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Characterisation and CPUE for the red gurnard fishery in GUR 2 from 1989 to 2023

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Plain language summary

Red gurnard is an important component of inshore trawl fisheries around New Zealand. Off the central east coast of the North Island (GUR 2), the target bottom trawl fishery for gurnard is focused in Hawke Bay, with bycatch in the deeper tarakihi target fishery representing around a third of the catch.

Abundance of red gurnard in GUR 2 is monitored using catch-per-unit-effort (CPUE) from the inshore trawl fishery, and a CPUE-based target abundance level has been established to facilitate its management within the Quota Management System. In this report, this information is given for 1990 to 2023. In 2023 red gurnard was assessed as being likely to be at or above the target.

Gurnard abundance appears to be cyclical, with increases and decreases occurring over 5–7 year periods. Fine-scale changes in the distribution of red gurnard within Hawke Bay and the neighbouring coastal areas are also evident in tow-level data available since 2008, with the population moving between deeper and shallower areas. In 2022 and 2023 red gurnard appear to have had a deeper distribution, but it is unclear if this is related to the impacts of Cyclone Gabrielle.

EXECUTIVE SUMMARY

Middleton, D.A.J.[1]; Neubauer, P.[2]; Thompson, F.N.[2] (2024). Characterisation and CPUE for the red gurnard fishery in GUR 2 from 1989 to 2023.

***New Zealand Fisheries Assessment Report 2024/63*. 98 p.**

An updated characterisation and catch-per-unit-effort (CPUE) analysis for the GUR 2 fishery suggests little change in this fishery since the previous analysis in 2016, other than a decline in catch during 2021–2023. The majority of the commercial catch is taken by bottom trawl effort targeting red gurnard, with tarakihi target trawl effort taking around a third of the catch.

The CPUE-based abundance index suggests that abundance declined during 2020–2021 and has been at or about the B_{MSY} compatible target reference from 2021 to 2023, with reduced relative exploitation rates due to the reduced catch.

Spatial residuals from an event-level CPUE model suggest that gurnard were concentrated in the deeper areas of Hawke Bay during 2016–2018, but their distribution expanded to nearer shore areas during 2019–2021. A move back to deeper areas, including south of Hawke Bay, is apparent in 2022 and 2023, but a lack of fishing in northern inshore parts of Hawke Bay in 2023 implies that in is difficult to determine the extent to which this change may have been influenced by the effects of Cyclone Gabrielle in February 2023. Higher catch rates evident in CPUE analyses that include effort from the deeper tarakihi target fishery support the hypothesis of a shift in gurnard distribution to deeper areas in 2022 and 2023.

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1. INTRODUCTION

Red gurnard (GUR; *Chelidonichthys kumu*) was introduced to the Quota Management System (QMS) on 01 October 1986. Gurnard are caught in inshore fisheries throughout New Zealand, and are a key part of the inshore trawl fishery in Fisheries Management Area 2 (FMA 2, often referred to simply as 'Area 2'; Figure 1).

With the exception of early changes related to the quota appeals process, the GUR 2 TACC has remained constant since QMS introduction and no allowances for non-commercial fisheries or other sources of mortality have been set (Table 1). Catches have generally followed a cyclical pattern, remaining below the TACC with the exception of peaks in 2010 and 2016 (Figure 2). Catches during 2021–2023 were the lowest recorded in the QMS era, but not as low as those recorded in the mid-1970s.

Recreational harvests of 38 t and 39 t were estimated in the 2012 and 2018 National Panel Surveys, respectively, but no quantitative estimates of customary non-commercial catch are currently available (Fisheries New Zealand 2023).

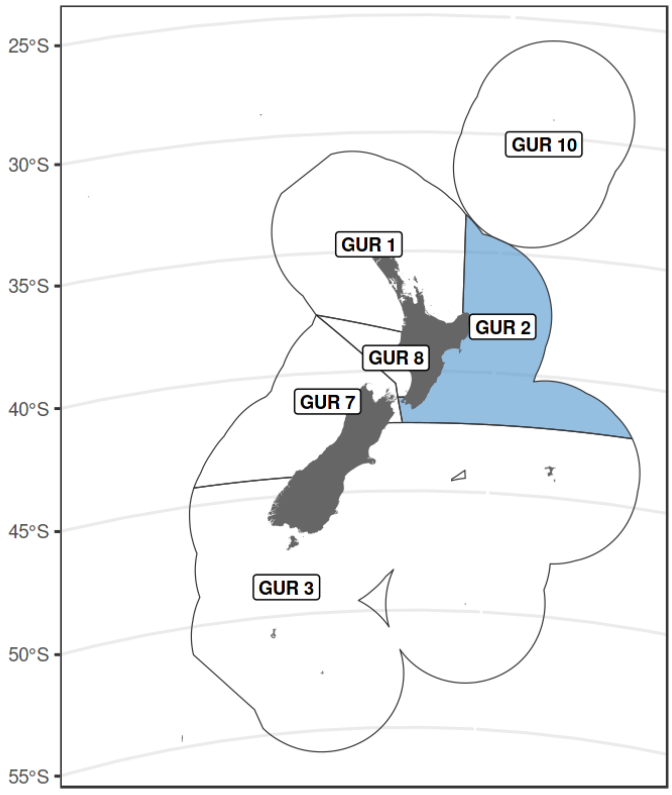

Figure 1: Quota Management Areas for red gurnard with GUR 2 highlighted.

Table 1: Total Allowable Catch (TAC), Total Allowable Commercial Catch (TACC), and allowances (all tonnes) for GUR 2, as at 1 October 2023.

			Allowances		
Stock	TAC	TACC	Customary	Recreational	Other mortality
GUR 2	-	725.462	-	-	-

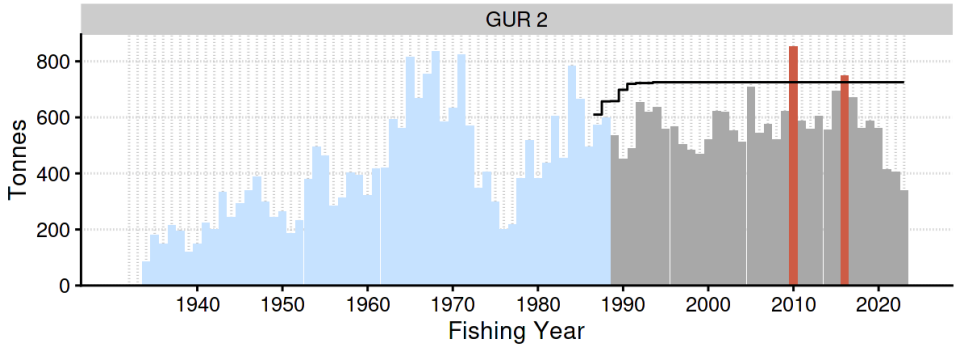

Figure 2: Total Allowable Commercial Catch (TACC; black line) and Monthly Harvest Return/Quota Management Report totals (bars) for GUR 2 from 1989 to 2023. Years where the TACC was exceeded are highlighted in red. Catches prior to 1989 are shown in blue using the information compiled in the Fisheries Assessment Plenary Report (Fisheries New Zealand 2023). Tabulated data are provided in Table B.1.

Gurnard in the GUR 2 Quota Management Area is considered to be a single stock (Fisheries New Zealand 2023) and, in common with other gurnard stocks, has been placed in Group 2 of the National Inshore Finfish Fisheries Plan (Fisheries New Zealand 2022) with the expectation that the stock is monitored using partial quantitative stock assessments.

In 2014, mean CPUE from 1991 to 2010 for the FMA 2 bottom trawl fishery targeting gurnard, snapper or trevally was adopted as the target reference point for GUR 2. In 2020 the reference period was extended from 1991 to 2018, on the grounds that the new period included two peaks in abundance.

Schofield et al. (2018) characterised the GUR 2 fishery and updated the standardised CPUE to the 2016 fishing year. The indices were subsequently updated in 2018, 2019, 2020 and 2022, with the 2022 update extending the analysis to the end of the 2021 fishing year (Fisheries New Zealand 2023). Here, the fishery characterisation and standardised CPUE analyses are updated using statutory catch, effort and landings data to the end of the 2023 fishing year.

There is no minimum legal size for gurnard caught by commercial fishers, nor are there provisions for returning gurnard caught commercially to the sea if likely to survive. For recreational fishers, the minimum legal size for gurnard is 25 cm with a daily limit of 20 fish as part of a combined-species bag limit.

2. METHODS

Extracts (report logs 13159, 15964) of statutory commercial catch, effort, and landings data were provided by Fisheries New Zealand and processed using standardised grooming routines (Appendix A).

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

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

2.1 Terminology

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

For species managed under the Quota Management System (QMS) we use the term **removals** to refer to the known mortality of fish; 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 GUR from a trip to the fishing event records from the trip using the hierarchical method of Starr (2007). If red gurnard 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 red gurnard 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 GUR 2 and extracting the associated catch and effort data for fishing events within the GUR 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).

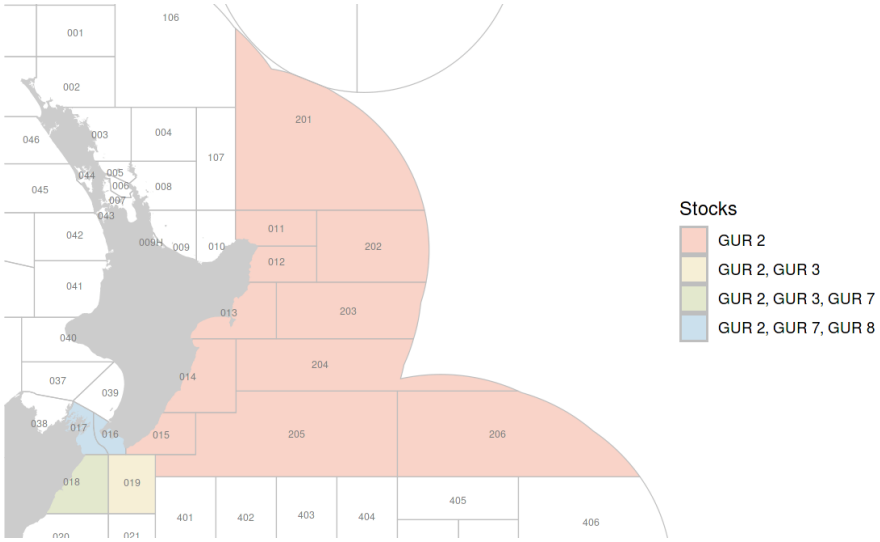

Figure 3: Statistical Areas that intersect the GUR 2 Quota Management Area.

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 GUR were caught. Datasets for CPUE modelling were prepared at differing resolutions:

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

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

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

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

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

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

2.7 Maximum-likelihood CPUE modelling

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

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

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

3. FISHERY CHARACTERISATION

The majority of GUR 2 landings are directly to a Licensed Fish Receiver (Figure 4). There is a good correspondence between aggregated groomed landings and MHR/QMR totals, except for a slight shortfall in landings in 1990.

Most landings are of unprocessed (green) fish (Figure 5); while the conversion factor for some landed states of gurnard changed at the start of the period (Figure 6), the impact is minor in GUR 2 due to the dominance of unprocessed landings.

There is a good correspondence between total catches and catches that are allocated to fishing events in the characterisation dataset (Figure 7).

3.1 Catch and effort reporting

Most trips have estimated catches of GUR 2, which are scaled to landings. Only a small proportion of landings were from trips landing GUR 2 without any estimated catches (Figure 8a). Estimated catches accounted for 85% to 94% of landings from 1990 to 2002, increasing to 93% to 100% thereafter (Figure 8b). The majority of fishing events and fishing days from trips landing GUR 2 reported a catch of gurnard (Figure 8c,d).

Until 2007, reporting of effort from trips landing GUR 2 was mainly on the CELR form, with the TCEPR form used for some trawl effort (Figure 9). From 2008, reporting on the TCER form dominated until the introduction of the Electronic Reporting System. Electronic reporting of a small amount of trawl effort was evident in 2018; this increased in 2019, with electronically reported data dominating from 2020 on.

3.2 Key fisheries

The majority of GUR 2 is taken by bottom trawling (Figure 10). There have been periodic increases in the catch taken by Danish seine but, overall, this has remained a minor part of the fishery. A small part of the trawl catch from 2017 has been taken by precision bottom trawl (PRB); this is included with conventional bottom trawl catch in the trawl fishery characterisation below.

Most of the trawl catch is from gurnard target fishing (Figure 11) with catches from tarakihi target tows comprising most of the remainder, although catches from flatfish target trawling were important in the mid-late 1990s. Danish seine catches, when these occur, have also been predominantly target catches (Figure 11).

When targeted, gurnard have typically been ranked first or second in the estimated catch from a fishing event (Figure 12), with an average reporting rank around three when tarakihi is targeted. Mean reporting rank has increased for both target and non-target catches with the introduction of electronic reporting, indicating that smaller catches are now reported at the event level.

The mean number of trawls per day during 2021–2023 was somewhat lower than that during the previous two decades (Figure 13).

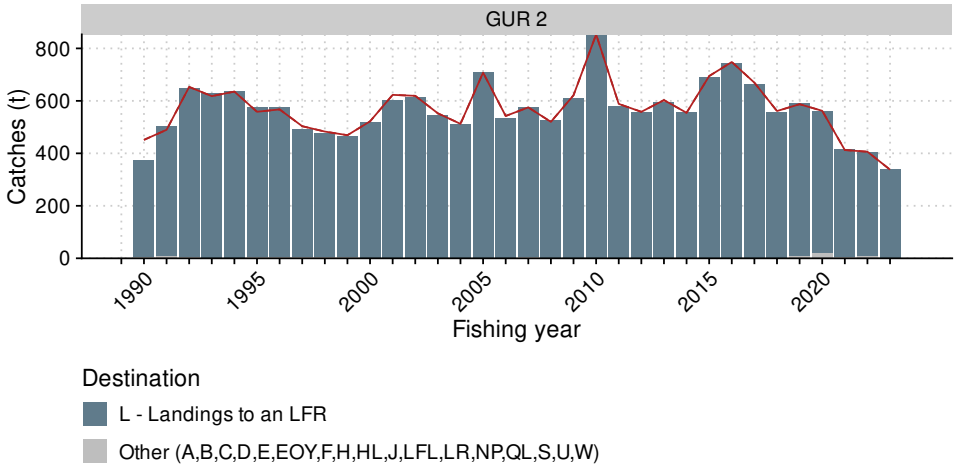

Figure 4: Catches of red gurnard by destination (bars), compared with Monthly Harvest Return / Quota Management Report (MHR/QMR) totals (line), for Quota Management Area GUR 2. Destination codes are defined in Table 2 and tabulated catches are given in Appendix B.

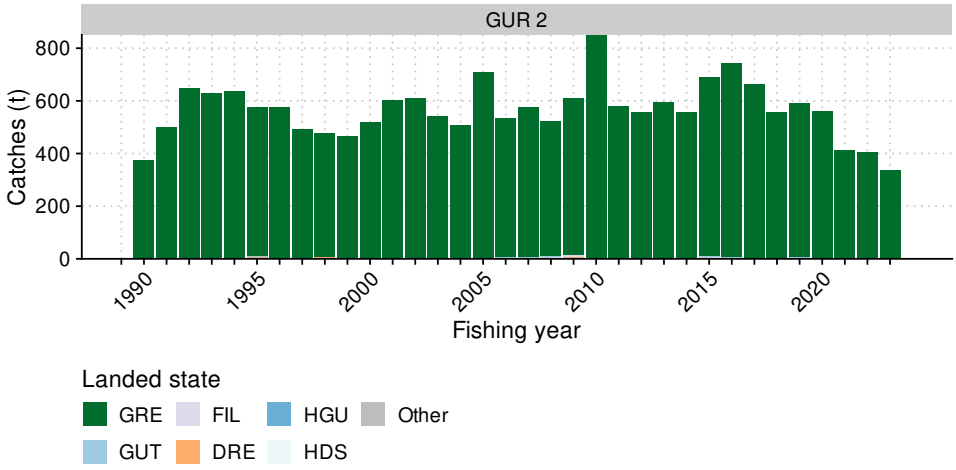

Figure 5: Product state of red gurnard landings from Quota Management Area GUR 2. Catches are tabulated in Appendix B, and product state codes are defined in the glossary Table D.1.

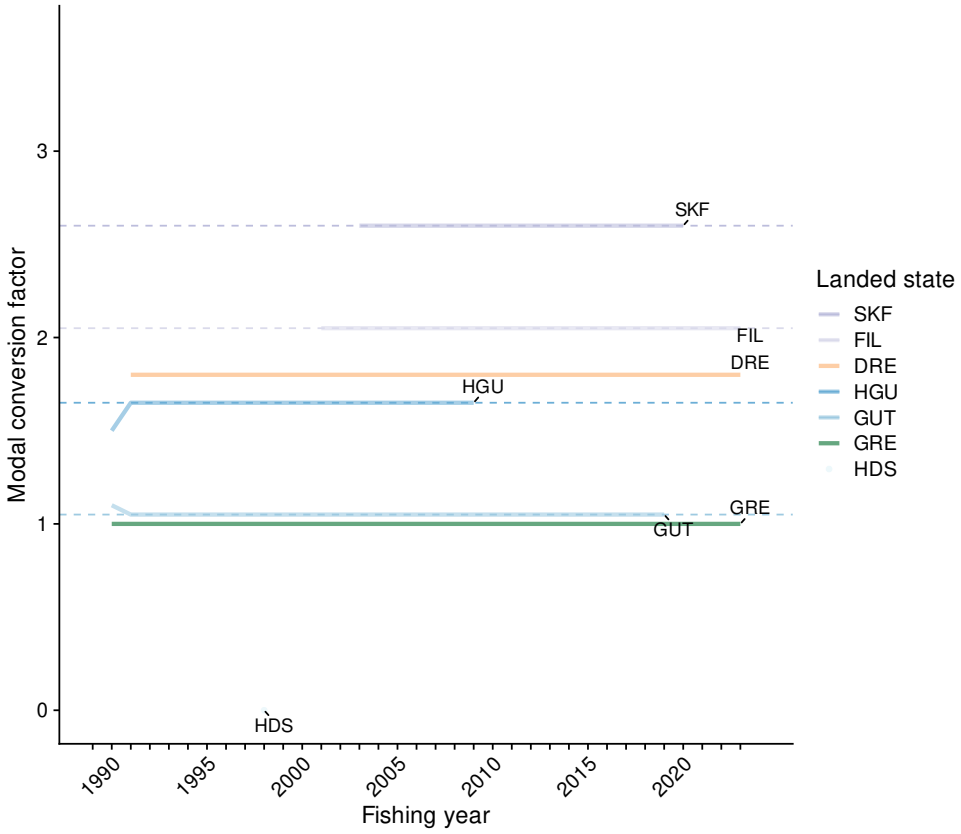

Figure 6: The modal annual conversion factor reported for the product states used in GUR 2 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table B.5, and landed state codes are defined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

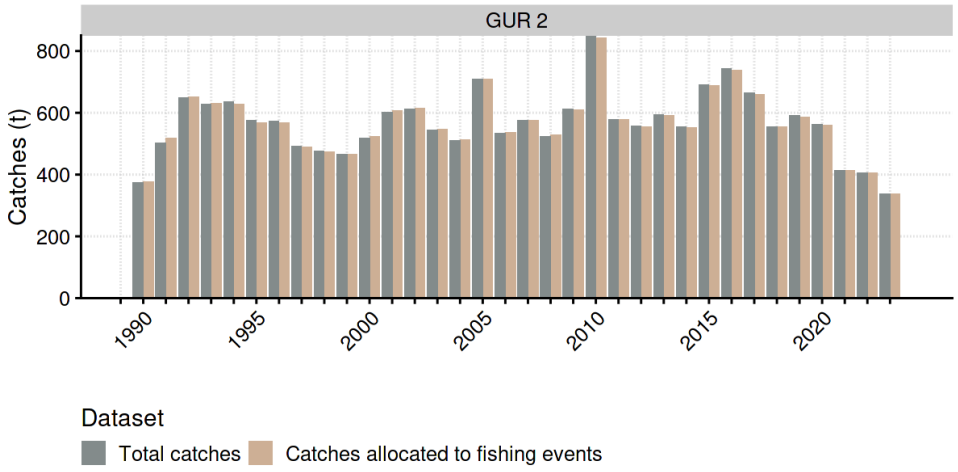

Figure 7: Total catches (t) of red gurnard from GUR 2 in comparison with catches allocated to fishing events in the characterisation dataset.

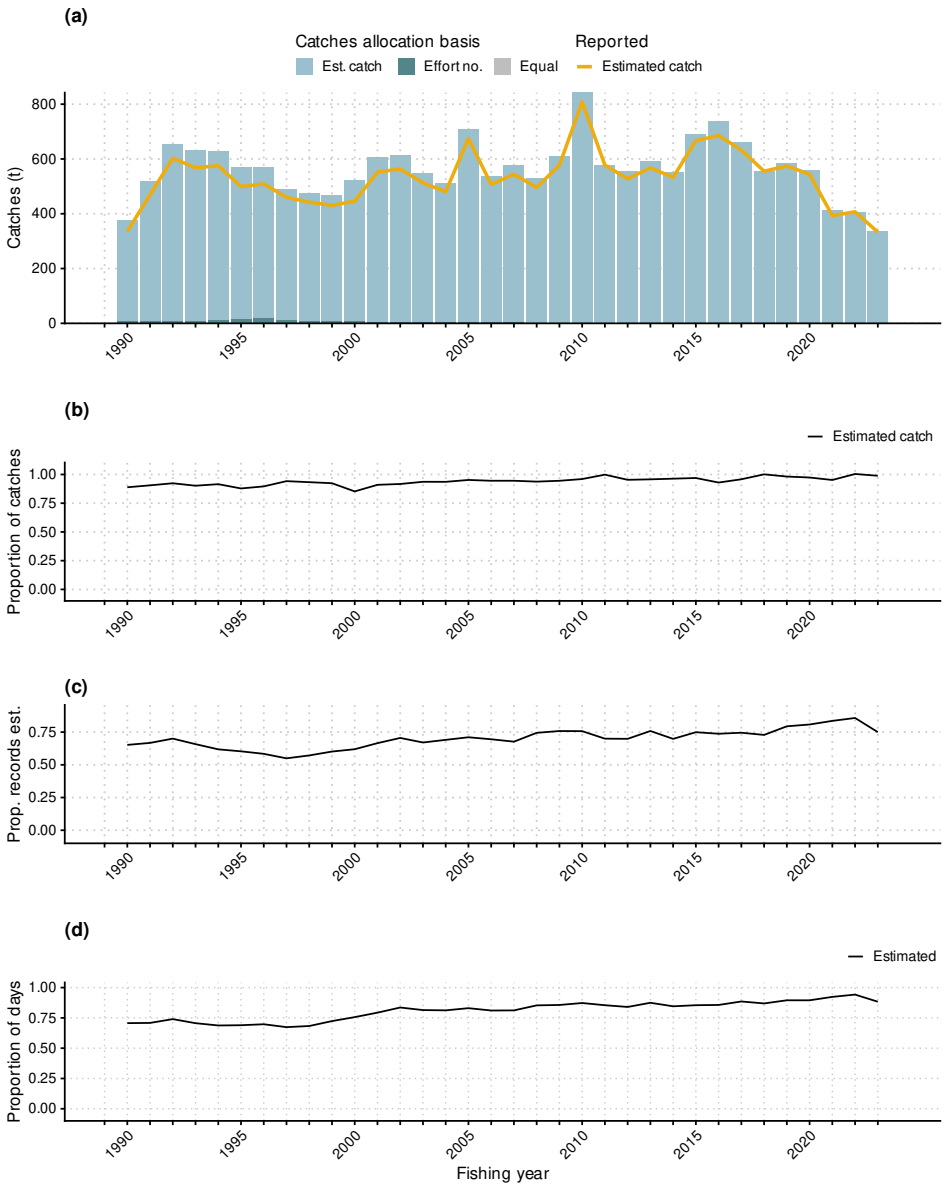

Figure 8: (a) bars: red gurnard catches allocated to fishing events in the GUR 2 QMA with allocation method indicated by fill colour (see Section 2.3); line: total estimated catch of GUR; (b) the proportion of GUR 2 catches included in estimated catch data; (c) the proportion of fishing event records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

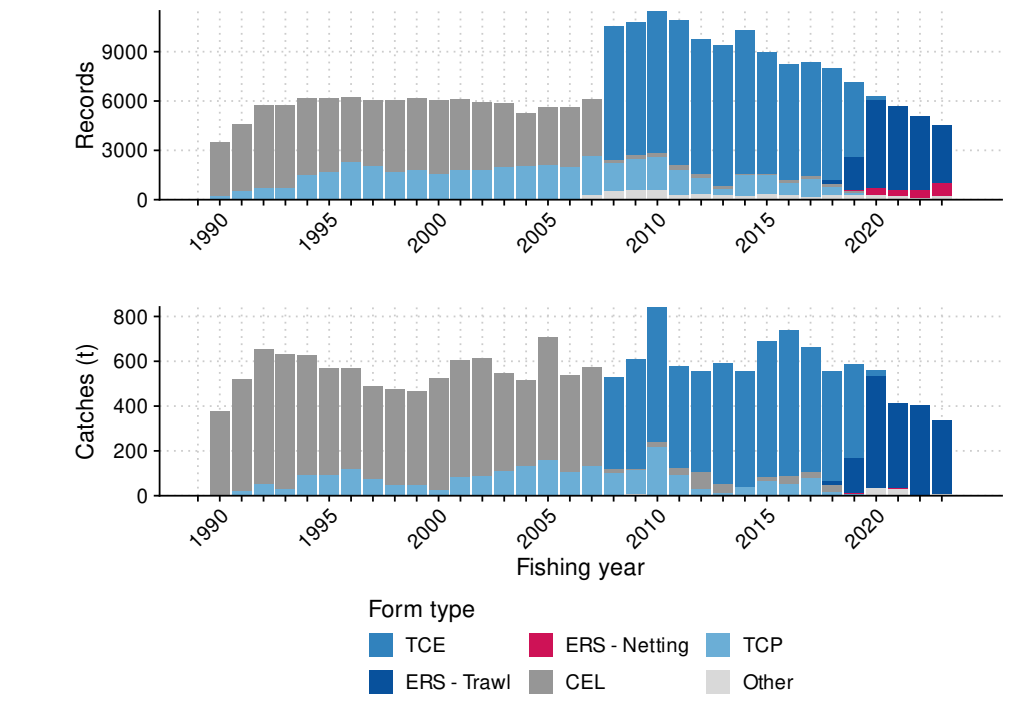

Figure 9: Reporting forms used on trips catching red gurnard within the GUR 2 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Lining, ERS - Other Lining, ERS - Potting, ERS - Seining, LCE,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

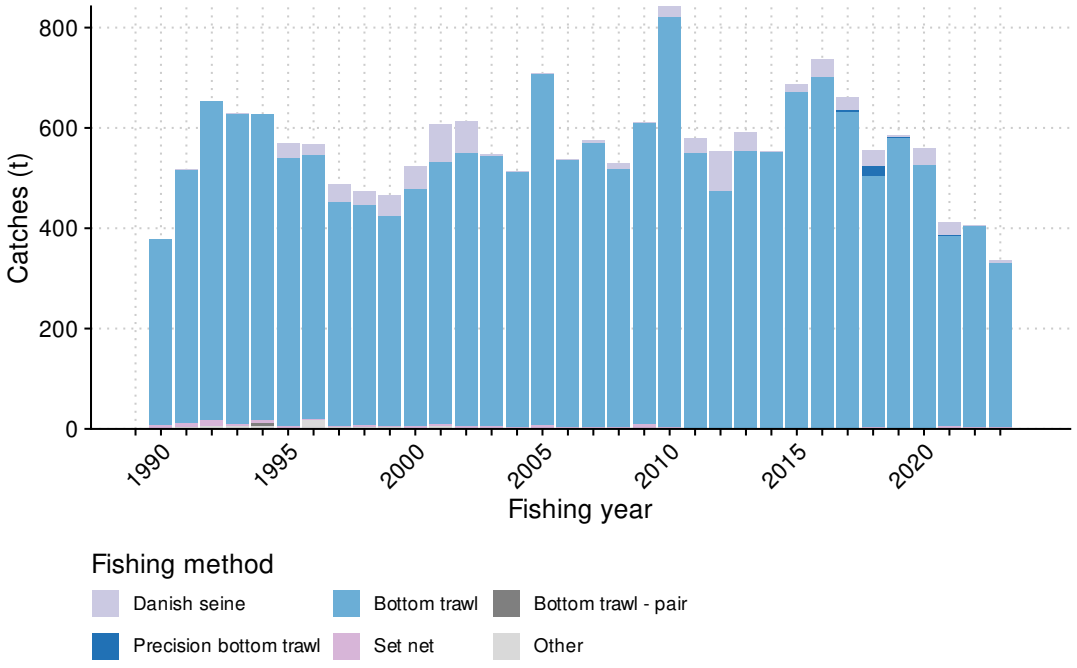

Figure 10: Catches of red gurnard by fishing method, for events within the GUR 2 Quota Management Area. Methods grouped as Other include: BLL, BS, CP, CRP, DL, DV, HL, L, MW, PL, POT, PS, PSH, RLP, SLL, T. Tabulated results are provided in Appendix B, and a list of the main fishing method codes is included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

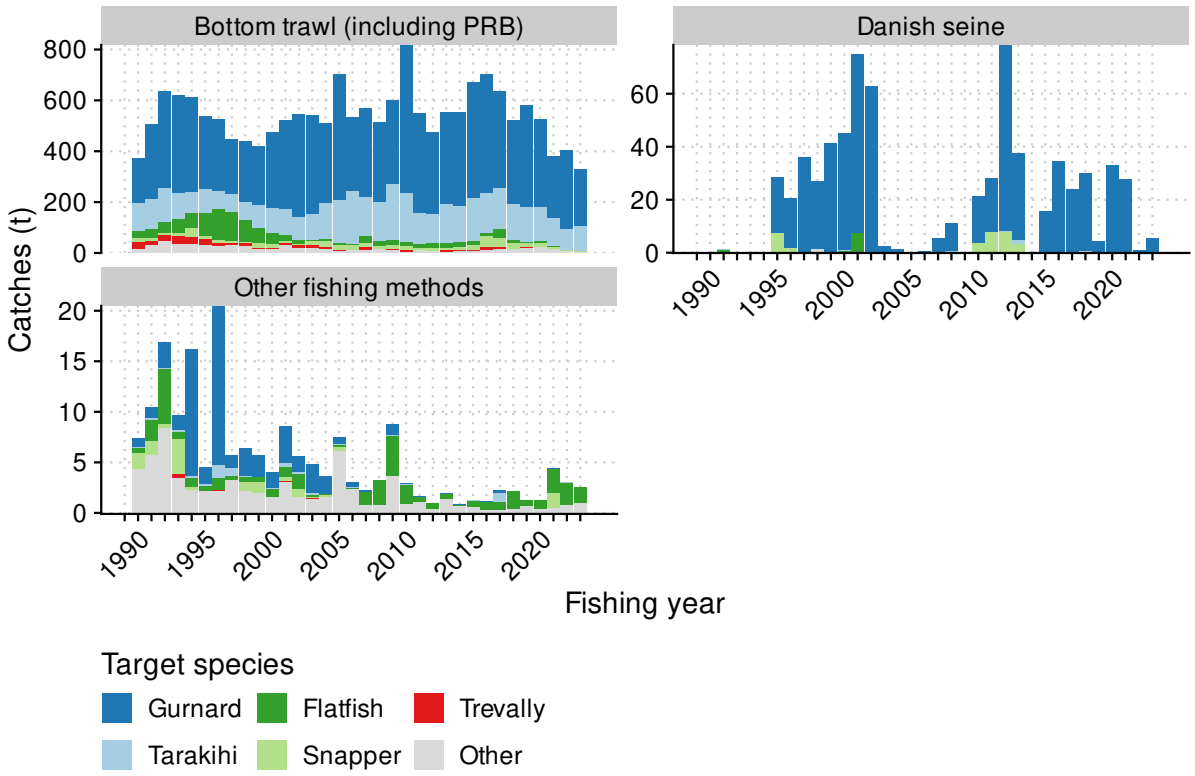

Figure 11: Catches of red gurnard by fishing method and declared target species, for events within the GUR 2 Quota Management Area. Precision bottom trawl (PRB) catches are included with conventional bottom trawl (BT) catches. Fishing methods grouped as Other include: BLL, BPT, BS, CP, CRP, DL, DV, HL, L, MW-PRM, PL, POT, PS, PSH, RLP, SLL, SN, T. Species grouped as Other include target species with less than 5% of the red gurnard catch within the GUR 2 Quota Management Area in a fishing year.

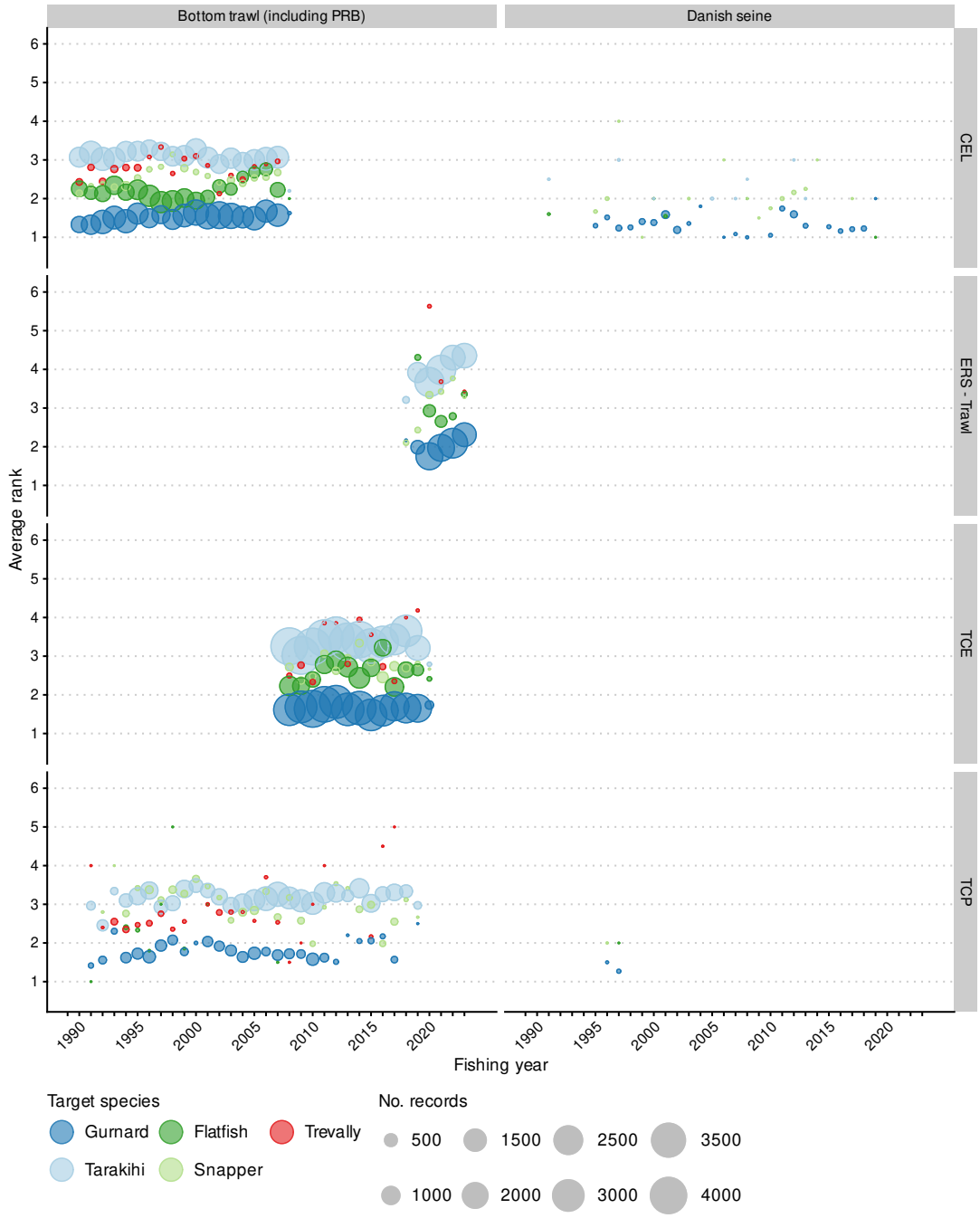

Figure 12: Average rank of red gurnard in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the GUR 2 Quota Management Area. The area of the circles scales with the number of records.

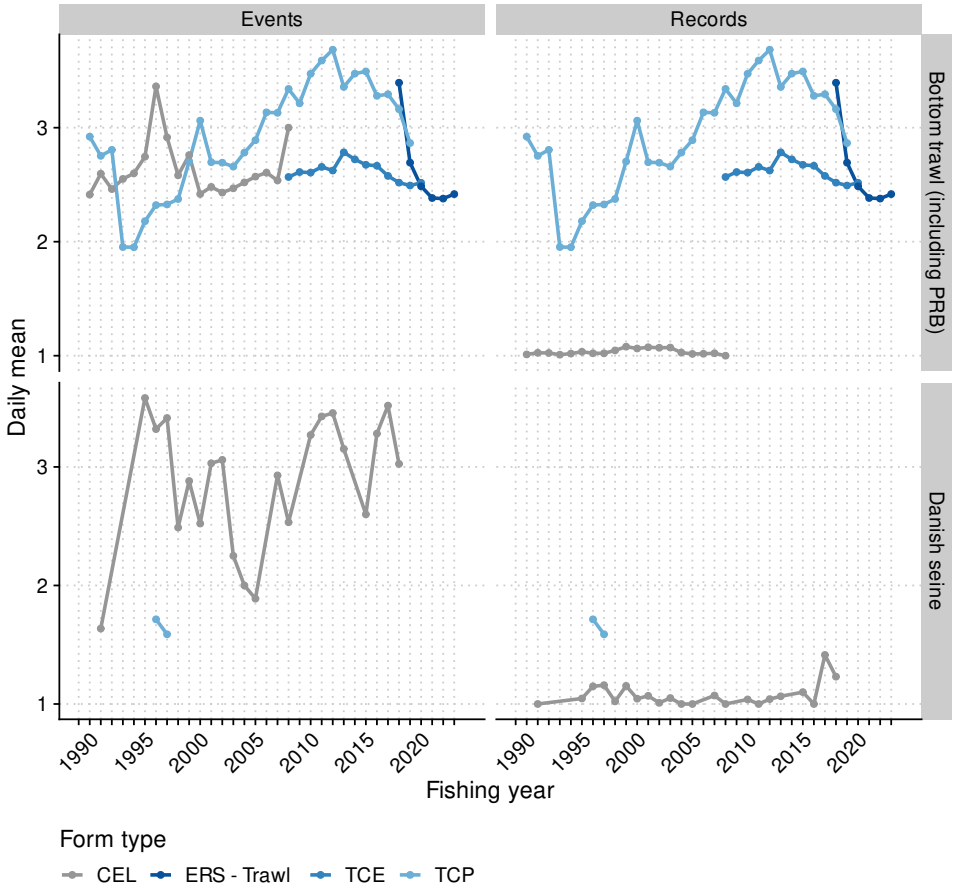

Figure 13: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the GUR 2 QMA on trips landing catch from GUR 2. Data are included for years where a form was used on at least five vessel-days.

3.3 The bottom trawl (including PRB) fishery

Since the introduction of the TCER form in 2008, all catch and effort from the GUR 2 bottom trawl fishery has been reported with fine scale (latitude/longitude) spatial information (Figure 14).

Gurnard are caught along the whole GUR 2 coastline, from East Cape to Cook Strait, but catches are concentrated within Hawke Bay (Figure 15). Gurnard target trawl fishing has focussed within Hawke Bay (the southern part of Statistical Area 013 and the very north of Statistical Area 014) which has consistently been the core area of the fishery (Figure 16, Figure 18). Tarakihi target fishing is notably absent within Hawke Bay but otherwise extends over the entire GUR 2 coastline, whereas gurnard is only taken by snapper target fishing from Hawke Bay north to East Cape (Figure 16). Catches of gurnard by flatfish (Figure 16) and trevally (Figure 17) target effort were more spatially constrained during 2019–2023 than in earlier periods.

Catches are taken throughout the year (Figure 19); gurnard target effort shows little seasonality, whereas tarakihi target catches are lower in autumn (Mar–May). Catch rates are consistent year-round (Figure 20).

Gurnard target trawling is mostly shallower than 100 m, with peak effort from 30 m to 50 m (Figure 21). Snapper and trevally target trawling extends somewhat deeper, with gurnard caught throughout the depth range. Tarakihi target trawling is mostly deeper than 50 m, extending to 250 m and with peak effort from 75 m to 125 m. Gurnard catches rates when targeting tarakihi or trevally are reduced at depths greater than 100 m (Figure 22).

The depth distribution of gurnard target trawling has shown some variability over time (Figure 23); while the bulk of the effort is usually shallower than 50 m, some periods—including those since 2020—show the catch distribution extending deeper. The fishing depth distribution when targeting tarakihi appears to have been more stable, but the gurnard catch-weighted distribution shows more variation, extending deeper in periods when gurnard target effort moves deeper.

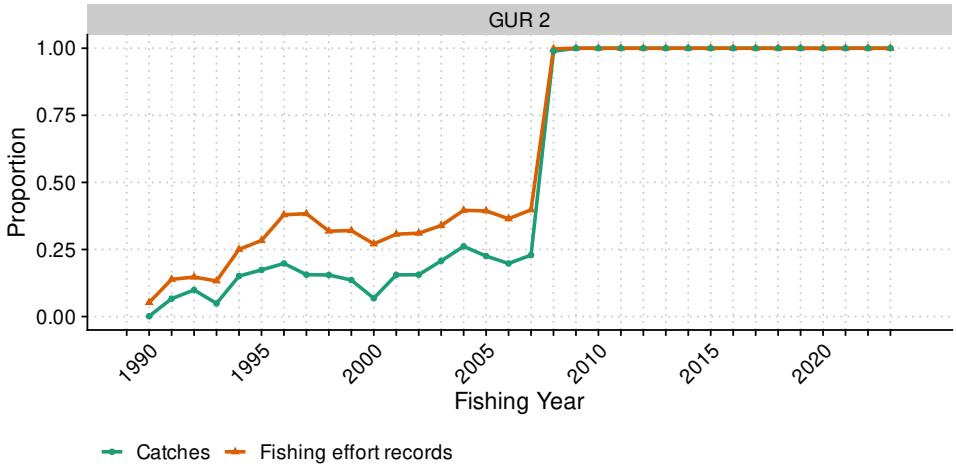

Figure 14: The proportion of records and catches reported with a latitude/longitude for the GUR 2 bottom trawl (including PRB) fishery.

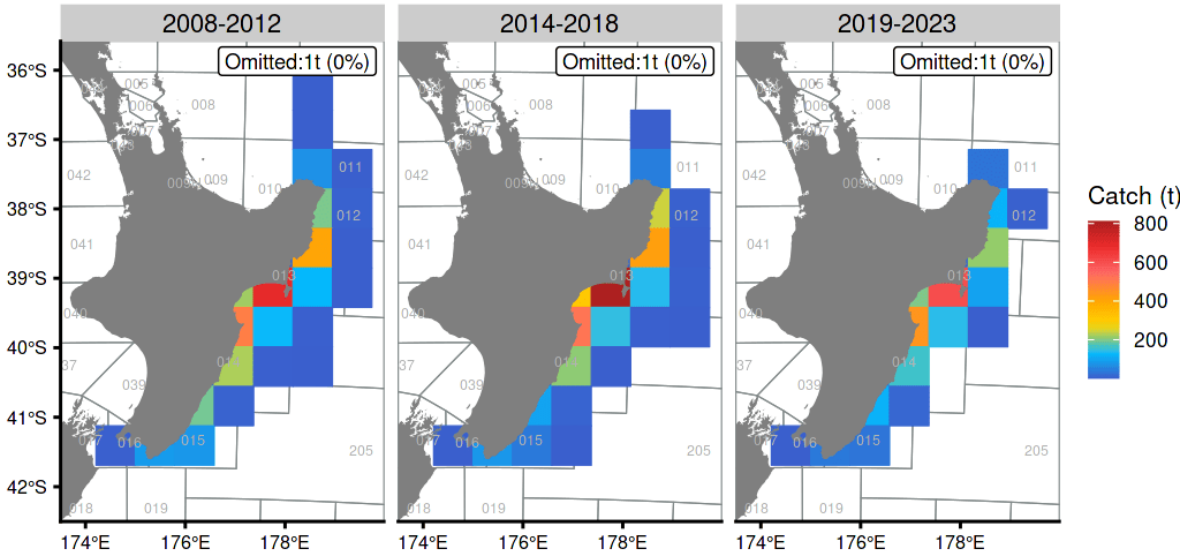

Figure 15: Catches (t) for the GUR 2 bottom trawl (including PRB) fishery, for 5-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

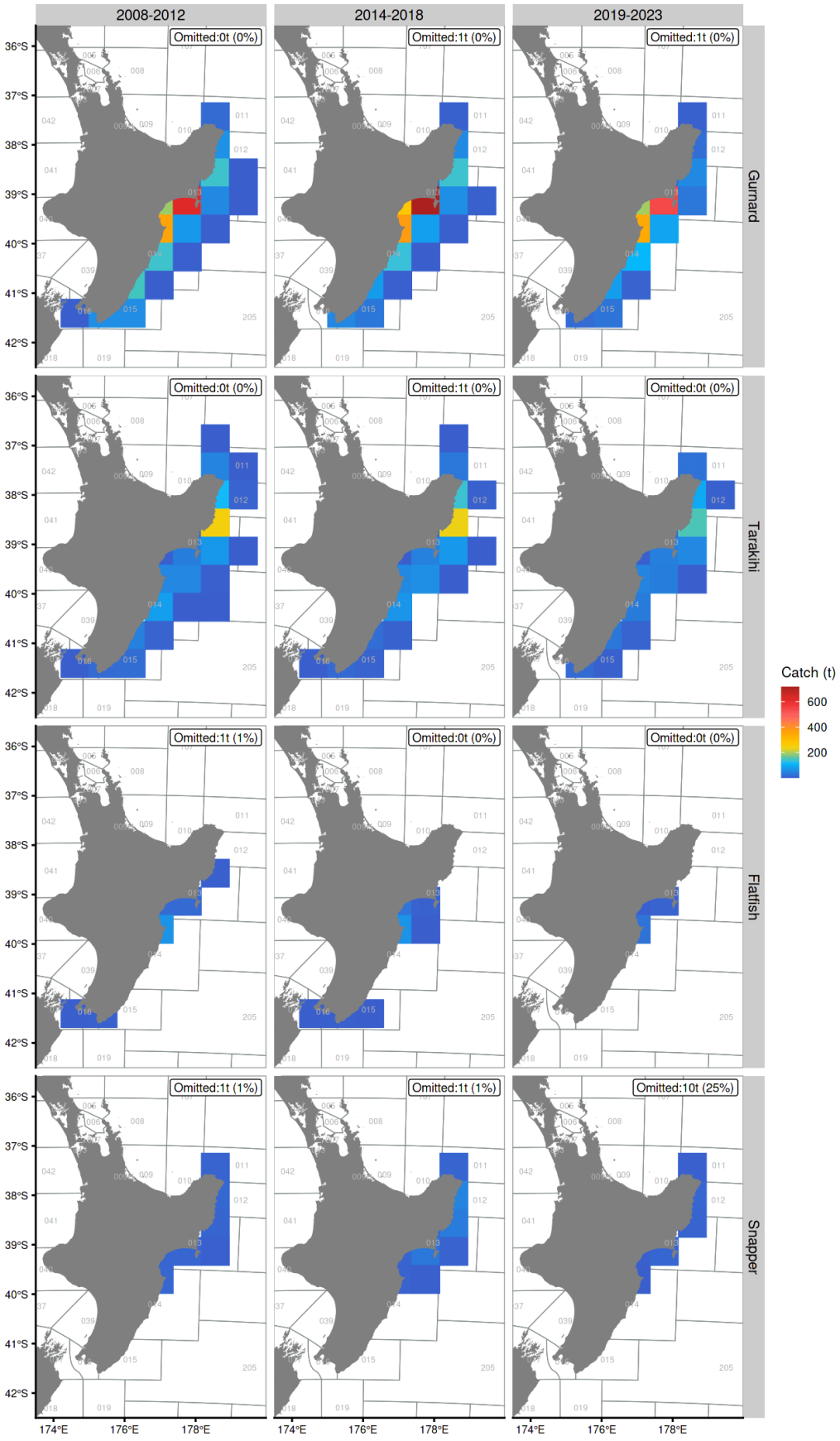

Figure 16: Catches of red gurnard from the bottom trawl (including PRB) fishery by key target species. These plots use a 64 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

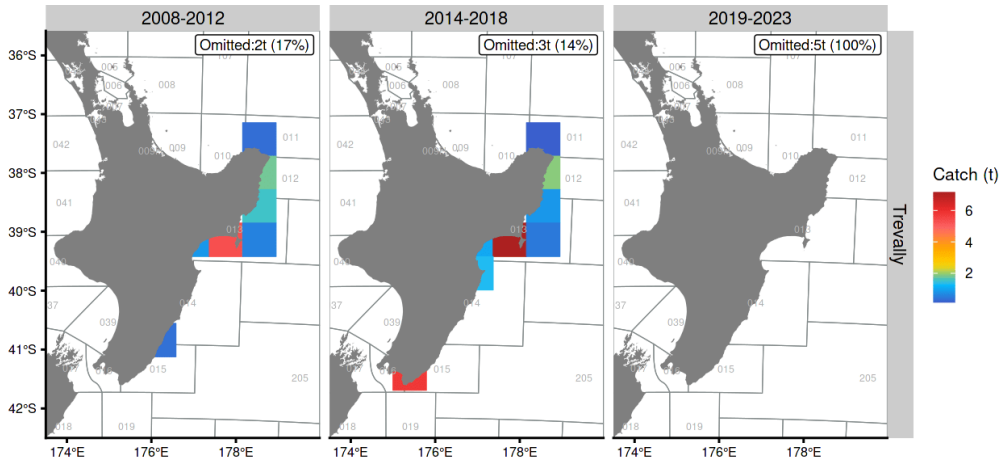

Figure 17: Catches of red gurnard from the bottom trawl (including PRB) fishery by key target species. These plots use a 64 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

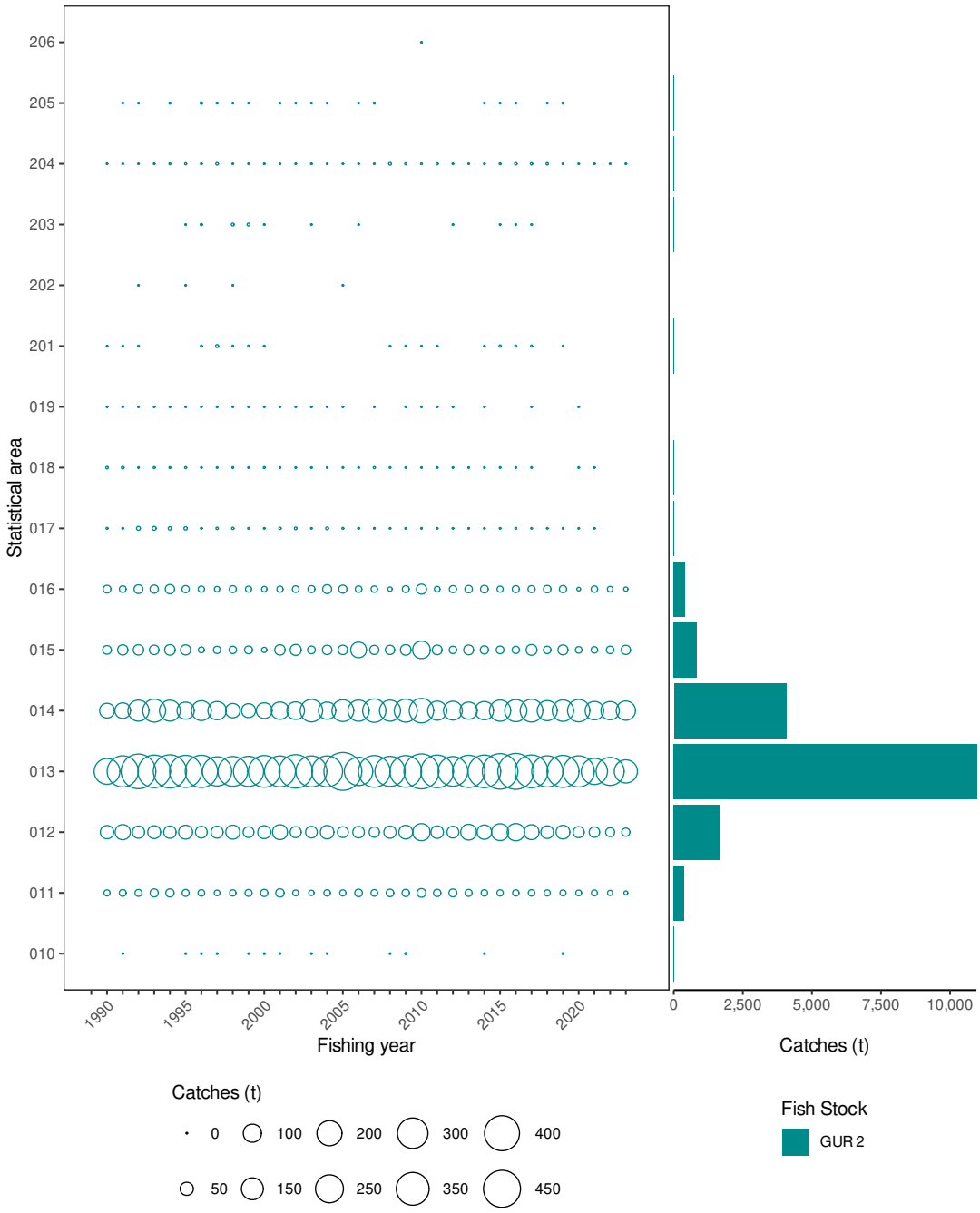

Figure 18: Annual GUR 2 catches (t) by statistical area for the bottom trawl (including PRB) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of GUR 2 for each statistical area.

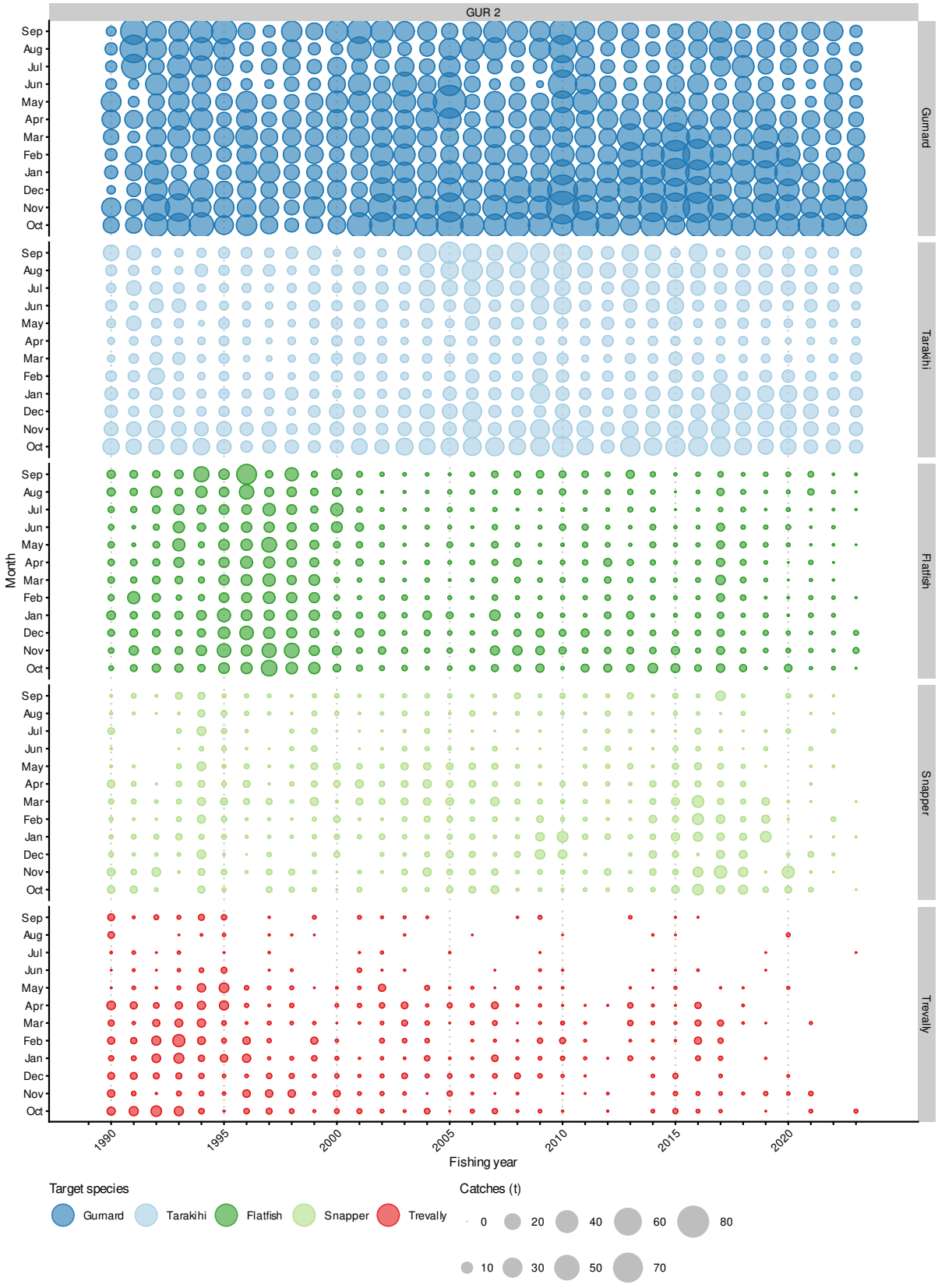

Figure 19: Seasonal distribution of GUR 2 catches by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly catches.

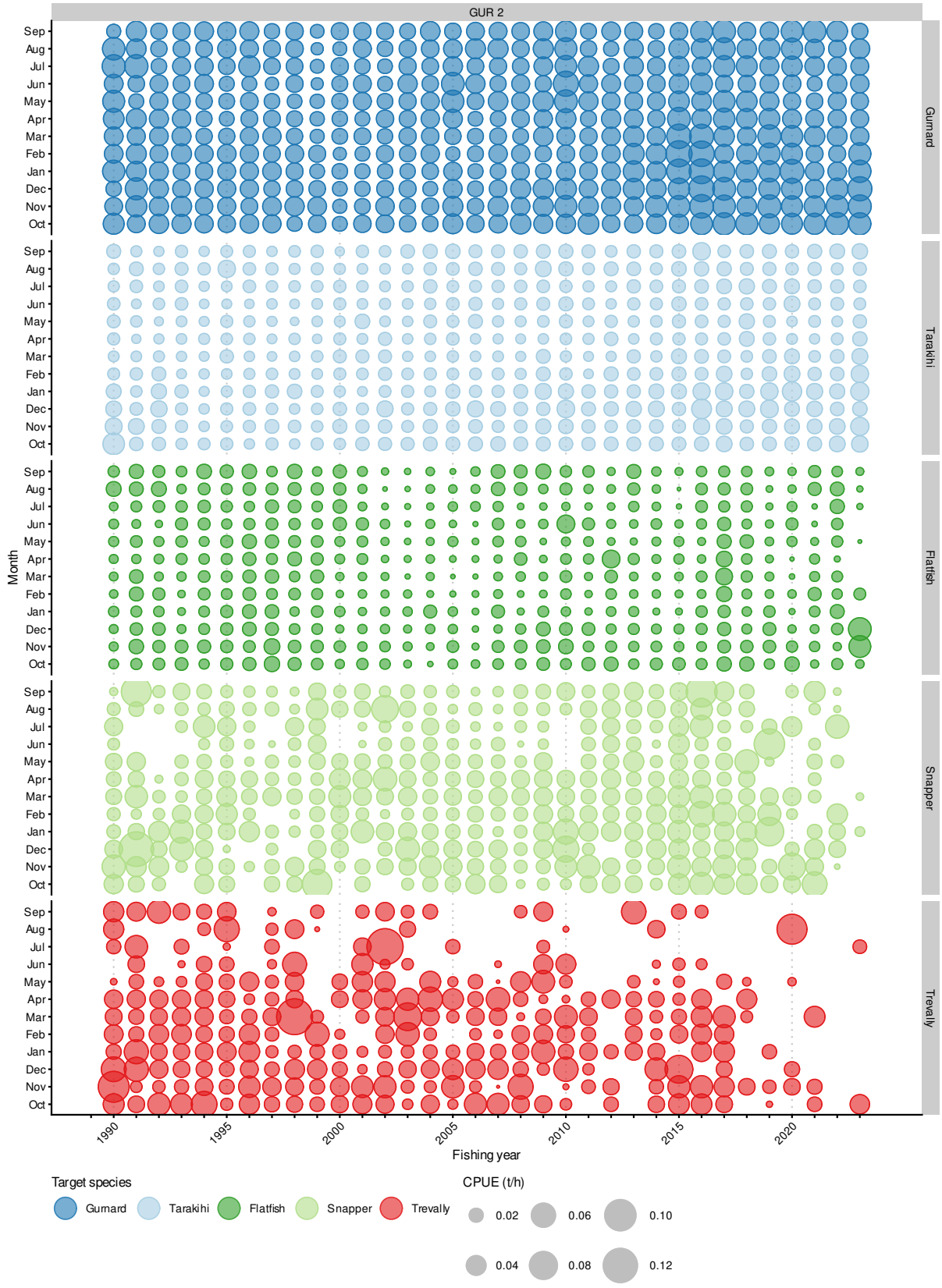

Figure 20: Seasonal distribution of GUR 2 raw aggregate CPUE (t/h) by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

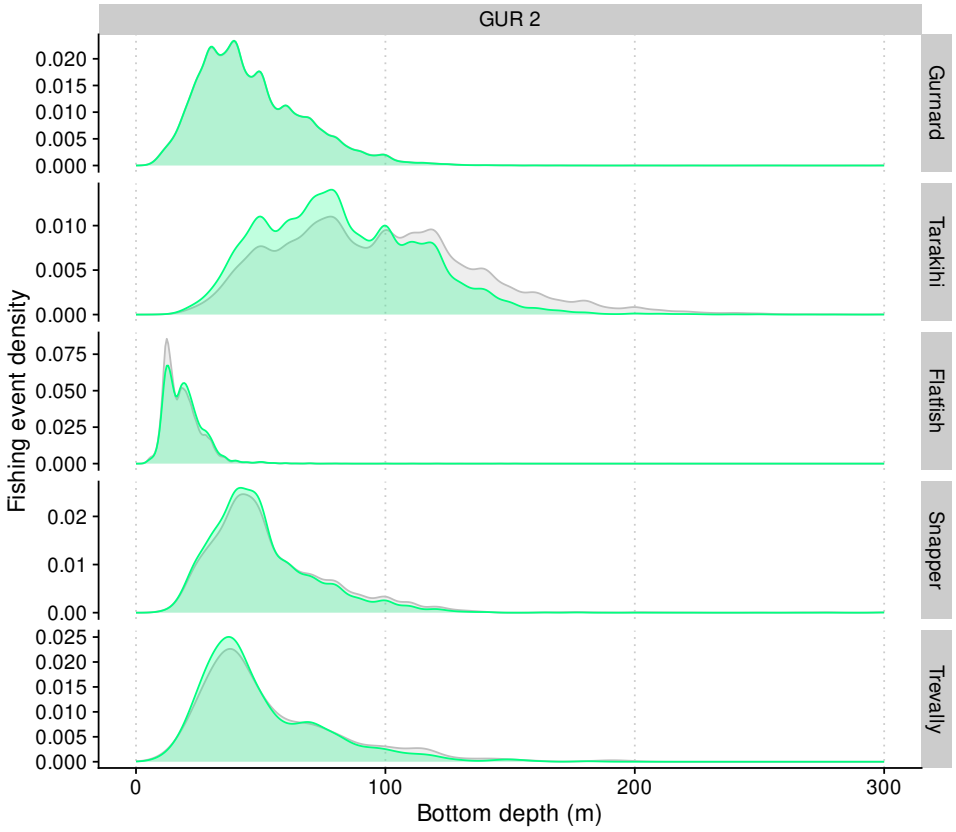

Figure 21: Effort depth distribution by target species for trips landing GUR 2 from the bottom trawl (including PRB) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, green fill = positive effort (i.e., estimated catch > 0).

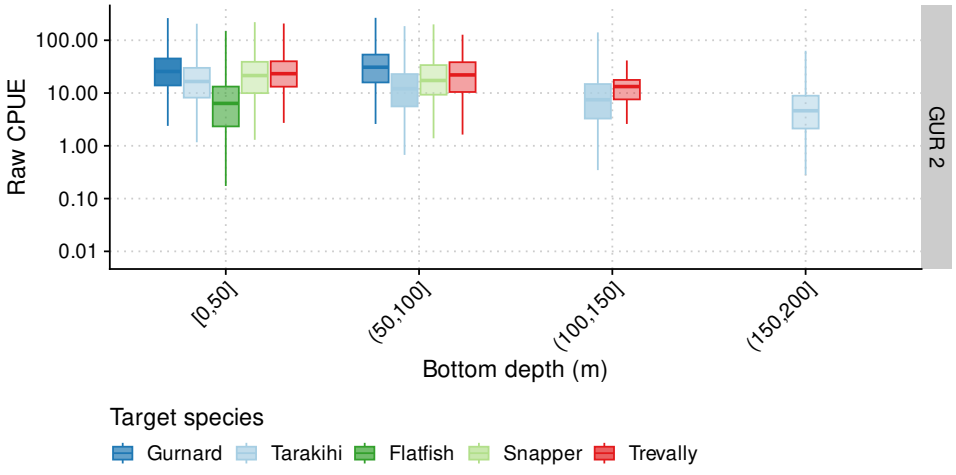

Figure 22: Raw CPUE (t/h) by depth bin and target species for events catching red gurnard from the bottom trawl (including PRB) target fisheries in GUR 2. Boxplots are included for depth bins that include at least 5% of the events in the dataset for a particular target species, and events with a raw CPUE greater than the 99.9th percentile have been removed. The box indicates the median and quartiles, while the whiskers extend to the largest and smallest values no more than 1.5 times the inter-quartile range from the hinge.

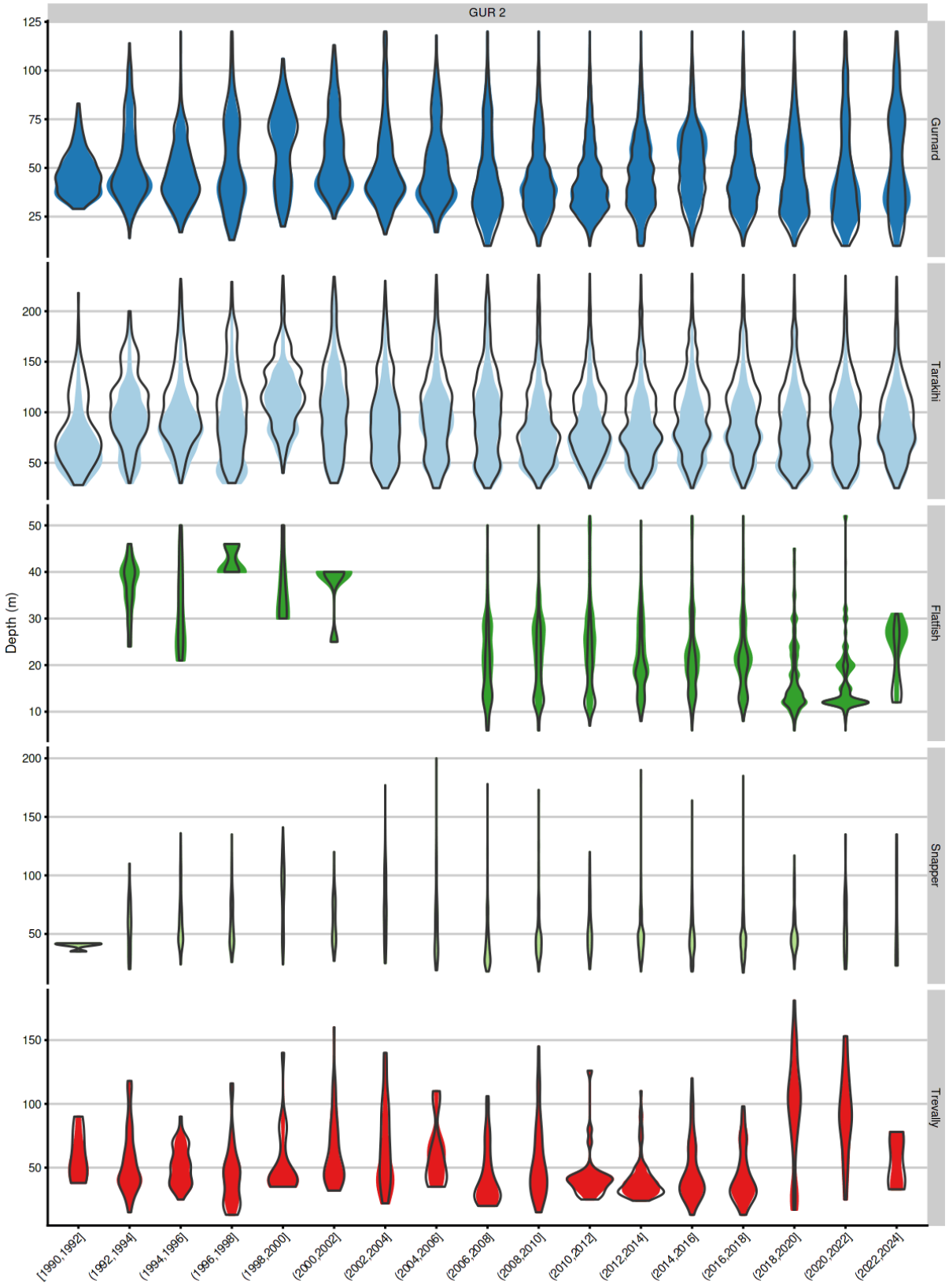

Figure 23: Catch-weighted (coloured) and unweighted (unfilled) effort depth distribution by target species for trips landing GUR 2 from the bottom trawl (including PRB) fishery.

3.4 The Danish seine fishery

Like the bottom trawl fishery, the largest proportion of gurnard catches by Danish seine has come from Statistical Area 013. However, prior to 2015 at least, Danish seine fishing has had a generally more northerly distribution with almost as much catch taken from Statistical Area 012 (Figure 24).

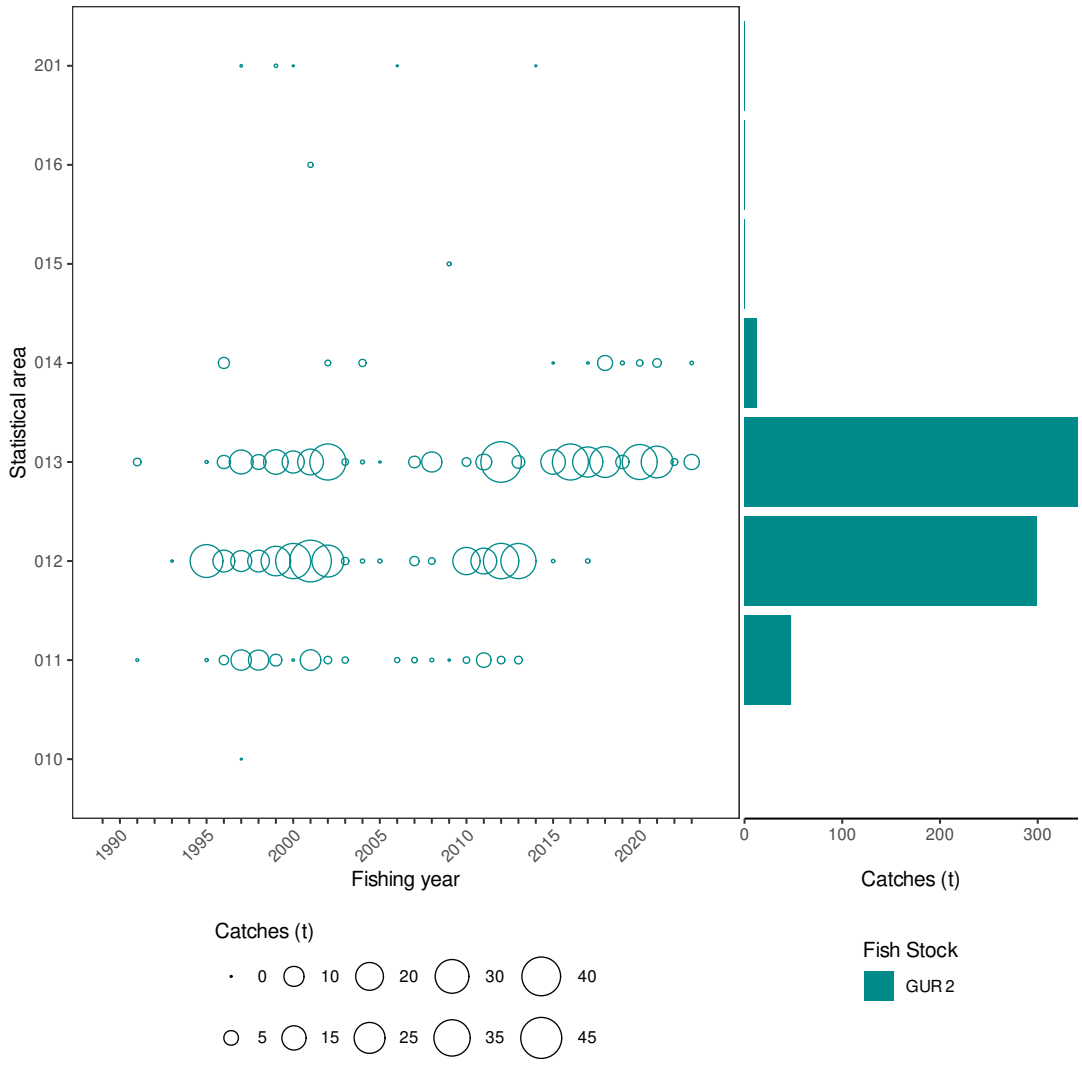

Figure 24: Annual GUR 2 catches (t) by statistical area for the Danish seine fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of GUR 2 for each statistical area.

4. CATCH-PER-UNIT-EFFORT

Two primary CPUE models were fitted (Table 3), based on those originally developed by Schofield et al. (2018). The first was a daily index, using pseudo-CELR data from 1989 to 2023; this is the agreed index used for monitoring red gurnard in FMA 2.

The second index uses event-level data from 2008 to 2023. Event-level data provide a wider range of covariates for use in the standardisation, but these data are only considered useful for monitoring abundance of GUR 2 after the introduction of the TCER form. As a result, this is considered to be a supporting index. However, this model allows the examination of spatial residuals that assist in interpreting localised changes in the distribution of gurnard.

The third model fitted was also an event-level model, adding tarakihi target effort and focusing on the core area of the fishery. This model was considered by the Inshore Fisheries Assessment Working Group in 2022, and it was recommended that tarakihi target effort be included in future tow-level indices for GUR 2. Detailed diagnostics for this model are included in Appendix C.

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

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
GUR 2 BT.MIX pseudoCELR	daily	allockg	Stepwise	7	5	Weibull
GUR 2 BT.MIX event	event	allockg_top5	Stepwise	5	5	Weibull
GUR 2 BT.MIX.TAR event	event	allockg_top5	Stepwise	5	5	Weibull

4.1 GUR 2 BT.MIX pseudoCELR

The GUR 2 BT.MIX pseudoCELR series is defined in Table 4; it differs from the models developed by Schofield et al. (2018) by using splines rather than polynomials for continuous variables, not offering the concatenation of month and area as a pseudo-interaction term, and offering the number of tows in a day as an alternative effort variable alongside total daily tow duration.

The core vessel selection, using the same criteria as Schofield et al. (2018), retained 85.5% of the catch while reducing the core fleet in the modelling dataset to 49 vessels (Figure 25). The resulting fleet shows good overlap, with some vessels operating throughout the period (Figure 26). The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 5.

The core fleet dataset (Table 6) peaks at 32 vessels that undertook 989 trips in 2002, reducing to 12 vessels undertaking 280 trips by 2023. Catches ranged from 100 t to 560 t per annum, with gurnard caught on at least 93% of days fished. All records in the dataset had catches allocated on the basis of estimated catch (Figure 27). The percentage of days with a catch of gurnard was consistently high throughout the period (Figure 28) so, following Schofield et al. (2018), we only consider a model for positive catches.

Stepwise selection for the Weibull model of positive catches retained most of the same explanatory variables that were retained in the model fitted by Schofield et al. (2018), except for the area_month pseudo-interaction term (now offered as a true interaction; Table 7). Fishing duration was retained as the effort variable in preference to the number of tows. Diagnostics for the Weibull model (Figure 29) were noticeably better than those for a log-normal error distribution, although a gamma distribution would also have been satisfactory (Figure 30).

The effect of standardisation on positive catches is apparent throughout the series, with the standardised index generally higher than the unstandardised index during 1990–2007, and lower during 2008–2023 (Figure 31). Step plots (Figure 32) illustrate that most of the effect of standardisation on the annual index is attributable to fishing duration and vessel key.

The distribution of daily fishing duration has remained similar over the period, but a greater proportion of shorter fishing durations in 1990, 2022 and 2023 have some influence (Figure 33). Vessel coefficients indicate a transition in the core fleet in the mid 2000s, with the core fleet since 2007 comprising a greater proportion of vessels with higher gurnard catch rates (Figure 34). The dataset is dominated by gurnard target effort, and lower catch rates of gurnard are expected when vessels are targeting snapper or trevally (Figure 35).

Residual implied coefficients by target species (Figure 36) and statistical area (Figure 37) illustrate that the index is dominated by data from gurnard target fishing in Statistical Area 013. During 2018–2023, there is evidence of somewhat higher catch rates in Statistical Area 013, and lower rates in Statistical Area 014.

The final standardised series (Figure 38, Table 8) continues to show evidence of shorter term (4–5 year) cycles in the abundance of red gurnard superimposed on longer term trends. Abundance showed a generally decreasing trend from 1990 until the late 2000s, but generally increased during the 2010s. During 2021–2023 the series was at the long-term mean.

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 GUR 2 BT.MIX pseudoCELR CPUE series.

Series	GUR 2 BT.MIX pseudoCELR
QMS stock	GUR 2
Reporting forms	CEL, TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	GUR, SNA, TRE
Statistical Areas	011, 012, 013, 014, 015, 016
Period	1989-10-01, 2023-09-30
Resolution	Day
Core fleet years	7
Core fleet trips	5
Default model	allockg ~ fyear + vessel_key + ns(log(fishing_duration), 3) + target_species + effort_num + stat_area*month + ns(effort_height, 3) + ns(effort_width, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

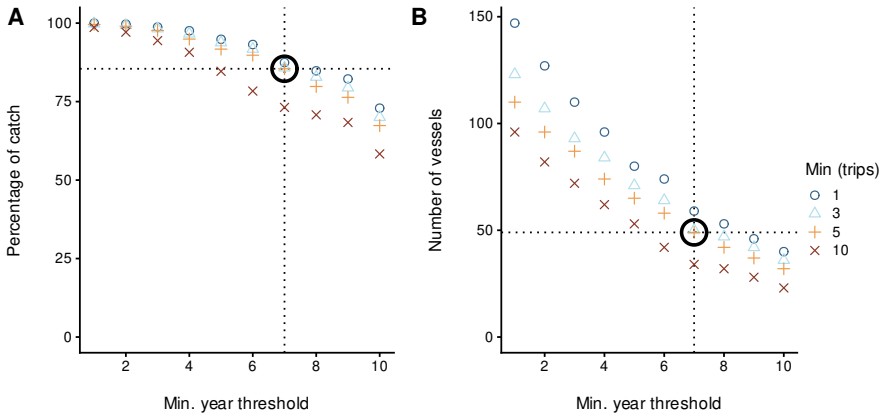

Figure 25: Percentage of catch and number of vessels for different core vessel selection criteria for the GUR 2 BT.MIX pseudoCELR CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

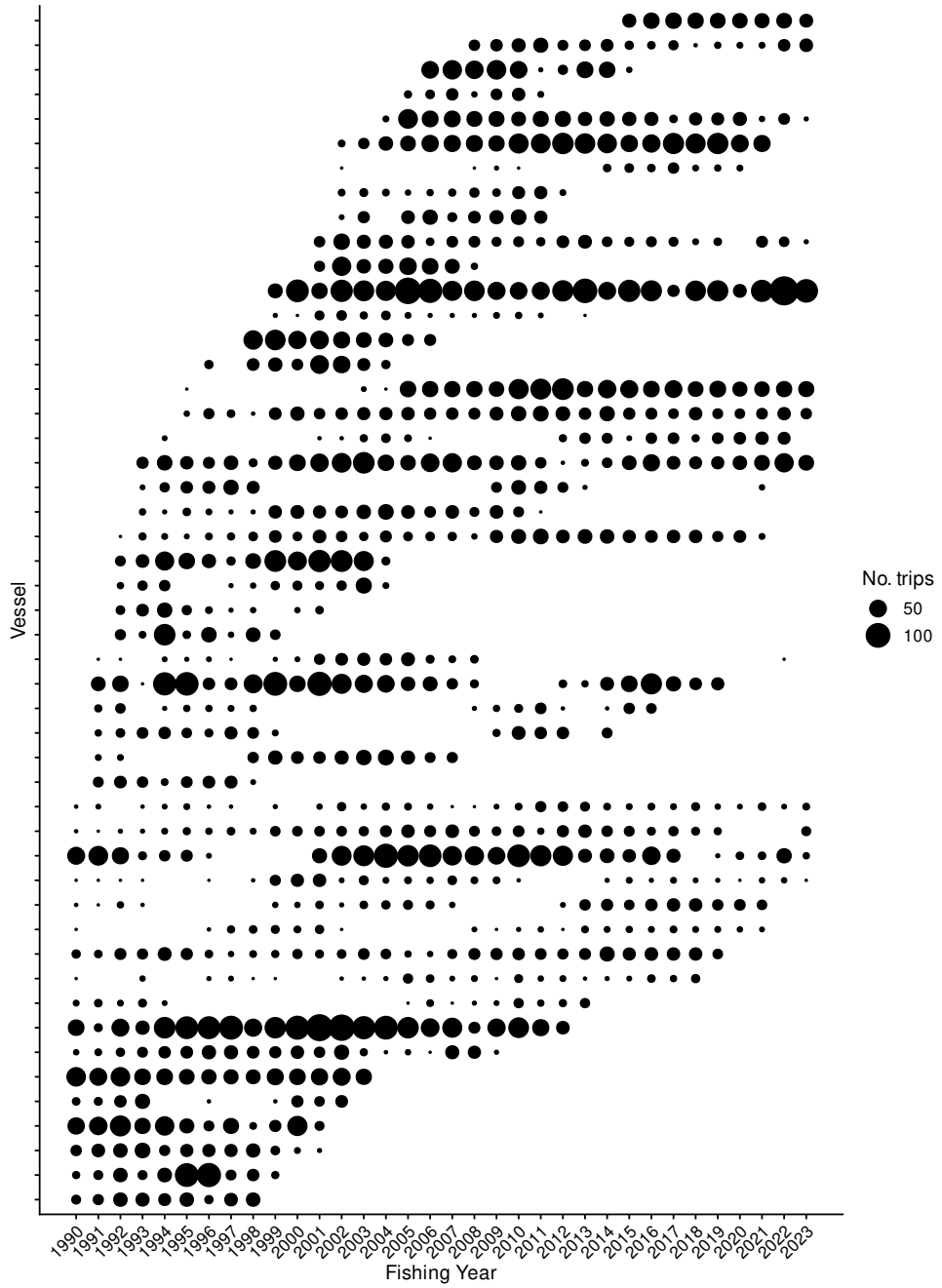

Figure 26: Number of trips by fishing year for core vessels in the GUR 2 BT.MIX pseudoCELR series. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

Table 5: Summary of the GUR 2 BT.MIX pseudoCELR dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	214 (100%) n: 839	317 (100%) n: 1095	410 (100%) n: 1589	420 (100%) n: 1626	428 (100%) n: 1882	314 (100%) n: 1505	289 (100%) n: 1235	230 (100%) n: 1119	245 (100%) n: 1243
Fishing duration is not NA	213 (99%) n: 834	316 (100%) n: 1087	408 (100%) n: 1585	419 (100%) n: 1625	428 (100%) n: 1880	314 (100%) n: 1500	286 (99%) n: 1220	228 (99%) n: 1110	244 (100%) n: 1229
Fishing duration over 30mins	213 (99%) n: 834	316 (100%) n: 1087	407 (99%) n: 1583	419 (100%) n: 1622	427 (100%) n: 1875	313 (100%) n: 1497	286 (99%) n: 1220	228 (99%) n: 1109	244 (100%) n: 1229
Fishing duration under 24hrs	211 (99%) n: 832	315 (99%) n: 1086	405 (99%) n: 1580	417 (99%) n: 1617	426 (99%) n: 1870	309 (98%) n: 1485	284 (98%) n: 1203	224 (98%) n: 1100	243 (99%) n: 1221
Core fleet selection	101 (47%) n: 370	168 (53%) n: 574	207 (51%) n: 865	184 (44%) n: 802	236 (55%) n: 1075	211 (67%) n: 980	219 (76%) n: 899	184 (80%) n: 857	205 (84%) n: 1028

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	253 (100%) n: 1513	312 (100%) n: 1719	364 (100%) n: 1759	404 (100%) n: 2002	396 (100%) n: 1886	332 (100%) n: 1511	502 (100%) n: 1710	302 (100%) n: 1478	370 (100%) n: 1553
Fishing duration is not NA	248 (98%) n: 1480	309 (99%) n: 1698	364 (100%) n: 1759	404 (100%) n: 2002	396 (100%) n: 1886	332 (100%) n: 1511	502 (100%) n: 1710	302 (100%) n: 1478	370 (100%) n: 1553
Fishing duration over 30mins	248 (98%) n: 1478	309 (99%) n: 1697	364 (100%) n: 1758	404 (100%) n: 2001	396 (100%) n: 1885	332 (100%) n: 1510	502 (100%) n: 1710	302 (100%) n: 1477	370 (100%) n: 1551
Fishing duration under 24hrs	242 (96%) n: 1457	308 (99%) n: 1691	364 (100%) n: 1756	403 (100%) n: 2000	394 (99%) n: 1882	330 (100%) n: 1506	502 (100%) n: 1709	302 (100%) n: 1476	369 (99%) n: 1548
Core fleet selection	219 (87%) n: 1254	269 (86%) n: 1404	306 (84%) n: 1511	362 (90%) n: 1836	358 (90%) n: 1729	288 (87%) n: 1348	453 (90%) n: 1545	254 (84%) n: 1373	327 (88%) n: 1422

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	312 (100%) n: 1300	340 (100%) n: 1303	595 (100%) n: 1772	385 (100%) n: 1494	328 (100%) n: 1291	366 (100%) n: 1202	373 (100%) n: 1358	473 (100%) n: 1203	506 (100%) n: 1285
Fishing duration is not NA	312 (100%) n: 1300	340 (100%) n: 1303	595 (100%) n: 1772	385 (100%) n: 1494	328 (100%) n: 1291	366 (100%) n: 1202	373 (100%) n: 1358	473 (100%) n: 1202	506 (100%) n: 1285
Fishing duration over 30mins	312 (100%) n: 1299	340 (100%) n: 1302	595 (100%) n: 1772	385 (100%) n: 1494	328 (100%) n: 1290	366 (100%) n: 1202	373 (100%) n: 1356	473 (100%) n: 1199	506 (100%) n: 1285
Fishing duration under 24hrs	312 (100%) n: 1297	339 (100%) n: 1300	595 (100%) n: 1772	384 (100%) n: 1491	327 (100%) n: 1289	365 (100%) n: 1200	372 (100%) n: 1353	473 (100%) n: 1199	503 (99%) n: 1278
Core fleet selection	283 (90%) n: 1175	316 (93%) n: 1225	561 (94%) n: 1699	375 (97%) n: 1431	313 (95%) n: 1243	354 (97%) n: 1153	365 (98%) n: 1281	467 (99%) n: 1159	499 (98%) n: 1248

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	413 (100%) n: 1159	334 (100%) n: 1142	403 (100%) n: 1185	356 (100%) n: 1005	245 (100%) n: 962	306 (100%) n: 1109	218 (100%) n: 677
Fishing duration is not NA	413 (100%) n: 1159	334 (100%) n: 1142	403 (100%) n: 1185	356 (100%) n: 1005	245 (100%) n: 962	306 (100%) n: 1109	218 (100%) n: 677
Fishing duration over 30mins	413 (100%) n: 1159	334 (100%) n: 1142	403 (100%) n: 1183	356 (100%) n: 1004	245 (100%) n: 959	306 (100%) n: 1108	218 (100%) n: 676
Fishing duration under 24hrs	412 (100%) n: 1158	334 (100%) n: 1141	402 (100%) n: 1180	354 (100%) n: 1002	244 (100%) n: 958	306 (100%) n: 1108	218 (100%) n: 676
Core fleet selection	399 (97%) n: 1083	306 (92%) n: 975	392 (97%) n: 1050	343 (97%) n: 895	232 (95%) n: 797	243 (79%) n: 830	172 (79%) n: 548

Table 6: Summary of the GUR 2 BT.MIX pseudoCELR 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 red gurnard.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	17	286	370	2 923.75	101.15	95.14
1991	21	357	574	5 073.17	168.36	96.52
1992	25	556	865	7 981.52	207.35	97.11
1993	27	459	802	7 666.83	183.85	93.77
1994	26	717	1 075	9 425.72	236.38	96.19
1995	25	662	980	8 632.38	210.79	95.10
1996	29	568	899	8 289.88	218.86	97.11
1997	26	493	857	7 927.67	184.03	94.63
1998	28	557	1 028	9 189.00	205.22	93.77
1999	29	727	1 254	11 664.50	218.94	96.17
2000	25	747	1 404	13 557.18	269.26	95.80
2001	30	903	1 511	13 491.48	306.35	97.55
2002	32	989	1 836	16 457.40	362.13	97.60
2003	30	906	1 729	15 682.53	357.55	97.86
2004	29	759	1 348	12 337.08	288.07	97.92
2005	29	838	1 545	14 921.52	453.15	98.77
2006	30	789	1 373	12 273.62	253.81	97.31
2007	28	745	1 422	12 888.28	327.25	98.45
2008	30	604	1 175	10 812.70	282.61	96.85
2009	29	643	1 225	11 574.43	315.57	95.43
2010	28	835	1 699	16 400.35	561.22	96.23
2011	26	680	1 431	14 018.95	374.74	96.79
2012	25	618	1 243	11 811.28	313.25	96.94
2013	22	559	1 153	11 381.60	353.78	96.88
2014	23	572	1 281	12 825.40	364.73	94.61
2015	23	540	1 159	11 650.43	467.29	96.89
2016	22	617	1 248	11 910.72	498.58	95.67
2017	21	497	1 083	10 628.02	398.68	96.68
2018	20	461	975	9 207.62	306.28	96.10
2019	20	444	1 050	10 355.52	391.51	96.10
2020	16	328	895	9 008.27	343.47	96.42
2021	17	370	797	7 414.45	231.92	95.61
2022	13	435	830	6 971.90	242.90	96.51
2023	12	280	548	4 753.93	171.52	94.53

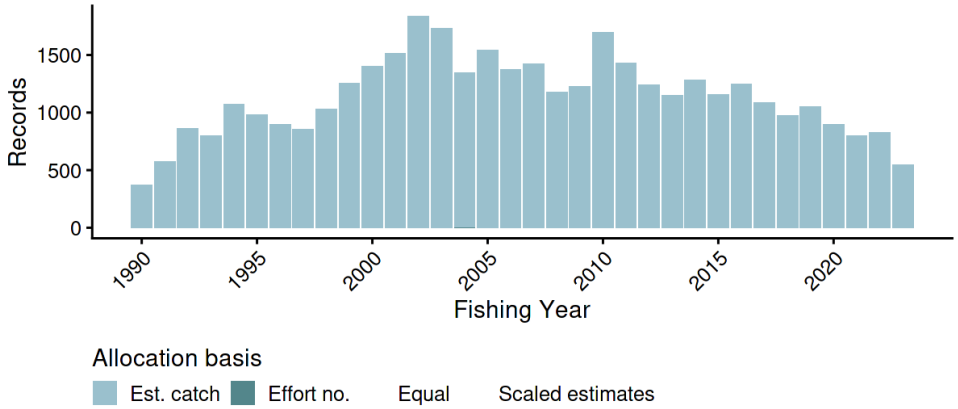

Figure 27: Allocation basis for attributing landings to records in the GUR 2 BT.MIX pseudoCELR catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

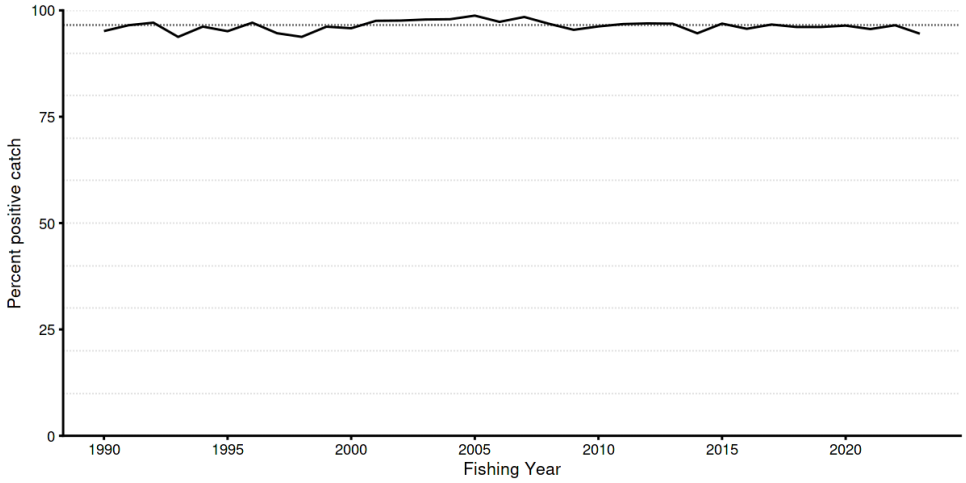

Figure 28: Percentage of positive catch records in the GUR 2 BT.MIX pseudoCELR catch-per-unit-effort dataset.

Table 7: Summary of stepwise selection for the Weibull model for positive catches in the GUR 2 BT.MIX pseudoCELR series. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
fyear	35	489 948	6.7	6.7	*
+ ns(log(fishing_duration), 3)	3	475 399	43.4	36.6	*
+ vessel_key	48	465 871	67.6	24.2	*
+ target_species	2	465 318	69.0	1.4	*
+ effort_num	1	464 956	69.9	0.9	
+ month	11	464 660	70.7	0.8	
+ stat_area	5	464 423	71.3	0.6	
+ stat_area:month	55	464 275	72.0	0.6	
+ ns(effort_height, 3)	3	464 220	72.1	0.2	
+ ns(effort_width, 3)	3	464 217	72.1	0.0	

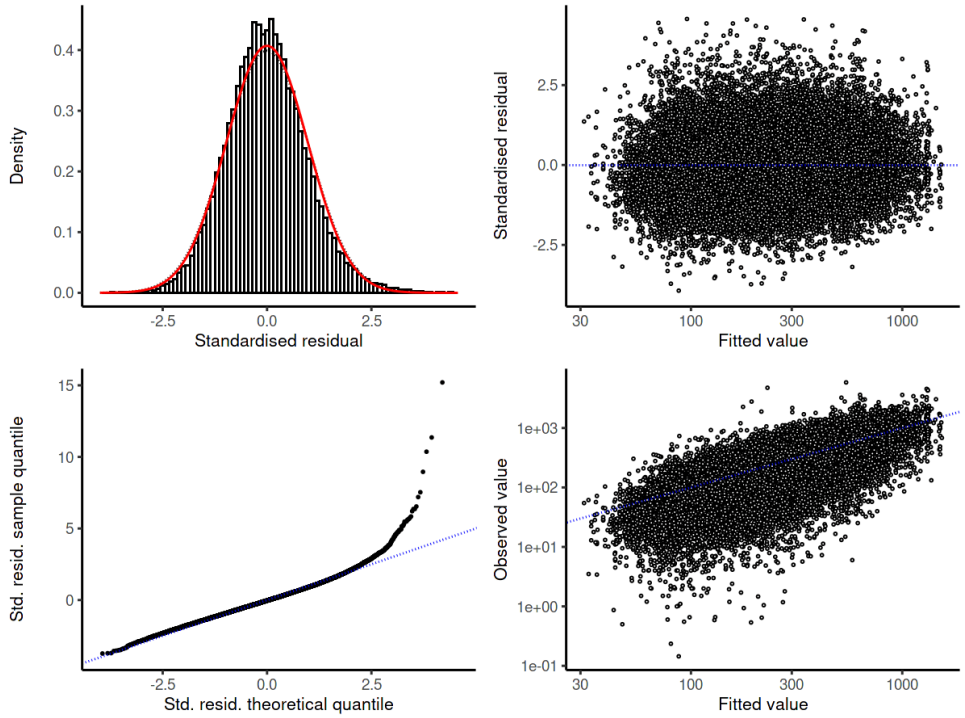

Figure 29: Diagnostic plots for the selected Weibull model for positive catches in the GUR 2 BT.MIX pseudoCELR dataset.

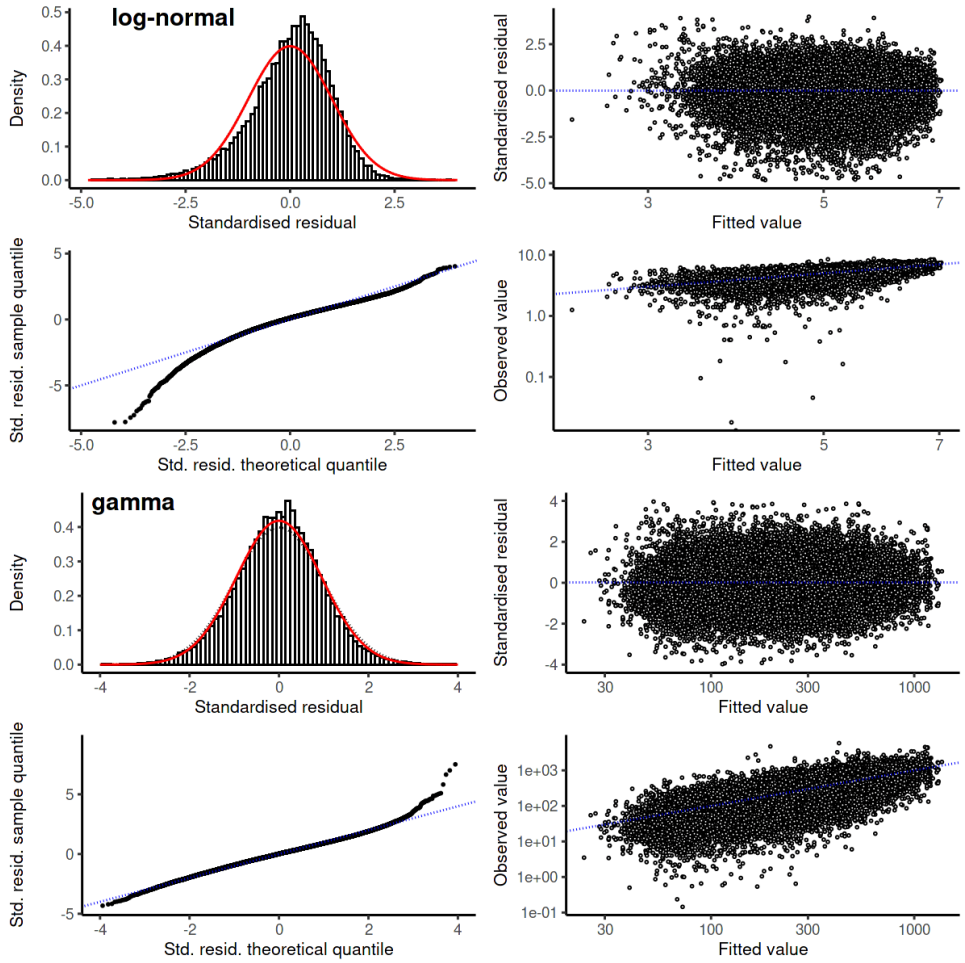

Figure 30: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the GUR 2 BT.MIX pseudoCELR dataset.

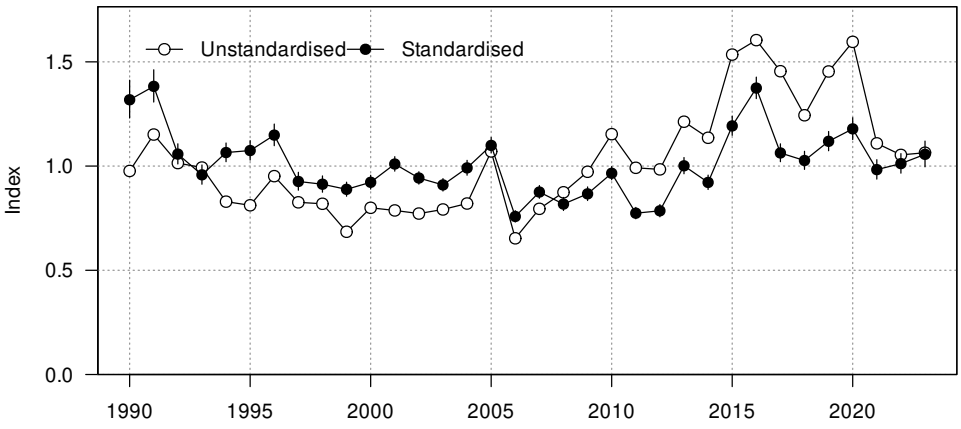

Figure 31: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the GUR 2 BT.MIX pseudoCELR dataset.

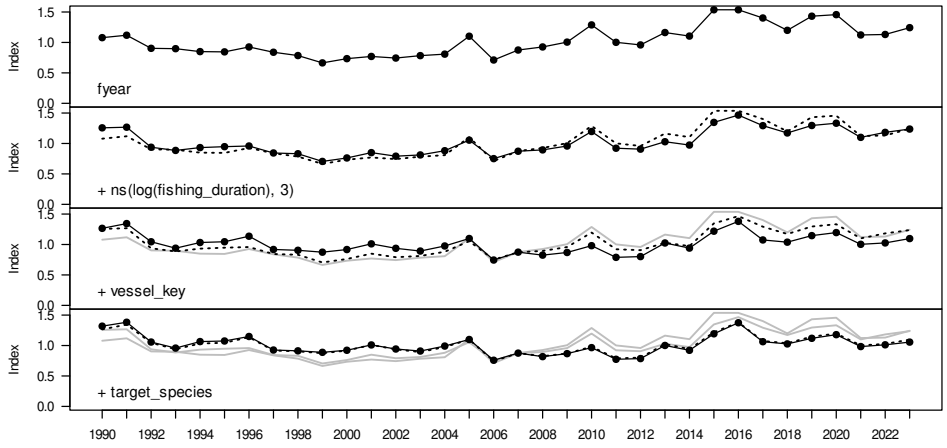

Figure 32: Changes to the GUR 2 BT.MIX pseudoCELR positive catch index as terms are successively entered into the Weibull model.

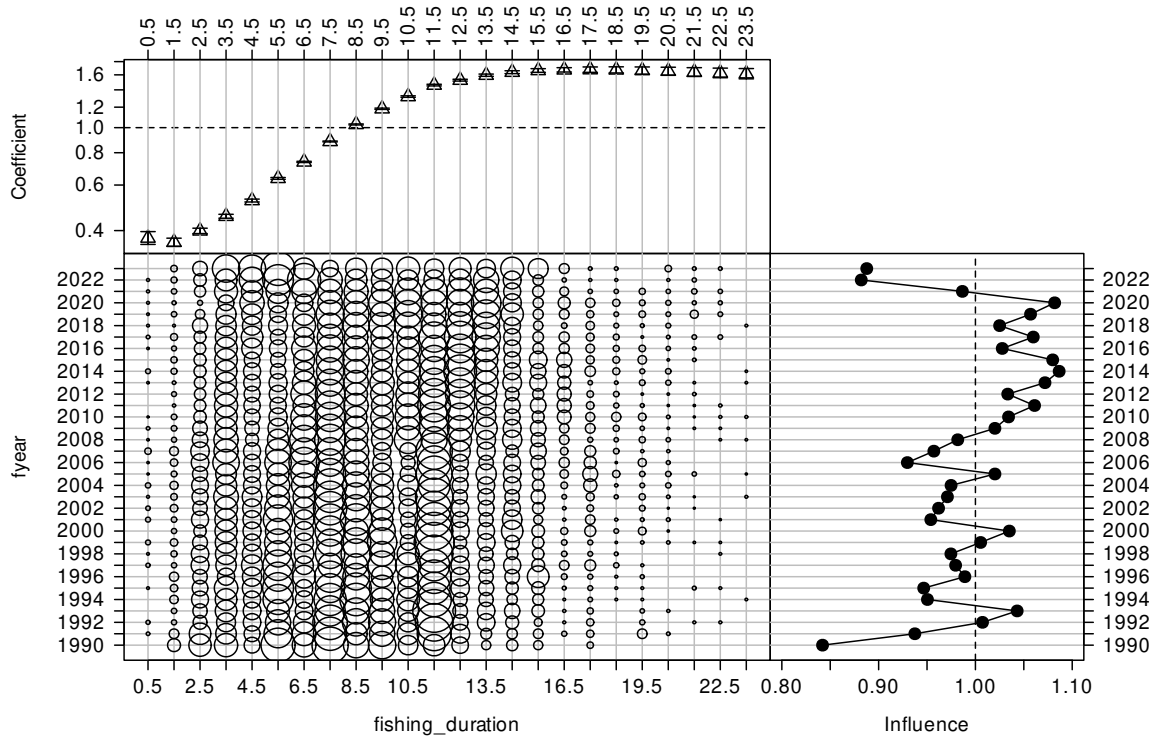

Figure 33: CDI plot for fishing duration (h) for the Weibull model of positive catches in the GUR 2 BT.MIX pseudoCELR catch-per-unit-effort dataset.

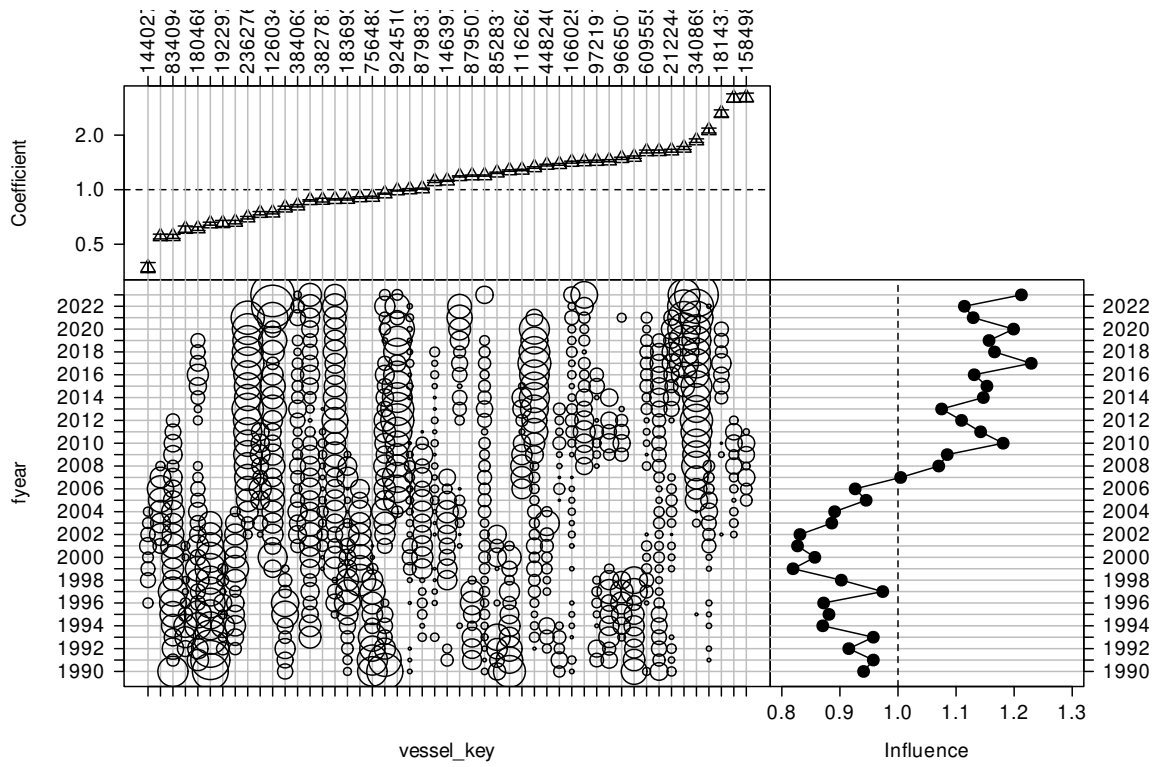

Figure 34: CDI plot for vessel key for the Weibull model of positive catches in the GUR 2 BT.MIX pseudoCELR catch-per-unit-effort dataset.

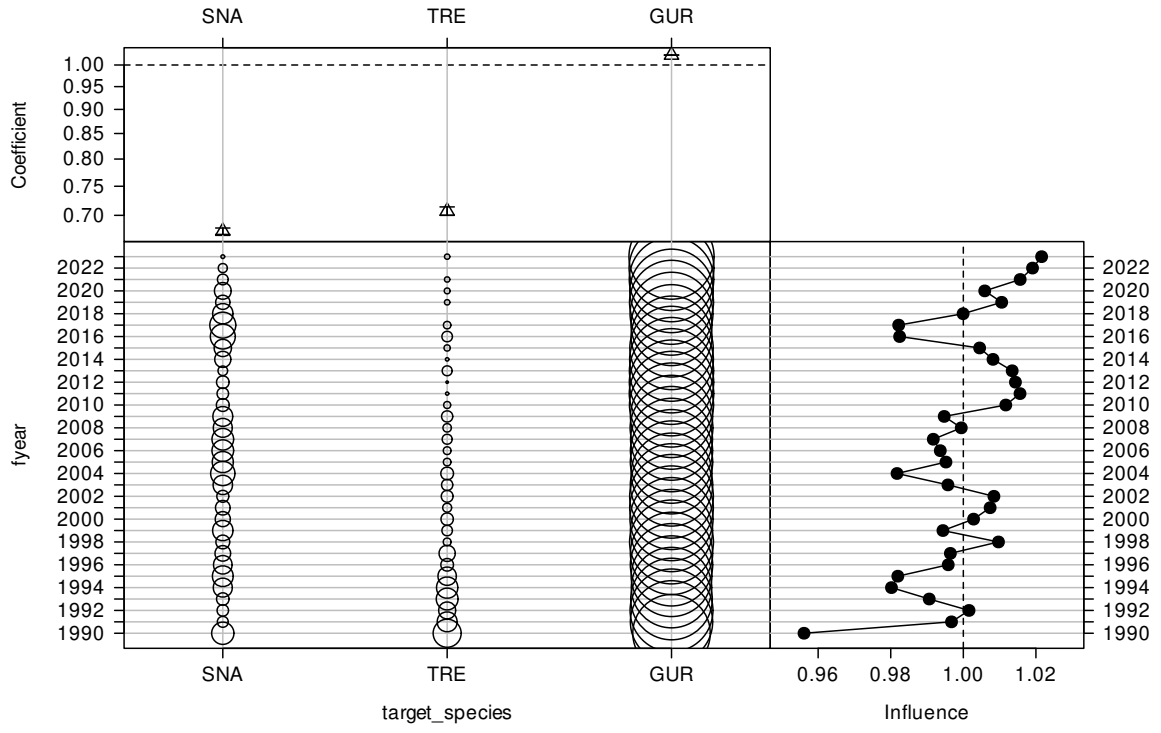

Figure 35: CDI plot for target species for the Weibull model of positive catches in the GUR 2 BT.MIX pseudoCELR catch-per-unit-effort dataset.

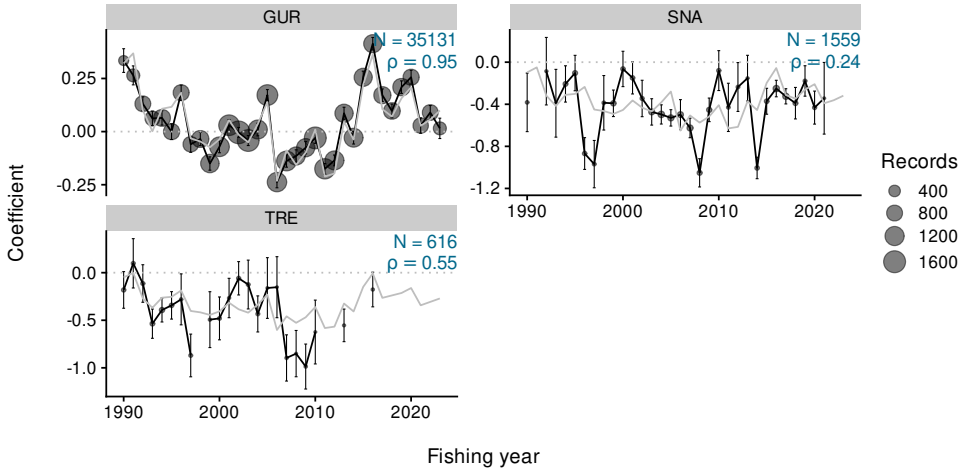

Figure 36: Residual implied coefficients for target-year in the Weibull positive catch model for the GUR 2 BT.MIX pseudoCELR dataset.

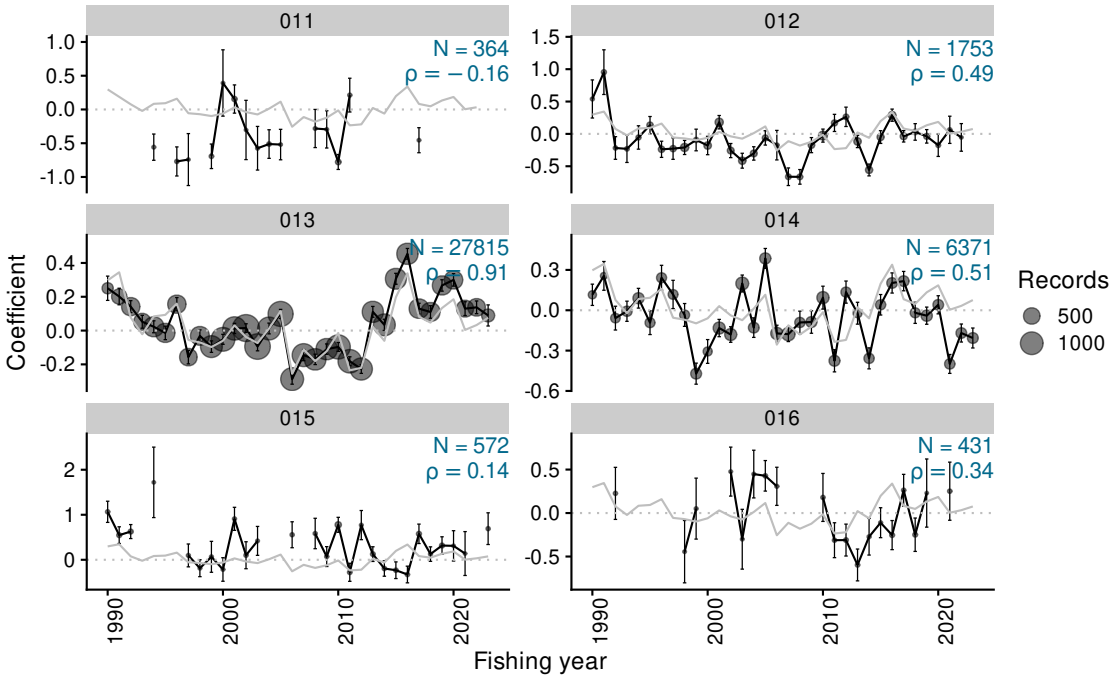

Figure 37: Residual implied coefficients for area-year in the Weibull positive catch model for the GUR 2 BT.MIX pseudoCELR dataset.

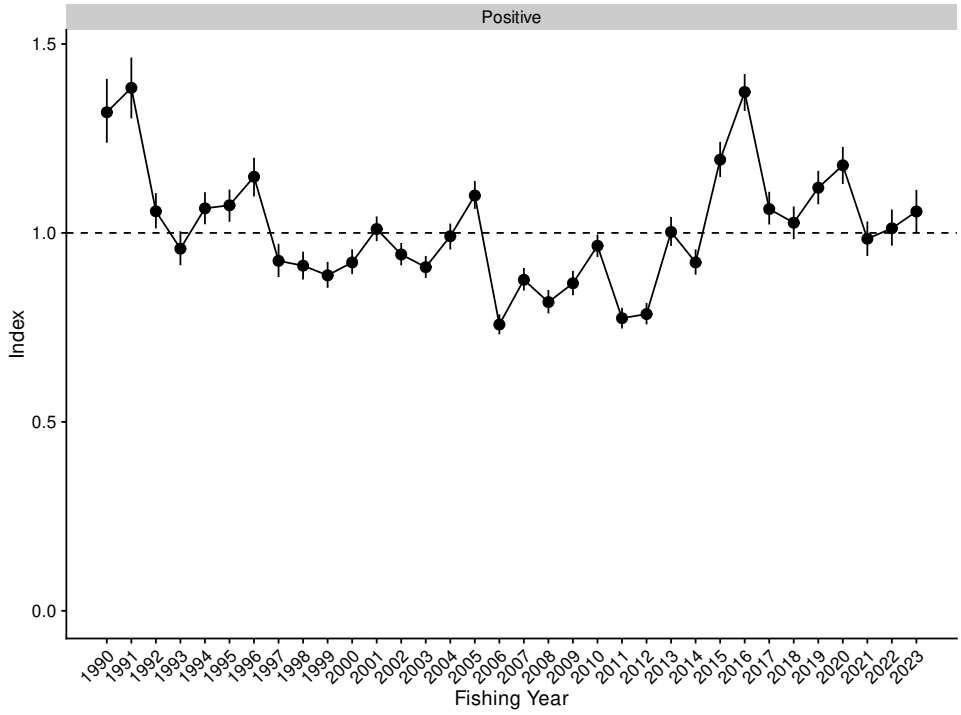

Figure 38: Standardised indices and 95% confidence intervals for the GUR 2 BT.MIX pseudoCELR dataset.

Table 8: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in GUR 2 BT.MIX pseudoCELR.

	Positive			
Fishing year	index	SE	LCI	UCI
1990	1.319	0.043	1.239	1.408
1991	1.384	0.041	1.303	1.464
1992	1.057	0.024	1.012	1.105
1993	0.958	0.023	0.915	1.004
1994	1.065	0.022	1.023	1.108
1995	1.073	0.022	1.030	1.115
1996	1.149	0.026	1.097	1.199
1997	0.926	0.022	0.883	0.971
1998	0.913	0.019	0.877	0.950
1999	0.888	0.017	0.855	0.923
2000	0.922	0.017	0.891	0.957
2001	1.010	0.017	0.978	1.044
2002	0.943	0.015	0.914	0.973
2003	0.909	0.015	0.881	0.939
2004	0.991	0.018	0.956	1.025
2005	1.099	0.019	1.064	1.137
2006	0.758	0.014	0.732	0.785
2007	0.876	0.015	0.848	0.907
2008	0.817	0.016	0.787	0.849
2009	0.867	0.016	0.835	0.899
2010	0.966	0.015	0.936	0.996
2011	0.774	0.014	0.747	0.802
2012	0.785	0.014	0.758	0.815
2013	1.003	0.020	0.966	1.042
2014	0.922	0.017	0.889	0.957
2015	1.194	0.024	1.148	1.241
2016	1.373	0.025	1.323	1.420
2017	1.063	0.022	1.022	1.109
2018	1.027	0.022	0.984	1.070
2019	1.120	0.023	1.076	1.164
2020	1.179	0.025	1.130	1.228
2021	0.985	0.023	0.939	1.030
2022	1.012	0.024	0.966	1.062
2023	1.057	0.029	0.999	1.114

4.2 GUR 2 BT.MIX event

The GUR 2 BT.MIX event series is defined in Table 9; as with the daily series, the key difference from the models developed by Schofield et al. (2018) is the use of splines rather than polynomials for continuous variables.

The core vessel selection, using the same criteria as Schofield et al. (2018), retained 92.1% of the catch while reducing the core fleet in the modelling dataset to 31 vessels (Figure 39). The resulting fleet shows good overlap, with key vessels operating throughout the period (Figure 40). The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 10.

The core fleet dataset (Table 11) peaks at 27 vessels in 2012, reducing to 12 vessels by 2023. Effort was highest in 2010, with 3771 tows undertaken during 816 trips. Catches ranged from 180 t to 520 t per annum, with gurnard caught on at least 92% of tows. A slightly declining trend in the proportion of tows with gurnard catches was evident during 2020–2023, suggesting that a combined model should be considered. All records in the dataset had catches allocated on the basis of estimated catch (Figure 41).

Only two variables (vessel_key and bottom_depth) are retained in a binomial model for the occurrence of gurnard catch, in addition to fishing year which is forced into the model, (Table 12) and there is little effect of standardisation on the index (Figure 42, Figure 43). Although the two vessels with the greatest occurrence of gurnard captures left the fishery after 2012, there is little trend in the influence of fleet composition on the occurrence of gurnard catches (Figure 44). The probability of gurnard catch is estimated to peak at depths of 25 m to 50 m (Figure 45); the fishing depth distribution shifted somewhat deeper in 2022–2023 with increased effort in 55 m to 100 m depths.

Stepwise selection for the Weibull model of positive catches retained bottom depth, tow start latitude, and month, in addition to the explanatory variables that were retained in the daily model (Table 13). Diagnostics for the Weibull model (Figure 46) are again better than those for the log-normal error distribution but similar to those for a gamma model (Figure 47). The effect of standardisation on positive catches is most apparent before 2010, and from 2017, and largely acts to reduce inter-annual variation (Figure 48). Most of the effect of standardisation is attributable to the vessel effects, and fishing duration (Figure 49).

While there are reasonably large between-vessel differences in gurnard catch rates (Figure 50), the stability of the fleet over the period of the model means that there is little trend in the influence of these effects. Most tows were from 2 h to 5 h long; there was evidence of a general increase in tow duration from 2008 to 2020 (Figure 51) although this was balanced by an increased prevalence of shorter tows thereafter, especially in 2022.

The effect of bottom depth on the magnitude of catches (Figure 52) was similar to that in the occurrence model, with the greatest catches at depths of 25 m to 55 m. As with the daily aggregated dataset, gurnard target effort dominates and catch rates were higher than when targeting snapper or trevally (Figure 53). Catch rates were highest in the south of the area (Figure 54), and a southward shift of the fishing distribution was evident in 2023. Seasonality is evident in catch rates (Figure 55) with higher catches in spring-summer, and lower catches in winter.

As was the case in the daily model, residual implied coefficients by target species (Figure 56) and statistical area (Figure 57) illustrate the dominance of data from gurnard target fishing in Statistical Area 013, with some deviations from the overall index for other target species and areas. The pattern of higher catch rates in Statistical Area 013, and lower rates in Statistical Area 014, during 2018–2023 is also evident in the event-level model.

Because the standardised index for the occurrence of catch only drops slightly towards the end of the series, there was little difference between the positive and combined event-level indices (Figure 58, Table 14).

Table 9: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the GUR 2 BT.MIX event CPUE series.

Series	GUR 2 BT.MIX event
QMS stock	GUR 2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	GUR, SNA, TRE
Statistical Areas	011, 012, 013, 014, 015, 016
Period	2007-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	5
Default model	allockg_top5 ~ fyear + vessel_key + ns(log(fishing_duration), 3) + stat_area*month + target_species + ns(start_longitude, 4) + ns(start_latitude, 4) + ns(bottom_depth, 3) + ns(effort_width, 3) + ns(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

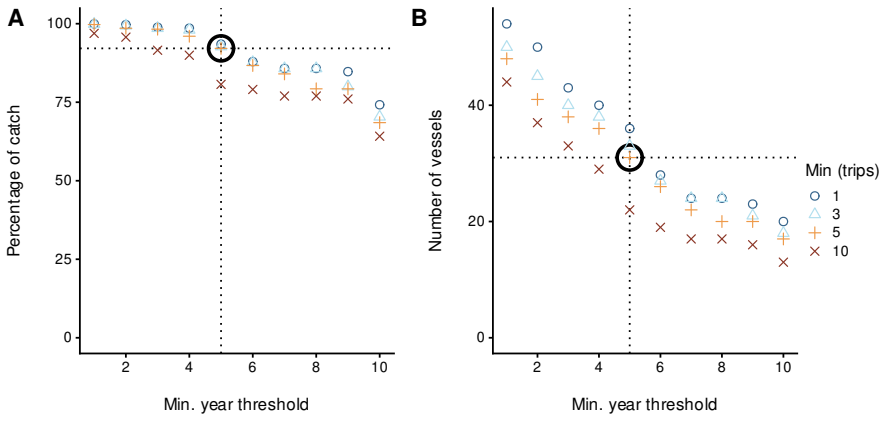

Figure 39: Percentage of catch and number of vessels for different core vessel selection criteria for the GUR 2 BT.MIX event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

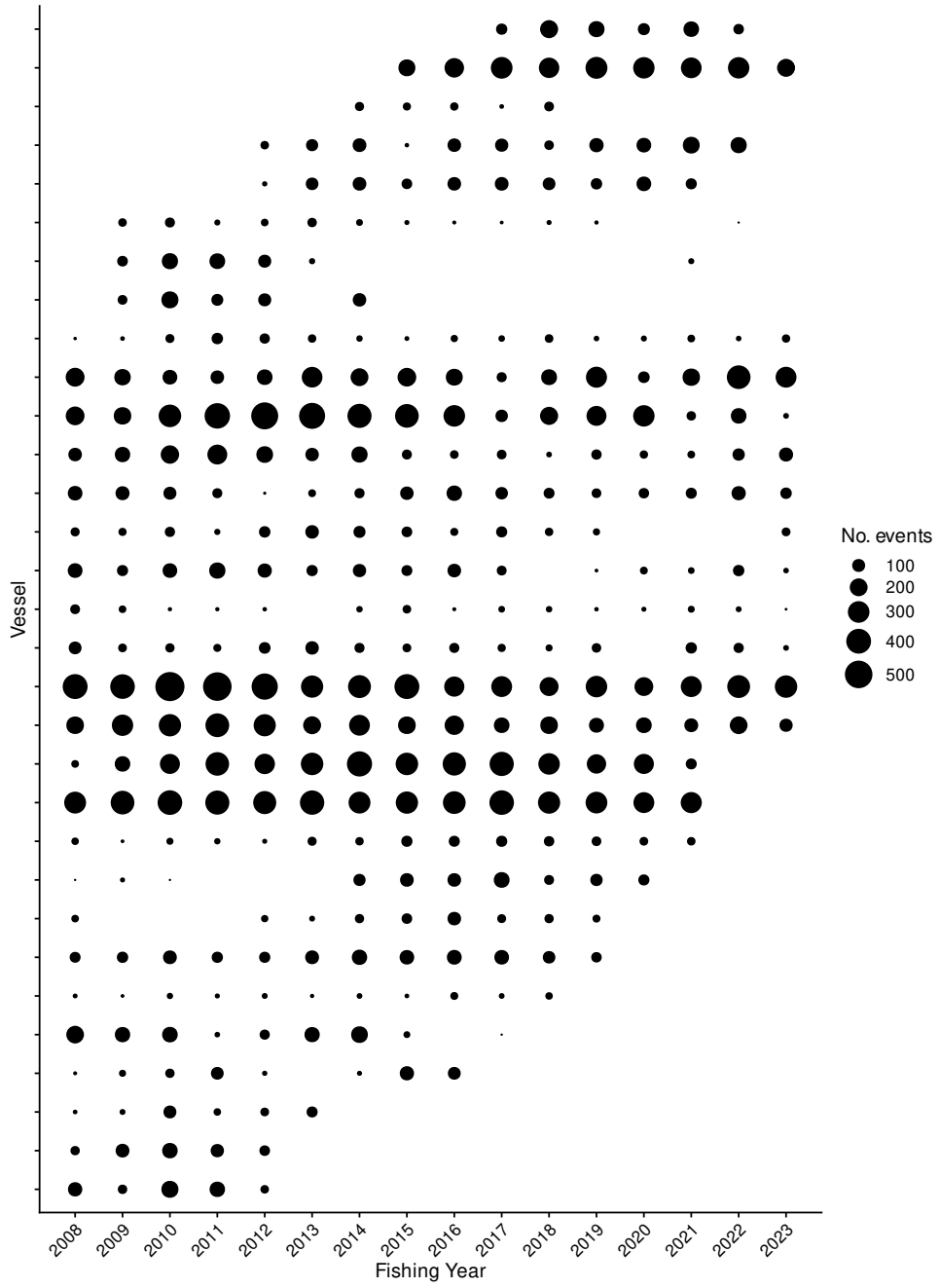

Figure 40: Number of events by fishing year for core vessels in the GUR 2 BT.MIX event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 10: Summary of the GUR 2 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. (Continued on next page)

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	324 (100%) n: 3262	355 (100%) n: 3316	606 (100%) n: 4455	398 (100%) n: 3868	334 (100%) n: 3244	380 (100%) n: 3160	386 (100%) n: 3465	487 (100%) n: 3132	525 (100%) n: 3160
Fishing duration is not NA	324 (100%) n: 3261	355 (100%) n: 3313	606 (100%) n: 4454	398 (100%) n: 3868	334 (100%) n: 3244	380 (100%) n: 3160	386 (100%) n: 3464	487 (100%) n: 3131	525 (100%) n: 3160
Fishing duration greater than 15mins	324 (100%) n: 3258	355 (100%) n: 3312	606 (100%) n: 4452	398 (100%) n: 3866	334 (100%) n: 3241	380 (100%) n: 3159	386 (100%) n: 3464	487 (100%) n: 3128	525 (100%) n: 3157
Fishing duration under 10hrs	323 (100%) n: 3250	354 (100%) n: 3308	606 (100%) n: 4448	397 (100%) n: 3860	334 (100%) n: 3239	379 (100%) n: 3157	386 (100%) n: 3462	487 (100%) n: 3127	524 (100%) n: 3153
Bottom depth less than 200m	322 (99%) n: 3249	354 (100%) n: 3307	606 (100%) n: 4448	397 (100%) n: 3858	334 (100%) n: 3239	379 (100%) n: 3155	386 (100%) n: 3462	487 (100%) n: 3121	524 (100%) n: 3151
Latitude in range	322 (99%) n: 3249	354 (100%) n: 3307	606 (100%) n: 4448	397 (100%) n: 3858	334 (100%) n: 3239	379 (100%) n: 3155	386 (100%) n: 3462	487 (100%) n: 3121	524 (100%) n: 3151
Core fleet selection	243 (75%) n: 2476	279 (79%) n: 2605	478 (79%) n: 3771	371 (93%) n: 3524	326 (98%) n: 3148	372 (98%) n: 3057	380 (98%) n: 3341	481 (99%) n: 3046	523 (100%) n: 3135

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	420 (100%) n: 2787	349 (100%) n: 2660	413 (100%) n: 2707	363 (100%) n: 2287	251 (100%) n: 2059	311 (100%) n: 2481	228 (100%) n: 1548
Fishing duration is not NA	420 (100%) n: 2787	349 (100%) n: 2660	413 (100%) n: 2706	363 (100%) n: 2286	251 (100%) n: 2059	311 (100%) n: 2481	228 (100%) n: 1547
Fishing duration greater than 15mins	419 (100%) n: 2784	349 (100%) n: 2660	413 (100%) n: 2703	362 (100%) n: 2280	250 (100%) n: 2050	311 (100%) n: 2477	227 (100%) n: 1538
Fishing duration under 10hrs	419 (100%) n: 2783	349 (100%) n: 2655	413 (100%) n: 2695	362 (100%) n: 2277	250 (100%) n: 2047	311 (100%) n: 2476	227 (100%) n: 1536
Bottom depth less than 200m	419 (100%) n: 2782	349 (100%) n: 2649	413 (100%) n: 2693	361 (99%) n: 2276	250 (100%) n: 2046	311 (100%) n: 2473	226 (99%) n: 1533
Latitude in range	419 (100%) n: 2781	349 (100%) n: 2649	412 (100%) n: 2686	361 (99%) n: 2274	250 (99%) n: 2043	311 (100%) n: 2473	226 (99%) n: 1533
Core fleet selection	409 (98%) n: 2716	334 (96%) n: 2565	407 (98%) n: 2634	352 (97%) n: 2198	241 (96%) n: 1971	249 (80%) n: 1940	180 (79%) n: 1230

Table 11: Summary of the GUR 2 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 red gurnard.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	23	559	2 476	8 704.37	242.56	96.97
2009	25	643	2 605	9 359.58	278.66	95.39
2010	25	816	3 771	13 699.83	478.19	95.89
2011	24	714	3 524	12 717.80	370.63	96.28
2012	27	698	3 148	11 476.70	326.08	96.09
2013	22	624	3 057	11 158.17	371.96	96.40
2014	25	666	3 341	12 328.15	379.62	95.45
2015	25	633	3 046	11 241.18	480.83	96.72
2016	24	704	3 135	11 685.37	522.88	95.98
2017	25	581	2 716	10 336.07	409.35	97.28
2018	23	615	2 565	9 734.12	333.85	96.18
2019	22	572	2 634	10 355.07	407.01	96.28
2020	17	429	2 194	9 052.47	351.50	95.90
2021	18	518	1 966	7 410.95	240.61	94.86
2022	14	513	1 940	7 044.28	248.58	94.38
2023	12	301	1 230	4 887.00	179.79	92.11

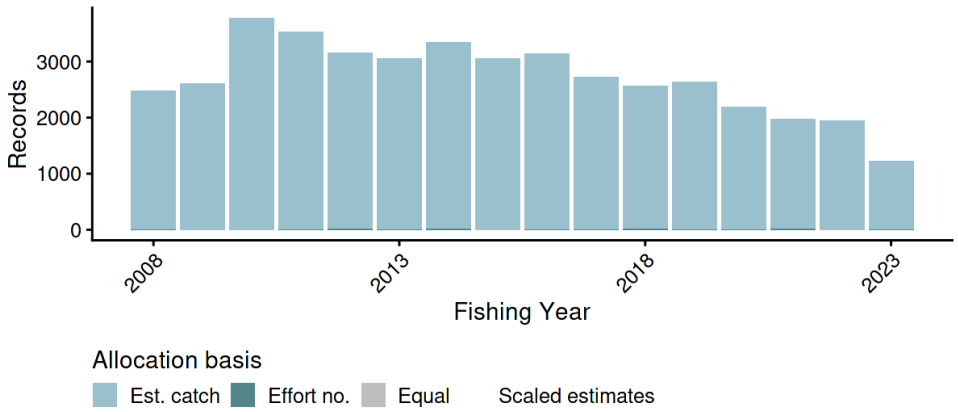

Figure 41: Allocation basis for attributing landings to records in the GUR 2 BT.MIX event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table 12: Summary of stepwise selection for occurrence of positive catch in the GUR 2 BT.MIX event series. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
fyear	14.00	14 664	0.60	0.60	*
+ vessel_key	30.00	14 117	4.70	4.10	*
+ ns(bottom_depth, 3)	3.00	13 821	6.80	2.10	*
+ ns(log(fishing_duration), 3)	3.00	13 761	7.20	0.40	
+ stat_area	5.00	13 708	7.60	0.40	
+ ns(effort_height, 3)	3.00	13 661	8.00	0.40	
+ month	11.00	13 626	8.40	0.40	
+ ns(start_longitude, 4)	4.00	13 602	8.60	0.20	
+ target_species	2.00	13 582	8.80	0.20	
+ ns(effort_width, 3)	3.00	13 564	8.90	0.20	
+ ns(start_latitude, 4)	4.00	13 562	9.00	0.10	

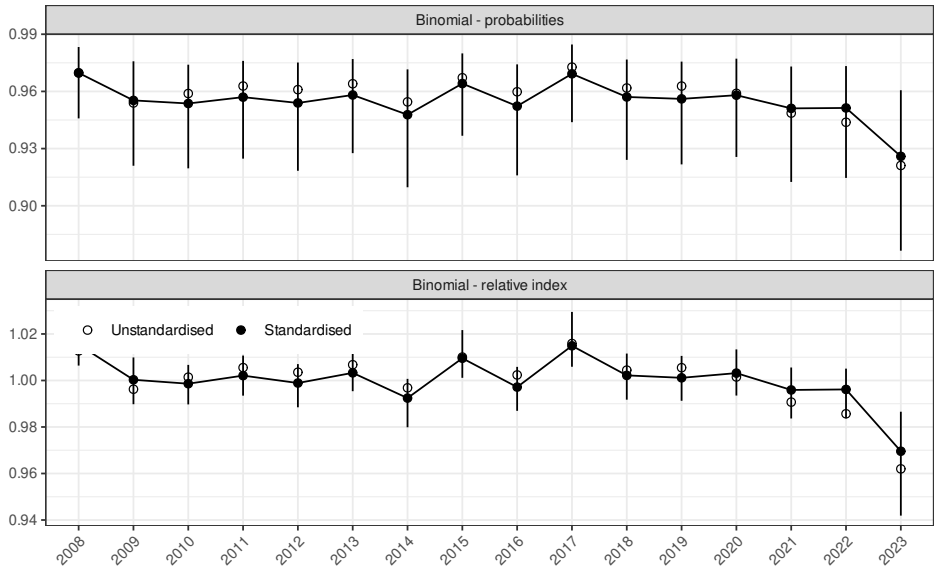

Figure 42: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the GUR 2 BT.MIX event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

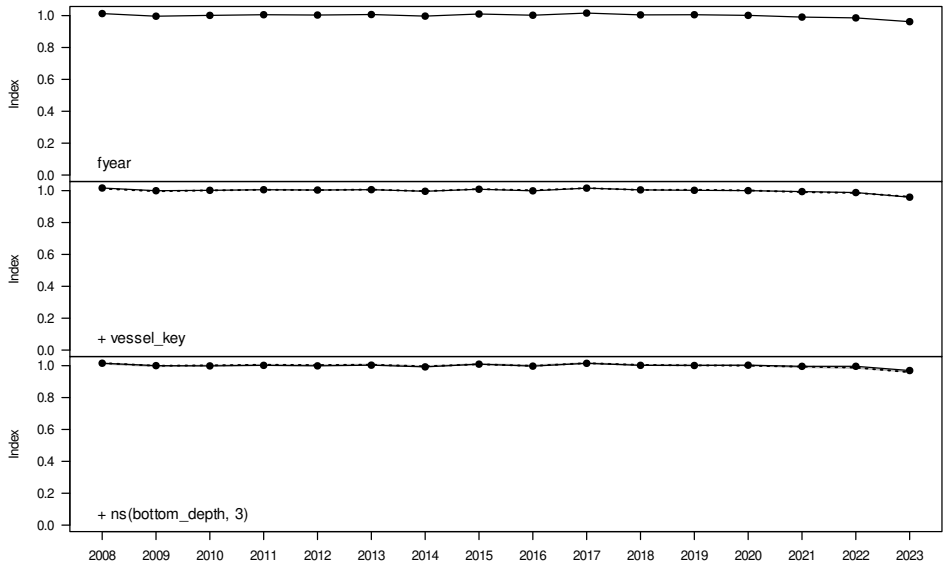

Figure 43: Step plot for occurrence of catch in the GUR 2 BT.MIX event dataset.

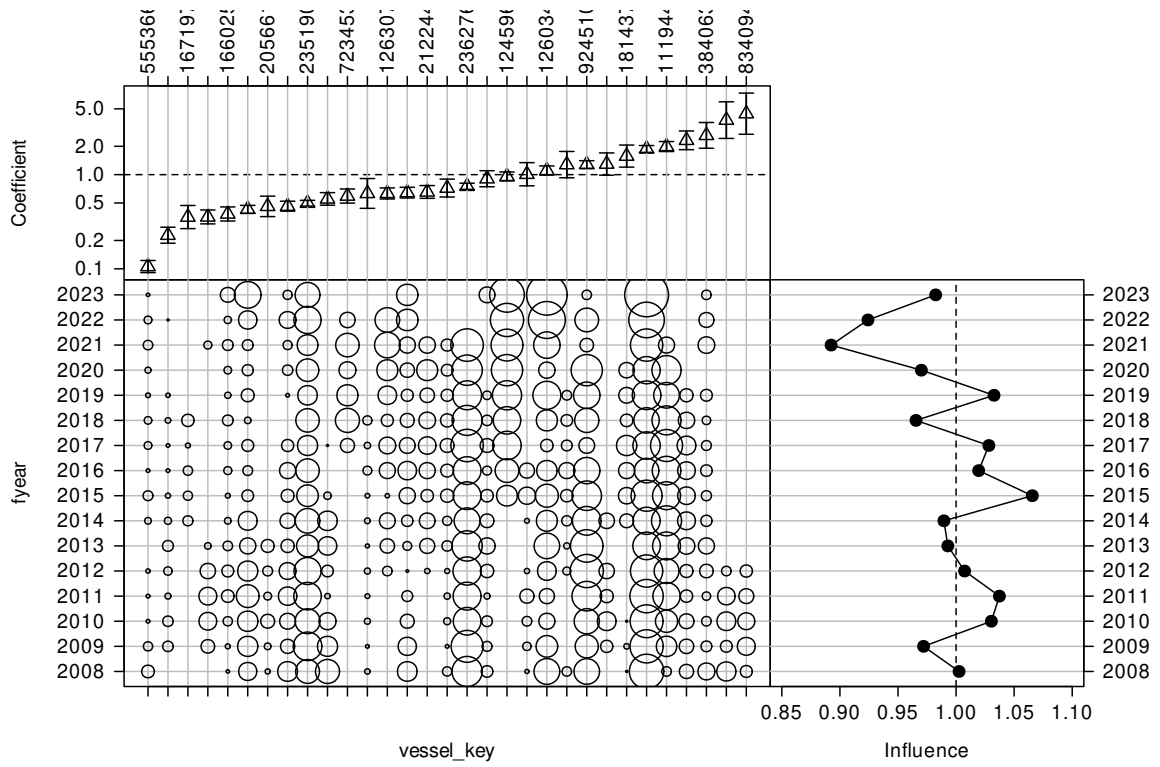

Figure 44: CDI plot for vessel key for the occurrence of positive catch in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

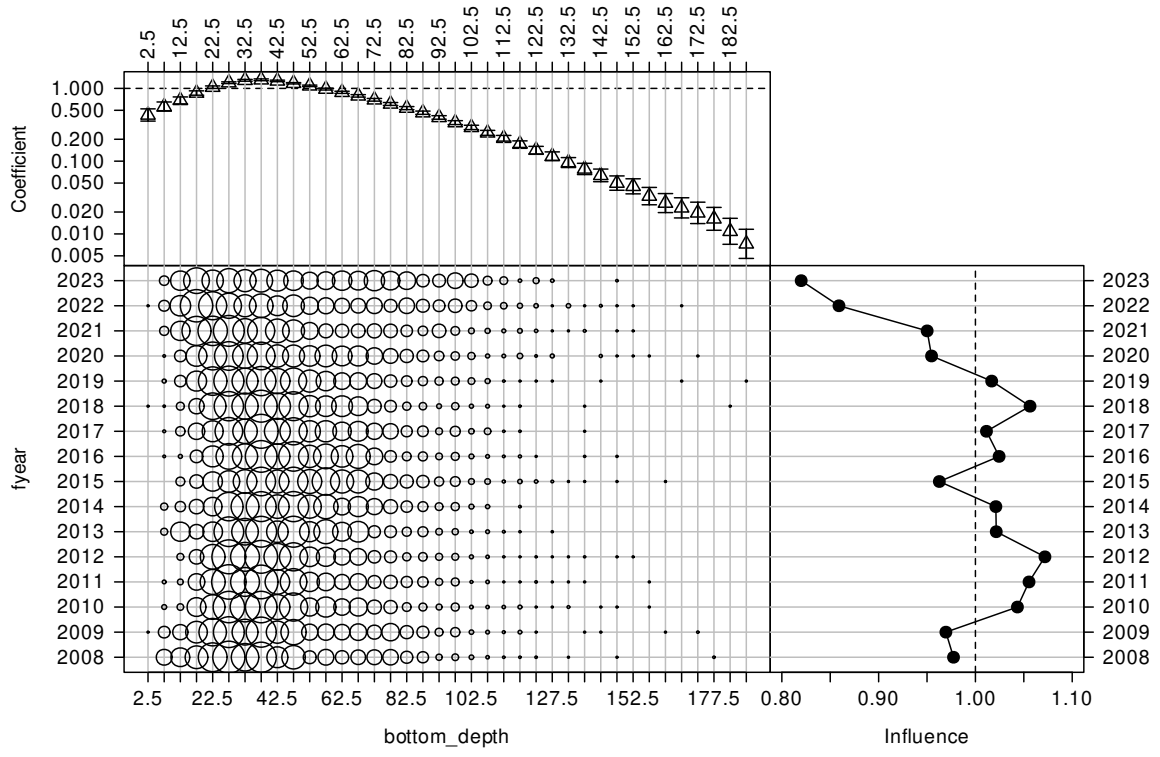

Figure 45: CDI plot for bottom depth (m) for the occurrence of positive catch in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

Table 13: Summary of stepwise selection for the Weibull model for positive catches in the GUR 2 BT.MIX event series. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
fyear	17	488 210	3.6	3.6	*
+ vessel_key	30	473 591	36.1	32.5	*
+ ns(log(fishing_duration), 3)	3	471 763	40.1	4.1	*
+ ns(bottom_depth, 3)	3	470 849	42.2	2.0	*
+ target_species	2	470 022	44.0	1.8	*
+ ns(start_latitude, 4)	4	469 499	45.2	1.2	*
+ month	11	469 020	46.3	1.1	*
+ ns(start_longitude, 4)	4	468 800	46.8	0.5	
+ ns(effort_height, 3)	3	468 666	47.1	0.3	
+ stat_area	5	468 572	47.3	0.2	
+ stat_area:month	55	468 375	48.0	0.7	
+ ns(effort_width, 3)	3	468 299	48.2	0.2	

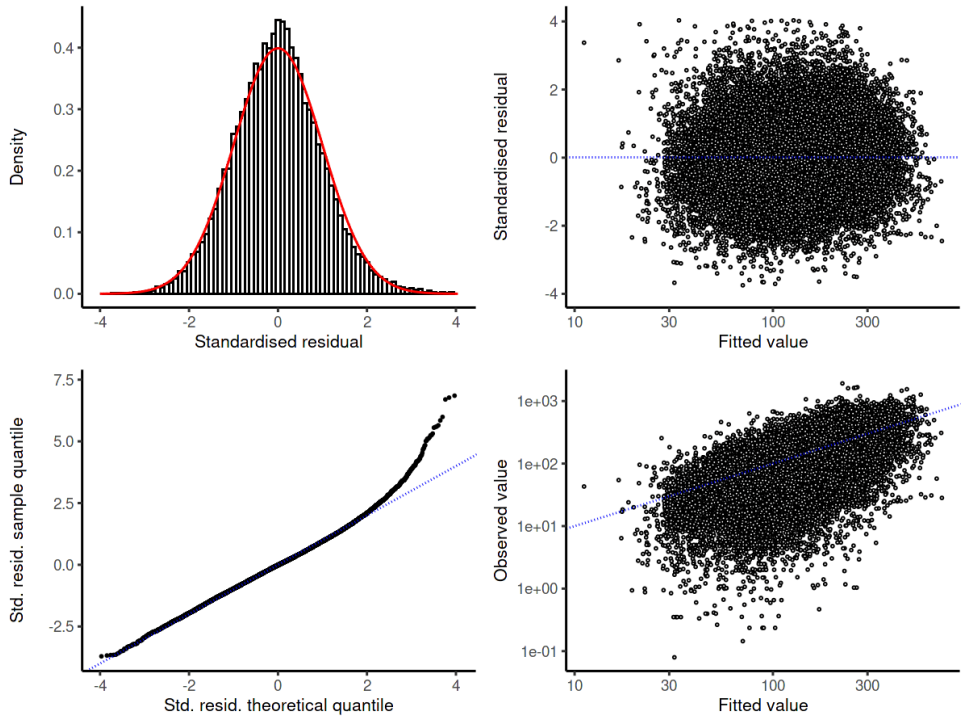

Figure 46: Diagnostic plots for the selected Weibull model for positive catches in the GUR 2 BT.MIX event dataset.

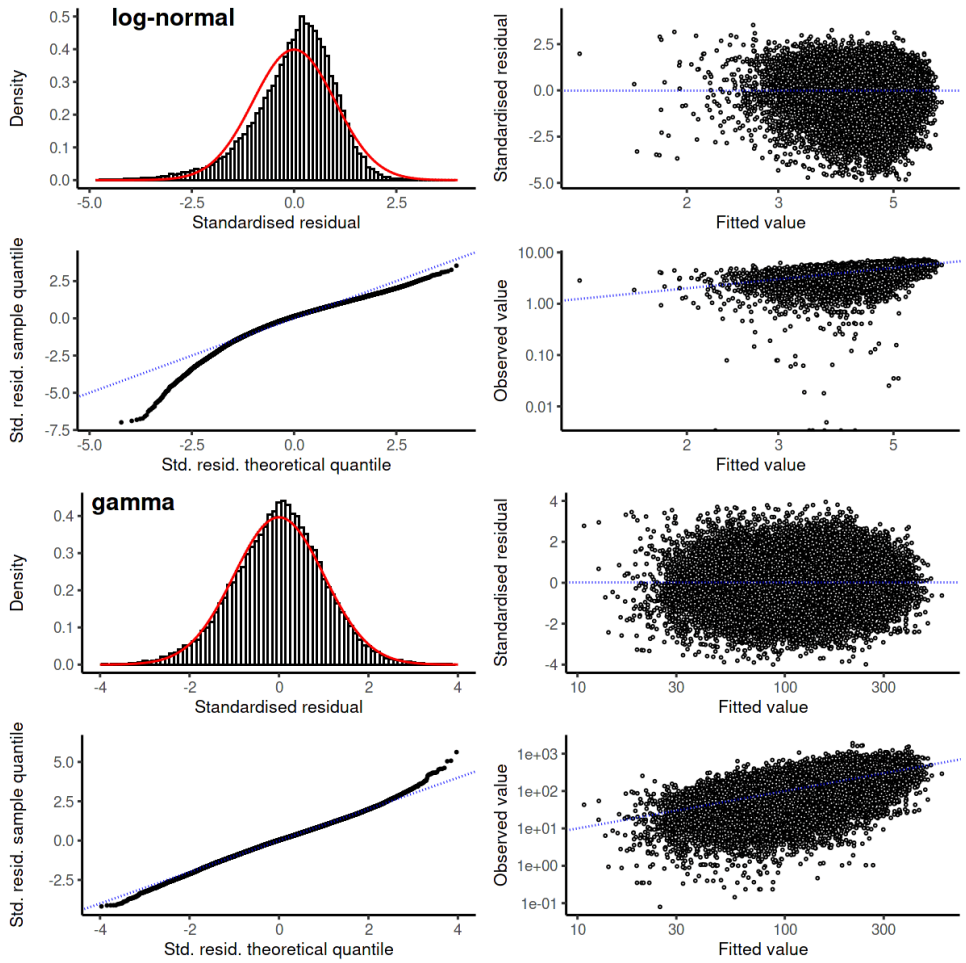

Figure 47: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the GUR 2 BT.MIX event dataset.

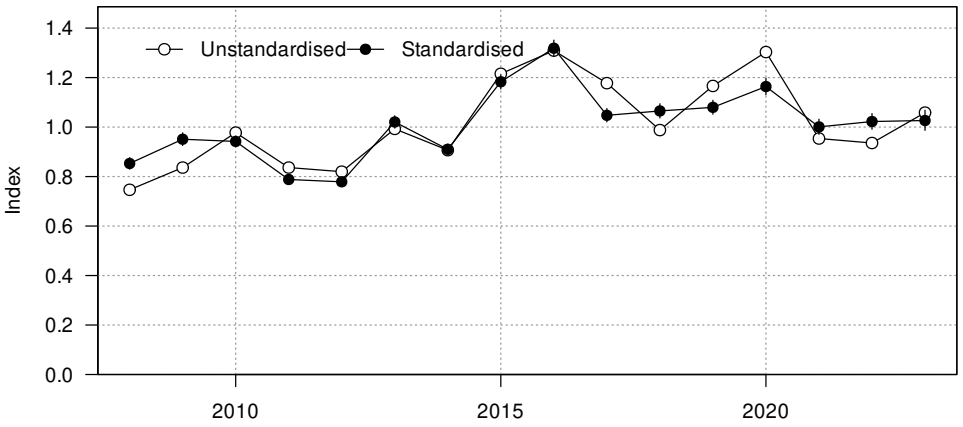

Figure 48: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the GUR 2 BT.MIX event dataset.

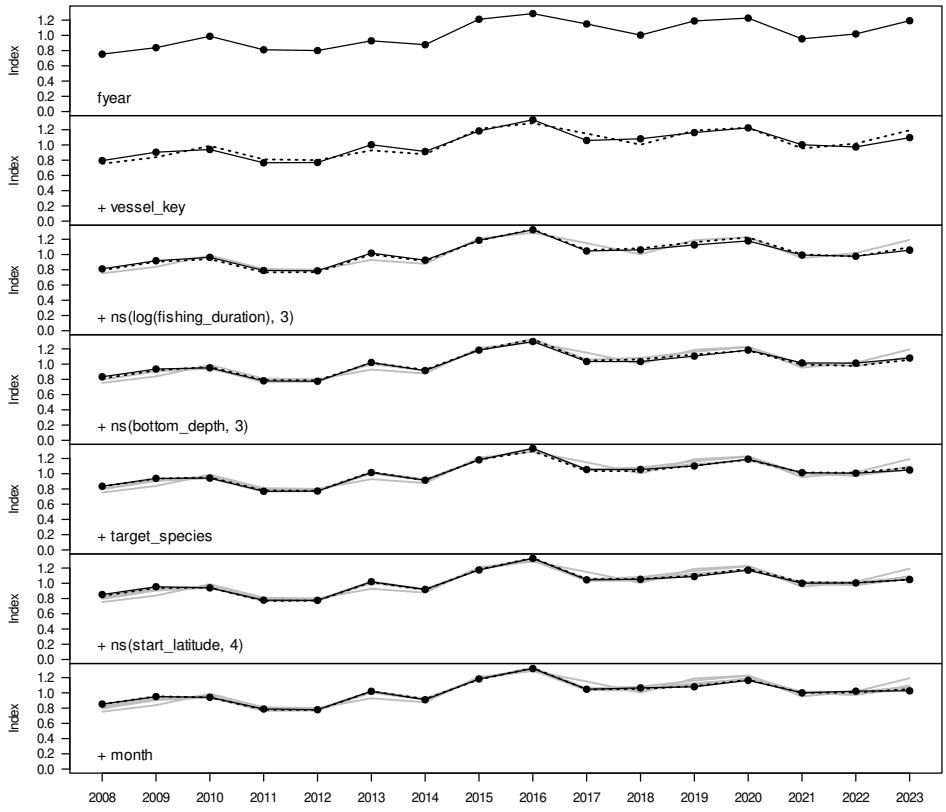

Figure 49: Changes to the GUR 2 BT.MIX event positive catch index as terms are successively entered into the Weibull model.

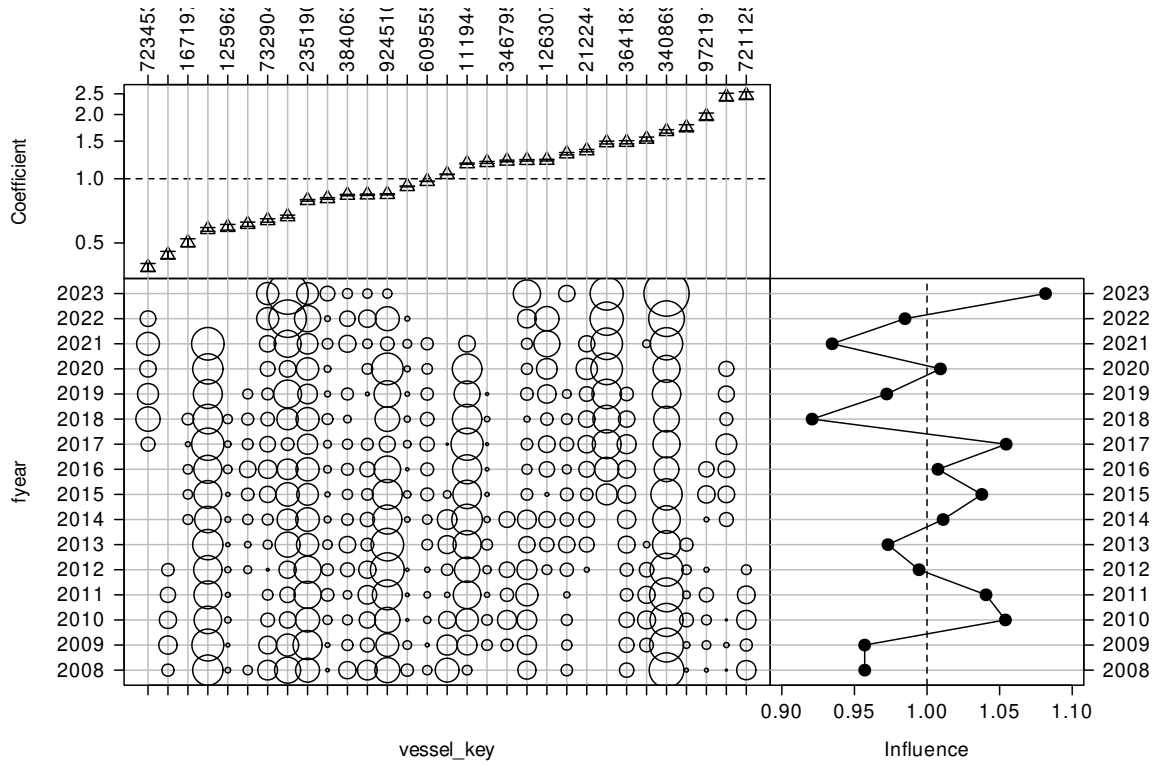

Figure 50: CDI plot for vessel key for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

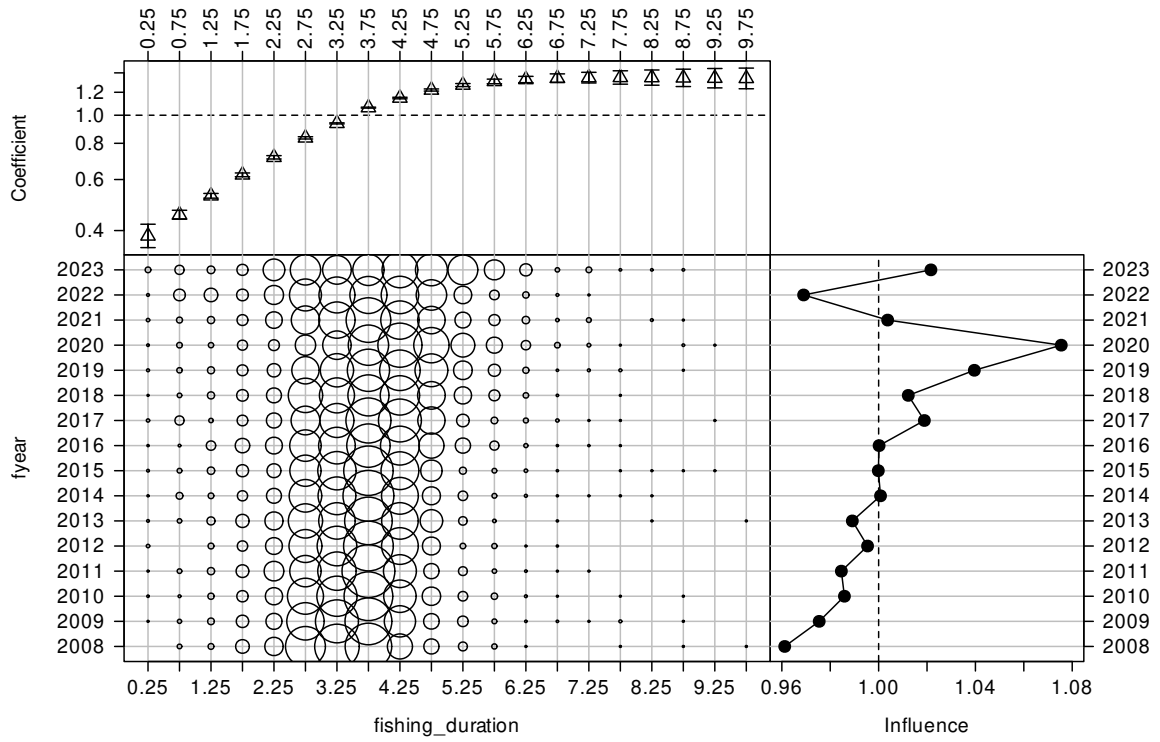

Figure 51: CDI plot for fishing duration (h) for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

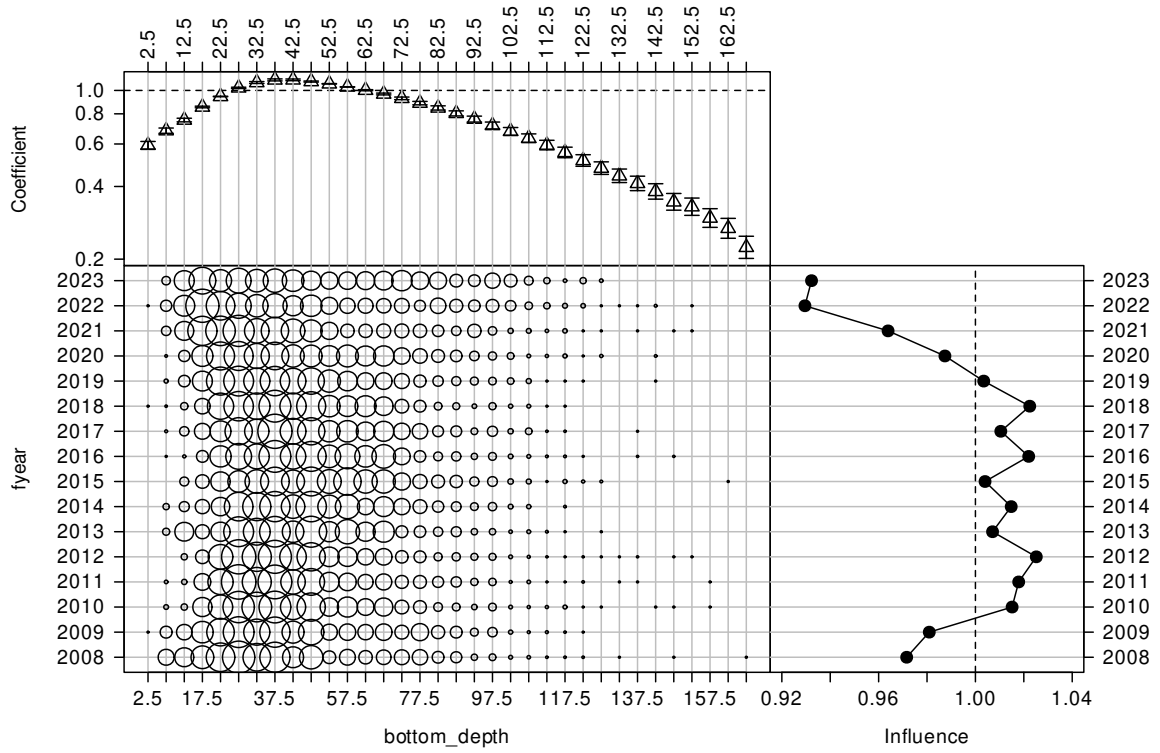

Figure 52: CDI plot for bottom depth (m) for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

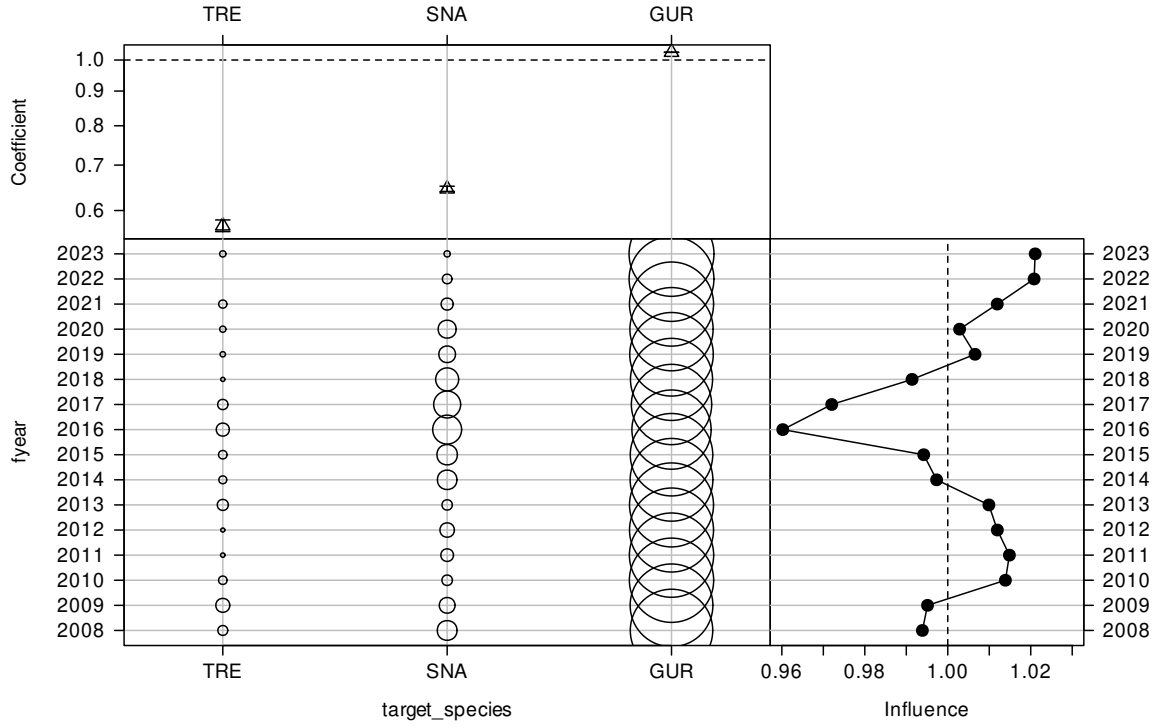

Figure 53: CDI plot for target species for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

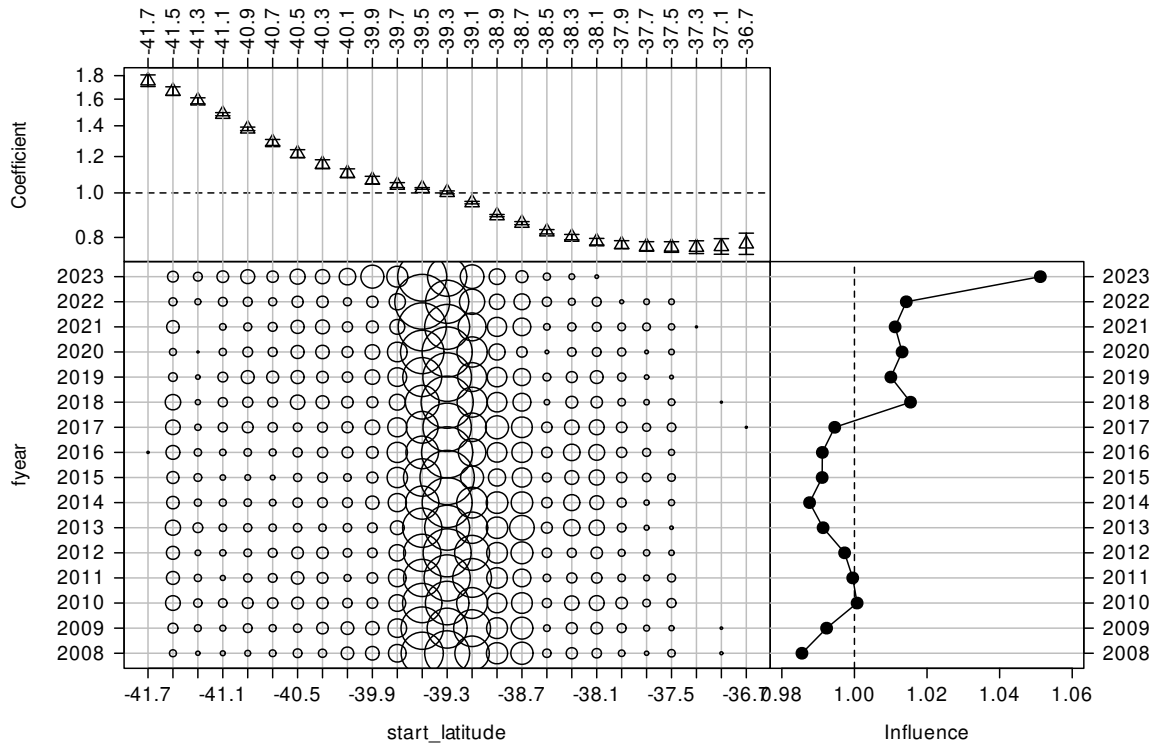

Figure 54: CDI plot for start latitude for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

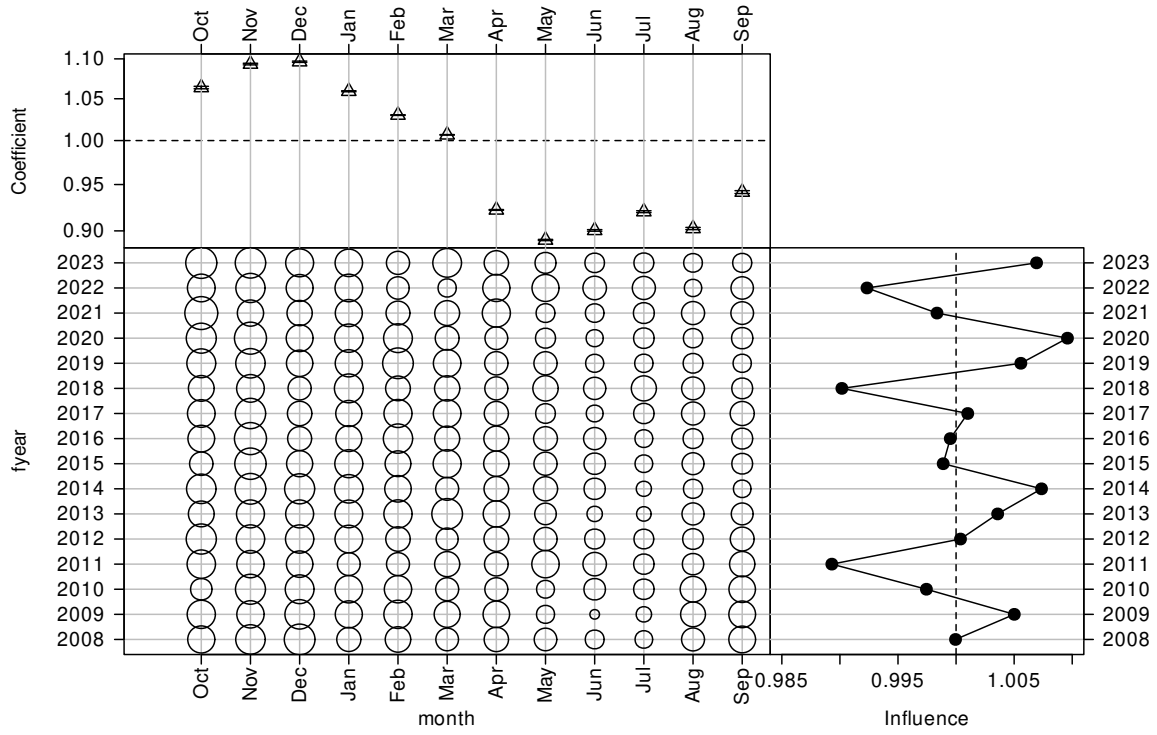

Figure 55: CDI plot for month for the Weibull model of positive catches in the GUR 2 BT.MIX event catch-per-unit-effort dataset.

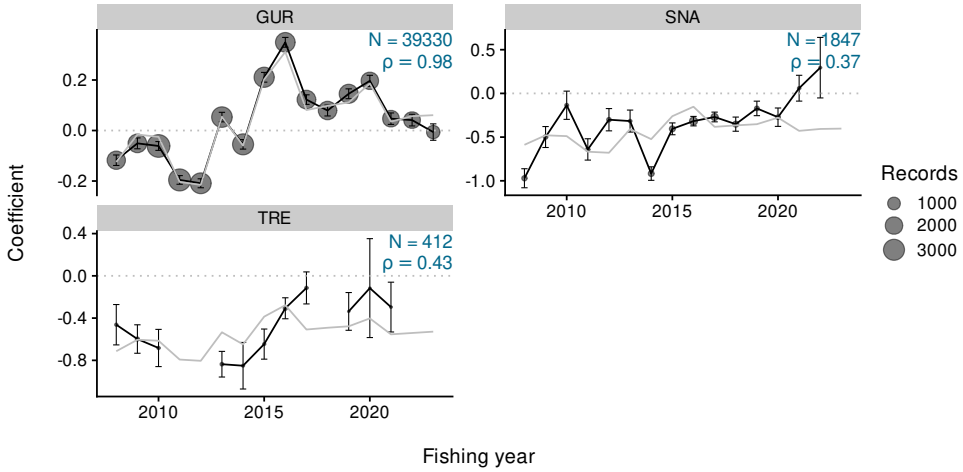

Figure 56: Residual implied coefficients for target-year in the Weibull positive catch model for the GUR 2 BT.MIX event dataset.

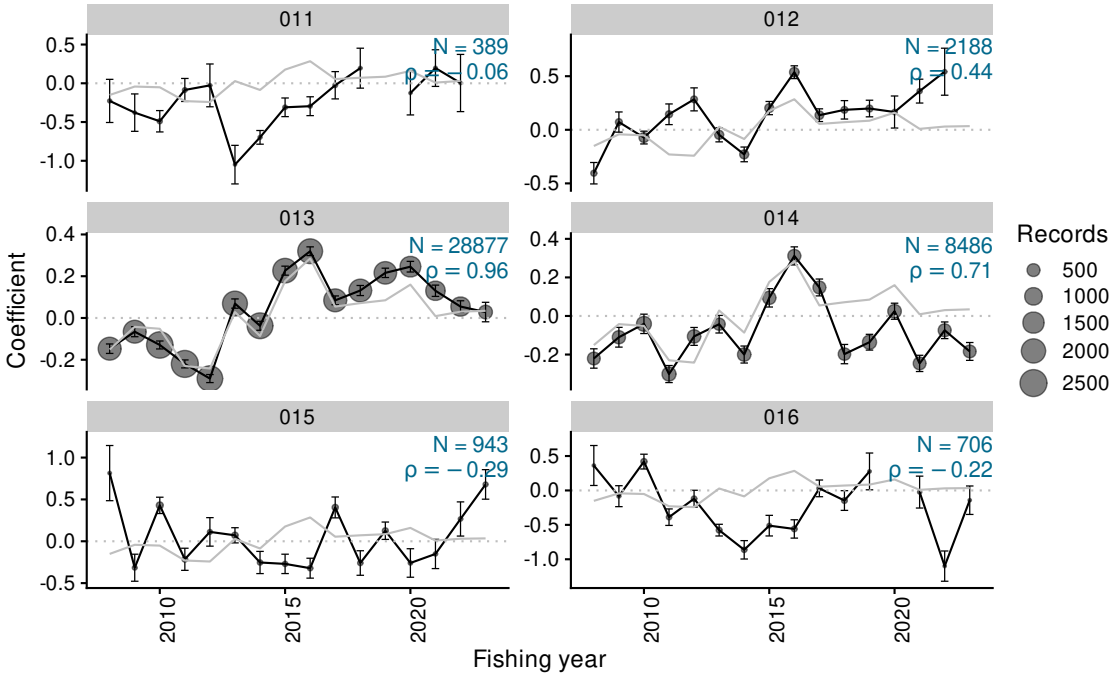

Figure 57: Residual implied coefficients for area-year in the Weibull positive catch model for the GUR 2 BT.MIX event dataset.

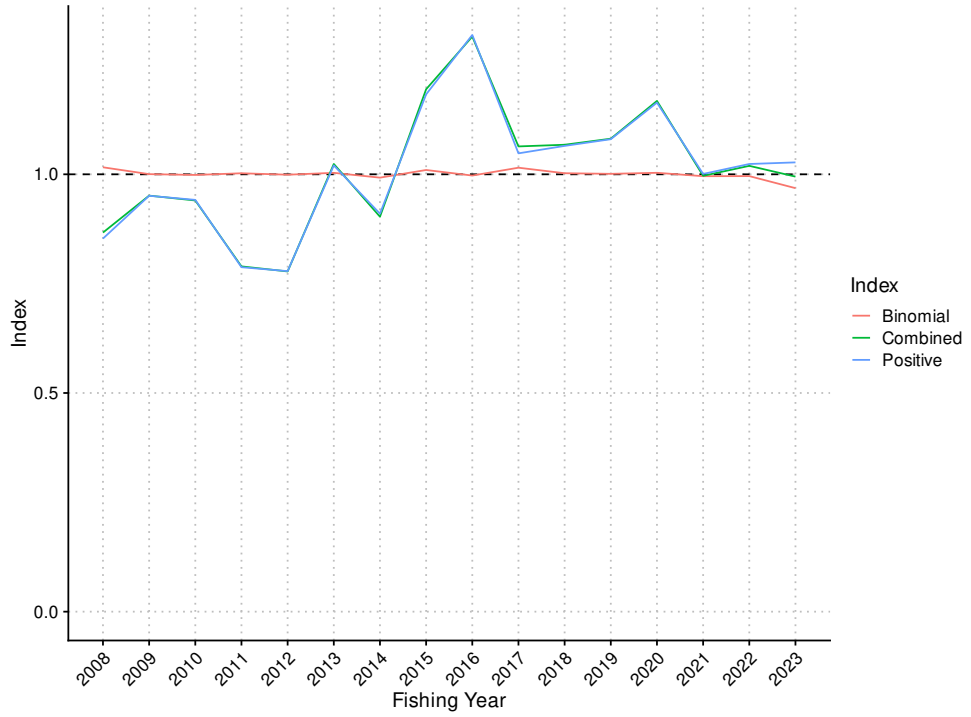

Figure 58: Standardised indices for the GUR 2 BT.MIX event dataset.

Table 14: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in GUR 2 BT.MIX event.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.016	0.006	1.006	1.030	0.867	0.013	0.841	0.893	0.853	0.012	0.830	0.876
2009	1.000	0.005	0.991	1.009	0.951	0.014	0.924	0.979	0.951	0.013	0.927	0.978
2010	0.999	0.004	0.990	1.006	0.940	0.011	0.918	0.961	0.942	0.010	0.921	0.962
2011	1.002	0.004	0.994	1.011	0.789	0.010	0.770	0.808	0.788	0.009	0.769	0.805
2012	0.999	0.005	0.990	1.008	0.778	0.010	0.759	0.797	0.779	0.009	0.760	0.797
2013	1.003	0.005	0.994	1.012	1.024	0.014	0.997	1.050	1.020	0.013	0.995	1.046
2014	0.992	0.005	0.981	1.000	0.903	0.011	0.880	0.925	0.910	0.010	0.891	0.930
2015	1.010	0.005	1.002	1.021	1.194	0.015	1.165	1.226	1.183	0.015	1.155	1.212
2016	0.997	0.005	0.987	1.005	1.315	0.017	1.282	1.350	1.319	0.016	1.287	1.351
2017	1.015	0.007	1.005	1.031	1.064	0.015	1.034	1.094	1.048	0.014	1.020	1.075
2018	1.002	0.005	0.993	1.012	1.068	0.016	1.037	1.099	1.065	0.015	1.036	1.094
2019	1.001	0.005	0.990	1.011	1.081	0.016	1.051	1.111	1.080	0.015	1.051	1.108
2020	1.003	0.005	0.993	1.014	1.168	0.018	1.135	1.204	1.164	0.017	1.132	1.199
2021	0.996	0.005	0.984	1.004	0.997	0.016	0.966	1.029	1.001	0.015	0.972	1.032
2022	0.996	0.006	0.983	1.005	1.019	0.016	0.988	1.052	1.024	0.016	0.992	1.055
2023	0.968	0.013	0.937	0.987	0.995	0.023	0.949	1.039	1.027	0.020	0.990	1.067

4.3 CPUE comparisons

The updated GUR 2 BT.MIX pseudoCELR index shows a high level of consistency with the previous GUR 2 index that used data up to the 2021 fishing year (Fisheries New Zealand 2023) (Figure 59). The updated index is also generally consistent with the analysis by Schofield et al. (2018), in terms of overall trend, although there are some differences between indices in certain years (2005–2007, 2014). During the update of the index carried out in 2020 it was identified that these differences may be attributable to a stricter implementation of the pseudoCELR approach to aggregating data at a daily resolution than implemented by Schofield et al. (2018), in particular affecting data that were reported on the TCEPR form.

There is also good consistency between the positive catch index from the GUR 2 BT.MIX event analysis and the previous index to the 2021 fishing year (Figure 60). These indices are also generally consistent with the positive catch, event-level index produced by Schofield et al. (2018), although with a noticeable difference in 2014 which is again likely to be attributable to a stricter approach to ensuring consistency between TCER and TCEPR data by using only the top 5 estimated catch records.

The updated indices developed in this report are compared in Figure 61. There is a high degree of consistency between the GUR 2 BT.MIX pseudoCELR series and the GUR 2 BT.MIX event, with little difference between the positive catch and combined series from the latter analysis. For the event-level series that includes tarakihi target data (GUR 2 BT.MIX.TAR event) a combined index is required due to temporal trends in the occurrence of gurnard catch in this wider fishery (Figure C.4). When tarakihi effort was originally added into the event-level model, with data to the 2021 fishing year, this index was very similar to the indices where tarakihi effort was excluded (Fisheries New Zealand 2023). In the update to 2023, the GUR 2 BT.MIX.TAR event index is still generally consistent with the other indices (Figure 61) but shows more variation, with lower values during 2009–2013 and higher values during 2017–2023.

Residual Implied Coefficients by target species (Figure C.21) suggest that the standardisation has not fully accounted for the differences between the gurnard and tarakihi target fisheries; as a result the GUR 2 BT.MIX.TAR event index represents a compromise between the two. Although the implied indices by target species show similar trends for most of the period, they diverge in 2023 with the tarakihi target effort responsible for the increase in the GUR 2 BT.MIX.TAR event index, while the primary indices suggest much less change from 2022. Possible spatial shifts in the distribution of gurnard within FMA 2 are considered below.

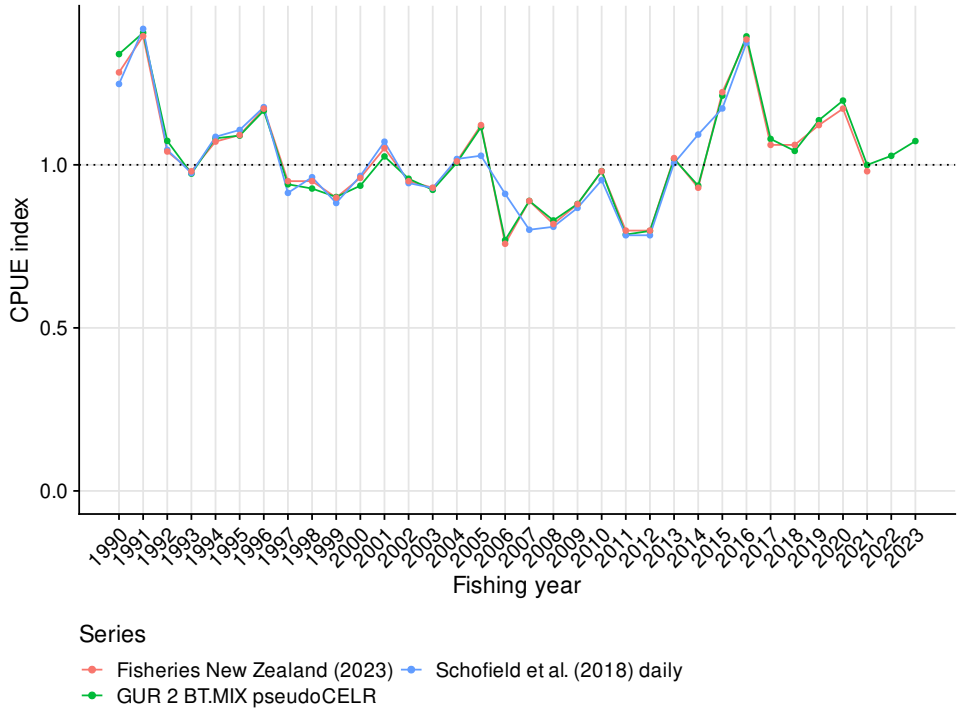

Figure 59: Comparison between the GUR 2 BT.MIX pseudoCELR series, the daily CPUE index estimated by Schofield et al. (2018), and the previous update to 2021 (Fisheries New Zealand 2023). All series are a positive catch index only and are scaled to a geometric mean of one for the years in common.

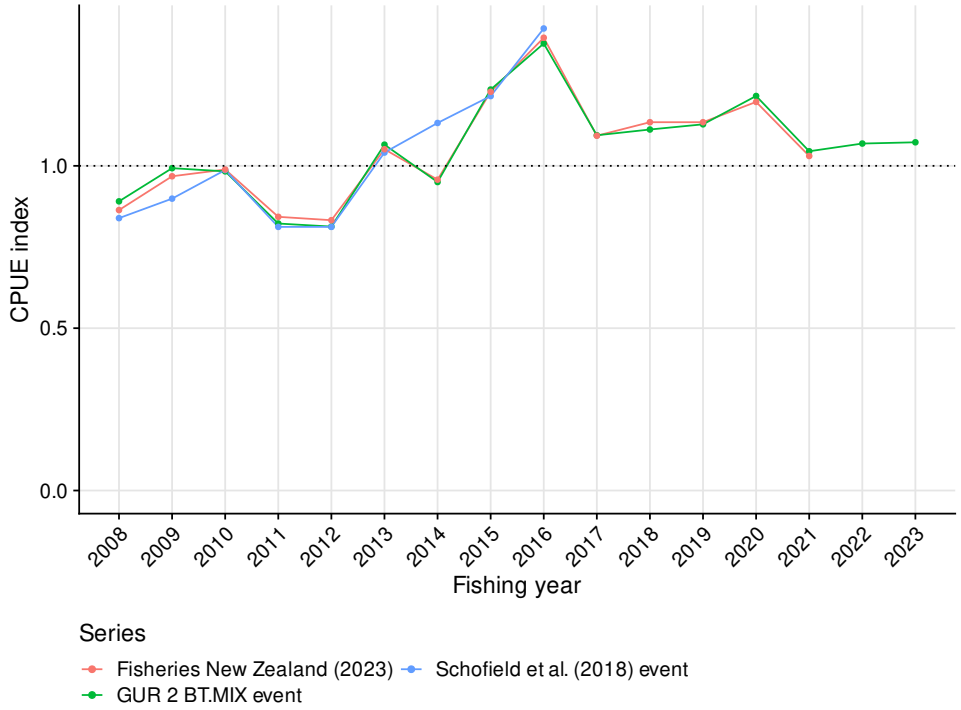

Figure 60: Comparison between the positive catch GUR 2 BT.MIX event series, the event-level CPUE index estimated by Schofield et al. (2018), and the previous update to 2021 (Fisheries New Zealand 2023). The indices are scaled to a geometric mean of one for the years in common

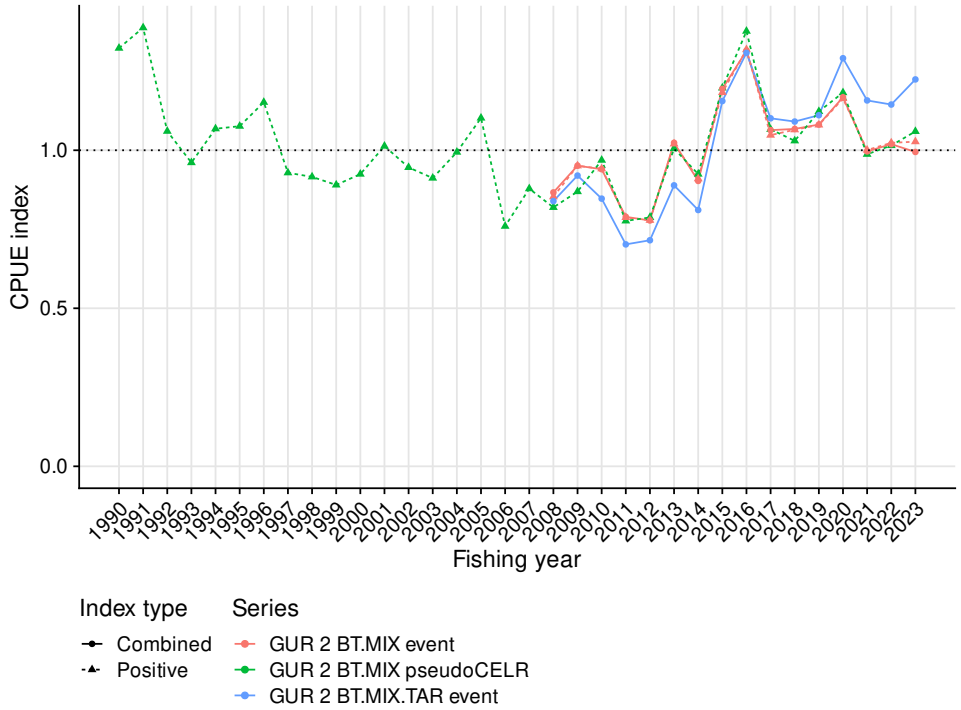

Figure 61: Comparison between the GUR 2 CPUE series produced from the current analyses. Indices are scaled to a geometric mean of one for the years in common.

4.4 Spatial residuals

Patterns in the residuals from models of event-level data can assist in identifying inter-annual variation in the fine-scale spatial distribution of gurnard. Schofield et al. (2018) demonstrated that during 2008 to 2016 there was evidence of a change in distribution of gurnard within Hawke Bay. During 2008–2010 gurnard were most abundant in the coastal waters of Hawke Bay, but there was a shift to deeper water during 2011–2013, and during 2014–2016 gurnard were most abundant offshore, in the deeper parts of Hawke Bay.

Using the residuals from the updated GUR 2 BT.MIX event model, it is apparent that during 2016–2018 gurnard were still found in greater abundance in the deeper parts of Hawke Bay, but in 2019–2021 were more uniformly distributed in Hawke Bay and were also more abundant in the coastal area between the Māhia Peninsula and Poverty Bay (Figure 62). The impacts of Cyclone Gabrielle in February 2023 led to a reduction in nearer shore fishing effort in the northern parts of Hawke Bay (Adam Langley, unpublished report for the Inshore Council of Seafood New Zealand); however, where data are available, they suggest that the gurnard distribution has shifted offshore with higher spatial residuals evident at the offshore extent of the fishery, including in the area to the south of Hawke Bay, and negative residuals in the southern part of Hawke Bay. However, residuals from 2022 suggest that this change in the gurnard distribution was already evident prior to Cyclone Gabrielle (Figure 62).

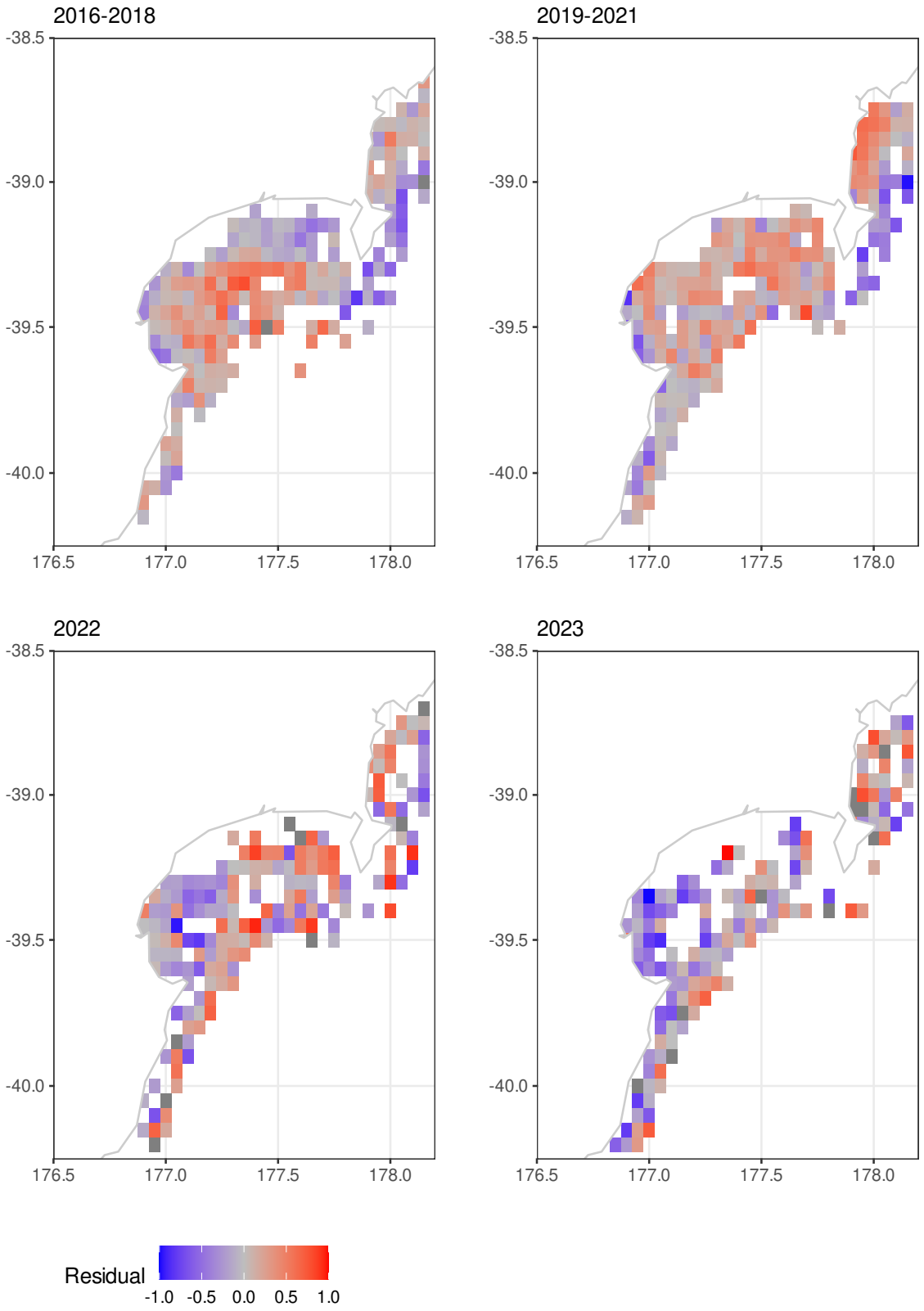

Figure 62: Mean residuals from the positive catch GUR 2 BT.MIX event model plotted using a 0.05 degree grid. For 2016–2018 and 2019–2021 grid cells were included if they contained at least 10 tow start positions; for 2022 and 2023 this threshold was reduced to three tows.

5. DISCUSSION

Commercial catches from the red gurnard fishery in the GUR 2 Quota Management Area during 2021–2023 dropped below 500 t for the first time since the 2000 fishing year, and were the lowest recorded since the stock was introduced to the QMS in 1989 (although pre-QMS catch data indicates that catches were lower in the mid 1970s). Otherwise, the characteristics of the fishery have changed little since the previous characterisation by Schofield et al. (2018). The majority of the catch is taken by targeted bottom trawling, with bycatch in the tarakihi target trawl fishery representing around a third of the catch. Gurnard bycatch has declined in the flatfish, snapper and trevally trawl fisheries since 2017, and there has been only a small amount of target Danish seine catch. The introduction of the Electronic Reporting System has seen the average reporting rank of gurnard decrease slightly, indicating that smaller catches are now being reported at the tow level that would previously not have been included in the top-5 or top-8 estimated catches for an event. The majority of the catch continued to be taken within Hawke Bay. Lower catches in the latter part of the 2023 fishing year are likely to be attributable to the impacts of Cyclone Gabrielle and reduced fishing effort in areas where land-derived material (including forestry "slash") was deposited in coastal areas.

Catch-per-unit-effort analyses indicated that gurnard are still caught on the large majority of fishing days when gurnard, snapper or trevally are targeted in Statistical Areas 011–016; however a slight drop in the occurrence of gurnard catches at the tow level was apparent in 2023. The main GUR 2 abundance index (the GUR 2 BT.MIX pseudoCELR series) suggests that abundance has been stable around the long-term average during 2021–2023, having been above the long-term average during 2015–2020. An event based index (GUR 2 BT.MIX event) shows very similar patterns, from 2008 onwards, to the primary index. An alternative event-level index, where tarahiki target effort is also included (GUR 2 BT.MIX.TAR event), shows broadly similar trends but is slightly lower than the main index during 2008–2014, and higher during 2017–2023. In particular the BT.MIX.TAR event index has remained at a similar level from 2014 to 2023, and does not show the drop to the long term average evident in the indices without tarakihi effort during 2021–2023 (Figure 61).

Because the tarakihi fishery generally operates in deeper waters than the gurnard, snapper, and trevally fisheries, it is likely that these differences in the indexes are at least partly attributable to fine-scale changes in the spatial distribution of gurnard. In particular, the higher index for 2021–2023 coincides with a period when gurnard has been distributed further offshore (Figure 62). There is evidence that this distributional change was already apparent in 2022. The lack of fishing in the nearer shore areas of northern Hawke Bay in 2023 mean that it is difficult to determine if further changes in distribution have occurred that might be attributable to the impacts of Cyclone Gabrielle.

5.1 Stock status

In 2018, the geometric mean CPUE from the GUR 2 BT.MIX pseudoCELR index from 1991 to 2018 was adopted as a B_{MSY} compatible target reference point for GUR 2. The updated CPUE analyses presented in this report indicates that GUR 2 has remained at or about this target level in 2022 and 2023 (Figure 63). The reduction in catches from the fishery means that the relative exploitation rate has decreased, with a decreasing trend evident during 2017–2023.

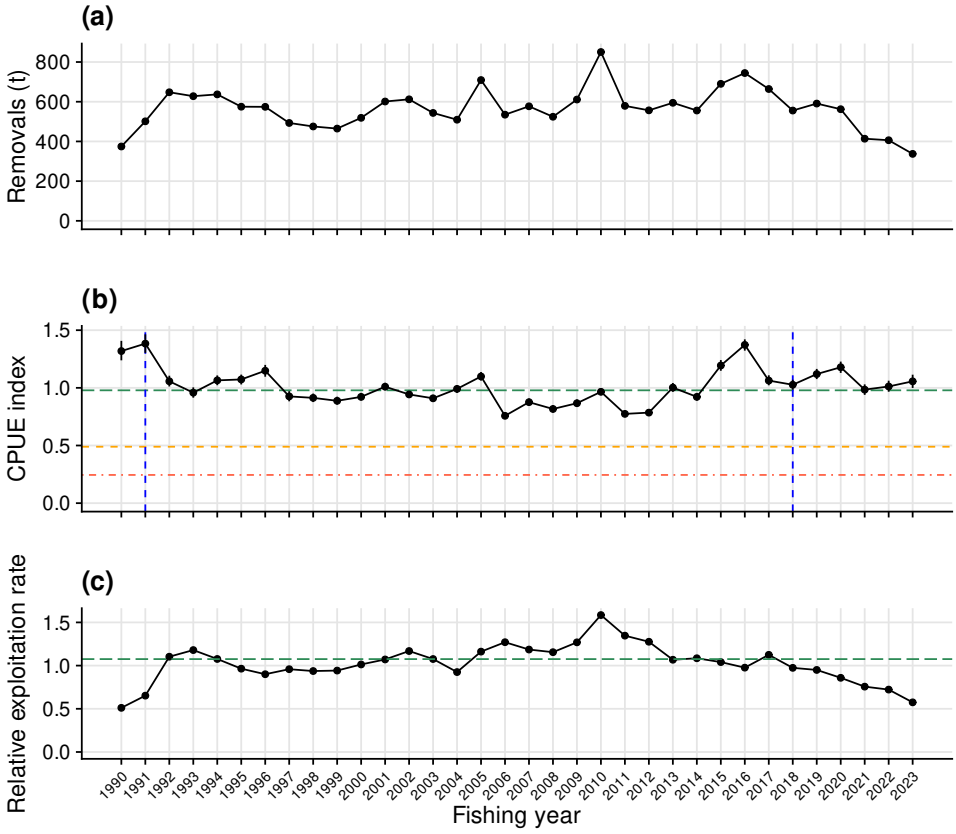

Figure 63: Commercial removals (a) and stock status (b) of GUR 2 relative to the reference period (1991–2018, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green long-dashed line. The hard and soft limits are represented by horizontal dot-dashed red and dashed orange lines, respectively. The relative exploitation rate (c) considers only commercial removals.

6. ACKNOWLEDGEMENTS

Updated CPUE analyses for GUR 2 in 2018, 2019, 2020 and 2022 were funded by Fisheries Inshore New Zealand (now the Seafood New Zealand Inshore Council). Fisheries New Zealand provided access to the data required for this analysis and the Inshore Fisheries Assessment Working Group, convened by Fisheries New Zealand, has reviewed and made constructive suggestions on the regular updates of these indices. Analyses were carried out using the Kahawai Collective's reproducible research platform. We acknowledge the earlier work on GUR 2 by Nokome Bentley, Adam Langley and Max Schofield that provided a starting point for the analyses reported here.

7. REFERENCES

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APPENDIX A: DATA GROOMING

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

A.1 Landings

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

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

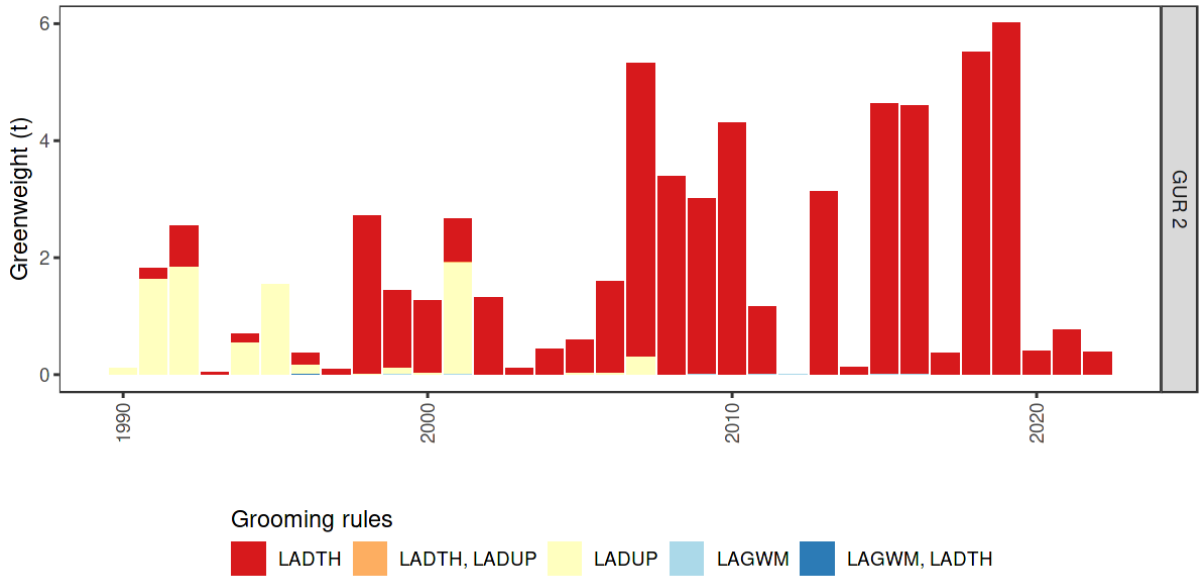

Figure A.1: The quantity of landings dropped, with the relevant grooming rules indicated, by stock and fishing year.

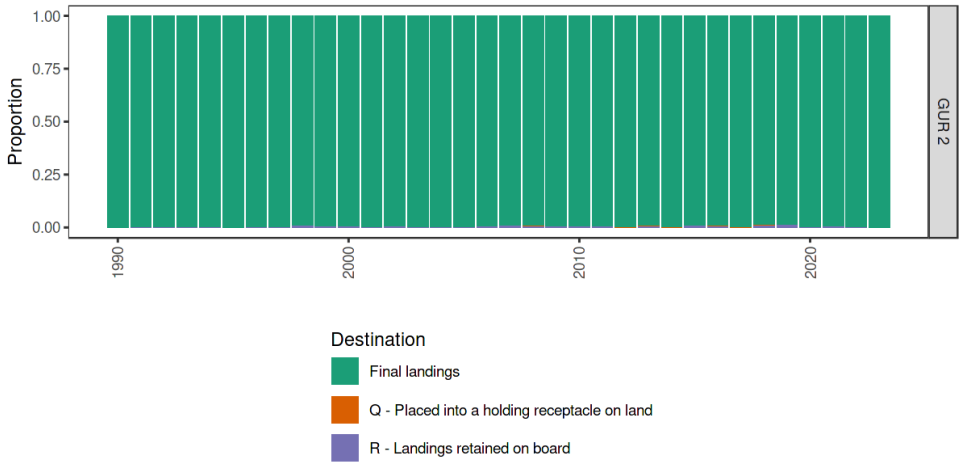

Figure A.2: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

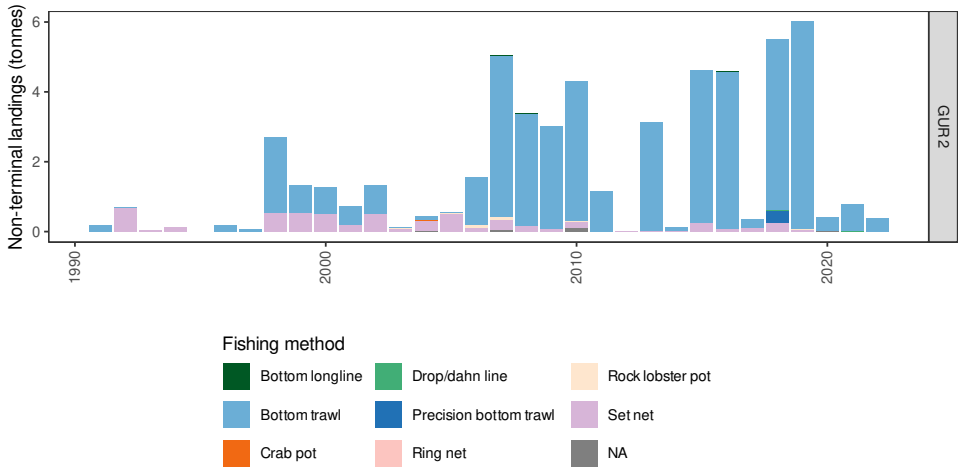

Figure A.3: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

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

			Greenweight (kg)	
QMA	Fishing year	Trips	Original	Adjusted
GUR 2	1997	1	51 020.0	51.020
GUR 2	2001	1	16 540.0	165.400
GUR 2	2006	1	4 950.0	49.500
GUR 2	2009	1	800.0	8.000
GUR 2	2010	3	3 010.0	30.100
GUR 2	2011	1	1 600.0	1.600
GUR 2	2012	2	1 840.0	18.400
GUR 2	2013	2	1 200.0	12.000
GUR 2	2014	1	12 493.5	124.935

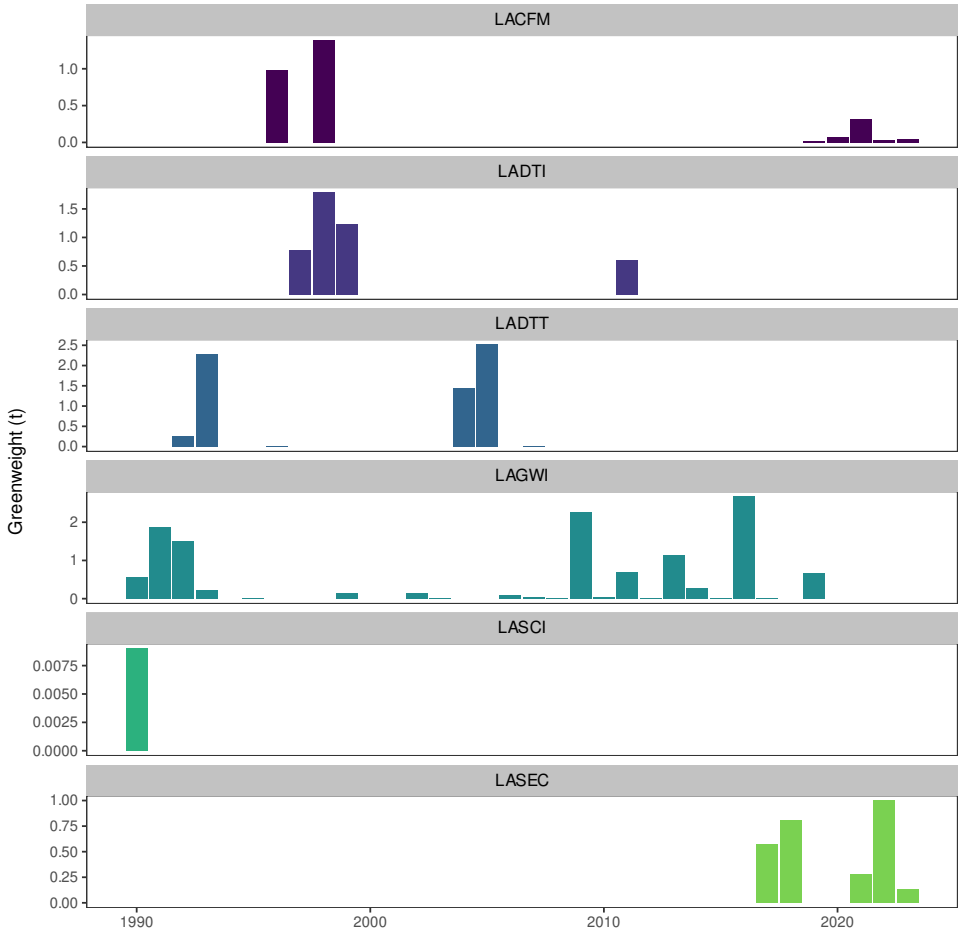

Figure A.4: The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.

A.2 Effort

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

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

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

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

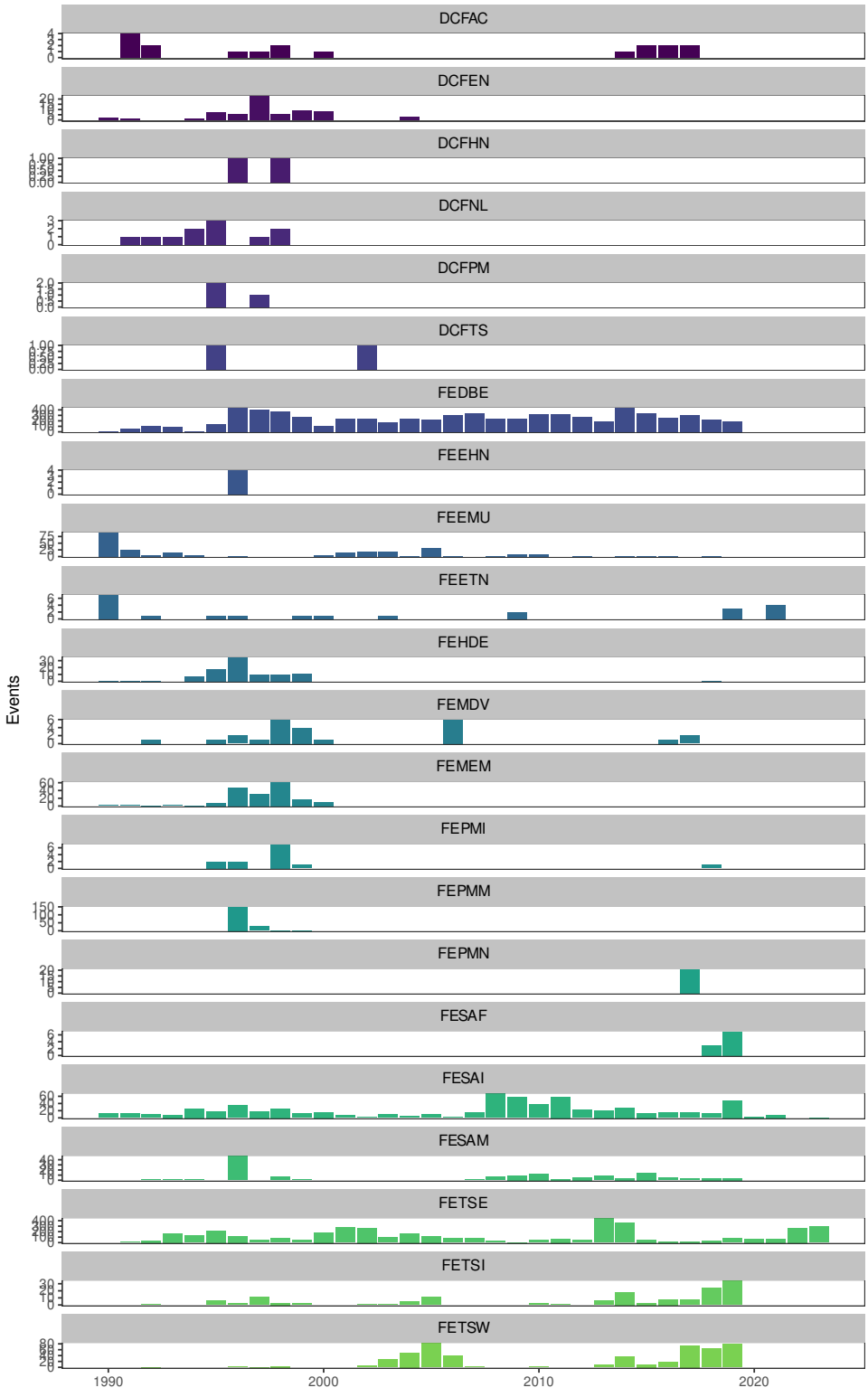

Figure A.5: The number of fishing events flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

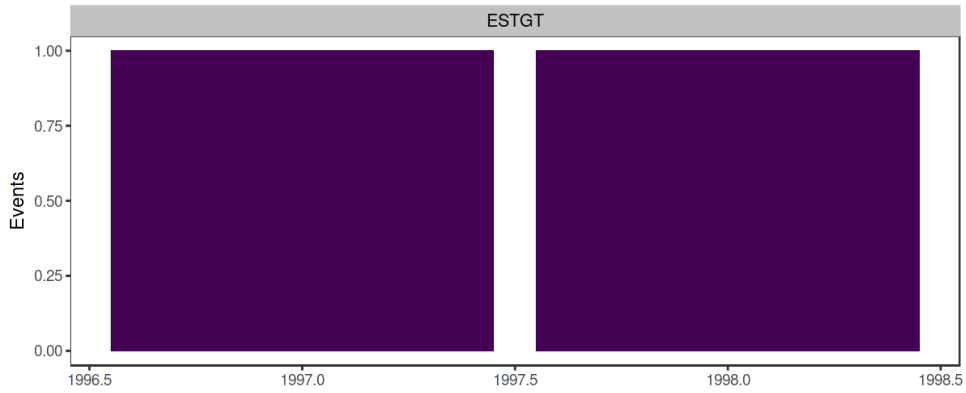

Figure A.6: The number of fishing events where the estimated catch of red gurnard was flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

APPENDIX B: TABULATED FISHERIES CHARACTERISATION DATA

Table B.1: Annual Total Allowable Commercial Catch (TACC; t) and Monthly Harvest Return/Quota Management Report totals (t) for GUR 2 from 1989 to 2023.

Fishing year	GUR 2	
	TACC	MHR/QMR
1989	657.90	536.44
1990	698.40	451.34
1991	719.60	489.63
1992	722.50	653.17
1993	722.50	617.96
1994	725.40	635.34
1995	725.40	558.43
1996	725.40	567.38
1997	725.40	503.43
1998	725.40	482.98
1999	725.40	469.14
2000	725.40	521.83
2001	725.40	622.89
2002	725.46	619.17
2003	725.46	552.48
2004	725.46	512.35
2005	725.46	707.70
2006	725.46	542.43
2007	725.46	575.10
2008	725.46	519.95
2009	725.46	621.30
2010	725.46	853.19
2011	725.46	588.38
2012	725.46	558.26
2013	725.46	602.91
2014	725.46	554.52
2015	725.46	694.56
2016	725.46	748.14
2017	725.46	669.36
2018	725.46	561.25
2019	725.46	587.23
2020	725.46	562.08
2021	725.46	412.58
2022	725.46	406.14
2023	725.46	337.82

Table B.2: Annual GUR 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 red gurnard was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches			Target catches	
			Total (t)	BT-PRB (%)	DS (%)	tonnes	%
1990	451.34	374.49	378.03	98.04	-	174.00	46.03
1991	489.63	501.30	518.04	97.75	0.23	295.57	57.05
1992	653.17	647.68	652.60	97.41	-	386.30	59.19
1993	617.96	627.90	629.71	98.46	0.01	387.82	61.59
1994	635.34	637.00	628.17	97.42	-	386.33	61.50
1995	558.43	574.88	568.31	94.18	5.02	306.77	53.98
1996	567.38	574.26	567.89	92.77	3.64	321.31	56.58
1997	503.43	493.01	488.54	91.49	7.34	253.54	51.90
1998	482.98	475.36	473.75	92.92	5.73	268.07	56.59
1999	469.14	464.76	466.07	89.89	8.89	276.82	59.39
2000	521.83	518.86	523.02	90.60	8.64	344.05	65.78
2001	622.89	601.08	606.72	86.26	12.32	423.33	69.77
2002	619.17	612.10	614.20	88.85	10.25	468.63	76.30
2003	552.48	543.56	547.66	98.65	0.46	393.55	71.86
2004	512.35	509.38	513.16	99.01	0.28	315.01	61.39
2005	707.70	709.17	708.62	98.90	0.04	492.87	69.55
2006	542.43	534.74	536.31	99.37	0.08	291.45	54.34
2007	575.10	576.98	575.78	98.68	0.93	356.59	61.93
2008	519.95	524.26	528.83	97.31	2.09	325.29	61.51
2009	621.30	611.07	610.83	98.52	0.04	331.17	54.22
2010	853.19	850.38	842.06	97.10	2.55	600.77	71.34
2011	588.38	579.16	578.18	94.84	4.87	412.17	71.29
2012	558.26	556.59	553.59	85.68	14.14	393.34	71.05
2013	602.91	594.57	592.66	93.34	6.33	396.23	66.86
2014	554.52	555.69	553.26	99.84	0.00	368.69	66.64
2015	694.56	690.09	688.11	97.56	2.26	473.24	68.77
2016	748.14	744.47	737.22	95.17	4.68	502.00	68.09
2017	669.36	664.09	660.04	96.02	3.64	401.79	60.87
2018	561.25	555.59	554.54	94.17	5.43	359.78	64.88
2019	587.23	590.73	585.02	99.05	0.73	402.89	68.87
2020	562.08	562.33	559.16	93.84	5.93	379.36	67.84
2021	412.58	413.73	412.85	92.17	6.76	271.60	65.79
2022	406.14	406.06	405.44	99.05	0.21	307.65	75.88
2023	337.82	337.28	336.85	97.58	1.68	231.02	68.58

Table B.3: Annual red gurnard catches (t) by destination code for the GUR 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	370.86	3.63	374.49
1991	493.00	8.30	501.30
1992	643.90	3.78	647.68
1993	625.90	2.00	627.90
1994	635.44	1.56	637.00
1995	571.88	3.00	574.88
1996	570.68	3.58	574.26
1997	490.33	2.68	493.01
1998	473.00	2.36	475.36
1999	461.92	2.84	464.76
2000	518.02	0.84	518.86
2001	600.46	0.63	601.08
2002	612.04	0.07	612.10
2003	543.54	0.02	543.56
2004	509.34	0.04	509.38
2005	708.92	0.24	709.17
2006	534.01	0.73	534.74
2007	573.66	3.31	576.98
2008	524.09	0.17	524.26
2009	610.91	0.16	611.07
2010	850.10	0.28	850.38
2011	578.22	0.93	579.16
2012	555.84	0.75	556.59
2013	594.29	0.27	594.57
2014	555.53	0.16	555.69
2015	689.86	0.23	690.09
2016	744.13	0.34	744.47
2017	663.85	0.24	664.09
2018	555.10	0.49	555.59
2019	584.44	6.29	590.73
2020	544.44	17.88	562.33
2021	408.25	5.48	413.73
2022	399.98	6.08	406.06
2023	336.78	0.51	337.28

Table B.4: Annual catches by landed state of red gurnard from the GUR 2 Quota Management Area. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HDS = Heads, 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	GRE	GUT	FIL	DRE	HGU	HDS	Other	Total
1990	372.01	1.74	-	-	0.73	-	-	374.48
1991	500.50	0.46	-	0.32	0.02	-	-	501.30
1992	644.13	1.59	-	0.15	1.81	-	-	647.68
1993	626.53	0.56	-	-	0.81	-	-	627.90
1994	634.53	1.75	-	0.21	0.51	-	-	637.00
1995	565.38	5.09	-	1.26	3.15	-	-	574.88
1996	570.12	3.57	-	0.07	0.13	-	-	573.89
1997	490.92	1.02	-	0.13	0.75	-	-	492.81
1998	469.55	0.84	-	2.32	1.15	1.39	0.11	475.36
1999	462.37	1.15	-	1.02	0.07	-	-	464.61
2000	516.62	0.89	-	1.35	-	-	-	518.86
2001	598.15	2.05	0.12	0.70	-	-	0.05	601.08
2002	611.13	0.90	0.04	0.04	-	-	-	612.10
2003	541.67	0.96	-	0.11	0.82	-	0.00	543.56
2004	507.67	1.66	0.01	0.04	-	-	-	509.38
2005	708.73	0.34	0.02	0.03	0.02	-	0.03	709.17
2006	531.27	0.37	-	3.09	-	-	-	534.74
2007	573.56	0.39	2.87	0.15	-	-	0.01	576.98
2008	516.26	0.12	6.01	0.81	1.06	-	-	524.26
2009	597.12	0.66	9.45	3.82	0.01	-	0.02	611.07
2010	847.58	1.60	0.83	0.30	-	-	0.08	850.38
2011	578.62	0.40	0.00	0.06	-	-	0.07	579.16
2012	554.89	1.48	0.01	0.15	-	-	0.06	556.59
2013	592.53	1.97	0.02	0.03	-	-	0.01	594.57
2014	553.43	0.29	0.30	1.67	-	-	0.00	555.69
2015	682.56	1.13	5.44	0.90	-	-	0.00	690.03
2016	739.87	1.06	1.74	1.80	-	-	0.00	744.47
2017	663.33	0.75	0.00	-	-	-	0.00	664.09
2018	553.83	1.74	0.00	-	-	-	0.02	555.59
2019	585.89	4.03	-	-	-	-	-	589.92
2020	562.04	-	0.01	0.26	-	-	0.01	562.33
2021	412.95	-	-	0.78	-	-	-	413.73
2022	404.98	-	-	1.08	-	-	-	406.06
2023	337.28	-	0.00	0.01	-	-	-	337.28

Table B.5: Annual modal conversion factor reported for product state codes of red gurnard from the GUR 2 Quota Management Areas. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HDS = Heads, HGU = Headed and gutted, SKF = Fillets: skin-off. – : no observations.

Fishing year	GRE	GUT	HGU	DRE	HDS	FIL	SKF
1990	1.00	1.10	1.50	-	-	-	-
1991	1.00	1.05	1.65	1.80	-	-	-
1992	1.00	1.05	1.65	1.80	-	-	-
1993	1.00	1.05	1.65	-	-	-	-
1994	1.00	1.05	1.65	1.80	-	-	-
1995	1.00	1.05	1.65	1.80	-	-	-
1996	1.00	1.05	1.65	1.80	-	-	-
1997	1.00	1.05	1.65	1.80	-	-	-
1998	1.00	1.05	1.65	1.80	0.00	-	-
1999	1.00	1.05	1.65	1.80	-	-	-
2000	1.00	1.05	-	1.80	-	-	-
2001	1.00	1.05	-	1.80	-	2.05	-
2002	1.00	1.05	-	1.80	-	2.05	-
2003	1.00	1.05	1.65	1.80	-	-	2.60
2004	1.00	1.05	-	1.80	-	2.05	-
2005	1.00	1.05	1.65	1.80	-	2.05	-
2006	1.00	1.05	-	1.80	-	-	-
2007	1.00	1.05	-	1.80	-	2.05	2.60
2008	1.00	1.05	1.65	1.80	-	2.05	-
2009	1.00	1.05	1.65	1.80	-	2.05	2.60
2010	1.00	1.05	-	1.80	-	2.05	2.60
2011	1.00	1.05	-	1.80	-	2.05	2.60
2012	1.00	1.05	-	1.80	-	2.05	2.60
2013	1.00	1.05	-	1.80	-	2.05	2.60
2014	1.00	1.05	-	1.80	-	2.05	2.60
2015	1.00	1.05	-	1.80	-	2.05	2.60
2016	1.00	1.05	-	1.80	-	2.05	2.60
2017	1.00	1.05	-	-	-	2.05	2.60
2018	1.00	1.05	-	-	-	2.05	2.60
2019	1.00	1.05	-	-	-	-	-
2020	1.00	-	-	1.80	-	2.05	2.60
2021	1.00	-	-	1.80	-	-	-
2022	1.00	-	-	1.80	-	-	-
2023	1.00	-	-	1.80	-	2.05	-

Table B.6: Reporting forms used for effort on trips landing red gurnard from the GUR 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	TCE	ERS - Trawl	ERS - Netting	Total	CEL	TCP	Other	TCE	ERS - Trawl	ERS - Netting	Total
1990	3311	184	-	-	-	-	3495	377.77	0.27	-	-	-	-	378.03
1991	4113	489	-	-	-	-	4602	496.51	21.53	-	-	-	-	518.04
1992	5084	669	-	-	-	-	5753	602.89	49.71	-	-	-	-	652.60
1993	4996	726	-	-	-	-	5722	600.86	28.85	-	-	-	-	629.71
1994	4707	1482	-	-	-	-	6189	535.05	93.12	-	-	-	-	628.17
1995	4447	1681	-	-	-	-	6128	475.04	93.27	-	-	-	-	568.31
1996	3894	2303	-	-	-	-	6197	448.46	119.43	-	-	-	-	567.89
1997	3967	2065	-	-	-	-	6032	417.05	71.49	-	-	-	-	488.54
1998	4404	1659	-	-	-	-	6063	427.76	45.99	-	-	-	-	473.75
1999	4425	1767	-	-	-	-	6192	417.10	48.97	-	-	-	-	466.07
2000	4523	1528	-	-	-	-	6051	497.42	25.60	-	-	-	-	523.02
2001	4332	1783	-	-	-	-	6115	525.36	81.35	-	-	-	-	606.72
2002	4176	1780	-	-	-	-	5956	529.05	85.15	-	-	-	-	614.20
2003	3849	1999	-	-	-	-	5848	437.59	110.07	-	-	-	-	547.66
2004	3198	2058	-	-	-	-	5256	380.21	132.94	-	-	-	-	513.16
2005	3479	2103	3	-	-	-	5585	550.63	157.99	0.00	-	-	-	708.62
2006	3638	1970	9	-	-	-	5617	430.90	105.41	0.00	-	-	-	536.31
2007	3506	2313	293	-	-	-	6112	444.88	130.22	0.68	-	-	-	575.78
2008	172	1760	494	8124	-	-	10550	18.62	98.12	1.44	410.65	-	-	528.83
2009	244	1880	566	8107	-	-	10797	2.70	107.79	6.33	494.01	-	-	610.83
2010	233	2006	596	8640	-	-	11475	21.97	213.78	2.46	603.86	-	-	842.06
2011	266	1545	255	8826	-	-	10892	28.46	90.86	1.36	457.50	-	-	578.18
2012	289	932	347	8185	-	-	9753	78.50	27.62	0.76	446.70	-	-	553.59
2013	207	366	248	8559	-	-	9380	37.80	11.31	1.65	541.90	-	-	592.66
2014	105	1258	212	8707	-	-	10282	0.22	37.02	0.64	515.37	-	-	553.26
2015	89	1100	357	7446	-	-	8992	15.60	64.77	1.14	606.60	-	-	688.11
2016	135	767	245	7080	-	-	8227	34.58	50.69	1.02	650.92	-	-	737.22
2017	187	1079	165	6900	-	-	8331	24.73	80.30	0.43	554.58	-	-	660.04
2018	228	468	274	6763	242	-	7975	30.82	14.46	1.51	490.82	16.94	-	554.54
2019	143	149	254	4580	1969	54	7149	1.06	2.32	4.39	420.56	156.56	0.12	585.02
2020	-	-	280	236	5366	391	6273	-	-	33.21	27.19	497.55	1.21	559.16
2021	-	-	224	-	5151	323	5698	-	-	29.51	-	380.54	2.80	412.85
2022	-	-	72	-	4457	529	5058	-	-	0.91	-	401.58	2.95	405.44
2023	-	-	188	-	3499	834	4521	-	-	5.65	-	328.69	2.51	336.85

Table B.7: Allocated catches (t) of red gurnard in GUR 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	PRB	Other	Total
1990	0.03	370.63	5.73	-	-	1.64	378.03
1991	-	506.36	6.89	1.19	-	3.61	518.04
1992	-	635.70	12.60	-	-	4.30	652.60
1993	0.29	620.00	4.83	0.03	-	4.56	629.71
1994	7.54	611.95	4.16	-	-	4.51	628.17
1995	0.00	535.24	2.82	28.55	-	1.70	568.31
1996	-	526.83	3.56	20.69	-	16.82	567.89
1997	-	446.95	3.65	35.88	-	2.05	488.54
1998	-	440.23	2.61	27.14	-	3.78	473.75
1999	0.80	418.96	2.68	41.43	-	2.20	466.07
2000	0.99	473.87	2.36	45.17	-	0.63	523.02
2001	-	523.38	4.45	74.76	-	4.13	606.72
2002	-	545.69	4.01	62.93	-	1.57	614.20
2003	-	540.27	3.12	2.52	-	1.76	547.66
2004	-	508.09	2.44	1.42	-	1.21	513.16
2005	-	700.86	7.24	0.25	-	0.27	708.62
2006	-	532.93	2.48	0.41	-	0.49	536.31
2007	-	568.16	2.18	5.33	-	0.12	575.78
2008	-	514.58	3.16	11.03	-	0.06	528.83
2009	-	601.80	7.64	0.23	-	1.16	610.83
2010	-	817.64	2.82	21.50	-	0.11	842.06
2011	-	548.36	1.53	28.16	-	0.13	578.18
2012	-	474.32	0.86	78.29	-	0.11	553.59
2013	-	553.21	1.89	37.51	-	0.05	592.66
2014	-	552.39	0.74	0.01	-	0.11	553.26
2015	-	671.35	1.17	15.55	-	0.04	688.11
2016	-	701.61	1.02	34.47	-	0.12	737.22
2017	-	630.24	1.04	24.06	3.50	1.20	660.04
2018	-	502.33	2.10	30.13	19.88	0.10	554.54
2019	-	579.13	1.24	4.28	0.31	0.06	585.02
2020	-	524.74	1.21	33.17	0.00	0.04	559.16
2021	-	380.51	2.80	27.90	0.03	1.61	412.85
2022	-	401.58	2.95	0.86	0.00	0.05	405.44
2023	-	328.68	2.51	5.65	0.00	0.00	336.85

APPENDIX C: ADDITIONAL CPUE SERIES

C.1 GUR 2 BT.MIX.TAR event

Table C.1: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the GUR 2 BT.MIX.TAR event CPUE series.

Series	GUR 2 BT.MIX.TAR event
QMS stock	GUR 2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	GUR, SNA, TRE, TAR
Statistical Areas	011, 012, 013, 014
Period	2007-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	5
Default model	allockg_top5 ~ fyear + vessel_key + ns(log(fishing_duration), 3) + stat_area*month + target_species + ns(start_longitude, 4) + ns(start_latitude, 4) + ns(bottom_depth, 3) + ns(effort_width, 3) + ns(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

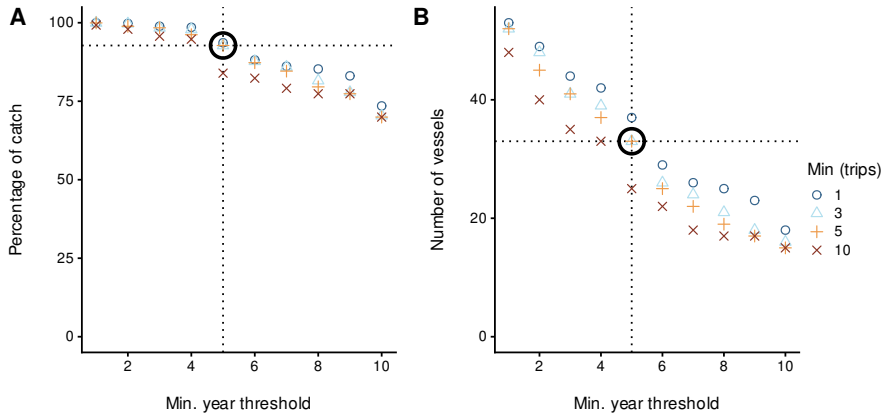

Figure C.1: Percentage of catch and number of vessels for different core vessel selection criteria for the GUR 2 BT.MIX.TAR event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

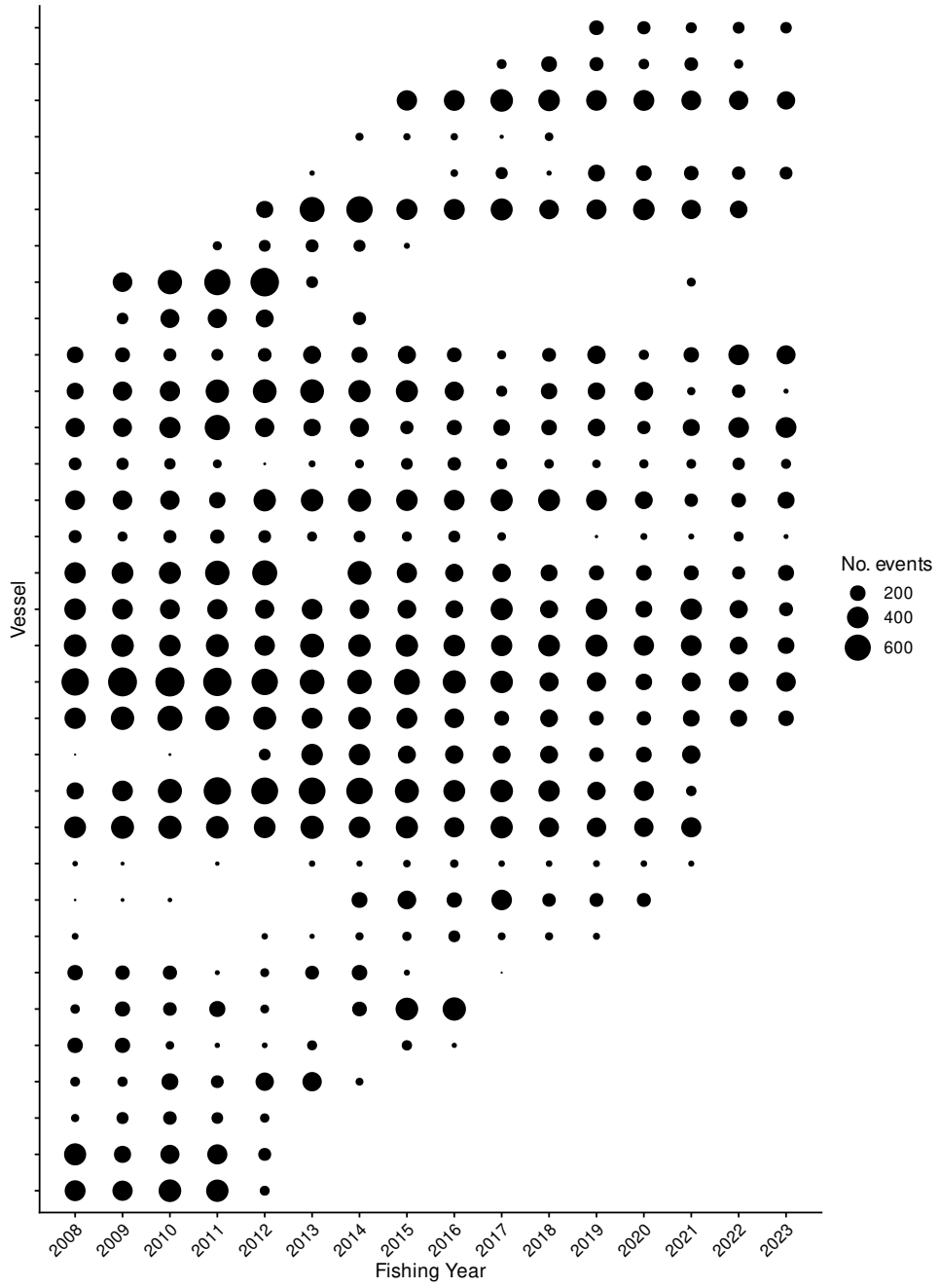

Figure C.2: Number of events by fishing year for core vessels in the GUR 2 BT.MIX.TAR event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.2: Summary of the GUR 2 BT.MIX.TAR event dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	448 (100%) n: 7982	537 (100%) n: 8300	679 (100%) n: 8958	488 (100%) n: 8316	420 (100%) n: 7284	495 (100%) n: 6996	496 (100%) n: 7617	630 (100%) n: 6833	657 (100%) n: 6062
Fishing duration is not NA	447 (100%) n: 7981	537 (100%) n: 8295	679 (100%) n: 8957	488 (100%) n: 8315	420 (100%) n: 7284	495 (100%) n: 6996	496 (100%) n: 7616	630 (100%) n: 6832	657 (100%) n: 6062
Fishing duration greater than 15mins	447 (100%) n: 7976	537 (100%) n: 8287	679 (100%) n: 8950	488 (100%) n: 8309	420 (100%) n: 7279	495 (100%) n: 6994	496 (100%) n: 7612	630 (100%) n: 6824	657 (100%) n: 6057
Fishing duration under 10hrs	446 (100%) n: 7962	537 (100%) n: 8280	678 (100%) n: 8937	487 (100%) n: 8297	420 (100%) n: 7275	495 (100%) n: 6986	496 (100%) n: 7608	630 (100%) n: 6815	656 (100%) n: 6047
Bottom depth less than 200m	444 (99%) n: 7744	536 (100%) n: 8167	678 (100%) n: 8825	487 (100%) n: 8219	420 (100%) n: 7230	495 (100%) n: 6901	496 (100%) n: 7547	629 (100%) n: 6744	656 (100%) n: 5990
Latitude in range	444 (99%) n: 7744	536 (100%) n: 8167	678 (100%) n: 8824	487 (100%) n: 8219	420 (100%) n: 7230	495 (100%) n: 6901	496 (100%) n: 7547	629 (100%) n: 6744	656 (100%) n: 5990
Core fleet selection	339 (76%) n: 5735	419 (78%) n: 6355	550 (81%) n: 7184	451 (92%) n: 7465	414 (98%) n: 7022	472 (95%) n: 6216	475 (96%) n: 6790	614 (97%) n: 6408	644 (98%) n: 5757

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	532 (100%) n: 5692	448 (100%) n: 5177	509 (100%) n: 5194	481 (100%) n: 4466	342 (100%) n: 4206	371 (100%) n: 3977	298 (100%) n: 3017
Fishing duration is not NA	532 (100%) n: 5691	448 (100%) n: 5177	509 (100%) n: 5193	481 (100%) n: 4465	342 (100%) n: 4206	371 (100%) n: 3977	298 (100%) n: 3016
Fishing duration greater than 15mins	532 (100%) n: 5684	448 (100%) n: 5177	509 (100%) n: 5189	480 (100%) n: 4455	341 (100%) n: 4192	371 (100%) n: 3969	297 (100%) n: 3004
Fishing duration under 10hrs	531 (100%) n: 5675	447 (100%) n: 5168	508 (100%) n: 5177	479 (100%) n: 4449	341 (100%) n: 4188	371 (100%) n: 3966	297 (100%) n: 3003
Bottom depth less than 200m	531 (100%) n: 5596	447 (100%) n: 5130	508 (100%) n: 5146	479 (100%) n: 4416	340 (100%) n: 4153	371 (100%) n: 3948	297 (100%) n: 2979
Latitude in range	531 (100%) n: 5595	447 (100%) n: 5130	508 (100%) n: 5139	479 (99%) n: 4413	340 (99%) n: 4148	371 (100%) n: 3948	297 (100%) n: 2979
Core fleet selection	512 (96%) n: 5294	420 (94%) n: 4770	502 (99%) n: 5015	469 (97%) n: 4313	331 (97%) n: 4060	307 (83%) n: 3397	250 (84%) n: 2661

Table C.3: Summary of the GUR 2 BT.MIX.TAR 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 red gurnard.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
2008	24	799	5 735	19 776.00	339.12	79.56
2009	24	899	6 355	22 174.78	418.91	80.47
2010	24	994	7 184	25 082.25	549.88	79.97
2011	24	911	7 465	26 111.62	451.37	73.36
2012	26	881	7 022	24 963.99	413.99	70.66
2013	22	758	6 216	22 396.83	472.02	79.41
2014	24	819	6 790	24 303.72	474.83	74.42
2015	24	806	6 408	23 426.71	613.77	80.10
2016	23	828	5 757	21 598.93	643.58	79.73
2017	23	705	5 294	20 036.78	511.56	79.45
2018	21	717	4 770	18 359.92	420.24	80.25
2019	22	767	5 015	19 101.43	501.94	81.42
2020	21	633	4 313	16 966.95	468.56	84.49
2021	21	737	4 060	15 250.13	330.58	82.02
2022	16	688	3 397	12 308.12	306.71	82.98
2023	14	481	2 661	9 991.07	249.78	78.32

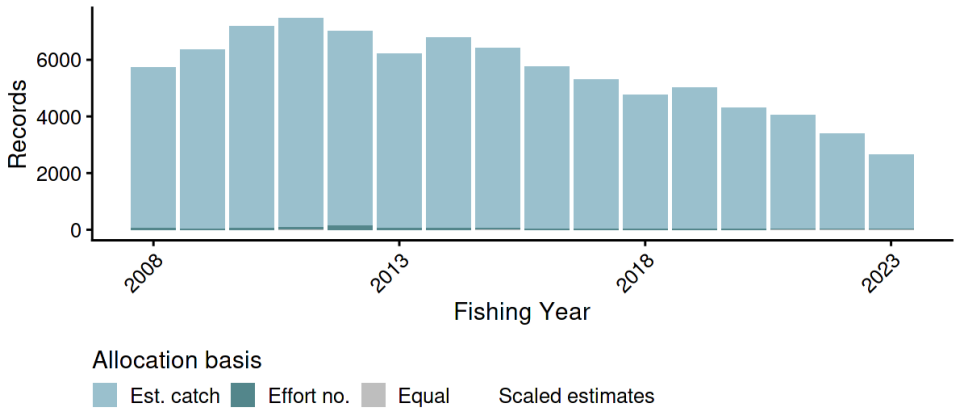

Figure C.3: Allocation basis for attributing landings to records in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table C.4: Summary of stepwise selection for occurrence of positive catch in the GUR 2 BT.MIX.TAR event series. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
fyear	14.00	91 072	0.70	0.70	*
+ ns(bottom_depth, 3)	3.00	67 932	26.00	25.20	*
+ ns(start_latitude, 4)	4.00	62 226	32.20	6.20	*
+ vessel_key	32.00	60 156	34.50	2.30	*
+ target_species	3.00	58 822	36.00	1.50	*
+ ns(start_longitude, 4)	4.00	58 248	36.60	0.60	
+ month	11.00	57 923	37.00	0.40	
+ ns(log(fishing_duration), 3)	3.00	57 775	37.20	0.20	
+ ns(effort_height, 3)	3.00	57 675	37.30	0.10	
+ stat_area	3.00	57 663	37.30	0.00	
+ stat_area:month	33.00	57 528	37.50	0.20	
+ ns(effort_width, 3)	3.00	57 521	37.50	0.00	

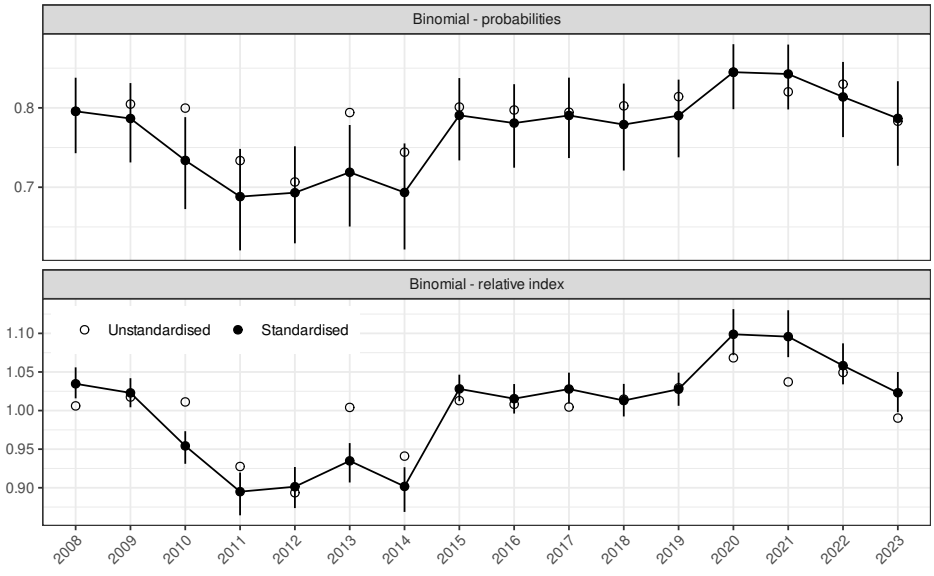

Figure C.4: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the GUR 2 BT.MIX.TAR event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

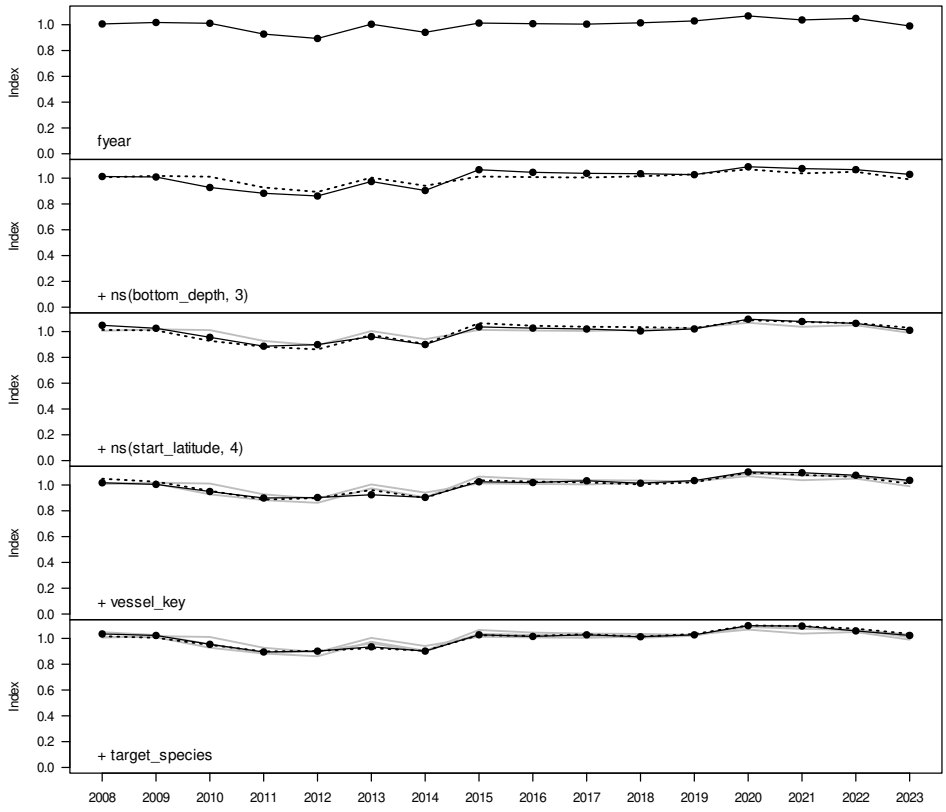

Figure C.5: Step plot for occurrence of catch in the GUR 2 BT.MIX.TAR event dataset.

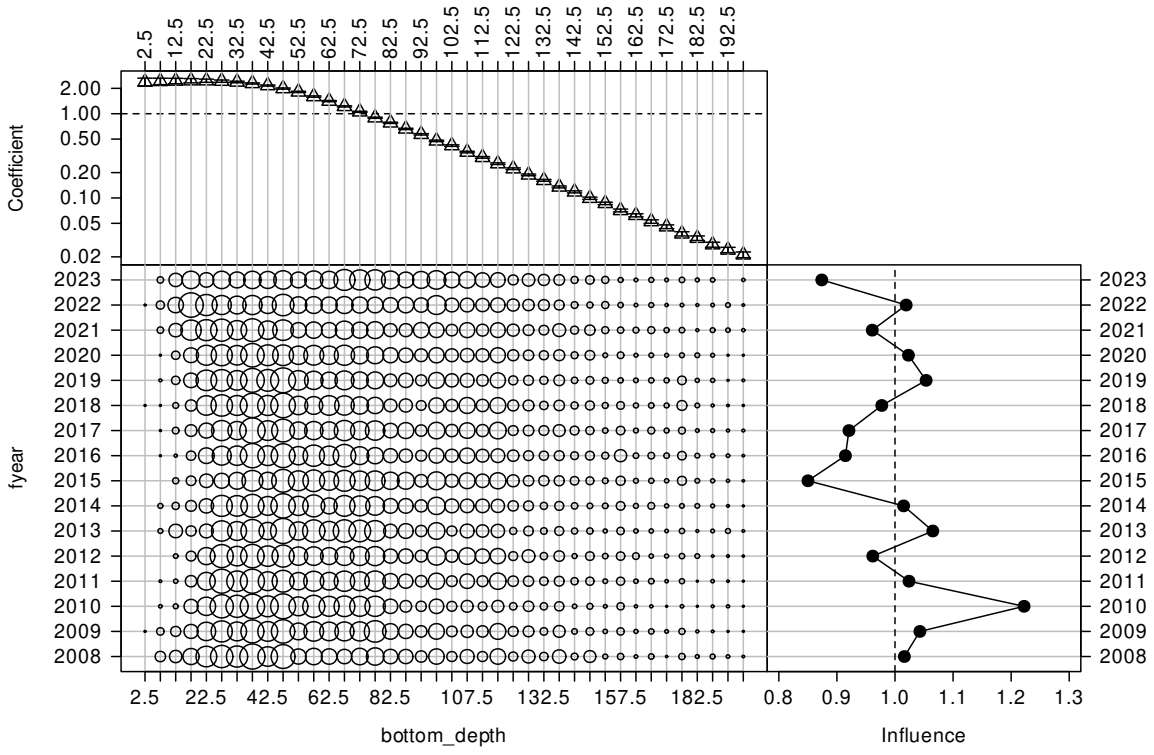

Figure C.6: CDI plot for bottom depth (m) for the occurrence of positive catch in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

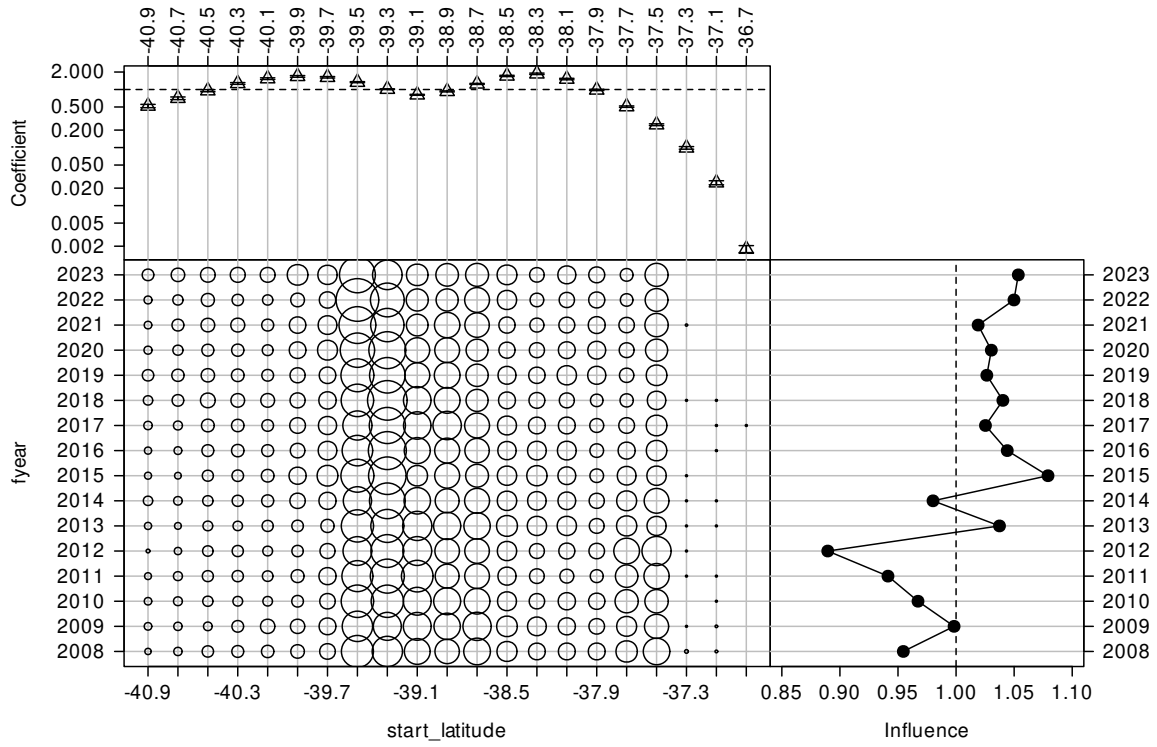

Figure C.7: CDI plot for start latitude for the occurrence of positive catch in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

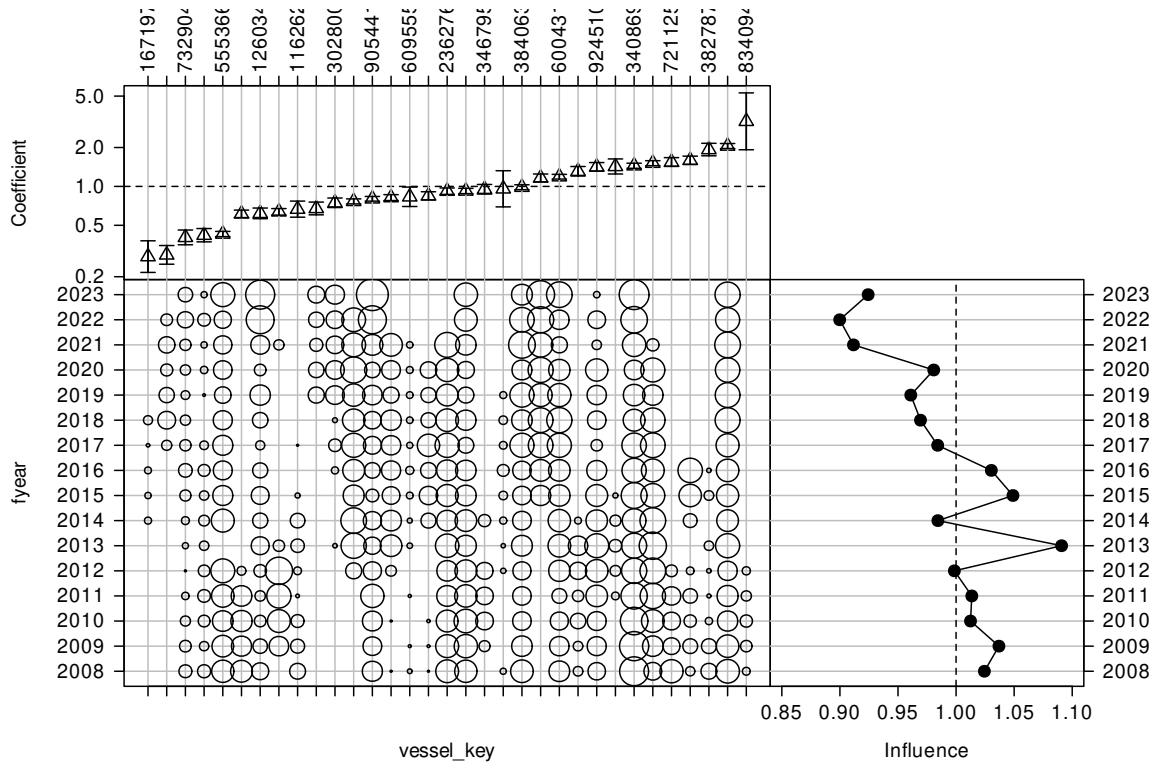

Figure C.8: CDI plot for vessel key for the occurrence of positive catch in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

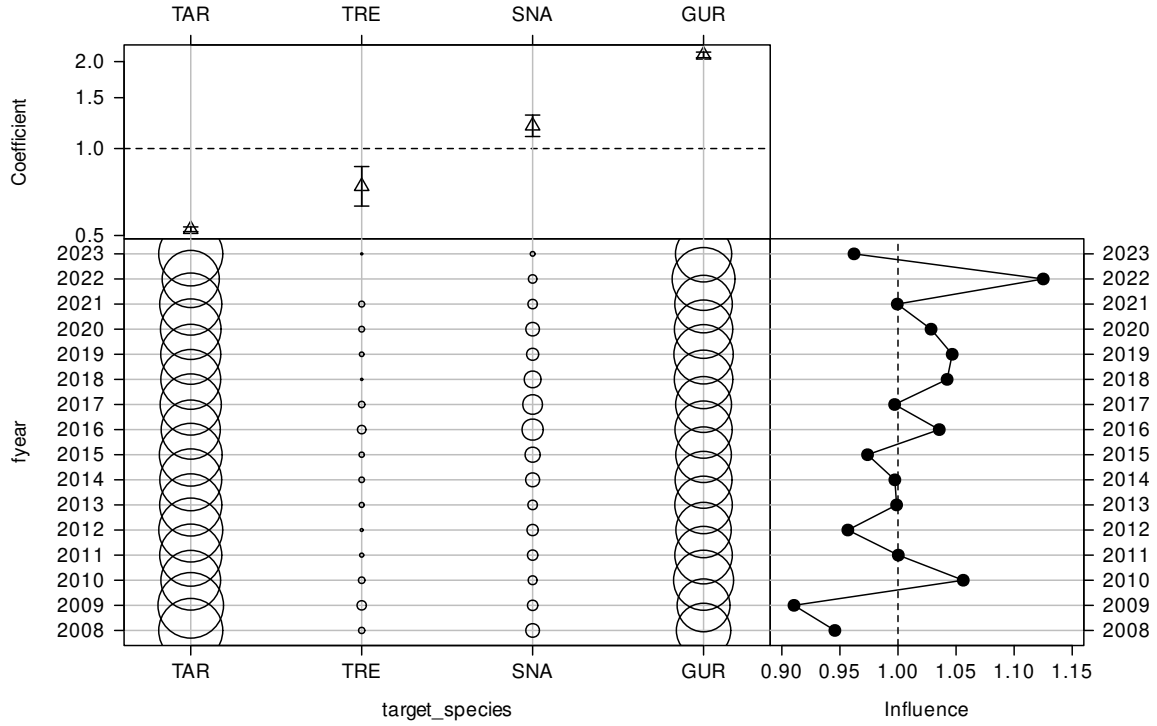

Figure C.9: CDI plot for target species for the occurrence of positive catch in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

Table C.5: Summary of stepwise selection for the Weibull model for positive catches in the GUR 2 BT.MIX.TAR event series. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	df	AIC	% deviance	addl. % deviance	Included
fyear	17	781 215	3.4	3.4	*
+ vessel_key	32	765 178	24.5	21.0	*
+ target_species	3	754 904	37.9	13.4	*
+ ns(bottom_depth, 3)	3	750 769	43.3	5.4	*
+ ns(log(fishing_duration), 3)	3	748 114	46.8	3.5	*
+ month	11	746 909	48.4	1.6	*
+ ns(start_latitude, 4)	4	746 026	49.5	1.2	*
+ ns(start_longitude, 4)	4	745 330	50.5	0.9	
+ ns(effort_height, 3)	3	745 114	50.8	0.3	
+ ns(effort_width, 3)	3	745 049	50.8	0.1	
+ stat_area	3	744 989	50.9	0.1	*
+ stat_area:month	33	744 191	52.1	1.1	*

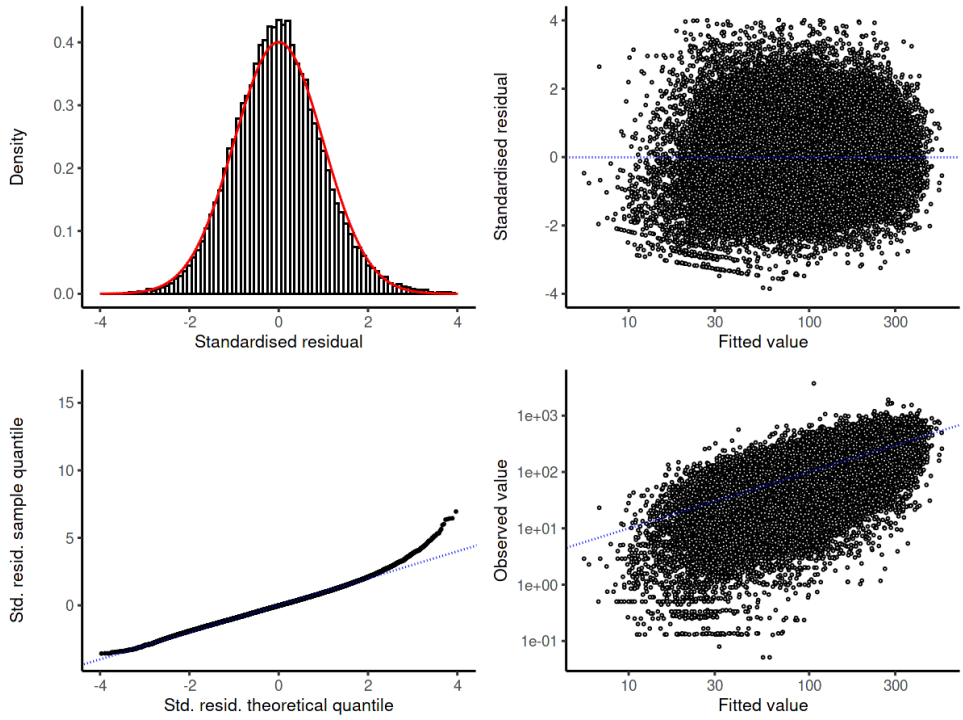

Figure C.10: Diagnostic plots for the selected Weibull model for positive catches in the GUR 2 BT.MIX.TAR event dataset.

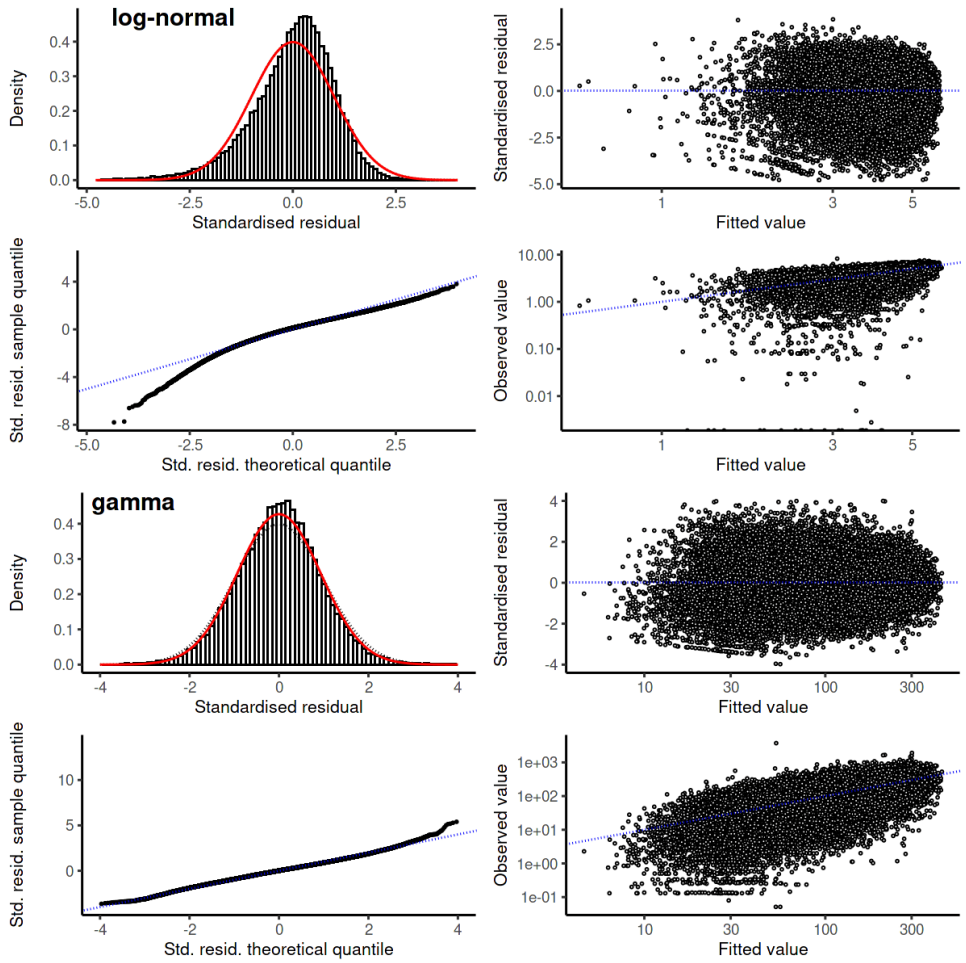

Figure C.11: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the GUR 2 BT.MIX.TAR event dataset.

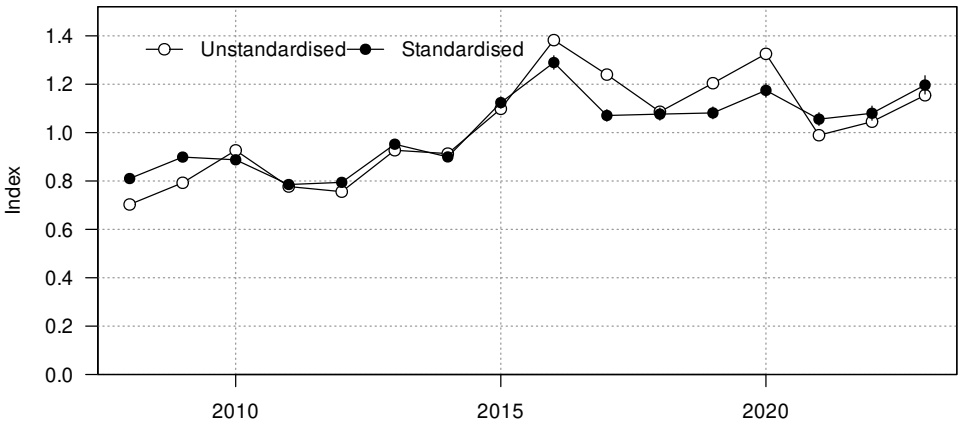

Figure C.12: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the GUR 2 BT.MIX.TAR event dataset.

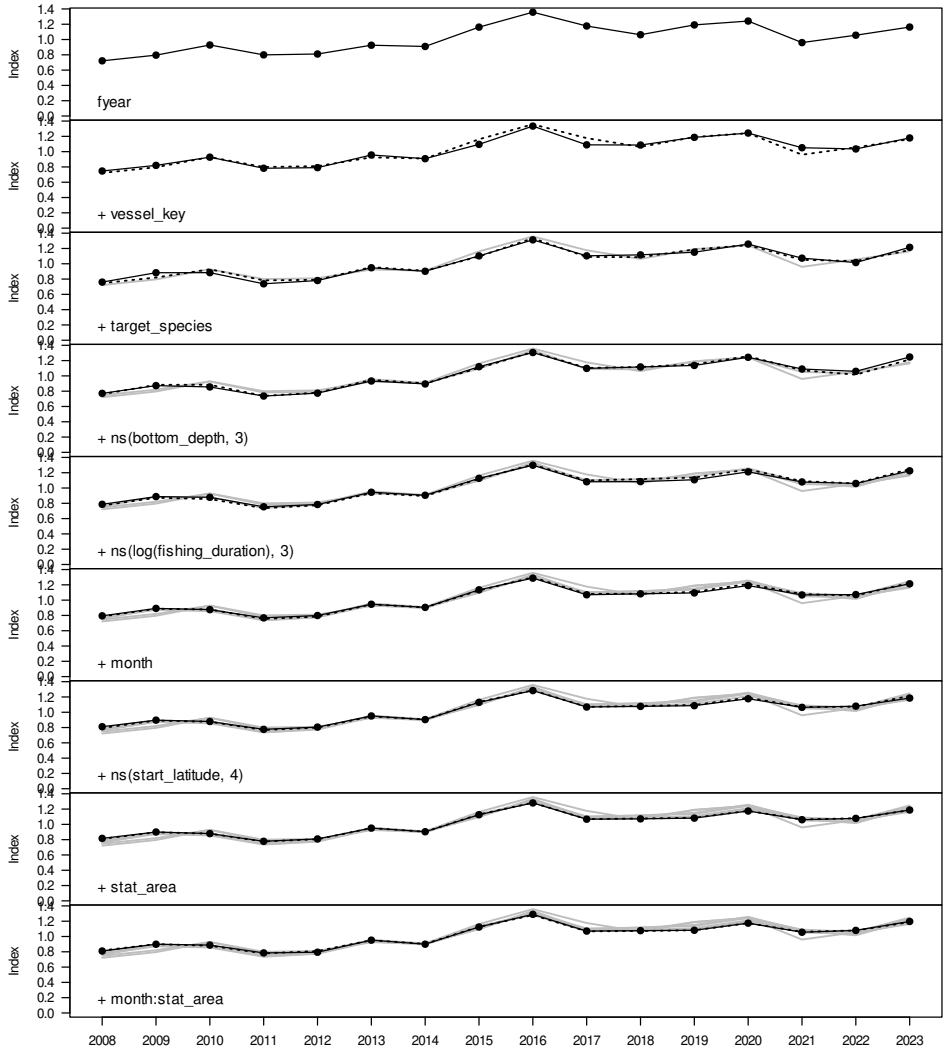

Figure C.13: Changes to the GUR 2 BT.MIX.TAR event positive catch index as terms are successively entered into the Weibull model.

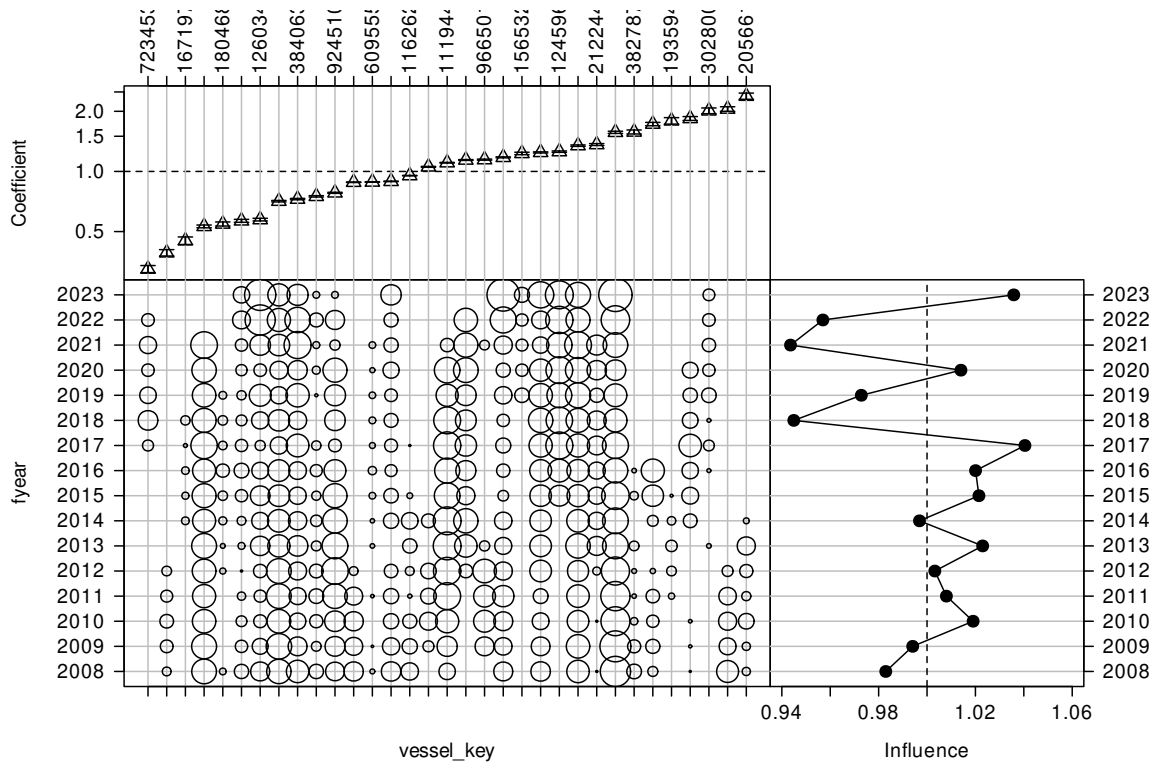

Figure C.14: CDI plot for vessel key for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

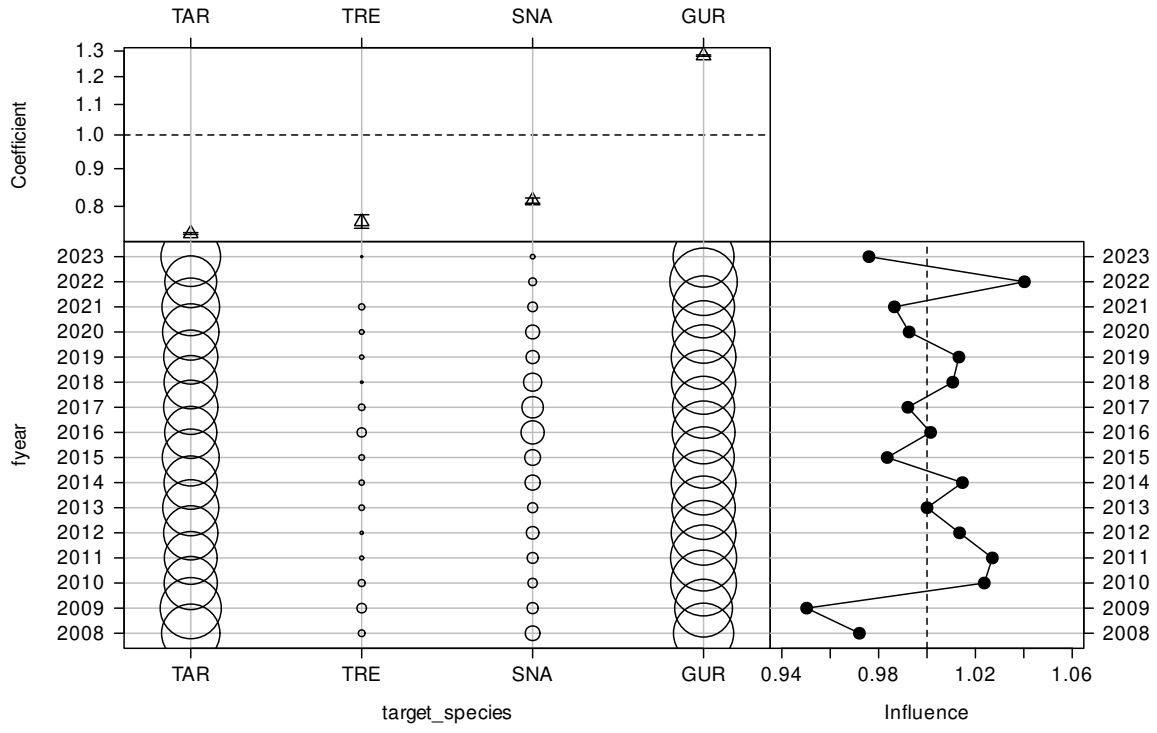

Figure C.15: CDI plot for target species for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

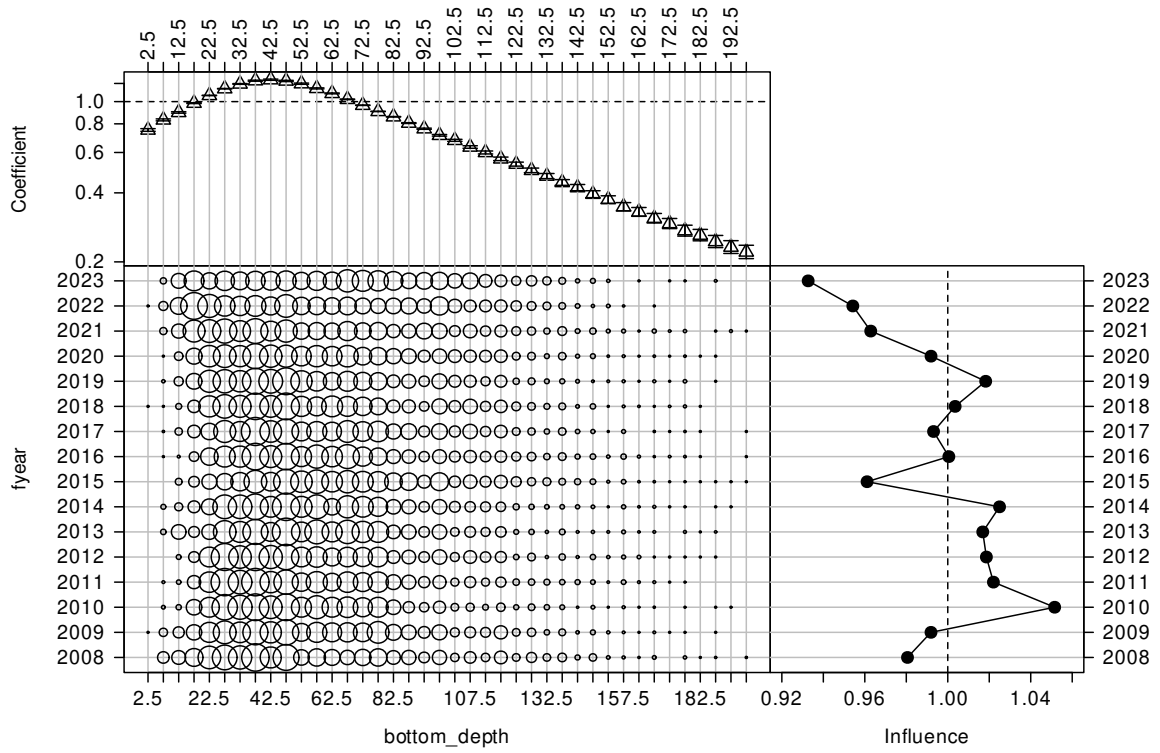

Figure C.16: CDI plot for bottom depth (m) for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

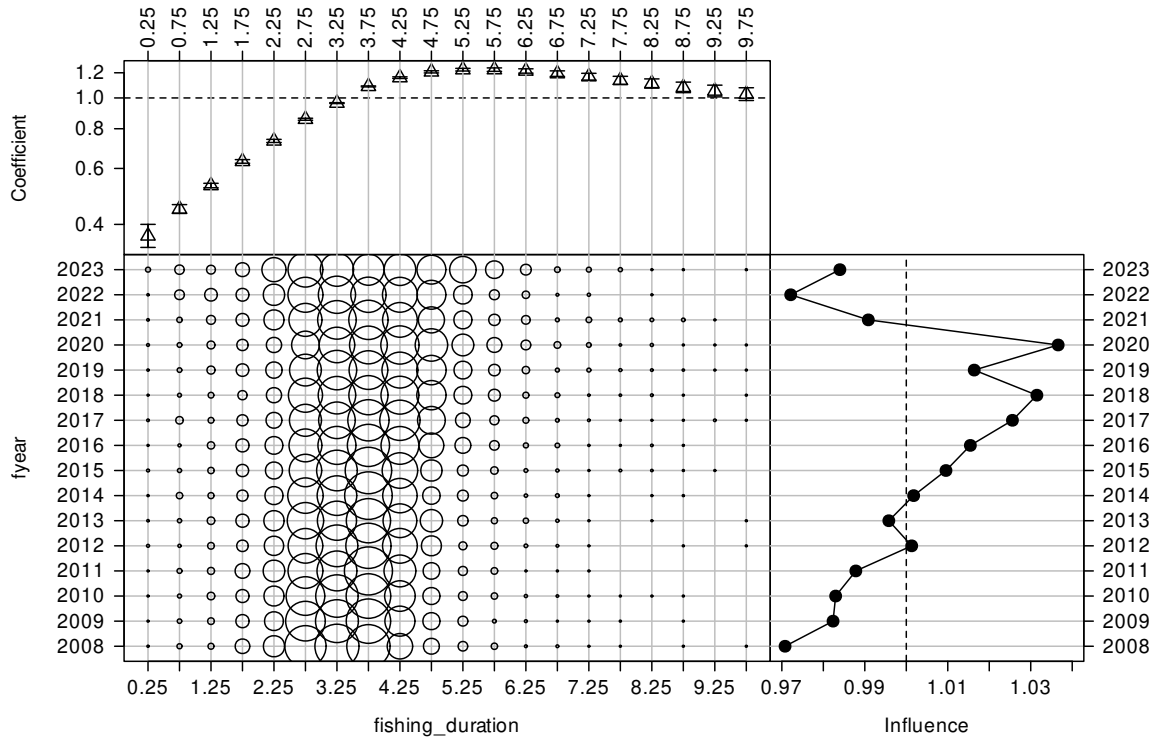

Figure C.17: CDI plot for fishing duration (h) for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

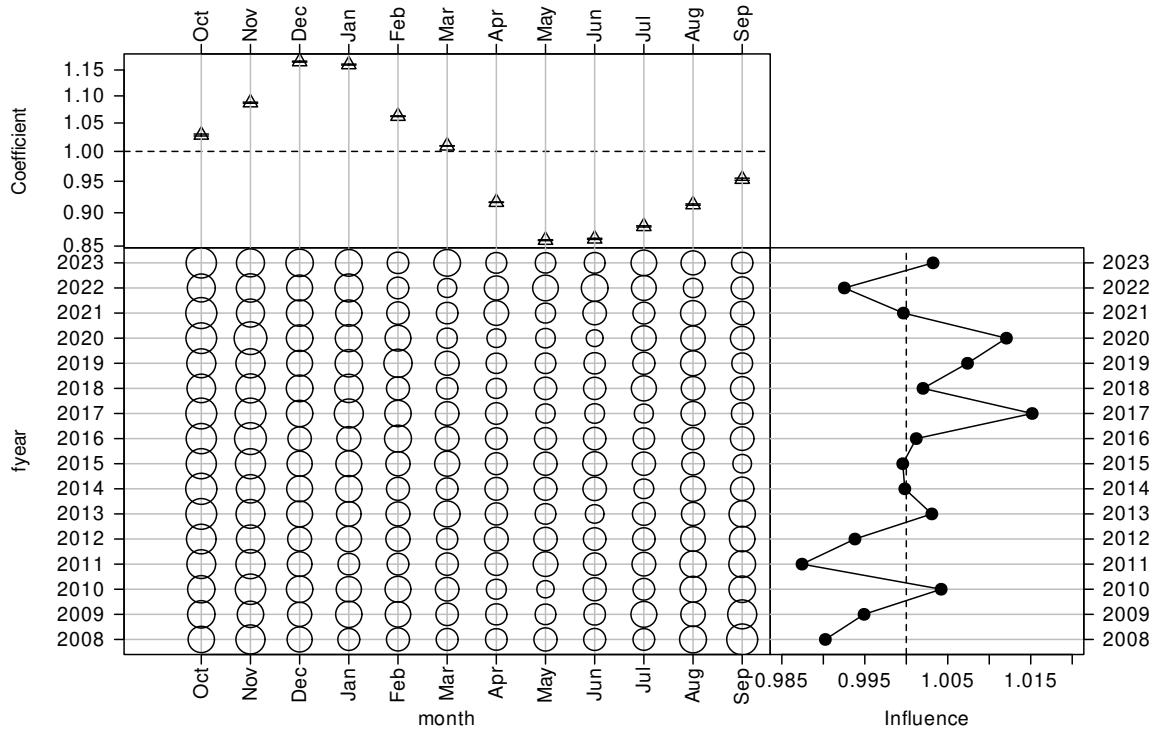

Figure C.18: CDI plot for month for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

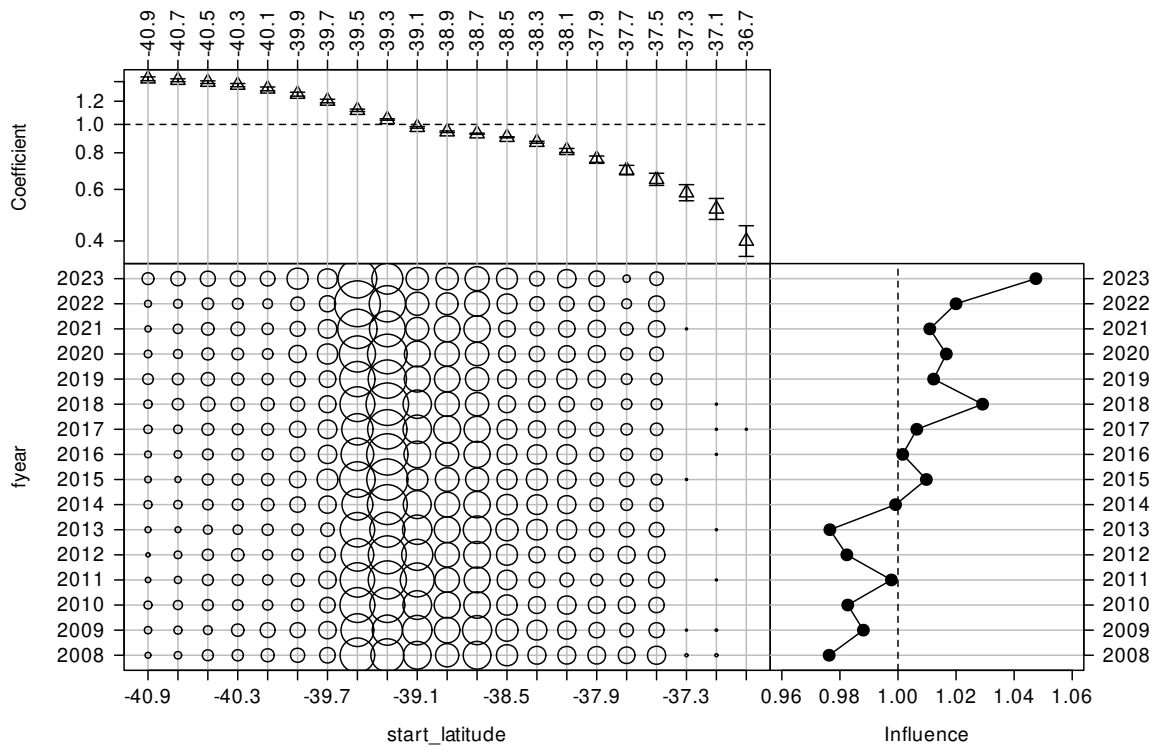

Figure C.19: CDI plot for start latitude for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

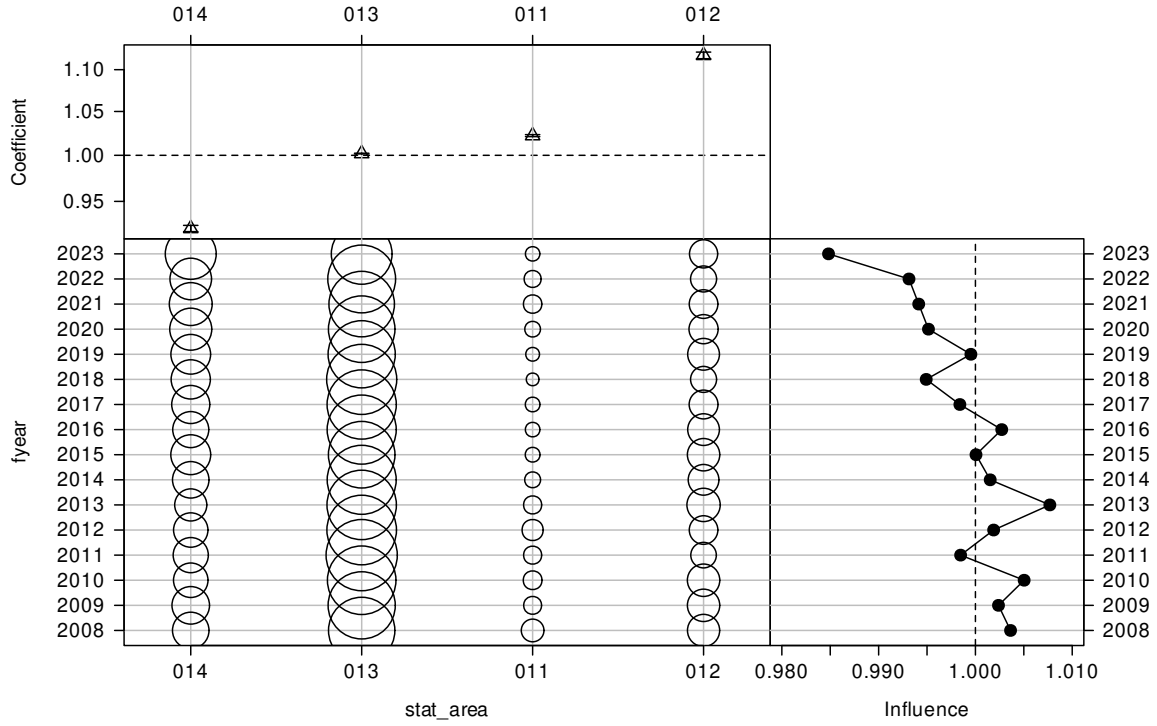

Figure C.20: CDI plot for statistical area for the Weibull model of positive catches in the GUR 2 BT.MIX.TAR event catch-per-unit-effort dataset.

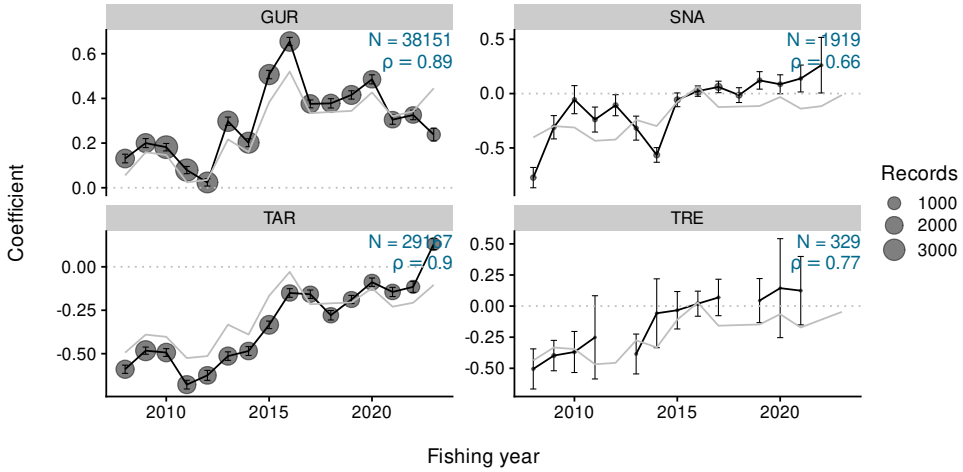

Figure C.21: Residual implied coefficients for target-year in the Weibull positive catch model for the GUR 2 BT.MIX.TAR event dataset.

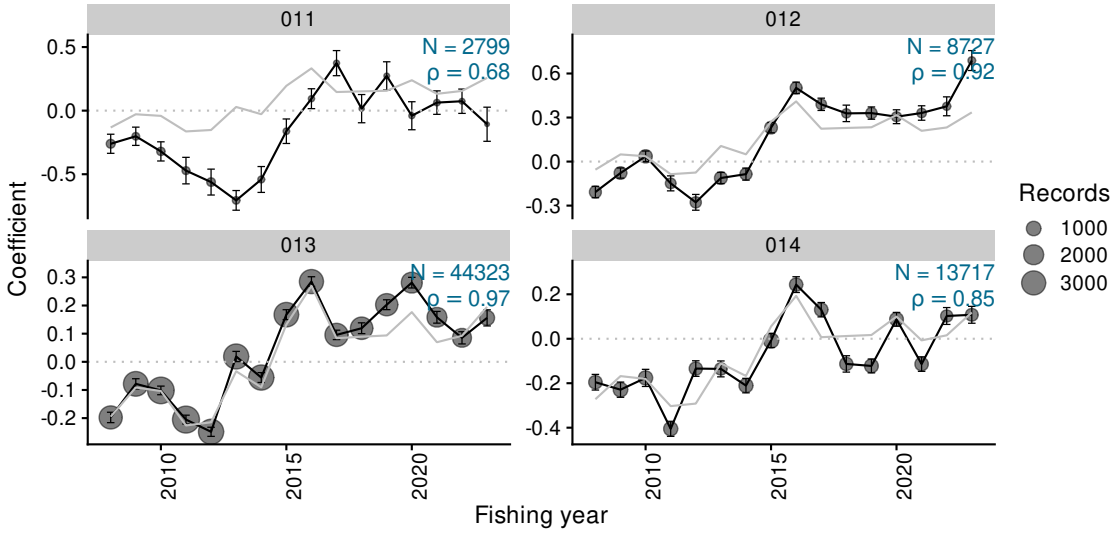

Figure C.22: Residual implied coefficients for area-year in the Weibull positive catch model for the GUR 2 BT.MIX.TAR event dataset.

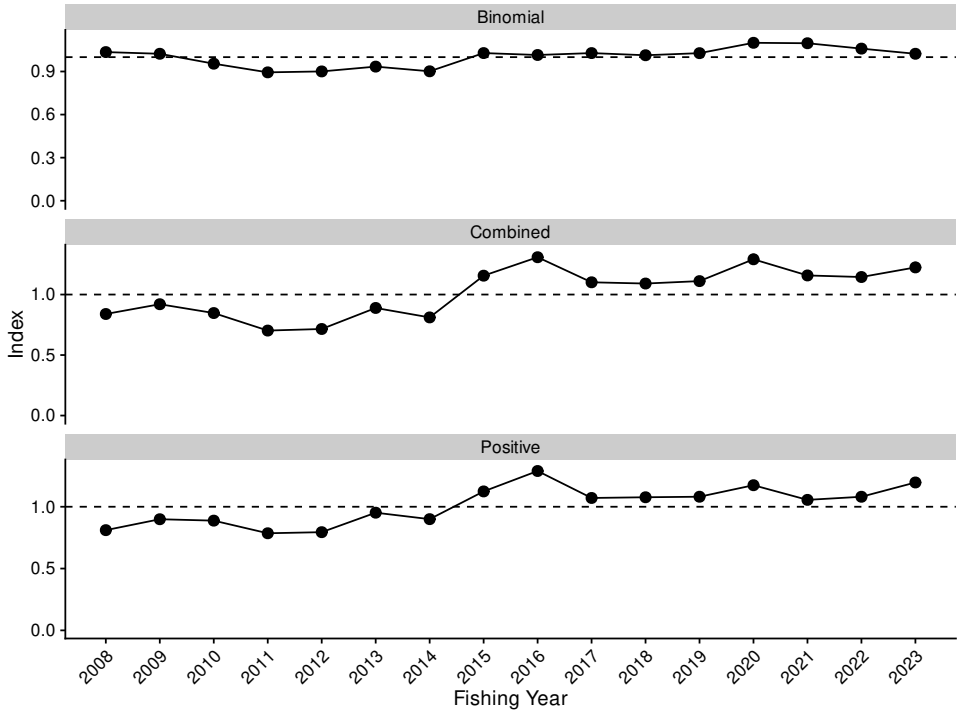

Figure C.23: Standardised indices and 95% confidence intervals for the GUR 2 BT.MIX.TAR event dataset.

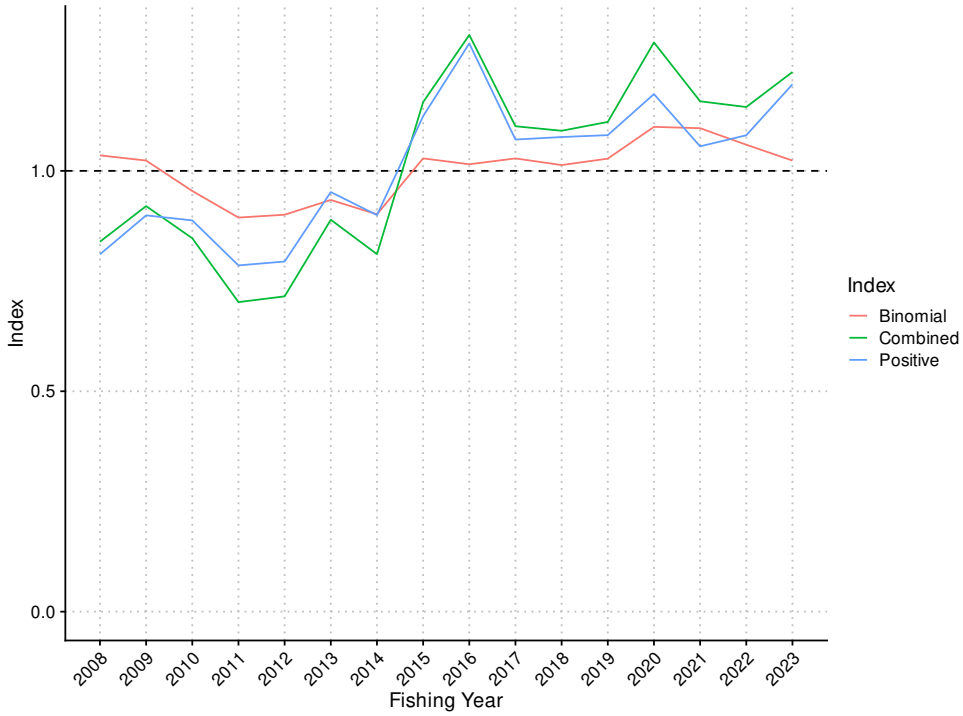

Figure C.24: Standardised indices for the GUR 2 BT.MIX.TAR event dataset.

Table C.6: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in GUR 2 BT.MIX.TAR event.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
2008	1.035	0.010	1.017	1.057	0.839	0.012	0.815	0.864	0.811	0.009	0.793	0.828
2009	1.023	0.009	1.005	1.042	0.920	0.012	0.897	0.945	0.899	0.009	0.881	0.917
2010	0.954	0.011	0.932	0.973	0.847	0.012	0.822	0.871	0.888	0.009	0.871	0.905
2011	0.894	0.014	0.865	0.920	0.702	0.013	0.676	0.729	0.786	0.008	0.770	0.801
2012	0.901	0.014	0.872	0.928	0.715	0.014	0.687	0.742	0.794	0.008	0.779	0.812
2013	0.934	0.013	0.906	0.957	0.889	0.014	0.859	0.916	0.952	0.009	0.933	0.970
2014	0.901	0.014	0.873	0.927	0.811	0.015	0.782	0.840	0.900	0.009	0.882	0.917
2015	1.028	0.009	1.010	1.047	1.156	0.016	1.126	1.186	1.124	0.012	1.101	1.148
2016	1.015	0.010	0.996	1.034	1.308	0.018	1.273	1.344	1.289	0.014	1.260	1.316
2017	1.028	0.010	1.009	1.048	1.101	0.016	1.070	1.132	1.071	0.011	1.049	1.094
2018	1.013	0.010	0.992	1.032	1.091	0.017	1.059	1.124	1.077	0.012	1.052	1.100
2019	1.028	0.011	1.008	1.050	1.111	0.017	1.079	1.146	1.081	0.012	1.059	1.104
2020	1.100	0.016	1.071	1.133	1.291	0.023	1.247	1.338	1.174	0.013	1.148	1.200
2021	1.097	0.015	1.069	1.130	1.158	0.021	1.117	1.198	1.056	0.013	1.029	1.080
2022	1.059	0.014	1.034	1.087	1.145	0.022	1.102	1.189	1.081	0.015	1.053	1.110
2023	1.023	0.014	0.999	1.052	1.224	0.024	1.178	1.271	1.196	0.019	1.159	1.233

APPENDIX D: GLOSSARY

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

Code	Description
DRE	Dressed
FIL	Fillets: skin-on
GRE	Green (or whole)
GUT	Gutted
HDS	Heads
HGU	Headed and gutted
SKF	Fillets: skin-off

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

Code	Description
CEL	Catch, Effort and Landing Return (CELR)
ERS - Trawl	Electronic Reporting System - Trawl
ERS - Netting	Electronic Reporting System - Netting
ERS - Lining	Electronic Reporting System - Lining
ERS - Potting	Electronic Reporting System - Potting
ERS - Seining	Electronic Reporting System - Seining
LCE	Lining Catch Effort Return (LCER)
NCE	Netting Catch, Effort and Landing Return (NCELR)
TCE	Trawl Catch Effort Return (TCER)
TCP	Trawl Catch, Effort and Processing Return (TCEPR)
TUN	Tuna Longlinging Catch Effort Return (TLCER)
LTC	Lining Trip Catch Effort Return (LTCER)

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
FLA	Flatfish	
GUR	Gurnard	*Chelidonichthys kumu*
SNA	Snapper	*Pagrus auratus* (*Chrysophrys auratus*)
TAR	Tarakihi	*Nemadactylus macropterus, Nemadactylus* sp. (King tarakihi)
TRE	Trevally	*Pseudocaranx georgianus*