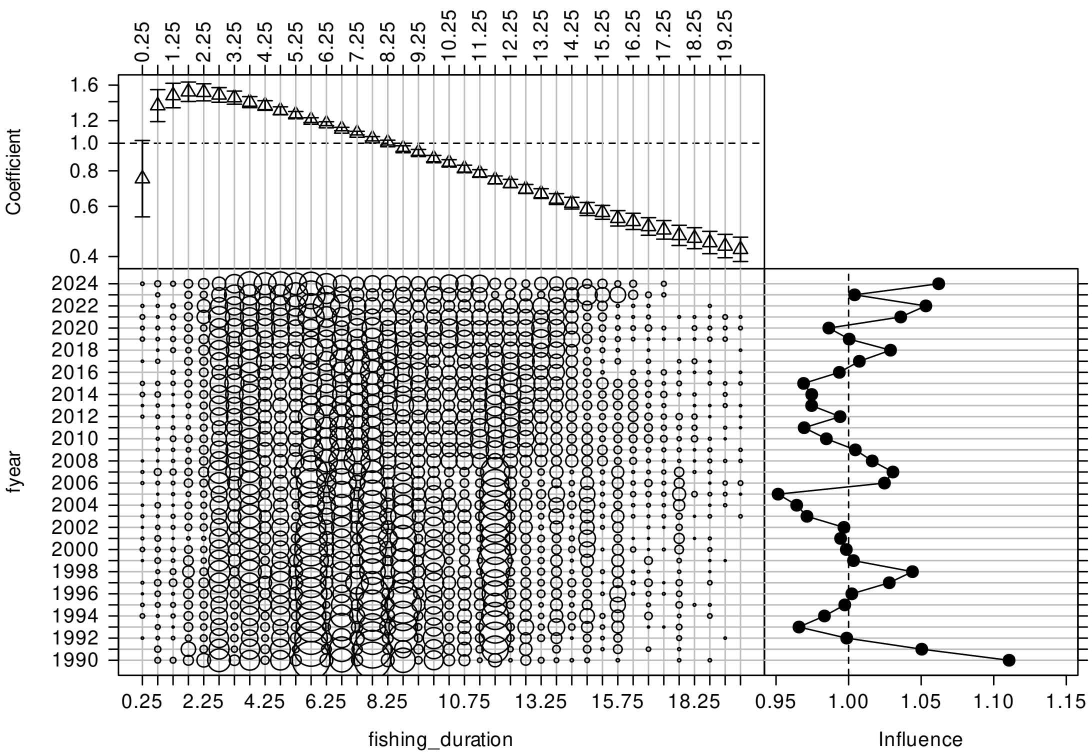

Figure C.81: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

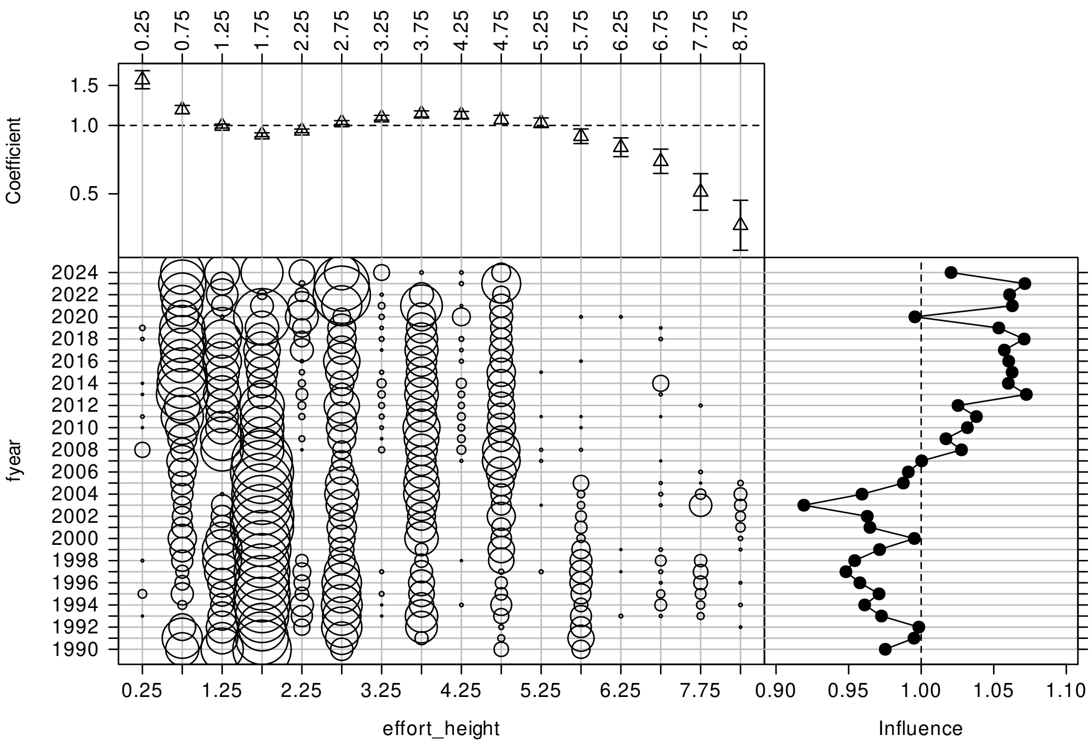

Figure C.82: CDI plot for effort height (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

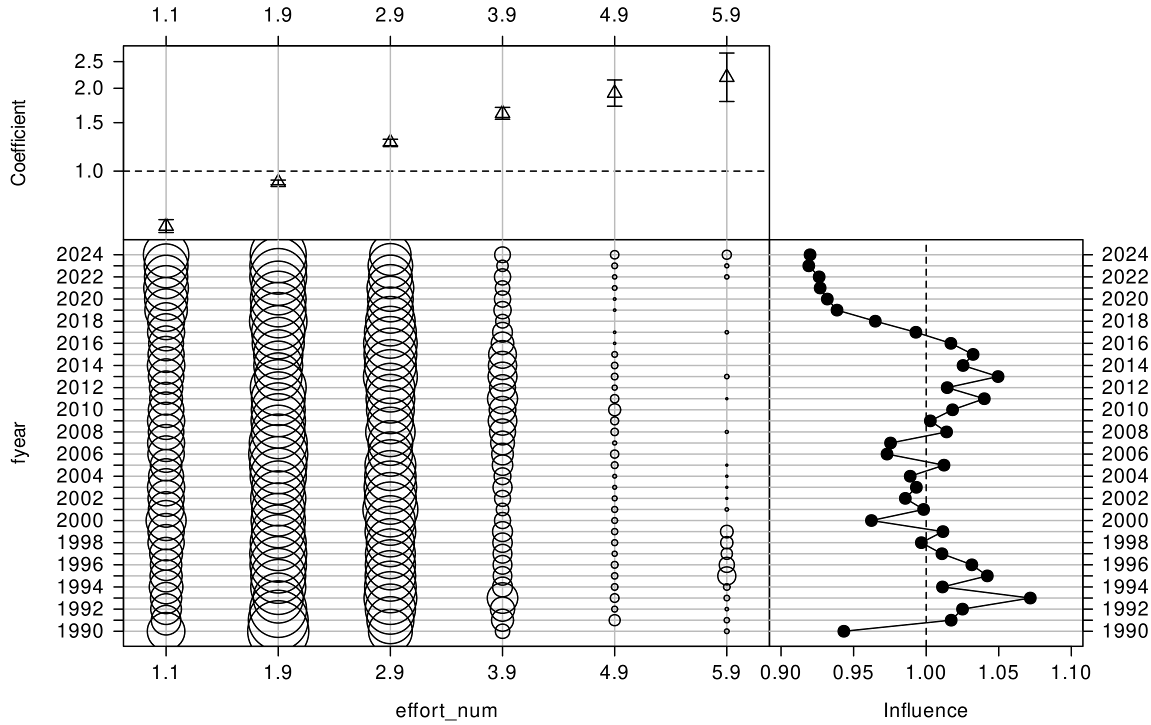

Figure C.83: CDI plot for effort num for the occurrence of positive catch in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

Table C.27: Summary table for the Weibull model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	393 933.6	0.00	0.00	*
fyear	34	391 618.7	4.94	4.94	*
vessel_key	51	388 859.0	10.88	5.94	*
stat_area	1	387 679.5	13.33	2.45	*
month	11	386 534.2	15.75	2.42	*
target_species	1	381 650.4	25.89	10.14	*
ns(log(fishing_duration), 3)	3	376 916.6	35.72	9.83	*
ns(effort_height, 3)	3	376 853.2	35.86	0.14	*
ns(effort_num, 3)	3	375 846.6	37.96	2.10	*

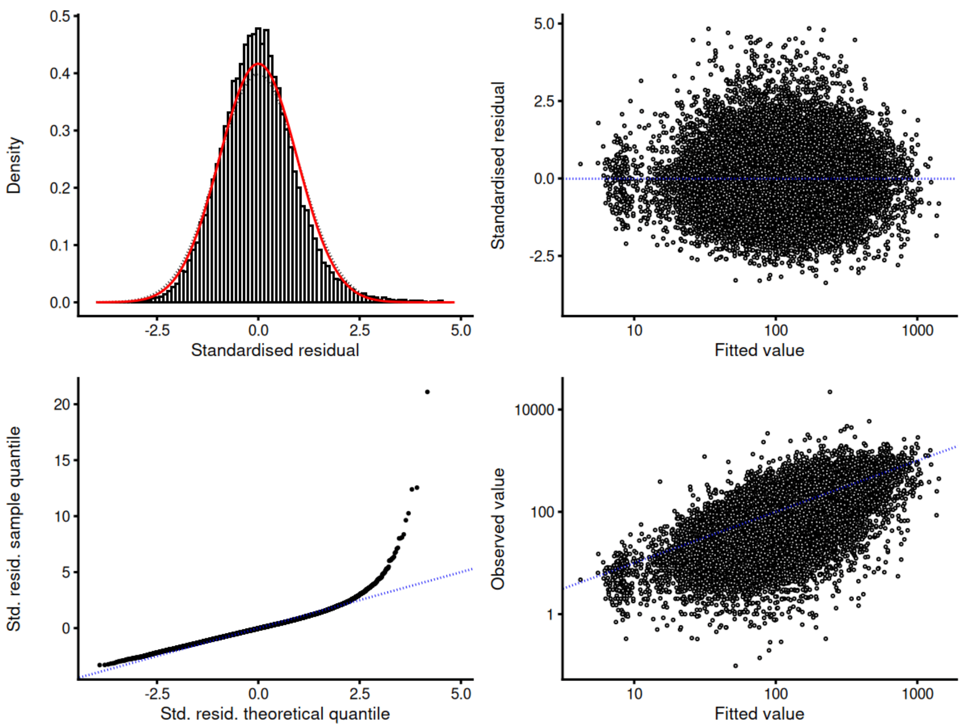

Figure C.84: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-MIX day dataset.

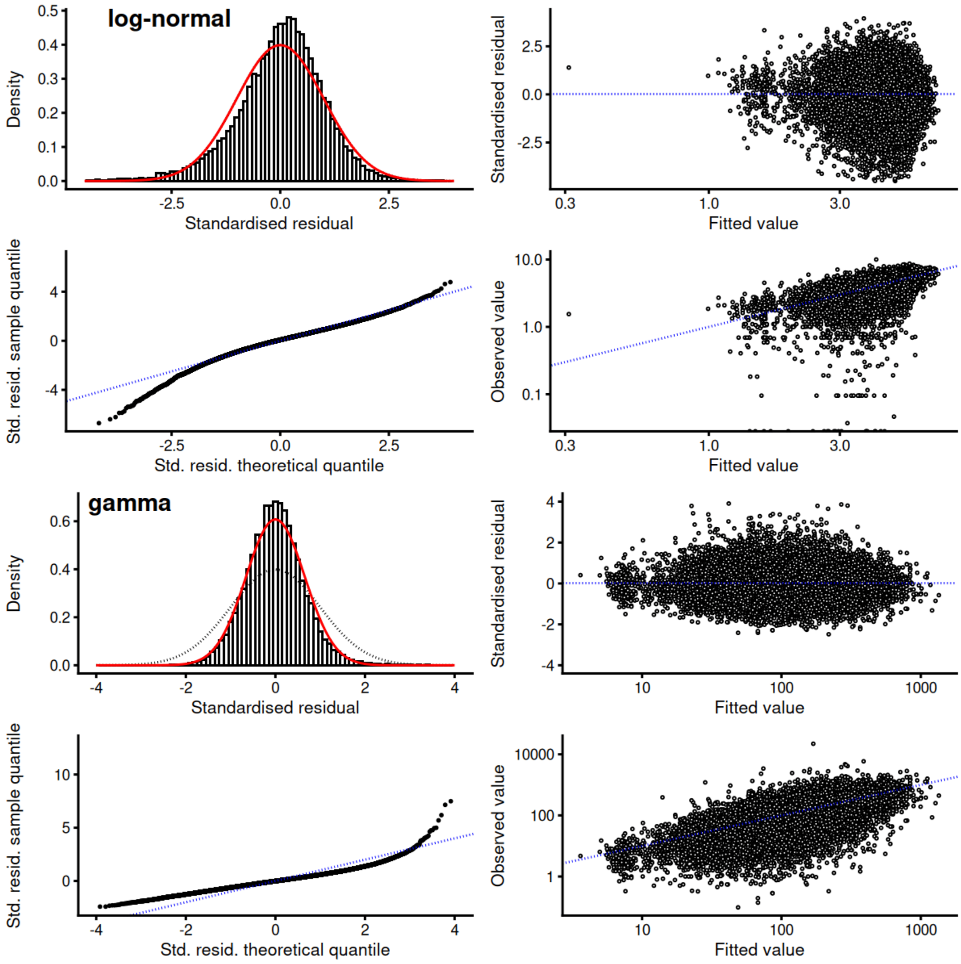

Figure C.85: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-MIX day dataset.

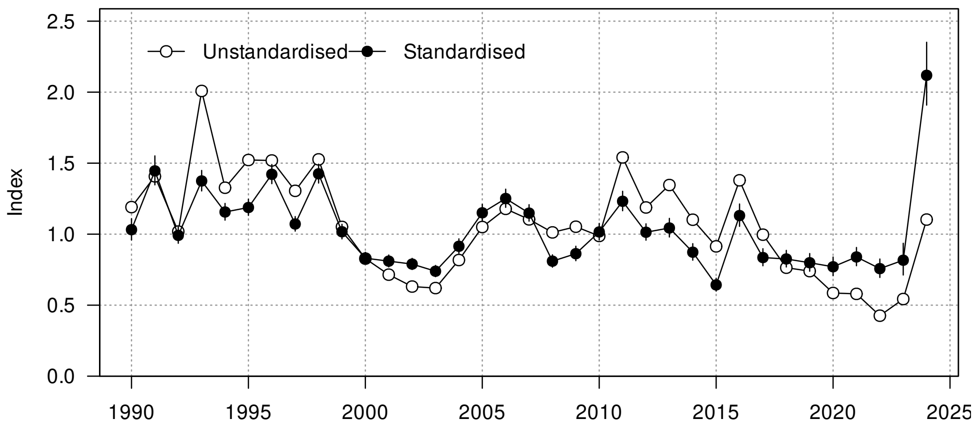

Figure C.86: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-MIX day dataset.

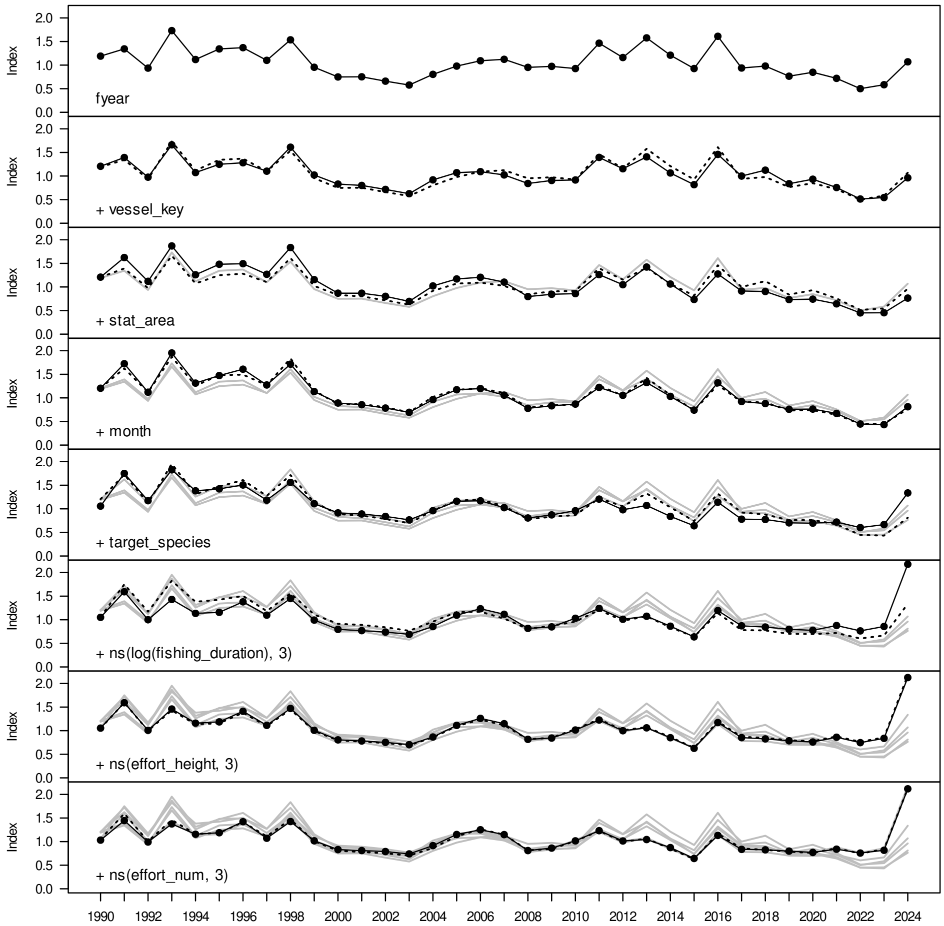

Figure C.87: Changes to the Hawke Bay FLA BT-MIX day positive catch index as terms are successively entered into the Weibull model.

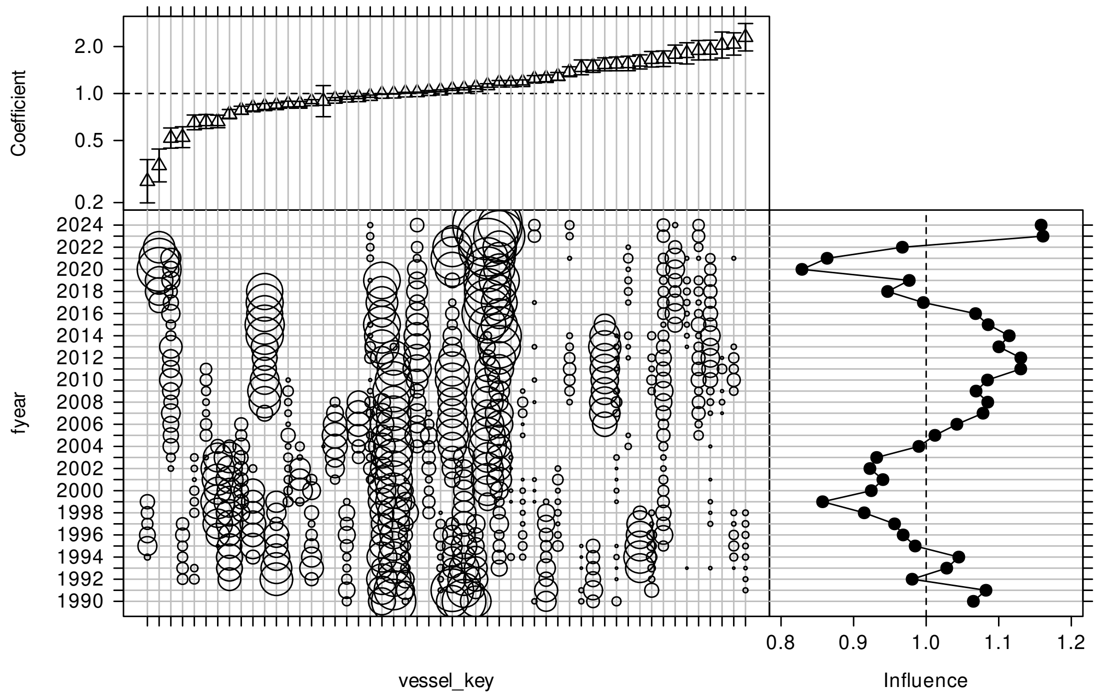

Figure C.88: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

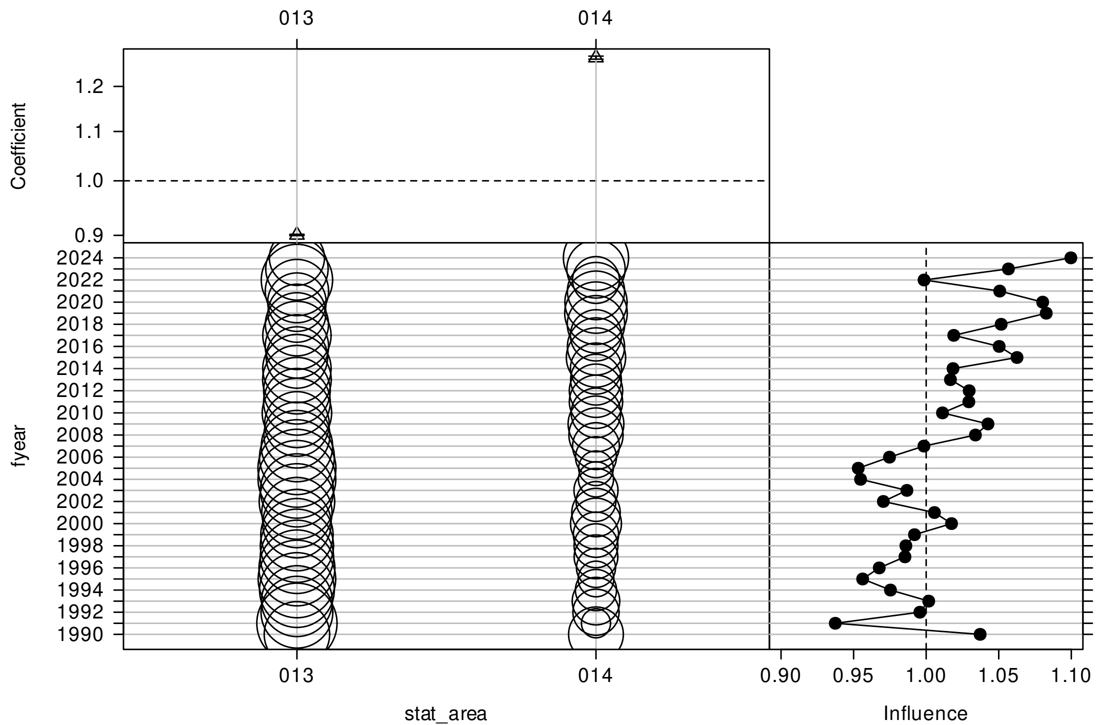

Figure C.89: CDI plot for statistical area for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

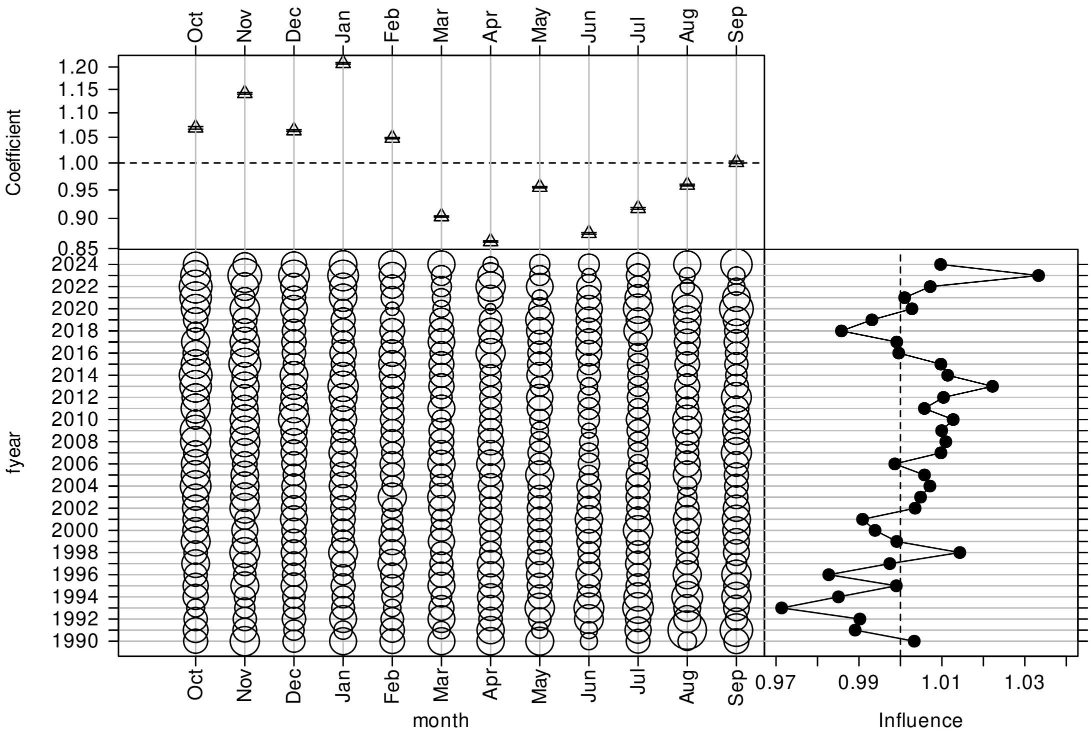

Figure C.90: CDI plot for month for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

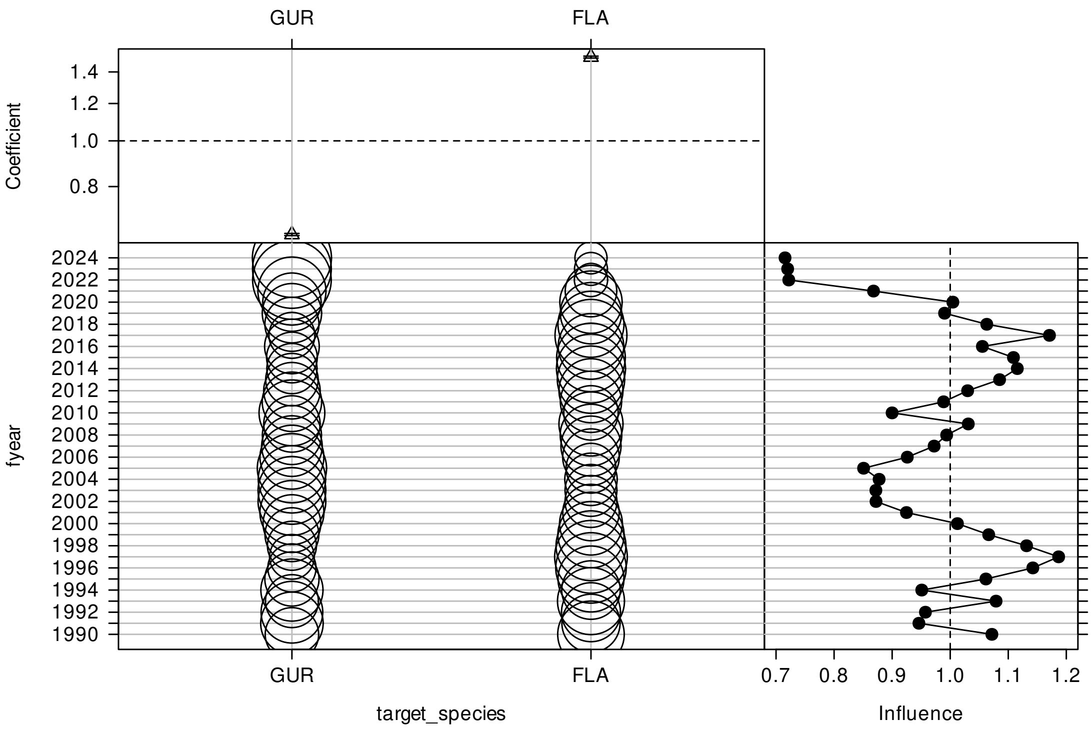

Figure C.91: CDI plot for target species for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

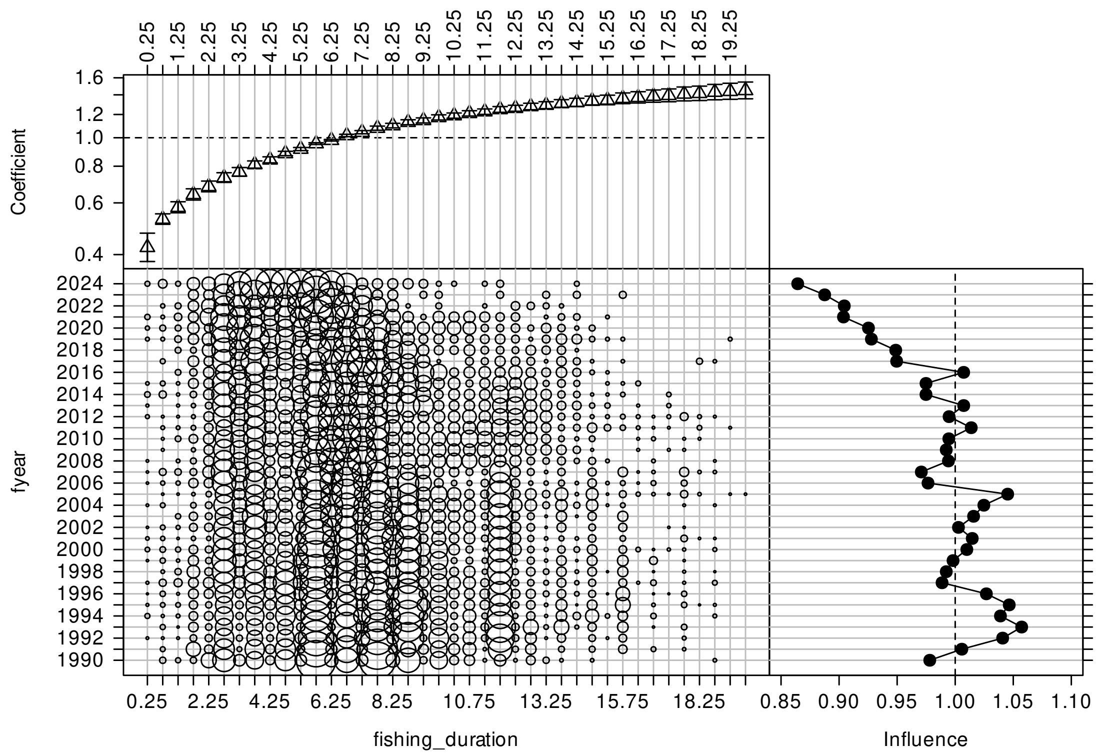

Figure C.92: CDI plot for fishing duration (h) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

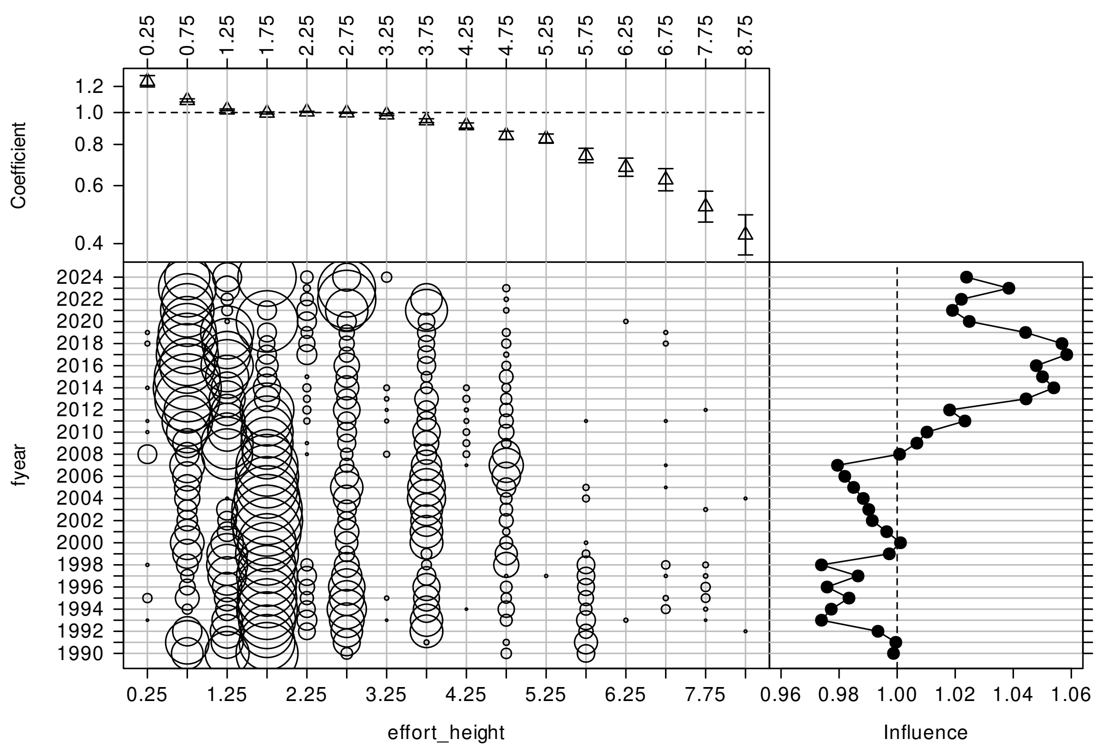

Figure C.93: CDI plot for effort height (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

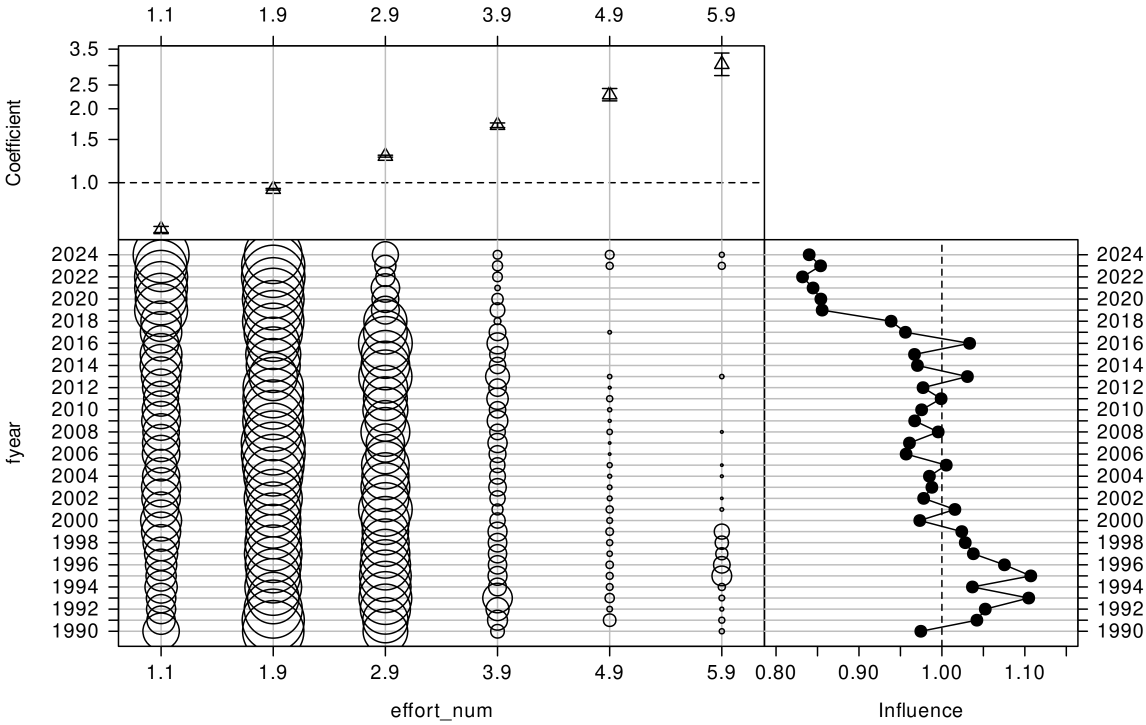

Figure C.94: CDI plot for effort num for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX day catch-per-unit-effort dataset.

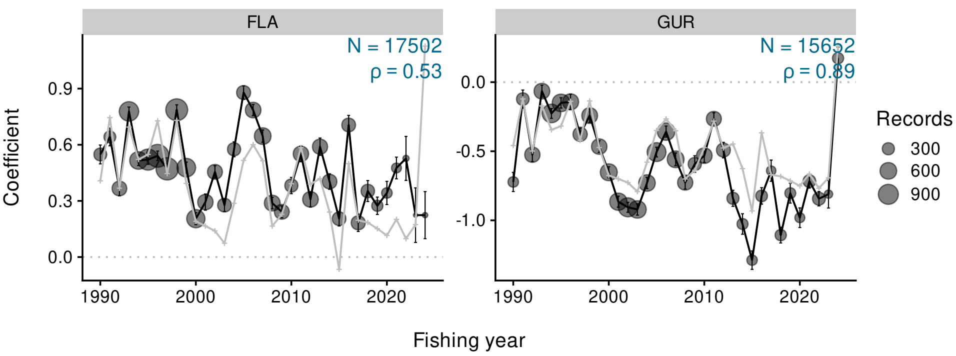

Figure C.95: Residual implied coefficients for target-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX day dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

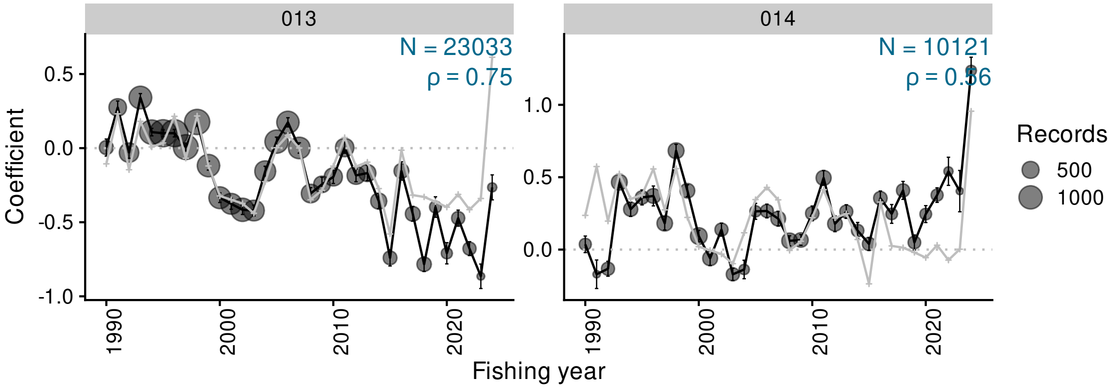

Figure C.96: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX day dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 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.

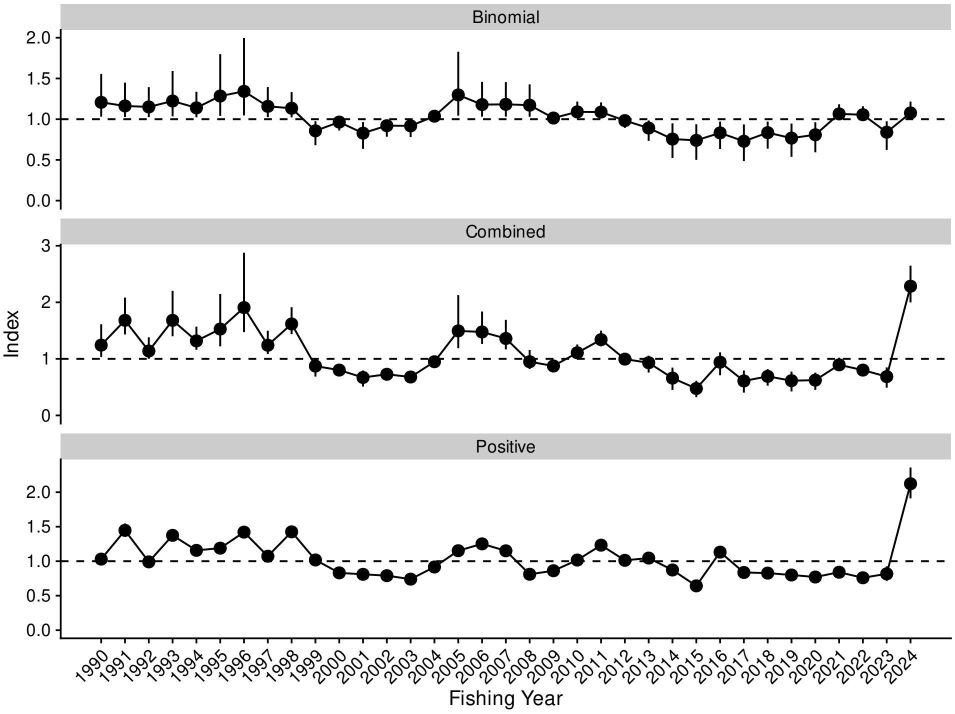

Figure C.97: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-MIX day dataset.

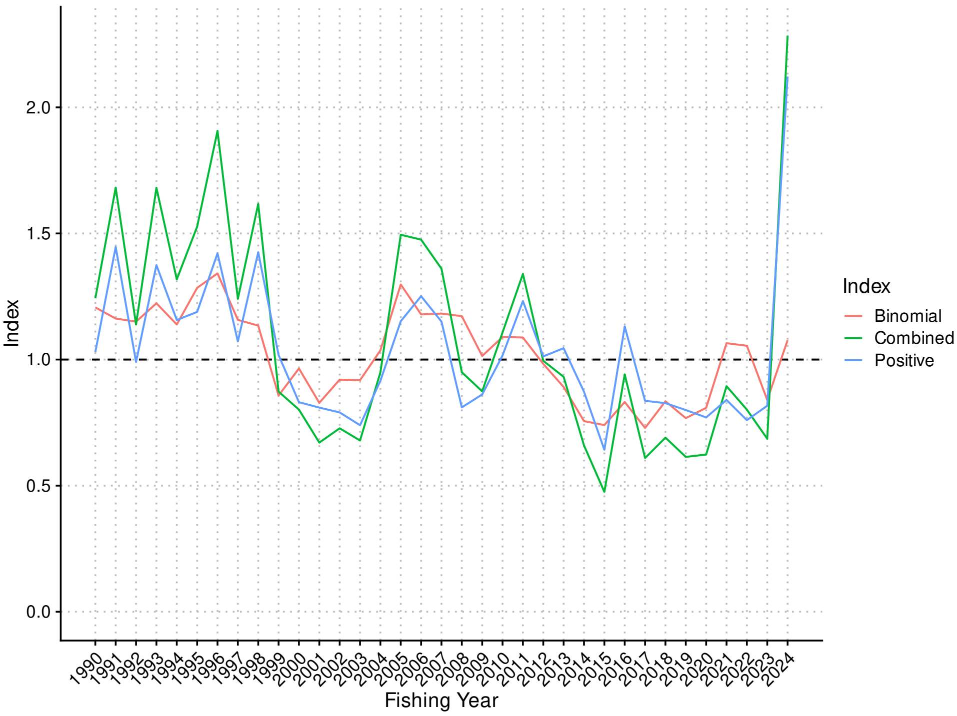

Figure C.98: Standardised indices for the Hawke Bay FLA BT-MIX day dataset.

Table C.28: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay FLA BT-MIX day series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1990	1.207	0.134	1.030	1.554	1.243	0.148	1.034	1.613	1.030	0.036	0.959	1.102
1991	1.162	0.108	1.027	1.449	1.682	0.166	1.432	2.083	1.446	0.050	1.352	1.547
1992	1.150	0.094	1.025	1.394	1.139	0.097	1.001	1.381	0.990	0.028	0.936	1.046
1993	1.223	0.142	1.035	1.591	1.681	0.205	1.401	2.203	1.375	0.037	1.301	1.445
1994	1.139	0.080	1.024	1.336	1.318	0.104	1.160	1.569	1.157	0.030	1.098	1.215
1995	1.284	0.193	1.041	1.798	1.527	0.236	1.222	2.147	1.189	0.029	1.130	1.245
1996	1.342	0.242	1.046	1.997	1.907	0.358	1.473	2.876	1.421	0.034	1.352	1.484
1997	1.157	0.094	1.025	1.395	1.241	0.105	1.086	1.497	1.072	0.025	1.022	1.120
1998	1.134	0.079	1.023	1.333	1.617	0.122	1.437	1.914	1.426	0.033	1.363	1.491
1999	0.857	0.075	0.680	0.975	0.873	0.082	0.687	1.010	1.018	0.025	0.969	1.069
2000	0.965	0.038	0.861	1.012	0.802	0.039	0.708	0.862	0.831	0.021	0.789	0.872
2001	0.828	0.084	0.636	0.964	0.671	0.072	0.510	0.794	0.810	0.020	0.770	0.849
2002	0.920	0.053	0.784	0.992	0.727	0.047	0.616	0.800	0.790	0.020	0.753	0.832
2003	0.918	0.053	0.781	0.990	0.679	0.045	0.576	0.753	0.740	0.019	0.703	0.779
2004	1.037	0.030	0.993	1.111	0.949	0.038	0.882	1.030	0.916	0.026	0.867	0.969
2005	1.298	0.200	1.043	1.828	1.495	0.240	1.189	2.128	1.152	0.030	1.095	1.214
2006	1.179	0.109	1.031	1.459	1.475	0.146	1.264	1.837	1.251	0.031	1.190	1.313
2007	1.182	0.108	1.031	1.455	1.360	0.133	1.168	1.690	1.151	0.030	1.093	1.210
2008	1.172	0.102	1.029	1.428	0.950	0.086	0.820	1.158	0.810	0.022	0.769	0.854
2009	1.014	0.034	0.944	1.076	0.874	0.038	0.797	0.946	0.862	0.027	0.813	0.917
2010	1.090	0.051	1.016	1.216	1.108	0.063	1.007	1.255	1.017	0.029	0.963	1.078
2011	1.087	0.048	1.017	1.206	1.340	0.070	1.223	1.499	1.232	0.035	1.164	1.300
2012	0.983	0.035	0.893	1.030	0.995	0.047	0.892	1.078	1.013	0.029	0.959	1.072
2013	0.891	0.064	0.734	0.985	0.932	0.076	0.758	1.055	1.045	0.032	0.981	1.107
2014	0.756	0.109	0.523	0.949	0.660	0.101	0.451	0.845	0.872	0.029	0.817	0.931
2015	0.740	0.112	0.501	0.938	0.475	0.074	0.322	0.613	0.642	0.023	0.601	0.692
2016	0.832	0.086	0.634	0.970	0.941	0.103	0.710	1.115	1.131	0.038	1.059	1.207
2017	0.729	0.115	0.485	0.936	0.610	0.100	0.403	0.794	0.836	0.030	0.781	0.897
2018	0.835	0.085	0.638	0.970	0.690	0.075	0.526	0.819	0.827	0.029	0.772	0.886
2019	0.768	0.104	0.538	0.946	0.614	0.089	0.424	0.775	0.800	0.029	0.745	0.859
2020	0.809	0.094	0.594	0.963	0.623	0.078	0.451	0.756	0.771	0.032	0.708	0.832
2021	1.065	0.045	1.005	1.183	0.894	0.054	0.808	1.020	0.840	0.032	0.778	0.902
2022	1.055	0.040	1.001	1.159	0.801	0.045	0.724	0.902	0.760	0.032	0.700	0.827
2023	0.840	0.090	0.623	0.975	0.686	0.092	0.490	0.849	0.817	0.054	0.715	0.926
2024	1.077	0.053	1.008	1.216	2.285	0.166	1.999	2.648	2.122	0.114	1.911	2.358

C.6 Hawke Bay LSO BT-MIX event

This series is a lemon sole (LSO) analogue to the ESO (Section 4.3) and SFL (Section 4.4) single species CPUE series accepted by the INSWG for monitoring these species. While this analysis used the same criteria to specify the LSO model (Table C.29) as was done for ESO and SFL, the resulting model was deemed by the INSWG to be unreliable for consideration as a monitoring series for LSO.

Table C.29: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay LSO BT-MIX event CPUE series.

Series	Hawke Bay LSO BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	LSO ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

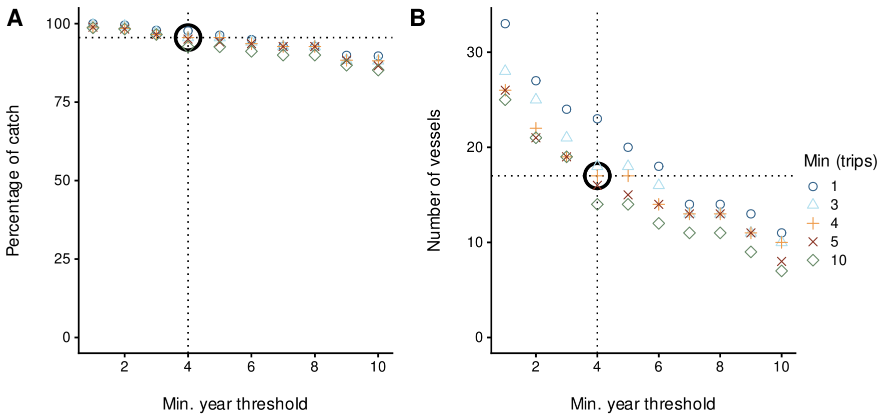

Figure C.99: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay LSO BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

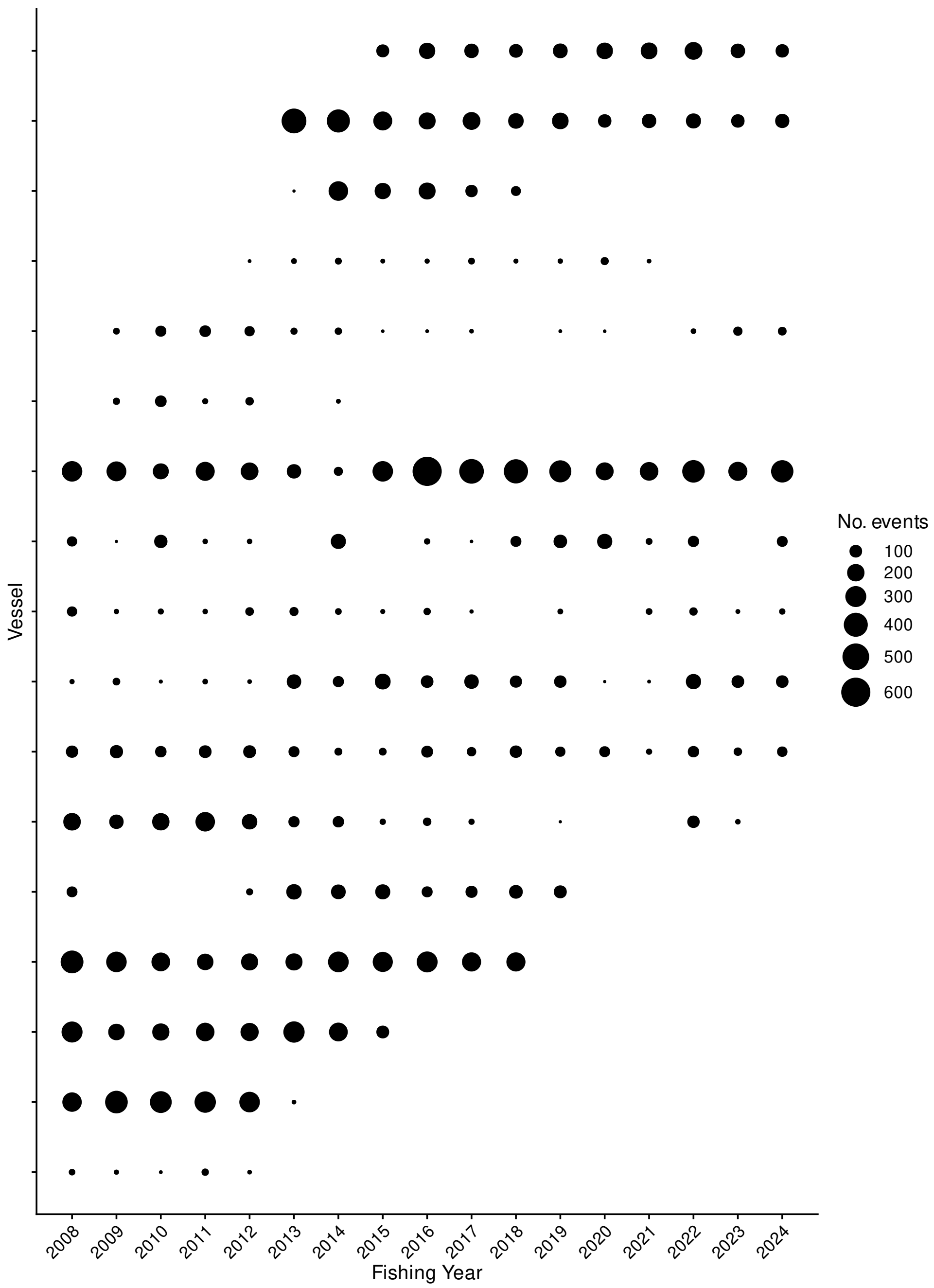

Figure C.100: Number of events by fishing year for core vessels in the Hawke Bay LSO BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.30: Summary of the Hawke Bay LSO BT-MIX 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2.2 (100%) n: 2087	0.48 (100%) n: 1515	1.4 (100%) n: 1601	1.9 (100%) n: 1669	1.6 (100%) n: 1390	2.9 (100%) n: 1673	3.4 (100%) n: 2086	9.1 (100%) n: 1782	31 (100%) n: 1867
Positive fishing duration	2.2 (100%) n: 2087	0.48 (100%) n: 1513	1.4 (100%) n: 1599	1.9 (100%) n: 1669	1.6 (100%) n: 1390	2.9 (100%) n: 1673	3.4 (100%) n: 2086	9.1 (100%) n: 1782	31 (100%) n: 1867
Fishing duration less than 6 h	2.1 (99%) n: 2077	0.48 (100%) n: 1506	1.4 (99%) n: 1595	1.9 (100%) n: 1664	1.6 (100%) n: 1387	2.9 (100%) n: 1669	3.4 (100%) n: 2068	9.1 (100%) n: 1779	31 (100%) n: 1864
Bottom depth < 150m	2.1 (99%) n: 2076	0.48 (100%) n: 1506	1.4 (99%) n: 1595	1.9 (100%) n: 1662	1.6 (100%) n: 1387	2.9 (100%) n: 1669	3.4 (100%) n: 2066	9.1 (100%) n: 1777	31 (100%) n: 1864
Core fleet selection	1.8 (84%) n: 1726	0.37 (77%) n: 1440	1.4 (99%) n: 1500	1.5 (79%) n: 1497	1.6 (100%) n: 1375	2.7 (93%) n: 1603	2.6 (74%) n: 1765	8.3 (91%) n: 1570	31 (100%) n: 1816

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	15 (100%) n: 1740	21 (100%) n: 1710	2.2 (100%) n: 1277	2 (100%) n: 946	1.4 (100%) n: 809	1.2 (100%) n: 1519	2 (100%) n: 885	2.5 (100%) n: 1093
Positive fishing duration	15 (100%) n: 1740	21 (100%) n: 1710	2.2 (100%) n: 1273	2 (99%) n: 943	1.4 (100%) n: 808	1.2 (100%) n: 1518	2 (100%) n: 884	2.5 (100%) n: 1093
Fishing duration less than 6 h	15 (100%) n: 1722	21 (100%) n: 1699	2.1 (98%) n: 1260	1.8 (92%) n: 933	1.4 (100%) n: 802	1.2 (100%) n: 1505	1.9 (97%) n: 871	2.5 (100%) n: 1085
Bottom depth < 150m	15 (100%) n: 1722	21 (100%) n: 1698	2.1 (98%) n: 1258	1.8 (92%) n: 933	1.4 (100%) n: 802	1.2 (100%) n: 1501	1.9 (97%) n: 870	2.5 (100%) n: 1081
Core fleet selection	14 (99%) n: 1450	21 (99%) n: 1377	2.1 (97%) n: 1071	1.8 (92%) n: 771	1.2 (91%) n: 629	0.83 (68%) n: 1163	1.4 (69%) n: 707	2.2 (88%) n: 882

Table C.31: Summary of the Hawke Bay LSO BT-MIX 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	11	638	1 726	5 399.32	1.83	9.97
2009	12	655	1 440	4 659.98	0.37	1.74
2010	12	660	1 500	4 906.92	1.42	4.67
2011	12	675	1 497	4 896.82	1.46	6.28
2012	14	620	1 375	4 426.40	1.61	8.87
2013	13	554	1 603	4 924.80	2.74	8.55
2014	14	634	1 765	5 571.35	2.56	10.48
2015	13	649	1 570	5 048.83	8.27	23.12
2016	13	697	1 816	5 688.55	31.02	39.65
2017	13	585	1 450	4 516.52	14.39	34.21
2018	10	543	1 377	4 462.23	20.82	35.88
2019	11	382	1 071	3 974.72	2.09	22.41
2020	8	259	771	2 908.67	1.83	30.87
2021	8	237	629	2 135.83	1.24	35.29
2022	9	397	1 163	4 153.62	0.83	18.06
2023	8	242	707	2 533.05	1.38	38.76
2024	8	332	882	2 918.95	2.22	49.21

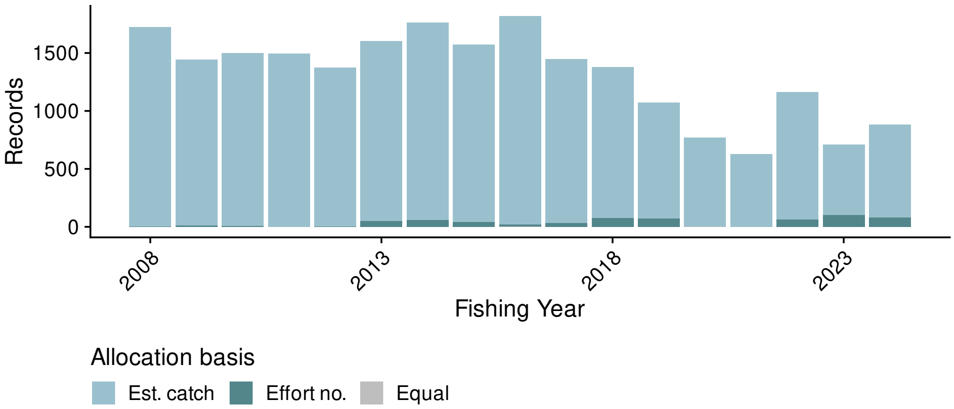

Figure C.101: The allocation approach used for attributing catches to records in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.32: Summary table for occurrence of positive catch in the Hawke Bay LSO BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	22 438.29	0.00	0.00	*
fyear	16	19 589.94	12.84	12.84	*
vessel_key	16	16 893.90	25.00	12.16	*
stat_area	1	16 641.84	26.13	1.13	*
month	11	16 537.32	26.69	0.56	*
target_species	1	16 532.66	26.72	0.03	*
ns(log(fishing_duration), 3)	3	16 510.48	26.85	0.13	*
ns(bottom_depth, 3)	3	16 226.84	28.14	1.29	*

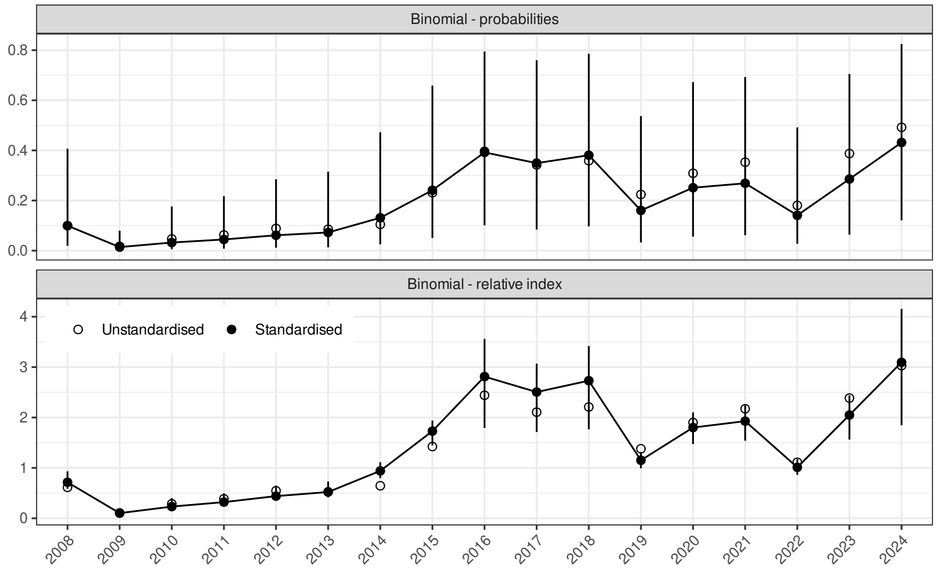

Figure C.102: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay LSO BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

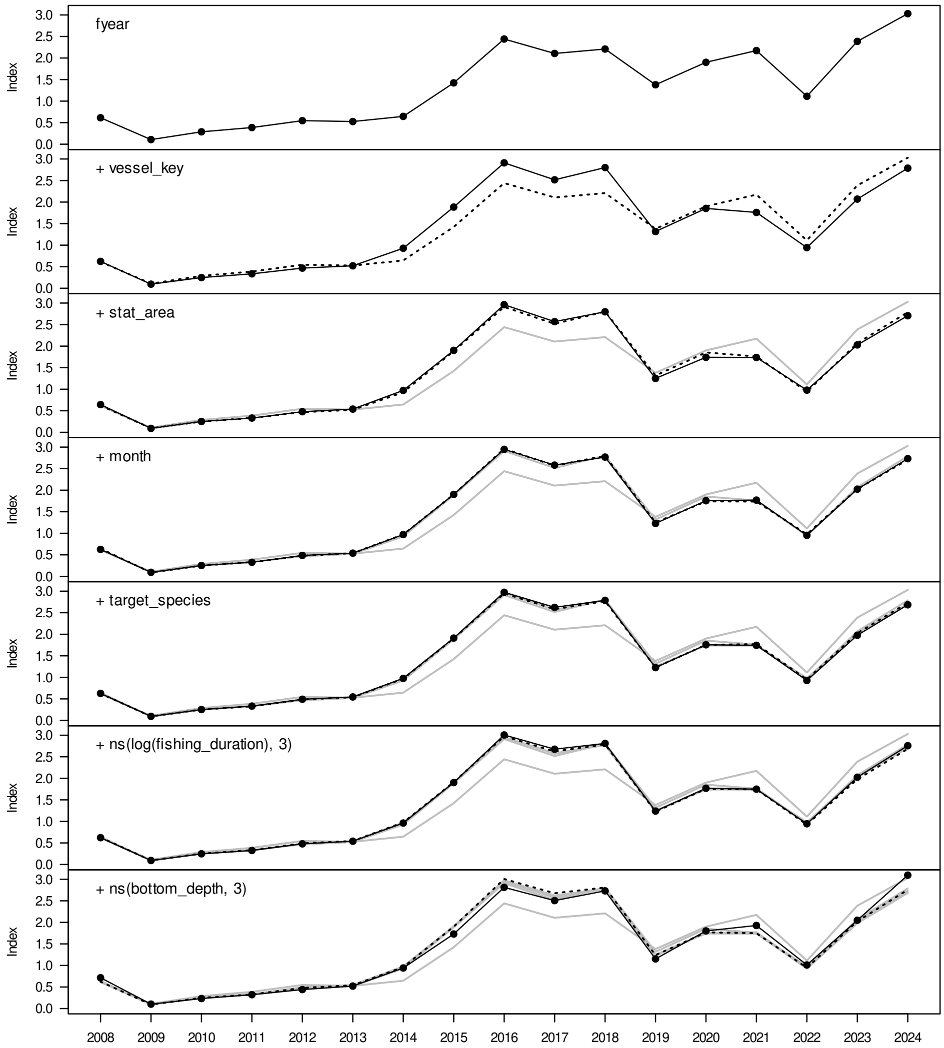

Figure C.103: Step plot for occurrence of catch in the Hawke Bay LSO BT-MIX event dataset.

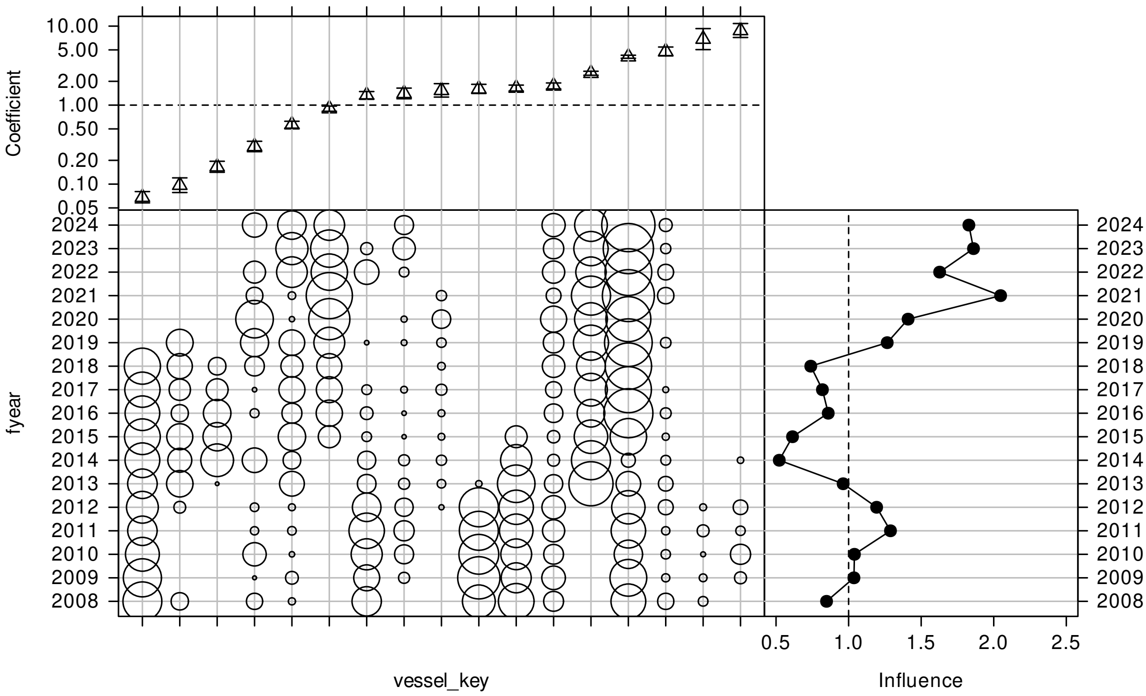

Figure C.104: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

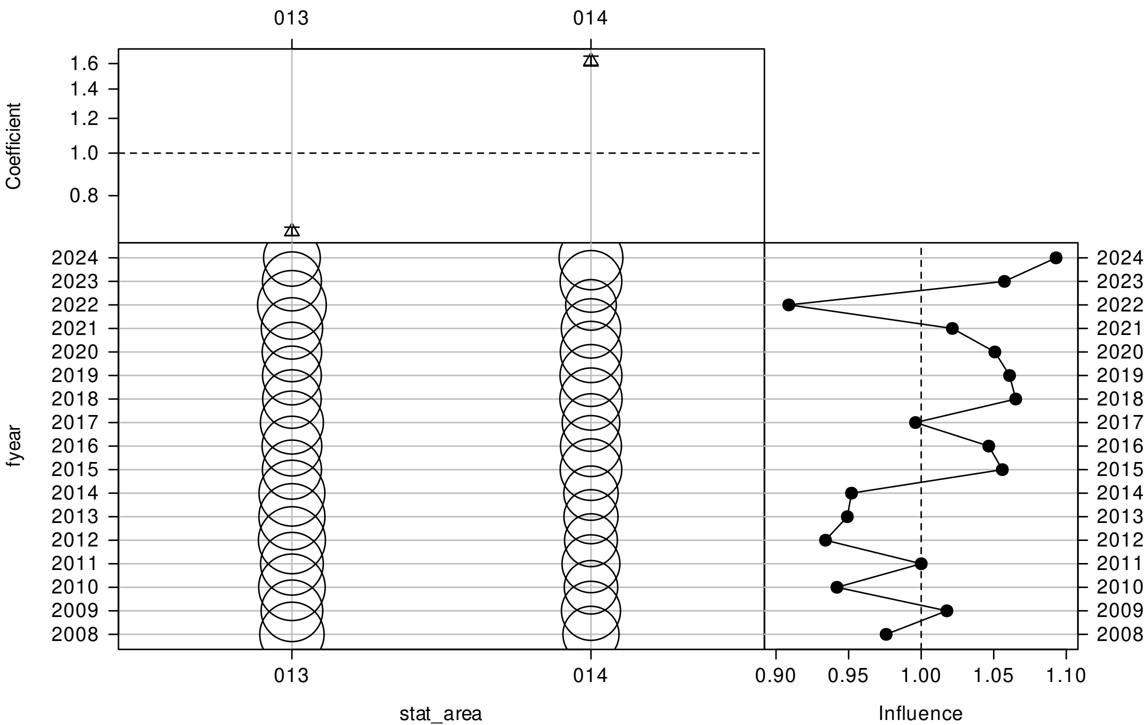

Figure C.105: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

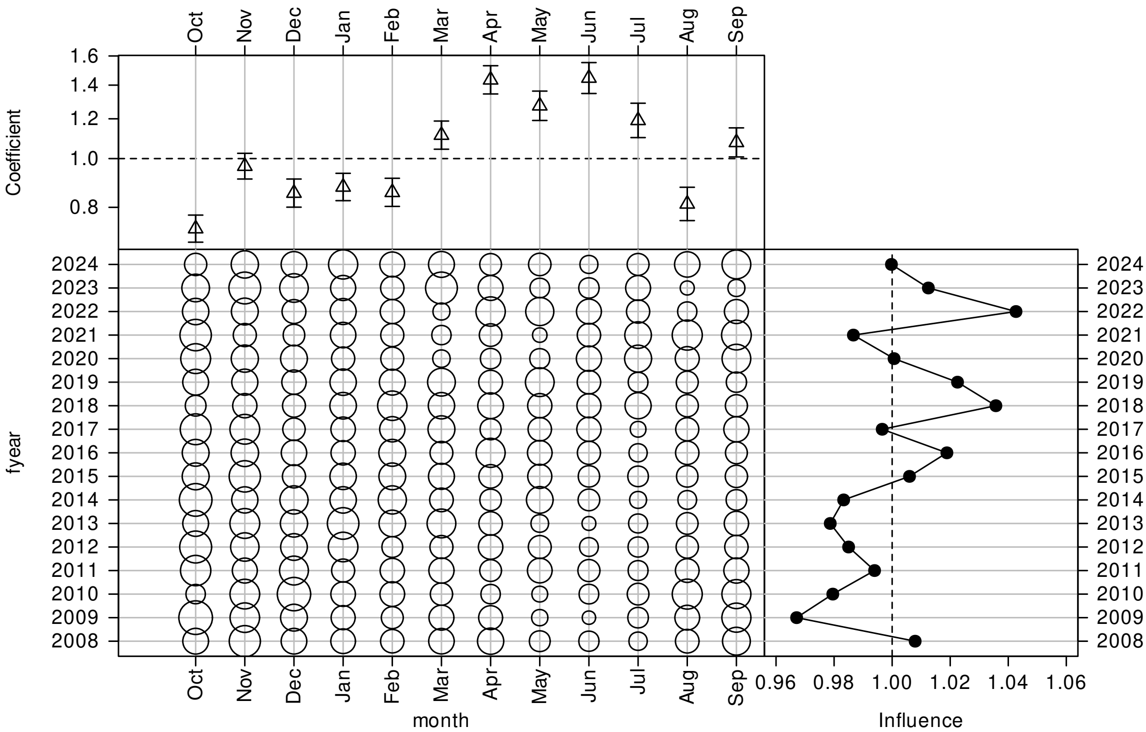

Figure C.106: CDI plot for month for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

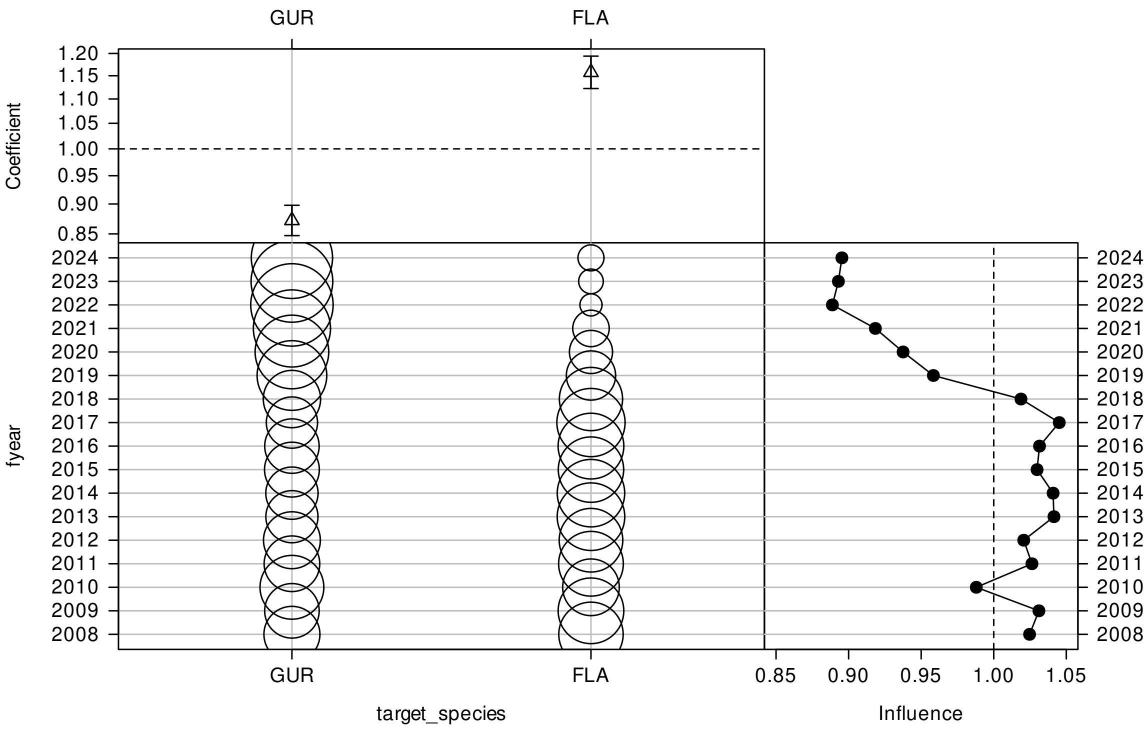

Figure C.107: CDI plot for target species for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

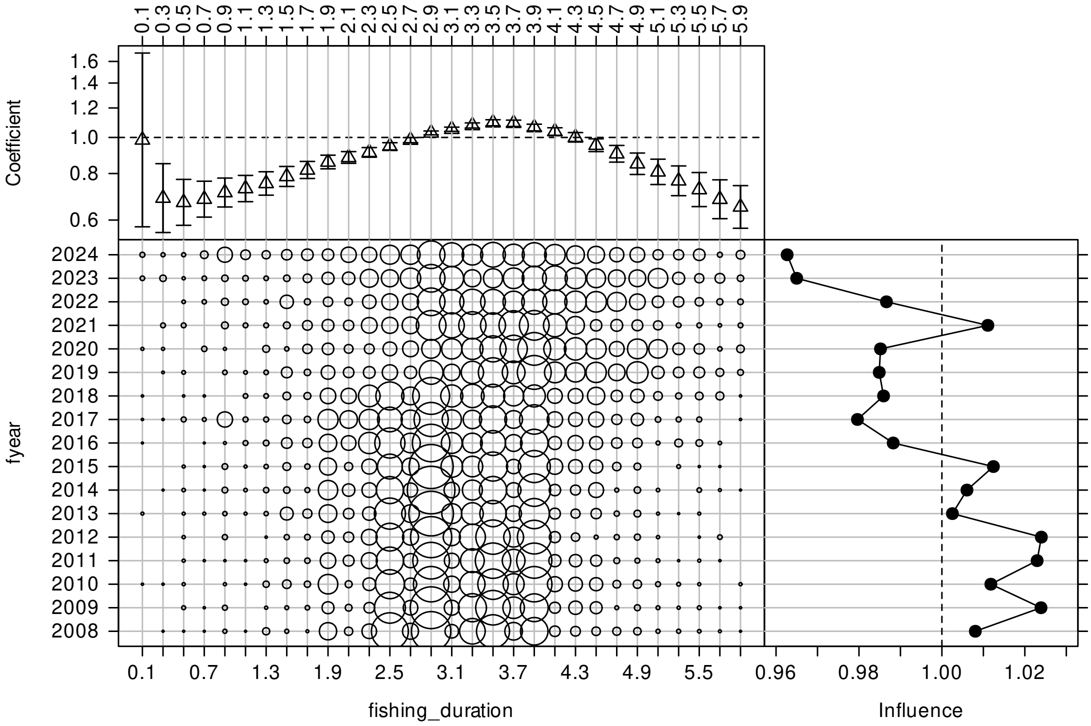

Figure C.108: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

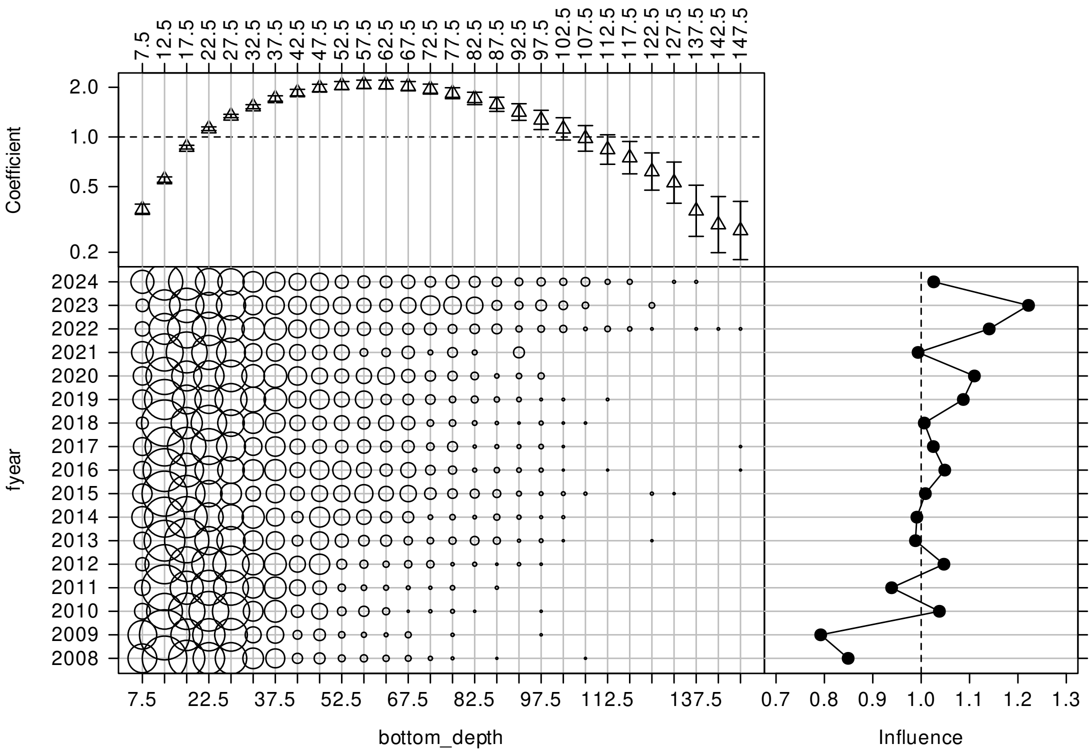

Figure C.109: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

Table C.33: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	16 145.71	0.00	0.00	*
fyear	16	14 610.79	29.43	29.43	*
vessel_key	16	13 794.28	41.56	12.14	*
stat_area	1	13 552.23	44.65	3.09	*
month	11	13 535.64	45.12	0.47	*
target_species	1	13 333.83	47.56	2.43	*
ns(log(fishing_duration), 3)	3	13 274.72	48.31	0.75	*
ns(bottom_depth, 3)	3	13 146.75	49.83	1.52	*

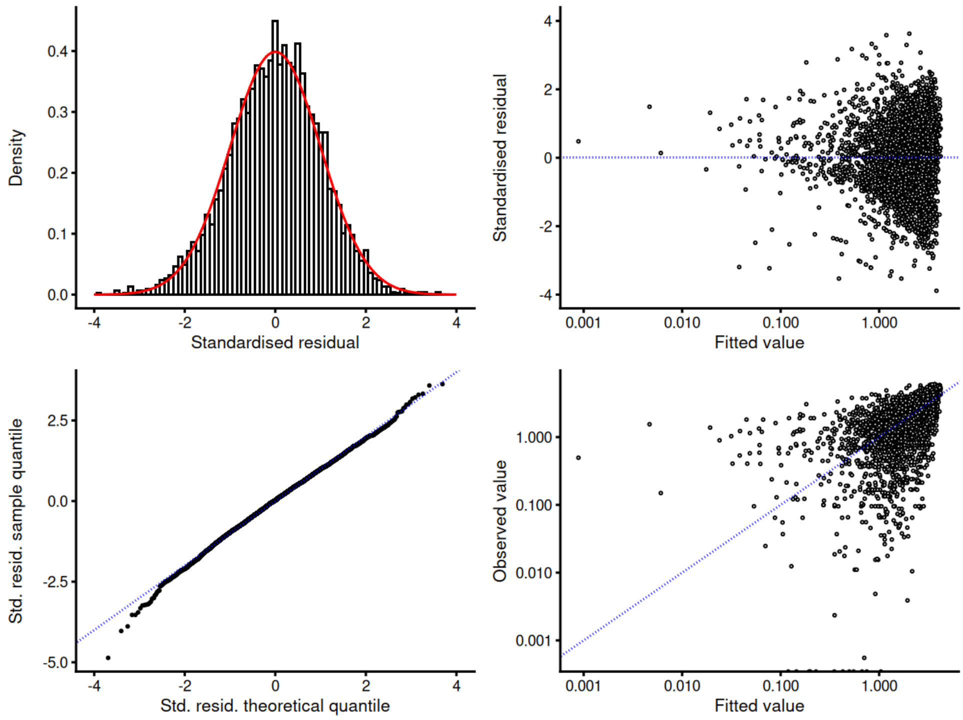

Figure C.110: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay LSO BT-MIX event dataset.

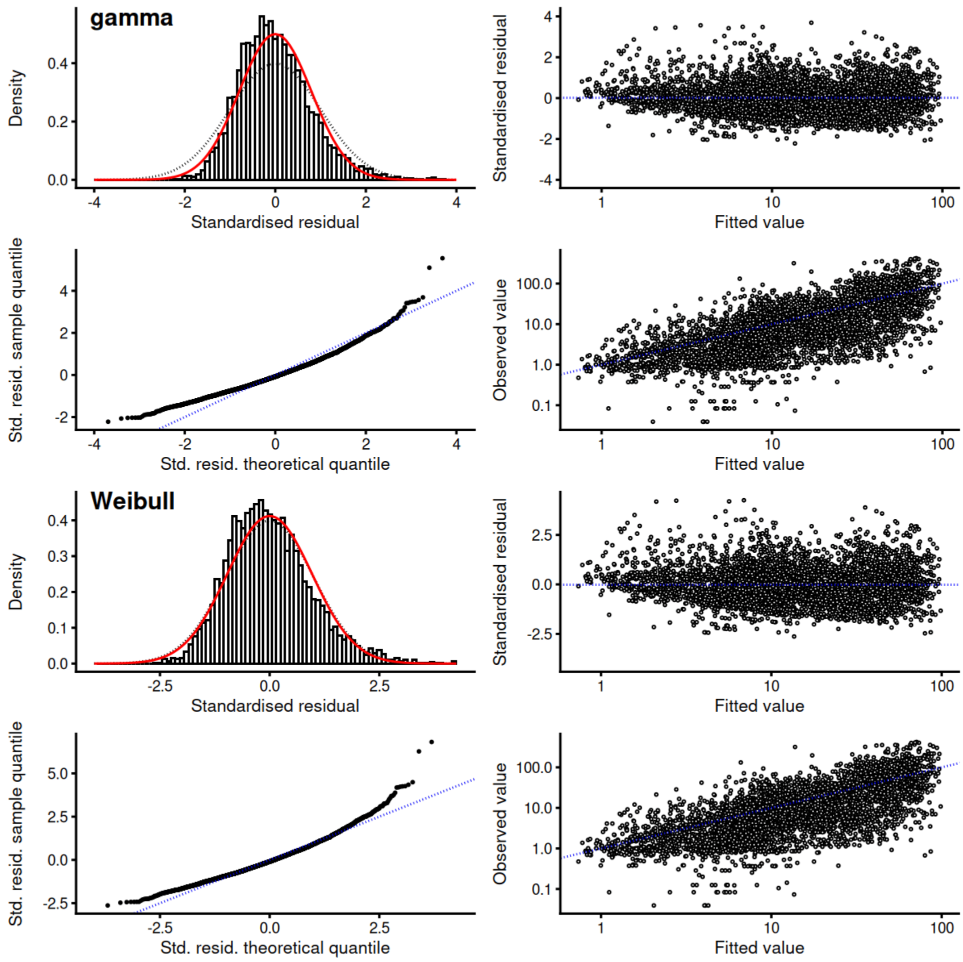

Figure C.111: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay LSO BT-MIX event dataset.

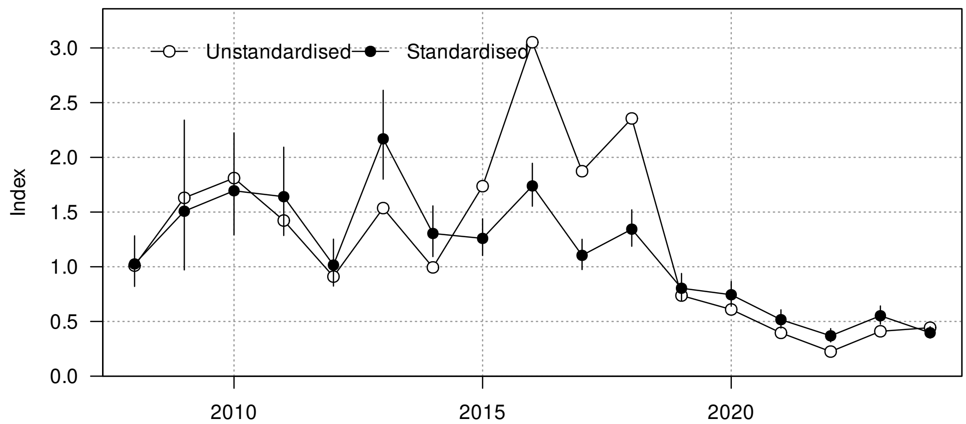

Figure C.112: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay LSO BT-MIX event dataset.

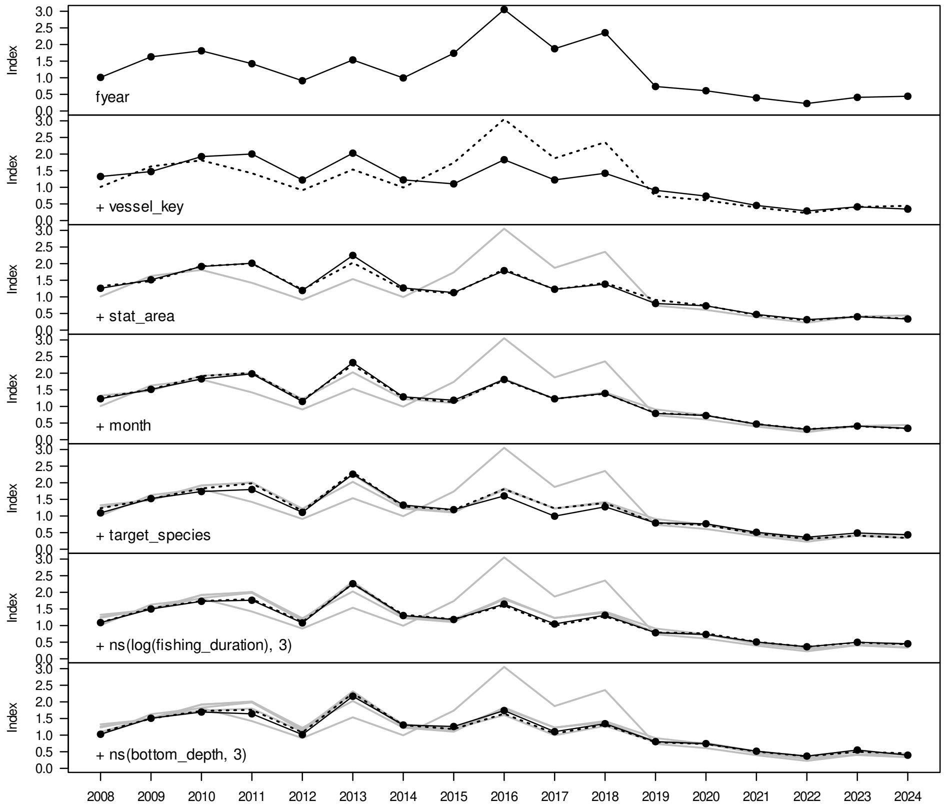

Figure C.113: Changes to the Hawke Bay LSO BT-MIX event positive catch index as terms are successively entered into the lognormal model.

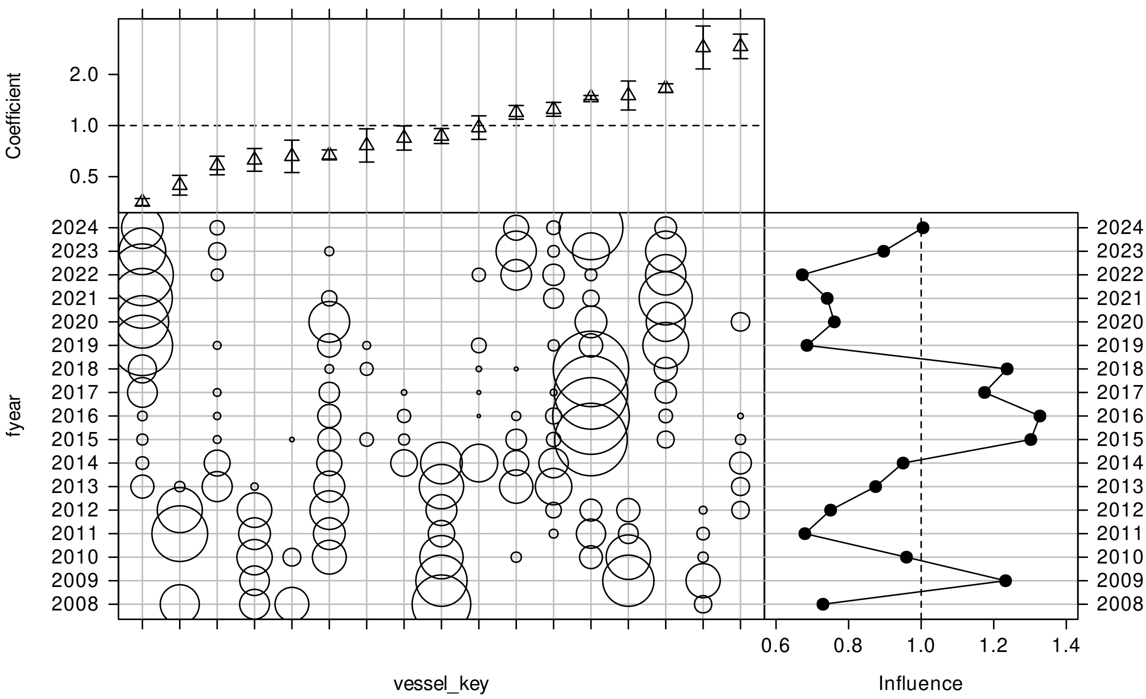

Figure C.114: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

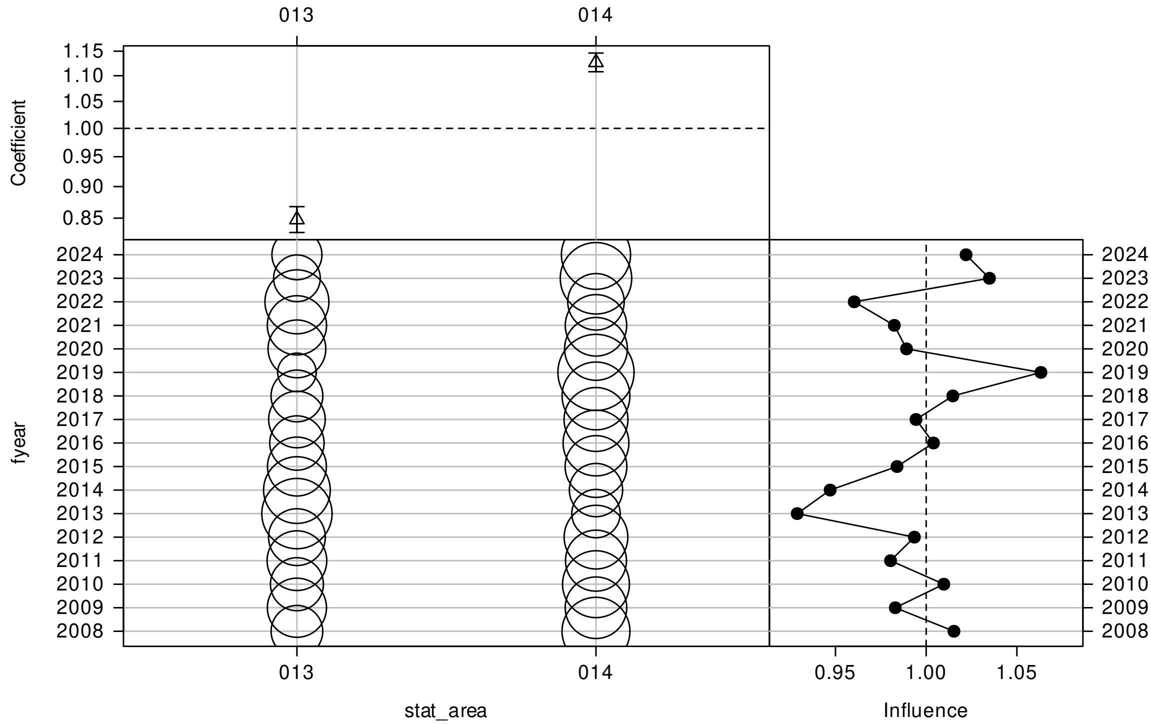

Figure C.115: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

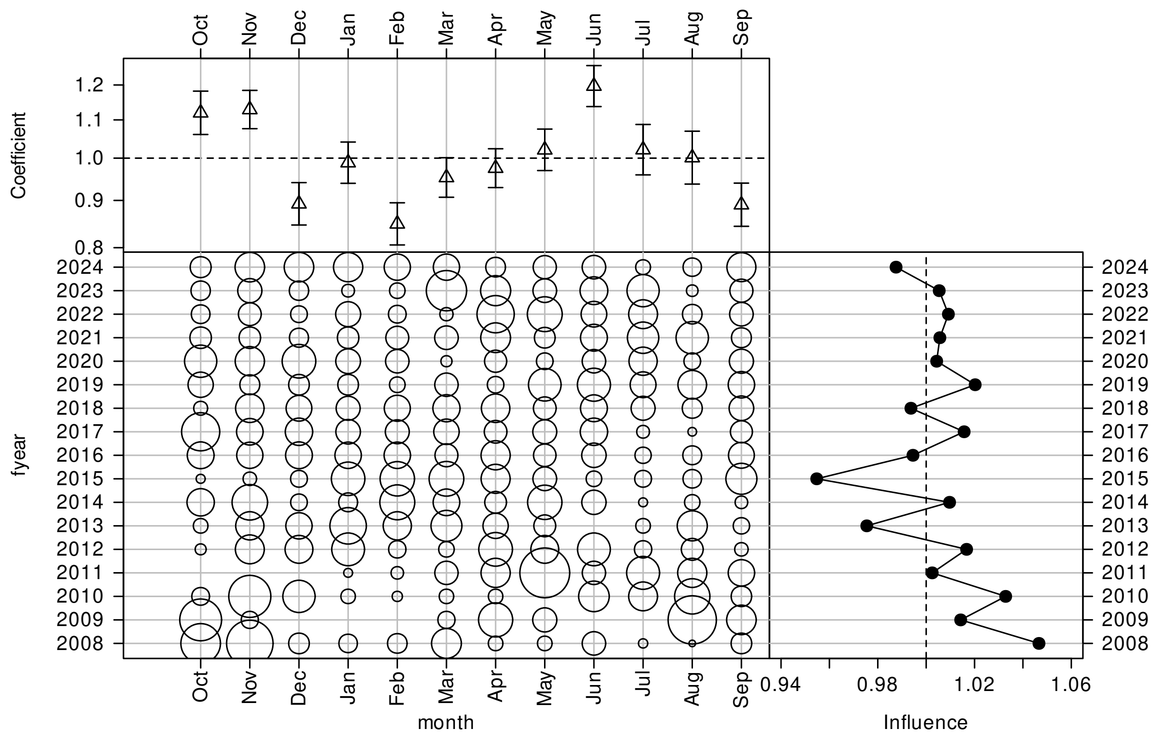

Figure C.116: CDI plot for month for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

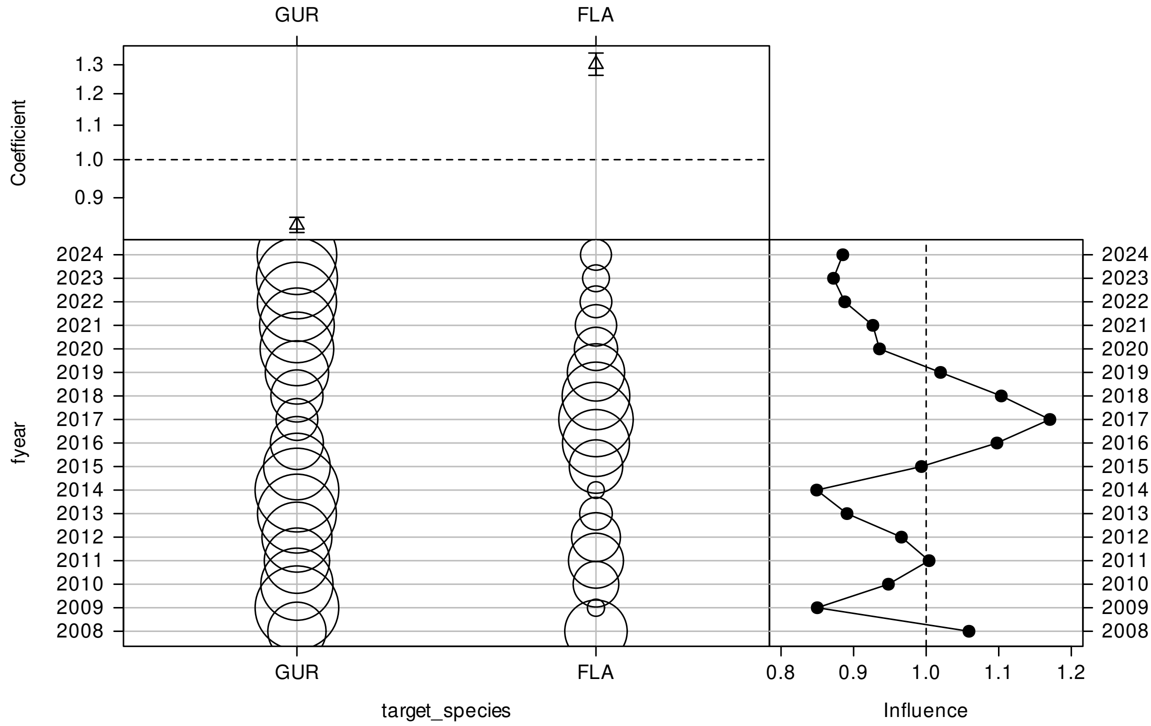

Figure C.117: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

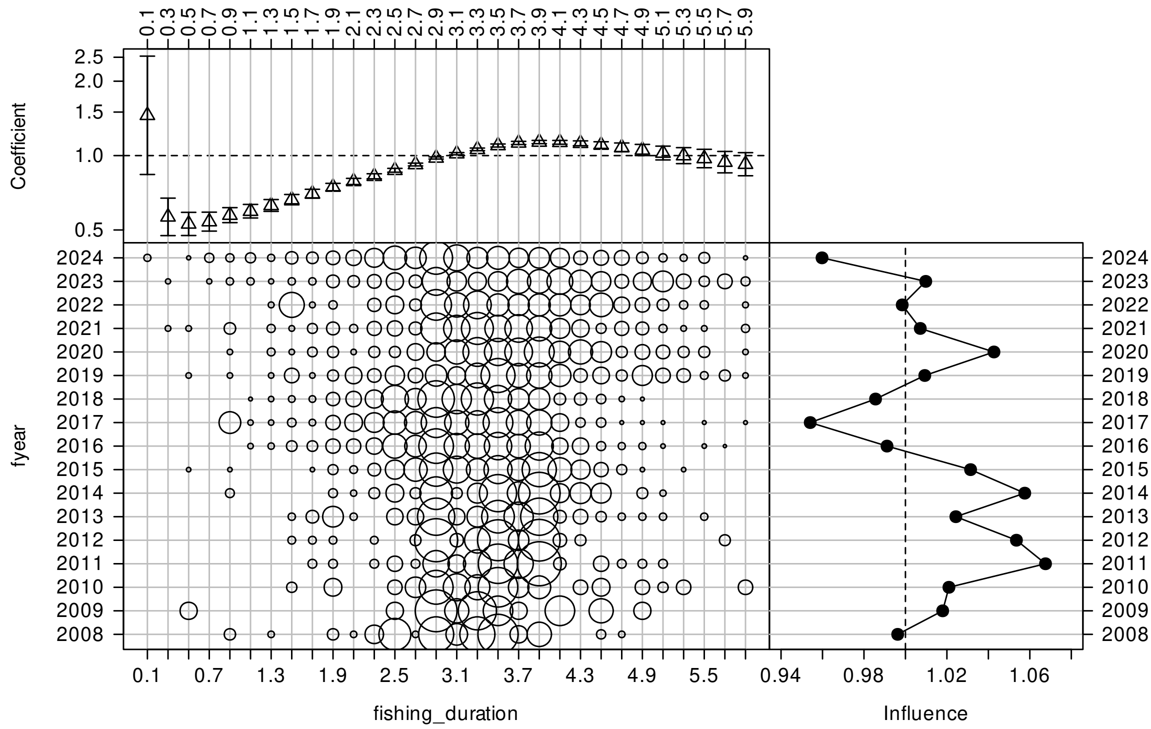

Figure C.118: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

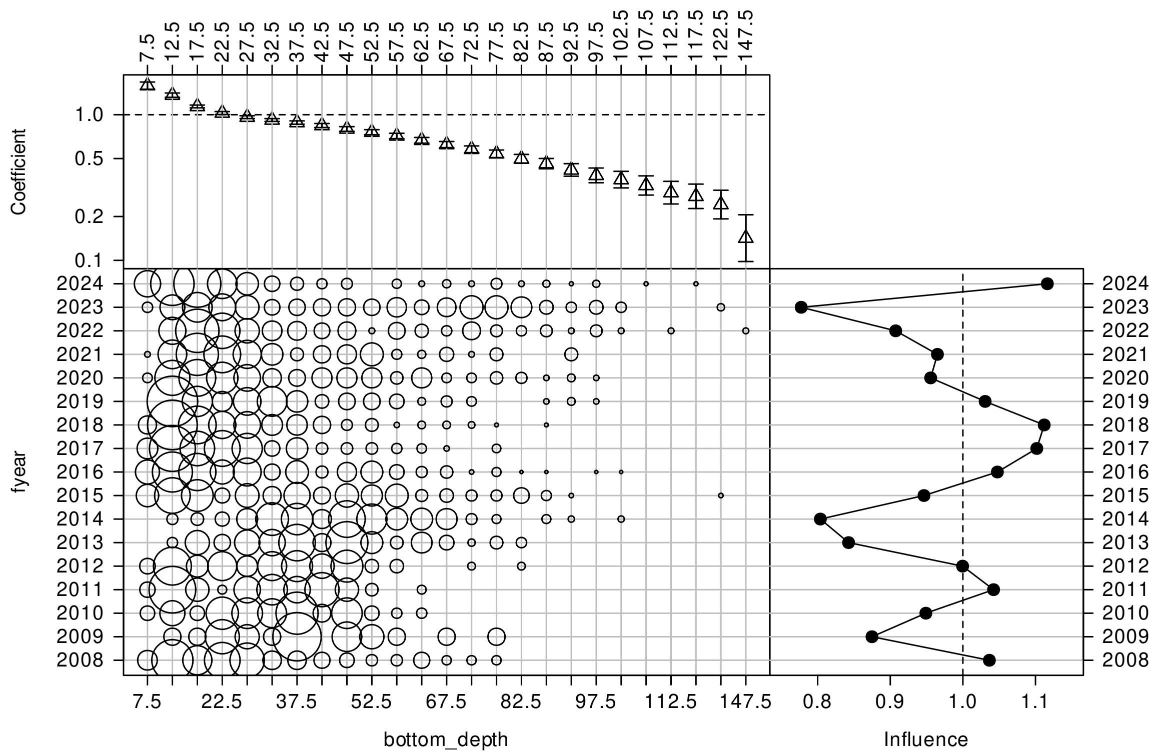

Figure C.119: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay LSO BT-MIX event catch-per-unit-effort dataset.

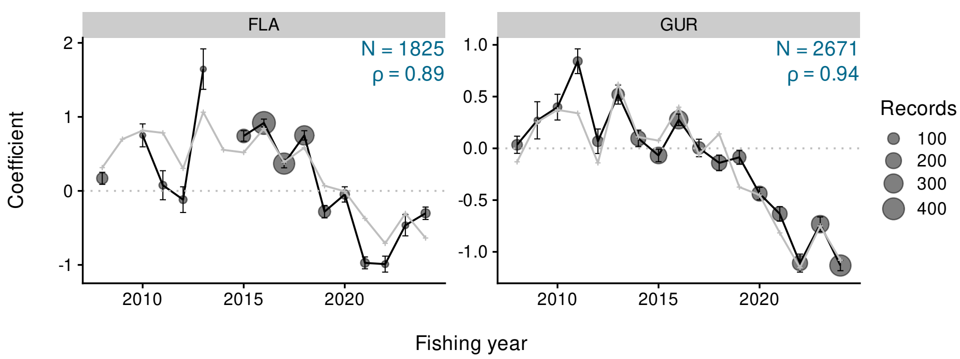

Figure C.120: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay LSO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

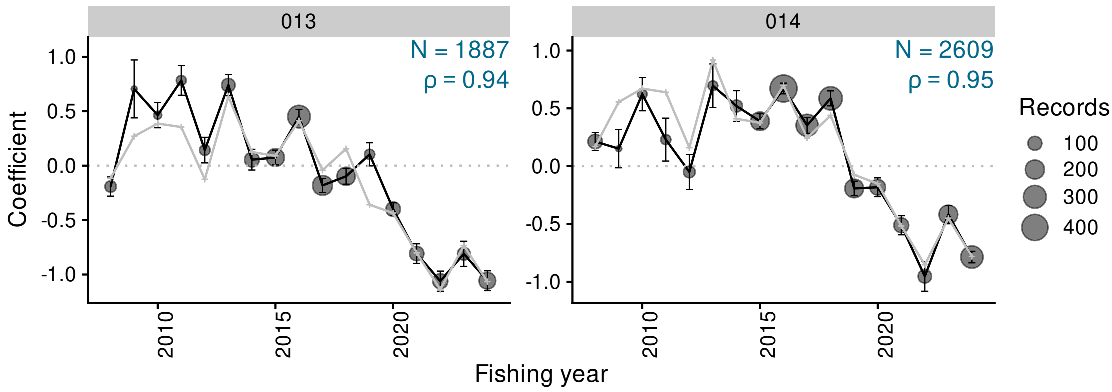

Figure C.121: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay LSO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 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.

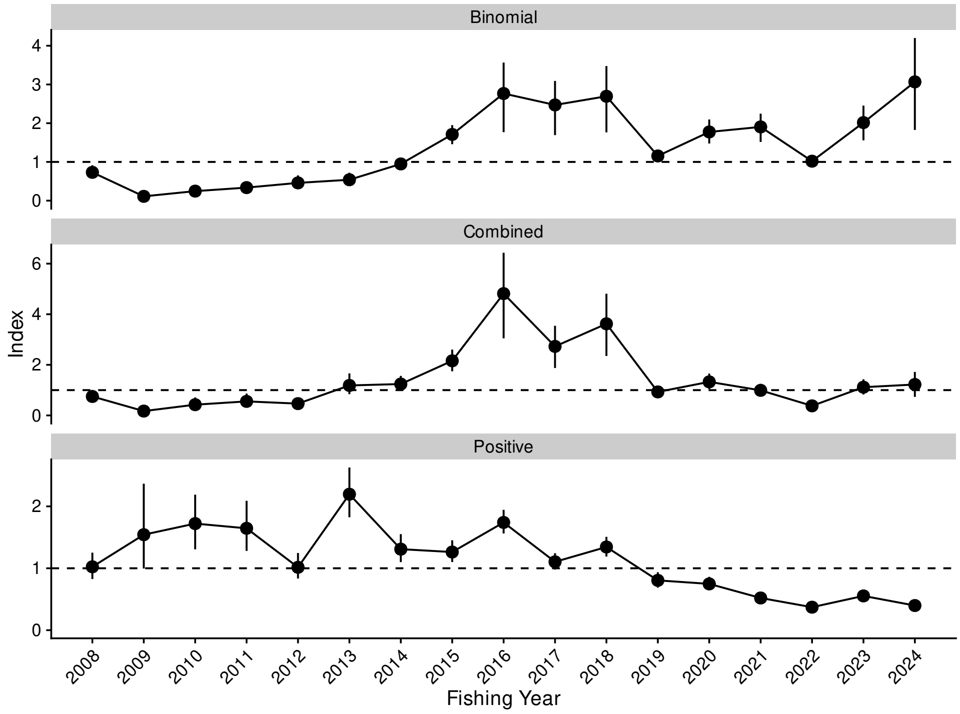

Figure C.122: Standardised indices and 95% confidence intervals for the Hawke Bay LSO BT-MIX event dataset.

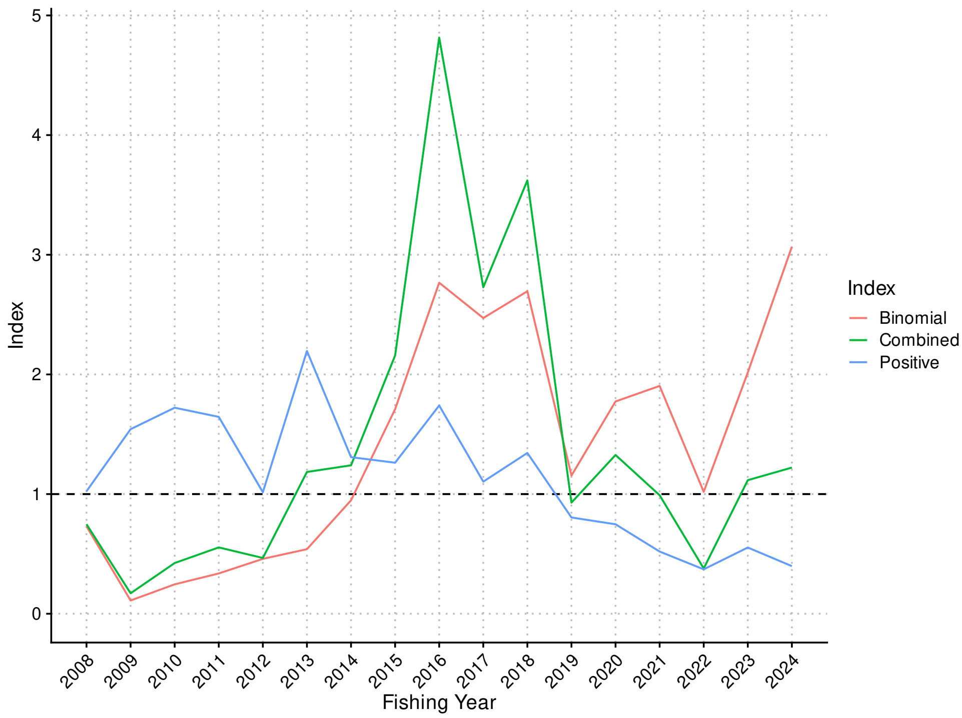

Figure C.123: Standardised indices for the Hawke Bay LSO BT-MIX event dataset.

Table C.34: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay LSO BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.730	0.084	0.583	0.913	0.748	0.118	0.545	1.008	1.024	0.109	0.826	1.252
2009	0.111	0.032	0.068	0.195	0.171	0.062	0.085	0.327	1.542	0.349	0.996	2.366
2010	0.246	0.054	0.173	0.386	0.424	0.115	0.258	0.710	1.722	0.225	1.306	2.189
2011	0.337	0.064	0.248	0.497	0.554	0.127	0.367	0.864	1.645	0.207	1.280	2.090
2012	0.459	0.079	0.345	0.653	0.466	0.092	0.326	0.686	1.016	0.105	0.834	1.247
2013	0.540	0.079	0.412	0.721	1.185	0.210	0.840	1.661	2.196	0.205	1.824	2.627
2014	0.948	0.081	0.792	1.110	1.240	0.151	0.970	1.563	1.309	0.115	1.099	1.551
2015	1.710	0.125	1.457	1.949	2.158	0.219	1.745	2.603	1.262	0.089	1.101	1.452
2016	2.766	0.459	1.768	3.566	4.815	0.863	3.048	6.430	1.740	0.097	1.562	1.944
2017	2.471	0.357	1.691	3.092	2.728	0.426	1.874	3.544	1.104	0.067	0.979	1.243
2018	2.695	0.437	1.764	3.475	3.621	0.628	2.350	4.810	1.344	0.081	1.189	1.507
2019	1.155	0.079	0.993	1.304	0.929	0.103	0.741	1.145	0.805	0.063	0.688	0.936
2020	1.774	0.158	1.476	2.096	1.327	0.157	1.040	1.654	0.748	0.055	0.645	0.862
2021	1.904	0.186	1.516	2.246	0.990	0.125	0.757	1.249	0.520	0.041	0.444	0.606
2022	1.019	0.081	0.859	1.175	0.378	0.044	0.297	0.468	0.371	0.029	0.317	0.431
2023	2.016	0.229	1.558	2.454	1.116	0.153	0.828	1.428	0.553	0.041	0.480	0.639
2024	3.067	0.606	1.826	4.200	1.222	0.252	0.732	1.719	0.398	0.025	0.351	0.449

C.7 Hawke Bay YBF BT-MIX event

This series is a yellow belly flounder (YBF) analogue to the ESO (Section 4.3) and SFL (Section 4.4) single species CPUE series accepted by the INSWG for monitoring these species. While this analysis used the same criteria to specify the YBF model (Table C.35) as was done for ESO and SFL, the resulting model was deemed by the INSWG to be unreliable for consideration as a monitoring series for YBF.

Table C.35: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay YBF BT-MIX event CPUE series.

Series	Hawke Bay YBF BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	YBF ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

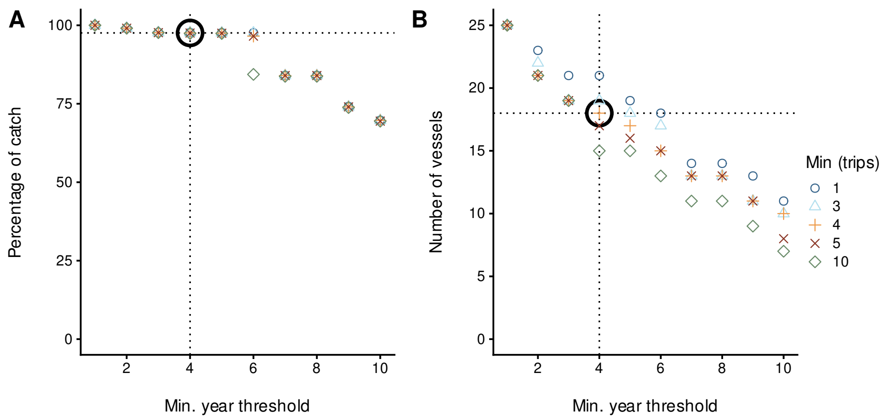

Figure C.124: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay YBF BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

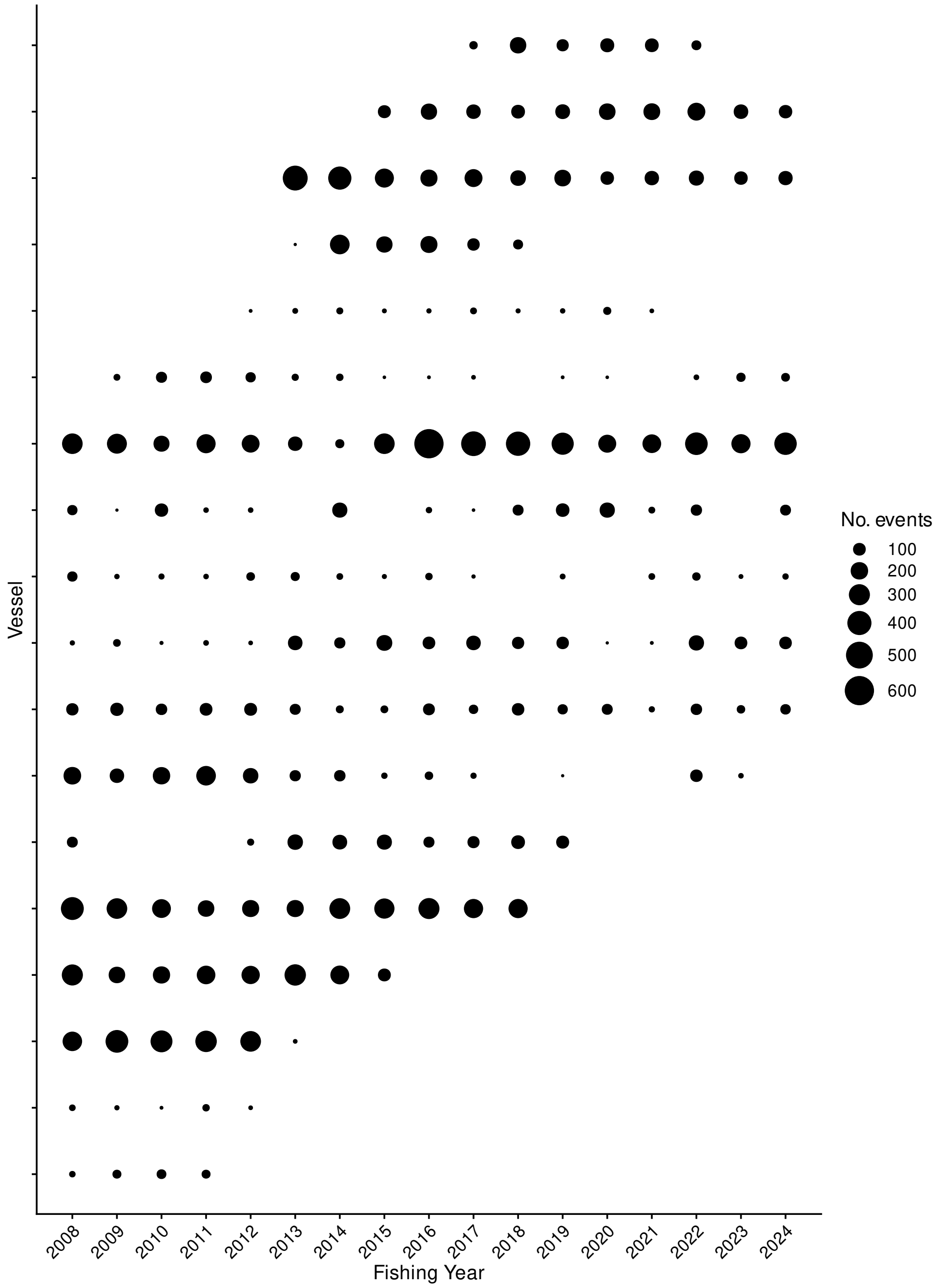

Figure C.125: Number of events by fishing year for core vessels in the Hawke Bay YBF BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.36: Summary of the Hawke Bay YBF BT-MIX 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.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	25 (100%) n: 2087	15 (100%) n: 1515	13 (100%) n: 1601	15 (100%) n: 1669	7.6 (100%) n: 1390	16 (100%) n: 1673	20 (100%) n: 2086	14 (100%) n: 1782	19 (100%) n: 1867
Positive fishing duration	25 (100%) n: 2087	15 (100%) n: 1513	12 (100%) n: 1599	15 (100%) n: 1669	7.6 (100%) n: 1390	16 (100%) n: 1673	20 (100%) n: 2086	14 (100%) n: 1782	19 (100%) n: 1867
Fishing duration less than 6 h	25 (100%) n: 2077	15 (99%) n: 1506	12 (99%) n: 1595	15 (100%) n: 1664	7.6 (100%) n: 1387	16 (100%) n: 1669	20 (98%) n: 2068	14 (100%) n: 1779	19 (100%) n: 1864
Bottom depth < 150m	25 (100%) n: 2076	15 (99%) n: 1506	12 (99%) n: 1595	15 (100%) n: 1662	7.6 (100%) n: 1387	16 (100%) n: 1669	20 (98%) n: 2066	14 (100%) n: 1777	19 (100%) n: 1864
Core fleet selection	23 (92%) n: 1747	15 (99%) n: 1457	12 (99%) n: 1472	15 (100%) n: 1524	7.6 (100%) n: 1335	16 (100%) n: 1603	18 (88%) n: 1755	13 (95%) n: 1570	19 (100%) n: 1816

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	11 (100%) n: 1740	12 (100%) n: 1710	10 (100%) n: 1277	5.7 (100%) n: 946	3.6 (100%) n: 809	4.7 (100%) n: 1519	1.9 (100%) n: 885	10 (100%) n: 1093
Positive fishing duration	11 (100%) n: 1740	12 (100%) n: 1710	10 (99%) n: 1273	5.7 (100%) n: 943	3.6 (100%) n: 808	4.7 (100%) n: 1518	1.9 (100%) n: 884	10 (100%) n: 1093
Fishing duration less than 6 h	11 (100%) n: 1722	12 (100%) n: 1699	10 (99%) n: 1260	5.7 (100%) n: 933	3.5 (99%) n: 802	4.7 (100%) n: 1505	1.9 (100%) n: 871	10 (100%) n: 1085
Bottom depth < 150m	11 (100%) n: 1722	12 (100%) n: 1698	10 (99%) n: 1258	5.7 (100%) n: 933	3.5 (99%) n: 802	4.7 (100%) n: 1501	1.9 (100%) n: 870	10 (100%) n: 1081
Core fleet selection	11 (100%) n: 1489	11 (99%) n: 1552	10 (99%) n: 1162	5.7 (100%) n: 895	3.5 (99%) n: 748	4.7 (100%) n: 1220	1.8 (97%) n: 707	10 (100%) n: 882

Table C.37: Summary of the Hawke Bay YBF BT-MIX 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 flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	12	646	1 747	5 479.57	22.59	40.07
2009	12	664	1 457	4 726.27	15.37	44.68
2010	12	653	1 472	4 796.83	12.41	31.86
2011	12	681	1 524	4 999.18	14.53	33.99
2012	13	604	1 335	4 269.03	7.55	30.49
2013	13	554	1 603	4 924.80	15.74	39.11
2014	13	630	1 755	5 529.60	18.04	34.25
2015	13	649	1 570	5 048.83	13.21	36.18
2016	13	697	1 816	5 688.55	19.25	30.67
2017	14	612	1 489	4 644.93	11.48	31.97
2018	11	604	1 552	4 980.98	11.38	32.15
2019	12	436	1 162	4 215.62	9.98	34.77
2020	9	369	895	3 272.77	5.67	32.51
2021	9	351	748	2 480.00	3.54	45.32
2022	10	452	1 220	4 317.17	4.72	37.62
2023	8	242	707	2 533.05	1.85	28.15
2024	8	332	882	2 918.95	10.46	48.19

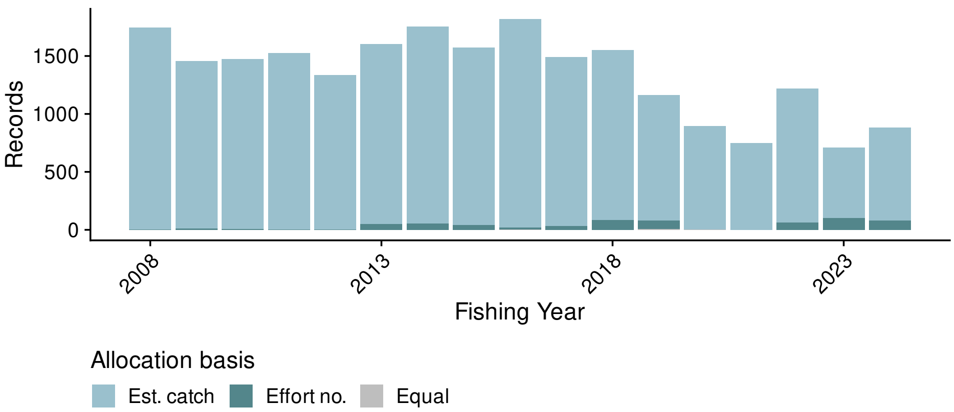

Figure C.126: The allocation approach used for attributing catches to records in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.38: Summary table for occurrence of positive catch in the Hawke Bay YBF BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	29 895.93	0.00	0.00	*
fyear	16	29 676.66	0.84	0.84	*
vessel_key	17	21 203.35	29.30	28.46	*
stat_area	1	20 315.75	32.27	2.98	*
month	11	20 125.75	32.98	0.71	*
target_species	1	19 014.75	36.71	3.72	*
ns(log(fishing_duration), 3)	3	18 991.86	36.80	0.10	*
ns(bottom_depth, 3)	3	17 171.92	42.91	6.11	*

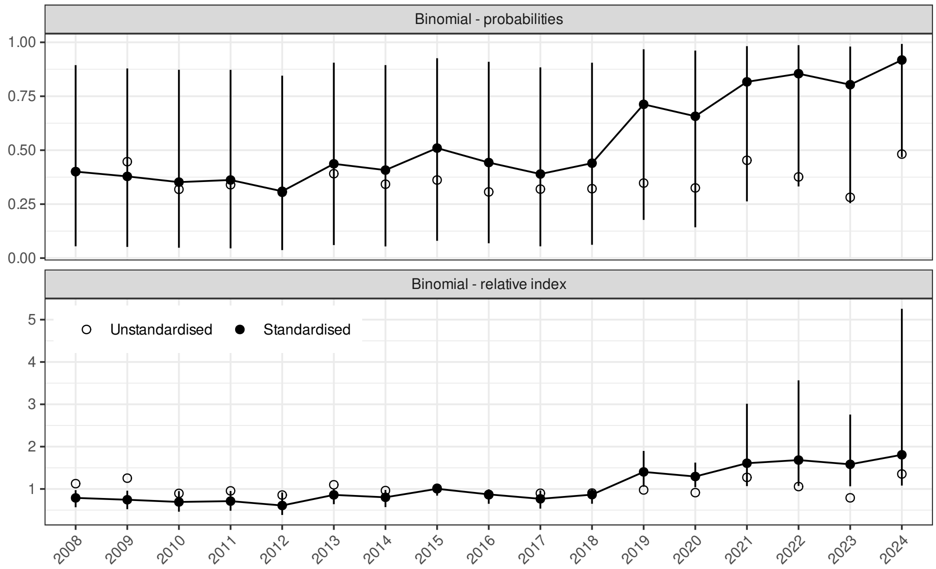

Figure C.127: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay YBF BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

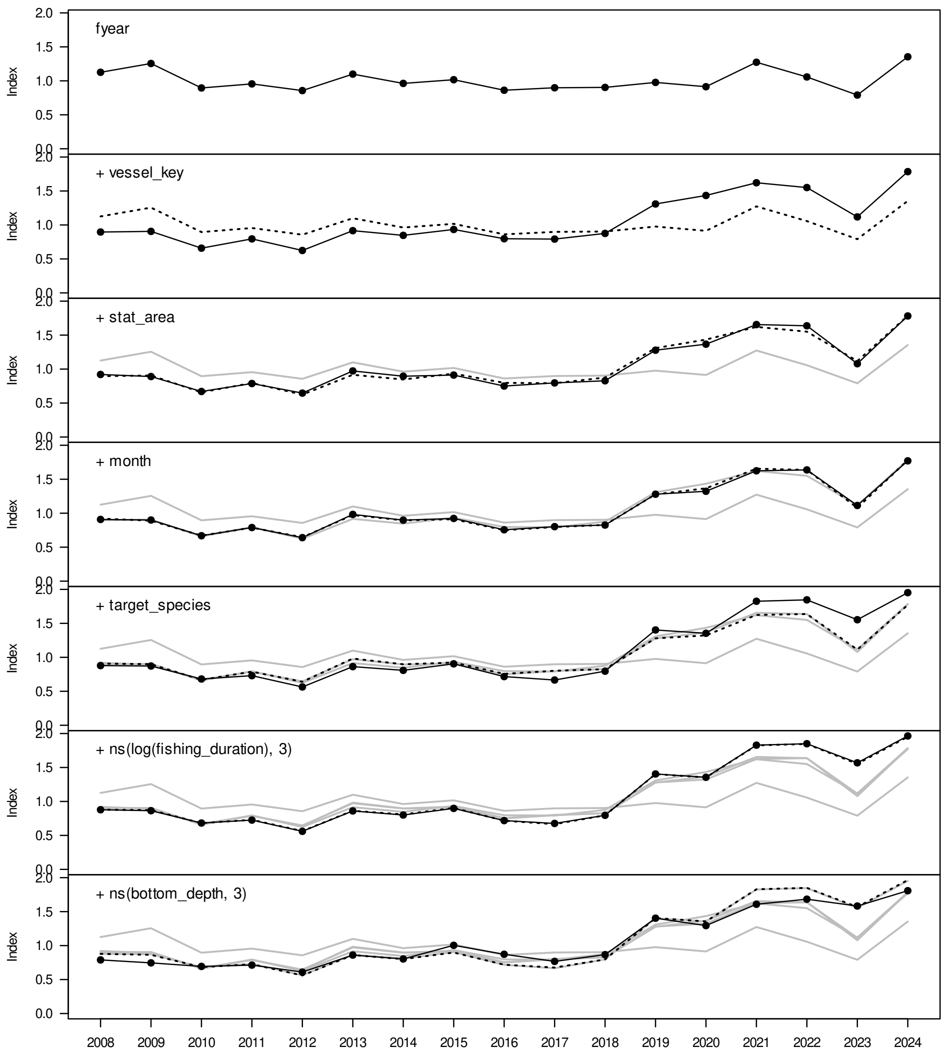

Figure C.128: Step plot for occurrence of catch in the Hawke Bay YBF BT-MIX event dataset.

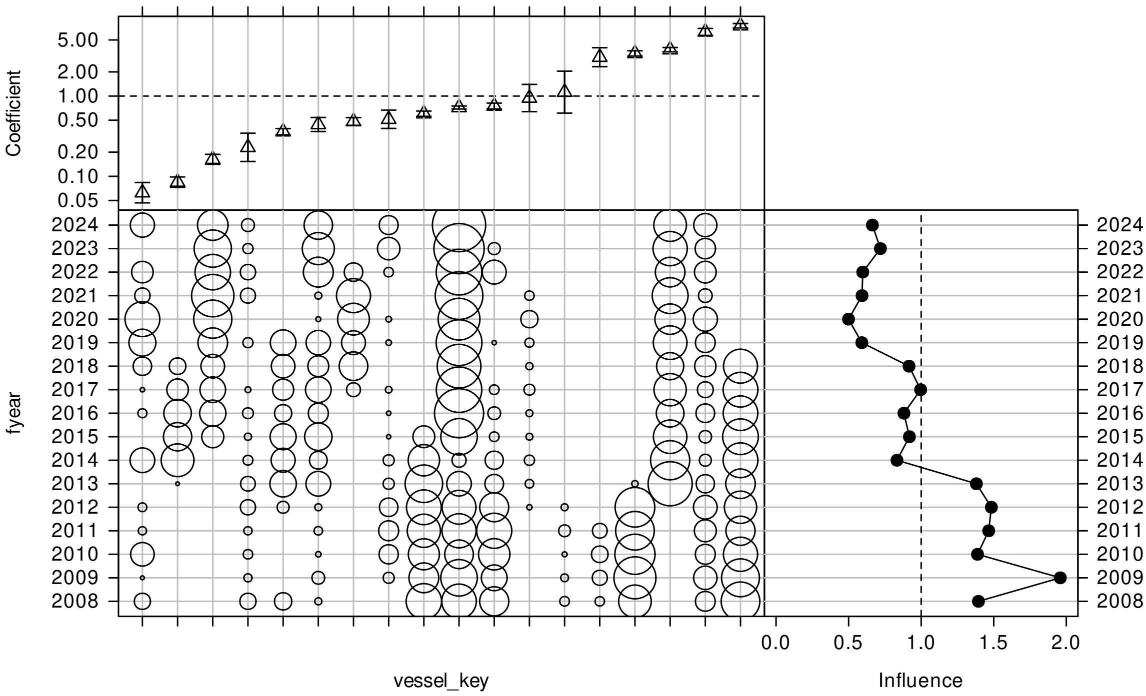

Figure C.129: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

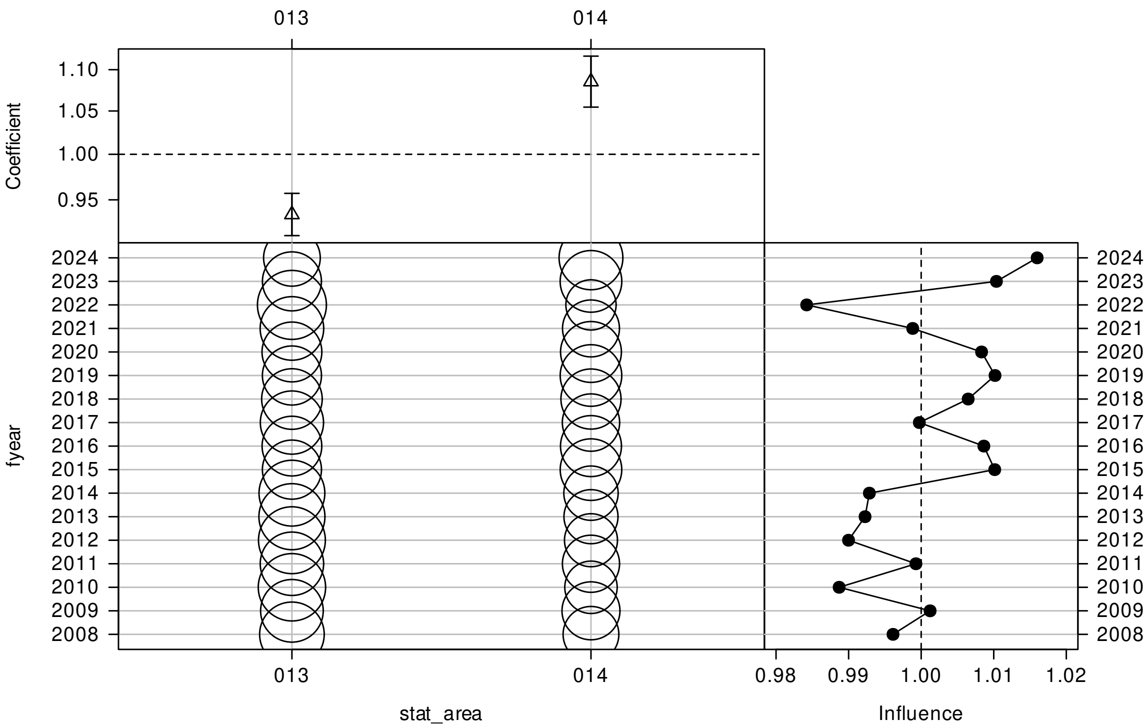

Figure C.130: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

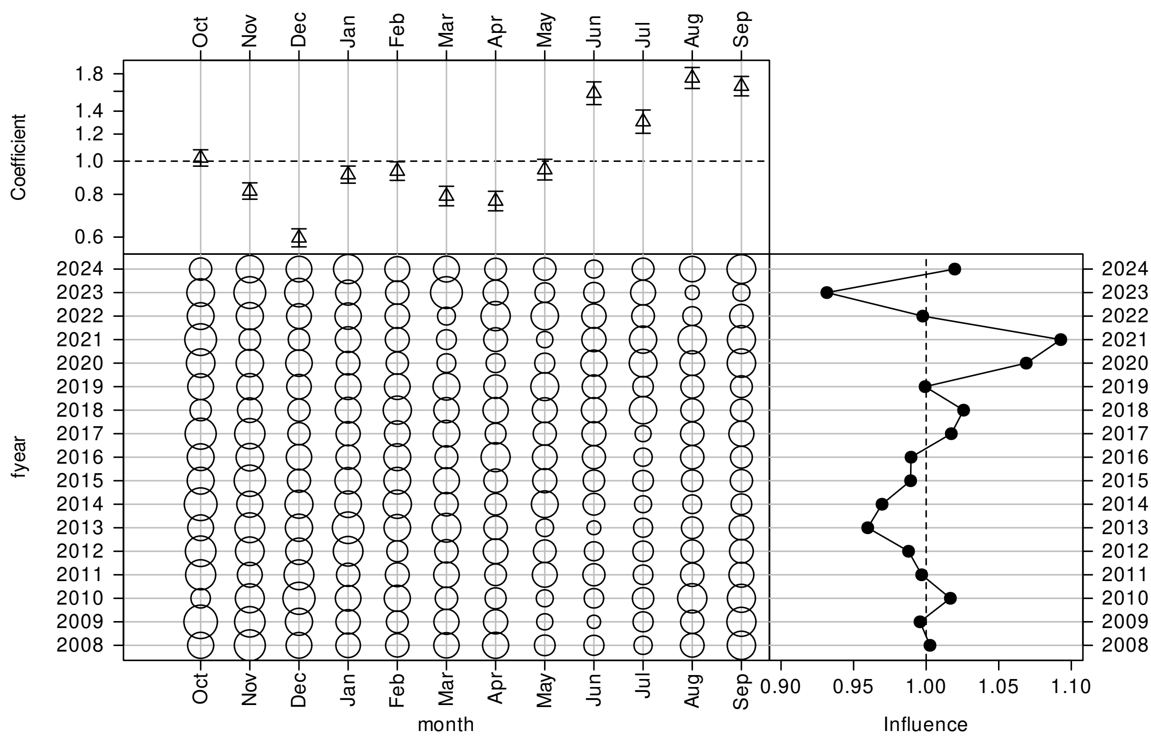

Figure C.131: CDI plot for month for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

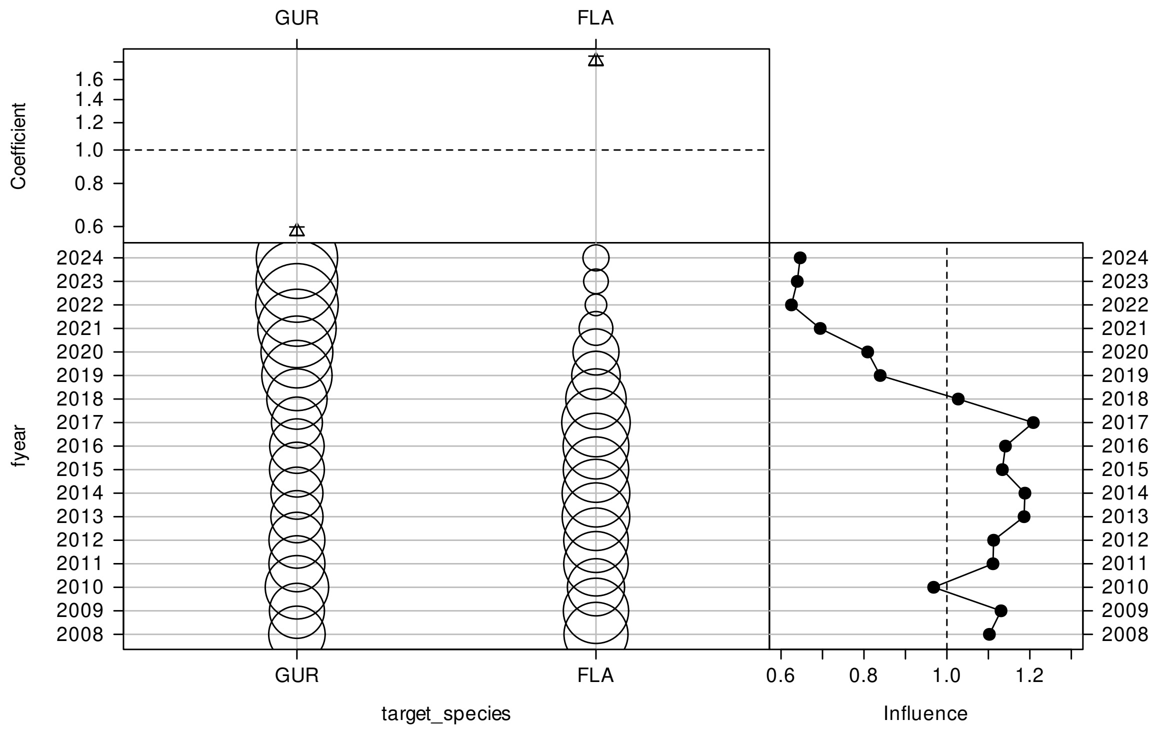

Figure C.132: CDI plot for target species for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

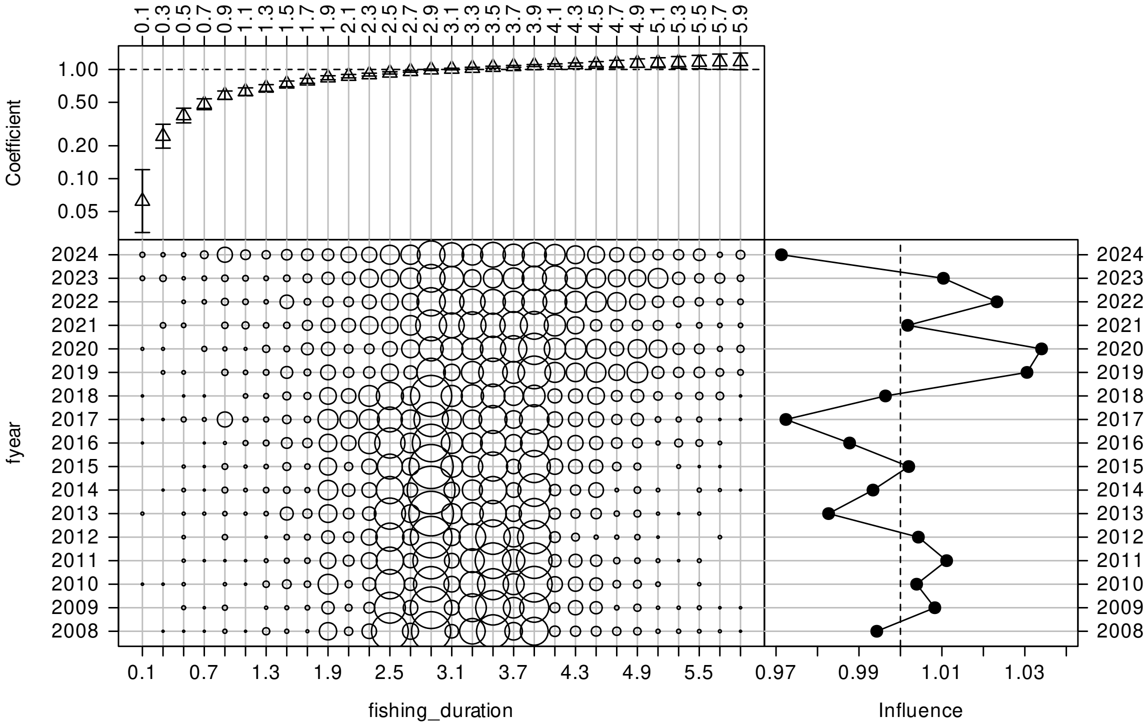

Figure C.133: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

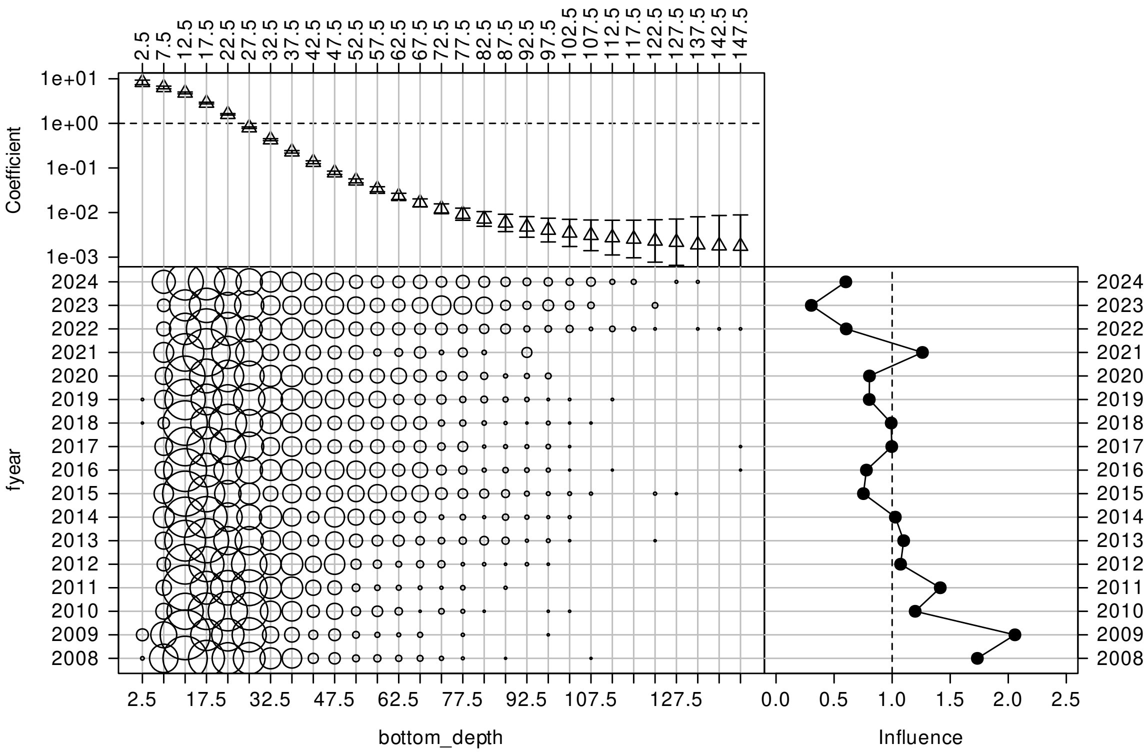

Figure C.134: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

Table C.39: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	25 798.66	0.00	0.00	*
fyear	16	24 537.48	14.61	14.61	*
vessel_key	17	23 815.92	22.13	7.53	*
stat_area	1	22 417.78	34.37	12.24	*
month	11	22 379.66	34.85	0.48	*
target_species	1	22 246.57	35.91	1.07	*
ns(log(fishing_duration), 3)	3	22 020.83	37.70	1.79	*
ns(bottom_depth, 3)	3	21 755.25	39.73	2.03	*

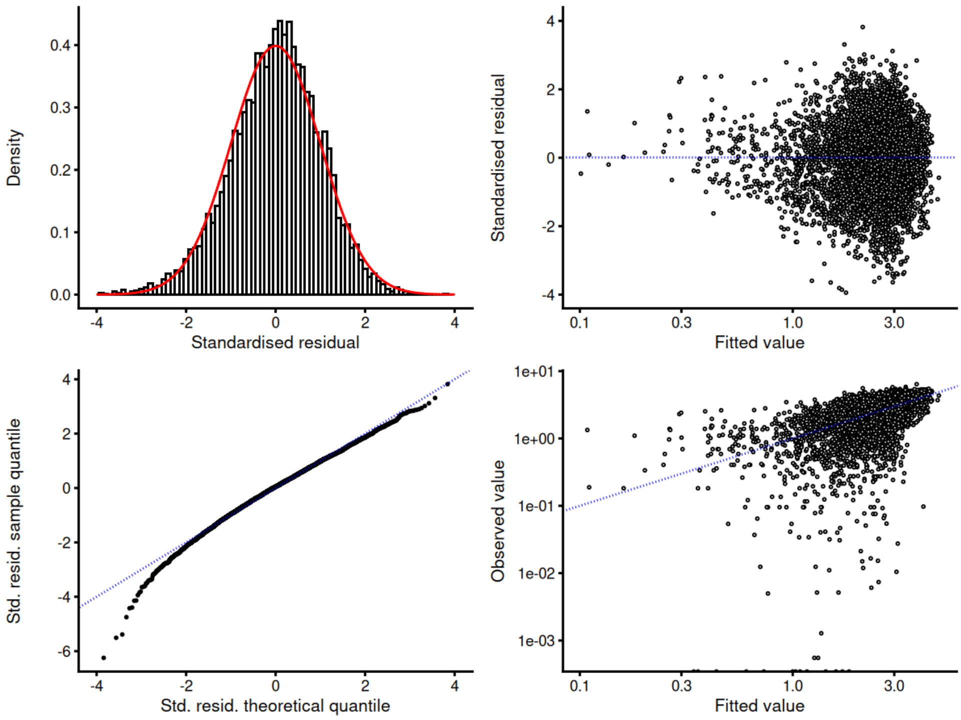

Figure C.135: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay YBF BT-MIX event dataset.

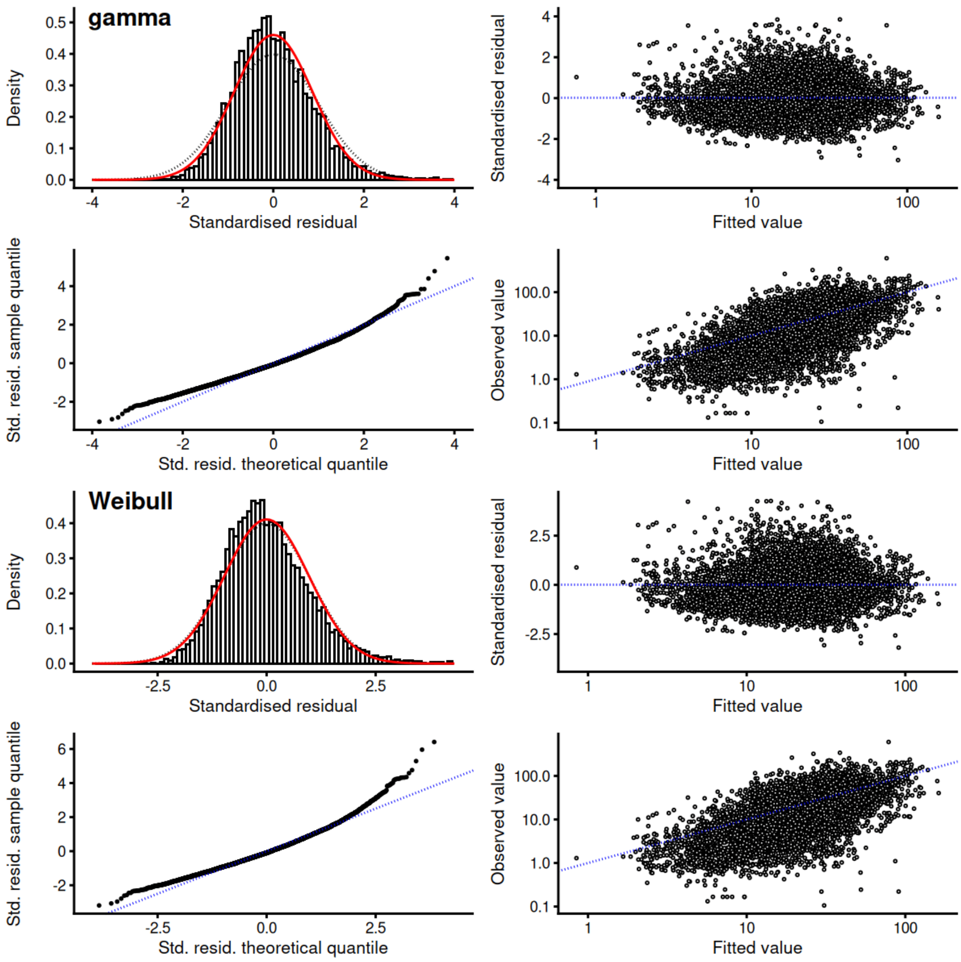

Figure C.136: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay YBF BT-MIX event dataset.

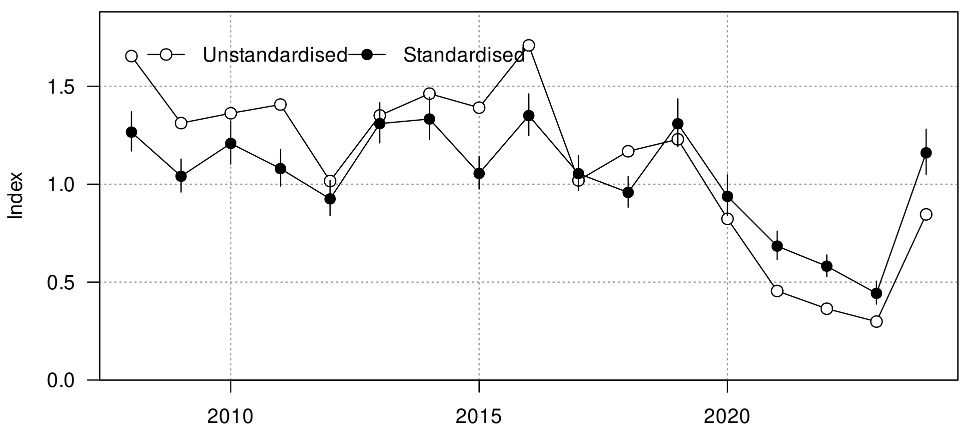

Figure C.137: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay YBF BT-MIX event dataset.

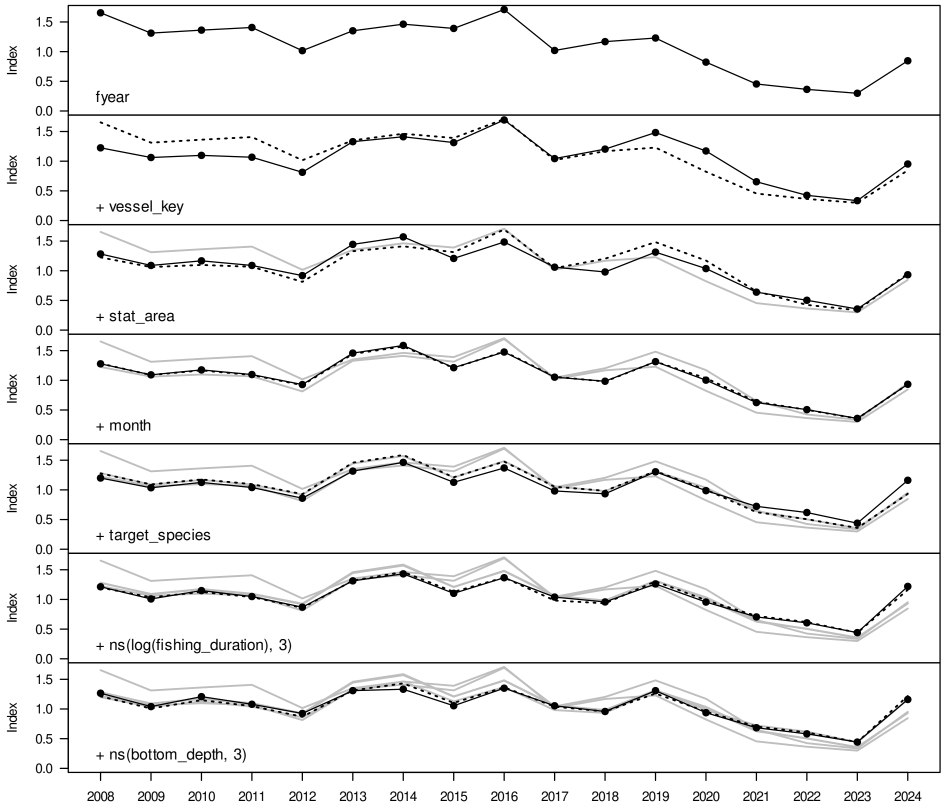

Figure C.138: Changes to the Hawke Bay YBF BT-MIX event positive catch index as terms are successively entered into the lognormal model.

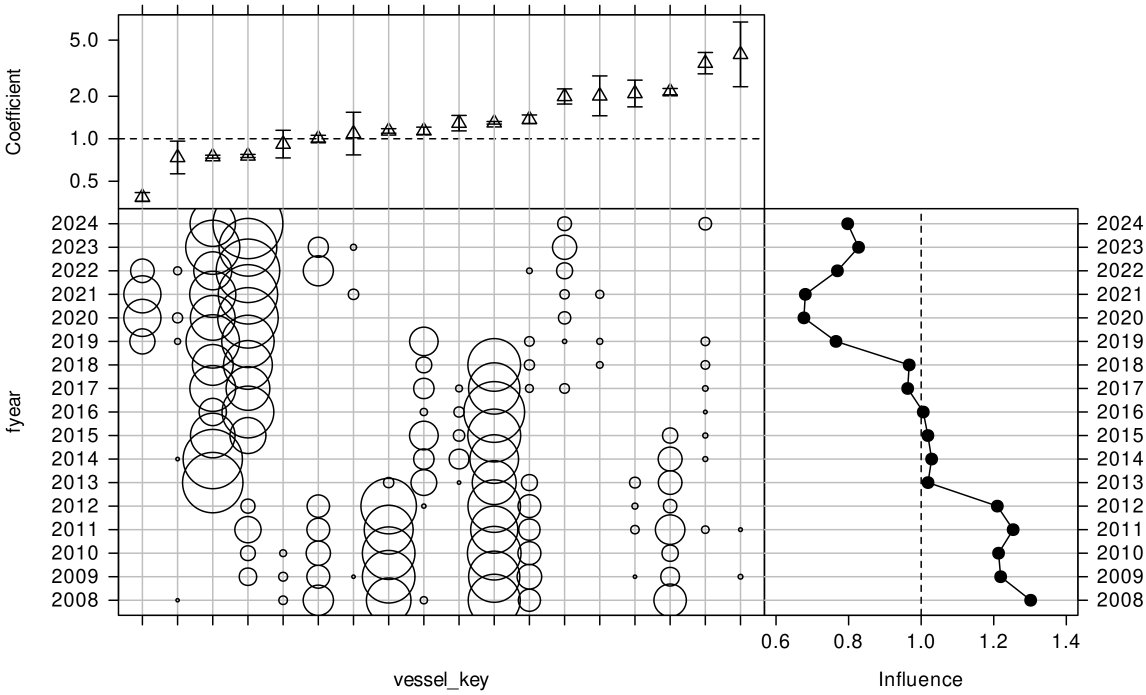

Figure C.139: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

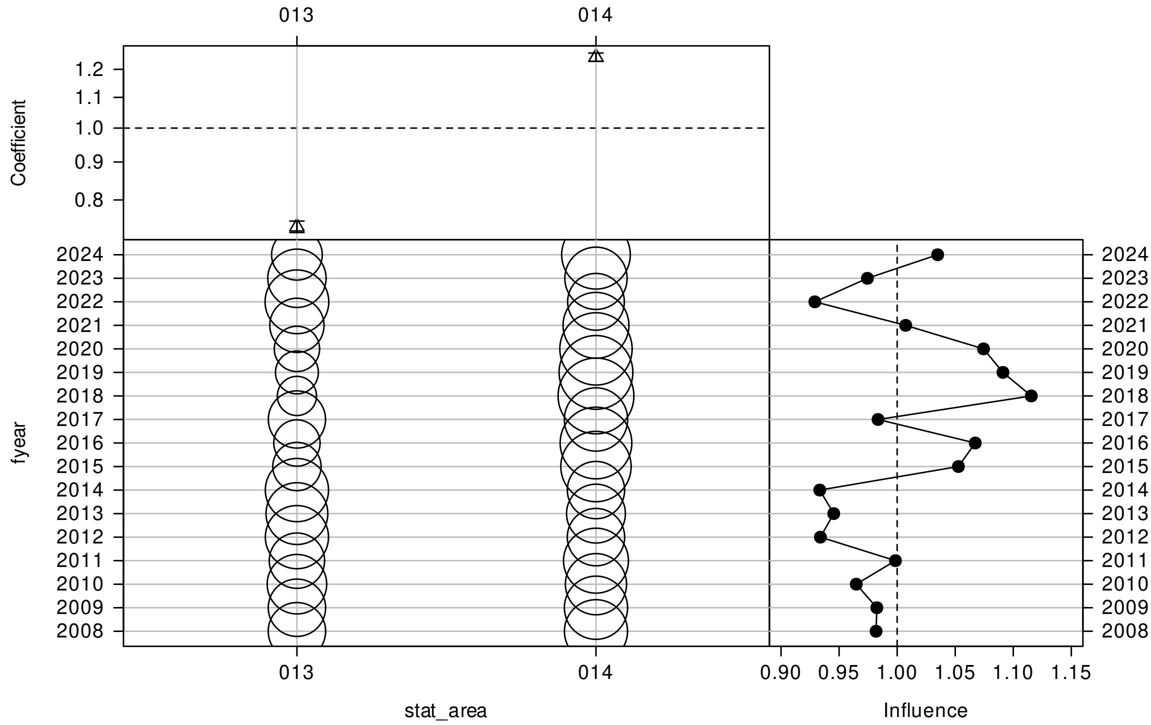

Figure C.140: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

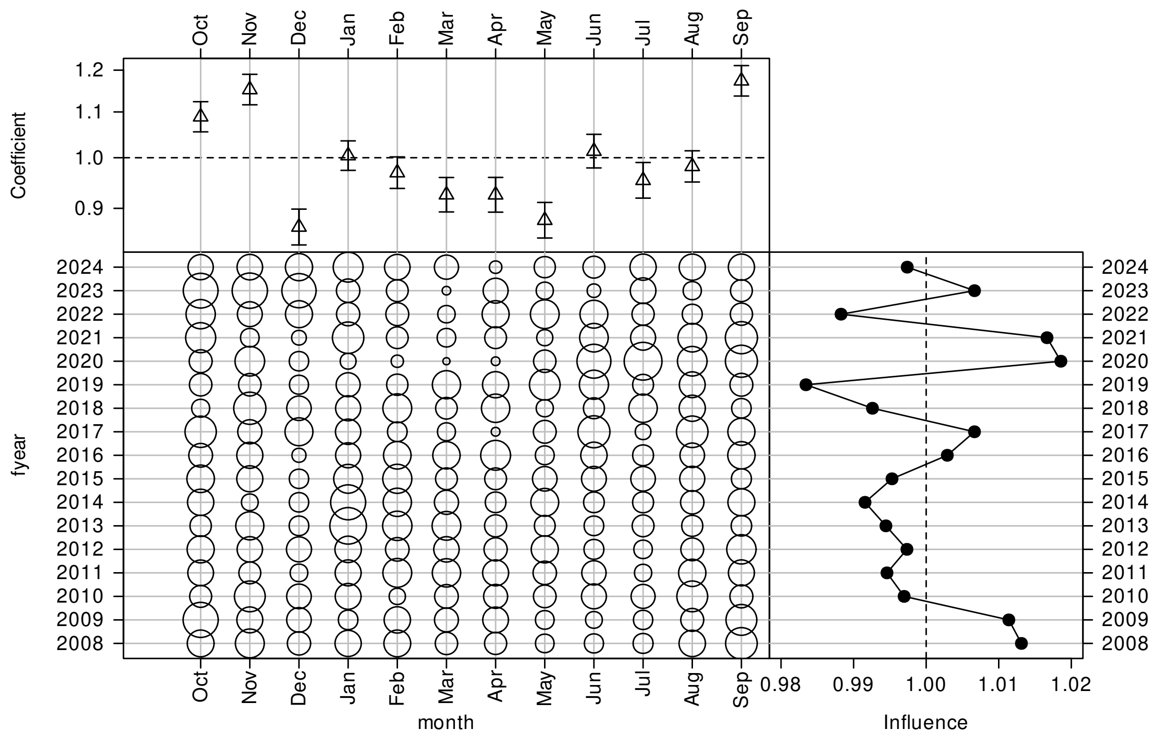

Figure C.141: CDI plot for month for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

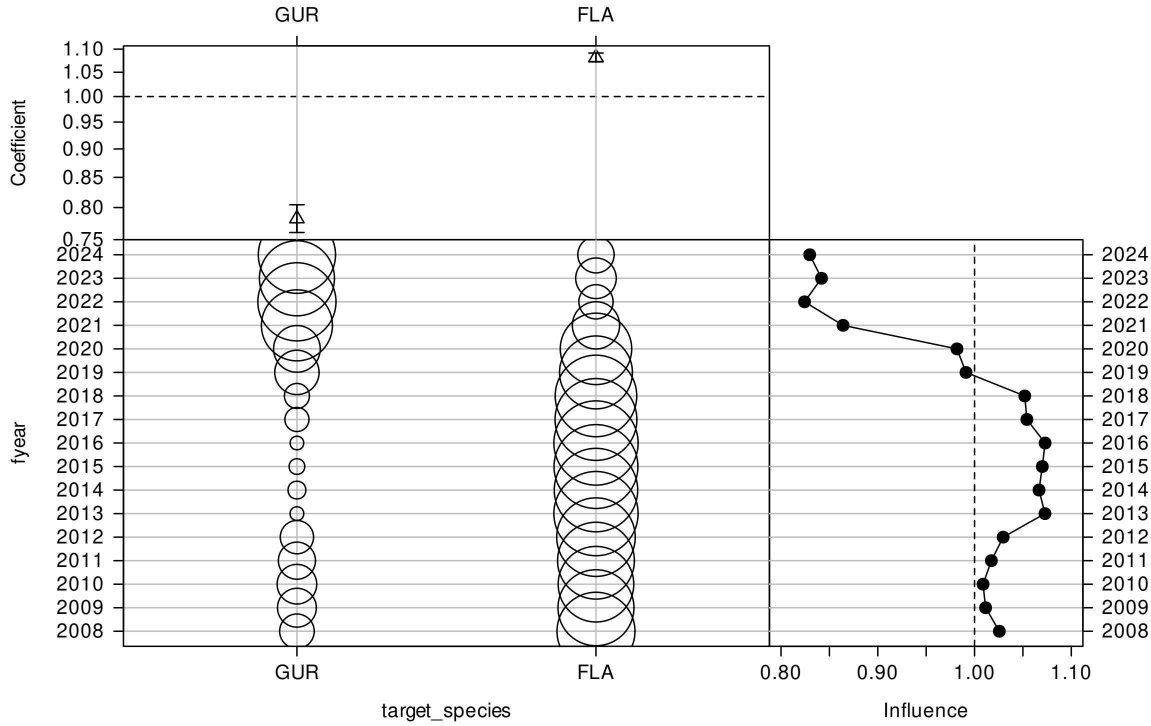

Figure C.142: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

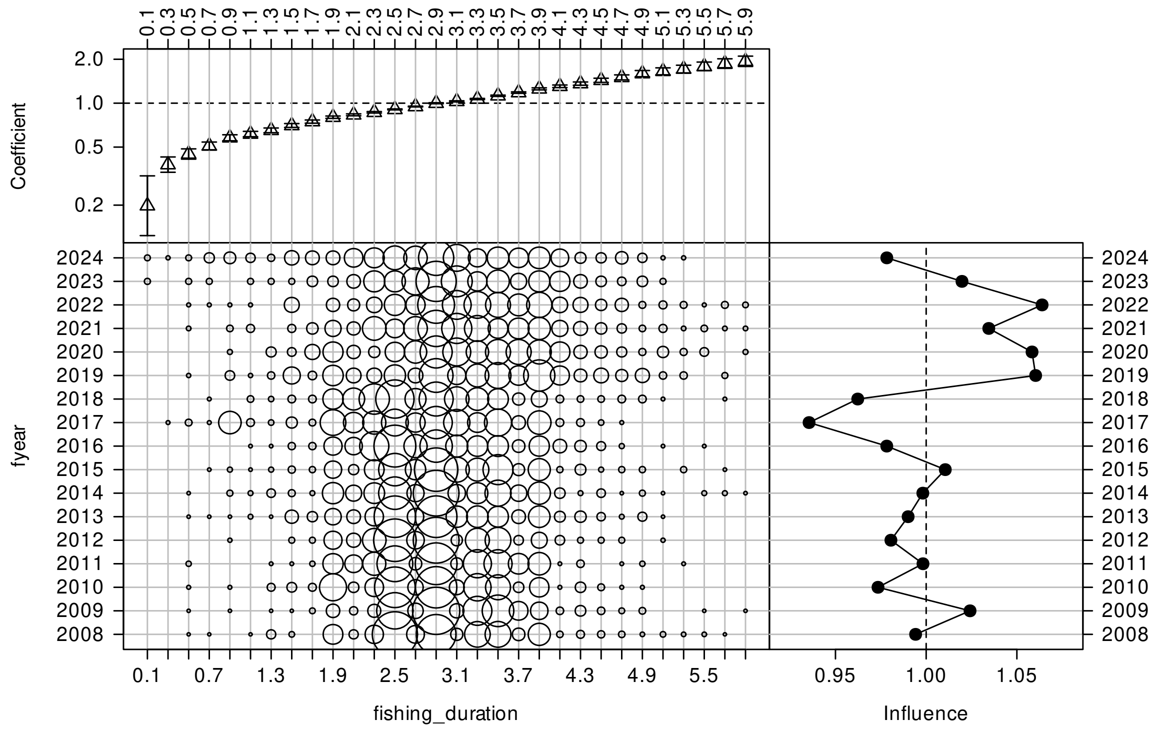

Figure C.143: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

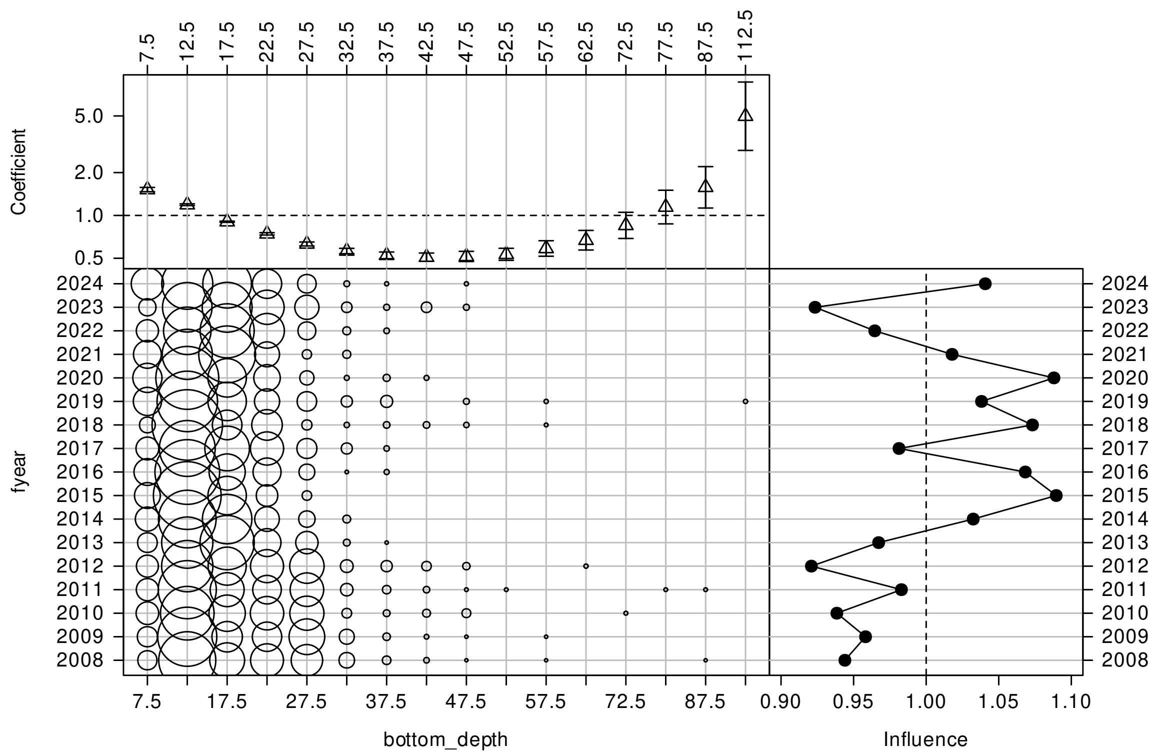

Figure C.144: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay YBF BT-MIX event catch-per-unit-effort dataset.

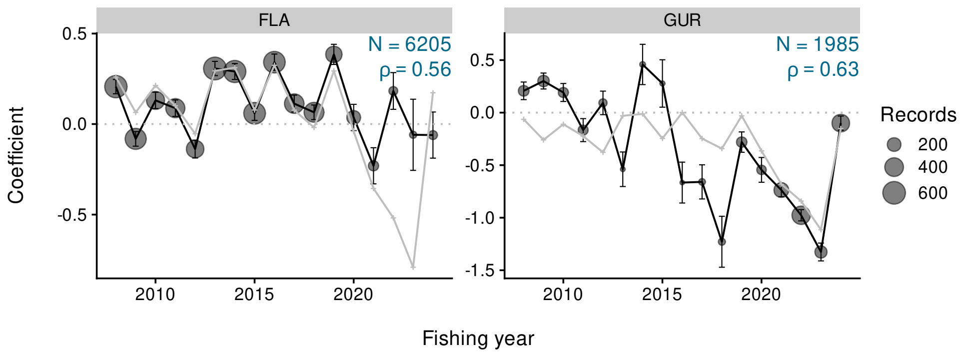

Figure C.145: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay YBF BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

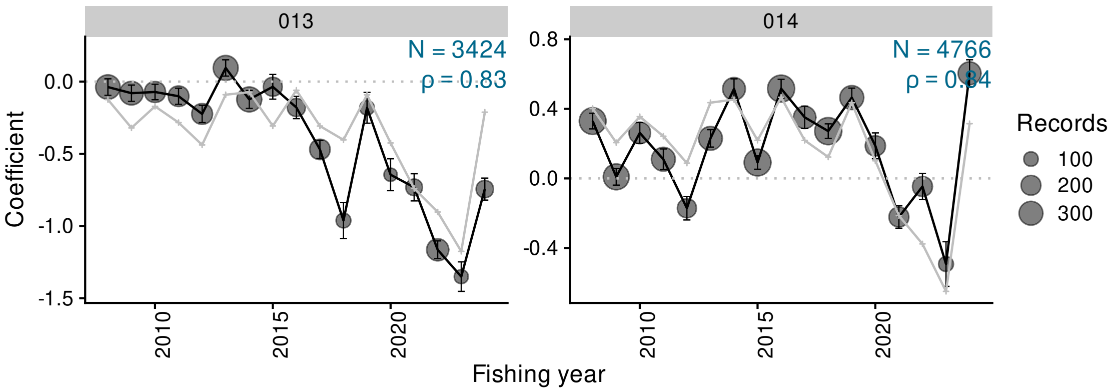

Figure C.146: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay YBF BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 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.

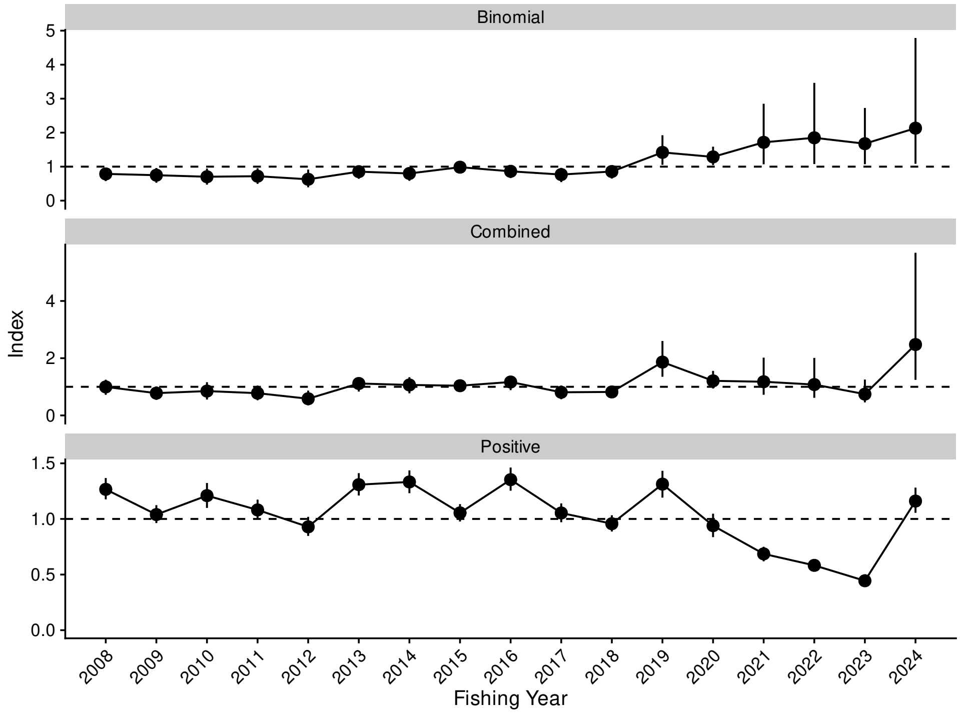

Figure C.147: Standardised indices and 95% confidence intervals for the Hawke Bay YBF BT-MIX event dataset.

Figure C.148: Standardised indices for the Hawke Bay YBF BT-MIX event dataset.

Table C.40: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay YBF BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.787	0.100	0.575	0.969	0.996	0.135	0.720	1.248	1.266	0.049	1.176	1.368
2009	0.749	0.111	0.527	0.960	0.778	0.120	0.543	1.015	1.039	0.041	0.963	1.124
2010	0.703	0.121	0.470	0.943	0.851	0.154	0.555	1.160	1.210	0.057	1.099	1.323
2011	0.719	0.117	0.494	0.952	0.777	0.131	0.529	1.043	1.081	0.046	0.995	1.173
2012	0.628	0.133	0.392	0.914	0.584	0.131	0.352	0.868	0.929	0.044	0.847	1.019
2013	0.853	0.088	0.643	0.988	1.116	0.125	0.833	1.324	1.308	0.051	1.210	1.412
2014	0.799	0.100	0.583	0.973	1.065	0.143	0.772	1.334	1.333	0.052	1.231	1.436
2015	0.984	0.058	0.838	1.065	1.038	0.077	0.865	1.167	1.055	0.040	0.977	1.133
2016	0.863	0.083	0.664	0.989	1.168	0.128	0.882	1.385	1.353	0.053	1.254	1.462
2017	0.767	0.107	0.545	0.964	0.809	0.123	0.567	1.047	1.054	0.043	0.970	1.140
2018	0.857	0.086	0.650	0.988	0.820	0.095	0.609	0.983	0.957	0.037	0.887	1.033
2019	1.420	0.222	1.054	1.924	1.864	0.319	1.351	2.602	1.313	0.061	1.192	1.432
2020	1.287	0.138	1.045	1.588	1.209	0.157	0.941	1.556	0.939	0.054	0.836	1.047
2021	1.716	0.454	1.070	2.850	1.177	0.331	0.722	2.020	0.686	0.033	0.619	0.750
2022	1.849	0.609	1.076	3.465	1.078	0.356	0.615	2.010	0.583	0.028	0.531	0.639
2023	1.676	0.422	1.071	2.727	0.744	0.203	0.456	1.253	0.444	0.029	0.390	0.502
2024	2.132	0.944	1.085	4.785	2.477	1.133	1.243	5.685	1.161	0.058	1.055	1.282

C.8 Hawke Bay ESO BT-MIX event (full covariates, stepwise)

Table C.41: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) CPUE series.

Series	Hawke Bay ESO BT-MIX event (full covariates, stepwise)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	ESO ~ fyear + vessel_key + stat_area + month + ns(log(fishing_duration), 3) + ns(bottom_depth, 3) + ns(effort_height, 3) + ns(effort_width, 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

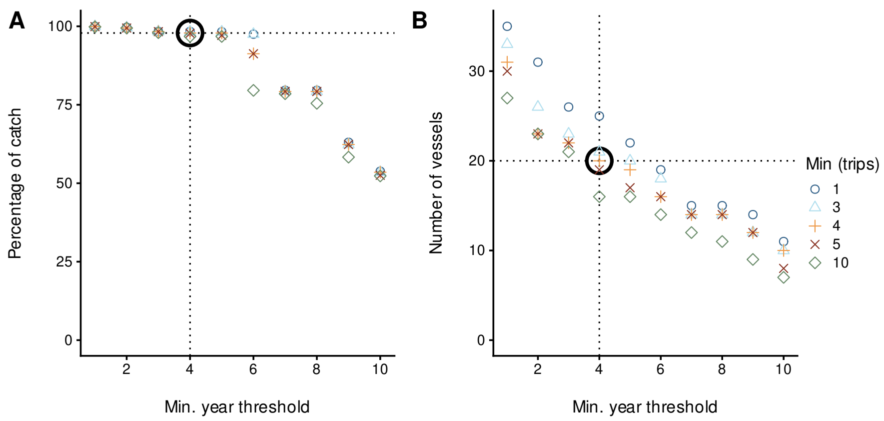

Figure C.149: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

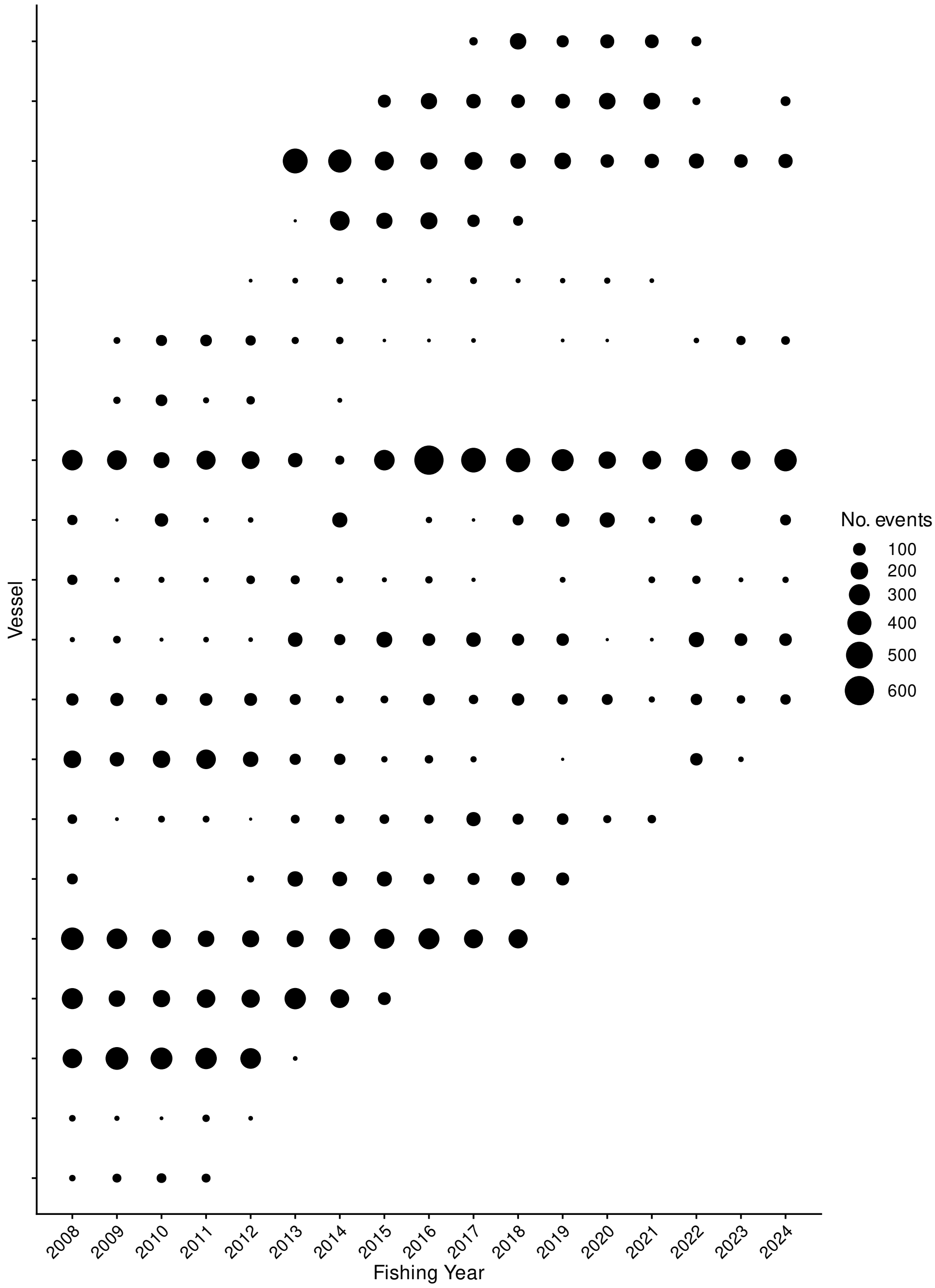

Figure C.150: Number of events by fishing year for core vessels in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.42: Summary of the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	39 (100%) n: 2087	30 (100%) n: 1515	37 (100%) n: 1601	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Positive fishing duration	39 (100%) n: 2087	30 (100%) n: 1513	37 (100%) n: 1599	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Fishing duration less than 6 h	39 (100%) n: 2077	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1664	37 (100%) n: 1387	82 (100%) n: 1669	63 (98%) n: 2068	30 (100%) n: 1779	44 (100%) n: 1864
Bottom depth < 150m	39 (100%) n: 2076	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1662	37 (100%) n: 1387	82 (100%) n: 1669	63 (97%) n: 2066	30 (100%) n: 1777	44 (100%) n: 1864
Headline height less than 10 m	39 (99%) n: 2068	29 (100%) n: 1500	37 (100%) n: 1595	64 (100%) n: 1662	37 (100%) n: 1387	82 (100%) n: 1669	63 (97%) n: 2063	30 (100%) n: 1775	44 (100%) n: 1864
Trawl width less than 80 m	39 (99%) n: 2068	29 (100%) n: 1500	37 (100%) n: 1595	64 (100%) n: 1662	37 (100%) n: 1387	82 (100%) n: 1669	63 (97%) n: 2060	30 (100%) n: 1775	44 (100%) n: 1864
Core fleet selection	37 (94%) n: 1793	29 (99%) n: 1484	37 (99%) n: 1579	64 (99%) n: 1566	37 (100%) n: 1378	82 (100%) n: 1647	60 (92%) n: 1811	28 (91%) n: 1622	44 (100%) n: 1863

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1277	11 (100%) n: 946	9 (100%) n: 809	10 (100%) n: 1519	5.4 (100%) n: 885	14 (100%) n: 1093
Positive fishing duration	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1273	11 (99%) n: 943	9 (100%) n: 808	10 (100%) n: 1518	5.4 (100%) n: 884	14 (100%) n: 1093
Fishing duration less than 6 h	27 (99%) n: 1722	21 (99%) n: 1699	20 (100%) n: 1260	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1505	5.4 (100%) n: 871	14 (100%) n: 1085
Bottom depth < 150m	27 (99%) n: 1722	21 (99%) n: 1698	20 (100%) n: 1258	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1501	5.4 (100%) n: 870	14 (100%) n: 1081
Headline height less than 10 m	27 (98%) n: 1719	21 (99%) n: 1697	19 (99%) n: 1251	11 (97%) n: 914	9 (100%) n: 802	9.3 (90%) n: 1324	4.7 (87%) n: 735	14 (99%) n: 1025
Trawl width less than 80 m	27 (98%) n: 1717	21 (99%) n: 1697	19 (99%) n: 1251	11 (97%) n: 901	9 (100%) n: 802	9.3 (90%) n: 1321	4.5 (83%) n: 724	13 (91%) n: 1003
Core fleet selection	26 (95%) n: 1612	20 (95%) n: 1627	19 (98%) n: 1241	11 (96%) n: 899	9 (99%) n: 788	8.9 (87%) n: 1042	4.2 (78%) n: 572	13 (90%) n: 826

Table C.43: **Summary of the Hawke Bay ESO BT-MIX event (full covariates, stepwise) 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 flatfish.**

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	13	654	1 793	5 666.82	37.09	80.15
2009	14	673	1 484	4 832.40	29.14	78.84
2010	14	683	1 579	5 200.67	36.71	70.93
2011	14	700	1 566	5 152.73	63.82	77.20
2012	15	622	1 378	4 437.47	37.15	70.32
2013	14	567	1 647	5 098.95	81.58	69.52
2014	15	646	1 811	5 743.08	59.68	73.22
2015	14	661	1 622	5 239.20	27.61	58.26
2016	14	711	1 863	5 865.78	43.90	48.09
2017	15	642	1 612	5 109.17	26.23	51.05
2018	12	623	1 627	5 268.70	20.46	45.54
2019	13	459	1 241	4 496.43	19.33	57.78
2020	10	371	899	3 295.97	10.70	52.28
2021	10	368	788	2 635.32	8.99	66.12
2022	10	420	1 042	3 619.62	8.94	62.76
2023	7	216	572	2 026.85	4.24	54.90
2024	8	317	826	2 707.40	12.93	67.55

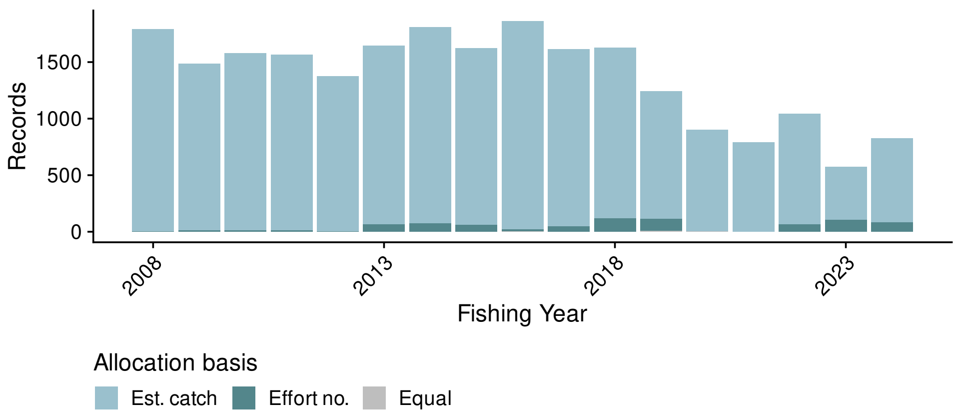

Figure C.151: **The allocation approach used for attributing catches to records in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).**

Table C.44: **Summary of stepwise selection for occurrence of positive catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) 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	15	29 152	4.3	4.3	*
+ vessel_key	19	19 814	35.1	30.8	*
+ ns(bottom_depth, 3)	3	19 157	37.3	2.2	*
+ ns(effort_height, 3)	3	18 702	38.8	1.5	*
+ ns(effort_width, 3)	3	18 560	39.3	0.5	
+ month	11	18 495	39.6	0.3	
+ ns(log(fishing_duration), 3)	3	18 481	39.7	0.1	
+ stat_area	1	18 472	39.7	0.0	

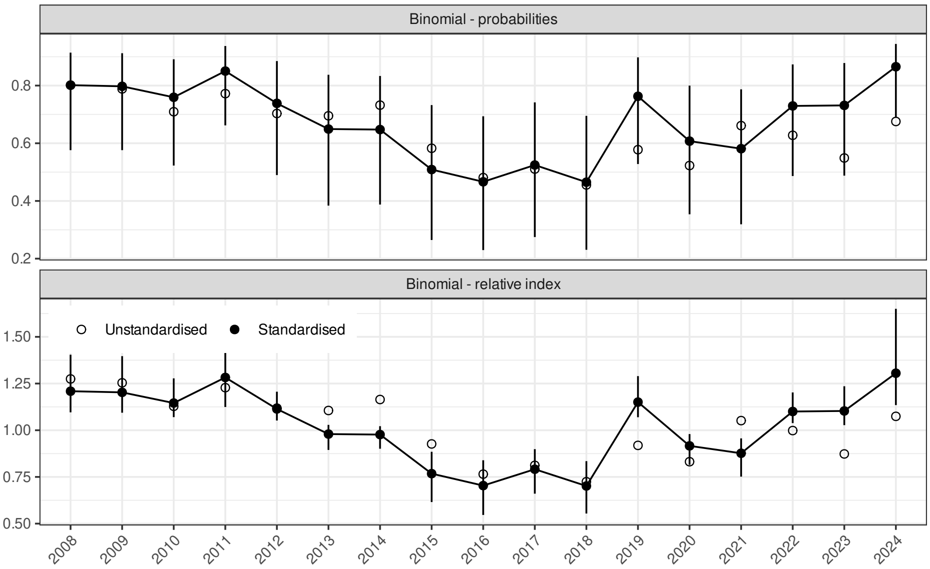

Figure C.152: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

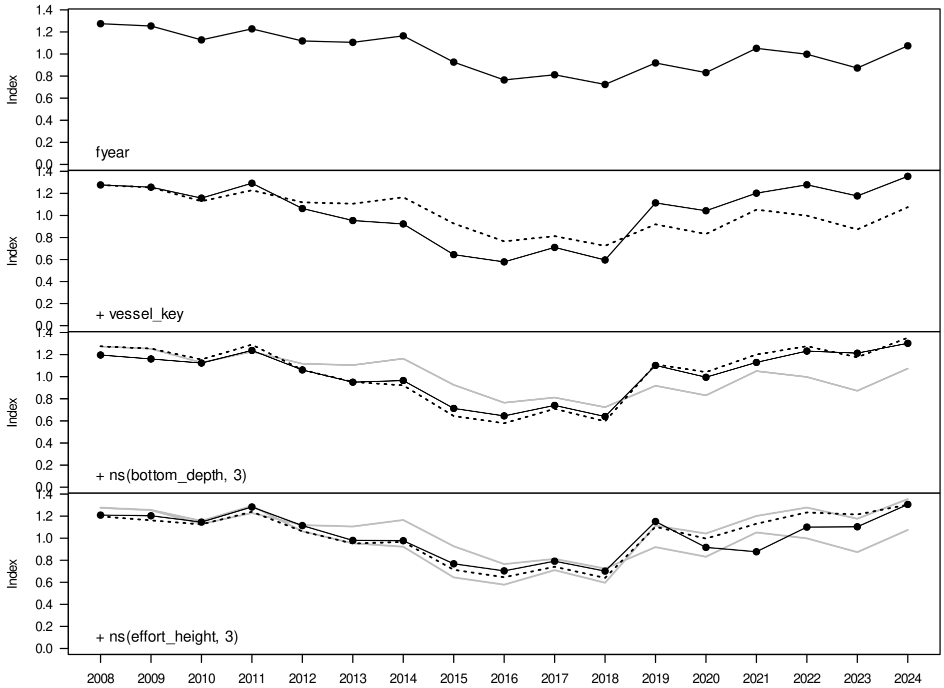

Figure C.153: Step plot for occurrence of catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

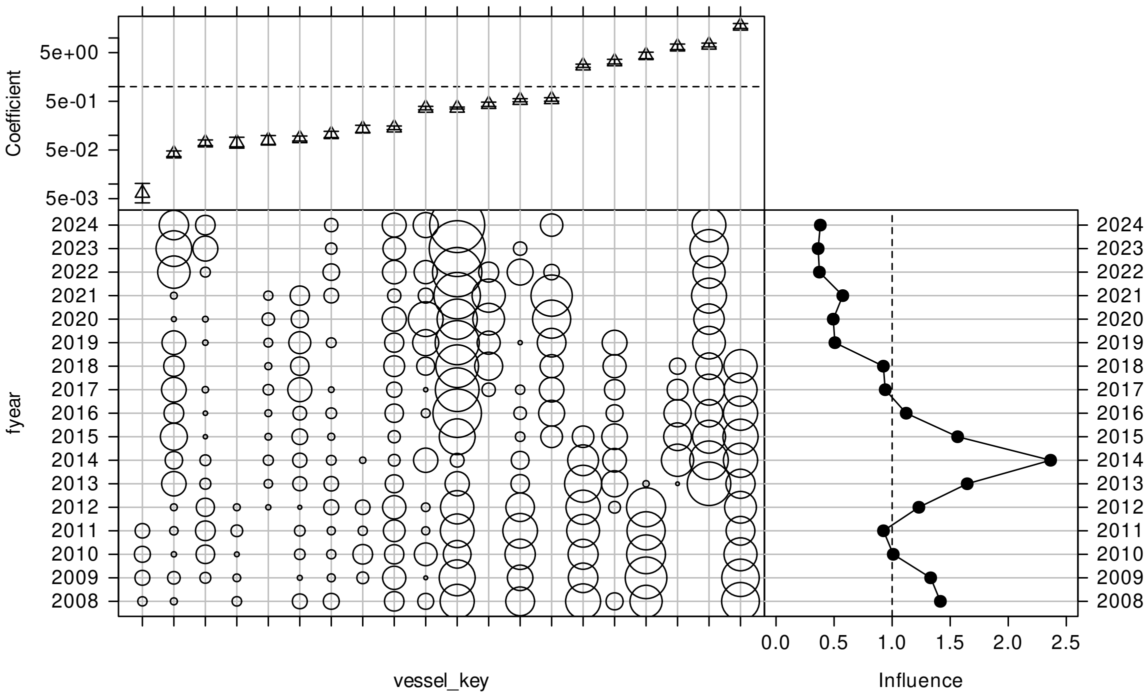

Figure C.154: **CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset.**

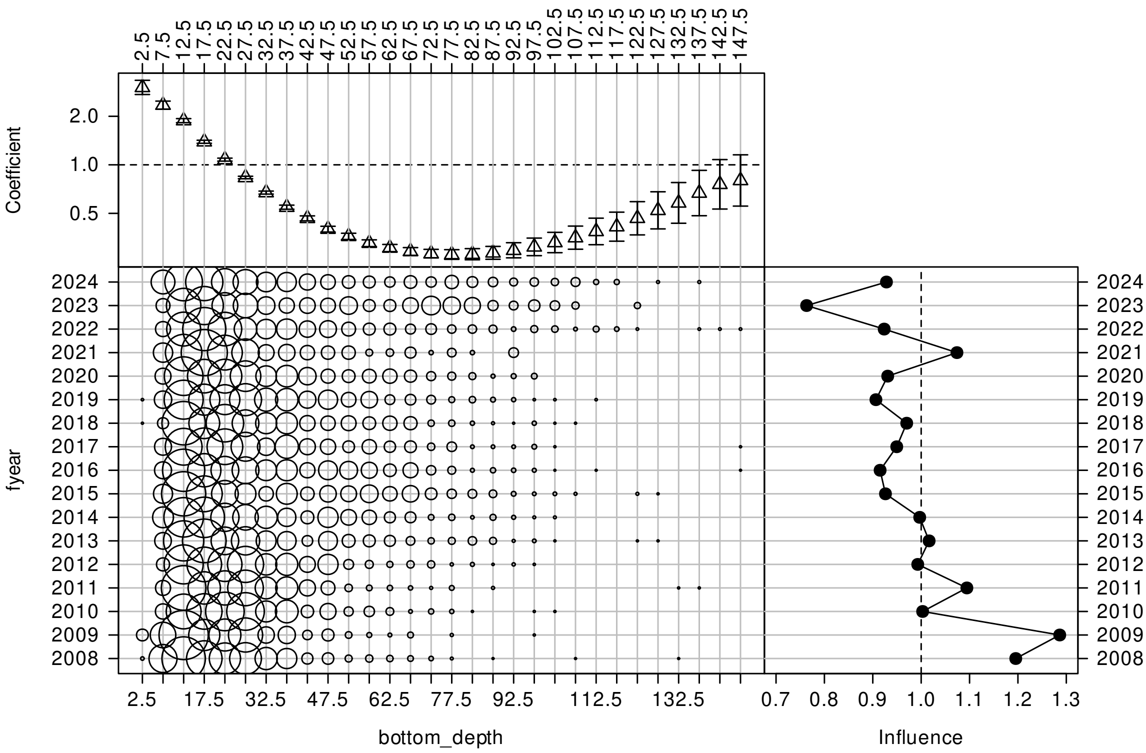

Figure C.155: **CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset.**

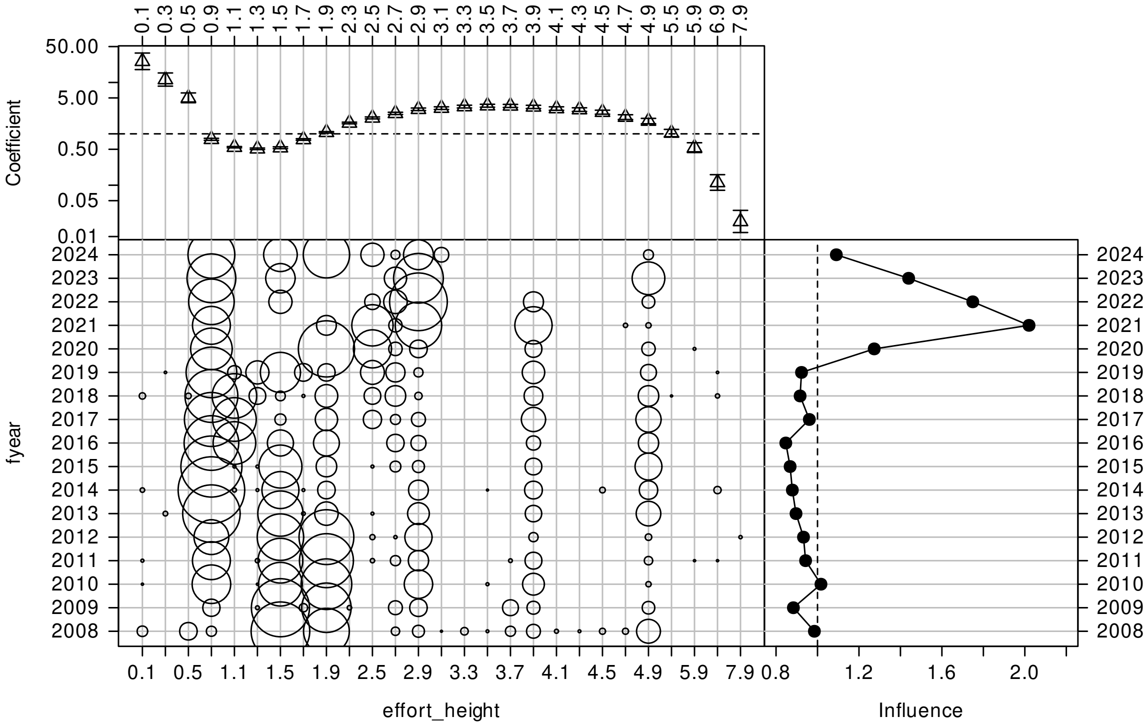

Figure C.156: CDI plot for effort height (m) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset.

Table C.45: Summary of stepwise selection for the lognormal model for positive catches in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) 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	15	47 166	13.0	13.0	*
+ ns(bottom_depth, 3)	3	44 551	26.9	13.9	*
+ vessel_key	19	43 202	33.4	6.5	*
+ ns(effort_width, 3)	3	42 999	34.3	0.9	
+ ns(log(fishing_duration), 3)	3	42 813	35.1	0.8	
+ month	11	42 713	35.6	0.5	
+ stat_area	1	42 627	36.0	0.4	
+ ns(effort_height, 3)	3	42 614	36.1	0.1	

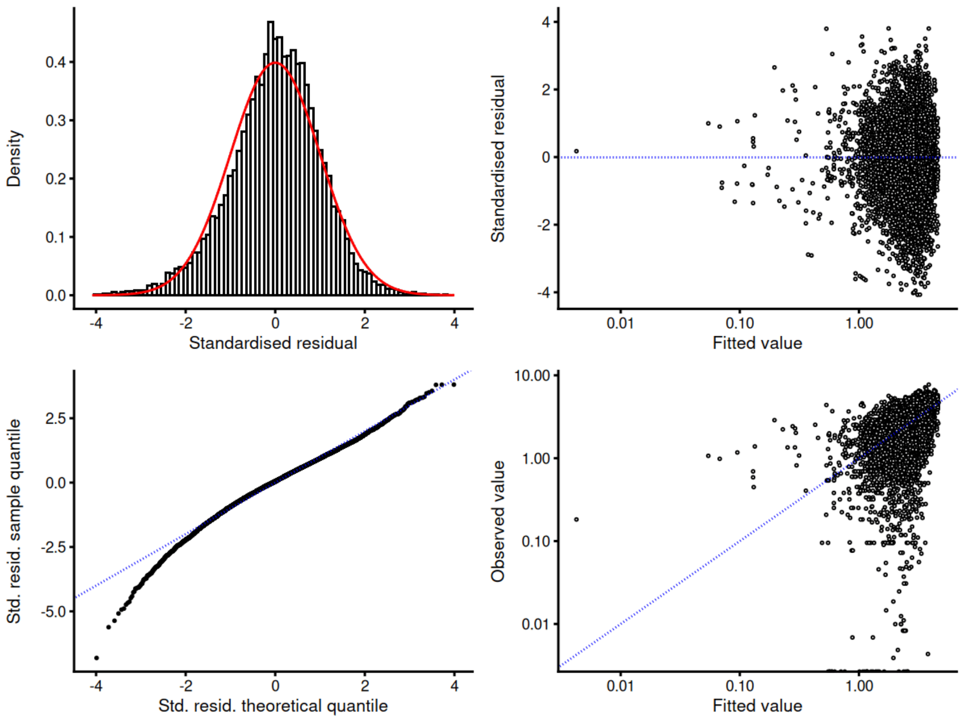

Figure C.157: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

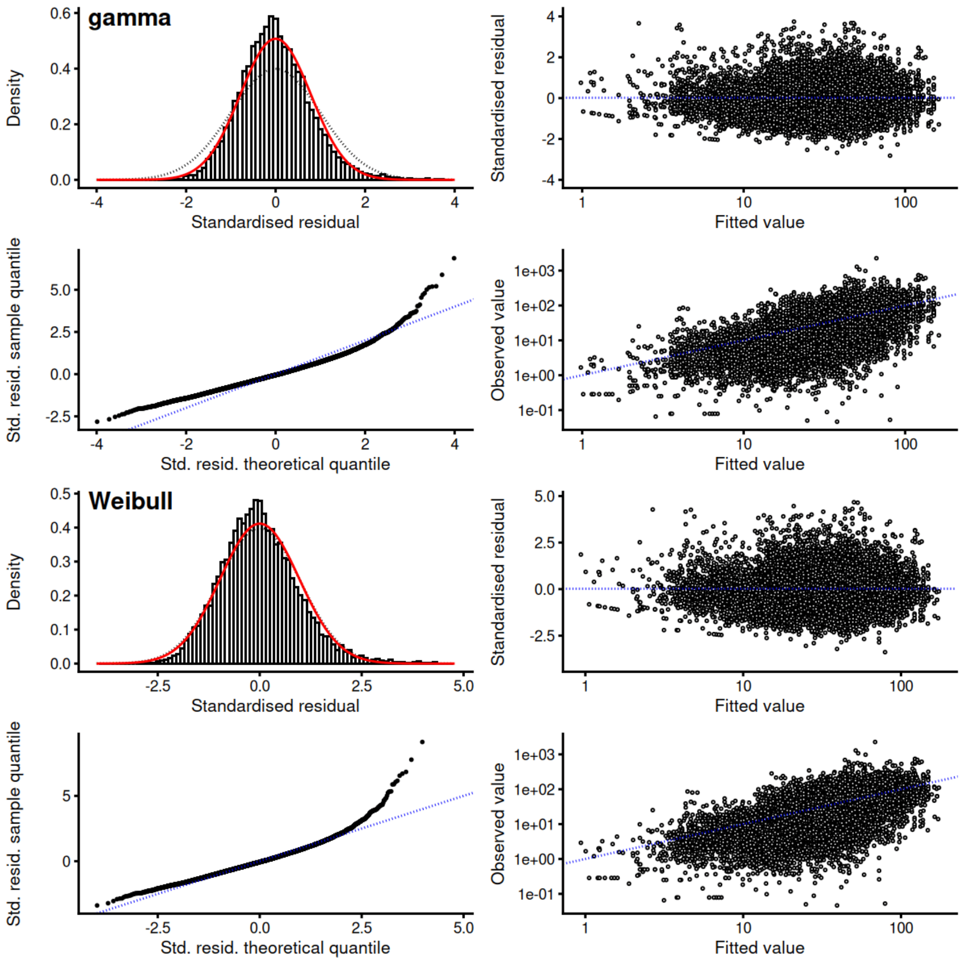

Figure C.158: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

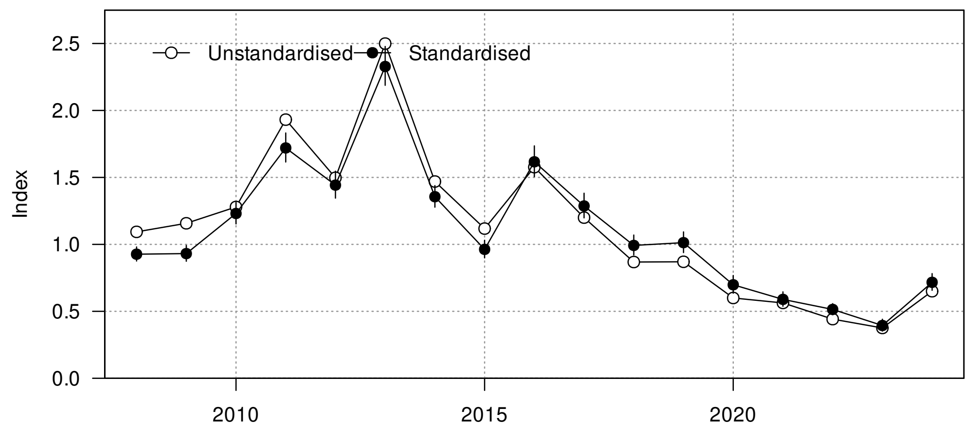

Figure C.159: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

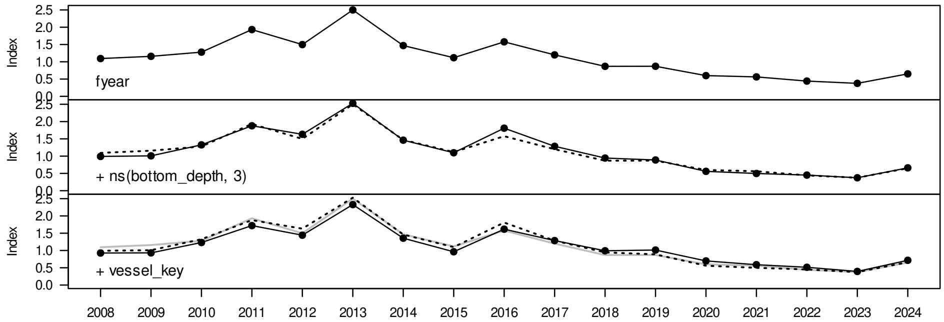

Figure C.160: Changes to the Hawke Bay ESO BT-MIX event (full covariates, stepwise) positive catch index as terms are successively entered into the lognormal model.

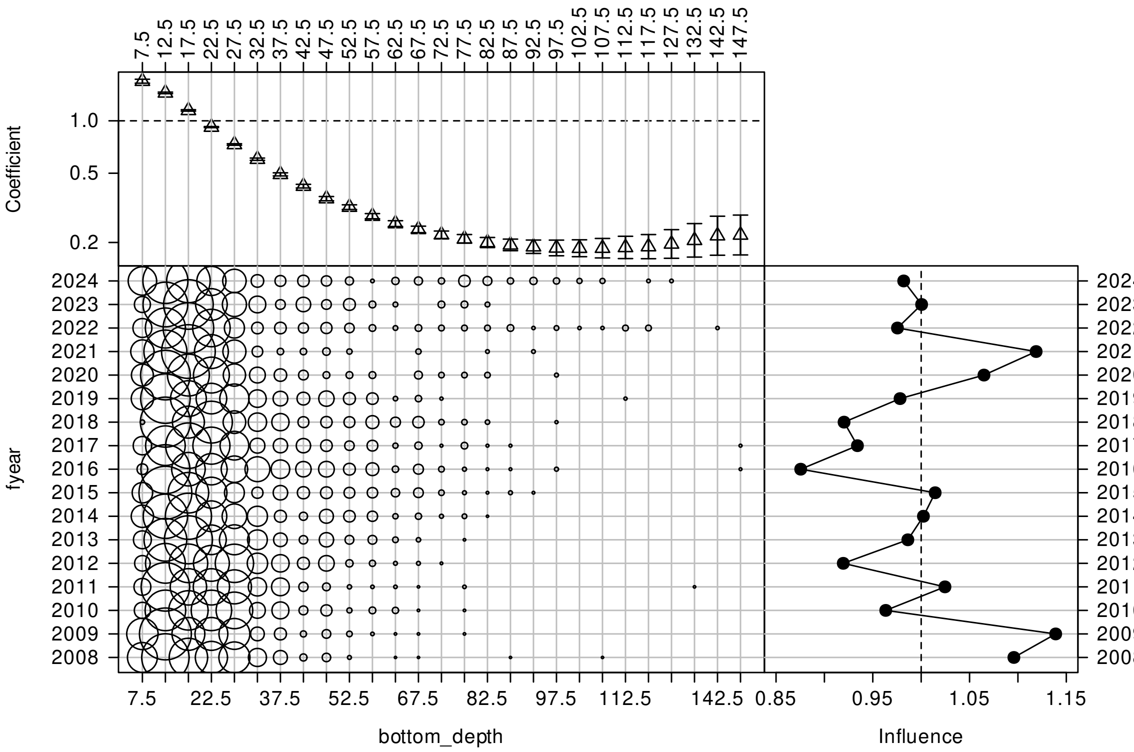

Figure C.161: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset.

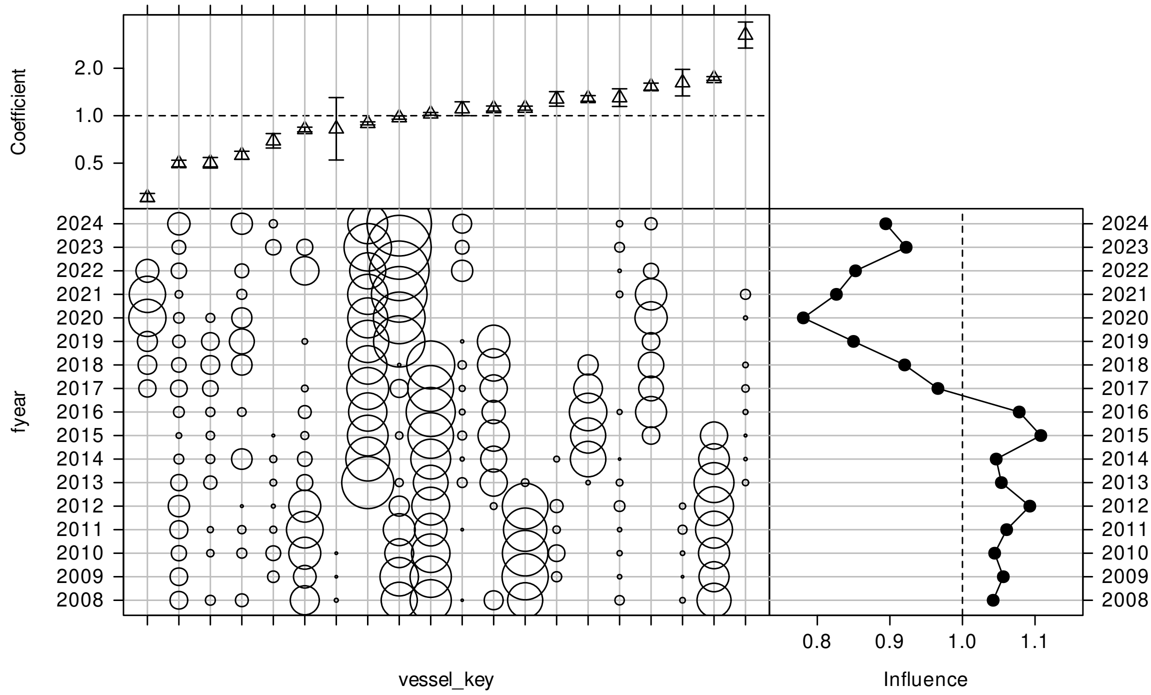

Figure C.162: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) catch-per-unit-effort dataset.

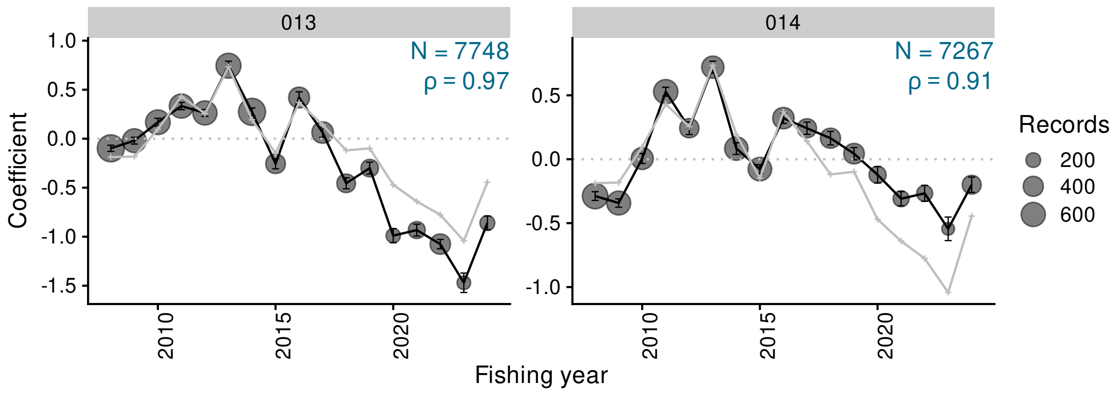

Figure C.163: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted 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.

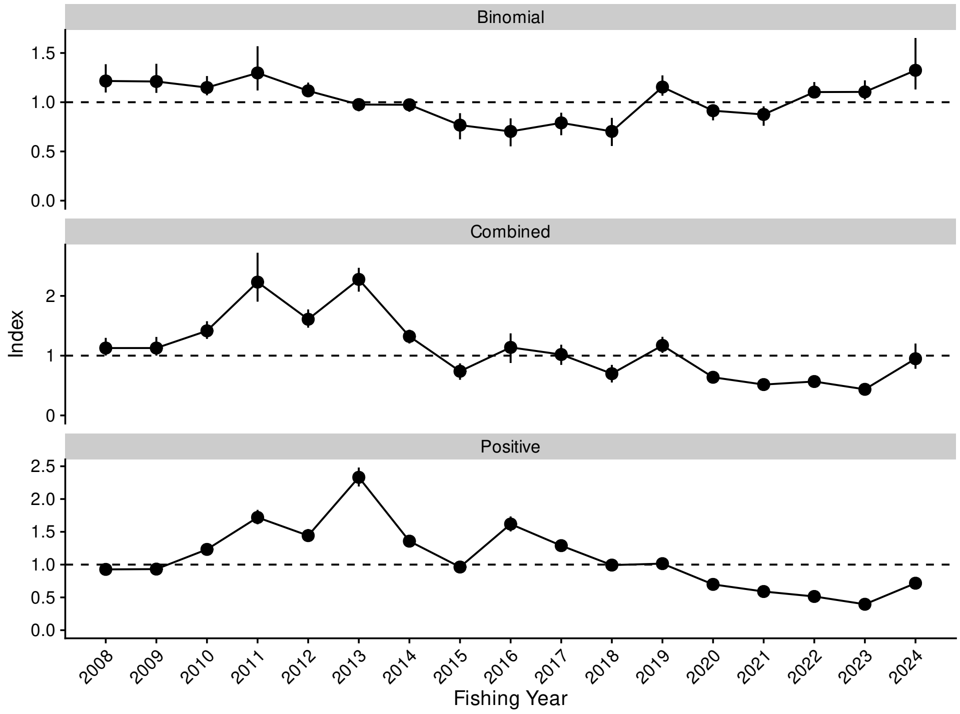

Figure C.164: Standardised indices and 95% confidence intervals for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

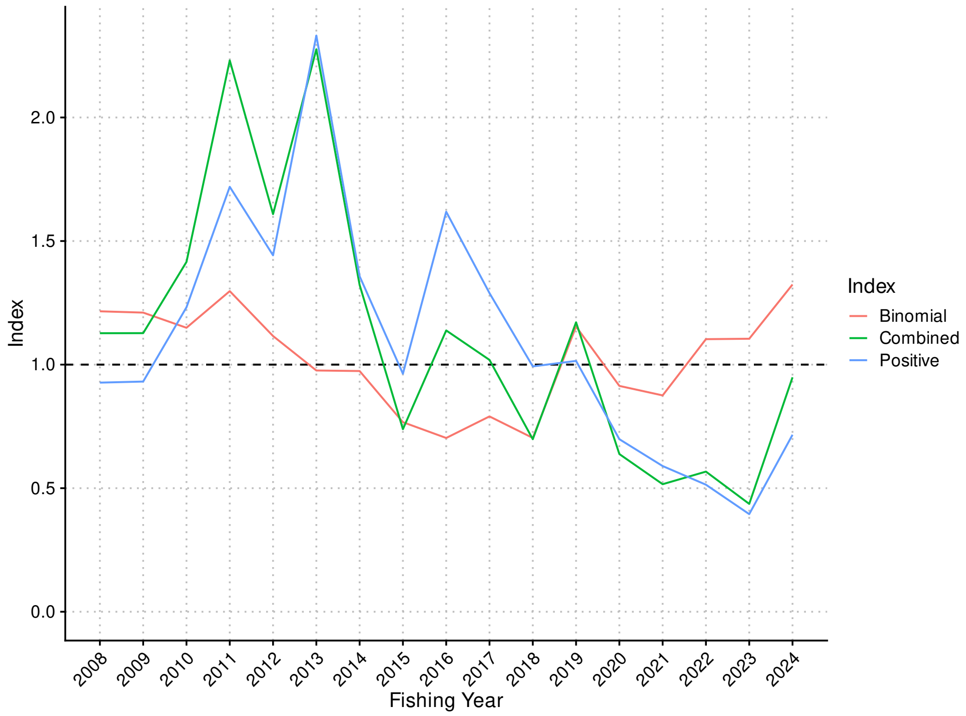

Figure C.165: Standardised indices for the Hawke Bay ESO BT-MIX event (full covariates, stepwise) dataset.

Table C.46: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay ESO BT-MIX event (full covariates, stepwise) series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.216	0.073	1.098	1.386	1.127	0.076	1.002	1.298	0.927	0.025	0.879	0.977
2009	1.210	0.075	1.095	1.390	1.127	0.080	1.000	1.313	0.931	0.030	0.874	0.993
2010	1.149	0.050	1.070	1.266	1.416	0.076	1.280	1.576	1.232	0.040	1.158	1.316
2011	1.297	0.115	1.119	1.569	2.231	0.209	1.904	2.722	1.719	0.056	1.615	1.836
2012	1.116	0.038	1.052	1.199	1.609	0.078	1.468	1.773	1.442	0.051	1.345	1.543
2013	0.976	0.030	0.908	1.024	2.276	0.102	2.071	2.470	2.331	0.074	2.191	2.481
2014	0.974	0.032	0.903	1.028	1.322	0.059	1.203	1.433	1.357	0.041	1.278	1.440
2015	0.767	0.068	0.623	0.889	0.739	0.070	0.596	0.871	0.963	0.033	0.901	1.032
2016	0.703	0.073	0.552	0.836	1.138	0.126	0.877	1.373	1.619	0.058	1.506	1.735
2017	0.790	0.058	0.665	0.893	1.019	0.086	0.845	1.183	1.289	0.047	1.200	1.383
2018	0.703	0.073	0.555	0.841	0.698	0.075	0.551	0.845	0.993	0.039	0.918	1.071
2019	1.154	0.053	1.066	1.273	1.171	0.069	1.046	1.315	1.015	0.038	0.941	1.092
2020	0.914	0.041	0.816	0.977	0.638	0.041	0.557	0.718	0.698	0.032	0.639	0.765
2021	0.875	0.050	0.761	0.958	0.516	0.039	0.436	0.590	0.590	0.027	0.535	0.642
2022	1.103	0.043	1.038	1.205	0.567	0.031	0.513	0.635	0.514	0.021	0.475	0.556
2023	1.105	0.050	1.027	1.222	0.436	0.032	0.383	0.509	0.395	0.022	0.354	0.442
2024	1.324	0.133	1.130	1.652	0.949	0.108	0.780	1.203	0.716	0.033	0.656	0.785

C.9 South Taranaki SFL BT-MIX event

This series was an attempt to see if the data for sand flounder (SFL) from the South Taranaki Bight were adequate for monitoring SFL in this region. This analysis used the same criteria to specify the SFL model (Table C.47) as was done for ESO and SFL in Hawke Bay. Unfortunately, the resulting model was deemed by the INSWG to be unreliable for consideration as a monitoring series for SFL in the South Taranaki Bight.

Table C.47: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the South Taranaki SFL BT-MIX event CPUE series.

Series	South Taranaki SFL BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	039
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	2
Default model	SFL ~ fyear + vessel_key + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

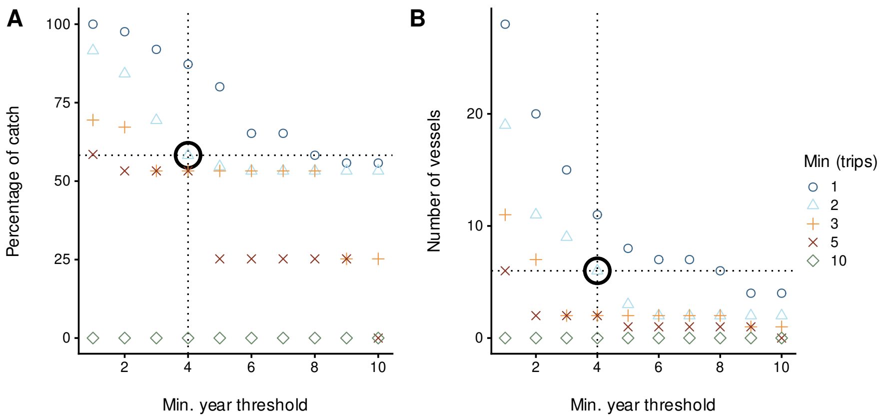

Figure C.166: Percentage of catch and number of vessels for different core vessel selection criteria for the South Taranaki SFL BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

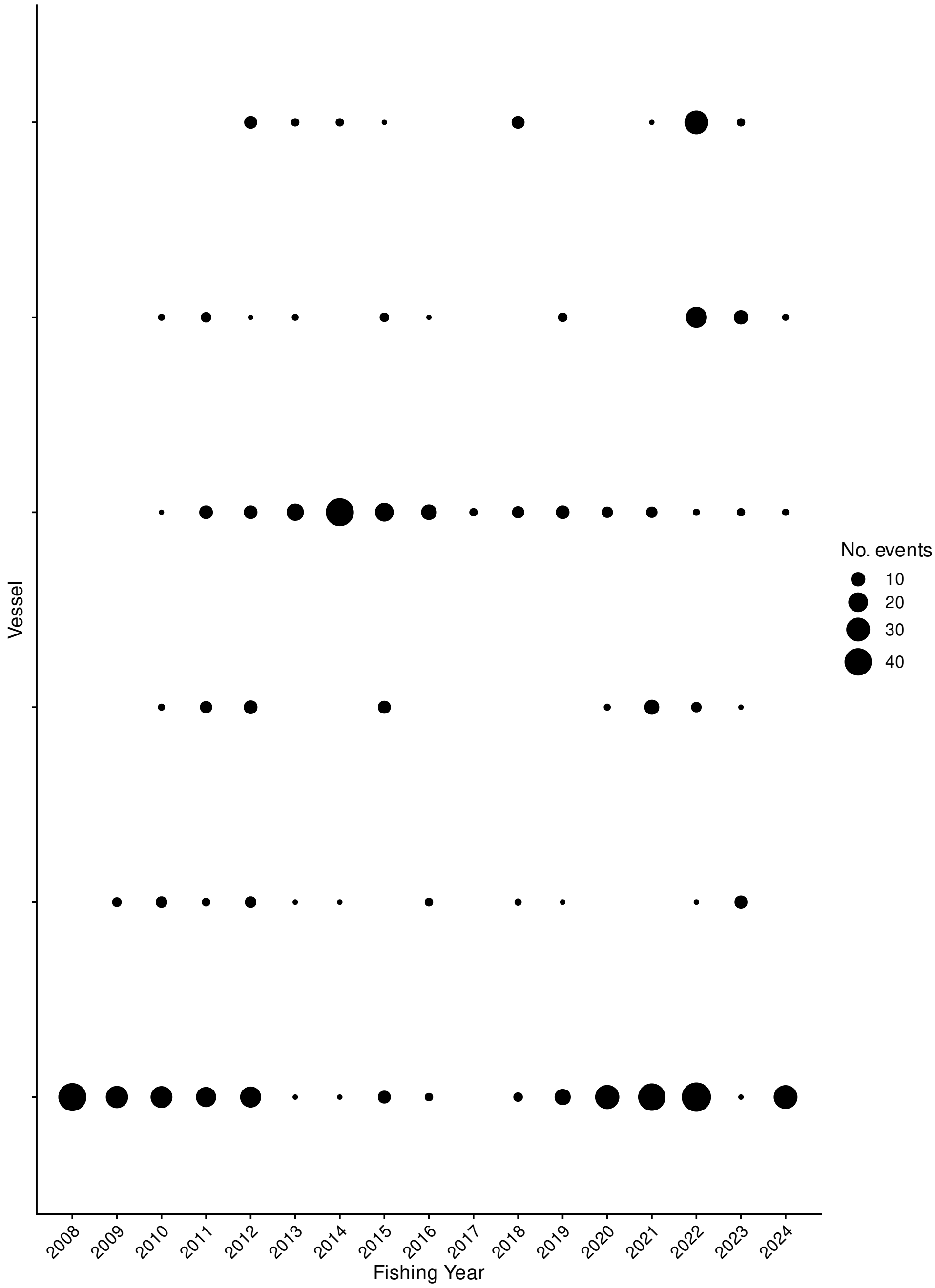

Figure C.167: Number of events by fishing year for core vessels in the South Taranaki SFL BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.48: Summary of the South Taranaki SFL BT-MIX 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. Catch data for years with less than three vessels are omitted (indicated by x).

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	x (100%) n: 45	x (100%) n: 42	1.5 (100%) n: 52	4.7 (100%) n: 69	1.2 (100%) n: 62	0.34 (100%) n: 42	6.3 (100%) n: 59	6.1 (100%) n: 98	0.61 (100%) n: 30
Positive fishing duration	x (100%) n: 45	x (100%) n: 42	1.5 (100%) n: 52	4.7 (100%) n: 69	1.2 (100%) n: 62	0.34 (100%) n: 42	6.3 (100%) n: 59	6.1 (100%) n: 98	0.61 (100%) n: 30
Fishing duration less than 6 h	x (100%) n: 45	x (100%) n: 42	1.5 (100%) n: 52	4.7 (100%) n: 69	1.2 (100%) n: 62	0.34 (100%) n: 42	6.3 (100%) n: 59	6.1 (100%) n: 98	0.61 (100%) n: 30
Bottom depth < 150m	x (100%) n: 45	x (100%) n: 42	1.5 (100%) n: 52	4.7 (100%) n: 69	1.2 (100%) n: 62	0.34 (100%) n: 42	6.3 (100%) n: 59	6.1 (100%) n: 98	0.61 (100%) n: 30
Core fleet selection	x (93%) n: 42	x (74%) n: 30	0.32 (21%) n: 36	0.86 (18%) n: 45	1.1 (97%) n: 56	0.058 (17%) n: 22	6 (95%) n: 47	2 (34%) n: 39	0.36 (59%) n: 19

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	x (100%) n: 12	0.27 (100%) n: 30	0.27 (100%) n: 53	0.5 (100%) n: 109	0.12 (100%) n: 85	0.022 (100%) n: 123	0.12 (100%) n: 29	0.2 (100%) n: 139
Positive fishing duration	x (100%) n: 12	0.27 (100%) n: 30	0.27 (100%) n: 53	0.5 (100%) n: 109	0.12 (100%) n: 85	0.022 (100%) n: 123	0.12 (100%) n: 29	0.2 (100%) n: 139
Fishing duration less than 6 h	x (100%) n: 12	0.27 (100%) n: 30	0.27 (100%) n: 53	0.5 (100%) n: 108	0.12 (100%) n: 84	0.022 (100%) n: 123	0.12 (100%) n: 29	0.2 (100%) n: 139
Bottom depth < 150m	x (100%) n: 12	0.27 (100%) n: 30	0.27 (100%) n: 53	0.5 (100%) n: 108	0.12 (100%) n: 84	0.022 (100%) n: 122	0.12 (100%) n: 29	0.2 (100%) n: 139
Core fleet selection	x (0%) n: 3	0.22 (81%) n: 21	0.061 (23%) n: 27	0.11 (21%) n: 39	0.091 (76%) n: 58	0.017 (78%) n: 107	0.12 (100%) n: 26	0.002 (1%) n: 34

Table C.49: **Summary of the South Taranaki SFL BT-MIX 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 flatfish. Catch and effort data for years with less than three vessels are omitted (indicated by x).**

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	1	x	42	x	x	92.86
2009	2	x	30	x	x	90.00
2010	5	12	36	131.58	0.32	36.11
2011	5	14	45	153.68	0.86	51.11
2012	6	14	56	193.25	1.12	67.86
2013	5	11	22	72.50	0.06	18.18
2014	4	10	47	167.55	6.03	63.83
2015	5	16	39	143.87	2.04	82.05
2016	4	11	19	59.58	0.36	36.84
2017	1	x	3	x	x	0.00
2018	4	11	21	71.53	0.22	42.86
2019	4	8	27	91.82	0.06	25.93
2020	3	9	39	152.65	0.11	7.69
2021	4	14	58	225.48	0.09	12.07
2022	6	21	107	407.80	0.02	2.80
2023	6	13	26	77.97	0.12	23.08
2024	3	5	34	122.25	0.00	5.88

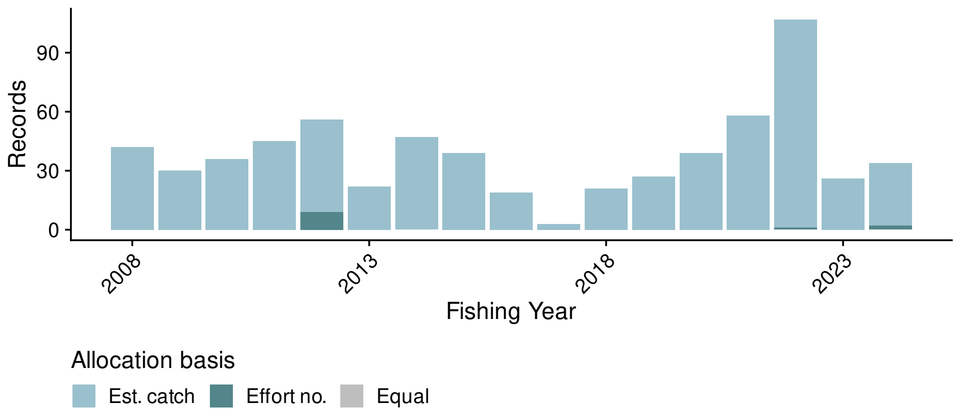

Figure C.168: **The allocation approach used for attributing catches to records in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).**

Table C.50: **Summary table for occurrence of positive catch in the South Taranaki SFL BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.**

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	869.13	0.00	0.00	*
fyear	16	593.12	35.52	35.52	*
vessel_key	5	562.07	40.25	4.73	*
month	11	516.89	48.00	7.75	*
target_species	1	464.61	54.26	6.26	*
ns(log(fishing_duration), 3)	3	468.22	54.54	0.28	*
ns(bottom_depth, 3)	3	454.58	56.80	2.27	*

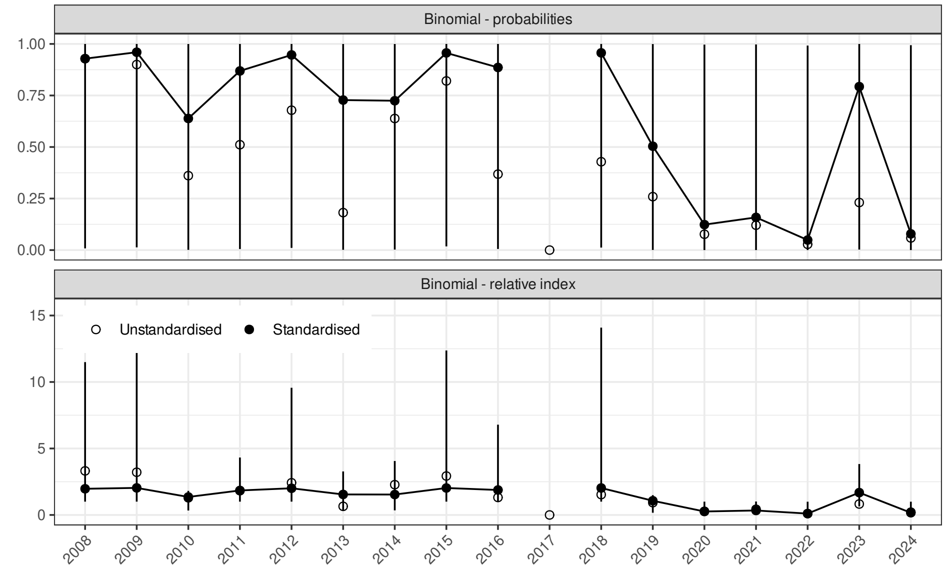

Figure C.169: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the South Taranaki SFL BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

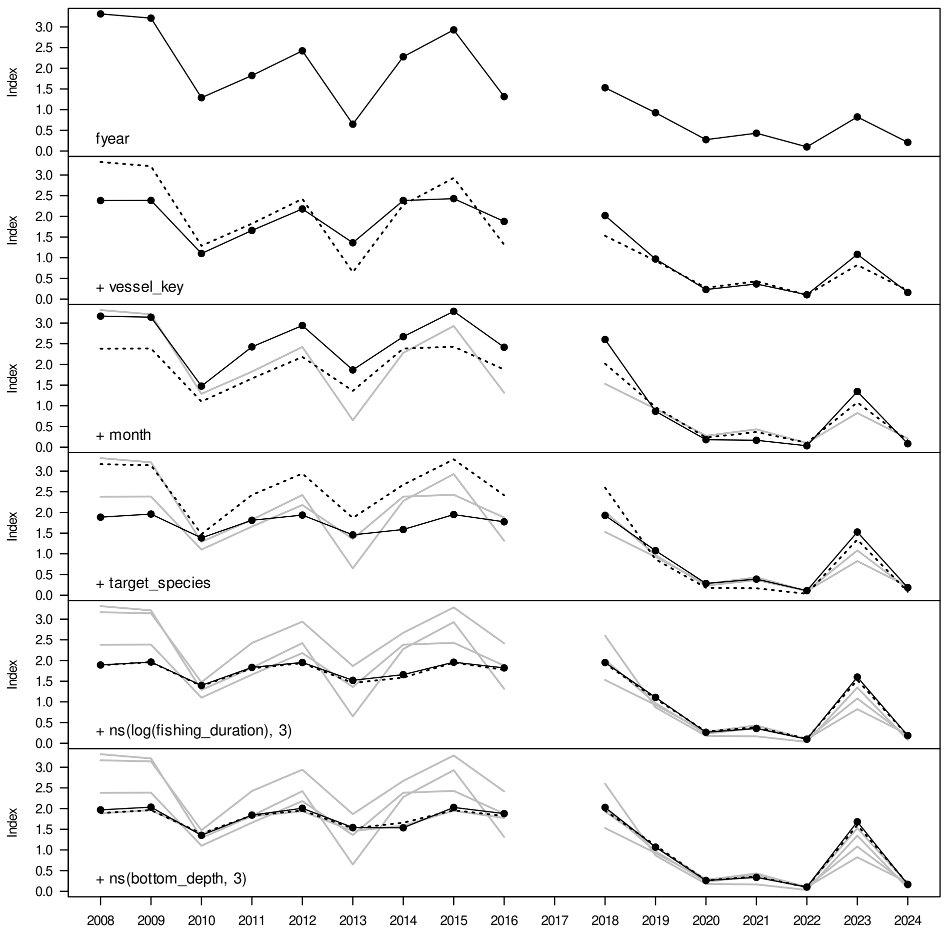

Figure C.170: Step plot for occurrence of catch in the South Taranaki SFL BT-MIX event dataset.

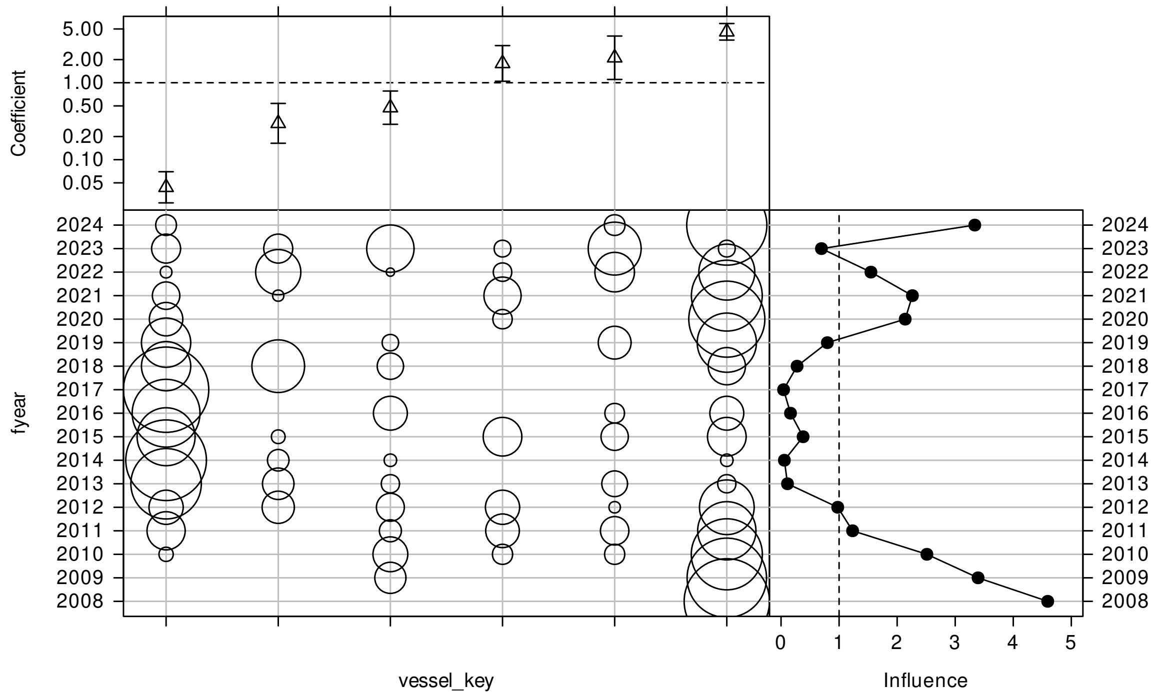

Figure C.171: CDI plot for vessel key for the occurrence of positive catch in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

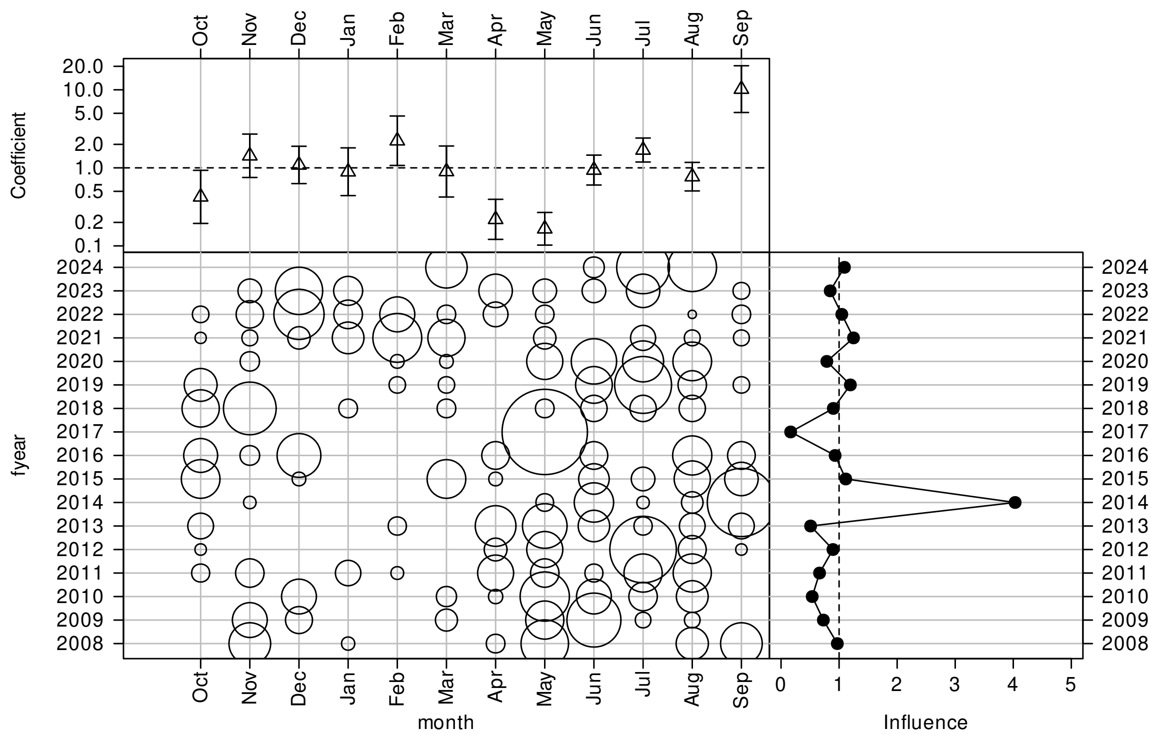

Figure C.172: CDI plot for month for the occurrence of positive catch in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

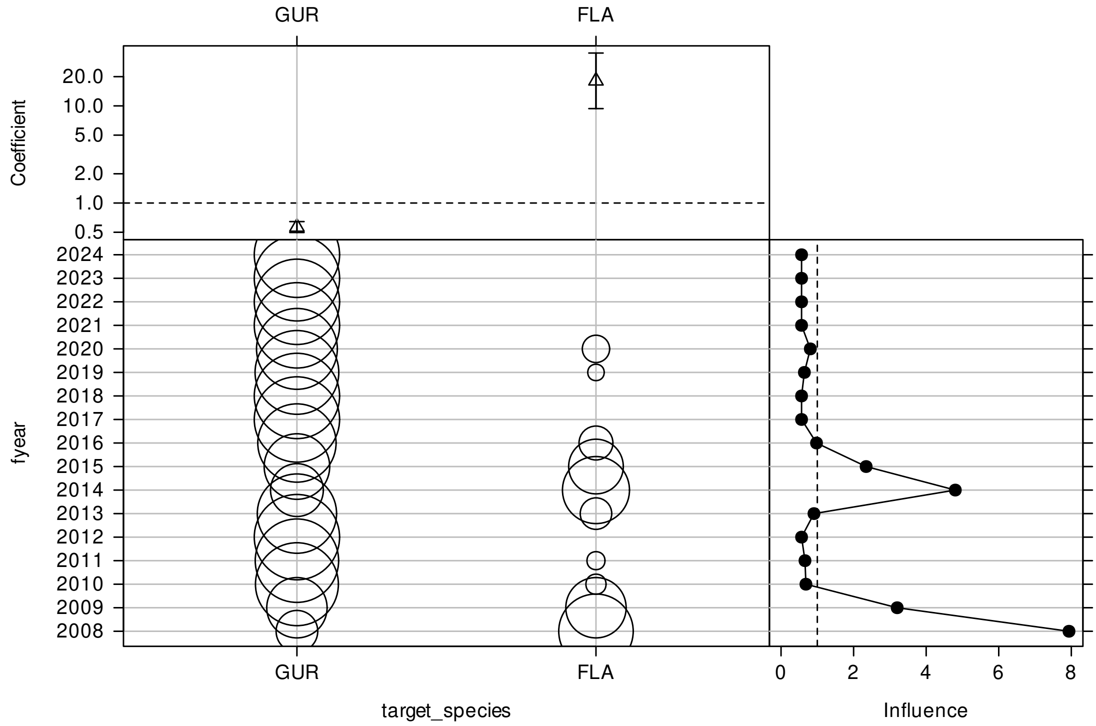

Figure C.173: CDI plot for target species for the occurrence of positive catch in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

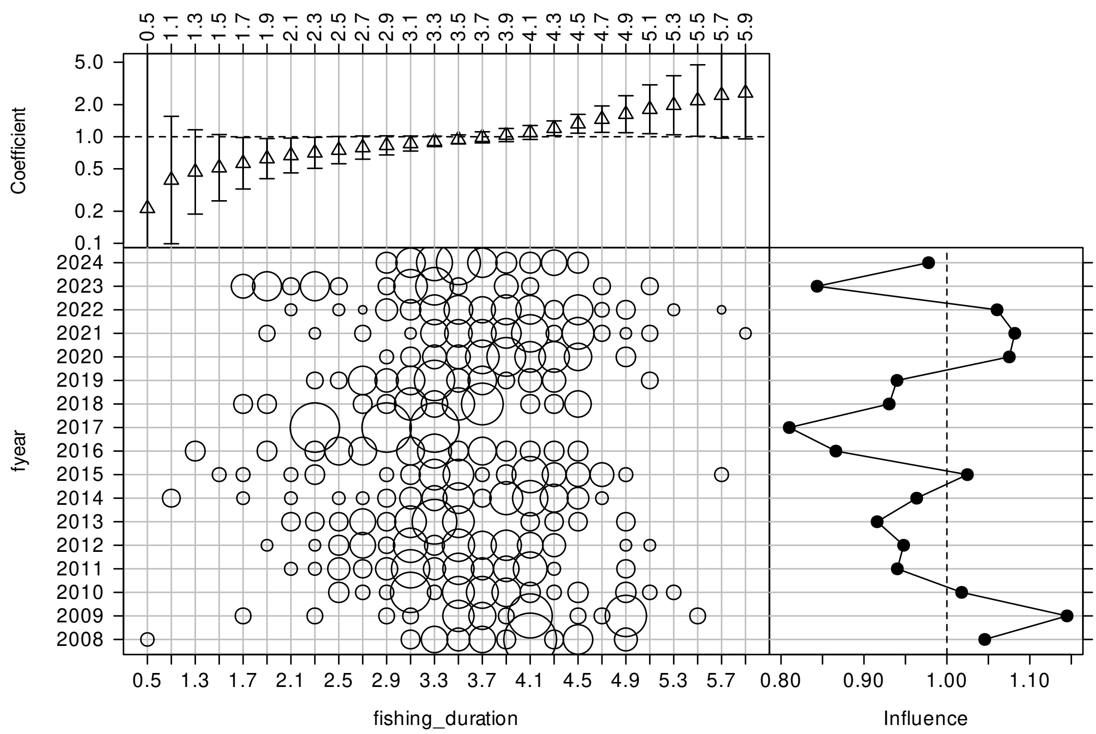

Figure C.174: CDI plot for fishing duration (h) for the occurrence of positive catch in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

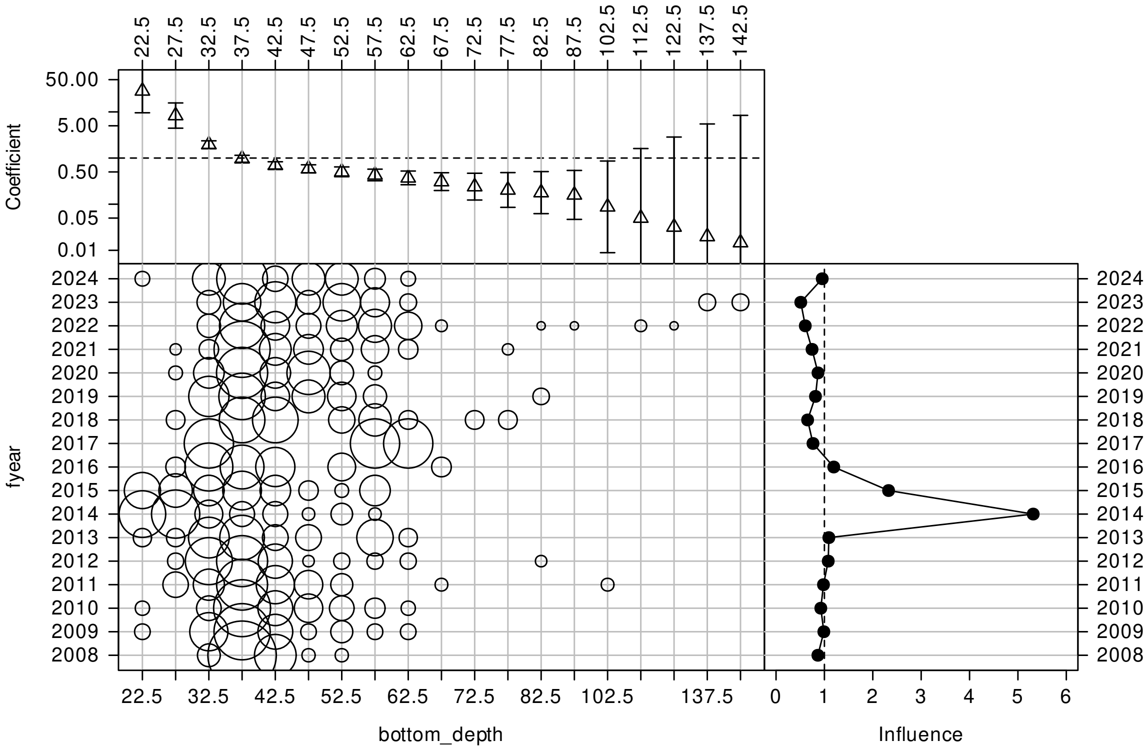

Figure C.175: CDI plot for bottom depth (m) for the occurrence of positive catch in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

Table C.51: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	962.06	0.00	0.00	*
fyear	15	864.04	40.08	40.08	*
vessel_key	5	806.85	54.20	14.12	*
month	11	783.73	61.76	7.56	*
target_species	1	782.51	62.25	0.49	*
ns(log(fishing_duration), 3)	3	776.83	63.97	1.72	*
ns(bottom_depth, 3)	3	771.26	65.60	1.63	*

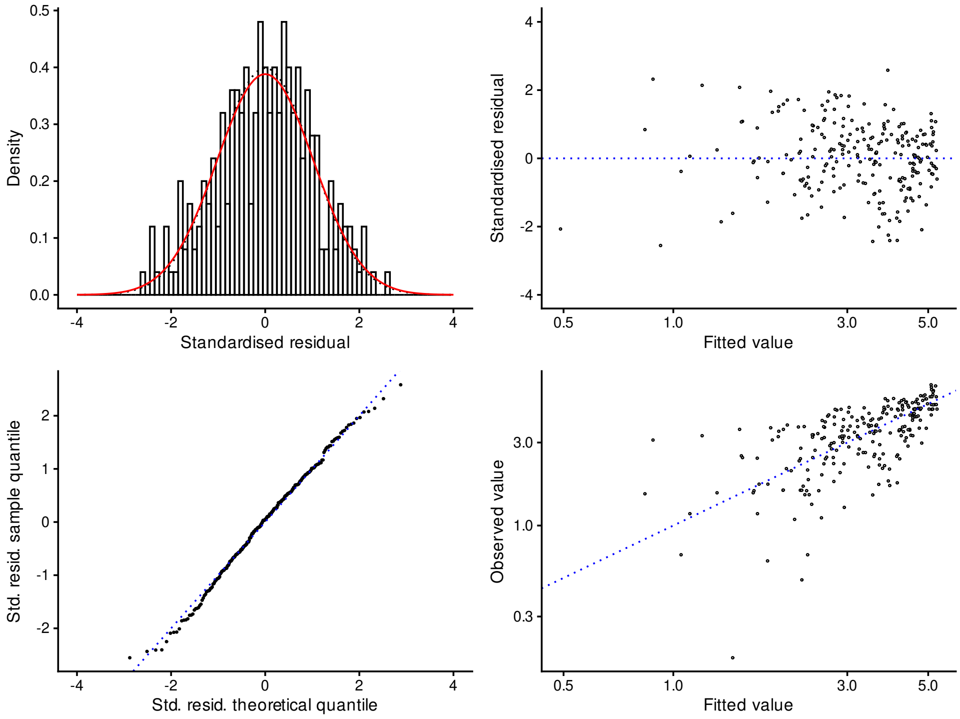

Figure C.176: Diagnostic plots for the selected lognormal model for positive catches in the South Taranaki SFL BT-MIX event dataset.

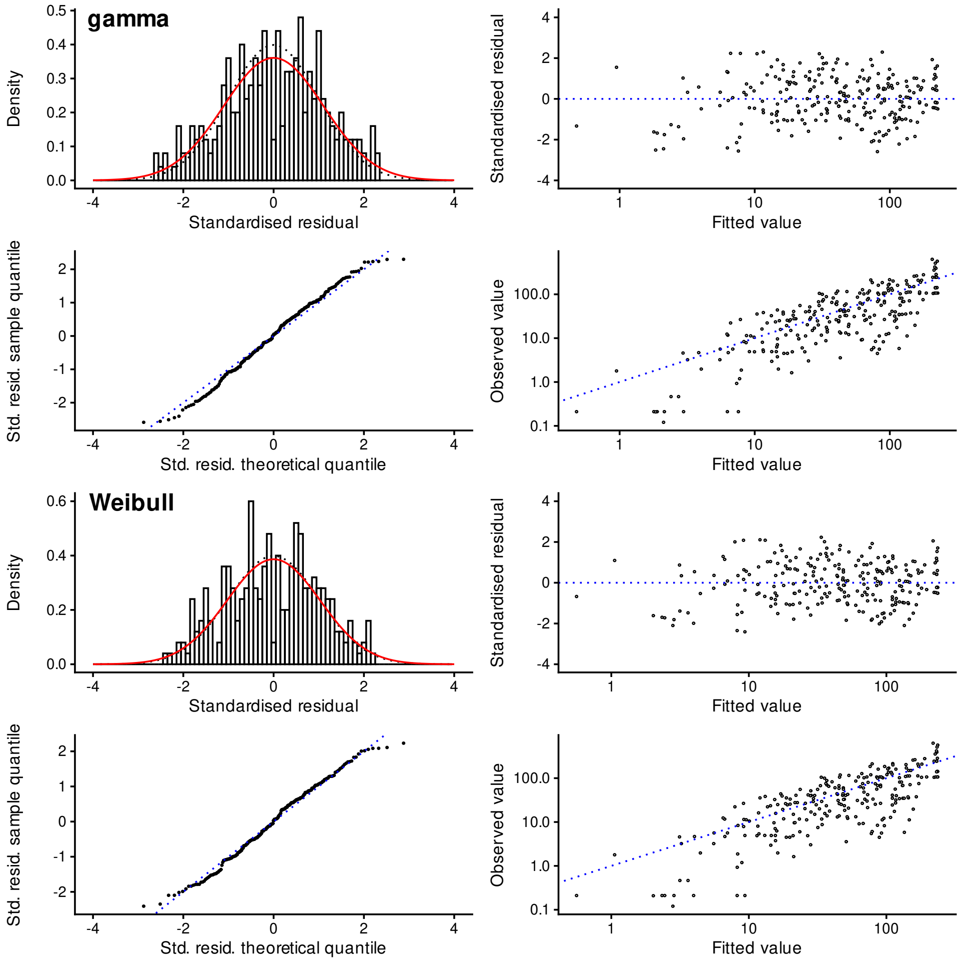

Figure C.177: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the South Taranaki SFL BT-MIX event dataset.

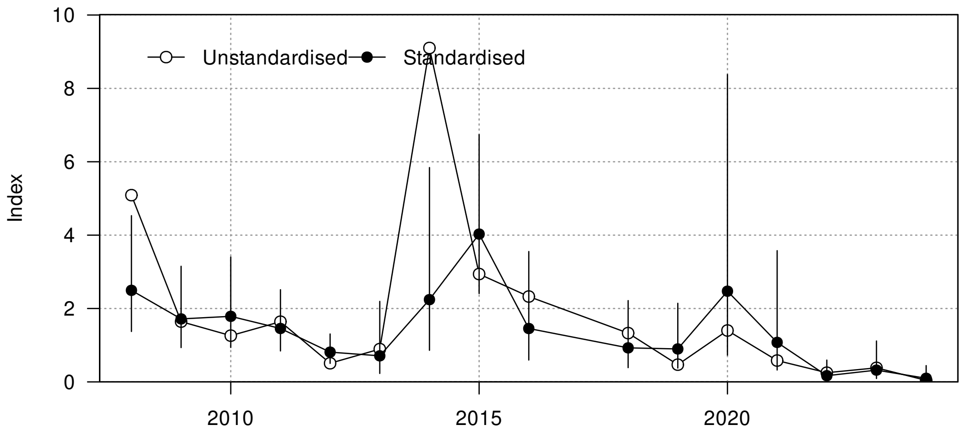

Figure C.178: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the South Taranaki SFL BT-MIX event dataset.

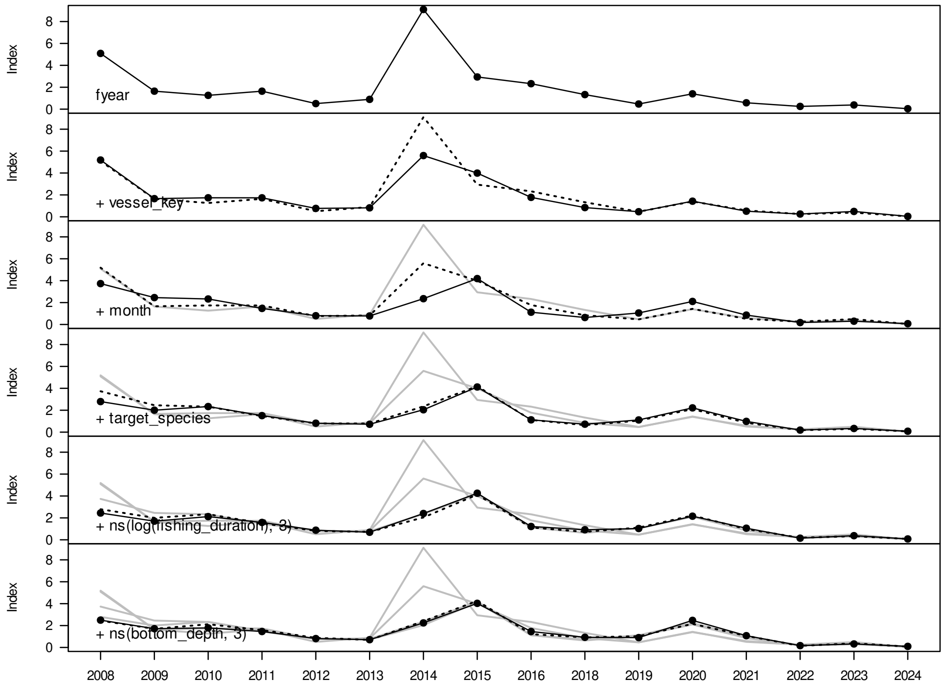

Figure C.179: Changes to the South Taranaki SFL BT-MIX event positive catch index as terms are successively entered into the lognormal model.

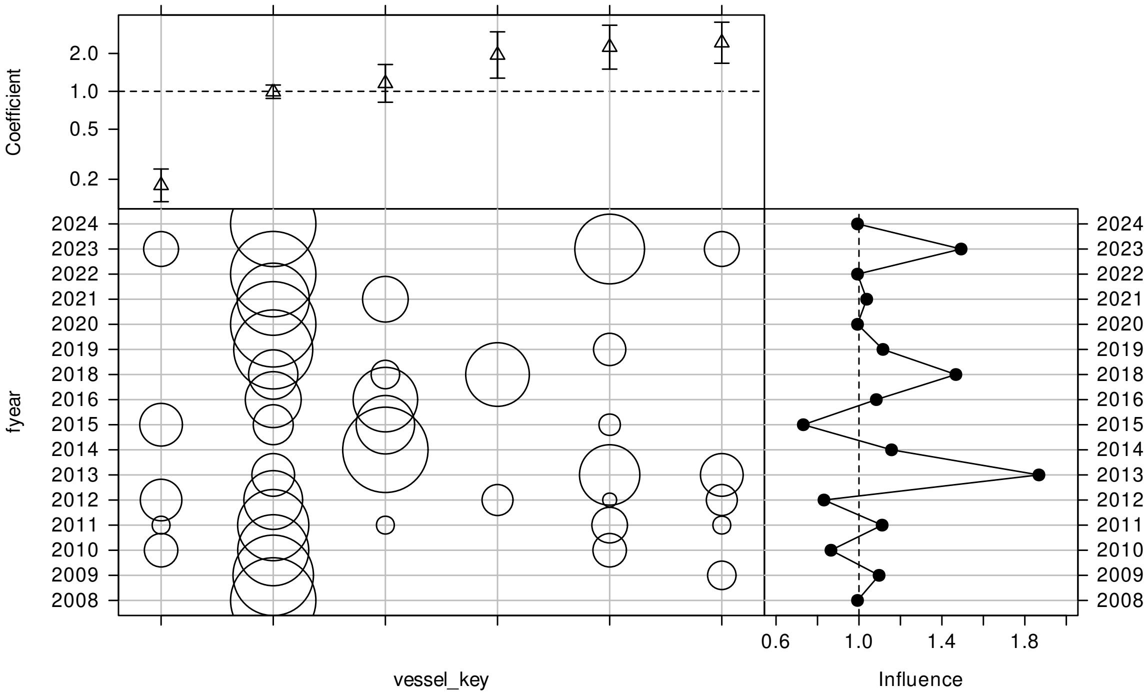

Figure C.180: CDI plot for vessel key for the lognormal model of positive catches in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

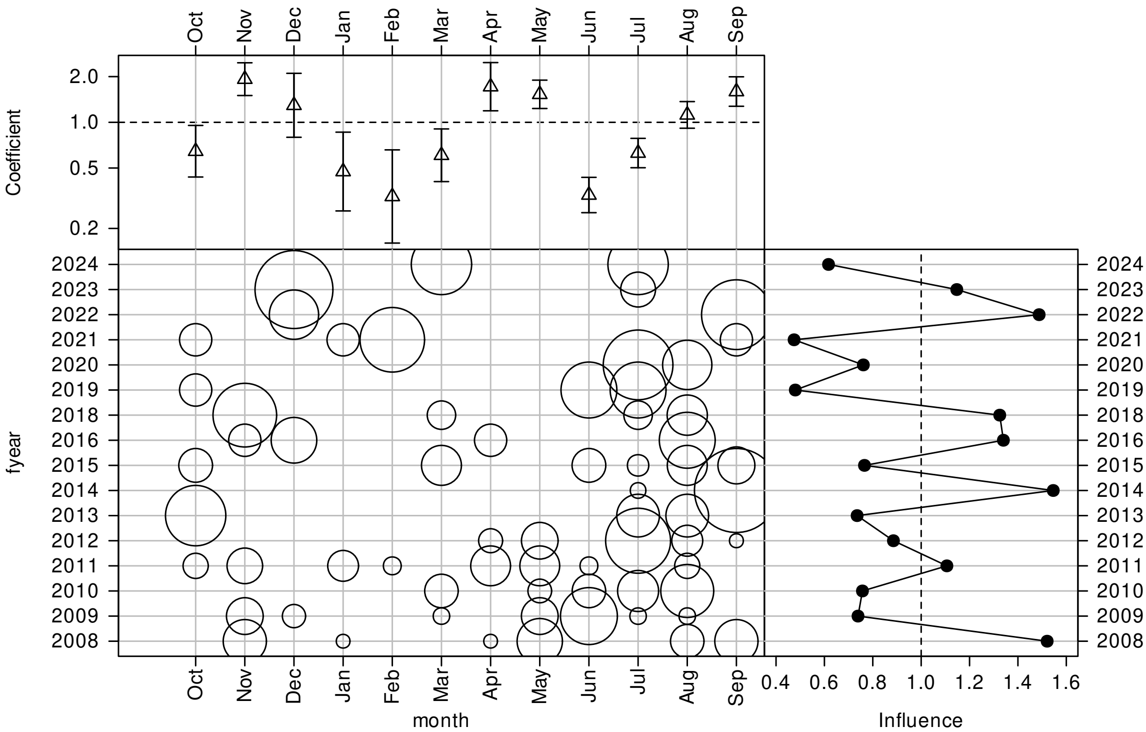

Figure C.181: CDI plot for month for the lognormal model of positive catches in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

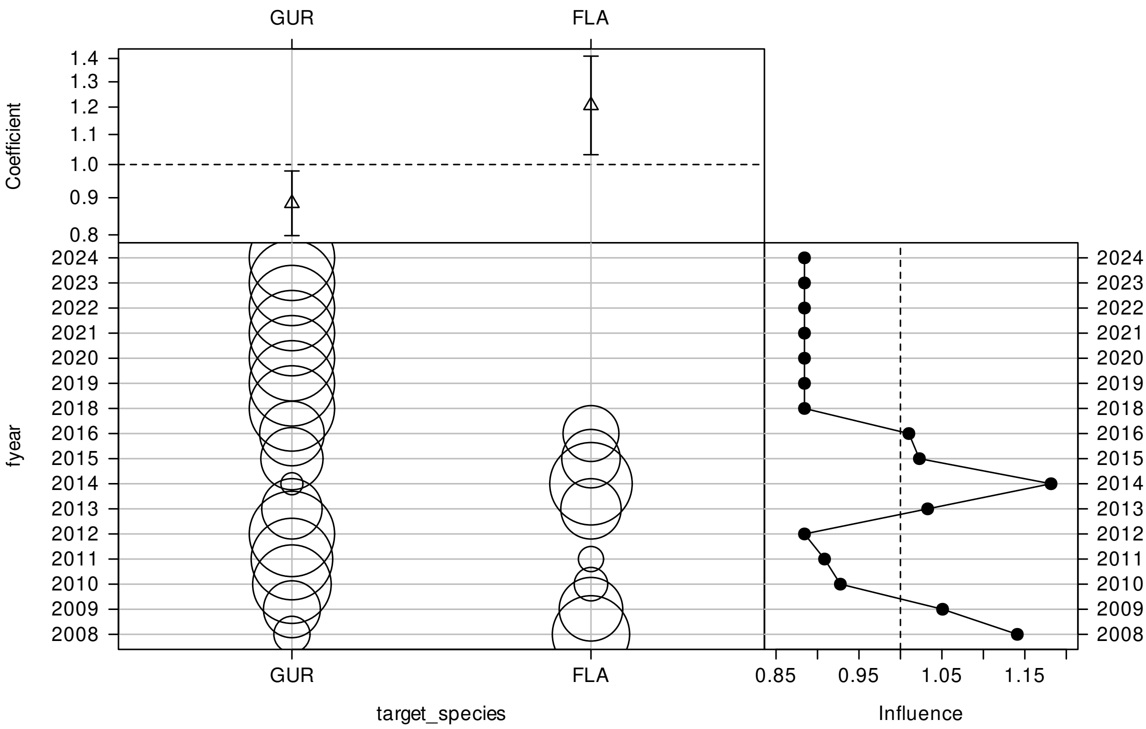

Figure C.182: CDI plot for target species for the lognormal model of positive catches in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

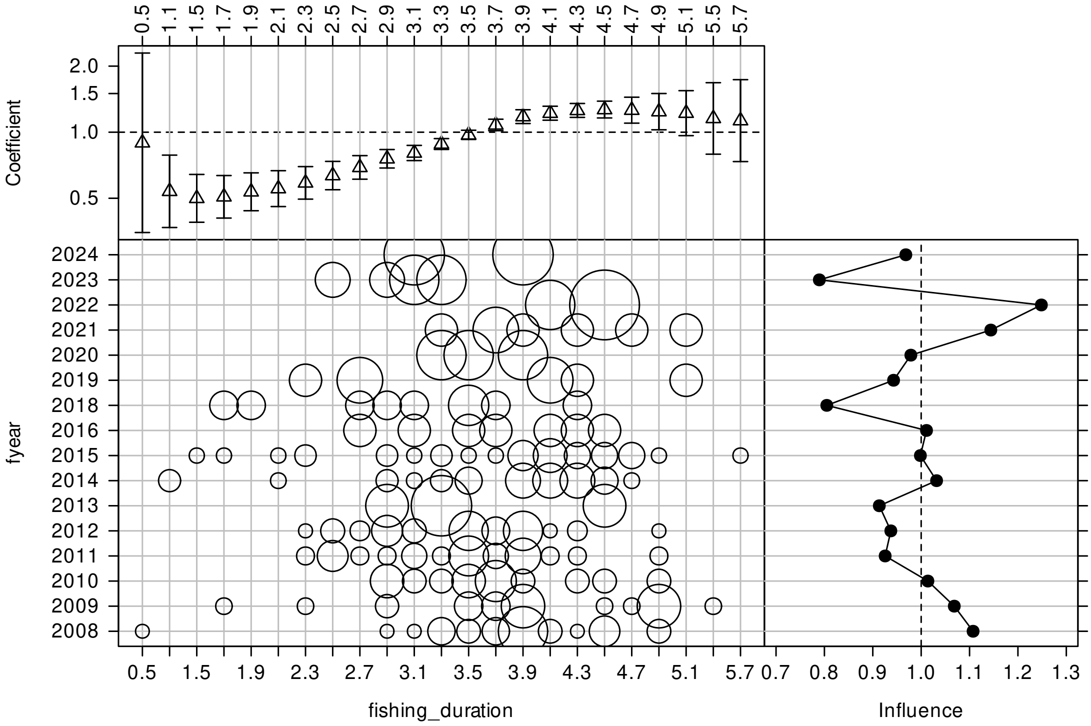

Figure C.183: CDI plot for fishing duration (h) for the lognormal model of positive catches in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

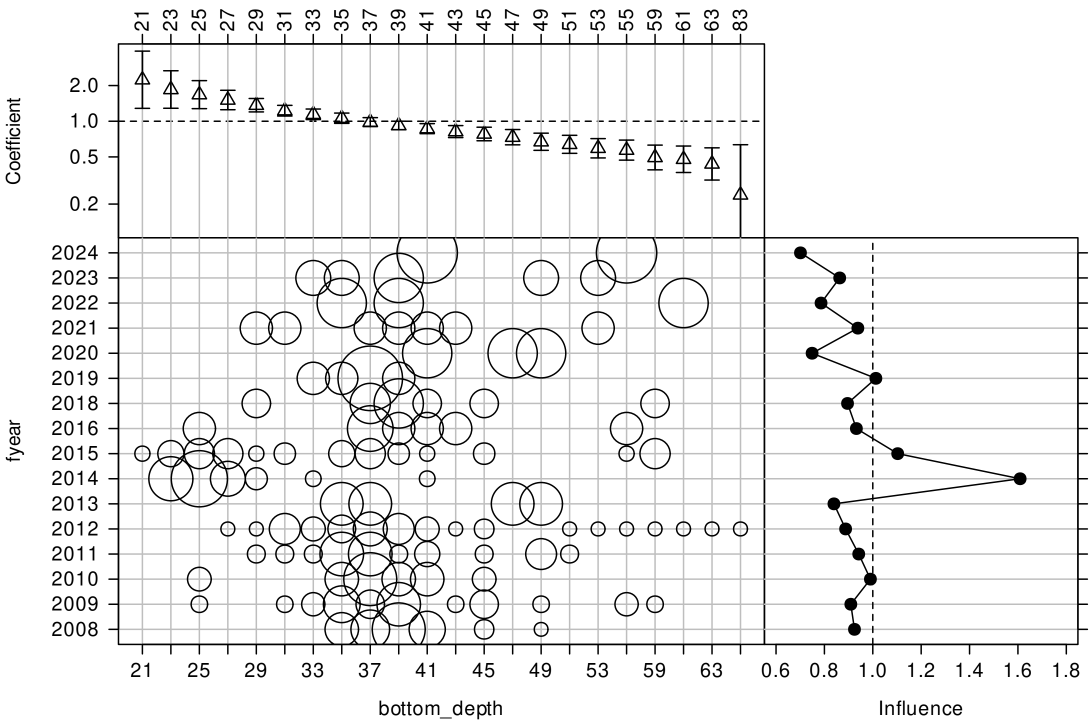

Figure C.184: CDI plot for bottom depth (m) for the lognormal model of positive catches in the South Taranaki SFL BT-MIX event catch-per-unit-effort dataset.

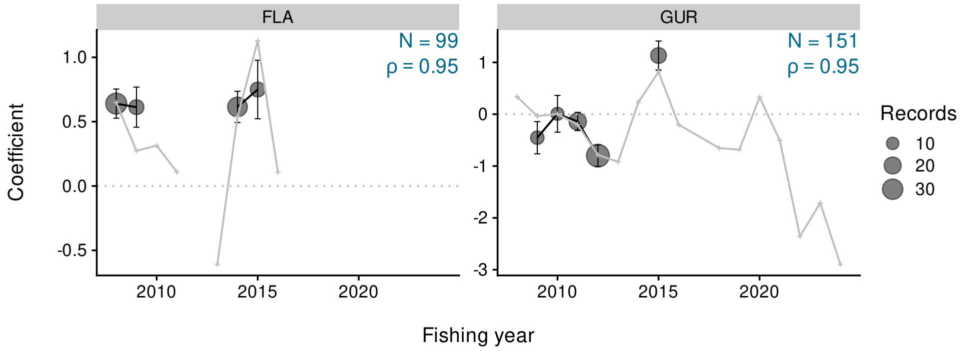

Figure C.185: Residual implied coefficients for target-year in the lognormal positive catch model for the South Taranaki SFL BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

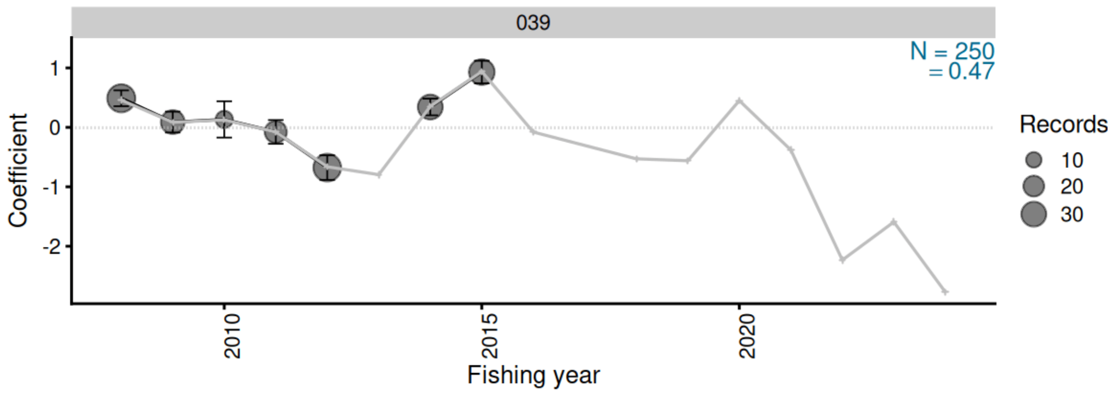

Figure C.186: Residual implied coefficients for area-year in the lognormal positive catch model for the South Taranaki SFL BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at 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.

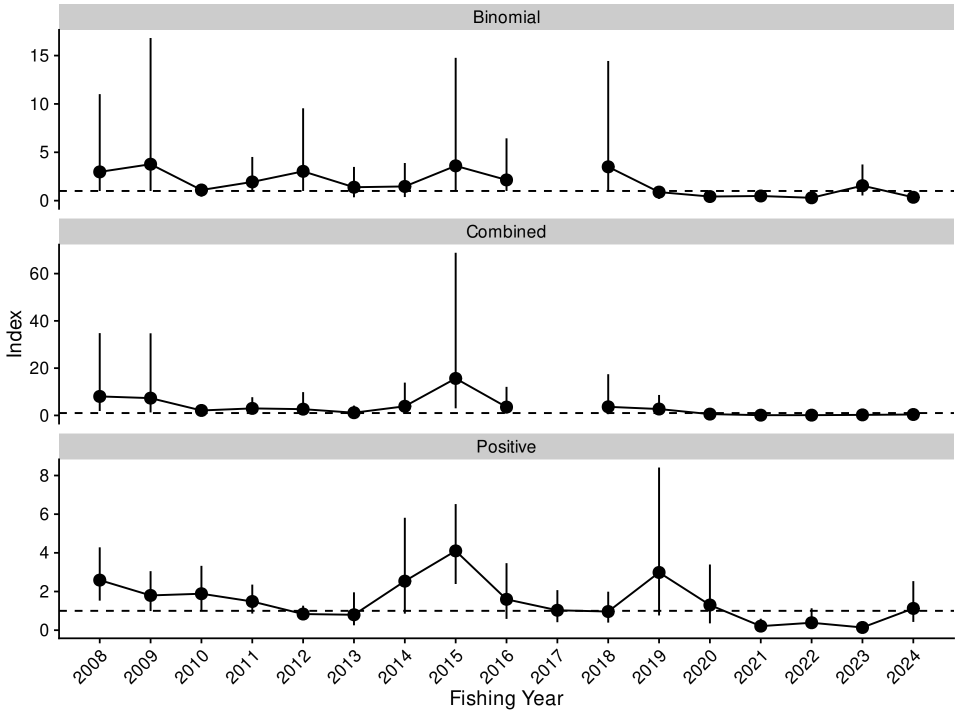

Figure C.187: Standardised indices and 95% confidence intervals for the South Taranaki SFL BT-MIX event dataset.

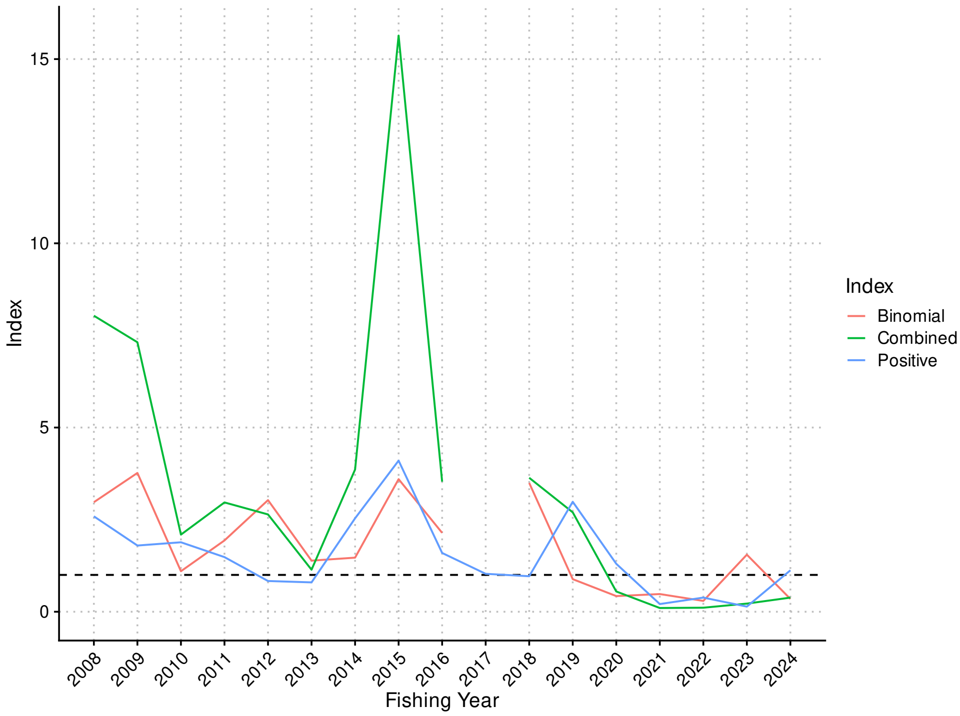

Figure C.188: Standardised indices for the South Taranaki SFL BT-MIX event dataset.

Table C.52: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the South Taranaki SFL BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	2.974	2.554	1.001	11.013	8.035	8.406	1.869	34.820	2.590	0.703	1.528	4.285
2009	3.767	4.035	1.001	16.818	7.315	8.543	1.256	34.744	1.797	0.526	0.989	3.052
2010	1.100	0.345	0.400	1.751	2.093	0.934	0.699	4.361	1.886	0.597	0.987	3.328
2011	1.935	0.897	1.000	4.517	2.967	1.693	1.070	7.708	1.483	0.383	0.857	2.358
2012	3.030	2.181	1.001	9.550	2.641	2.358	0.611	9.856	0.834	0.191	0.520	1.267
2013	1.387	0.801	0.347	3.488	1.141	1.011	0.194	4.157	0.797	0.435	0.251	1.958
2014	1.468	0.898	0.370	3.891	3.860	3.353	0.736	13.879	2.536	1.265	0.854	5.814
2015	3.599	3.512	1.001	14.767	15.639	16.791	3.001	68.822	4.101	1.055	2.388	6.523
2016	2.141	1.389	1.000	6.444	3.531	2.894	0.741	12.086	1.596	0.735	0.583	3.466
2017	-	-	-	-	-	-	-	-	1.030	0.423	0.412	2.072
2018	3.497	3.429	1.001	14.443	3.636	4.317	0.514	17.438	0.964	0.408	0.391	1.991
2019	0.885	0.324	0.175	1.444	2.698	2.117	0.359	8.656	2.985	1.952	0.761	8.413
2020	0.425	0.250	0.022	1.000	0.550	0.555	0.022	2.196	1.302	0.777	0.352	3.397
2021	0.481	0.250	0.031	1.012	0.102	0.110	0.005	0.437	0.209	0.139	0.051	0.594
2022	0.294	0.252	0.006	0.994	0.110	0.140	0.002	0.553	0.384	0.265	0.094	1.133
2023	1.549	0.818	0.533	3.742	0.221	0.217	0.026	0.878	0.140	0.108	0.024	0.446
2024	0.347	0.252	0.011	0.998	0.384	0.392	0.011	1.546	1.125	0.538	0.427	2.537

C.10 South Taranaki LSO BT-MIX event

This series was an attempt to see if the data for lemon sole (LSO) from the South Taranaki Bight were adequate for monitoring LSO in this region. This analysis used the same criteria to specify the LSO model (Table C.53) as was done for ESO and LSO in Hawke Bay. Unfortunately, the resulting model was deemed by the INSWG to be unreliable for consideration as a monitoring series for LSO in the South Taranaki Bight.

Table C.53: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the South Taranaki LSO BT-MIX event CPUE series.

Series	South Taranaki LSO BT-MIX event
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	039
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	2
Default model	LSO ~ fyear + vessel_key + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

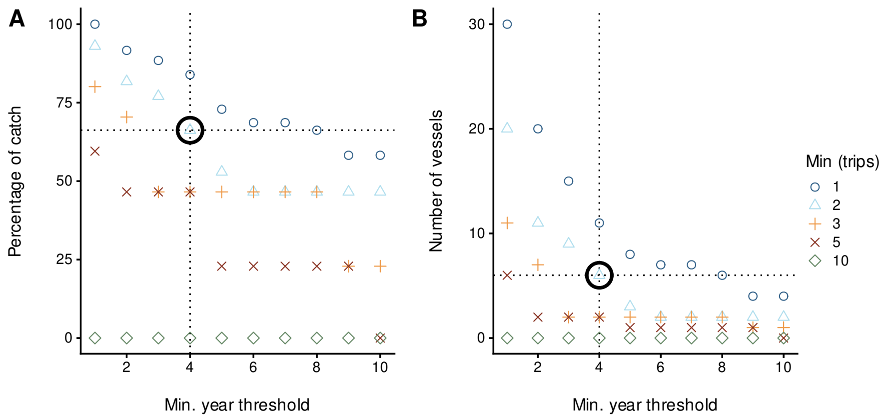

Figure C.189: Percentage of catch and number of vessels for different core vessel selection criteria for the South Taranaki LSO BT-MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

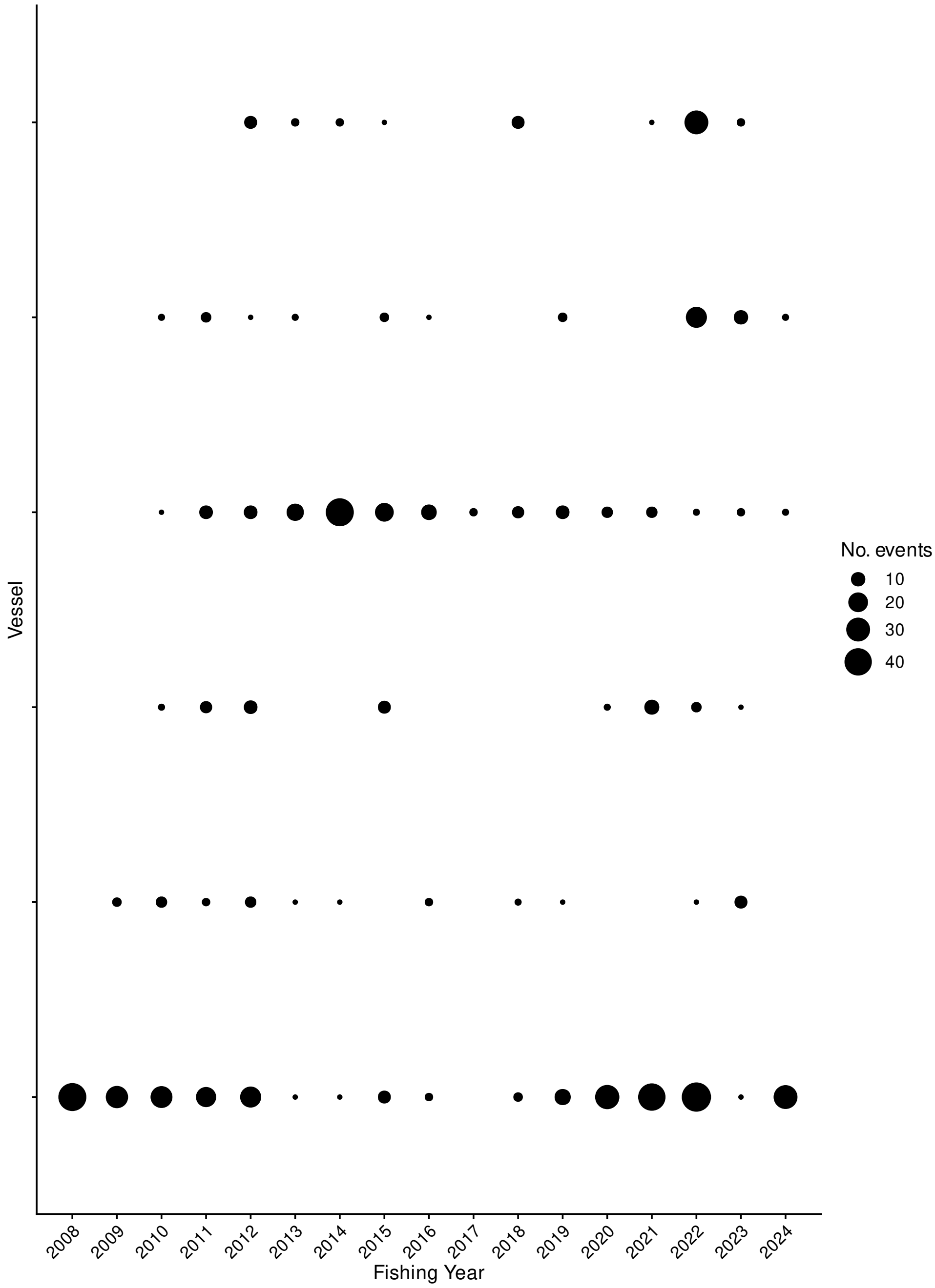

Figure C.190: Number of events by fishing year for core vessels in the South Taranaki LSO BT-MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.54: Summary of the South Taranaki LSO BT-MIX 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. Catch data for years with less than three vessels are omitted (indicated by x).

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	x (100%) n: 45	x (100%) n: 42	1.1 (100%) n: 52	1 (100%) n: 69	0.74 (100%) n: 62	1 (100%) n: 42	0.79 (100%) n: 59	1.4 (100%) n: 98	0.73 (100%) n: 30
Positive fishing duration	x (100%) n: 45	x (100%) n: 42	1.1 (100%) n: 52	1 (100%) n: 69	0.74 (100%) n: 62	1 (100%) n: 42	0.79 (100%) n: 59	1.4 (100%) n: 98	0.73 (100%) n: 30
Fishing duration less than 6 h	x (100%) n: 45	x (100%) n: 42	1.1 (100%) n: 52	1 (100%) n: 69	0.74 (100%) n: 62	1 (100%) n: 42	0.79 (100%) n: 59	1.4 (100%) n: 98	0.73 (100%) n: 30
Bottom depth < 150m	x (100%) n: 45	x (100%) n: 42	1.1 (100%) n: 52	1 (100%) n: 69	0.74 (100%) n: 62	1 (100%) n: 42	0.79 (100%) n: 59	1.4 (100%) n: 98	0.73 (100%) n: 30
Core fleet selection	x (59%) n: 42	x (45%) n: 30	0.84 (80%) n: 36	0.64 (63%) n: 45	0.6 (81%) n: 56	0.63 (61%) n: 22	0.75 (95%) n: 47	0.81 (60%) n: 39	0.47 (65%) n: 19

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	x (100%) n: 12	0.92 (100%) n: 30	1.2 (100%) n: 53	1.5 (100%) n: 109	1.1 (100%) n: 85	0.81 (100%) n: 123	0.13 (100%) n: 29	0.65 (100%) n: 139
Positive fishing duration	x (100%) n: 12	0.92 (100%) n: 30	1.2 (100%) n: 53	1.5 (100%) n: 109	1.1 (100%) n: 85	0.81 (100%) n: 123	0.13 (100%) n: 29	0.65 (100%) n: 139
Fishing duration less than 6 h	x (100%) n: 12	0.92 (100%) n: 30	1.2 (100%) n: 53	1.5 (100%) n: 108	1.1 (100%) n: 84	0.81 (100%) n: 123	0.13 (100%) n: 29	0.65 (100%) n: 139
Bottom depth < 150m	x (100%) n: 12	0.92 (100%) n: 30	1.2 (100%) n: 53	1.5 (100%) n: 108	1.1 (100%) n: 84	0.81 (100%) n: 122	0.13 (100%) n: 29	0.65 (100%) n: 139
Core fleet selection	x (43%) n: 3	0.62 (67%) n: 21	1 (89%) n: 27	0.96 (65%) n: 39	0.64 (58%) n: 58	0.6 (74%) n: 107	0.13 (100%) n: 26	0.11 (17%) n: 34

Table C.55: **Summary of the South Taranaki LSO BT-MIX 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 flatfish. Catch and effort data for years with less than three vessels are omitted (indicated by x).**

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	1	x	42	x	x	14.29
2009	2	x	30	x	x	66.67
2010	5	12	36	131.58	0.84	80.56
2011	5	14	45	153.68	0.64	66.67
2012	6	14	56	193.25	0.60	53.57
2013	5	11	22	72.50	0.63	95.45
2014	4	10	47	167.55	0.75	68.09
2015	5	16	39	143.87	0.81	53.85
2016	4	11	19	59.58	0.47	73.68
2017	1	x	3	x	x	100.00
2018	4	11	21	71.53	0.62	90.48
2019	4	8	27	91.82	1.05	59.26
2020	3	9	39	152.65	0.96	64.10
2021	4	14	58	225.48	0.64	55.17
2022	6	21	107	407.80	0.60	49.53
2023	6	13	26	77.97	0.13	80.77
2024	3	5	34	122.25	0.11	50.00

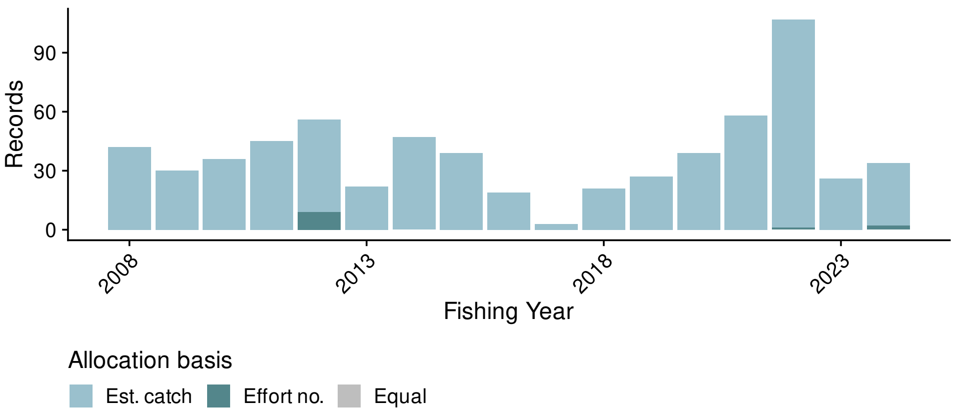

Figure C.191: **The allocation approach used for attributing catches to records in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).**

Table C.56: **Summary table for occurrence of positive catch in the South Taranaki LSO BT-MIX event series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.**

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	879.54	0.00	0.00	*
fyear	16	820.80	10.34	10.34	*
vessel_key	5	808.51	12.88	2.54	*
month	11	711.87	26.40	13.52	*
target_species	1	711.69	26.65	0.25	*
ns(log(fishing_duration), 3)	3	714.38	27.03	0.38	*
ns(bottom_depth, 3)	3	701.28	29.20	2.18	*

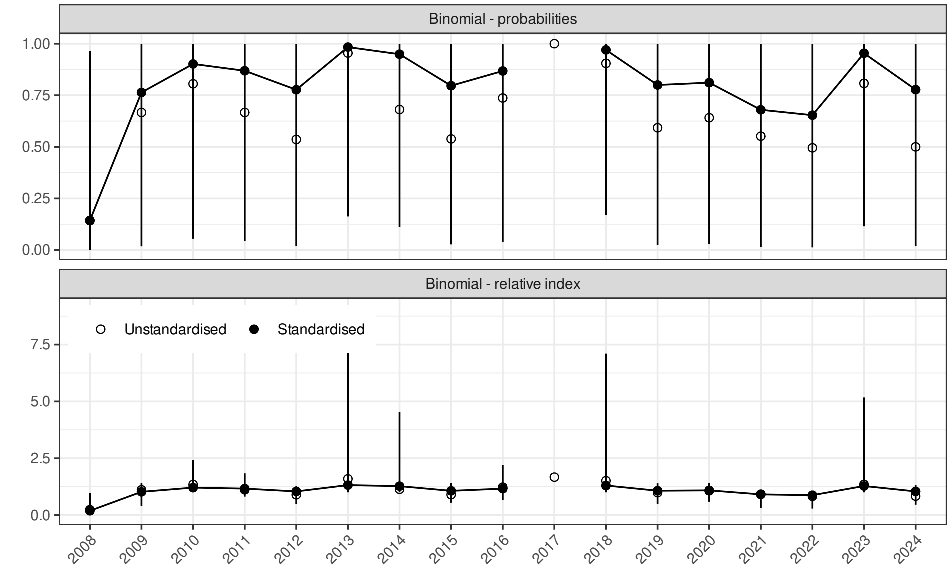

Figure C.192: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the South Taranaki LSO BT-MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

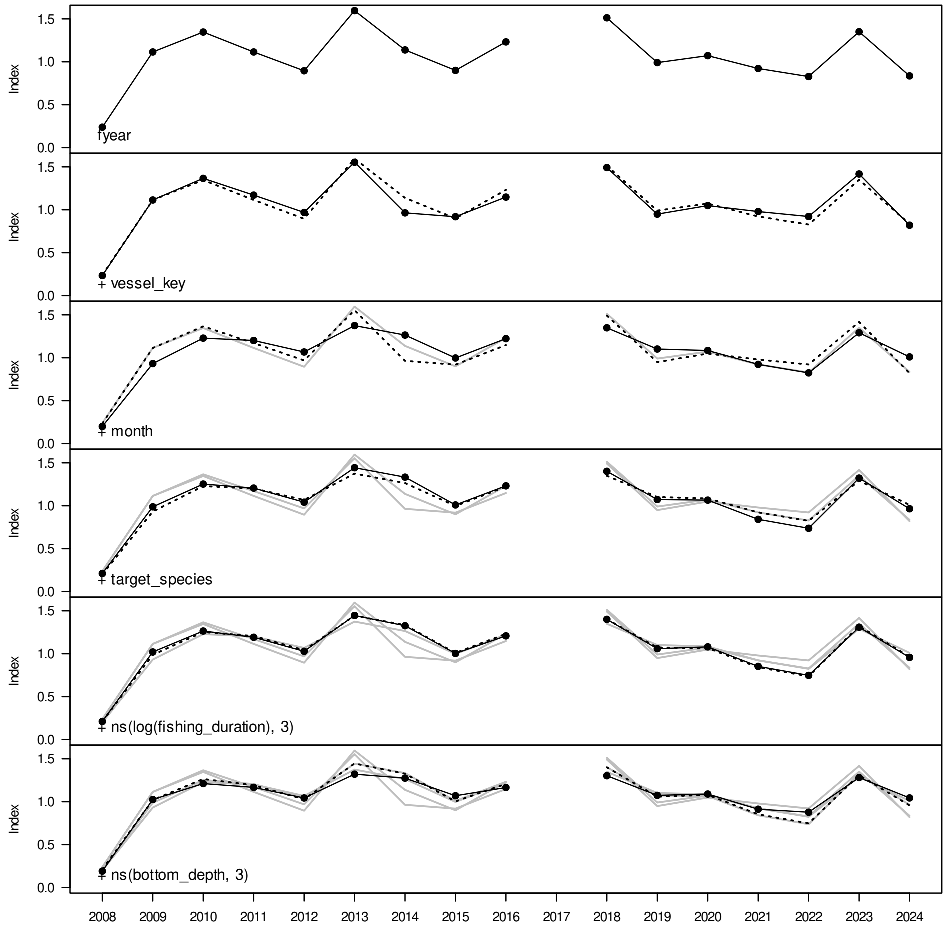

Figure C.193: Step plot for occurrence of catch in the South Taranaki LSO BT-MIX event dataset.

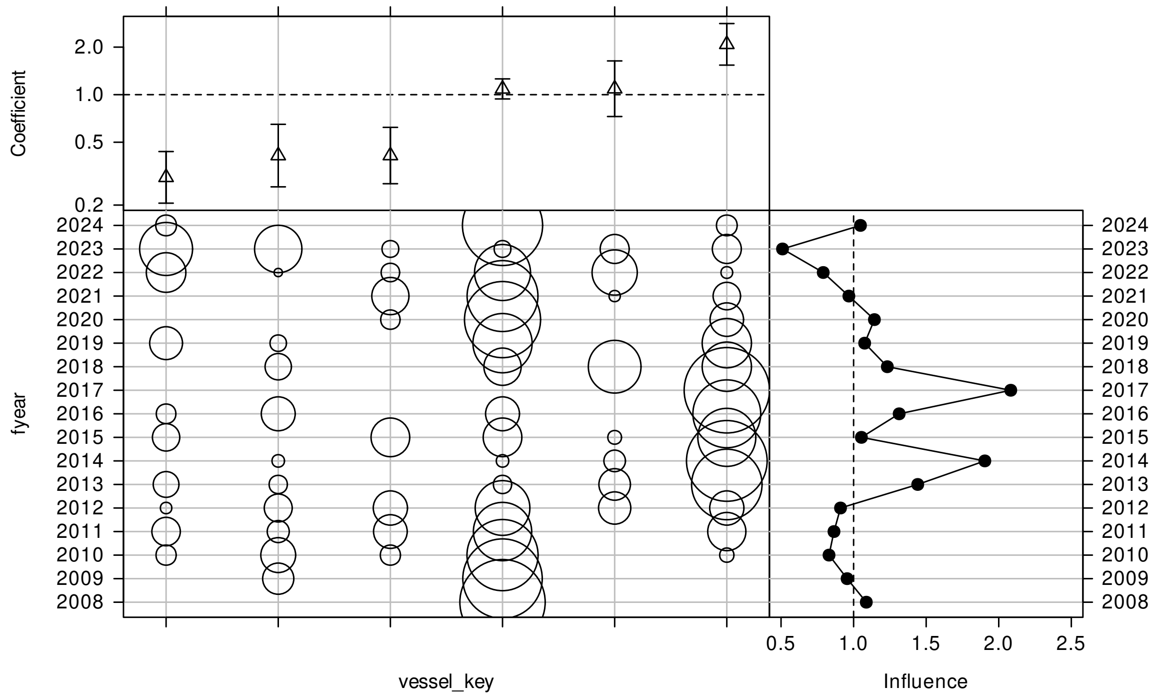

Figure C.194: CDI plot for vessel key for the occurrence of positive catch in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

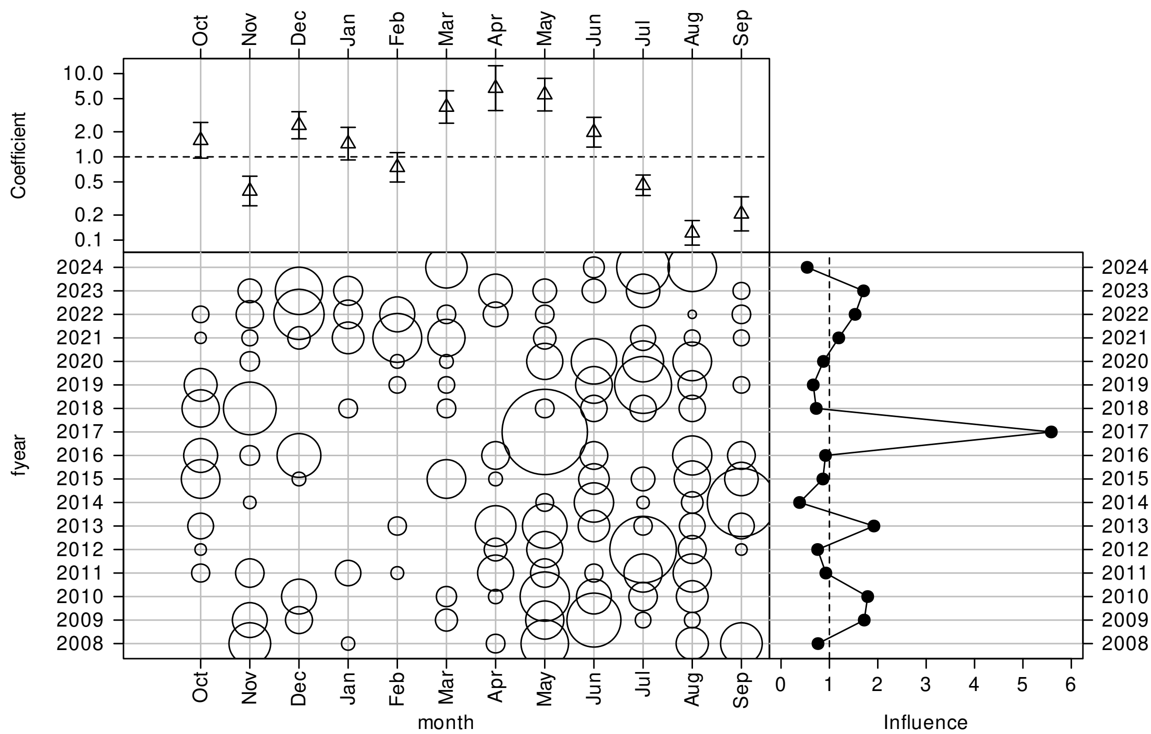

Figure C.195: CDI plot for month for the occurrence of positive catch in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

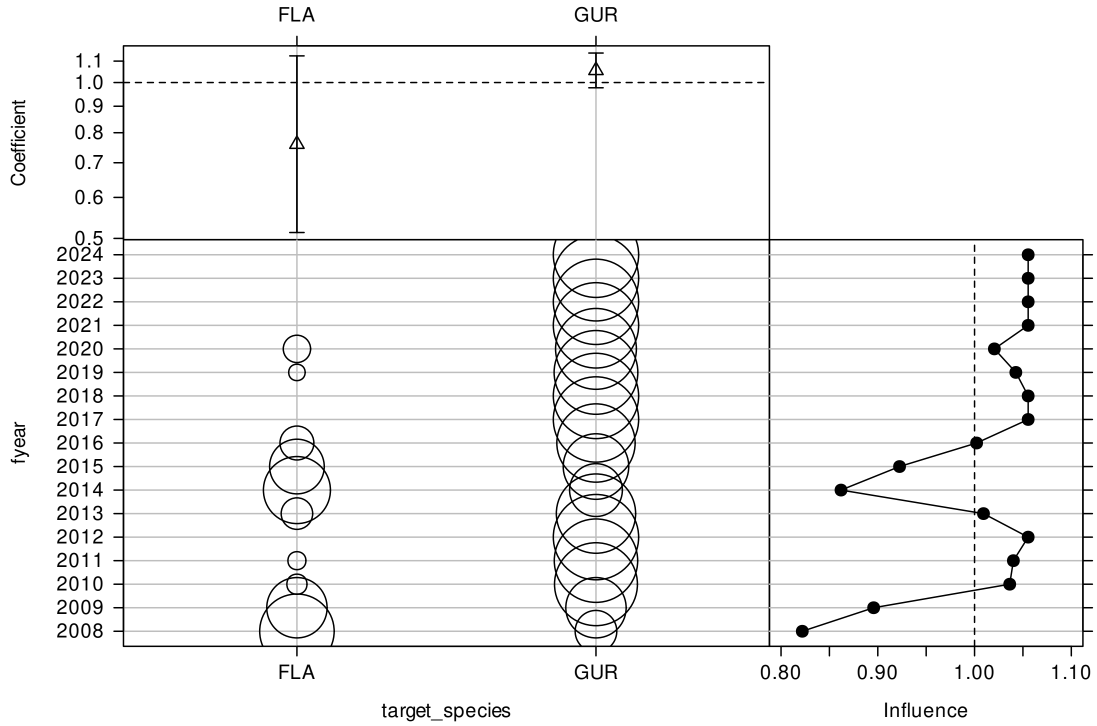

Figure C.196: CDI plot for target species for the occurrence of positive catch in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

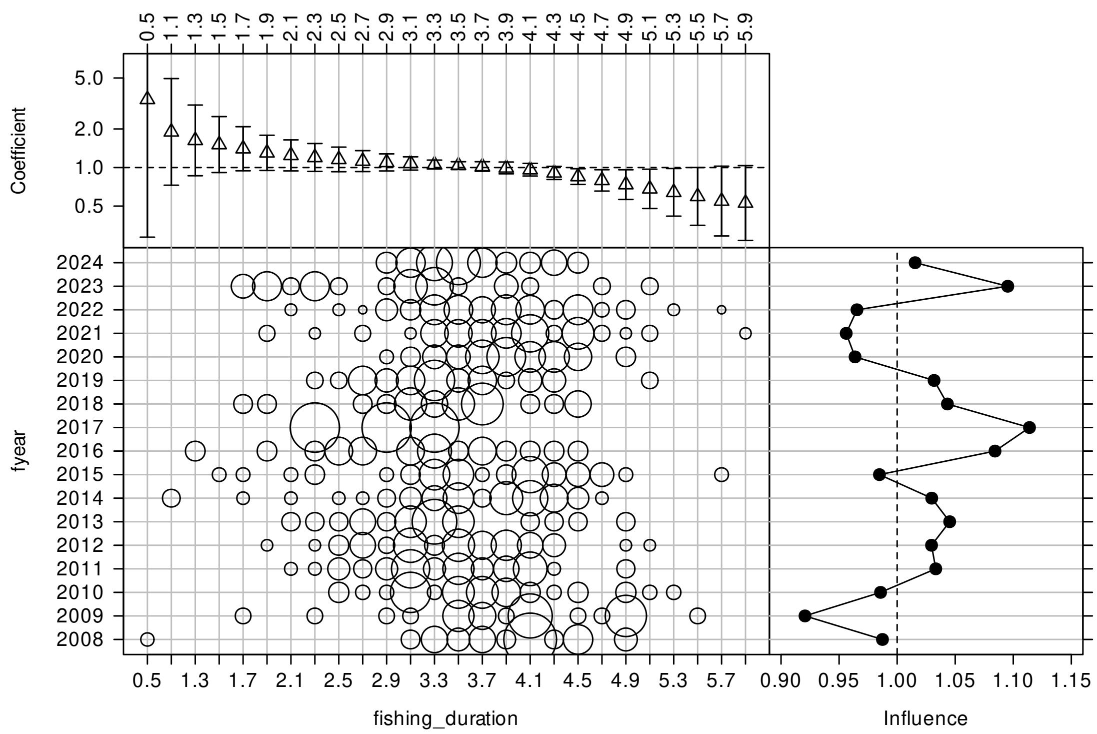

Figure C.197: CDI plot for fishing duration (h) for the occurrence of positive catch in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

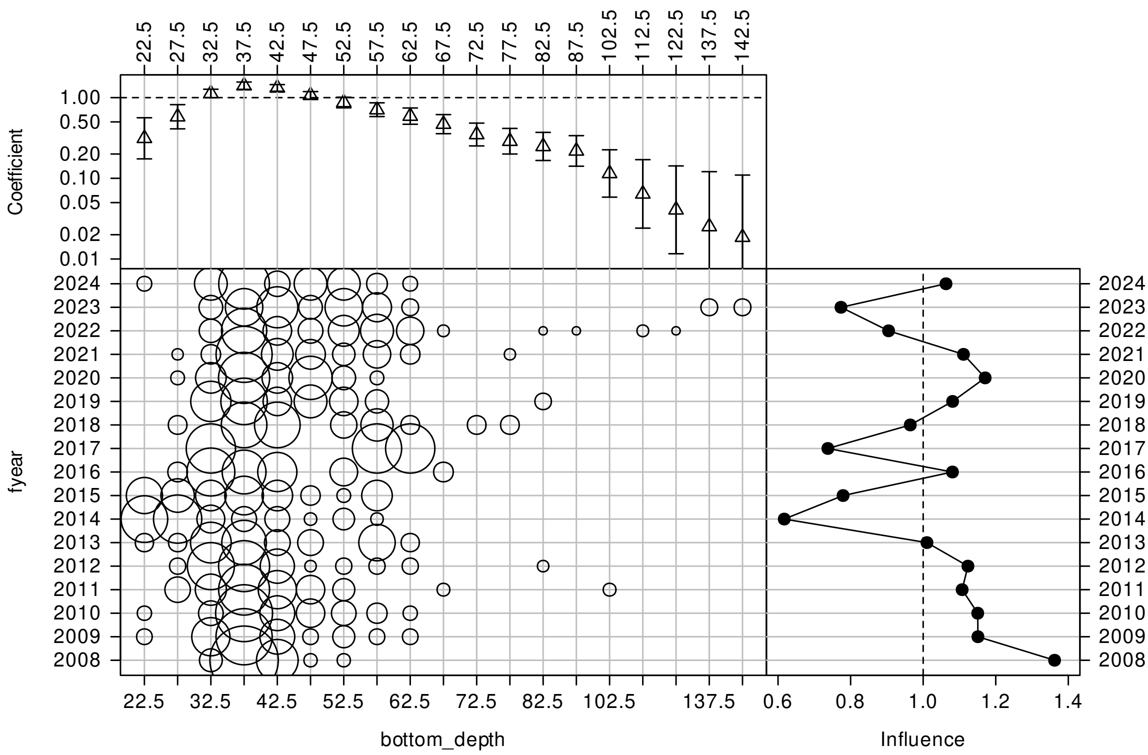

Figure C.198: CDI plot for bottom depth (m) for the occurrence of positive catch in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

Table C.57: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	1 300.71	0.00	0.00	*
fyear	16	1 146.32	38.07	38.07	*
vessel_key	5	1 134.54	41.44	3.37	*
month	11	1 089.09	50.76	9.32	*
target_species	1	1 090.96	50.78	0.02	*
ns(log(fishing_duration), 3)	3	1 088.64	51.82	1.04	*
ns(bottom_depth, 3)	3	1 081.57	53.41	1.59	*

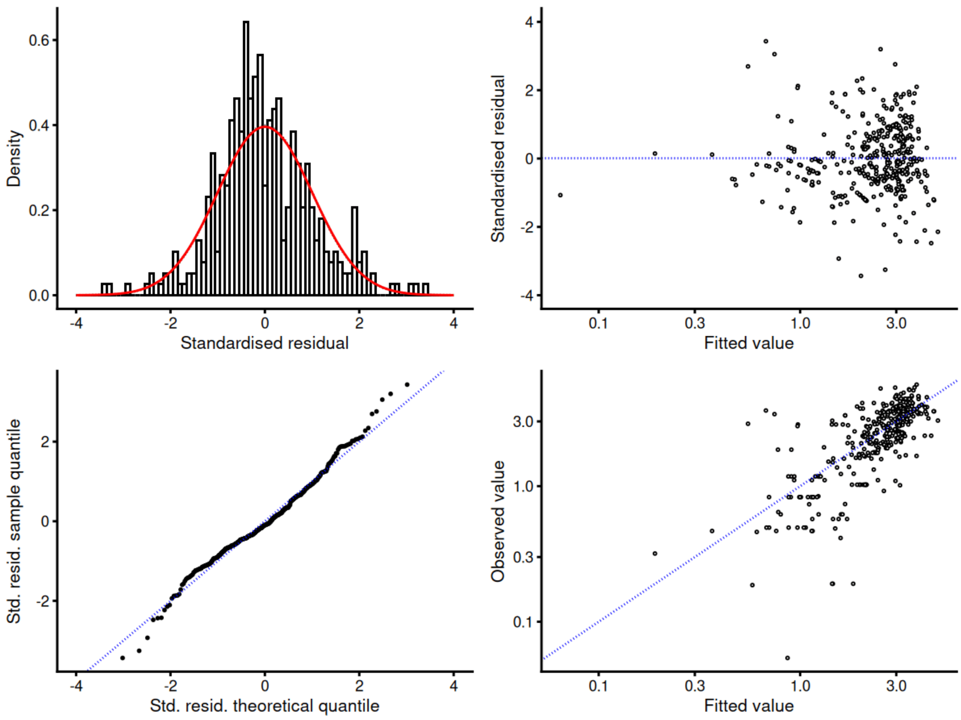

Figure C.199: Diagnostic plots for the selected lognormal model for positive catches in the South Taranaki LSO BT-MIX event dataset.

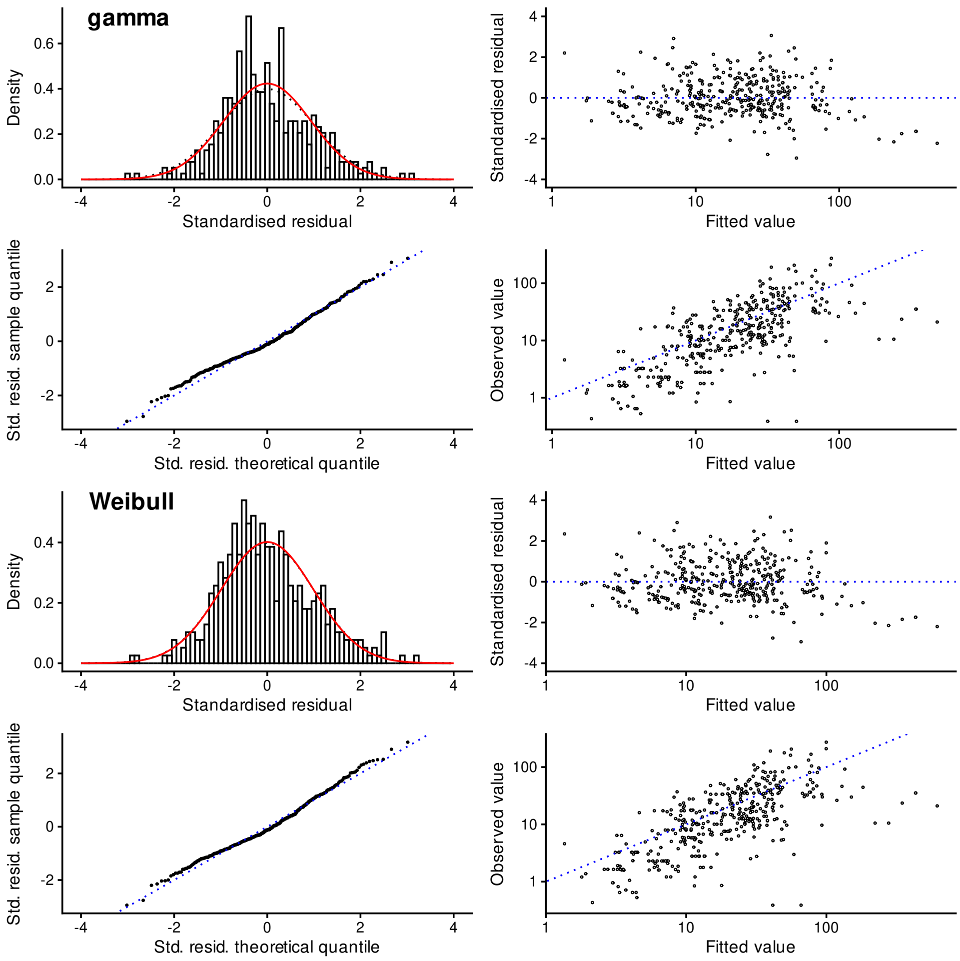

Figure C.200: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the South Taranaki LSO BT-MIX event dataset.

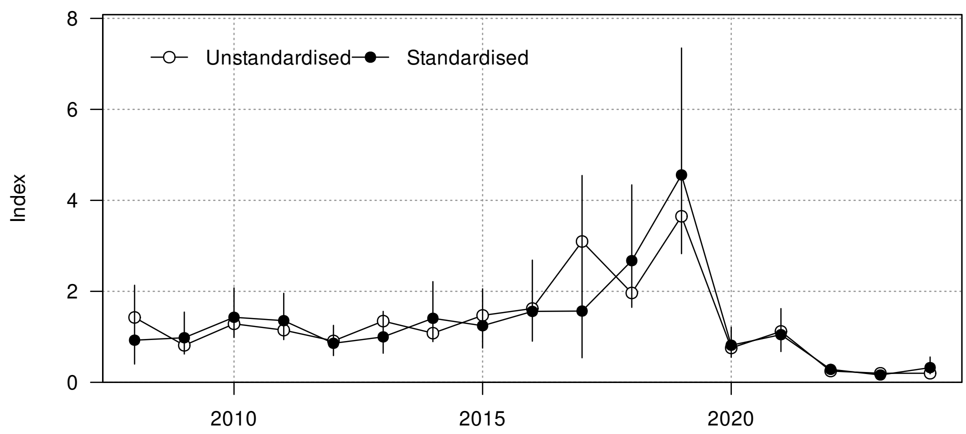

Figure C.201: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the South Taranaki LSO BT-MIX event dataset.

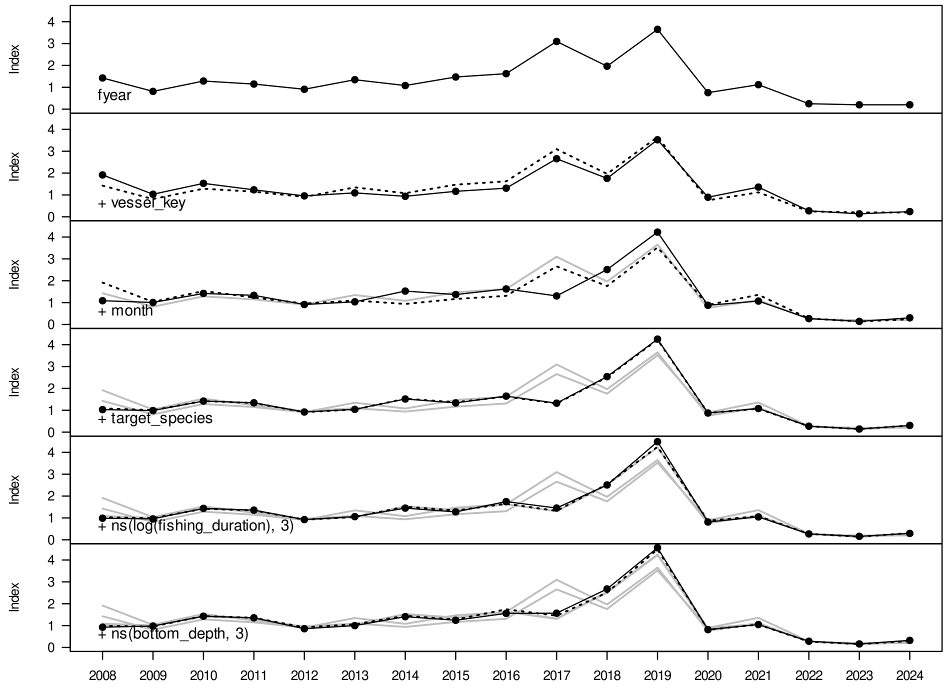

Figure C.202: Changes to the South Taranaki LSO BT-MIX event positive catch index as terms are successively entered into the lognormal model.

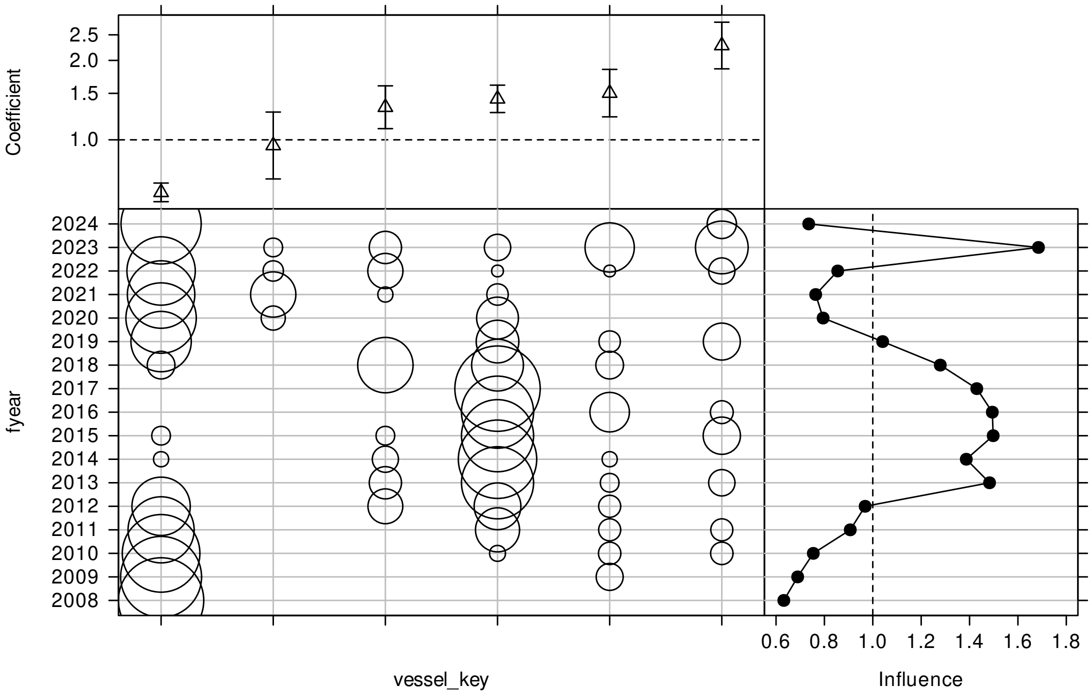

Figure C.203: CDI plot for vessel key for the lognormal model of positive catches in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

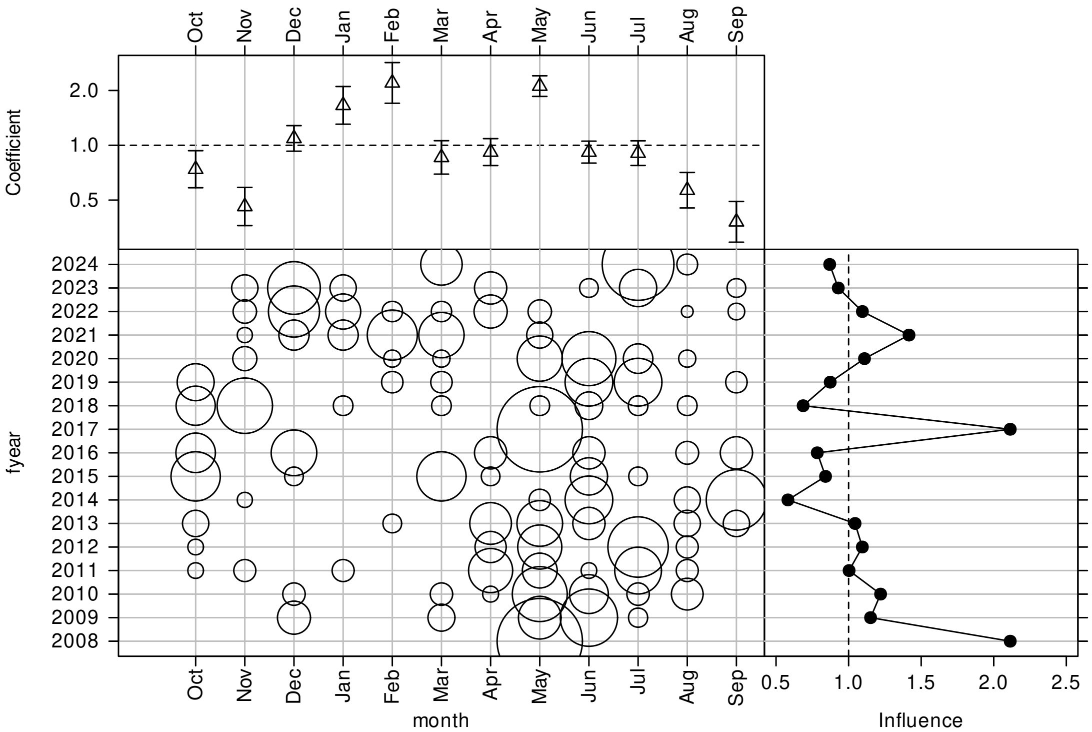

Figure C.204: **CDI plot for month for the lognormal model of positive catches in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.**

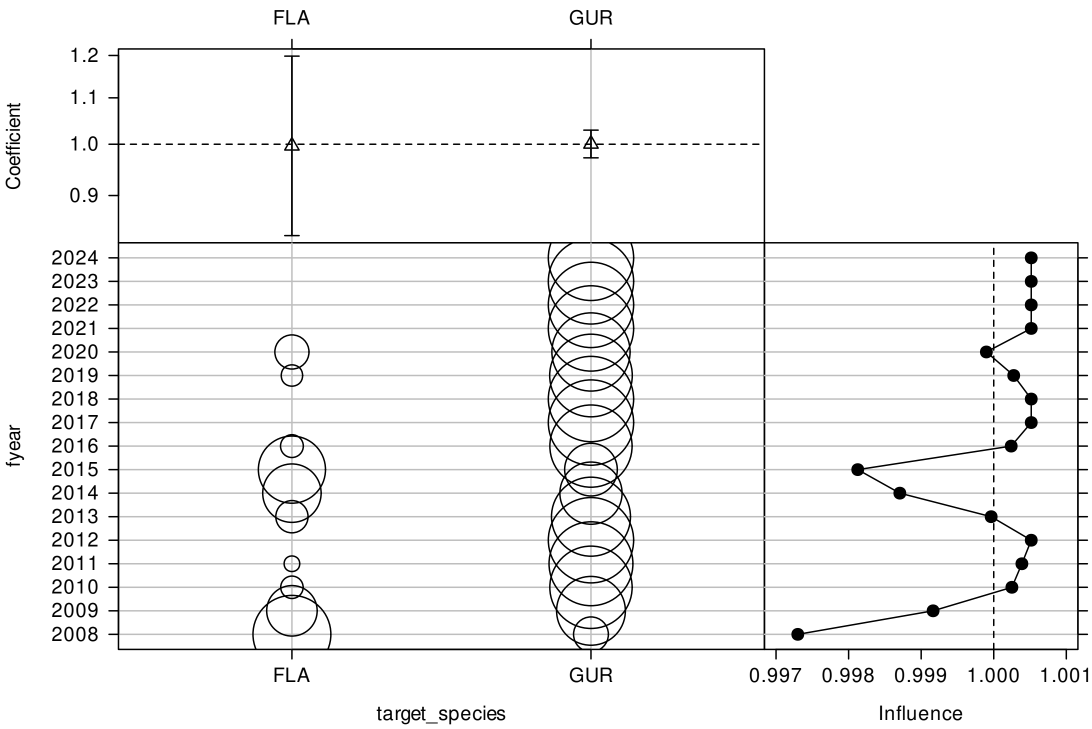

Figure C.205: **CDI plot for target species for the lognormal model of positive catches in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.**

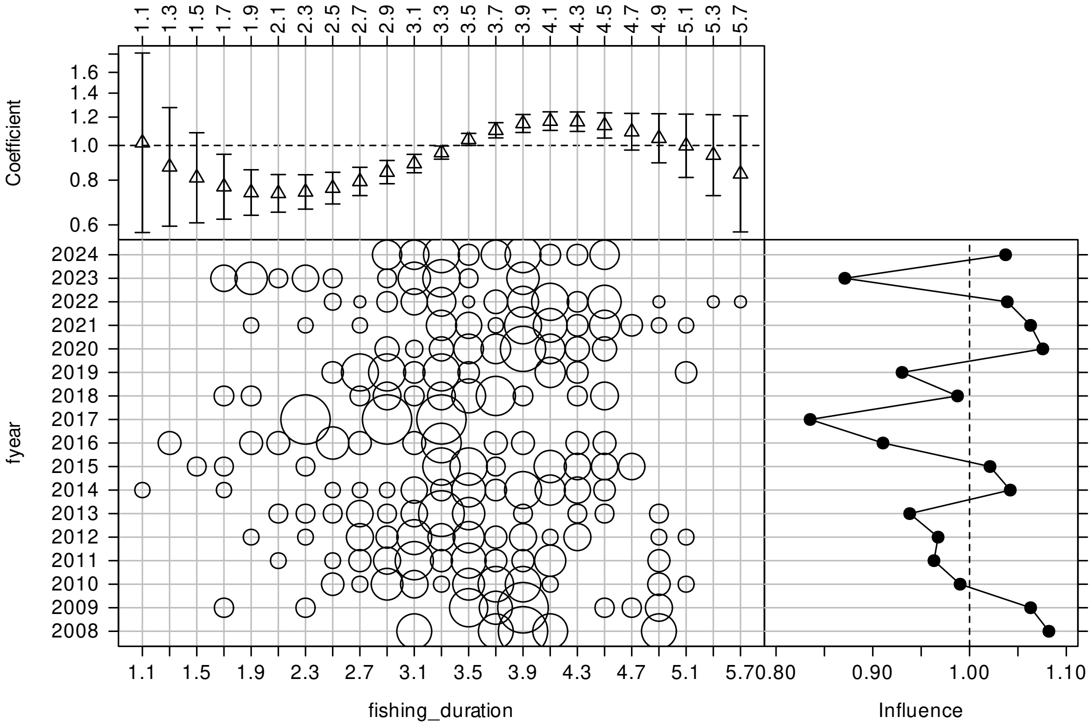

Figure C.206: CDI plot for fishing duration (h) for the lognormal model of positive catches in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

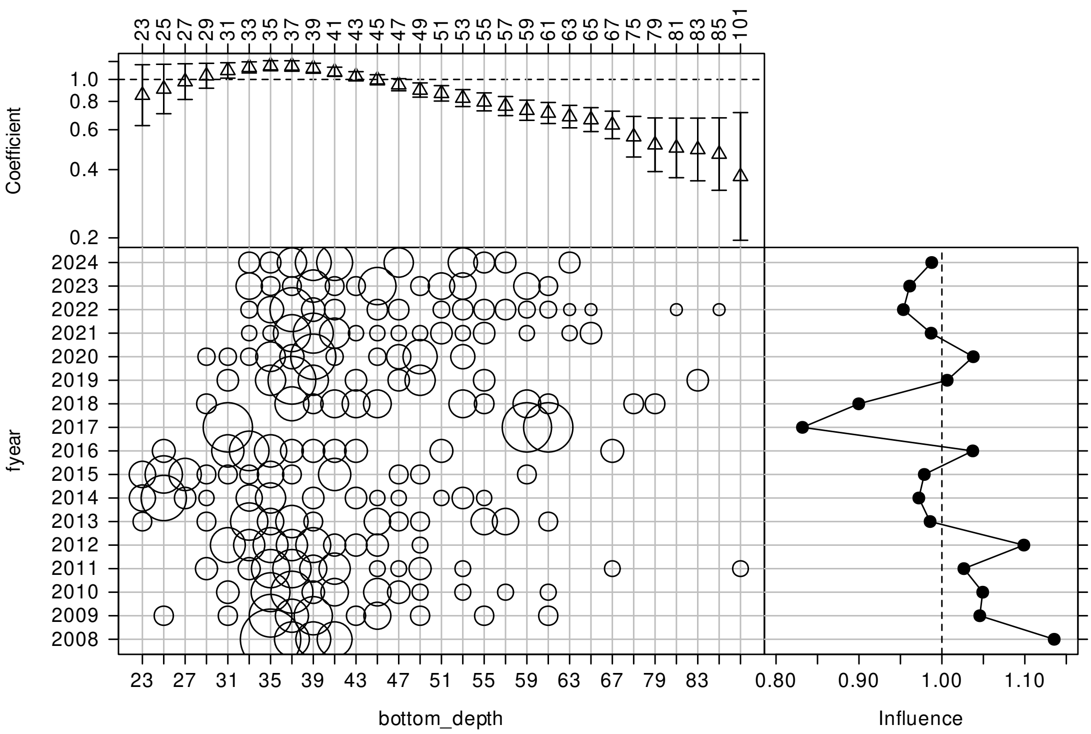

Figure C.207: CDI plot for bottom depth (m) for the lognormal model of positive catches in the South Taranaki LSO BT-MIX event catch-per-unit-effort dataset.

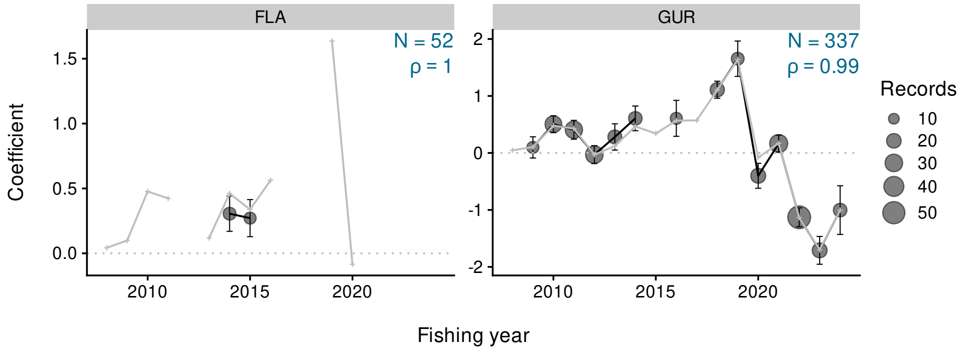

Figure C.208: Residual implied coefficients for target-year in the lognormal positive catch model for the South Taranaki LSO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

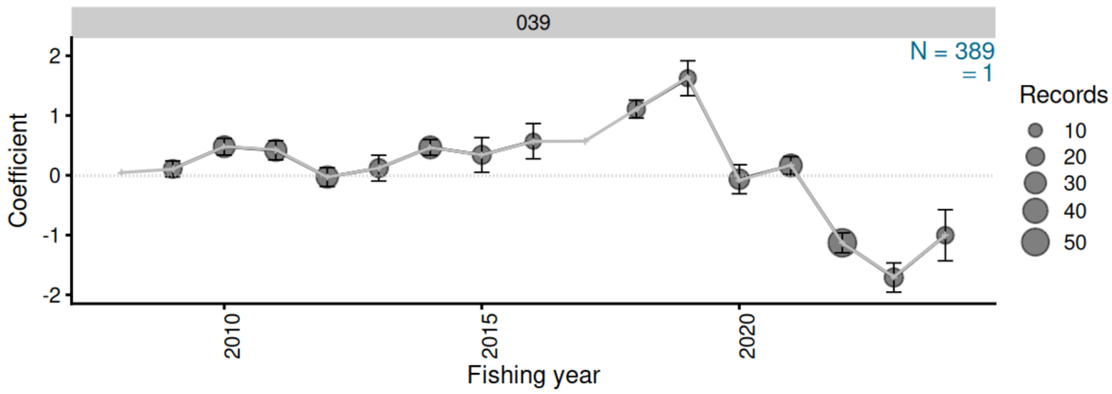

Figure C.209: Residual implied coefficients for area-year in the lognormal positive catch model for the South Taranaki LSO BT-MIX event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at 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.

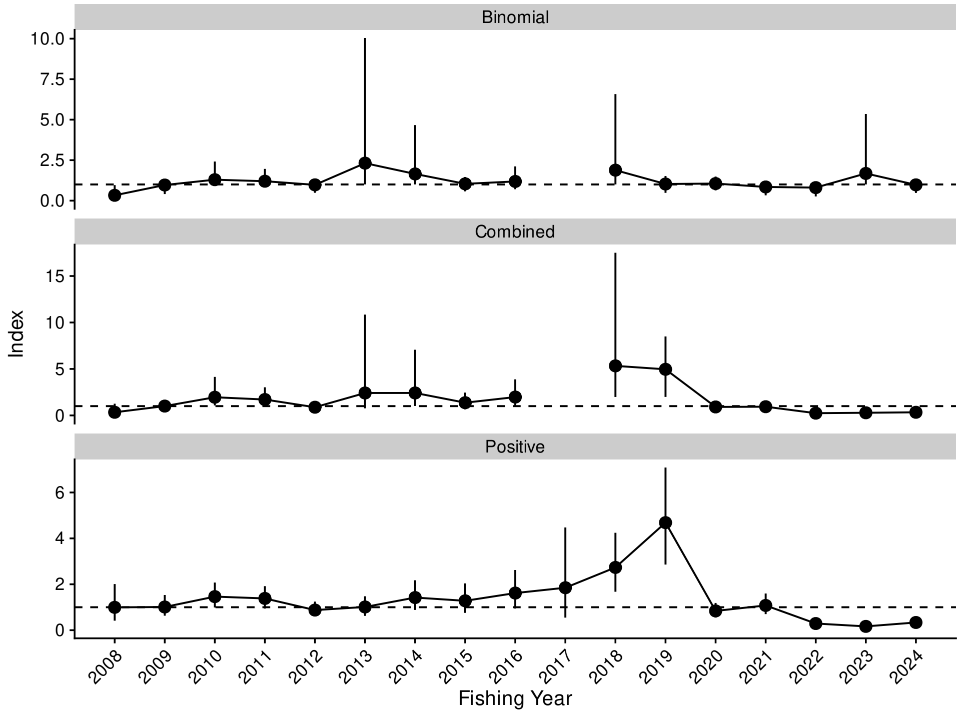

Figure C.210: Standardised indices and 95% confidence intervals for the South Taranaki LSO BT-MIX event dataset.

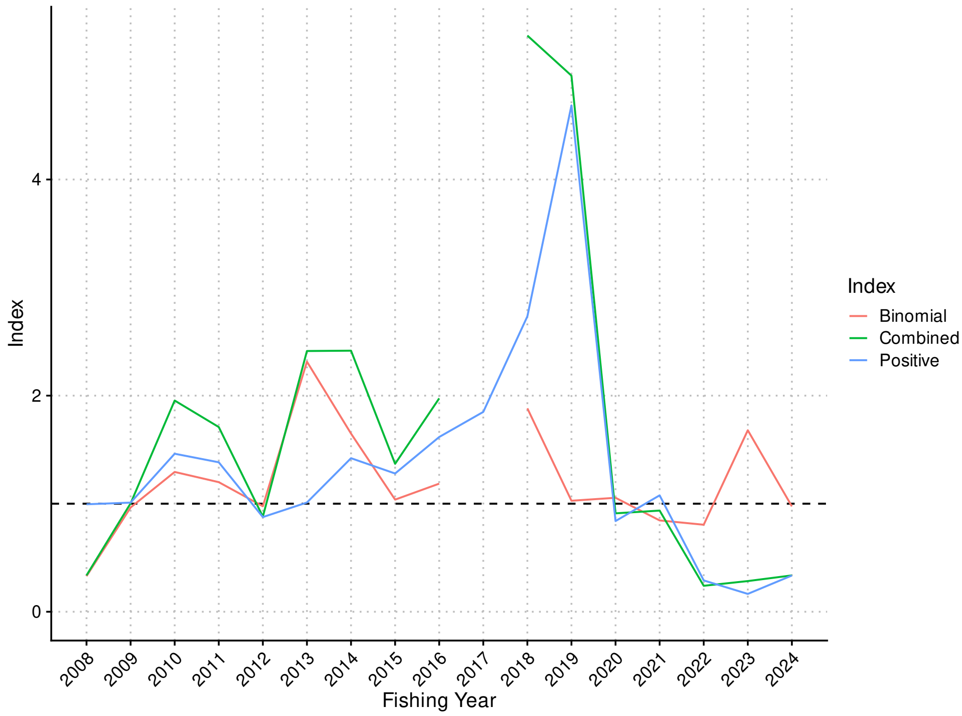

Figure C.211: Standardised indices for the South Taranaki LSO BT-MIX event dataset.

Table C.58: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the South Taranaki LSO BT-MIX event series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.329	0.240	0.018	0.958	0.337	0.317	0.017	1.260	0.995	0.407	0.414	2.009
2009	0.965	0.237	0.407	1.338	1.003	0.324	0.411	1.681	1.010	0.230	0.630	1.533
2010	1.294	0.380	0.928	2.415	1.955	0.783	1.077	4.145	1.462	0.277	0.990	2.075
2011	1.199	0.276	0.878	1.961	1.709	0.513	1.016	3.025	1.383	0.249	0.942	1.918
2012	0.976	0.205	0.485	1.287	0.880	0.248	0.391	1.364	0.876	0.166	0.595	1.245
2013	2.314	2.306	1.004	10.042	2.413	2.573	0.763	10.849	1.011	0.218	0.623	1.477
2014	1.649	0.934	1.003	4.665	2.416	1.544	1.015	7.067	1.421	0.330	0.882	2.175
2015	1.038	0.226	0.574	1.461	1.369	0.460	0.652	2.455	1.279	0.328	0.754	2.038
2016	1.186	0.360	0.704	2.115	1.975	0.757	0.916	3.882	1.617	0.429	0.942	2.622
2017	-	-	-	-	-	-	-	-	1.849	1.002	0.547	4.476
2018	1.882	1.422	1.004	6.578	5.332	3.959	1.984	17.503	2.734	0.655	1.674	4.244
2019	1.027	0.265	0.482	1.522	4.961	1.660	1.990	8.498	4.686	1.078	2.859	7.087
2020	1.055	0.218	0.633	1.488	0.911	0.245	0.481	1.442	0.839	0.162	0.549	1.186
2021	0.845	0.192	0.329	1.081	0.936	0.318	0.322	1.566	1.077	0.229	0.700	1.598
2022	0.805	0.203	0.260	1.055	0.240	0.080	0.074	0.387	0.290	0.050	0.202	0.397
2023	1.680	1.109	1.003	5.350	0.284	0.199	0.122	0.904	0.165	0.039	0.100	0.252
2024	0.975	0.212	0.477	1.307	0.336	0.114	0.146	0.593	0.335	0.087	0.185	0.524

C.11 Hawke Bay FLA BT-MIX event (split long vessels)

The INSWG was concerned that BT vessels which had participated in the FLA 2 fishery for a long period had learned to improve their capacity to catch FLA, with the associated increase in catch rate being interpreted as an increase in abundance rather than as an improvement in fishing power. This CPUE analysis was prepared as a sensitivity to test for this potential bias by splitting vessels that had been in the fishery for at least 12 years into two randomised blocks, forcing the split between 8 and 12 years. This model used the same criteria as specified for the Hawke Bay FLA BT-MIX event model (Section 4.2: compare Table C.59 with Table 4) except that the number of vessels in the analysis had been increased with shorter time blocks (Figure C.212; Figure C.213).

Figure C.241 compares the event-based combined target FLA/GUR BT CPUE series based on the aggregate flatfish (FLA) catch with the same analysis which randomly split vessels with participation of 12 or more years in the fishery (documented in Appendix C.11). While splitting the long participation vessels had only minor impact on this series, the INSWG agreed to accept the series without splitting for monitoring FLA abundance because the period covered by the series began in 2008, which was felt to be sufficiently recent for most technological changes to have already been integrated into the fishery. The INSWG also felt that the randomisation method used to split the vessels may have caused unintended effects in the series estimation procedure, which required validation.

Table C.59: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay FLA BT-MIX event (split long vessels) CPUE series.

Series	Hawke Bay FLA BT-MIX event (split long vessels)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	allockg_top8 ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3) + ns(effort_height, 3) + ns(effort_width, 3)
Stepwise selection	No
Positive catch distribution	Weibull

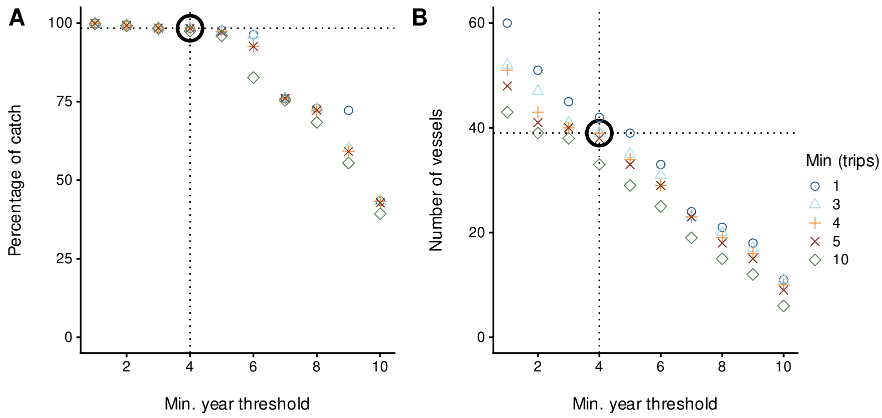

Figure C.212: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay FLA BT-MIX event (split long vessels) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

Figure C.213: Number of events by fishing year for core vessels in the Hawke Bay FLA BT-MIX event (split long vessels) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.60: Summary of the Hawke Bay FLA BT-MIX event (split long vessels) dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	132 (100%) n: 3836	113 (100%) n: 3542	119 (100%) n: 4050	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4248	90 (100%) n: 3637	166 (100%) n: 3539
Positive fishing duration	132 (100%) n: 3834	113 (100%) n: 3539	118 (100%) n: 4048	195 (100%) n: 4380	150 (100%) n: 3990	170 (100%) n: 3722	143 (100%) n: 4247	90 (100%) n: 3636	166 (100%) n: 3539
Fishing duration less than 6 h	132 (100%) n: 3813	113 (99%) n: 3515	118 (99%) n: 4033	195 (100%) n: 4365	148 (99%) n: 3966	169 (99%) n: 3713	141 (98%) n: 4223	90 (100%) n: 3625	166 (100%) n: 3516
Bottom depth < 150m	132 (100%) n: 3810	113 (99%) n: 3514	118 (99%) n: 4030	195 (100%) n: 4362	148 (99%) n: 3963	169 (99%) n: 3713	141 (98%) n: 4221	90 (100%) n: 3622	166 (100%) n: 3515
Trawl opening < 10m	131 (99%) n: 3802	112 (99%) n: 3504	118 (99%) n: 4030	195 (100%) n: 4357	148 (99%) n: 3963	169 (99%) n: 3710	141 (98%) n: 4212	90 (100%) n: 3618	166 (100%) n: 3515
Trawl width< 90m	131 (99%) n: 3796	112 (99%) n: 3504	118 (99%) n: 4030	195 (100%) n: 4357	148 (99%) n: 3963	169 (99%) n: 3710	140 (98%) n: 4208	90 (100%) n: 3617	166 (100%) n: 3515
Core fleet selection	121 (92%) n: 3276	111 (98%) n: 3307	117 (99%) n: 3935	195 (100%) n: 4330	148 (98%) n: 3945	168 (99%) n: 3690	132 (92%) n: 3958	84 (93%) n: 3467	166 (100%) n: 3510

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2800	53 (100%) n: 2513	55 (100%) n: 2190	36 (100%) n: 2438	22 (100%) n: 1523	47 (100%) n: 1886
Positive fishing duration	85 (100%) n: 3124	87 (100%) n: 3081	55 (100%) n: 2793	53 (100%) n: 2507	55 (100%) n: 2186	36 (100%) n: 2437	22 (100%) n: 1521	47 (100%) n: 1884
Fishing duration less than 6 h	85 (99%) n: 3097	87 (100%) n: 3054	55 (99%) n: 2752	52 (99%) n: 2458	55 (99%) n: 2153	35 (99%) n: 2415	21 (99%) n: 1482	47 (100%) n: 1859
Bottom depth < 150m	85 (99%) n: 3097	87 (100%) n: 3053	55 (99%) n: 2749	52 (99%) n: 2457	55 (99%) n: 2151	35 (99%) n: 2407	21 (99%) n: 1478	47 (100%) n: 1853
Trawl opening < 10m	84 (99%) n: 3092	87 (100%) n: 3052	54 (98%) n: 2735	51 (97%) n: 2438	55 (99%) n: 2151	32 (90%) n: 2192	15 (71%) n: 1259	45 (95%) n: 1735
Trawl width< 90m	84 (99%) n: 3092	87 (100%) n: 3052	54 (98%) n: 2735	51 (97%) n: 2389	55 (99%) n: 2151	32 (90%) n: 2189	15 (69%) n: 1246	43 (92%) n: 1709
Core fleet selection	84 (99%) n: 3080	87 (100%) n: 3045	54 (98%) n: 2699	51 (97%) n: 2370	55 (99%) n: 2150	32 (89%) n: 2114	15 (69%) n: 1246	43 (92%) n: 1677

Table C.61: Summary of the Hawke Bay FLA BT-MIX event (split long vessels) dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	19	907	3 276	10 889.17	121.33	70.88
2009	20	976	3 307	11 398.92	110.86	65.62
2010	20	1 087	3 935	13 682.43	117.22	65.41
2011	20	1 092	4 330	15 160.38	194.90	65.98
2012	21	1 072	3 945	13 663.73	147.73	64.23
2013	21	907	3 690	12 705.20	168.40	64.09
2014	20	997	3 958	13 772.72	132.16	61.29
2015	21	927	3 467	12 167.10	84.31	61.58
2016	20	1 019	3 510	12 206.58	165.66	69.34
2017	22	924	3 080	10 780.47	84.15	64.42
2018	20	871	3 045	10 804.97	86.86	63.91
2019	19	720	2 699	10 256.27	54.23	55.24
2020	16	624	2 370	9 298.85	51.19	57.30
2021	18	625	2 150	7 822.68	54.79	64.98
2022	12	569	2 114	7 736.13	31.85	60.08
2023	10	316	1 246	4 854.62	14.91	58.83
2024	9	403	1 677	6 014.31	42.92	55.81

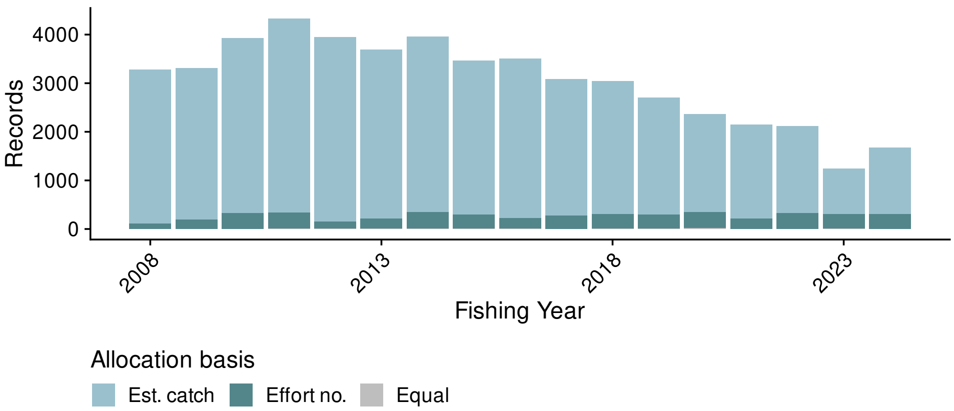

Figure C.214: The allocation approach used for attributing catches to records in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.62: Summary table for occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	67 943.22	0.00	0.00	*
fyear	16	67 620.13	0.52	0.52	*
vessel_key	38	56 822.78	16.53	16.00	*
stat_area	1	56 814.95	16.54	0.01	*
month	11	56 543.12	16.97	0.43	*
target_species	1	54 547.46	19.91	2.94	*
ns(log(fishing_duration), 3)	3	54 477.21	20.03	0.11	*
ns(bottom_depth, 3)	3	52 042.02	23.62	3.59	*
ns(effort_height, 3)	3	52 020.50	23.66	0.04	*
ns(effort_width, 3)	3	51 904.66	23.84	0.18	*

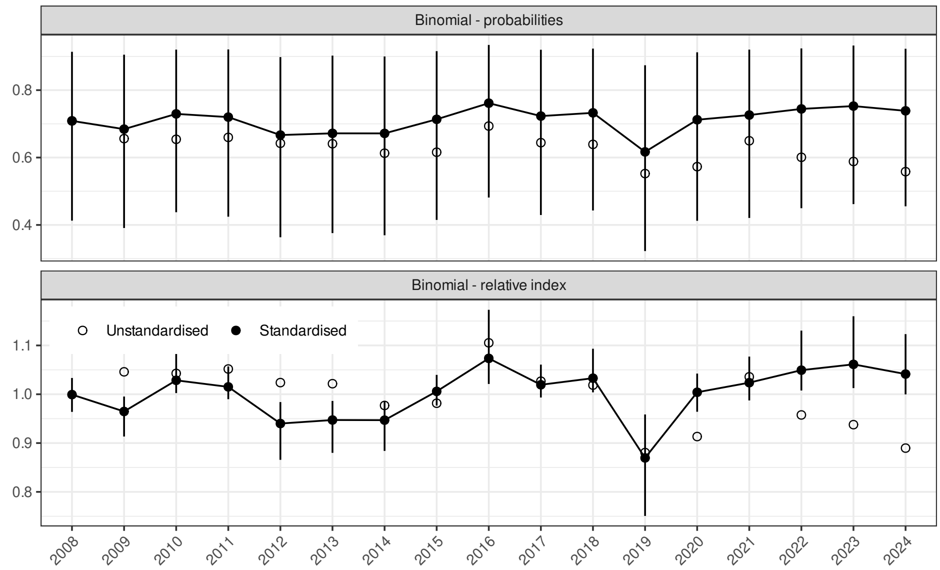

Figure C.215: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay FLA BT-MIX event (split long vessels) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

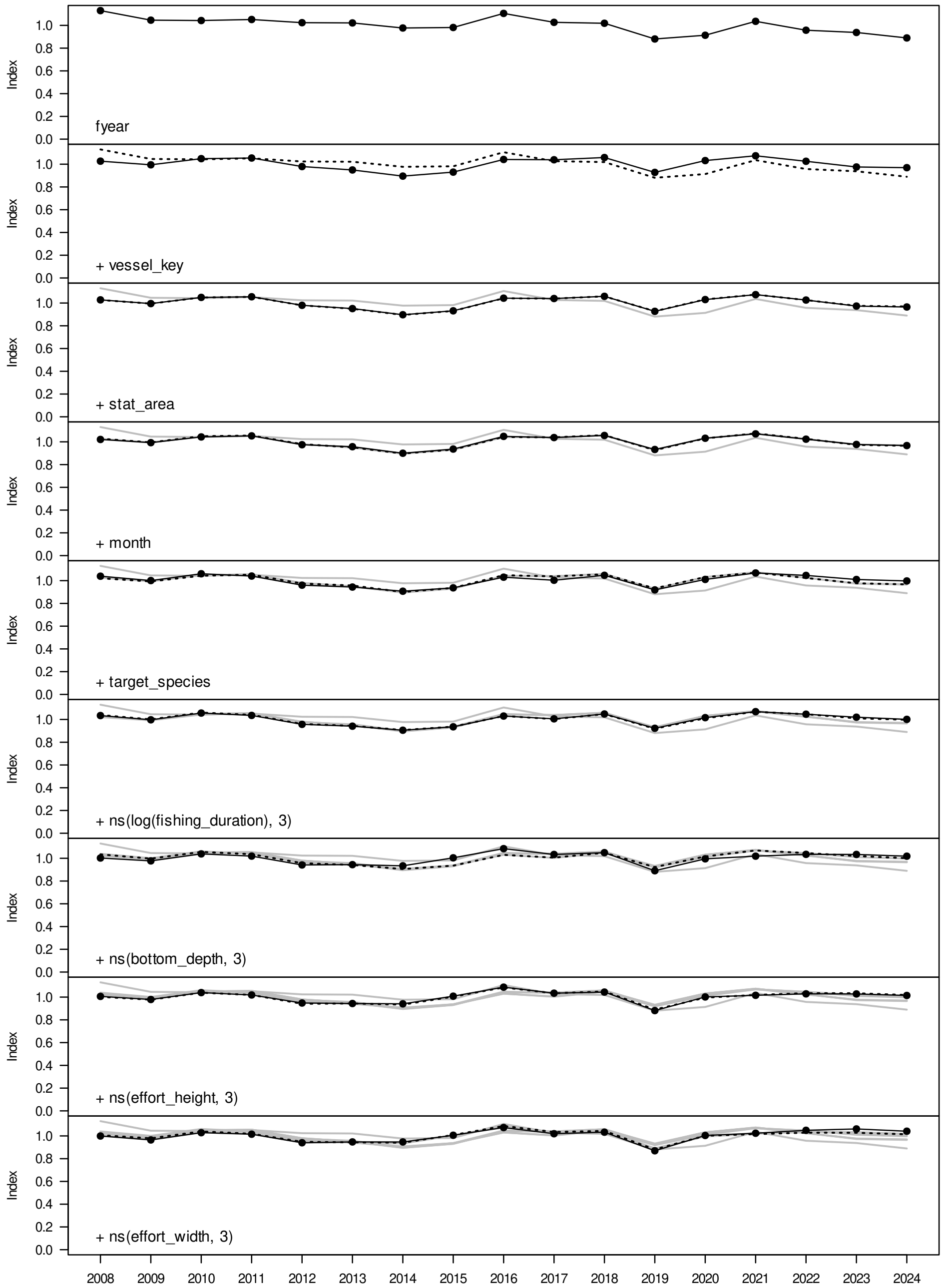

Figure C.216: Step plot for occurrence of catch in the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

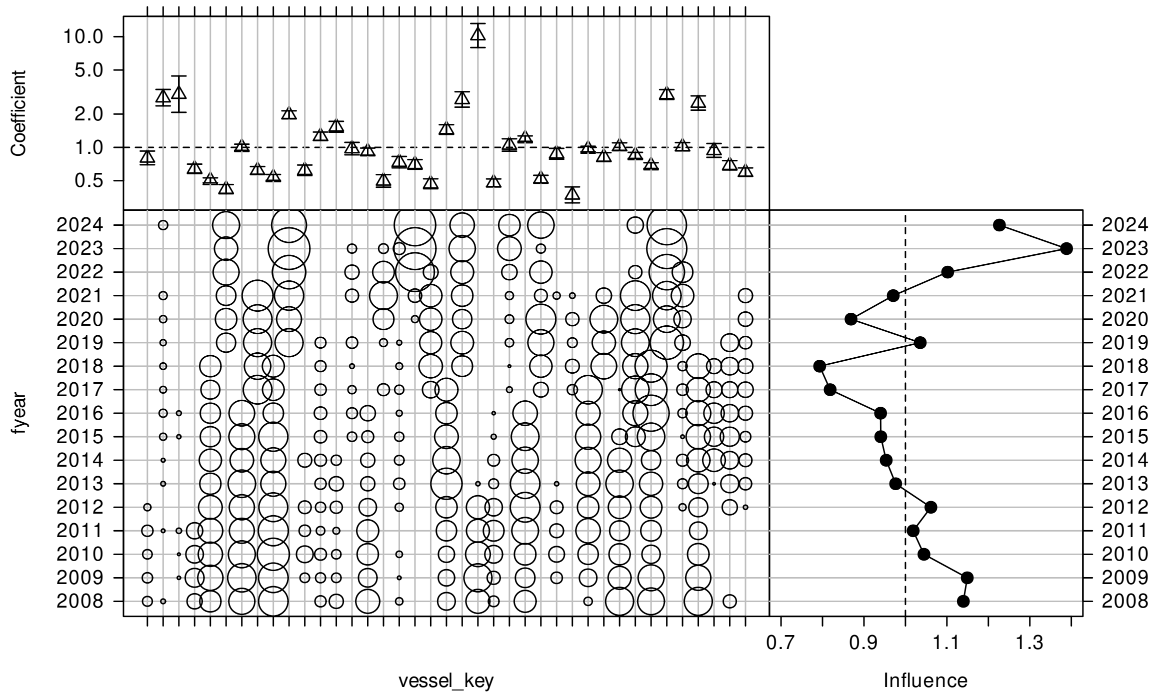

Figure C.217: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

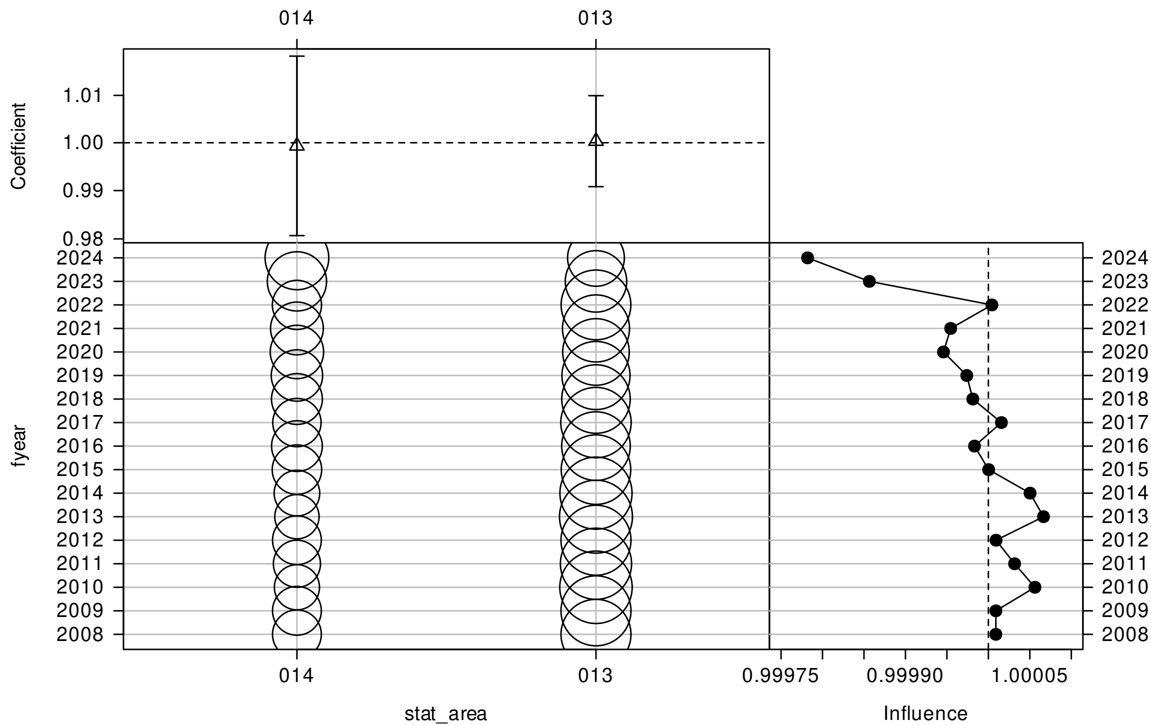

Figure C.218: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

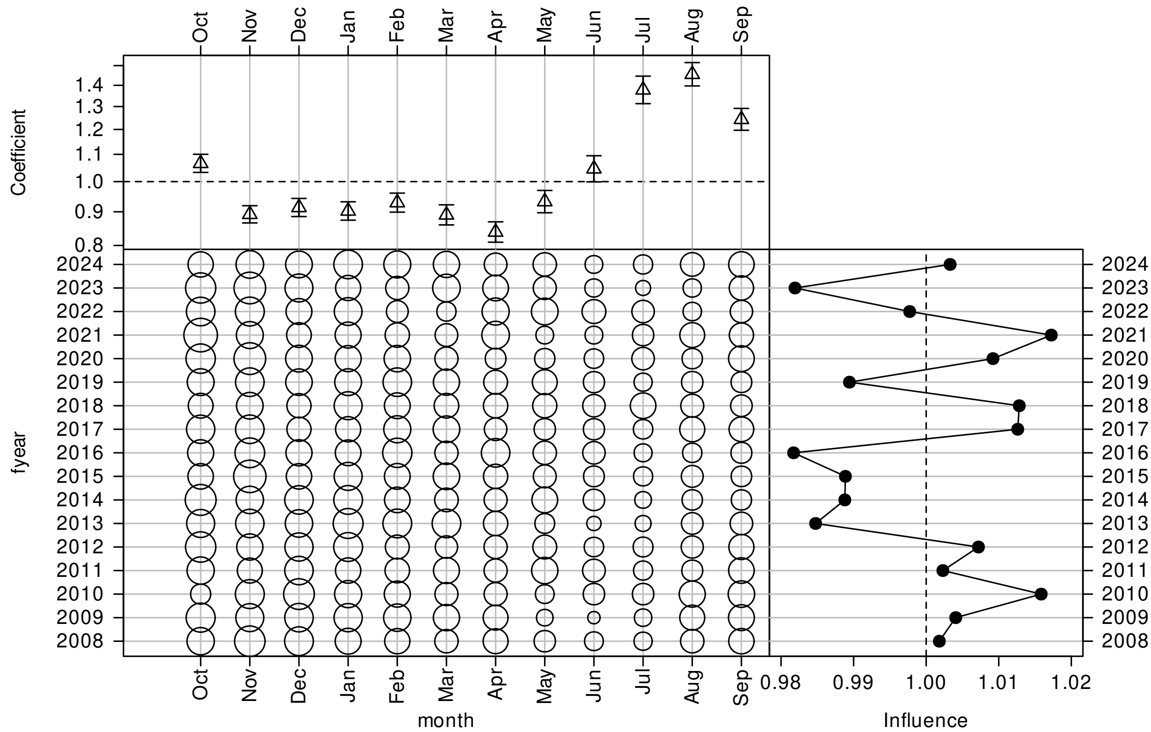

Figure C.219: CDI plot for month for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

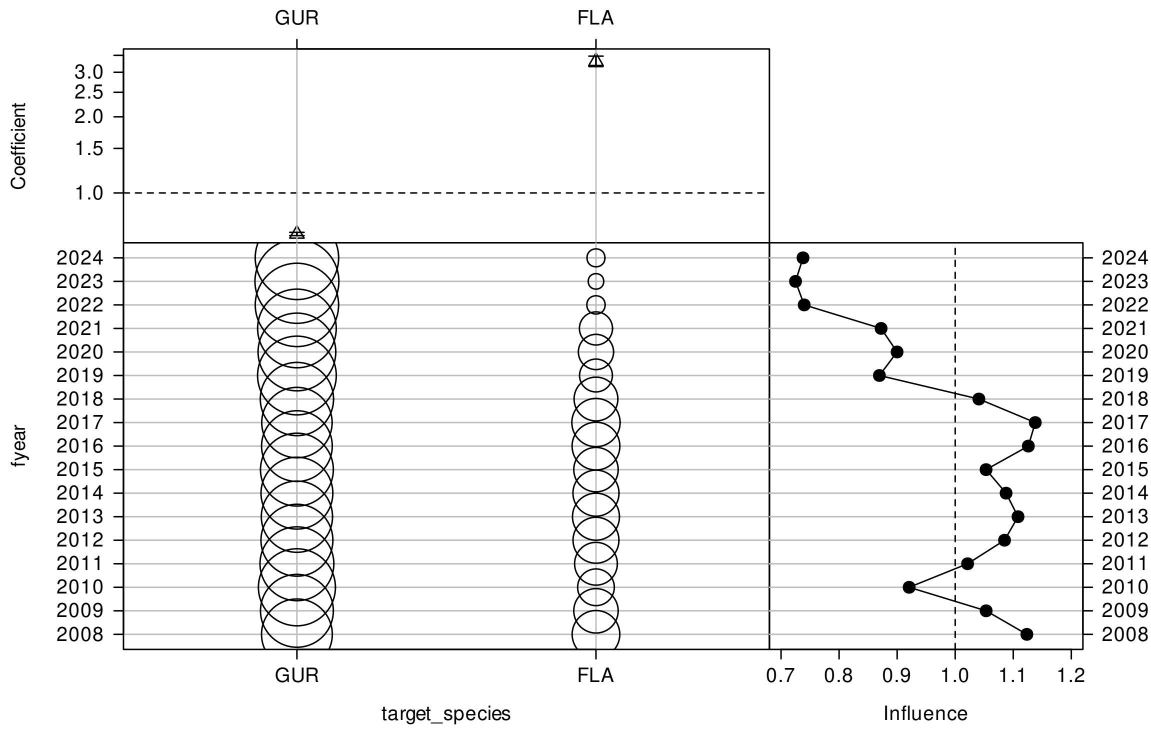

Figure C.220: CDI plot for target species for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

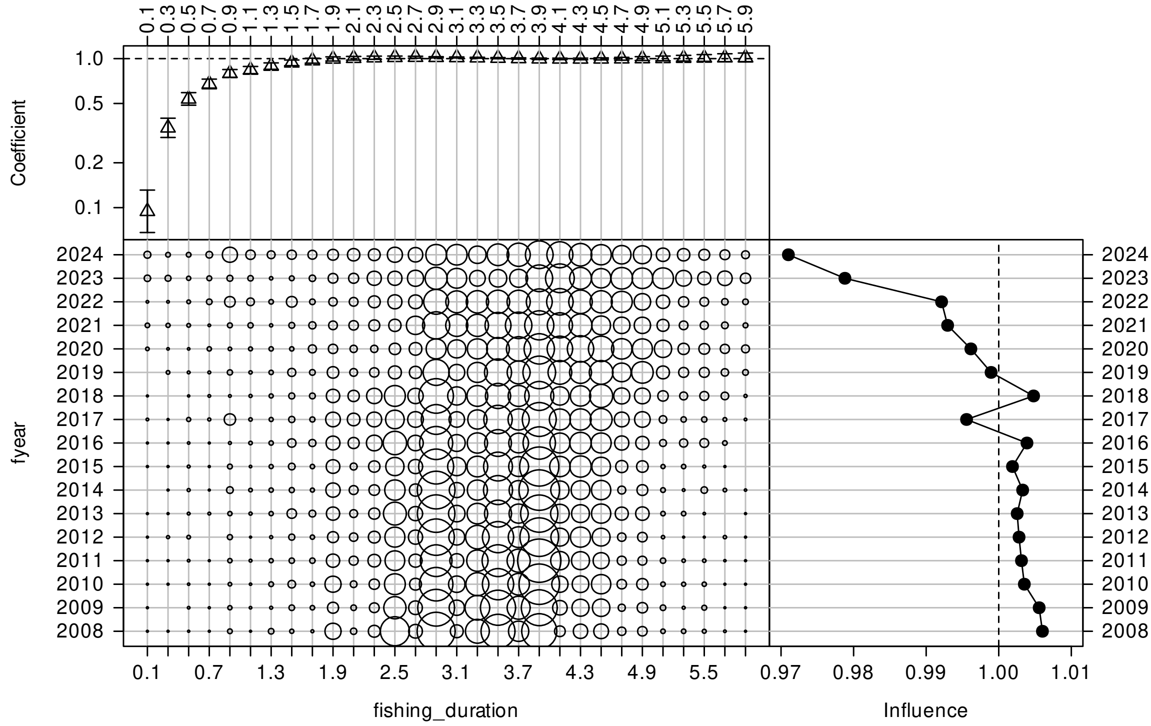

Figure C.221: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

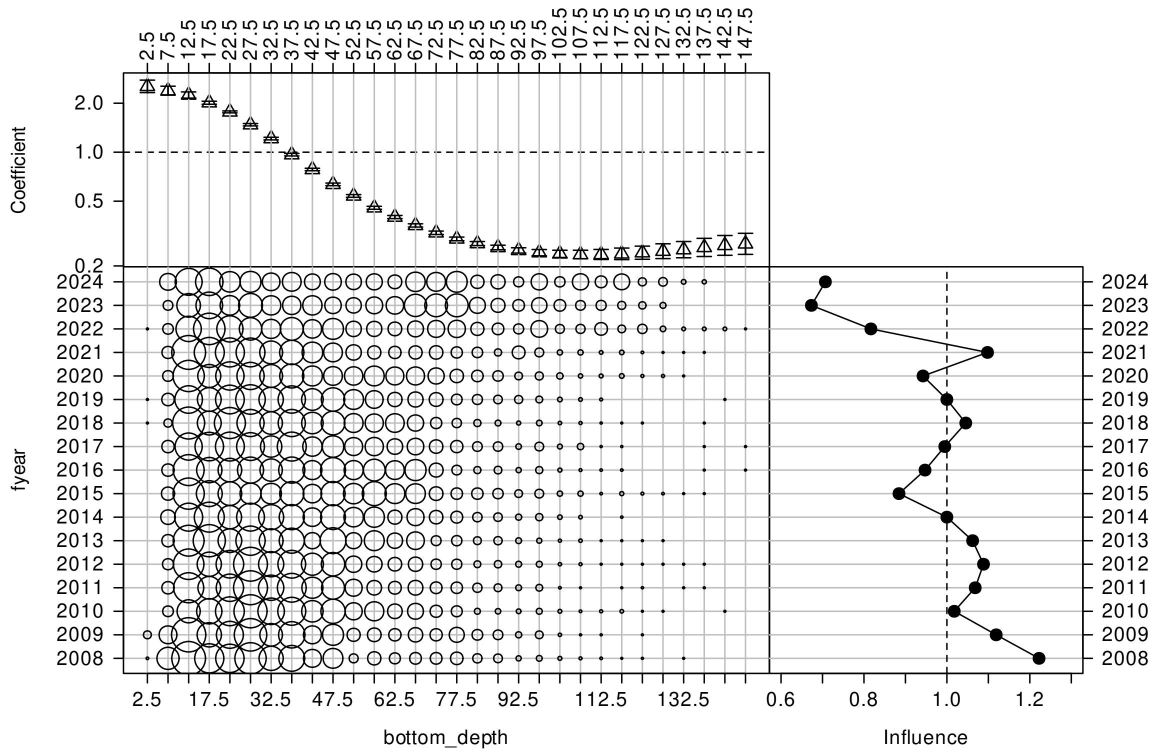

Figure C.222: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

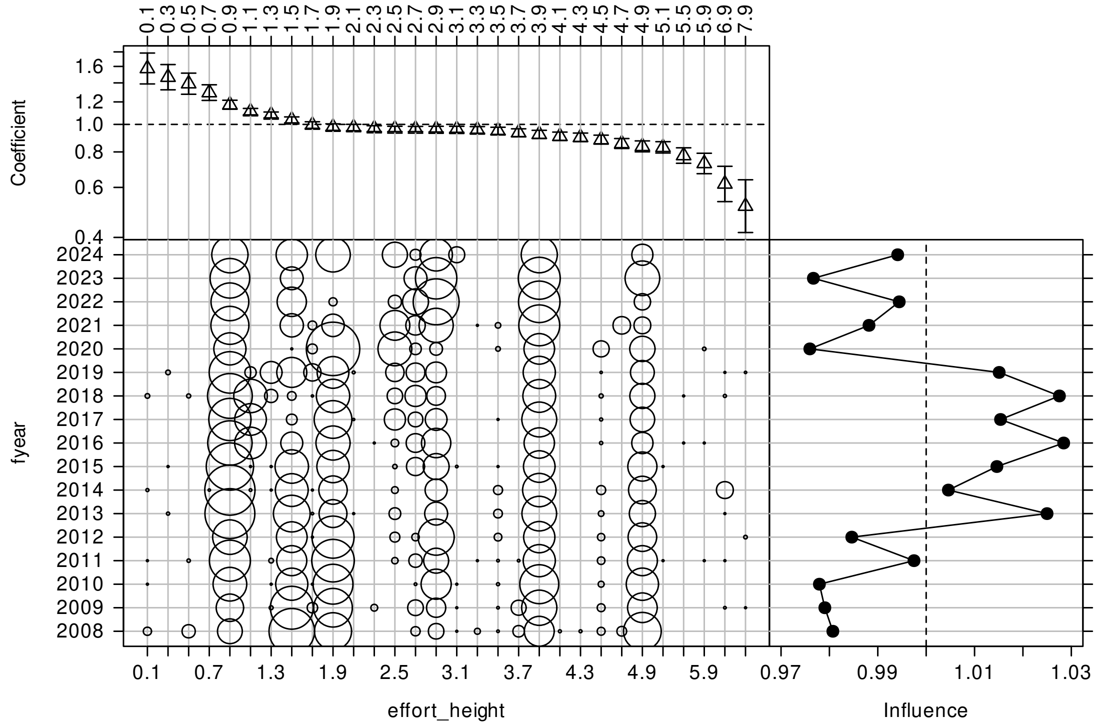

Figure C.223: CDI plot for effort height (m) for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

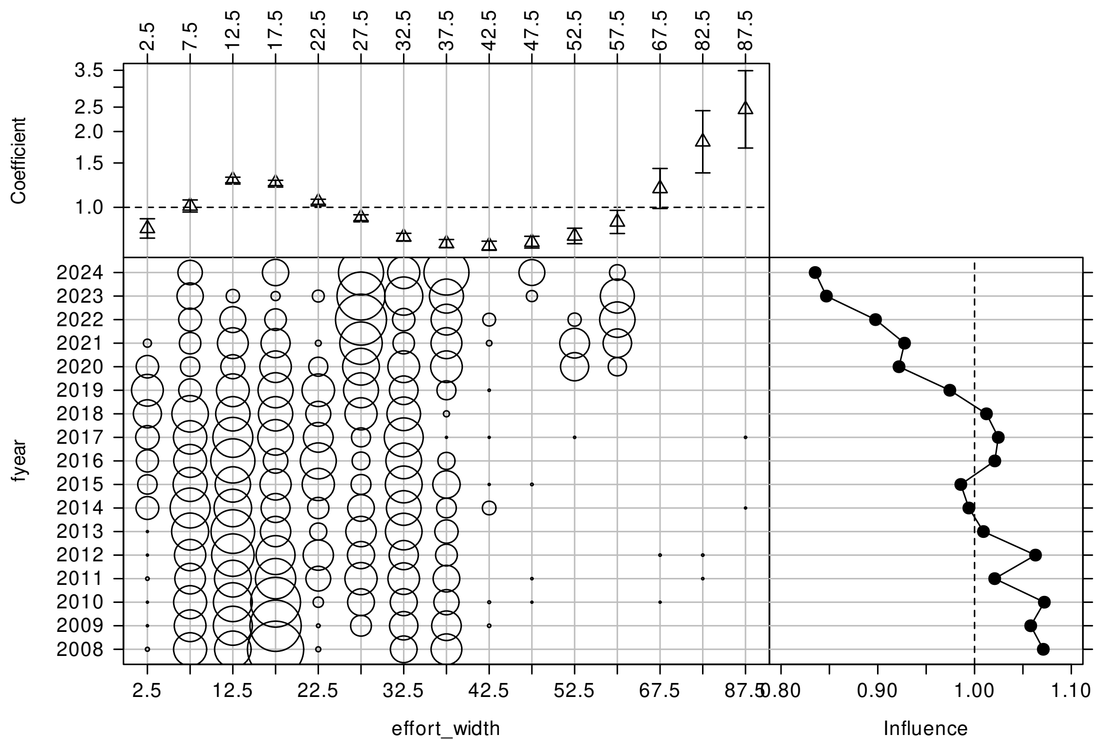

Figure C.224: CDI plot for effort width for the occurrence of positive catch in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

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

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	315 127.0	0.00	0.00	*
fyear	16	313 766.7	3.96	3.96	*
vessel_key	38	303 836.4	32.38	28.42	*
stat_area	1	303 030.5	34.67	2.29	*
month	11	302 772.6	35.47	0.79	*
target_species	1	298 841.6	46.64	11.17	*
ns(log(fishing_duration), 3)	3	298 742.9	46.94	0.30	*
ns(bottom_depth, 3)	3	294 524.2	58.94	12.00	*
ns(effort_height, 3)	3	294 459.5	59.14	0.20	*
ns(effort_width, 3)	3	294 417.7	59.28	0.14	*

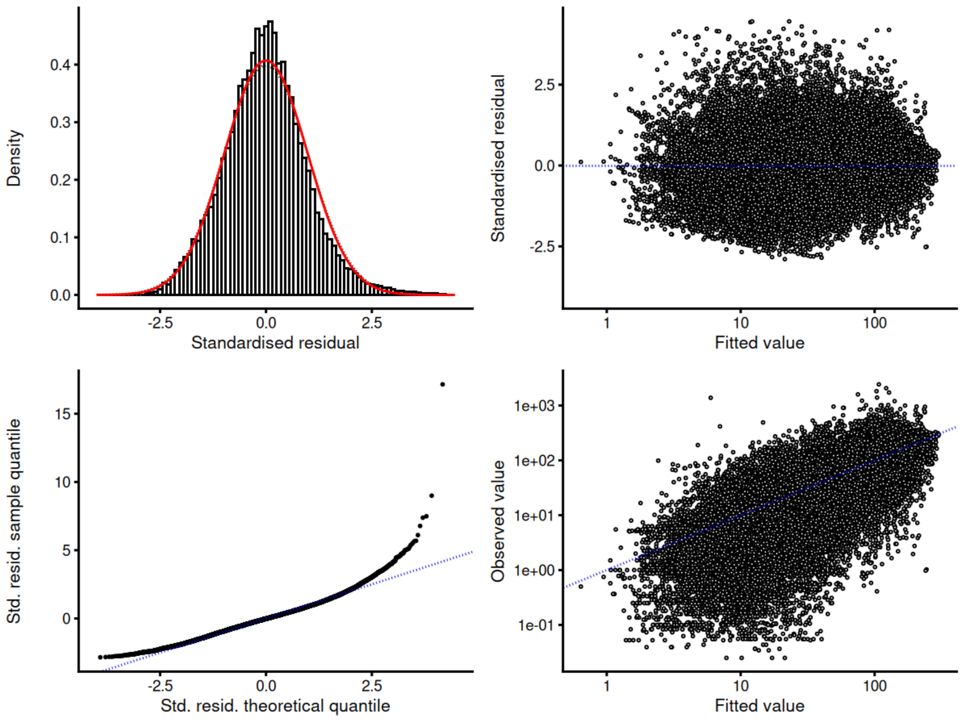

Figure C.225: Diagnostic plots for the selected Weibull model for positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

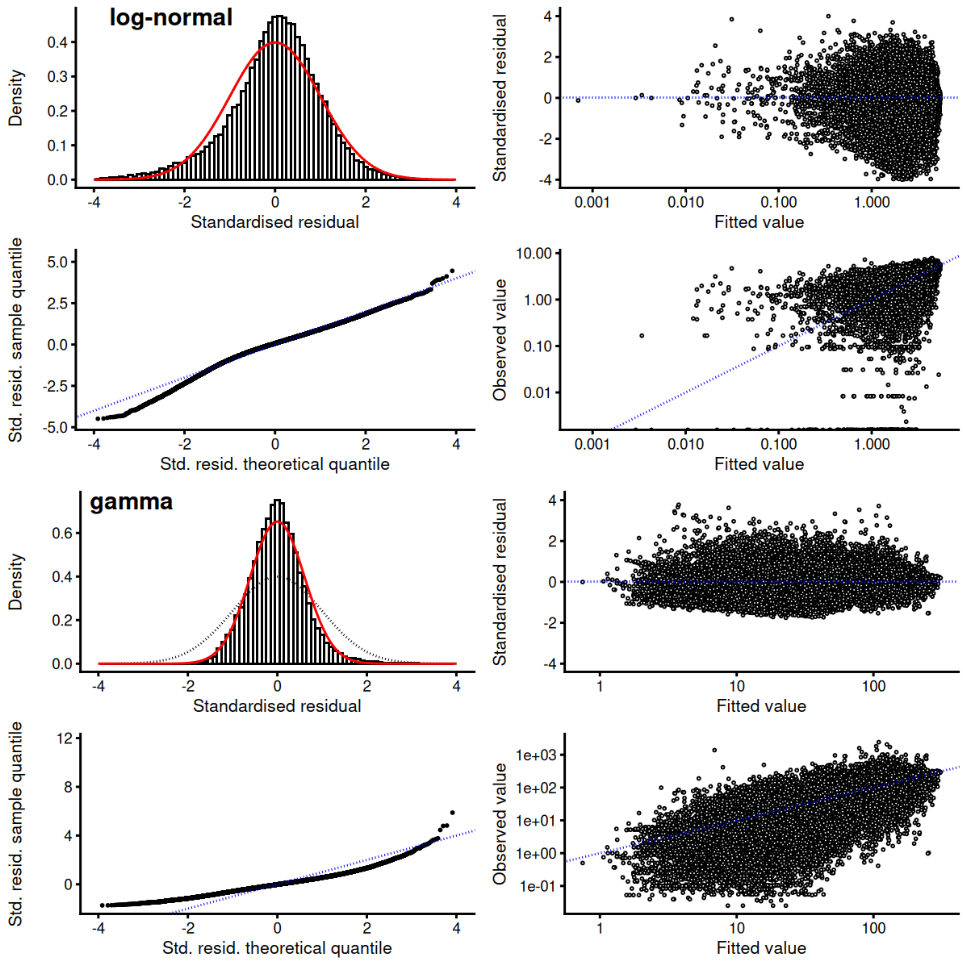

Figure C.226: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

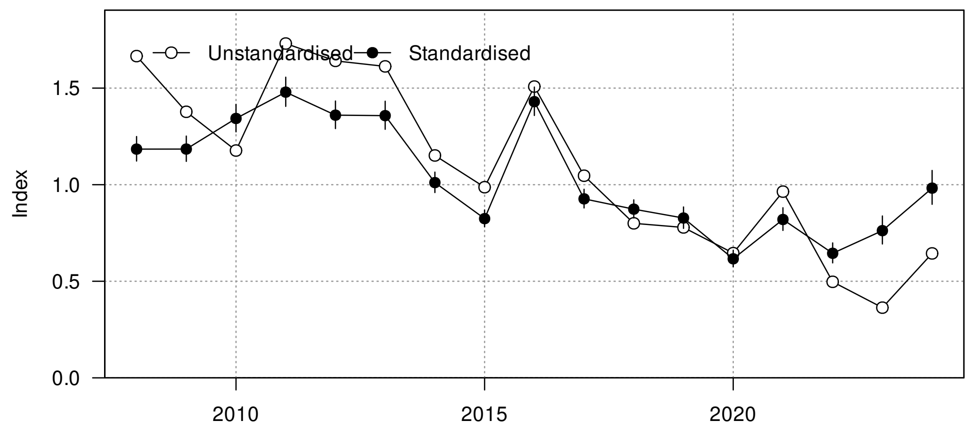

Figure C.227: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

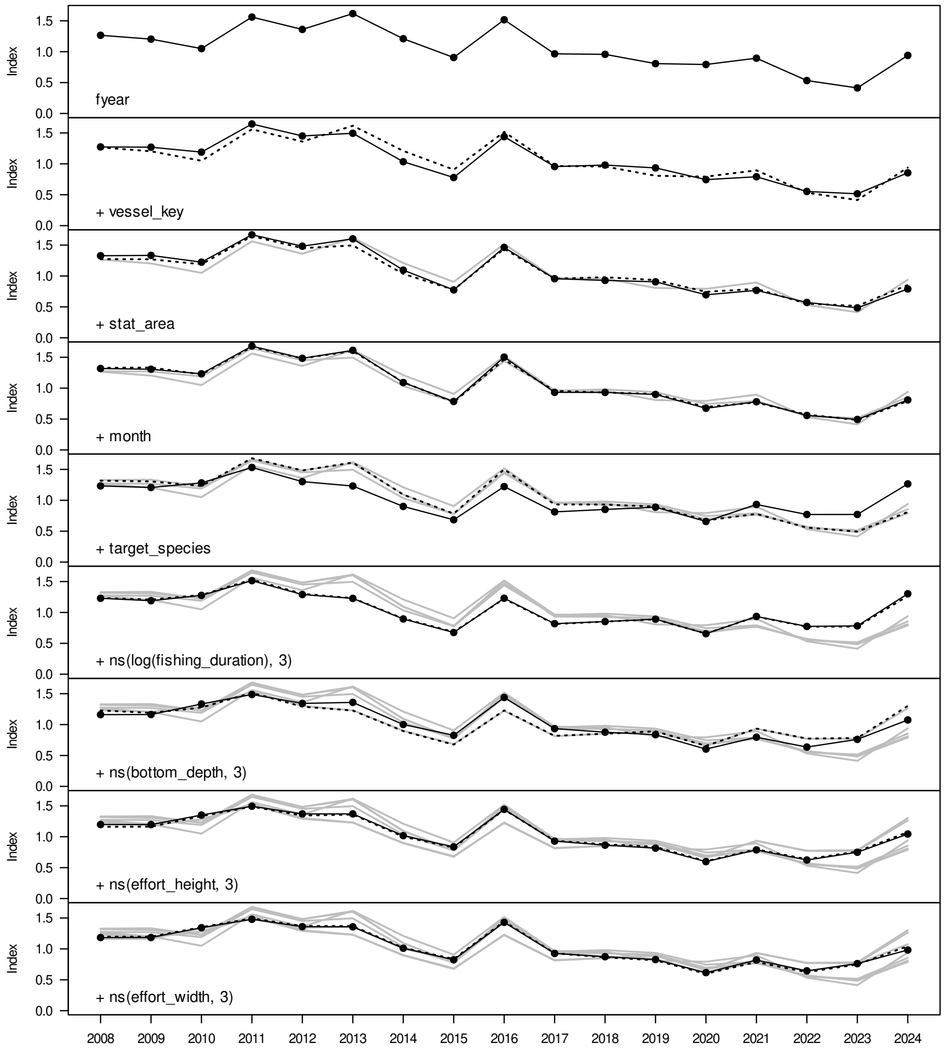

Figure C.228: Changes to the Hawke Bay FLA BT-MIX event (split long vessels) positive catch index as terms are successively entered into the Weibull model.

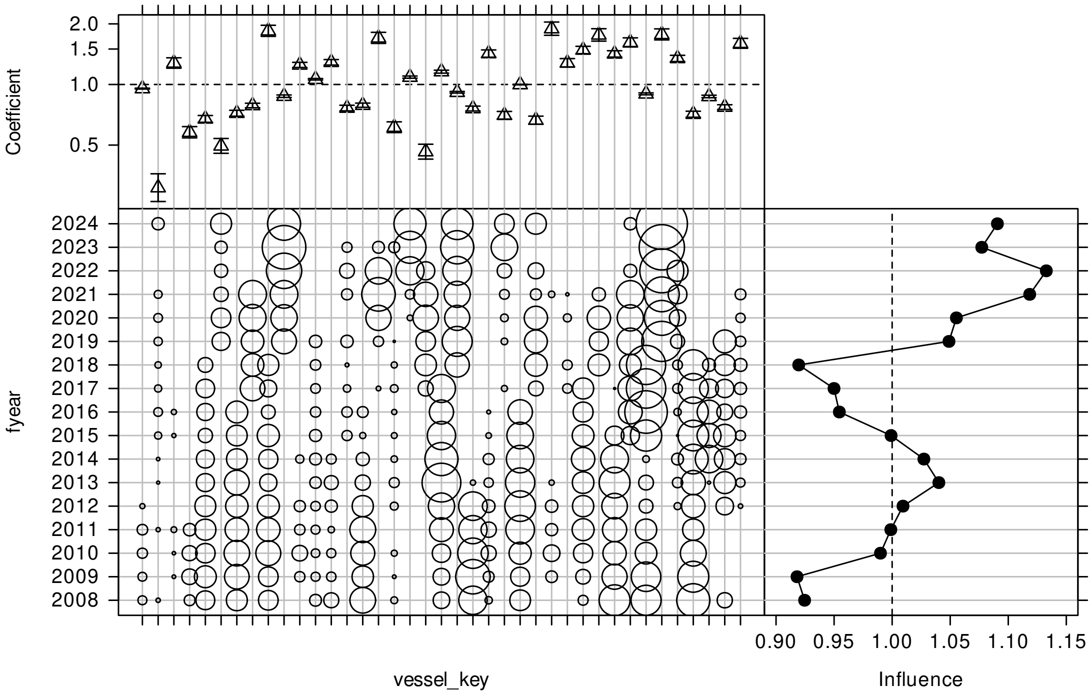

Figure C.229: CDI plot for vessel key for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

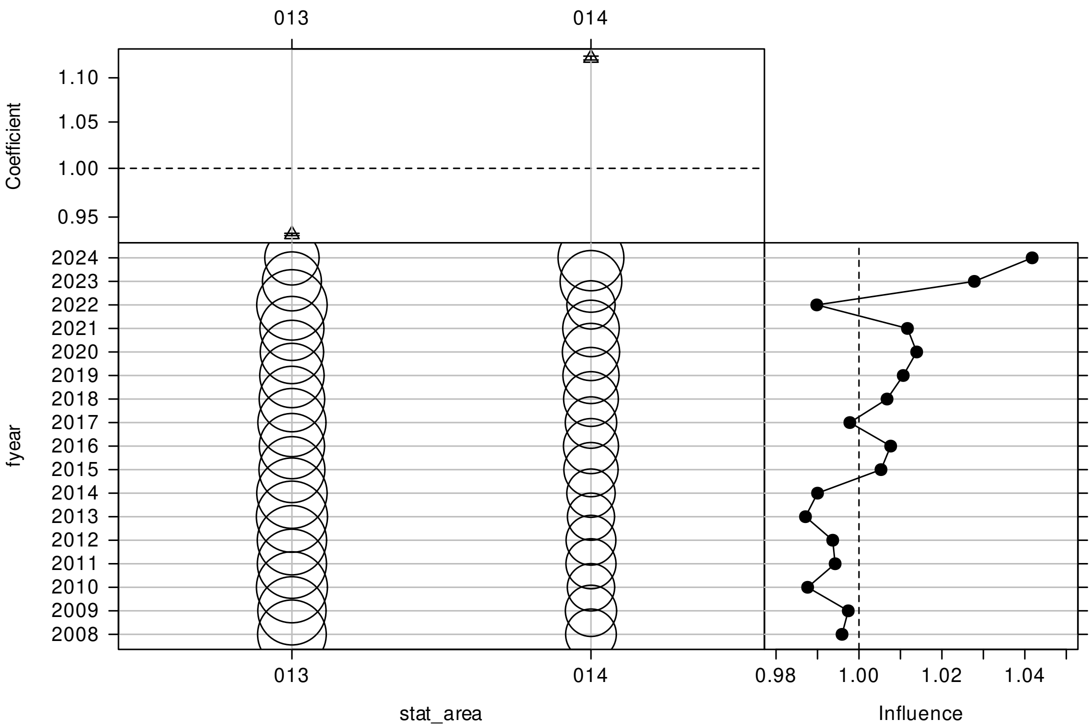

Figure C.230: CDI plot for statistical area for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

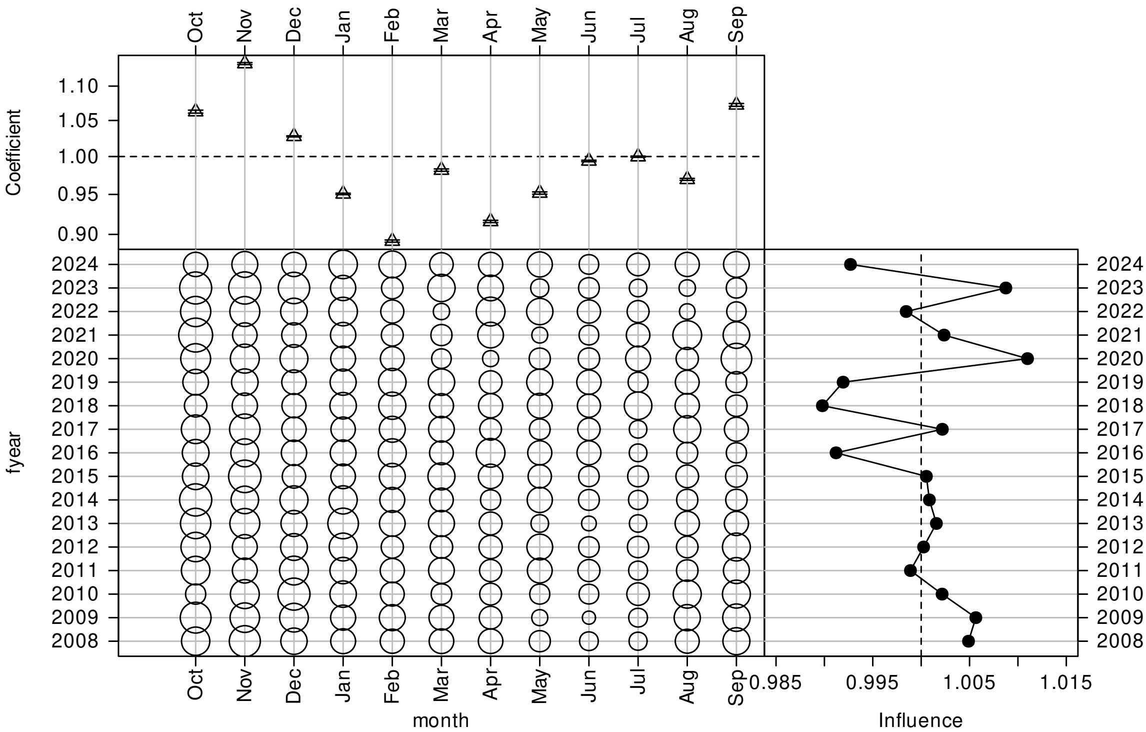

Figure C.231: CDI plot for month for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

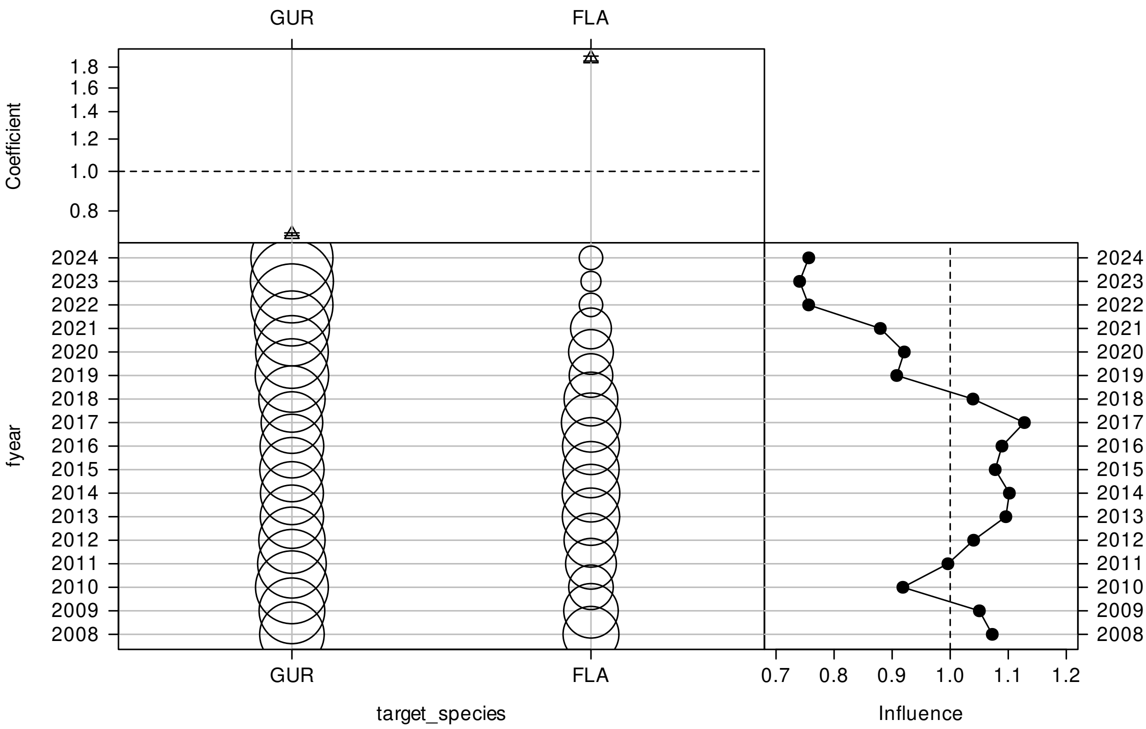

Figure C.232: CDI plot for target species for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

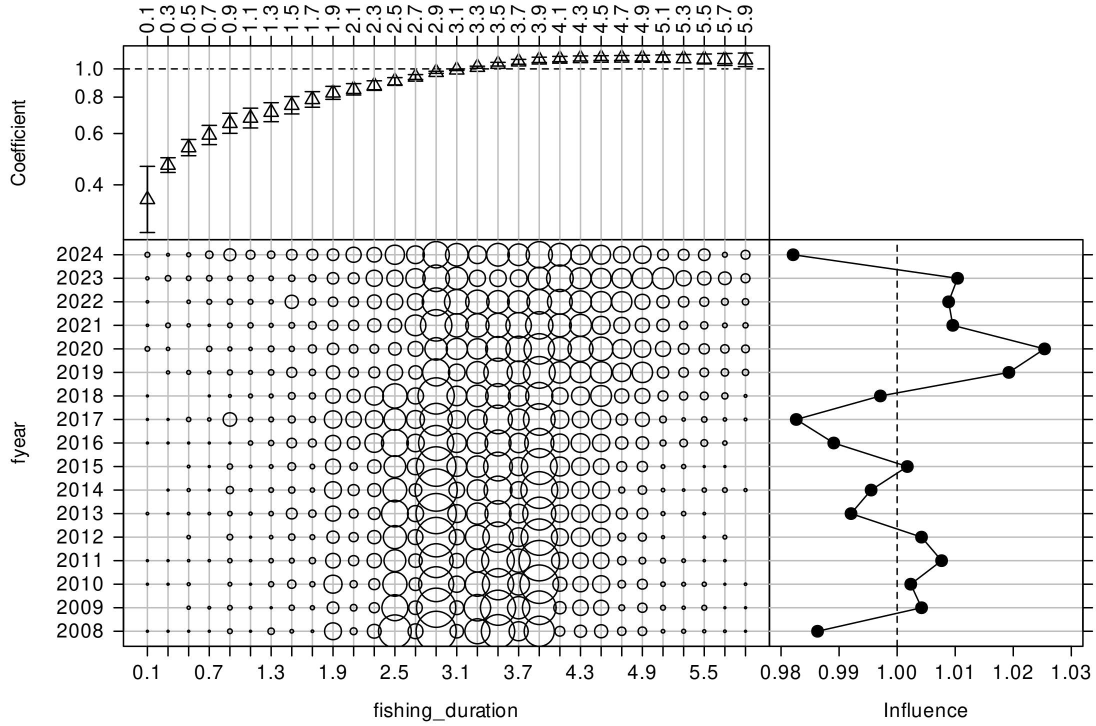

Figure C.233: CDI plot for fishing duration (h) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

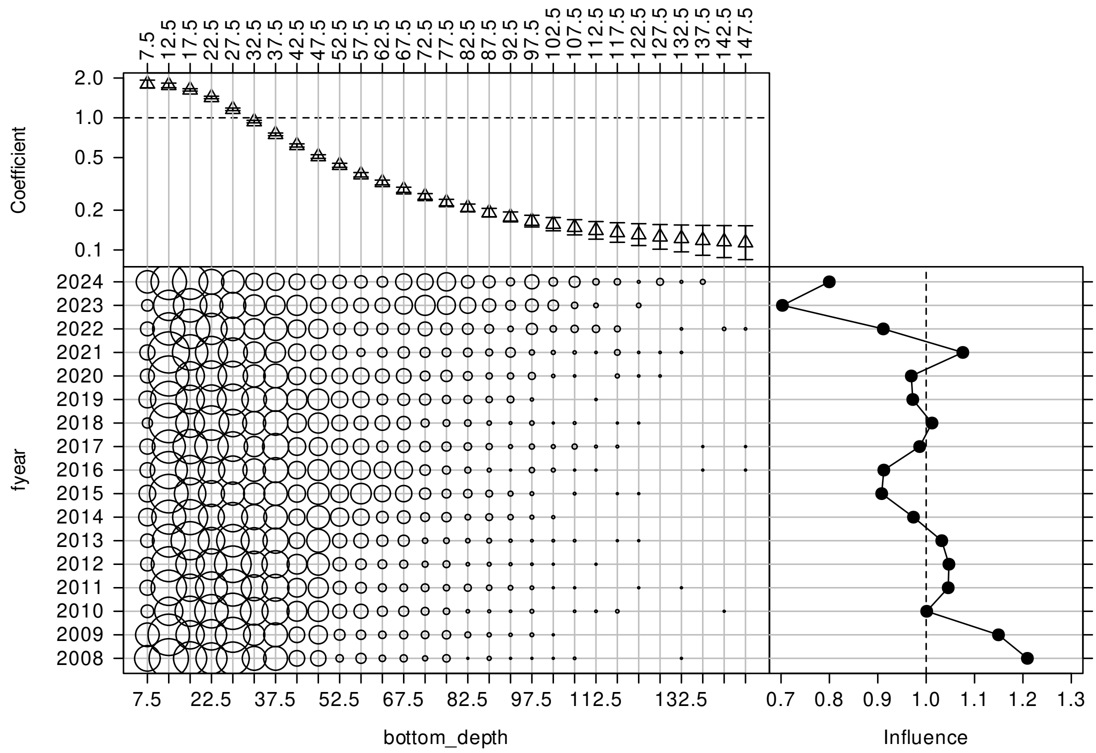

Figure C.234: CDI plot for bottom depth (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

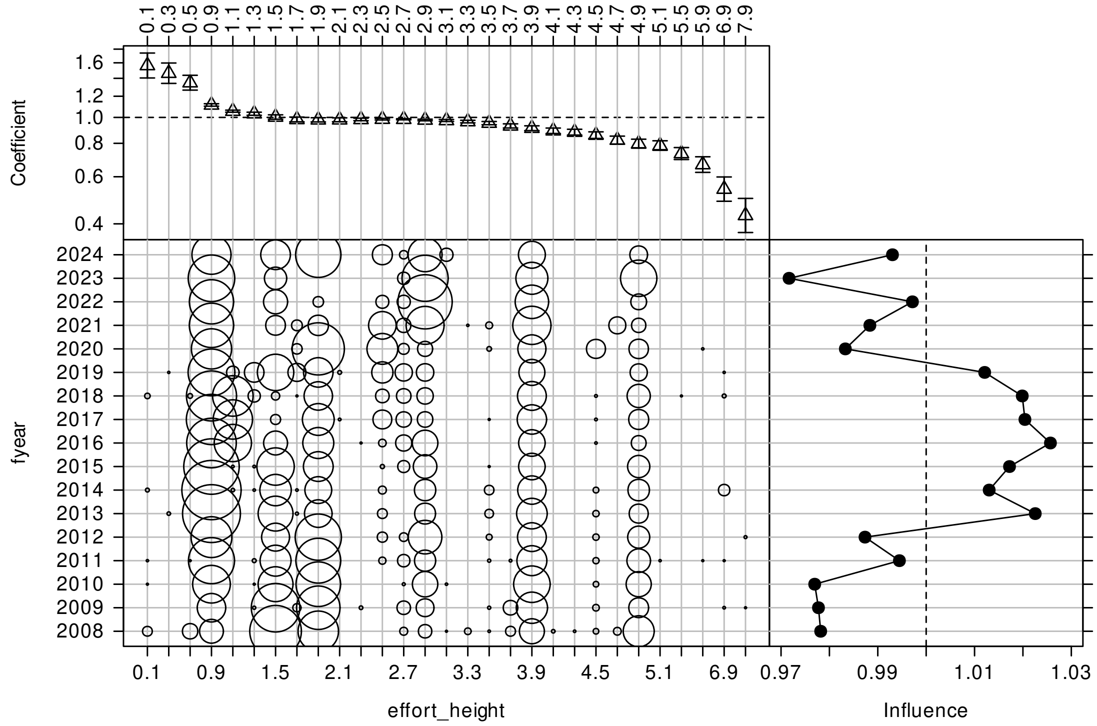

Figure C.235: CDI plot for effort height (m) for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

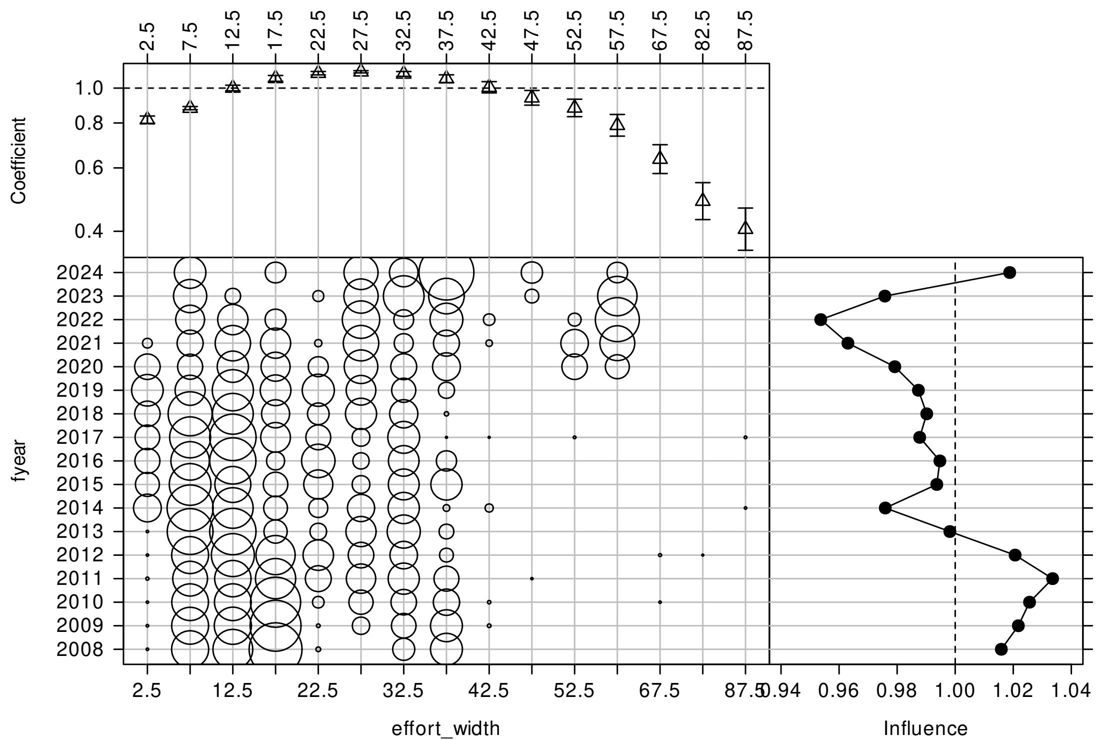

Figure C.236: CDI plot for effort width for the Weibull model of positive catches in the Hawke Bay FLA BT-MIX event (split long vessels) catch-per-unit-effort dataset.

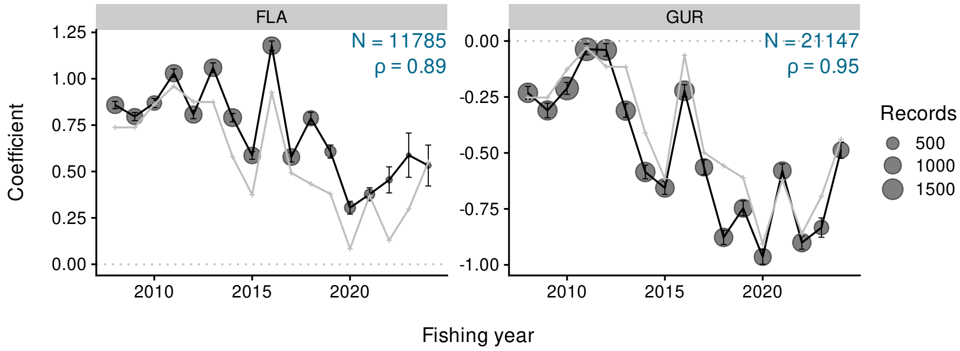

Figure C.237: Residual implied coefficients for target-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

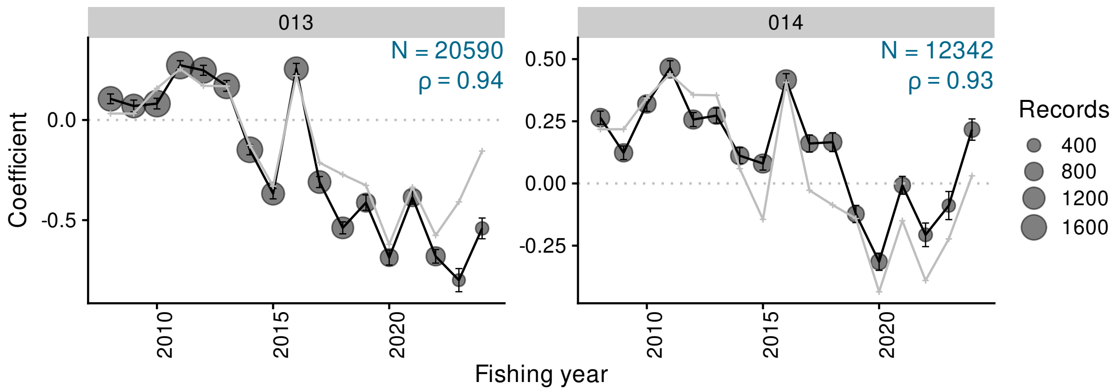

Figure C.238: Residual implied coefficients for area-year in the Weibull positive catch model for the Hawke Bay FLA BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when 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.

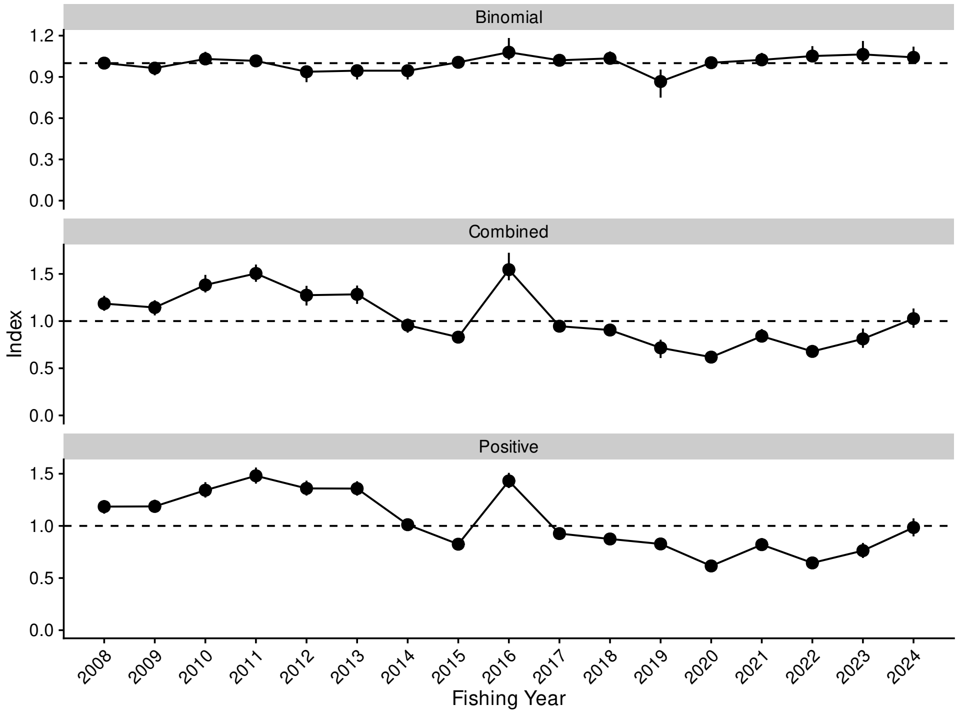

Figure C.239: Standardised indices and 95% confidence intervals for the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

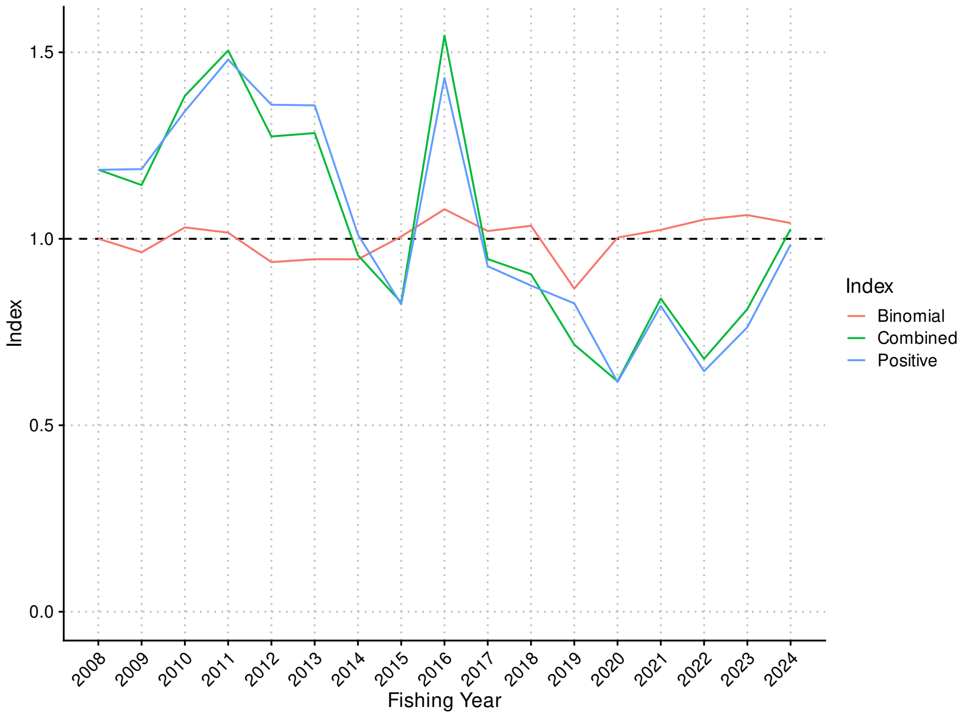

Figure C.240: Standardised indices for the Hawke Bay FLA BT-MIX event (split long vessels) dataset.

Table C.64: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay FLA BT-MIX event (split long vessels) series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.000	0.020	0.965	1.042	1.185	0.040	1.109	1.268	1.185	0.033	1.117	1.247
2009	0.964	0.021	0.912	0.996	1.144	0.041	1.060	1.221	1.187	0.032	1.126	1.251
2010	1.031	0.020	1.002	1.082	1.383	0.048	1.303	1.490	1.342	0.038	1.272	1.419
2011	1.016	0.017	0.990	1.055	1.505	0.047	1.416	1.599	1.480	0.039	1.405	1.560
2012	0.937	0.031	0.862	0.982	1.274	0.053	1.165	1.374	1.359	0.037	1.291	1.434
2013	0.945	0.027	0.881	0.986	1.284	0.050	1.182	1.377	1.358	0.035	1.290	1.428
2014	0.945	0.026	0.881	0.985	0.956	0.038	0.877	1.027	1.012	0.025	0.965	1.063
2015	1.006	0.016	0.977	1.038	0.829	0.024	0.785	0.878	0.824	0.021	0.783	0.866
2016	1.079	0.041	1.024	1.183	1.545	0.074	1.432	1.724	1.431	0.037	1.363	1.509
2017	1.021	0.018	0.994	1.063	0.946	0.030	0.892	1.008	0.926	0.024	0.881	0.976
2018	1.035	0.020	1.007	1.085	0.905	0.031	0.848	0.971	0.875	0.024	0.829	0.921
2019	0.866	0.052	0.749	0.953	0.716	0.050	0.608	0.803	0.827	0.027	0.775	0.882
2020	1.003	0.019	0.964	1.039	0.618	0.026	0.571	0.671	0.616	0.022	0.575	0.662
2021	1.024	0.023	0.986	1.075	0.840	0.036	0.775	0.915	0.820	0.031	0.760	0.883
2022	1.052	0.029	1.009	1.124	0.678	0.032	0.621	0.747	0.645	0.024	0.599	0.695
2023	1.064	0.039	1.010	1.161	0.811	0.052	0.716	0.921	0.763	0.037	0.692	0.837
2024	1.042	0.031	1.000	1.120	1.026	0.052	0.929	1.134	0.984	0.044	0.900	1.072

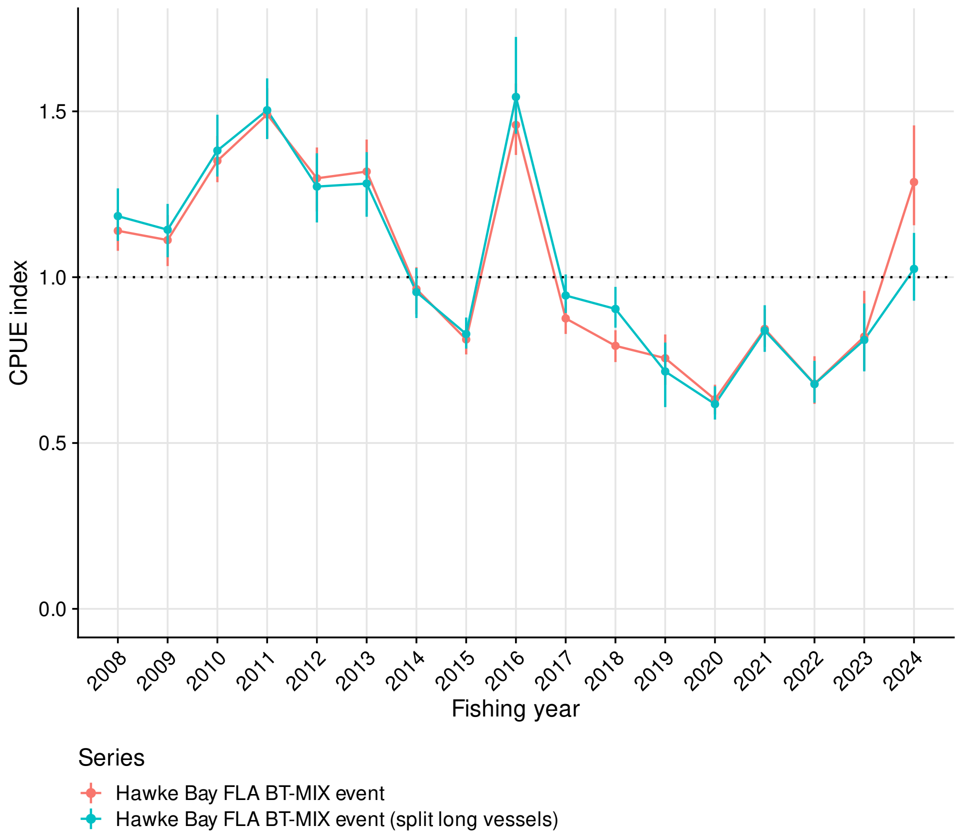

Figure C.241: Comparison of the event resolution series for flatfish species in Hawke Bay, with and without splitting vessels with long participation.

C.12 Hawke Bay ESO BT-MIX event (split long vessels)

The INSWG was concerned that BT vessels which had participated in the ESO 2 fishery for a long period had learned to improve their capacity to catch ESO, with the associated increase in catch rate being interpreted as an increase in abundance rather than as an improvement in fishing power. This CPUE analysis was prepared as a sensitivity to test for this potential bias by splitting vessels that had been in the fishery for at least 12 years into two randomised blocks, forcing the split between 8 and 12 years. This model used the same criteria as specified for the Hawke Bay ESO BT-MIX event model (Section 4.3: compare Table C.65 with Table 10) except that the number of vessels in the analysis had been increased with shorter time blocks (Figure C.242; Figure C.243).

Figure C.267 compares the event-based combined target FLA/GUR BT CPUE series based on the New Zealand sole (ESO) catch with the same analysis which randomly split vessels with participation of 12 or more years in the fishery (documented in Appendix C.12). While splitting the long participation vessels had some impact on this series, the INSWG agreed to accept the series without splitting for monitoring ESO abundance because the period covered by the series began in 2008, which was felt to be sufficiently recent for most technological changes to have already been integrated into the fishery. The INSWG also felt that the randomisation method used to split the vessels may have caused unintended effects in the series estimation procedure, which required validation.

Table C.65: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay ESO BT-MIX event (split long vessels) CPUE series.

Series	Hawke Bay ESO BT-MIX event (split long vessels)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	ESO ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

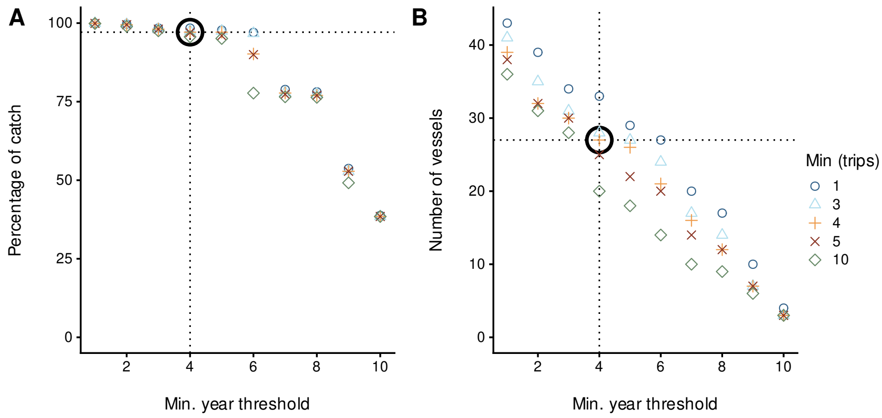

Figure C.242: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay ESO BT-MIX event (split long vessels) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

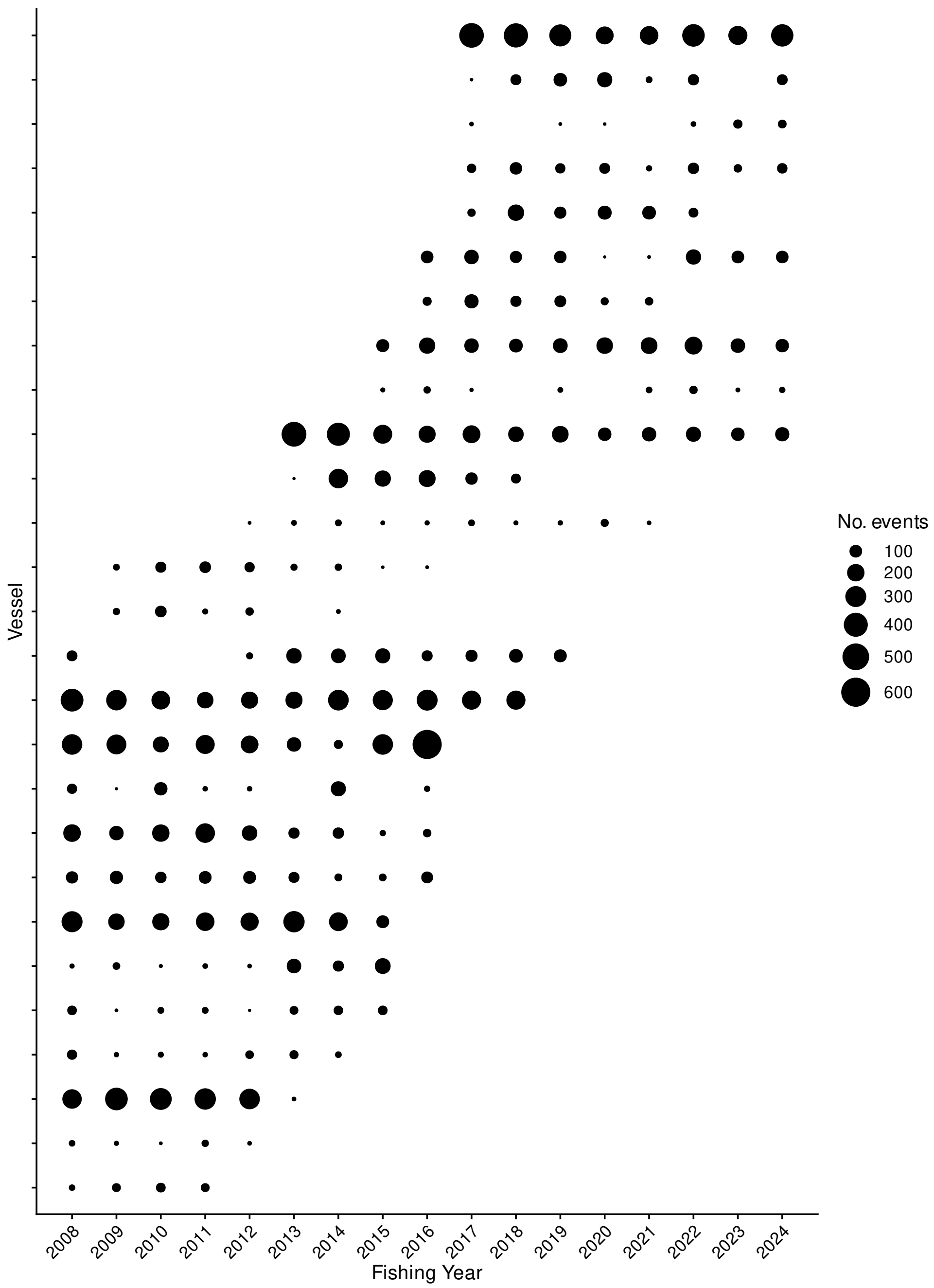

Figure C.243: Number of events by fishing year for core vessels in the Hawke Bay ESO BT-MIX event (split long vessels) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.66: Summary of the Hawke Bay ESO BT-MIX event (split long vessels) dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	39 (100%) n: 2087	30 (100%) n: 1515	37 (100%) n: 1601	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Positive fishing duration	39 (100%) n: 2087	30 (100%) n: 1513	37 (100%) n: 1599	64 (100%) n: 1669	37 (100%) n: 1390	82 (100%) n: 1673	65 (100%) n: 2086	30 (100%) n: 1782	44 (100%) n: 1867
Fishing duration less than 6 h	39 (100%) n: 2077	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1664	37 (100%) n: 1387	82 (100%) n: 1669	63 (98%) n: 2068	30 (100%) n: 1779	44 (100%) n: 1864
Bottom depth < 150m	39 (100%) n: 2076	29 (100%) n: 1506	37 (100%) n: 1595	64 (100%) n: 1662	37 (100%) n: 1387	82 (100%) n: 1669	63 (97%) n: 2066	30 (100%) n: 1777	44 (100%) n: 1864
Core fleet selection	37 (95%) n: 1801	29 (99%) n: 1490	37 (99%) n: 1579	64 (99%) n: 1566	37 (100%) n: 1378	82 (100%) n: 1647	60 (92%) n: 1817	28 (91%) n: 1624	44 (100%) n: 1863

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1277	11 (100%) n: 946	9 (100%) n: 809	10 (100%) n: 1519	5.4 (100%) n: 885	14 (100%) n: 1093
Positive fishing duration	28 (100%) n: 1740	21 (100%) n: 1710	20 (100%) n: 1273	11 (99%) n: 943	9 (100%) n: 808	10 (100%) n: 1518	5.4 (100%) n: 884	14 (100%) n: 1093
Fishing duration less than 6 h	27 (99%) n: 1722	21 (99%) n: 1699	20 (100%) n: 1260	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1505	5.4 (100%) n: 871	14 (100%) n: 1085
Bottom depth < 150m	27 (99%) n: 1722	21 (99%) n: 1698	20 (100%) n: 1258	11 (99%) n: 933	9 (100%) n: 802	10 (99%) n: 1501	5.4 (100%) n: 870	14 (100%) n: 1081
Core fleet selection	26 (96%) n: 1598	20 (95%) n: 1627	19 (98%) n: 1245	11 (99%) n: 931	9 (99%) n: 788	8.2 (80%) n: 1124	4.1 (76%) n: 693	13 (91%) n: 882

Table C.67: Summary of the Hawke Bay ESO BT-MIX event (split long vessels) dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	13	656	1 801	5 686.15	37.38	80.18
2009	14	675	1 490	4 852.32	29.18	78.86
2010	14	683	1 579	5 200.67	36.71	70.93
2011	14	700	1 566	5 152.73	63.82	77.20
2012	15	622	1 378	4 437.47	37.15	70.32
2013	14	567	1 647	5 098.95	81.58	69.52
2014	15	649	1 817	5 762.42	59.80	73.25
2015	14	662	1 624	5 245.20	27.65	58.31
2016	14	711	1 863	5 865.78	43.90	48.09
2017	14	635	1 598	5 062.25	26.38	51.50
2018	12	623	1 627	5 268.70	20.46	45.54
2019	12	460	1 245	4 511.78	19.27	57.83
2020	10	382	931	3 413.22	10.99	52.31
2021	10	368	788	2 635.32	8.99	66.12
2022	9	397	1 124	3 962.38	8.21	57.38
2023	7	235	693	2 485.07	4.14	50.51
2024	8	332	882	2 918.95	13.11	64.85

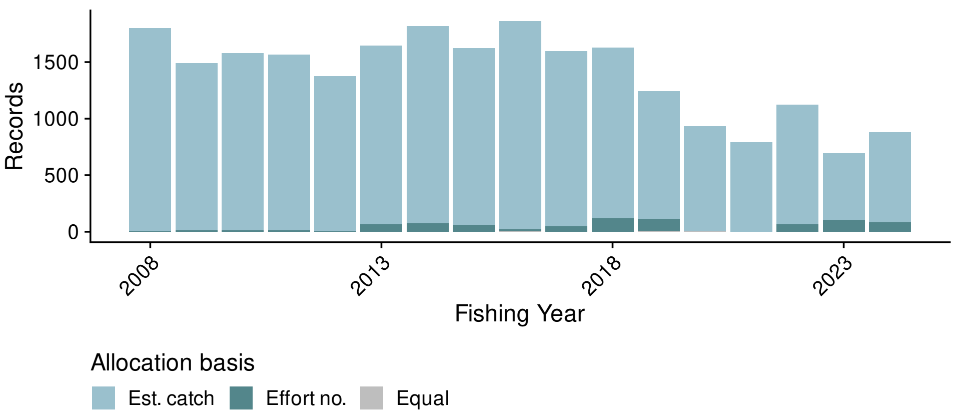

Figure C.244: The allocation approach used for attributing catches to records in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.68: Summary table for occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	30 961.65	0.00	0.00	*
fyear	16	29 634.81	4.39	4.39	*
vessel_key	26	19 988.99	35.71	31.32	*
stat_area	1	19 984.38	35.73	0.02	*
month	11	19 876.04	36.16	0.42	*
target_species	1	19 615.83	37.00	0.85	*
ns(log(fishing_duration), 3)	3	19 613.57	37.03	0.03	*
ns(bottom_depth, 3)	3	19 079.43	38.77	1.74	*

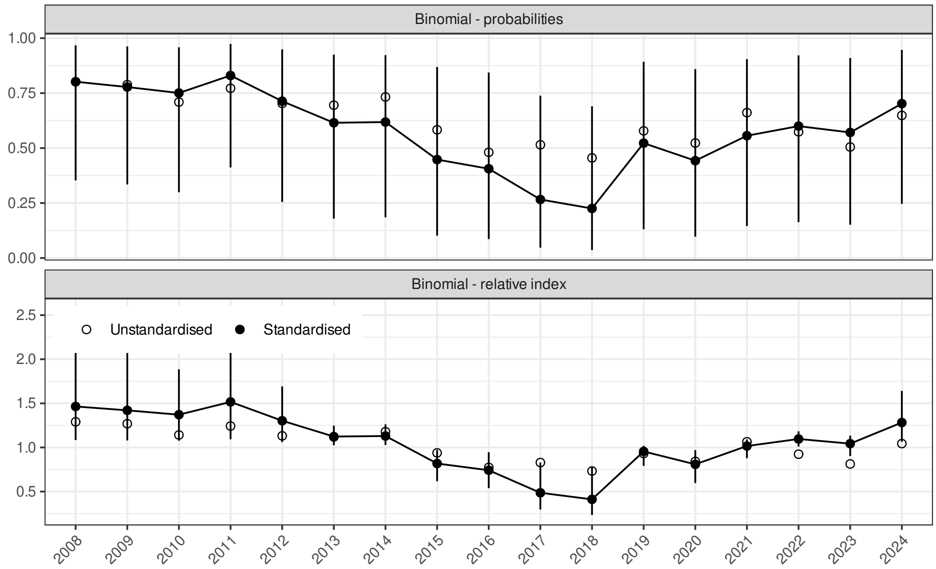

Figure C.245: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay ESO BT-MIX event (split long vessels) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

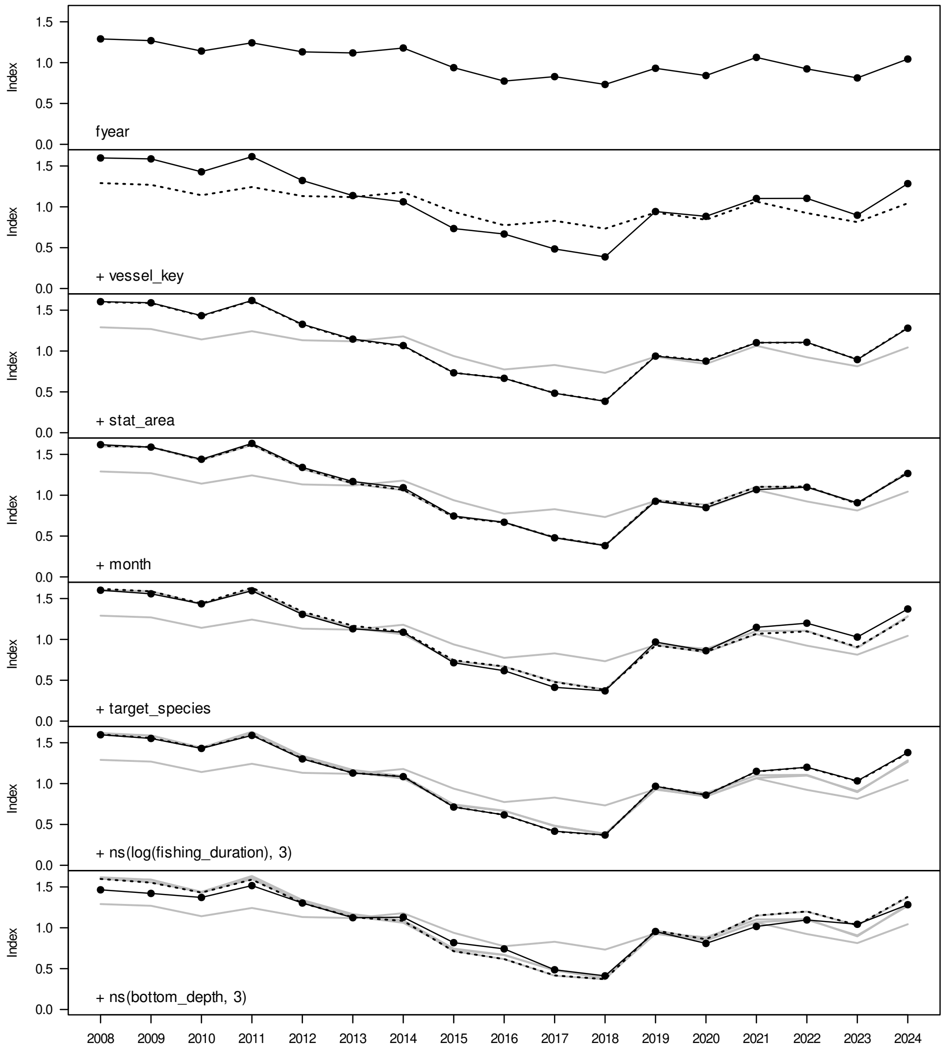

Figure C.246: Step plot for occurrence of catch in the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

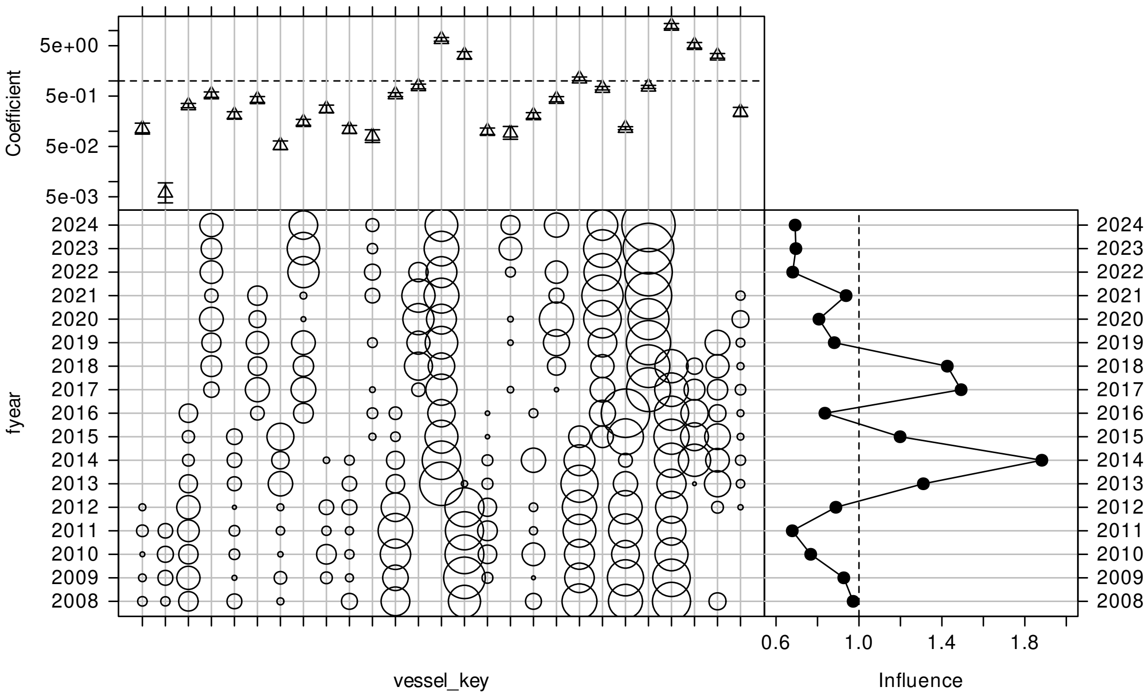

Figure C.247: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

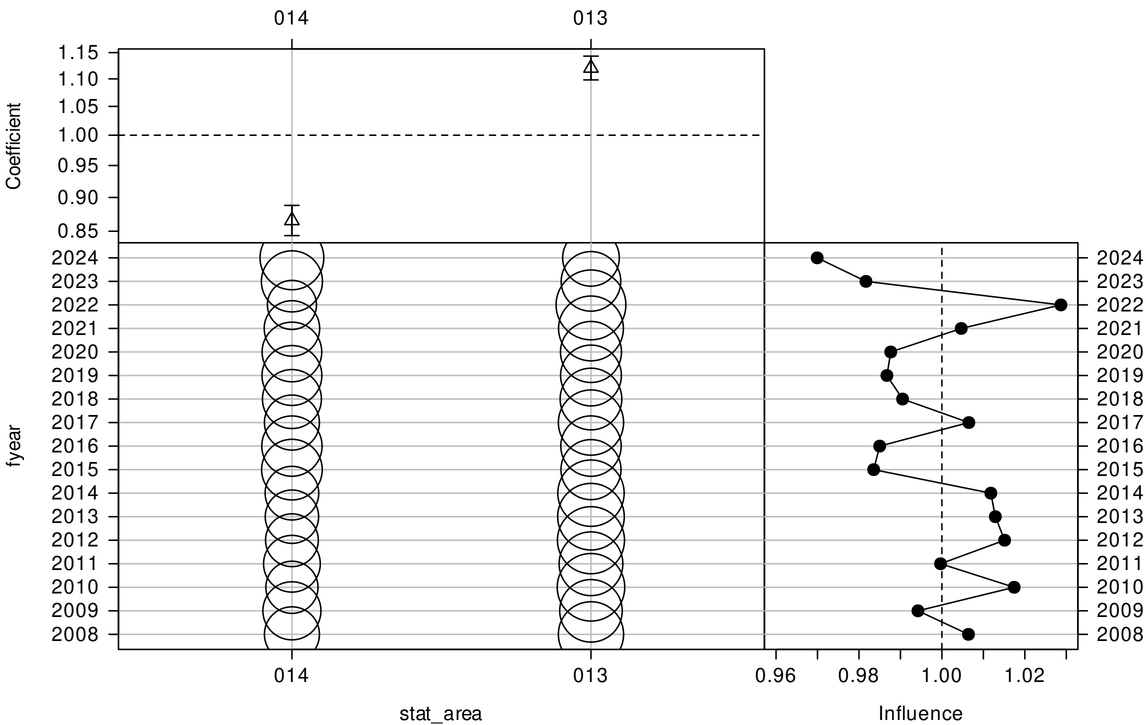

Figure C.248: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

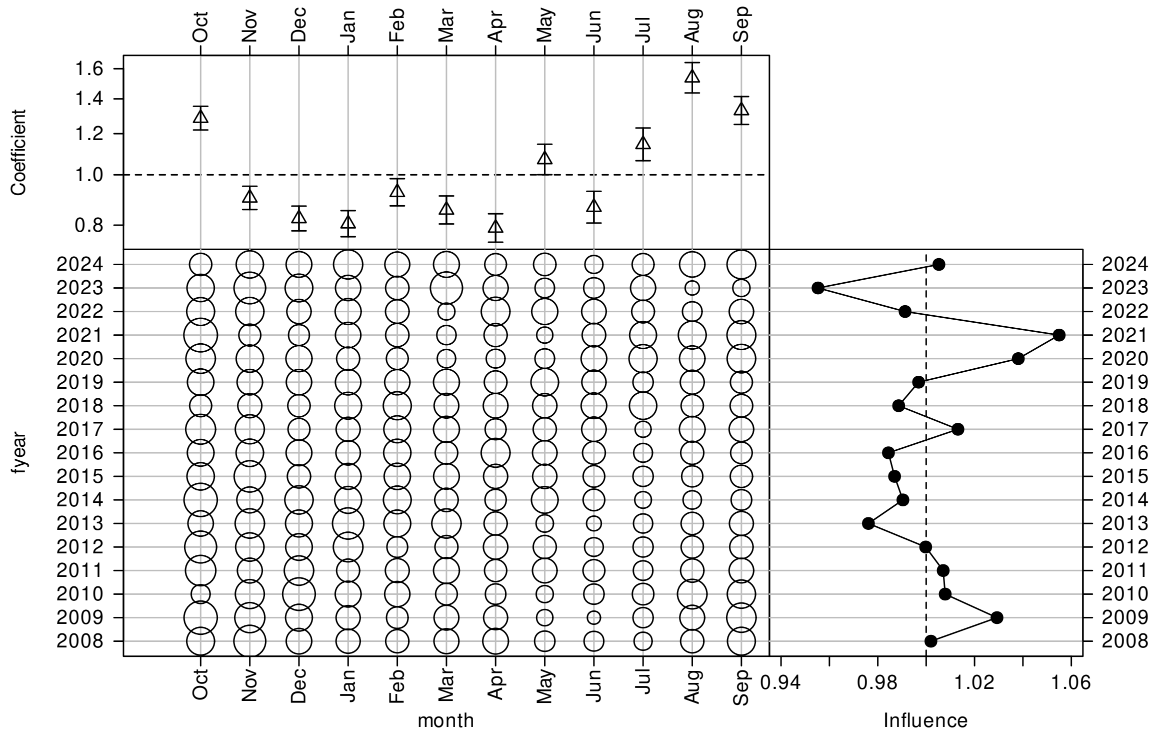

Figure C.249: CDI plot for month for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

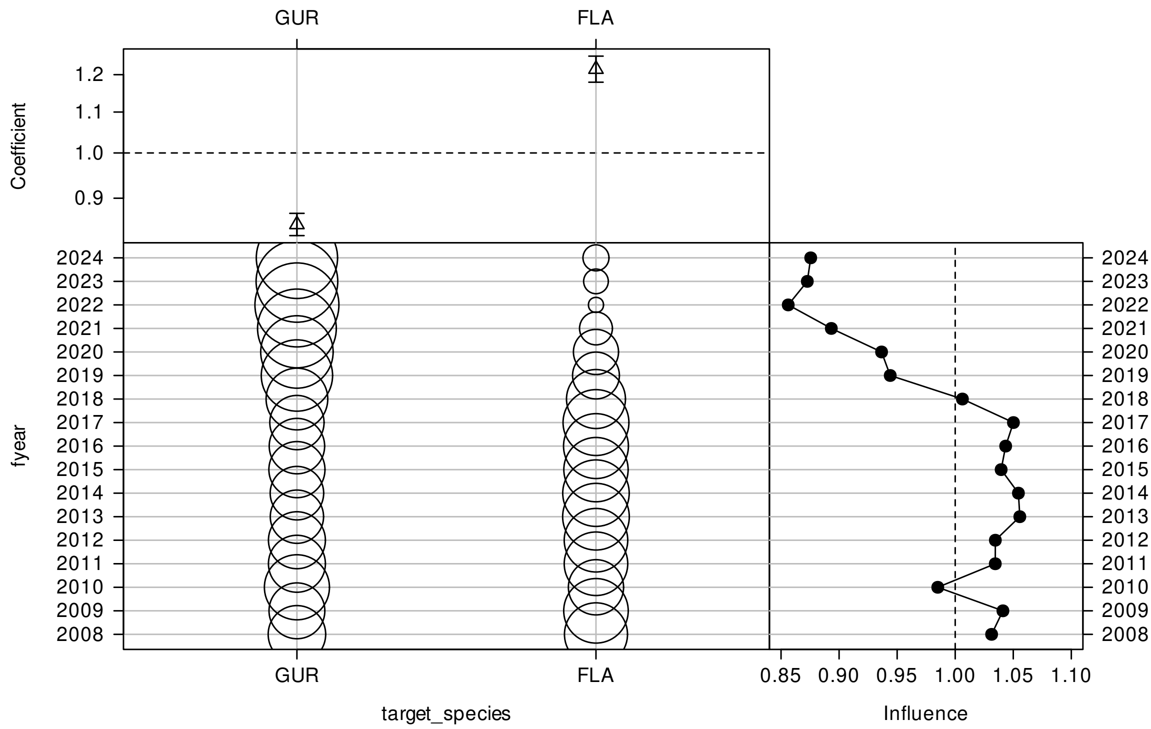

Figure C.250: CDI plot for target species for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

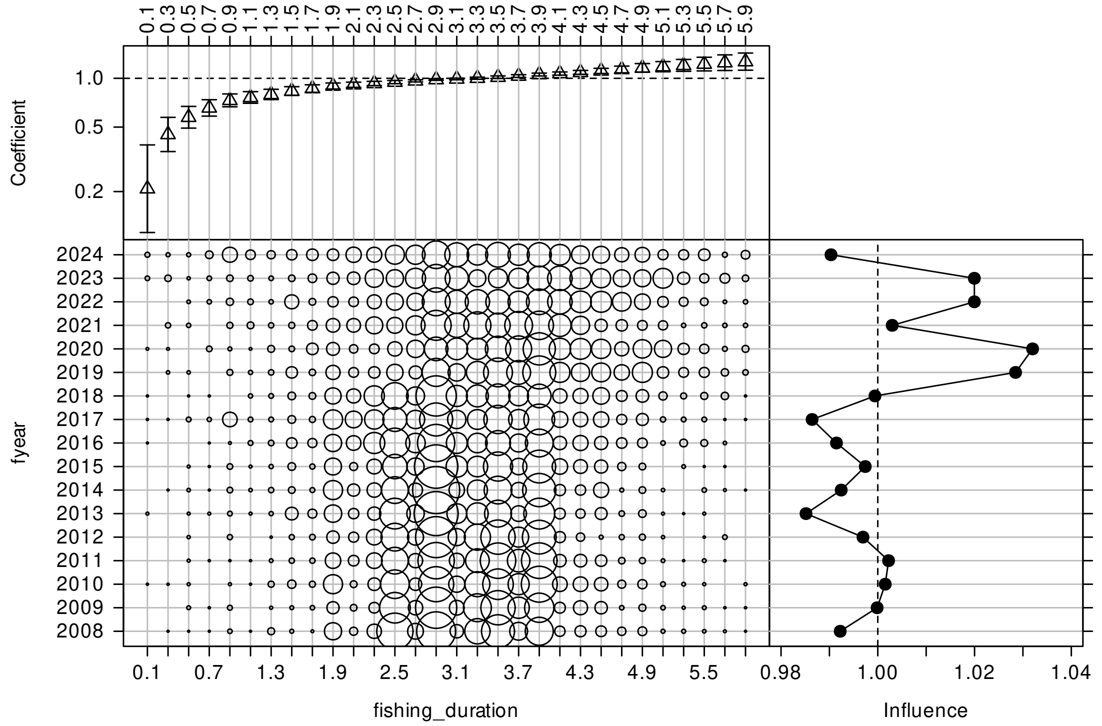

Figure C.251: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

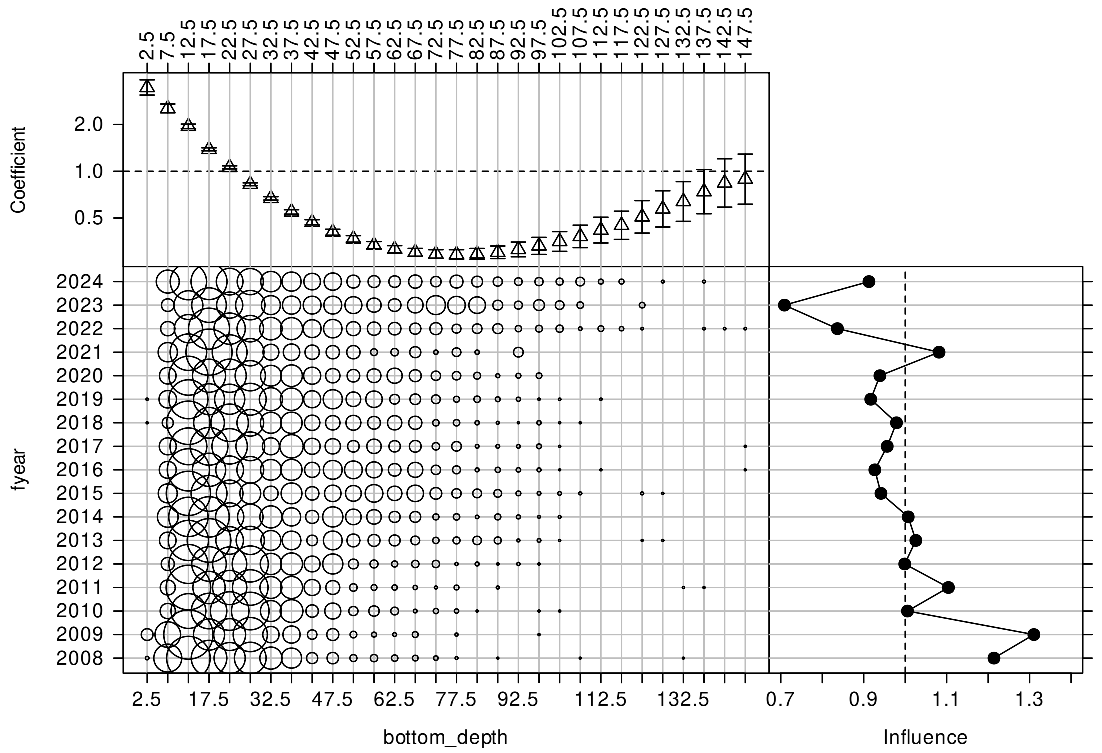

Figure C.252: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

Table C.69: Summary table for the lognormal model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	49 492.97	0.00	0.00	*
fyear	16	47 354.05	13.40	13.40	*
vessel_key	26	44 753.01	27.35	13.96	*
stat_area	1	44 234.37	29.82	2.46	*
month	11	44 124.23	30.43	0.61	*
target_species	1	42 955.73	35.62	5.19	*
ns(log(fishing_duration), 3)	3	42 777.58	36.40	0.78	*
ns(bottom_depth, 3)	3	41 978.62	39.70	3.30	*

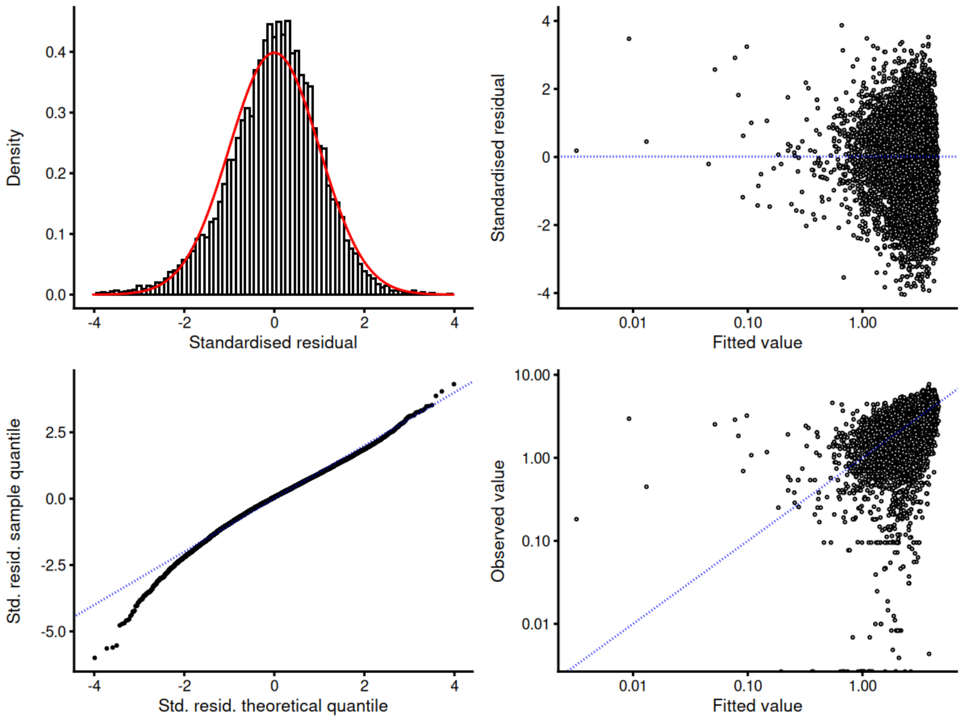

Figure C.253: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

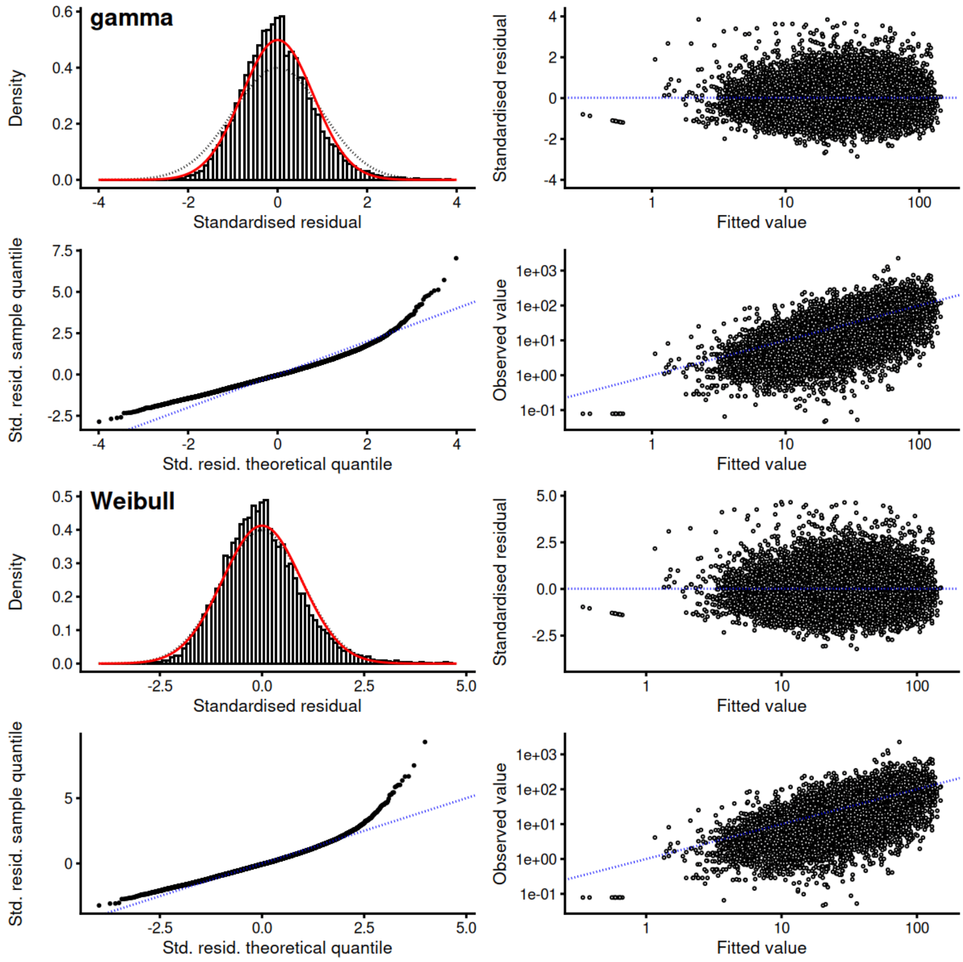

Figure C.254: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

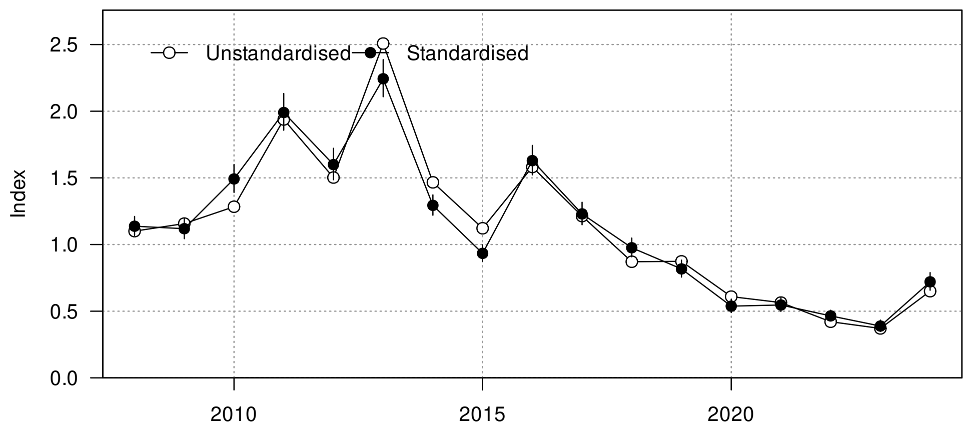

Figure C.255: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

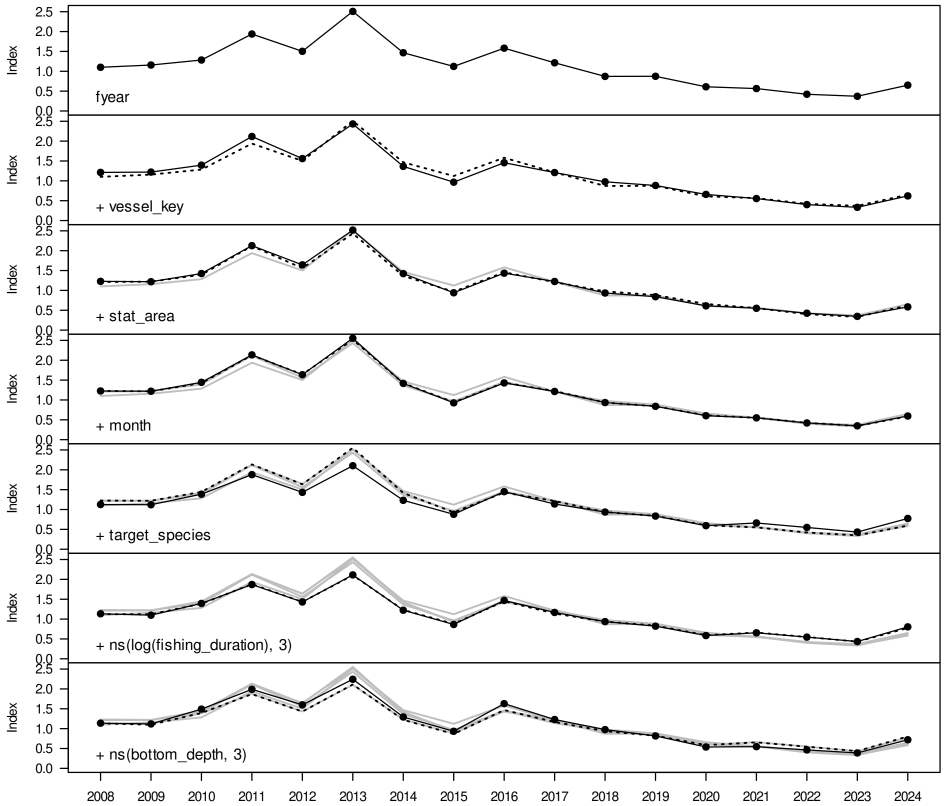

Figure C.256: Changes to the Hawke Bay ESO BT-MIX event (split long vessels) positive catch index as terms are successively entered into the lognormal model.

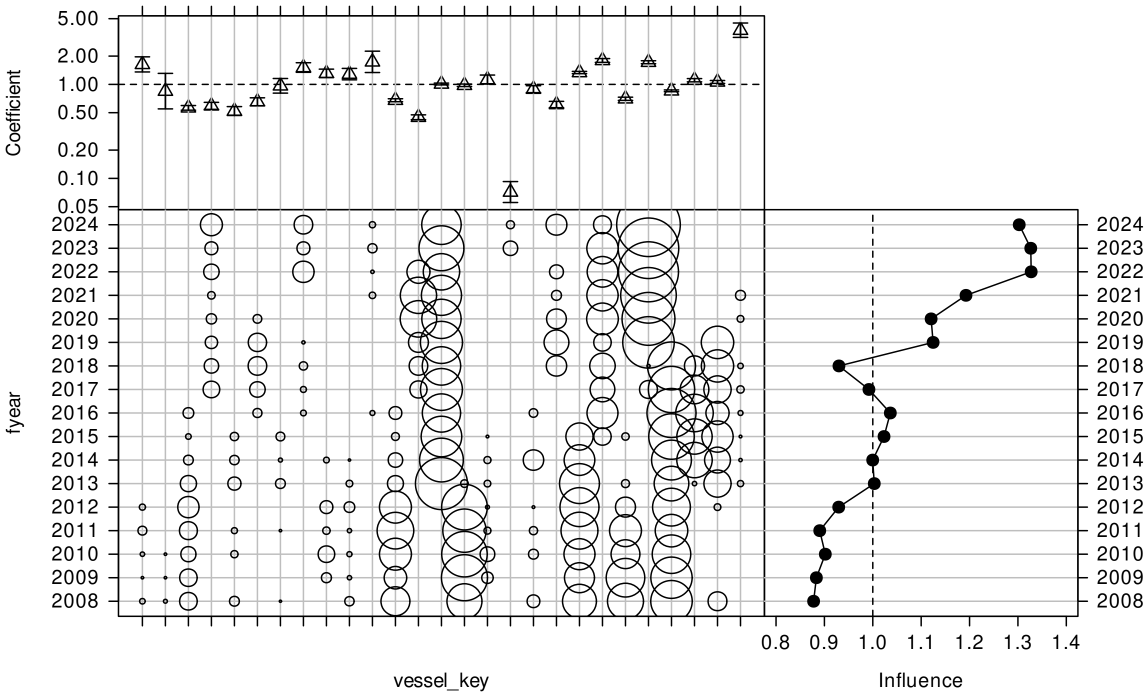

Figure C.257: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

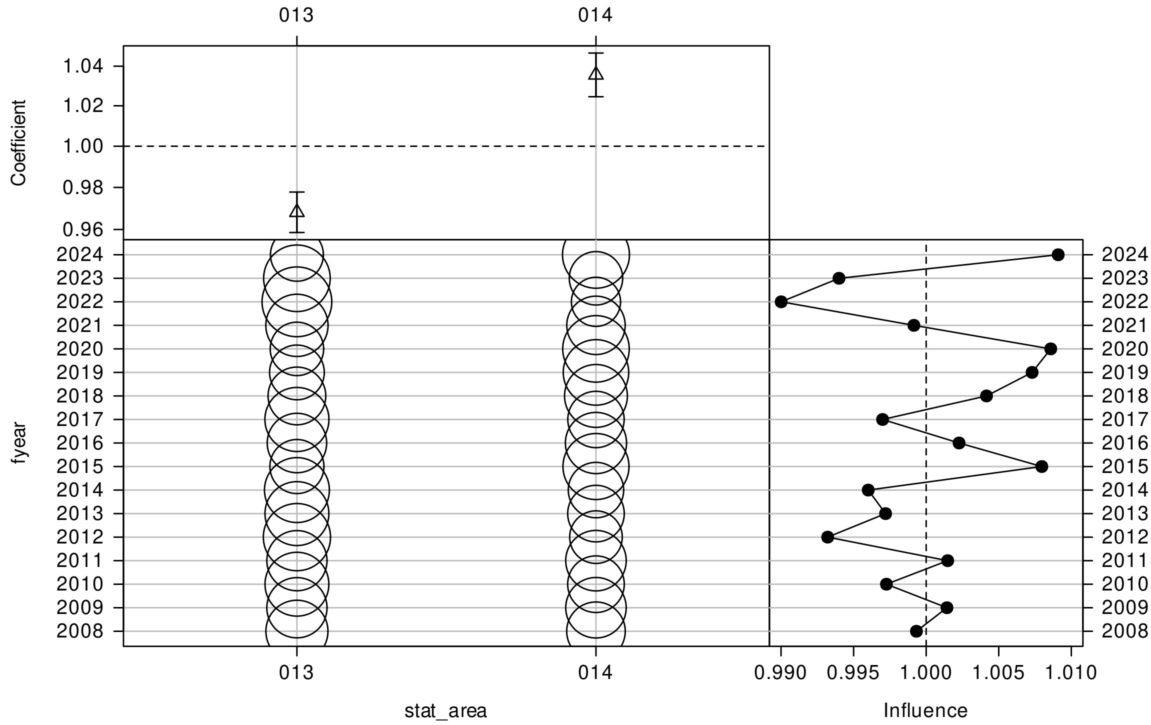

Figure C.258: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

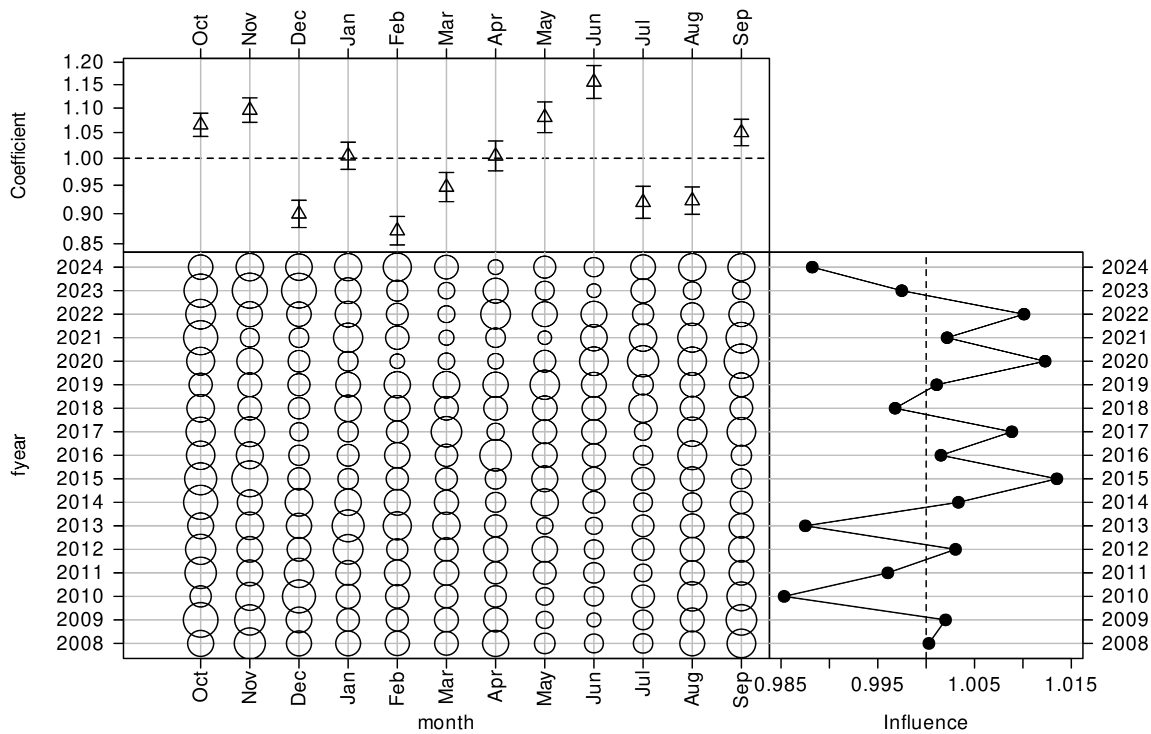

Figure C.259: CDI plot for month for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

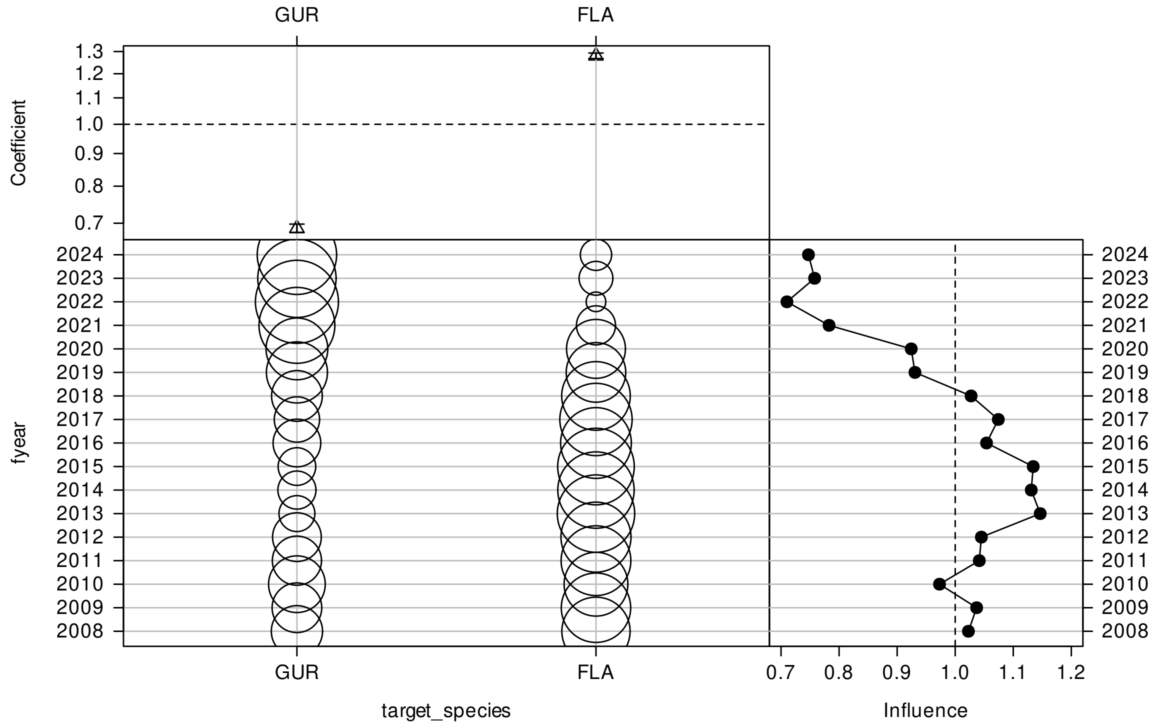

Figure C.260: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

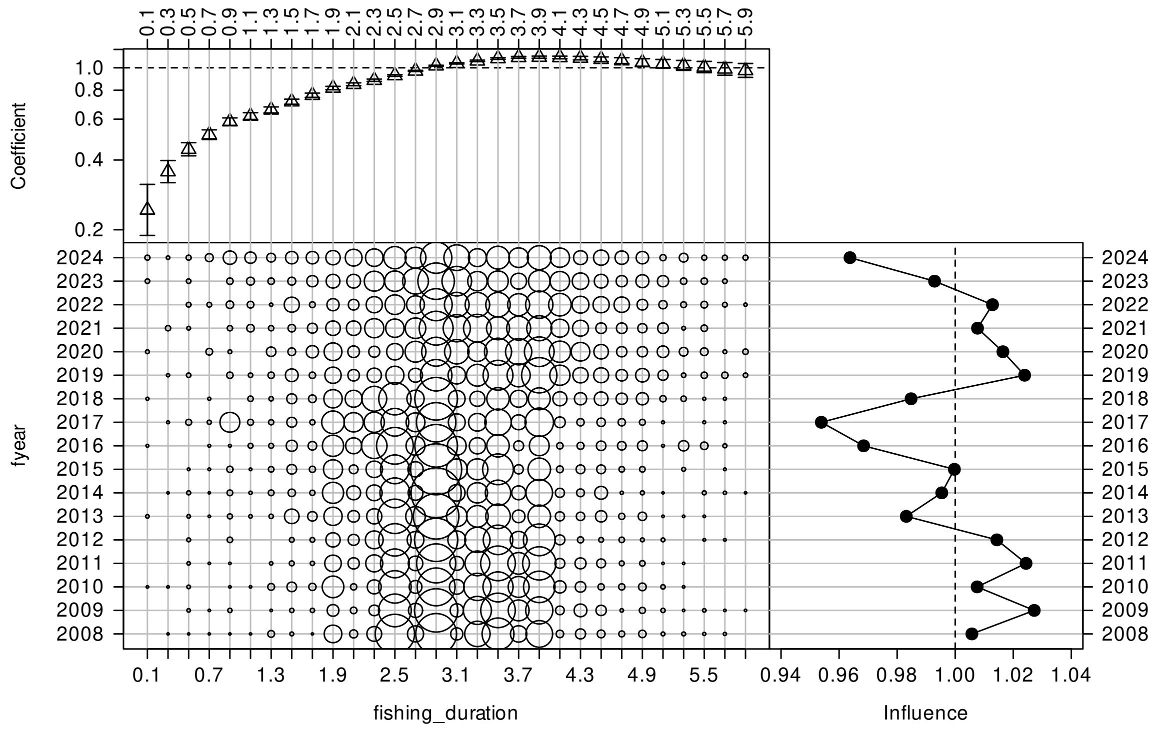

Figure C.261: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

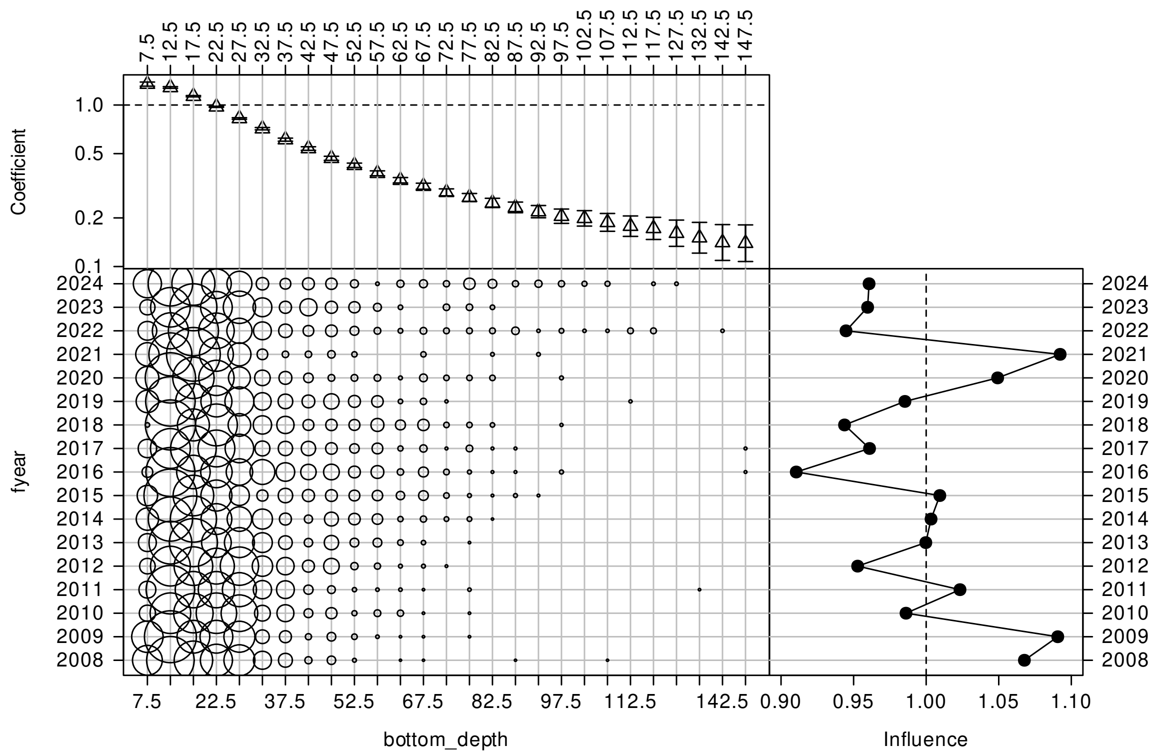

Figure C.262: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay ESO BT-MIX event (split long vessels) catch-per-unit-effort dataset.

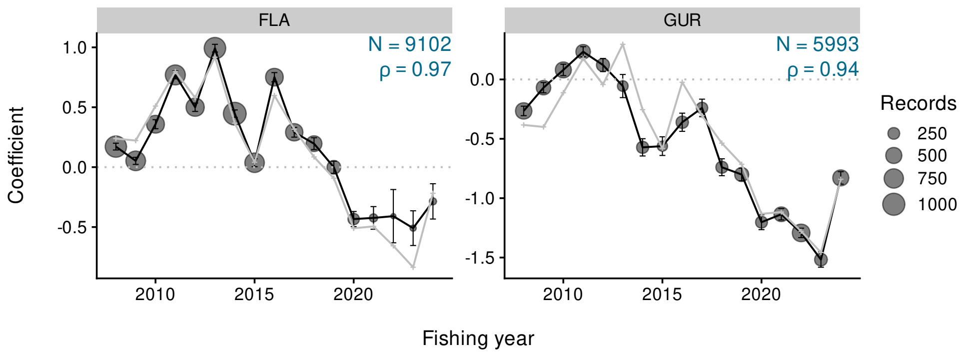

Figure C.263: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay ESO BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

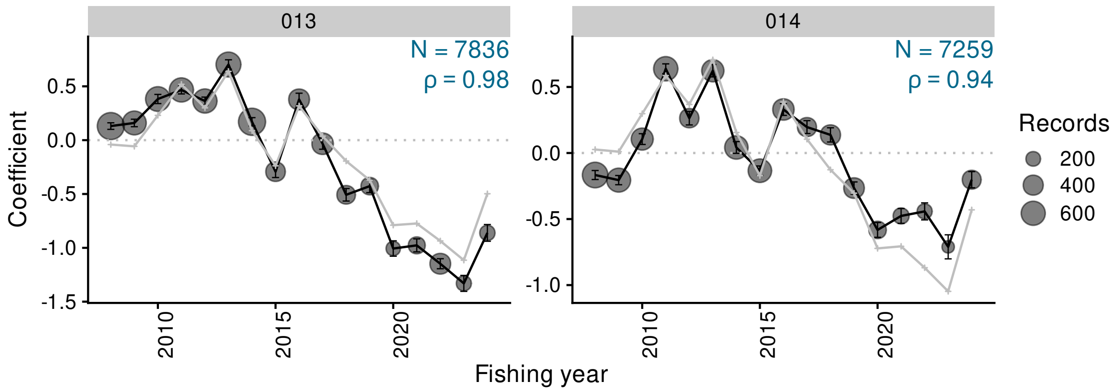

Figure C.264: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay ESO BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted 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.

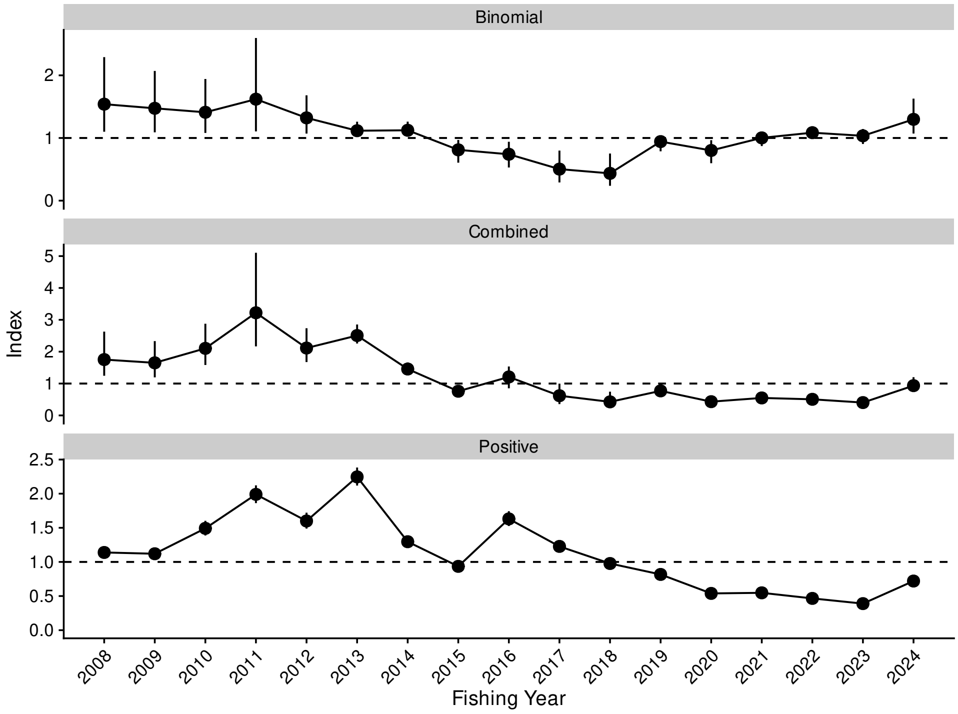

Figure C.265: Standardised indices and 95% confidence intervals for the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

Figure C.266: Standardised indices for the Hawke Bay ESO BT-MIX event (split long vessels) dataset.

Table C.70: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay ESO BT-MIX event (split long vessels) series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.540	0.304	1.100	2.291	1.753	0.353	1.244	2.629	1.139	0.035	1.070	1.208
2009	1.474	0.250	1.090	2.070	1.650	0.290	1.194	2.332	1.120	0.038	1.045	1.193
2010	1.410	0.220	1.081	1.942	2.104	0.330	1.583	2.877	1.492	0.055	1.387	1.603
2011	1.620	0.380	1.105	2.596	3.221	0.749	2.167	5.105	1.990	0.066	1.861	2.122
2012	1.321	0.156	1.070	1.681	2.114	0.271	1.674	2.736	1.600	0.059	1.489	1.721
2013	1.116	0.061	1.022	1.260	2.507	0.152	2.256	2.853	2.246	0.067	2.119	2.383
2014	1.123	0.059	1.031	1.261	1.456	0.091	1.308	1.664	1.296	0.039	1.222	1.376
2015	0.811	0.092	0.606	0.968	0.758	0.090	0.564	0.915	0.935	0.031	0.875	0.999
2016	0.740	0.105	0.529	0.940	1.207	0.175	0.851	1.535	1.631	0.055	1.526	1.743
2017	0.503	0.130	0.291	0.799	0.618	0.164	0.355	0.997	1.227	0.041	1.151	1.311
2018	0.435	0.131	0.237	0.752	0.425	0.131	0.230	0.744	0.977	0.035	0.908	1.045
2019	0.943	0.060	0.788	1.021	0.770	0.057	0.643	0.866	0.817	0.031	0.756	0.878
2020	0.801	0.094	0.597	0.965	0.431	0.054	0.317	0.530	0.539	0.026	0.489	0.591
2021	1.002	0.054	0.871	1.084	0.548	0.038	0.469	0.619	0.547	0.024	0.501	0.596
2022	1.085	0.047	1.003	1.186	0.505	0.030	0.450	0.568	0.466	0.020	0.428	0.507
2023	1.035	0.061	0.904	1.144	0.403	0.031	0.344	0.466	0.389	0.021	0.350	0.432
2024	1.297	0.142	1.071	1.628	0.934	0.115	0.749	1.199	0.720	0.033	0.659	0.789

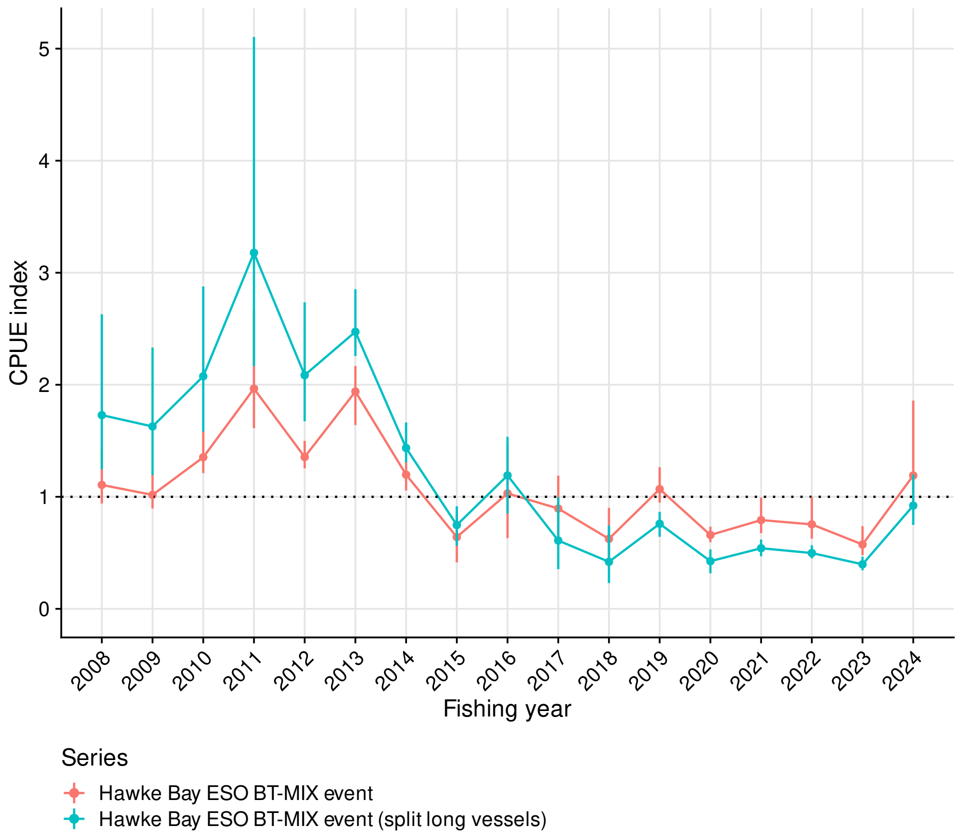

Figure C.267: Comparison of the event resolution series for New Zealand sole (ESO) in Hawke Bay, with and without splitting vessels with long participation.

C.13 Hawke Bay SFL BT-MIX event (split long vessels)

The INSWG was concerned that BT vessels which had participated in the SFL 2 fishery for a long period had learned to improve their capacity to catch SFL, with the associated increase in catch rate being interpreted as an increase in abundance rather than as an improvement in fishing power. This CPUE analysis was prepared as a sensitivity to test for this potential bias by splitting vessels that had been in the fishery for at least 12 years into two randomised blocks, forcing the split between 8 and 12 years. This model used the same criteria as specified for the Hawke Bay SFL BT-MIX event model (Section 4.4: compare Table C.71 with Table 16) except that the number of vessels in the analysis had been increased with shorter time blocks (Figure C.268; Figure C.269).

Figure C.293 compares the event-based combined target FLA/GUR BT CPUE series based on the sand flounder (SFL) catch with the same analysis which randomly split vessels with participation of 12 or more years in the fishery (documented in Appendix C.13). While splitting the long participation vessels had some impact on this series, the INSWG agreed to accept the series without splitting for monitoring SFL abundance because the period covered by the series began in 2008, which was felt to be sufficiently recent for most technological changes to have already been integrated into the fishery. The INSWG also felt that the randomisation method used to split the vessels may have caused unintended effects in the series estimation procedure, which required validation.

Table C.71: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the Hawke Bay SFL BT-MIX event (split long vessels) CPUE series.

Series	Hawke Bay SFL BT-MIX event (split long vessels)
QMS stock	FLA 2
Reporting forms	ERS - Trawl, TCE
Fishing methods	BT
Target species	FLA, GUR
Statistical Areas	013, 014
Period	2007-10-01, 2024-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	4
Default model	SFL ~ fyear + vessel_key + stat_area + month + target_species + ns(log(fishing_duration), 3) + ns(bottom_depth, 3)
Stepwise selection	No
Positive catch distribution	Lognormal

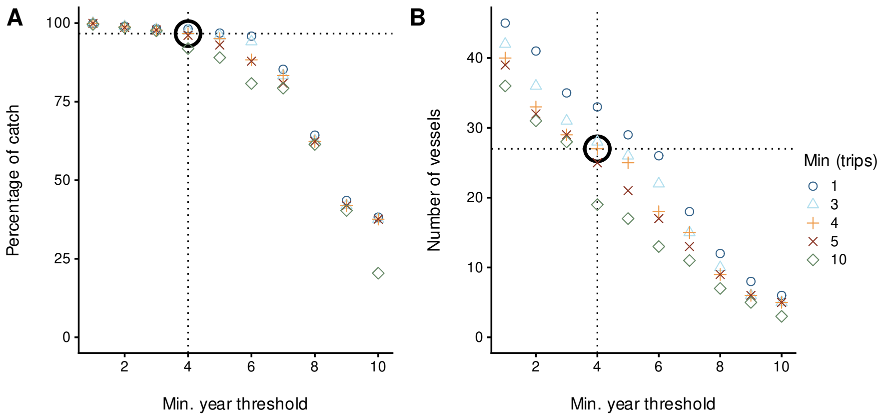

Figure C.268: Percentage of catch and number of vessels for different core vessel selection criteria for the Hawke Bay SFL BT-MIX event (split long vessels) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

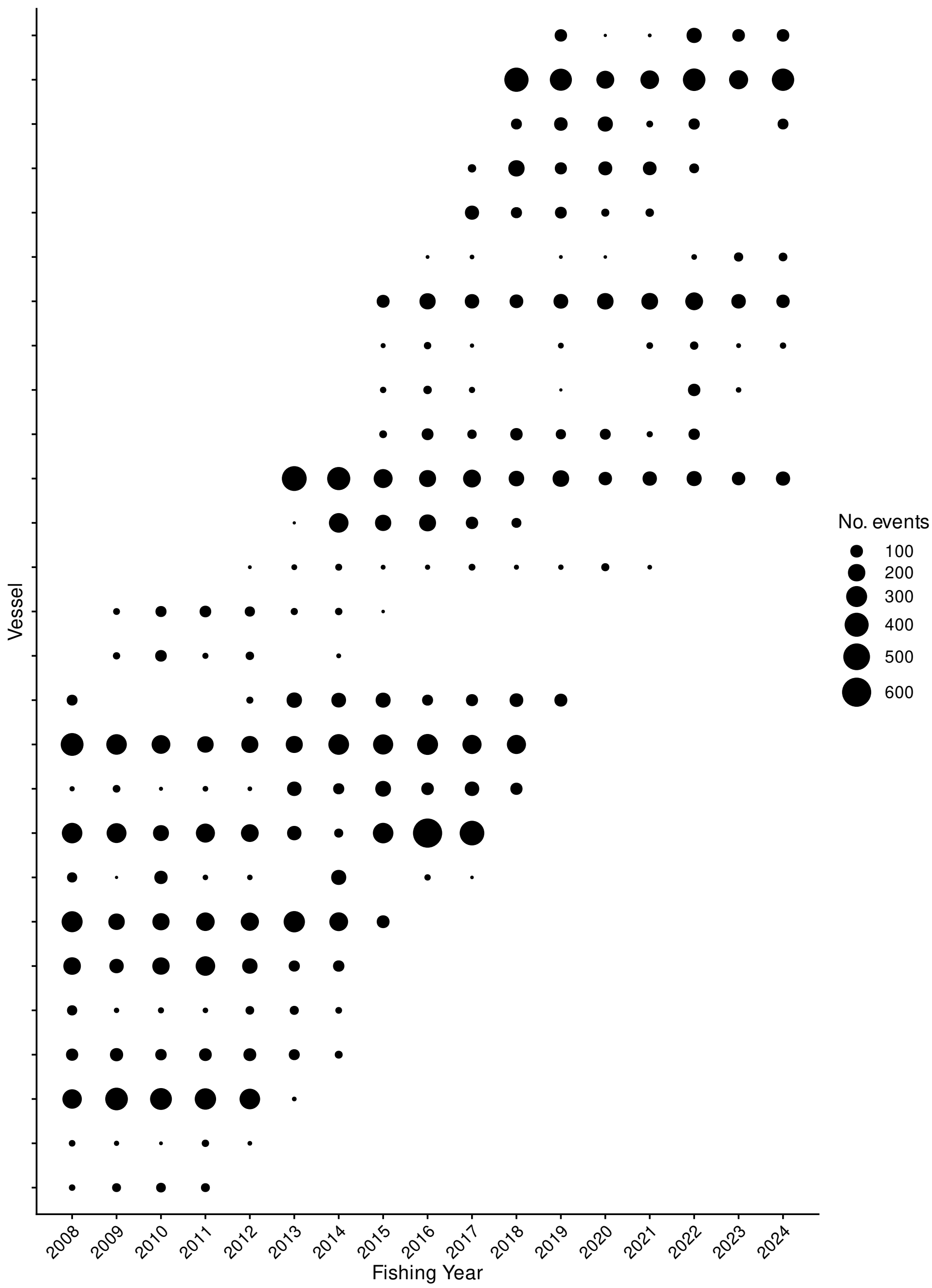

Figure C.269: Number of events by fishing year for core vessels in the Hawke Bay SFL BT-MIX event (split long vessels) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.72: **Summary of the Hawke Bay SFL BT-MIX event (split long vessels) dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied.**

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	36 (100%) n: 2087	45 (100%) n: 1515	34 (100%) n: 1601	52 (100%) n: 1669	19 (100%) n: 1390	38 (100%) n: 1673	31 (100%) n: 2086	25 (100%) n: 1782	55 (100%) n: 1867
Positive fishing duration	36 (100%) n: 2087	45 (100%) n: 1513	34 (100%) n: 1599	52 (100%) n: 1669	19 (100%) n: 1390	38 (100%) n: 1673	31 (100%) n: 2086	25 (100%) n: 1782	55 (100%) n: 1867
Fishing duration less than 6 h	36 (100%) n: 2077	45 (100%) n: 1506	34 (100%) n: 1595	52 (100%) n: 1664	19 (100%) n: 1387	38 (100%) n: 1669	31 (98%) n: 2068	25 (100%) n: 1779	55 (99%) n: 1864
Bottom depth < 150m	36 (100%) n: 2076	45 (100%) n: 1506	34 (100%) n: 1595	52 (99%) n: 1662	19 (100%) n: 1387	38 (100%) n: 1669	31 (98%) n: 2066	25 (100%) n: 1777	55 (99%) n: 1864
Core fleet selection	31 (87%) n: 1747	45 (99%) n: 1485	34 (99%) n: 1555	49 (94%) n: 1542	18 (99%) n: 1375	37 (98%) n: 1603	29 (93%) n: 1765	23 (94%) n: 1570	55 (99%) n: 1816

Filter	2017	2018	2019	2020	2021	2022	2023	2024
Ungroomed data	23 (100%) n: 1740	26 (100%) n: 1710	13 (100%) n: 1277	8.1 (100%) n: 946	5.9 (100%) n: 809	8.7 (100%) n: 1519	11 (100%) n: 885	17 (100%) n: 1093
Positive fishing duration	23 (100%) n: 1740	26 (100%) n: 1710	13 (100%) n: 1273	8 (99%) n: 943	5.9 (100%) n: 808	8.7 (100%) n: 1518	11 (100%) n: 884	17 (100%) n: 1093
Fishing duration less than 6 h	23 (99%) n: 1722	26 (100%) n: 1699	13 (99%) n: 1260	8 (99%) n: 933	5.9 (99%) n: 802	8.5 (98%) n: 1505	11 (99%) n: 871	17 (100%) n: 1085
Bottom depth < 150m	23 (99%) n: 1722	26 (100%) n: 1698	13 (99%) n: 1258	8 (99%) n: 933	5.9 (99%) n: 802	8.5 (98%) n: 1501	11 (99%) n: 870	17 (100%) n: 1081
Core fleet selection	22 (97%) n: 1617	25 (98%) n: 1627	13 (99%) n: 1248	8 (99%) n: 931	5.8 (99%) n: 788	7.8 (90%) n: 1220	11 (95%) n: 667	17 (96%) n: 817

Table C.73: Summary of the Hawke Bay SFL BT-MIX event (split long vessels) dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of flatfish.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	12	646	1 747	5 479.57	31.24	60.33
2009	13	672	1 485	4 832.98	44.71	69.02
2010	13	675	1 555	5 113.33	34.07	60.71
2011	13	692	1 542	5 065.48	49.23	66.02
2012	14	620	1 375	4 426.40	18.48	46.76
2013	13	554	1 603	4 924.80	37.22	57.70
2014	14	634	1 765	5 571.35	29.29	58.24
2015	13	649	1 570	5 048.83	23.48	59.94
2016	13	697	1 816	5 688.55	54.86	66.30
2017	15	644	1 617	5 121.83	22.07	55.53
2018	12	623	1 627	5 268.70	25.10	56.24
2019	13	462	1 248	4 522.53	12.57	54.89
2020	10	382	931	3 413.22	8.00	53.17
2021	10	368	788	2 635.32	5.85	57.11
2022	10	452	1 220	4 317.17	7.81	57.21
2023	7	234	667	2 401.93	10.52	55.32
2024	7	317	817	2 757.63	16.74	70.38

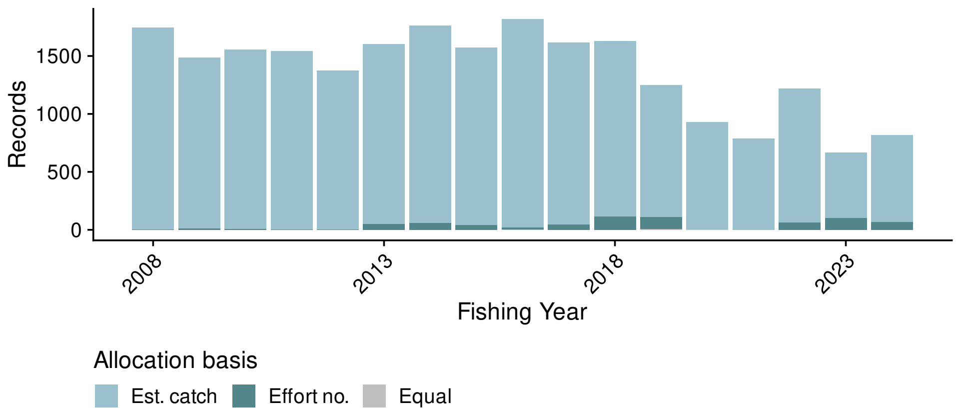

Figure C.270: The allocation approach used for attributing catches to records in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset. Catches were allocated in proportion to the estimated catch for each record (Est. catch allocation), in proportion to the number of fishing events per record (Effort no. allocation), or equally across fishing effort records (Equal allocation).

Table C.74: Summary table for occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) series. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	31 585.38	0.00	0.00	*
fyear	16	31 306.42	0.98	0.98	*
vessel_key	26	28 082.76	11.36	10.37	*
stat_area	1	27 879.48	12.01	0.65	*
month	11	27 672.72	12.73	0.72	*
target_species	1	27 003.43	14.86	2.13	*
ns(log(fishing_duration), 3)	3	26 994.26	14.90	0.05	*
ns(bottom_depth, 3)	3	26 503.11	16.48	1.57	*

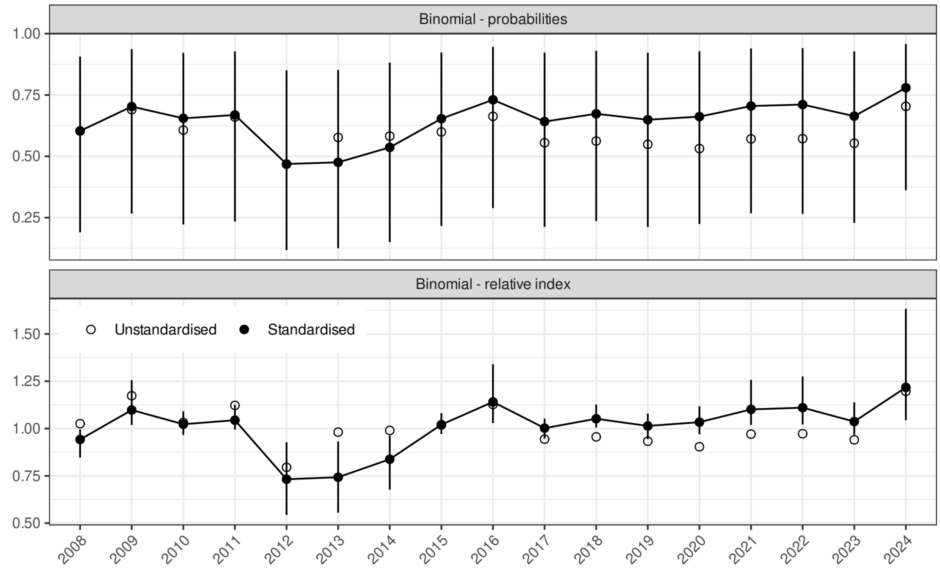

Figure C.271: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the Hawke Bay SFL BT-MIX event (split long vessels) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

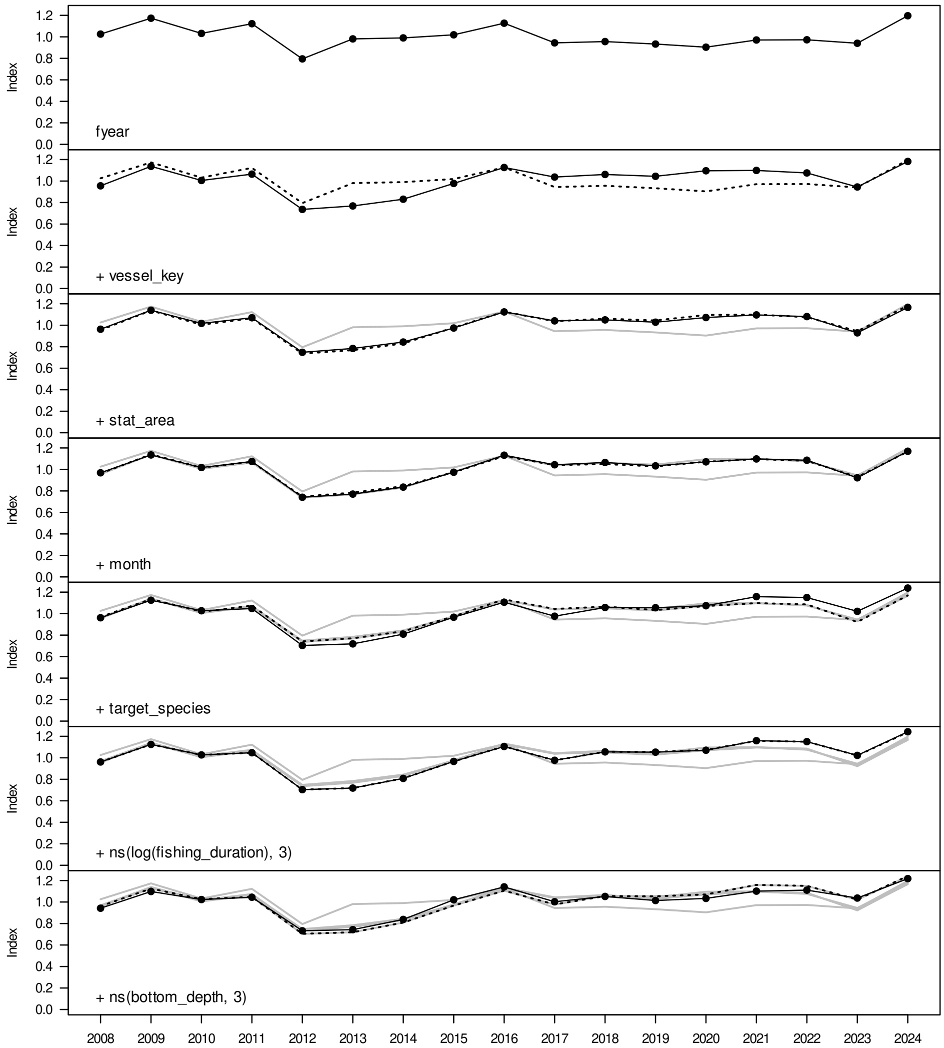

Figure C.272: Step plot for occurrence of catch in the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

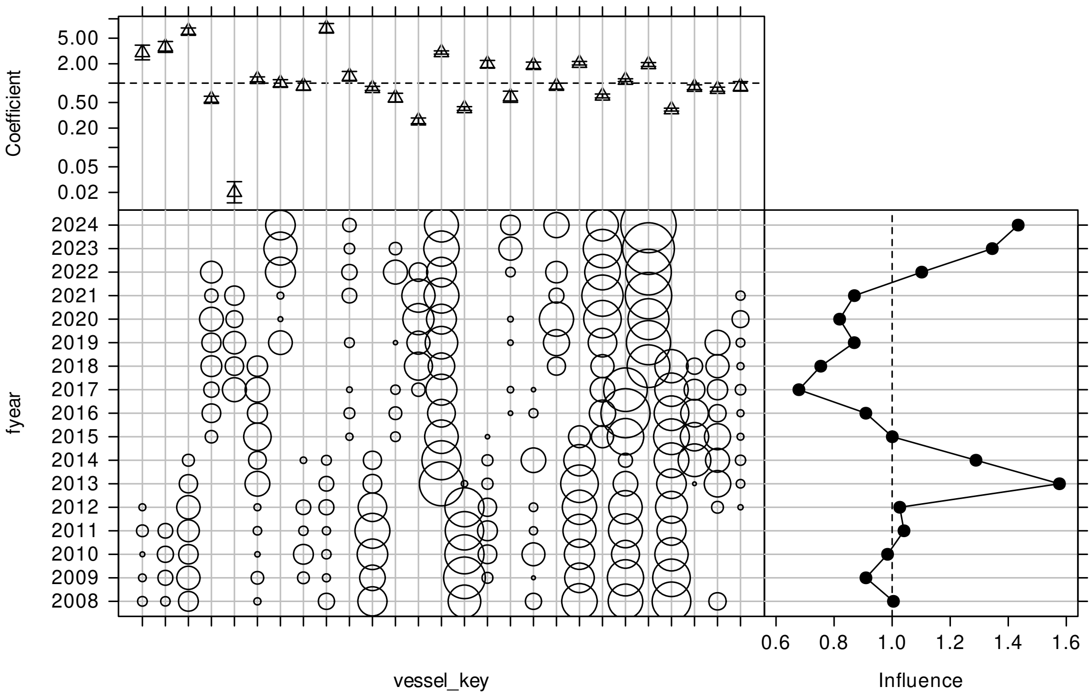

Figure C.273: CDI plot for vessel key for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

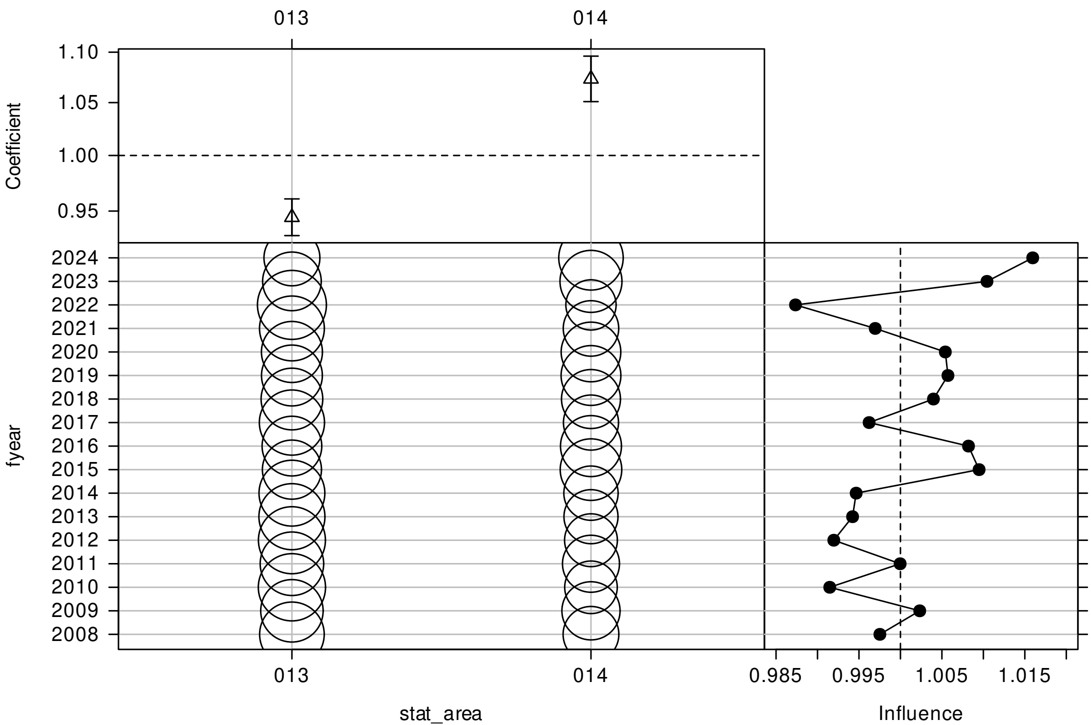

Figure C.274: CDI plot for statistical area for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

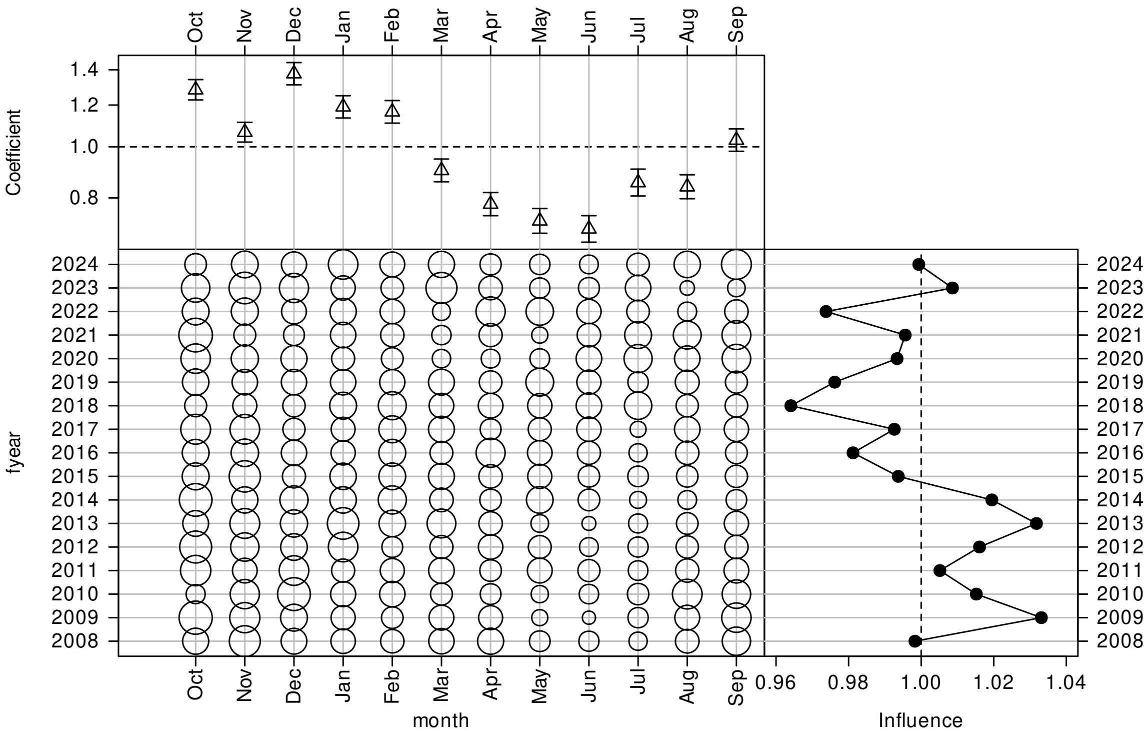

Figure C.275: CDI plot for month for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

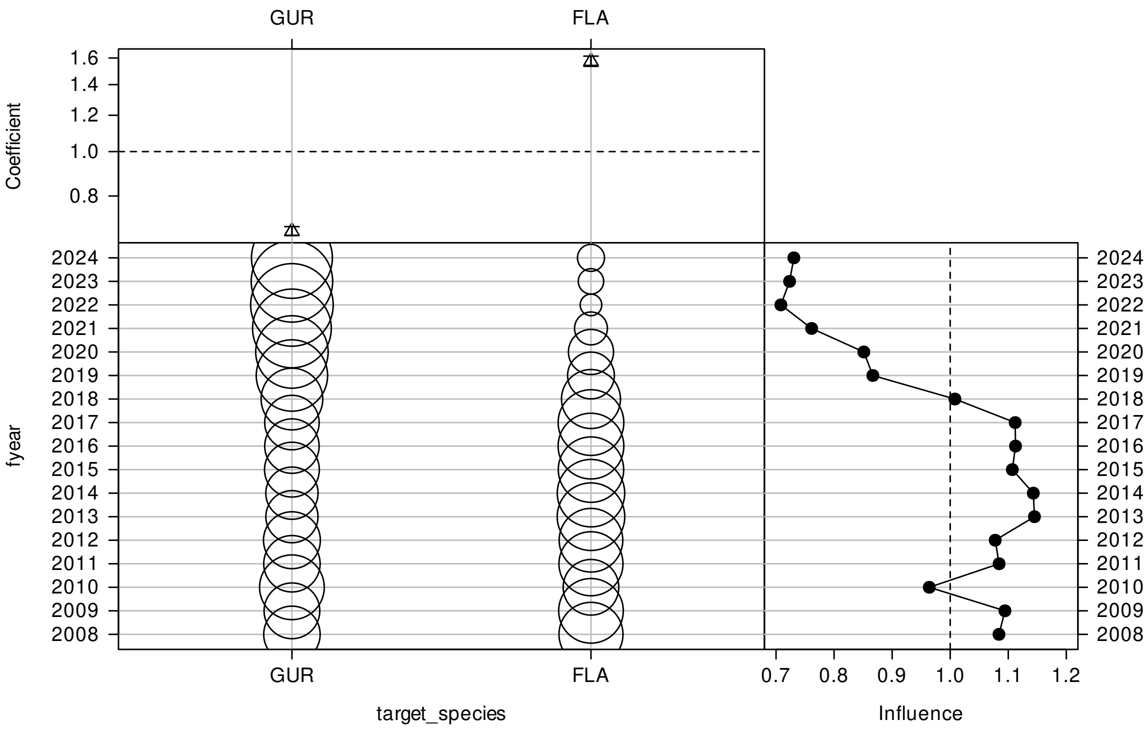

Figure C.276: CDI plot for target species for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

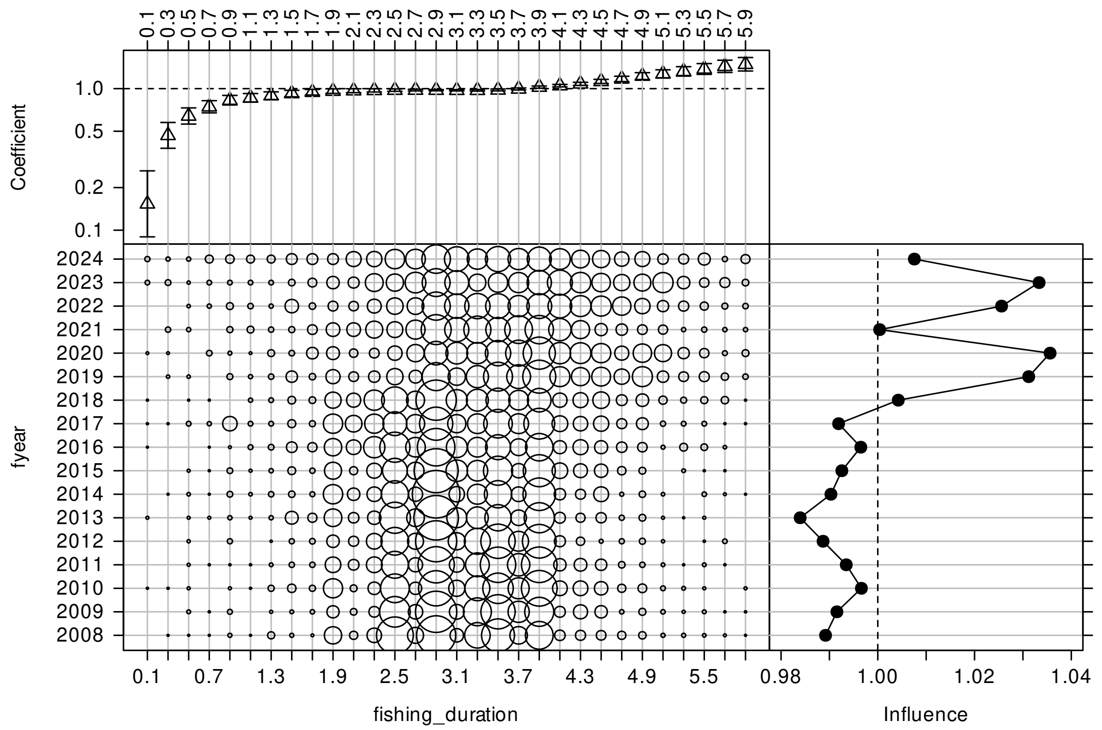

Figure C.277: CDI plot for fishing duration (h) for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

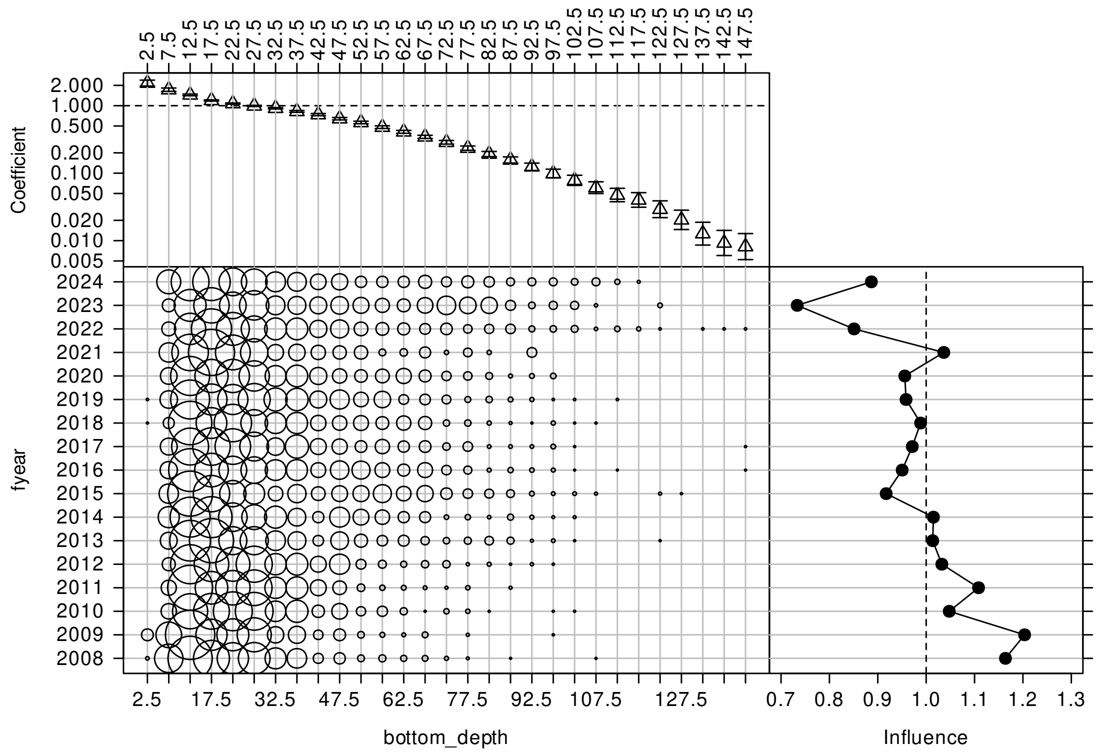

Figure C.278: CDI plot for bottom depth (m) for the occurrence of positive catch in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

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

Predictor	df	AIC	% deviance	addl. % deviance	Included
intercept	1	48 098.25	0.00	0.00	*
fyear	16	46 633.79	10.23	10.23	*
vessel_key	26	45 030.40	20.33	10.10	*
stat_area	1	43 419.73	29.08	8.75	*
month	11	43 256.38	30.02	0.94	*
target_species	1	42 286.48	34.76	4.74	*
ns(log(fishing_duration), 3)	3	42 219.26	35.10	0.34	*
ns(bottom_depth, 3)	3	41 546.92	38.20	3.10	*

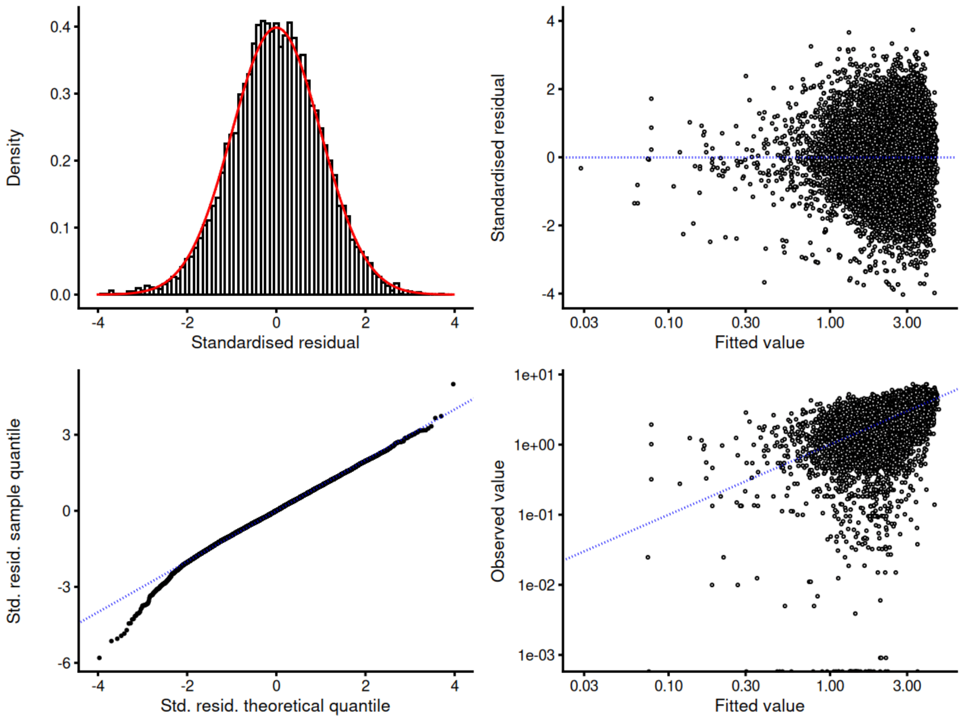

Figure C.279: Diagnostic plots for the selected lognormal model for positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

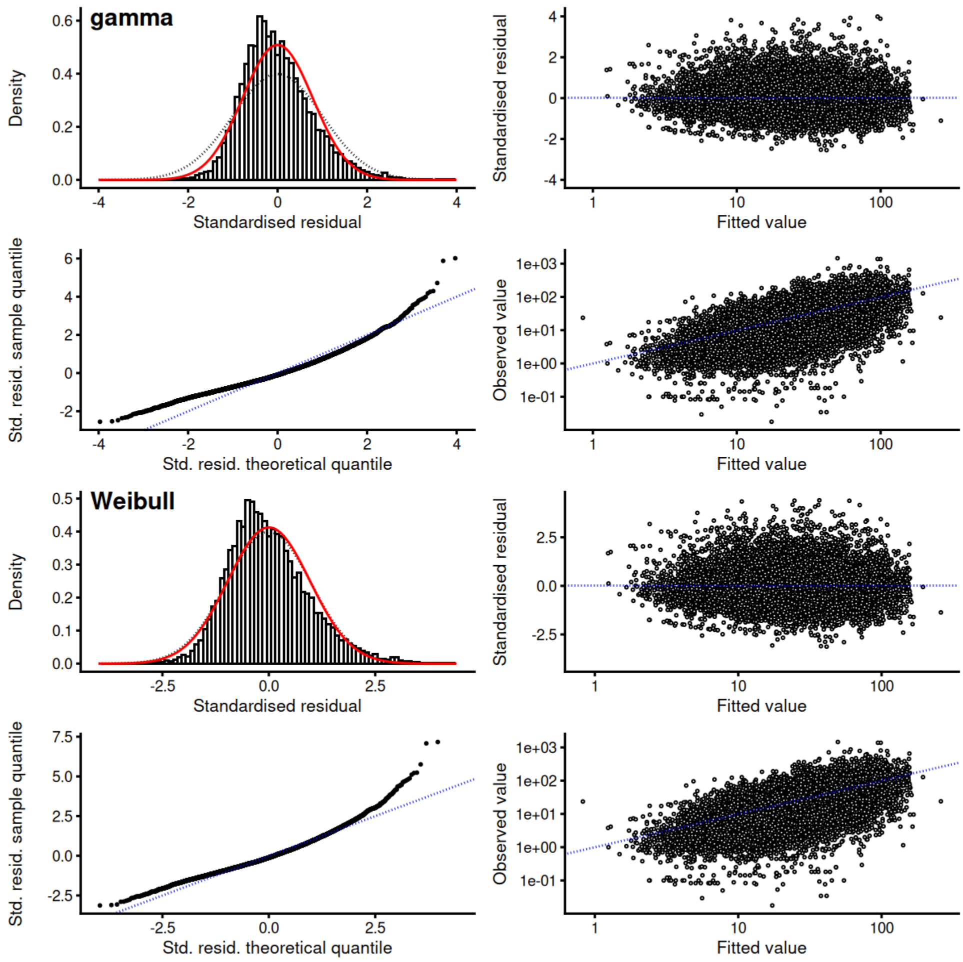

Figure C.280: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

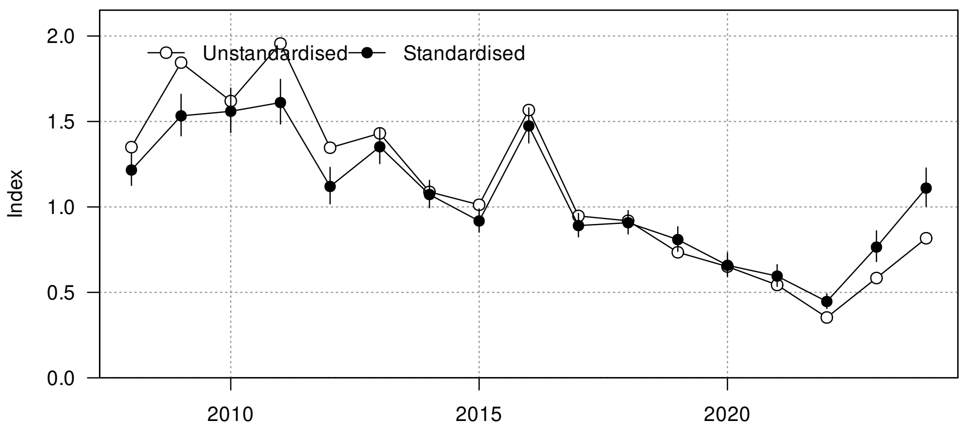

Figure C.281: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

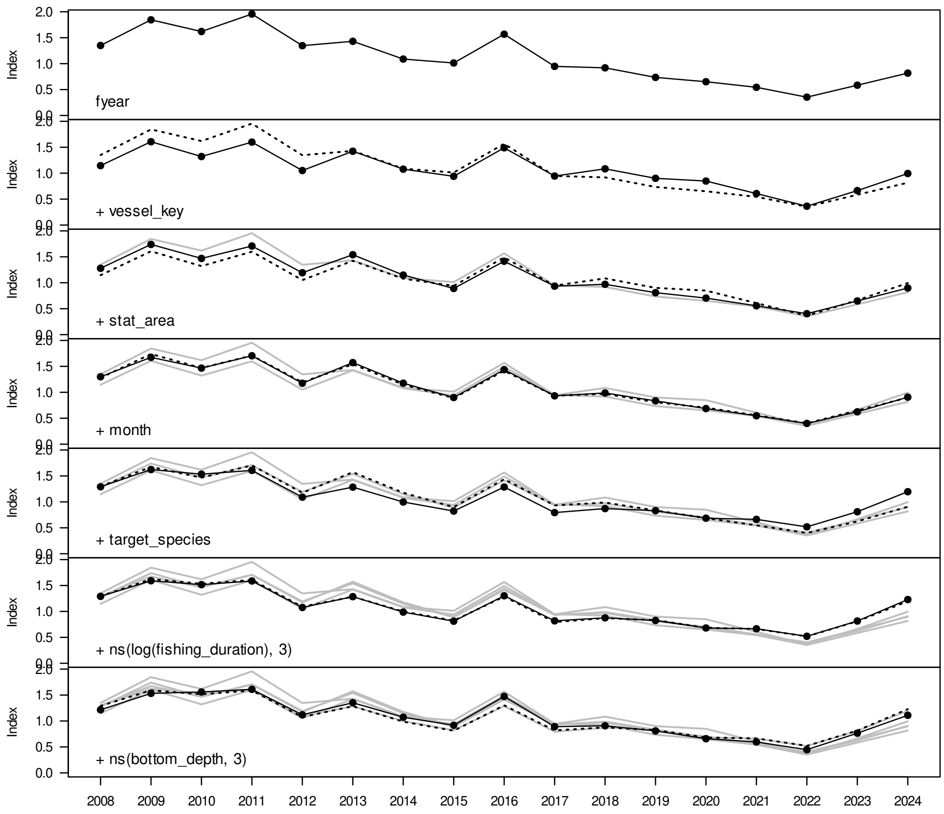

Figure C.282: Changes to the Hawke Bay SFL BT-MIX event (split long vessels) positive catch index as terms are successively entered into the lognormal model.

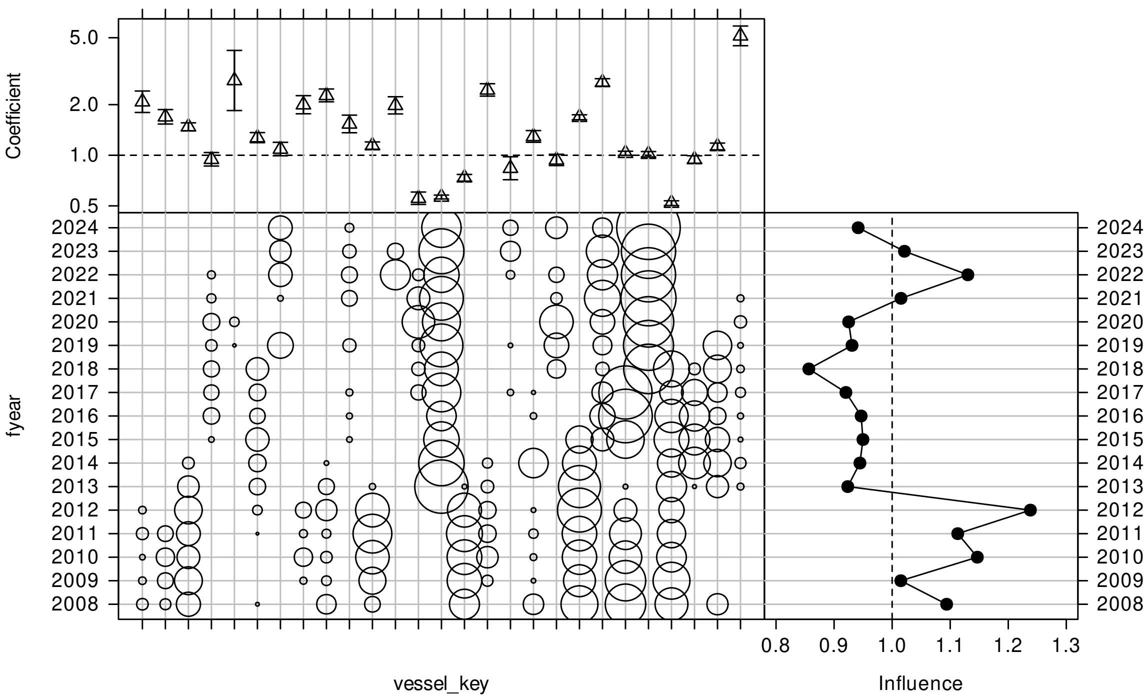

Figure C.283: CDI plot for vessel key for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

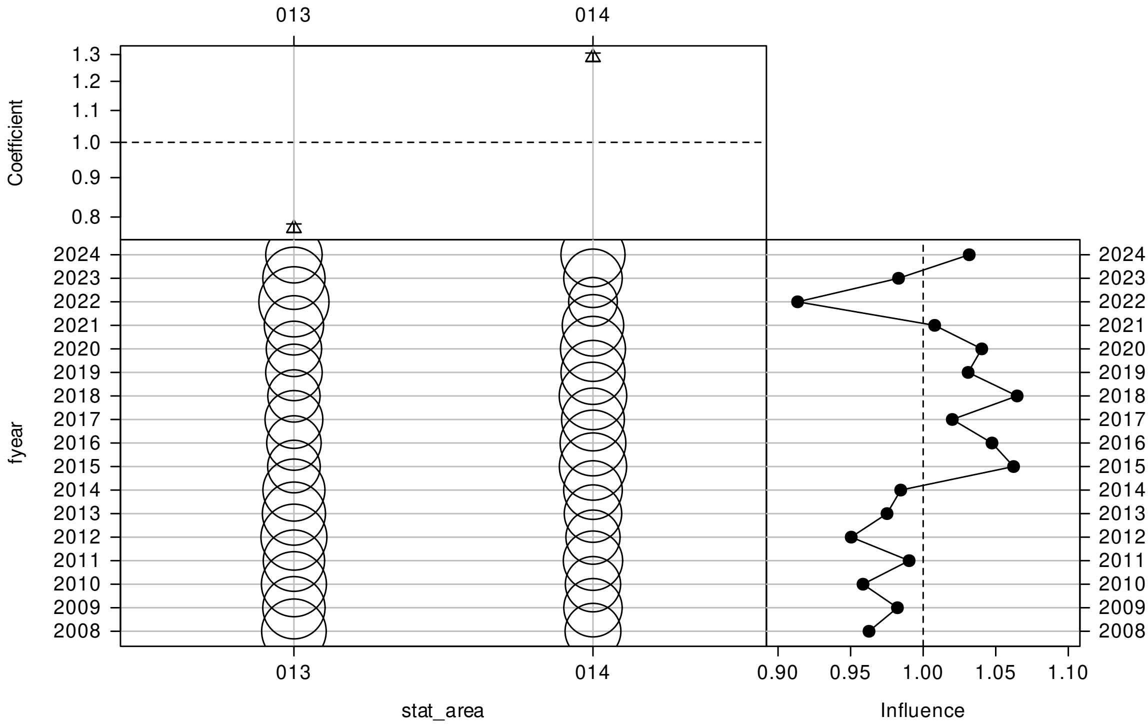

Figure C.284: CDI plot for statistical area for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

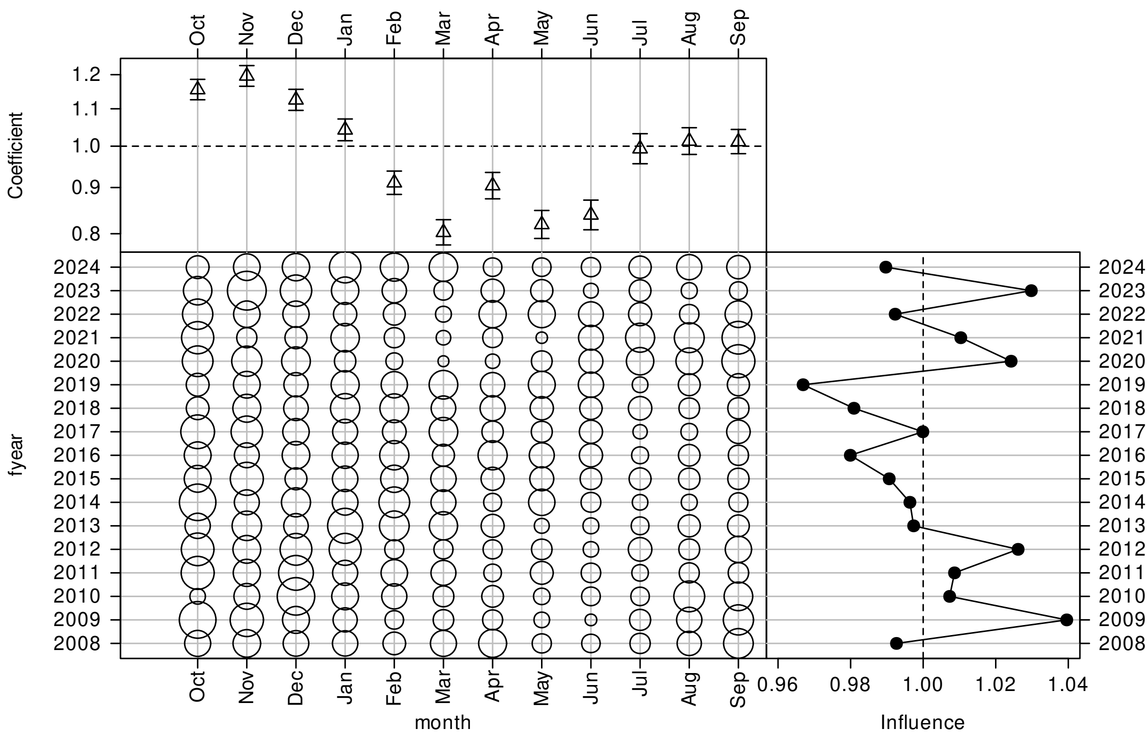

Figure C.285: CDI plot for month for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

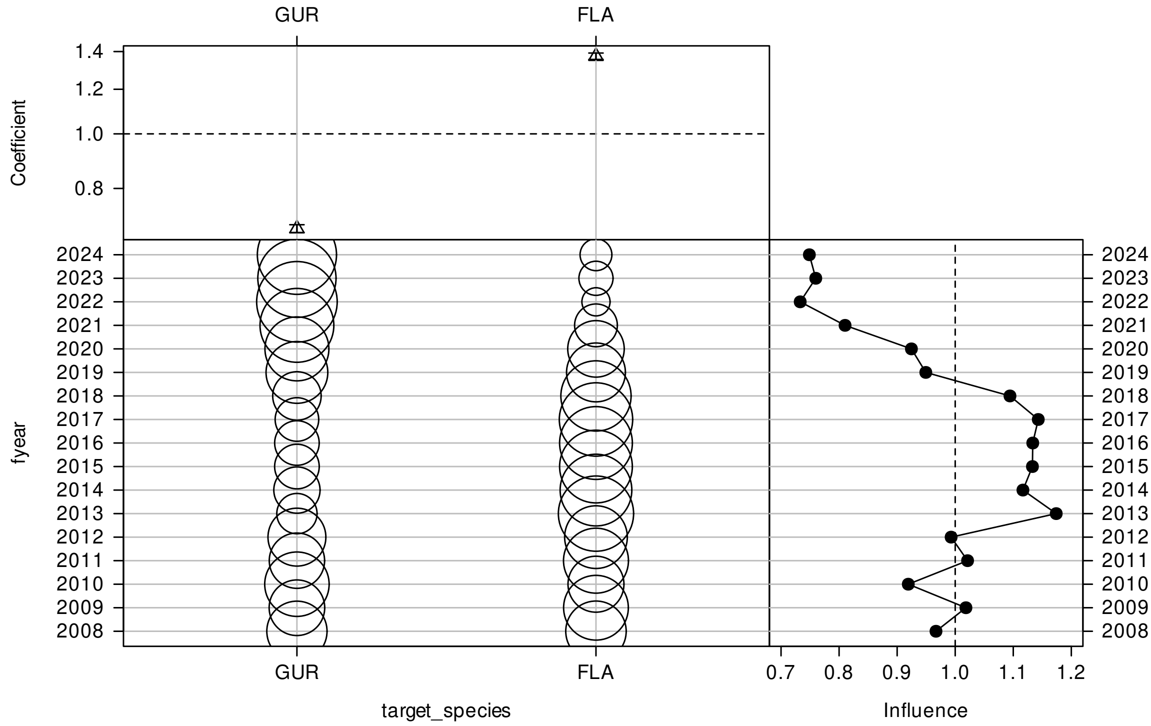

Figure C.286: CDI plot for target species for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

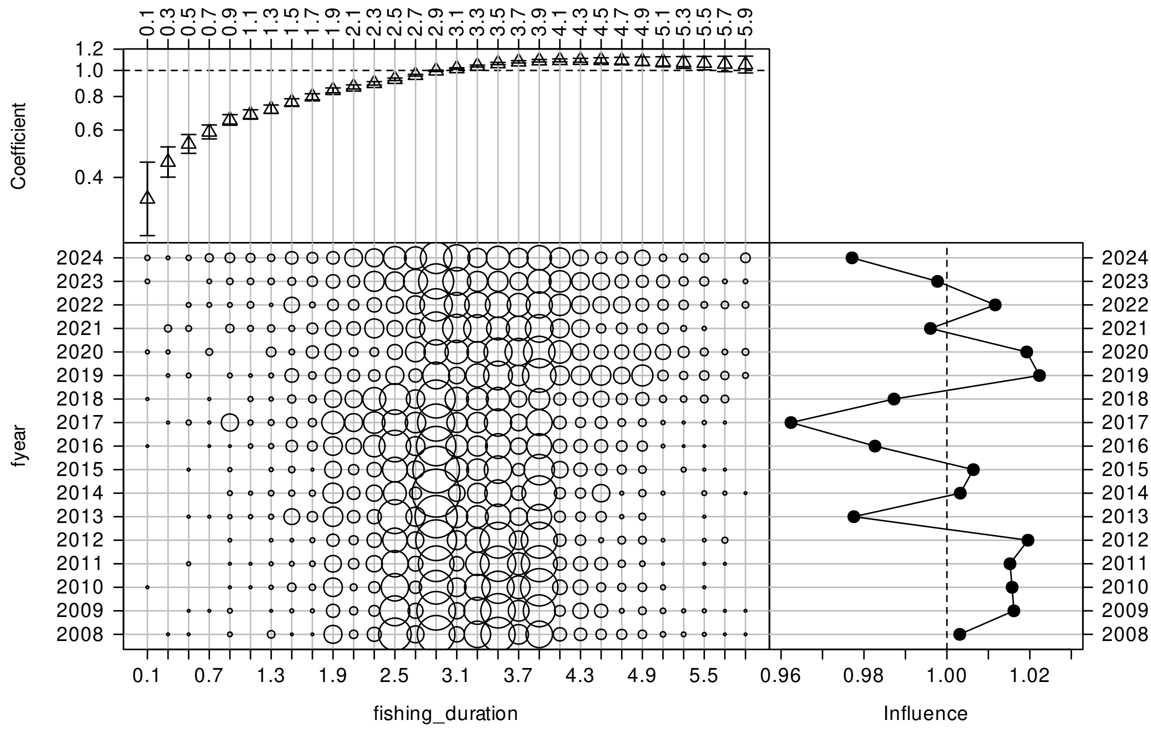

Figure C.287: CDI plot for fishing duration (h) for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

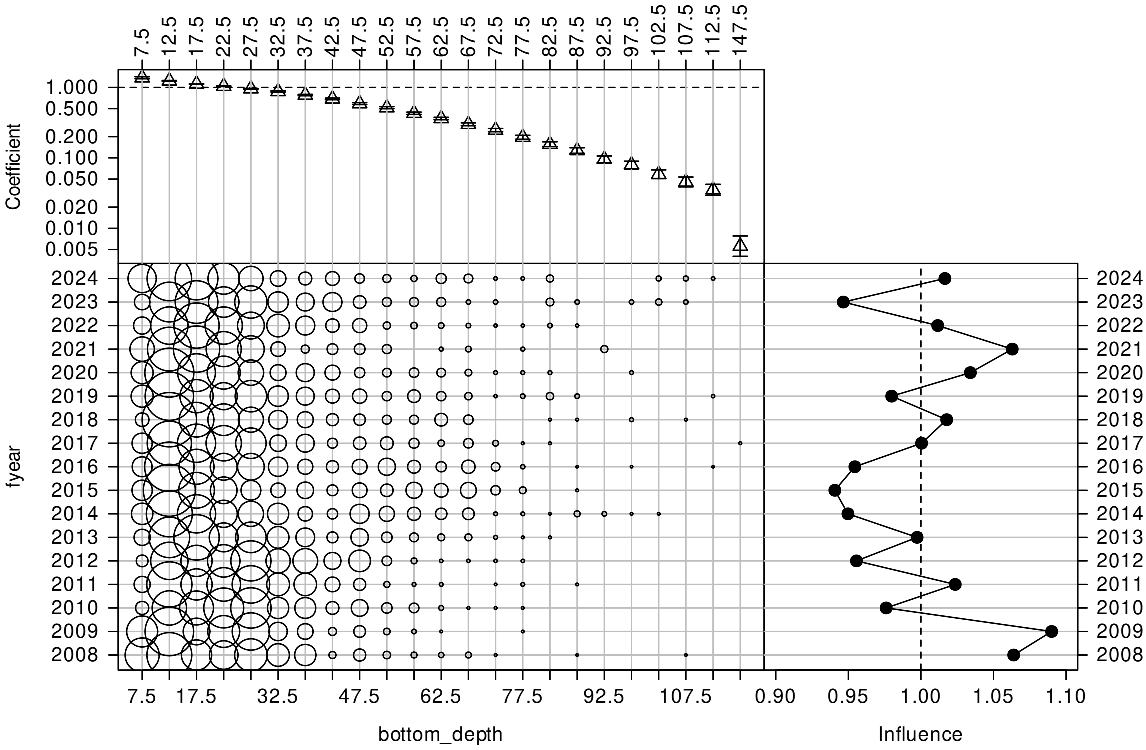

Figure C.288: CDI plot for bottom depth (m) for the lognormal model of positive catches in the Hawke Bay SFL BT-MIX event (split long vessels) catch-per-unit-effort dataset.

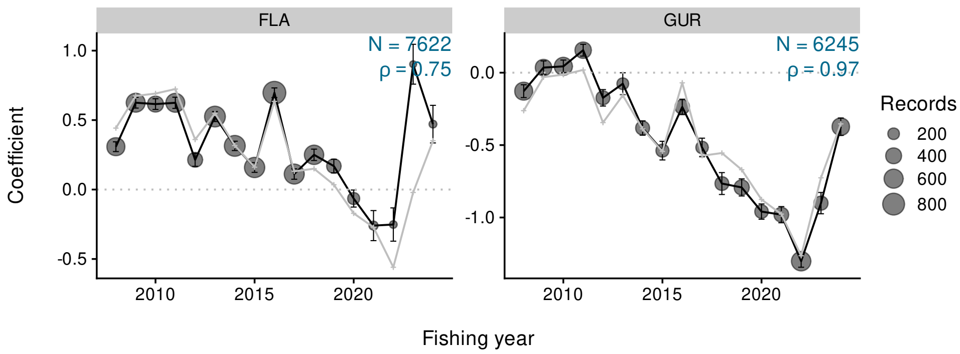

Figure C.289: Residual implied coefficients for target-year in the lognormal positive catch model for the Hawke Bay SFL BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a target-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

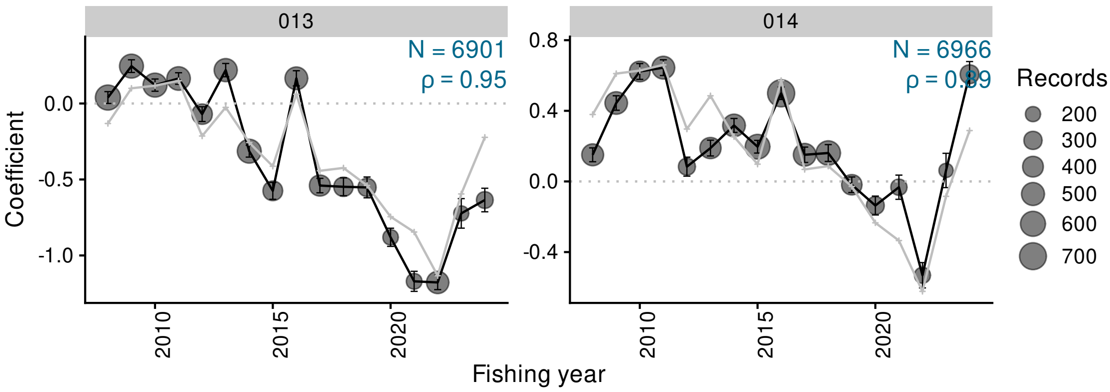

Figure C.290: Residual implied coefficients for area-year in the lognormal positive catch model for the Hawke Bay SFL BT-MIX event (split long vessels) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted 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.

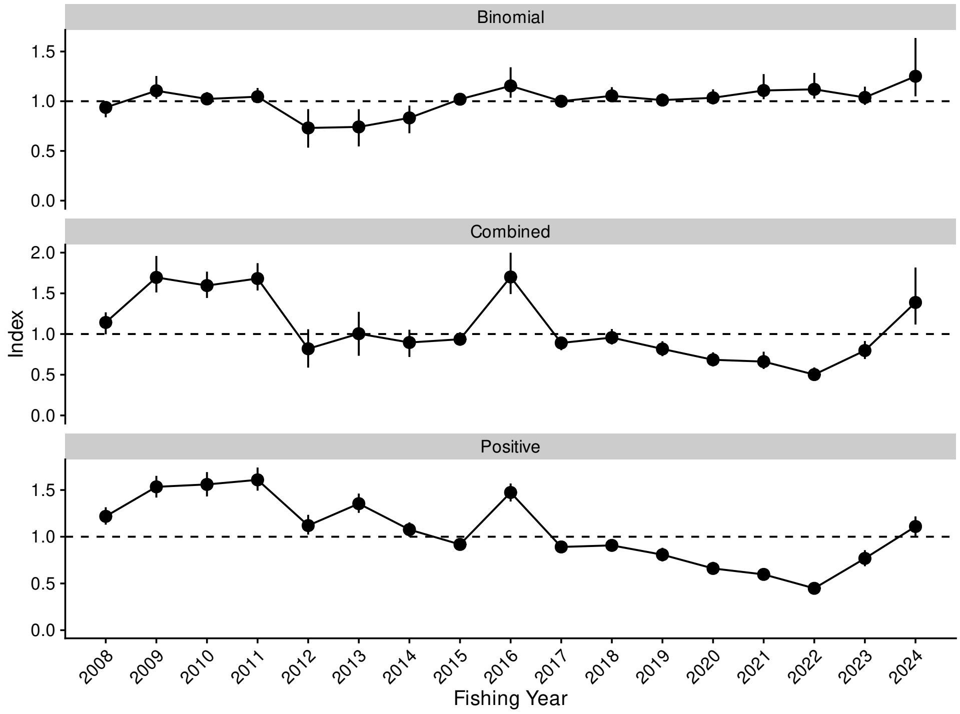

Figure C.291: Standardised indices and 95% confidence intervals for the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

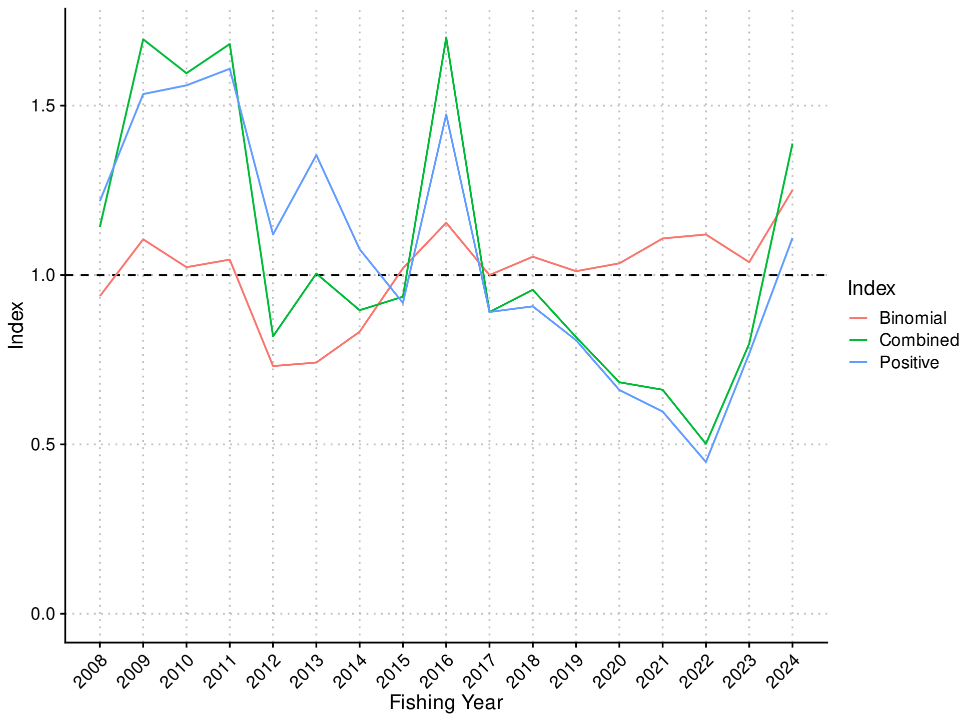

Figure C.292: Standardised indices for the Hawke Bay SFL BT-MIX event (split long vessels) dataset.

Table C.76: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in the Hawke Bay SFL BT-MIX event (split long vessels) series.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	0.938	0.039	0.838	0.992	1.142	0.069	0.997	1.267	1.218	0.048	1.129	1.316
2009	1.105	0.059	1.024	1.254	1.696	0.114	1.511	1.959	1.534	0.059	1.419	1.652
2010	1.023	0.031	0.972	1.092	1.596	0.083	1.443	1.767	1.560	0.066	1.431	1.692
2011	1.045	0.034	0.999	1.133	1.682	0.086	1.535	1.871	1.609	0.063	1.493	1.741
2012	0.731	0.099	0.533	0.920	0.819	0.120	0.587	1.059	1.120	0.054	1.023	1.234
2013	0.742	0.095	0.546	0.919	1.004	0.138	0.733	1.273	1.354	0.053	1.255	1.462
2014	0.832	0.071	0.678	0.956	0.896	0.085	0.718	1.053	1.076	0.040	0.999	1.154
2015	1.020	0.028	0.972	1.082	0.936	0.042	0.857	1.022	0.918	0.034	0.853	0.987
2016	1.154	0.078	1.035	1.341	1.701	0.129	1.491	1.999	1.474	0.049	1.377	1.570
2017	1.000	0.029	0.936	1.051	0.891	0.043	0.801	0.970	0.891	0.034	0.825	0.957
2018	1.054	0.034	1.008	1.141	0.956	0.048	0.871	1.061	0.907	0.035	0.840	0.976
2019	1.011	0.033	0.949	1.079	0.817	0.047	0.728	0.911	0.808	0.037	0.736	0.882
2020	1.034	0.039	0.968	1.120	0.683	0.044	0.602	0.775	0.661	0.034	0.598	0.731
2021	1.108	0.064	1.020	1.273	0.661	0.054	0.571	0.783	0.597	0.033	0.534	0.663
2022	1.120	0.066	1.026	1.284	0.502	0.039	0.436	0.590	0.448	0.022	0.408	0.495
2023	1.038	0.047	0.963	1.147	0.797	0.057	0.693	0.914	0.768	0.044	0.684	0.856
2024	1.251	0.150	1.050	1.636	1.388	0.179	1.117	1.817	1.110	0.054	1.005	1.218

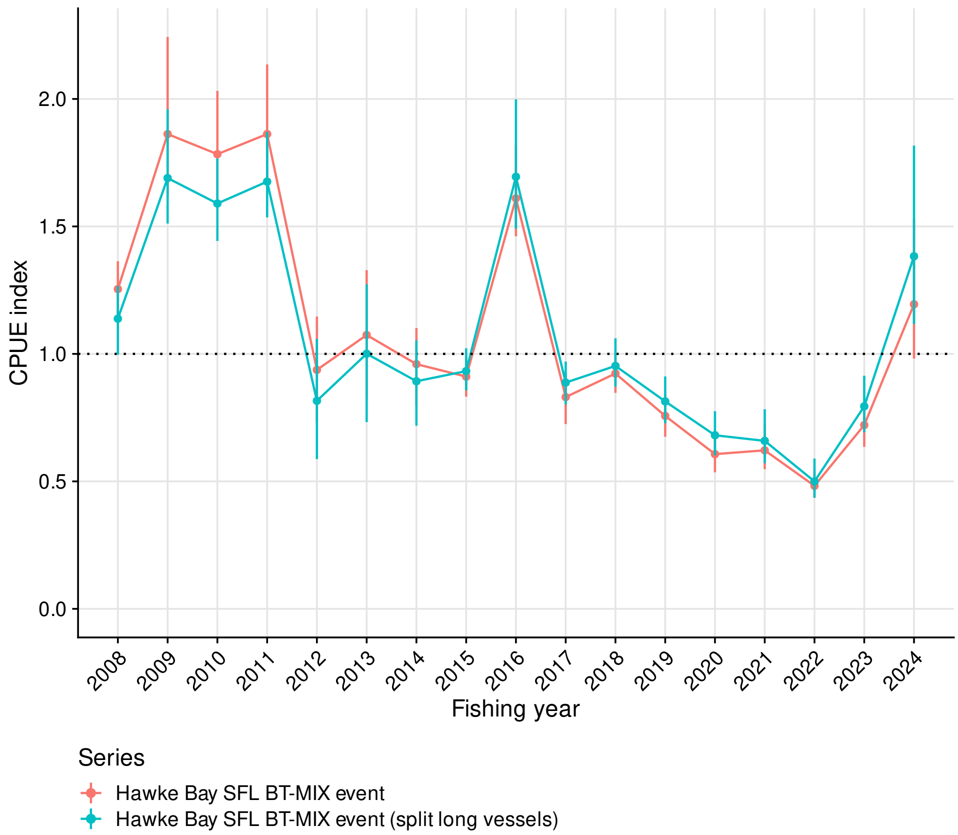

Figure C.293: Comparison of the event resolution series for sand flounder (SFL) in Hawke Bay, with and without splitting vessels with long participation.

APPENDIX D: GLOSSARY

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

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

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

Code	Description
CEL	Catch, Effort and Landing Return (CELR)
ERS - Lining	Electronic Reporting System - Lining
ERS - Netting	Electronic Reporting System - Netting
ERS - Potting	Electronic Reporting System - Potting
ERS - Seining	Electronic Reporting System - Seining
ERS - Trawl	Electronic Reporting System - Trawl
LCE	Lining Catch Effort Return (LCER)
LTC	Lining Trip Catch Effort Return (LTCER)
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)

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

Code	Description
BPT	Bottom trawl - pair
BT	Bottom trawl
DS	Danish seine
PRB	Precision bottom trawl
SN	Set net

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

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
FLA	Flatfish	
GUR	Gurnard	*Chelidonichthys kumu*
JDO	John dory	*Zeus faber*
MOK	Blue moki	*Latridopsis ciliaris*
RCO	Red cod	*Pseudophycis bachus*
SNA	Snapper	*Pagrus auratus* (*Chrysophrys auratus*)
SPO	Rig	*Mustelus lenticulatus*
TAR	Tarakihi	*Nemadactylus macropterus, Nemadactylus* sp. (King tarakihi)
TRE	Trevally	*Pseudocaranx georgianus*
WAR	Common warehou	*Seriolella brama*