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Characterisation and CPUE for the gemfish fishery in SKI 1 and SKI 2 from 1990 to 2022

New Zealand Fisheries Assessment Report 2023/15

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EXECUTIVE SUMMARY

Middleton, D.A.J.[1]; Neubauer, P.[2]; Thompson, F.N.[2] (2023). Characterisation and CPUE for the gemfish fishery in SKI 1 and SKI 2 from 1990 to 2022.

***New Zealand Fisheries Assessment Report 2023/15*. 211 p.**

Gemfish (SKI) was introduced to the Quota Management System on 01 October 1986. Originally the SKI stocks were specifically silver gemfish, *Rexea solandri*, but in 2005 the scope was widened to include *Rexea* spp. generally. Catches are assumed to be comprised almost exclusively of *Rexea solandri*, but some catch of long-finned gemfish (*R. antefurcata*) may occur in the northern fisheries within the SKI 1 and SKI 2 Quota Management Areas, which are considered to include a single biological stock of *R. solandri*.

The northern gemfish fisheries developed in the 1960s and 1970s, with catches increasing substantially during the 1980s. Declining catches in the 1990s preceded a series of cuts in the Total Allowable Catch. In SKI 1 and SKI 2, gemfish are taken primarily by bottom trawling between 300 and 500 m, and landed unprocessed. The target fishery has been undertaken by larger 'inshore' vessels but, as the stock has rebuilt, gemfish have been caught in the more traditional inshore fisheries, particularly the tarakihi fishery.

Gemfish were historically targeted from the Wairarapa Coast, in SKI 2, round to the west coast of the North Island, off Ninety Mile Beach; however, after the catch reductions in the early 2000s, targeting became focussed in the western Bay of Plenty. In SKI 1, the target fishery continued to take the majority of the gemfish catch until 2015, whereas in SKI 2 bycatch has dominated since 2005.

The last fully-quantitative assessment of northern gemfish was in 2008, and the stocks are currently classified as Group 2 stocks to be monitored with relative abundance indices based on standardised catch-per-unit-effort (CPUE). However, developing appropriate CPUE indices proved challenging for a period as a result of the significant changes in the fishery in the early 2000s. A CPUE index for SKI 2 was accepted in 2014 and, during 2020–2022, new indices have been developed. An index based on tarakihi-target effort throughout SKI 1 and SKI 2 and beginning in 1990 is considered to index the sub-adult and adult fish, while an index of adult stock abundance beginning in 1994 has been developed using gemfish and hoki target effort off the North Island east coast.

Abundance of sub-adult and adult fish declined from 1990 to 2000, then slowly increased for the following 15 years before a more rapid increase in abundance was observed between 2016 and 2018, peaking in 2020. Abundance of adult fish, measured by the gemfish-hoki index, subsequently increased substantially over the period 2017–2022.

B_{MSY} compatible reference points have been agreed by the Fisheries Assessment Plenary, with the geometric mean CPUE from the gemfish and hoki target series for the period 2004 to 2017 adopted as the soft limit reference point. The target is assumed to be twice the soft limit value. The northern gemfish stock was assessed as Likely (>60%) to be above the target reference point in 2021, and abundance has increased further in 2022.

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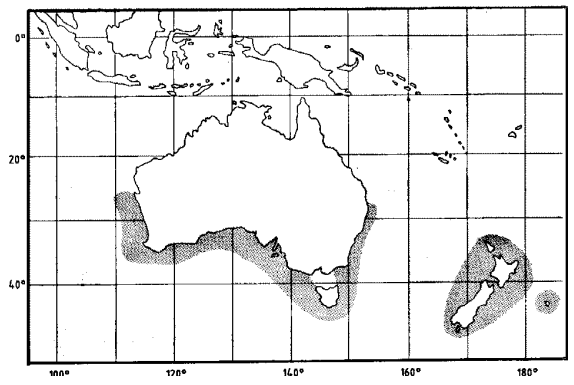
1. INTRODUCTION

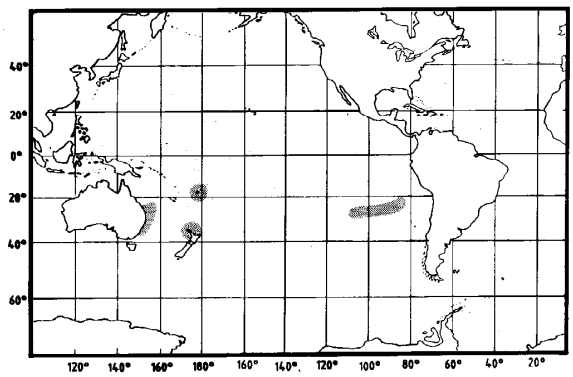
Gemfish (SKI; *Rexea solandri*) was introduced to the Quota Management System (QMS) on 01 October 1986. In 2005, the gemfish QMS stocks were widened to include *Rexea* spp. generally, rather than specifically *Rexea solandri*, as a consequence of changes to s319 of the Fisheries Act 1996 (David Foster, Ministry for Primary Industries, pers. comm.; see also s10(3) of the Fisheries (Reporting) Amendment Regulations 2005).

There are currently seven species recognised in the genus *Rexea* (Nakamura & Parin 1993, Roberts & Stewart 1997). Indicating the *Rexea* spp. expected to be encountered in New Zealand waters, species-specific reporting codes – for use by fisheries observers and in research activities – were introduced in 2005 for *Rexea prometheoides* (royal escolar, REP) and *R. antefurcata* (long-finned gemfish, LFG), in addition to *R. solandri* (RSO).

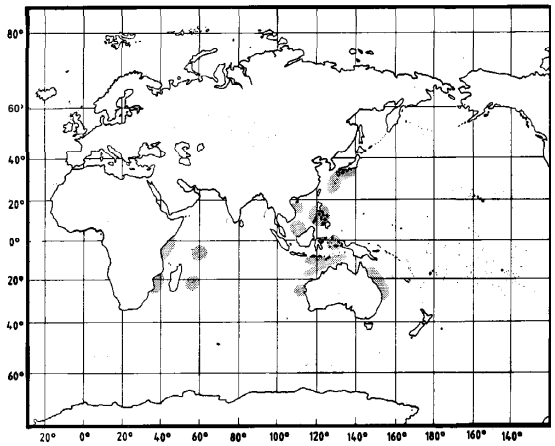
Records of *R. antefurcata* are confined to northern New Zealand waters including the Kermadec and Norfolk ridges, and off Northland, whereas *R. solandri* are widespread in New Zealand from the Norfolk Ridge to the Snares Island slope and including parts of the Chatham Rise and Challenger Plateau (Nakamura & Parin 1993, McMillan et al. 2019, Figure 1). There appear to be no records of *R. prometheoides* in New Zealand waters; an early (1989) record was subsequently confirmed as a misidentification of *R. antefurcata* (Andrew Stewart, Te Papa, pers. comm.). As a result, it is assumed that catches of gemfish in New Zealand fisheries are almost exclusively *R. solandri*, although there is the possibility that *R. antefurcata* may be included in some catches from northern New Zealand.



(a) *R. solandri* (fig. 89)



(b) *R. antefurcata* (fig. 79)



(c) *R. prometheoides* (fig. 87)

Figure 1: Distributions of the three *Rexea* species for which New Zealand research codes have been specified; from Nakamura & Parin (1993). (Map source: Food and Agriculture Organization of the United Nations. Reproduced with permission.)

Gemfish (specifically *R. solandri*) in SKI 1 and SKI 2, which together comprise Fisheries Management Areas (FMAs) 1, 2 and 9 (Figure 2), are considered to be a single biological stock, located mainly off the east coast North Island and migrating north to spawn north of the North Island during May–June (Fisheries New Zealand 2022). Catch limits for SKI 1 and SKI 2, effective for the 2023 fishing year, are given in Table 1.

Annual commercial catches were around the TACC in both areas from the early 2000s, but have shown an increasing trend since 2015 (Figure 3). Recreational harvests have also increased substantially in both areas. A harvest of 2752 fish in SKI 1 was estimated in the 2012 panel survey, increasing to 7140 fish in the 2018 panel survey. In SKI 2 the 2012 survey recorded no recreational harvest, but the 2018 survey estimated a harvest of 1299 fish (Fisheries New Zealand 2022).

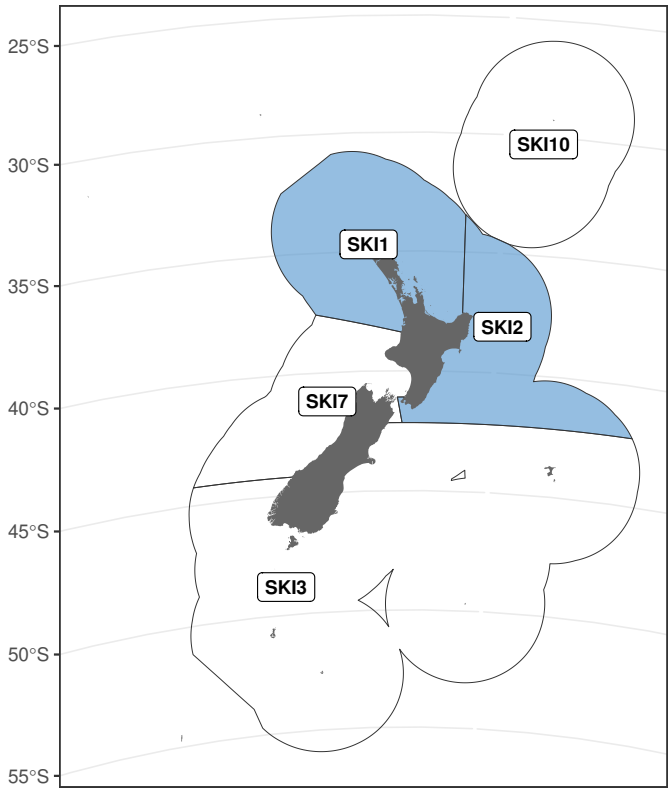


Figure 2: Quota Management Areas for gemfish with SKI 1 and SKI 2 highlighted.

Table 1: Total Allowable Catch (TAC), Total Allowable Commercial Catch (TACC), and allowances (all tonnes) for SKI 1 and SKI 2, as at 1 October 2022.

			Allowances		
Stock	TAC	TACC	Customary	Recreational	Other mortality
SKI 1	307	252	3	27	25
SKI 2	248	240	3	5	-

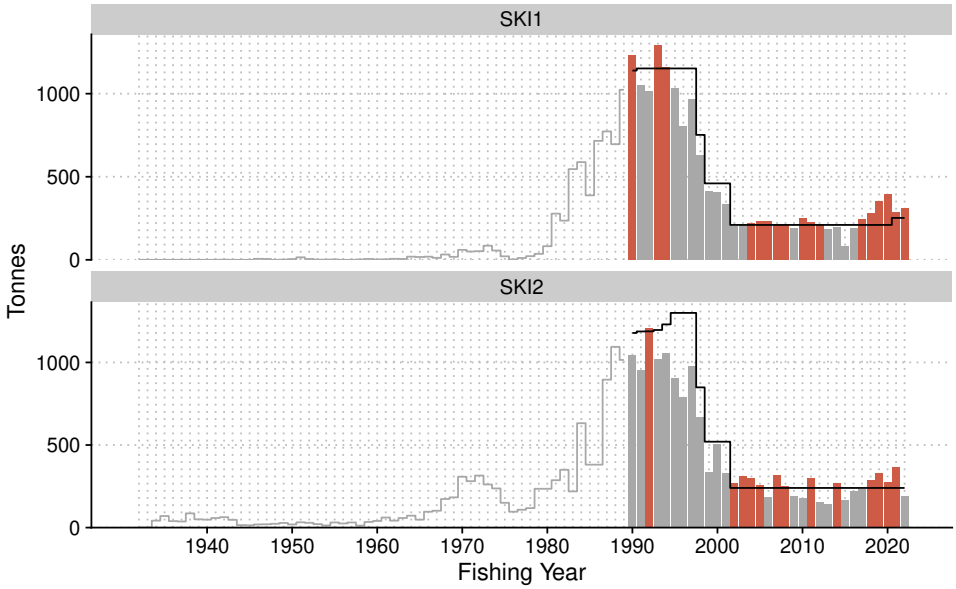


Figure 3: Total Allowable Commercial Catch (TACC; black line) and Monthly Harvest Return/Quota Management Return totals (bars) for SKI 1 and SKI 2 from 1990 to 2022. Years where the TACC was exceeded are highlighted in red. Catches prior to 1990 are shown by the grey line using the information compiled in the stock assessment plenary (Fisheries New Zealand 2022). Tabulated data are provided in Table B.1. Stocks highlighted in Figure 2 are all non-nominal stocks that will be analysed further in this report.

The most recent fully-quantitative stock assessment for SKI 1 and SKI 2 was conducted in 2008 (Fisheries New Zealand 2022). Subsequent trends in stock abundance have been assessed using standardised catch-per-unit-effort (CPUE) indices, with the National Inshore Finfish Fisheries Plan[3] classifying SKI 1 and SKI 2 as Group 2 stocks to be monitored with partial-quantitative stock assessments.

A CPUE analysis for SKI 2 was conducted in 2014 (Starr & Kendrick 2016); a range of CPUE series were considered, all of which showed similar trends. The preferred series was a delta-lognormal series using daily resolution data for bottom trawl targeting GUR, SNA, TAR, LIN, BAR, HOK and SKI (see species code definitions in Table E.4 of Appendix E).

CPUE series for SKI 1, used in the previous fully quantitative assessment, were not updated in 2014 due to the cessation of gemfish target fishing in SKI 1, although it was recommended that future CPUE analyses extend the SKI 2 series to include data from the Bay of Plenty part of SKI 1. An increase in abundance over the period from 2005–2007 to 2011–2013 was identified from the SKI 2 series, but CPUE-based reference points were not established.

This report uses the QMS-era statutory data, from the 1990 to the 2022 fishing years, to characterise the commercial fisheries for gemfish in SKI 1 and SKI 2 and to provide indices of abundance using statistical standardisation of catch and effort data (CPUE indices).

[3]https://www.mpi.govt.nz/dmsdocument/54529-National-Inshore-Finfish-October-2022

2. METHODS

Extracts (report logs 13159, 14884) of statutory 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.

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. Catches include declared accidental losses of fish but do not include fish that escape capture, for example by escaping through the mesh of a trawl.

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

2.2 Data sources

There are three types of statutory 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 weighted.

Landings and disposal data provide data on the catches of all stocks at the fishing trip resolution, with quantities verified (where practicable) by weighting. 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 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 SKI from a trip to the fishing event records from the trip using the hierarchical method of Starr (2007). If gemfish 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 gemfish 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 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:

$$gwt_{adj} = gwt_{rep} \frac{CF_{cur}}{CF_{rep}} \quad (1)$$

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.

		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 outsider 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	Transshippments		2018-06-30	Y	Y	Y	Y	Y
TL	Transshippments, 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	Sixth schedule 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	Transshippments, 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 of SKI 1 and SKI 2, and extracting the associated catch and effort data for fishing events within the SKI 1 and SKI 2 Quota Management Areas (Figure 2). Fishing events were selected based on start position (where available) or statistical area (Figure 4). 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 4).

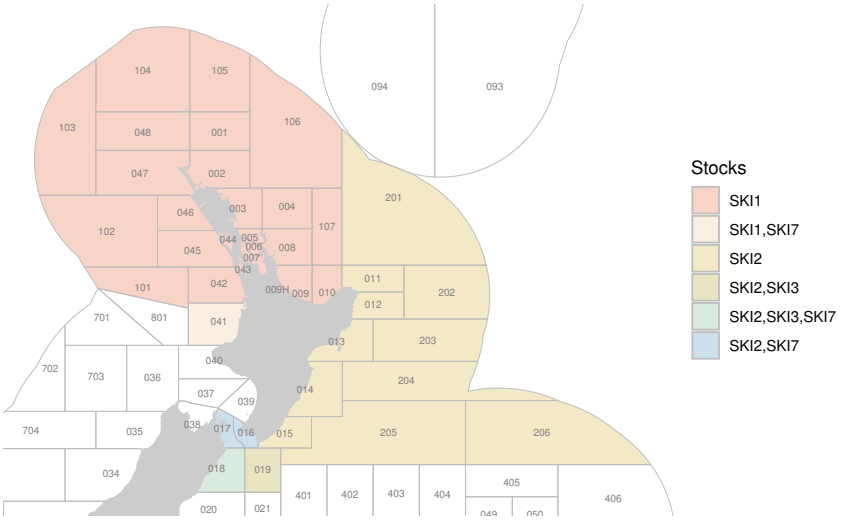


Figure 4: Statistical areas by stock for gemfish in New Zealand.

A relatively small quantity of duplicate or non-terminal landings were dropped (Figure A.1), and apparent order of magnitude errors were identified and corrected for a small number of trips (Table A.2).

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 SKI were caught. Datasets for CPUE modelling were prepared at differing levels of aggregation, as appropriate:

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 pseudo-CELR resolution data, landings were allocated to fishing events following the approach of Starr (2007), and summarised above.

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 gemfish, and a second GLM was developed for the magnitude of gemfish 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 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).

2.8 CPUE models for SKI 1 and SKI 2

The set of CPUE standardisation models considered is summarised in Table 3. These comprise a set of core models, accepted by the Stock Assessment Plenary process for monitoring the stock, key sensitivities that are considered to corroborate the trends seen in the core models, and a range of additional sensitivities that assisted the Inshore Fisheries Working Group in their review of the indices. The rationale for the different series is discussed in Section 4 with sensitivities discussed in Section 4.4 noting that, for completeness, Table 3 lists series that were considered by the working group but are not detailed in this document.

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

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
SKI1 SKI2 BT-TAR trip	trip	landkg	Stepwise	5	5	lognormal
SKI1 SKI2 TAR event	event	allockg_top5	Stepwise	3	3	lognormal
SKI1 SKI2 HOK-SKI event	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI daily	daily	allockg	Stepwise	5	3	Weibull
SKI1 SKI2 HOK-SKI (2021 structure)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event split vessels	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event (1994 fleet)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event (2021 fleet)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event (offer width)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 BT-TAR trip (no stat*mon)	trip	landkg	Stepwise	5	5	lognormal
SKI1 SKI2 HOK-SKI event (1994 fleet, split vessels)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event (2021 fleet, split vessels)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event (no stat*mon)	event	allockg_top5	Stepwise	3	3	Weibull
SKI1 SKI2 HOK-SKI event split vessels (no stat*mon)	event	allockg_top5	Stepwise	3	3	Weibull

3. FISHERY CHARACTERISATION

For the 1990 to 2022 fishing years, the majority of SKI 1 and SKI 2 landings were landed directly to a Licensed Fish Receiver (Figure 5) and comprised unprocessed (green) fish (Figure 6). There was a generally good correspondence between aggregated groomed landings and MHR/QMR totals (Figure 5). The small amount of 'Other' destination types evident in SKI 1 in 2022 (Figure 5) comprised mainly landings reported using the 'LFL' code that relates to landings of live fish.

The conversion factor for dressed (DRE) gemfish changed in the early 1990s, and for skin-off fillets (SKF) in the early 2000s (Figure 7); the impact on catch totals is minor for SKI 1 and SKI 2 due to the dominance of unprocessed landings (Figure 6).

There is a close correspondence between the annual landings in SKI 1 and SKI 2, and the total landings allocated to individual fishing events in the characterisation dataset (Figure 8).

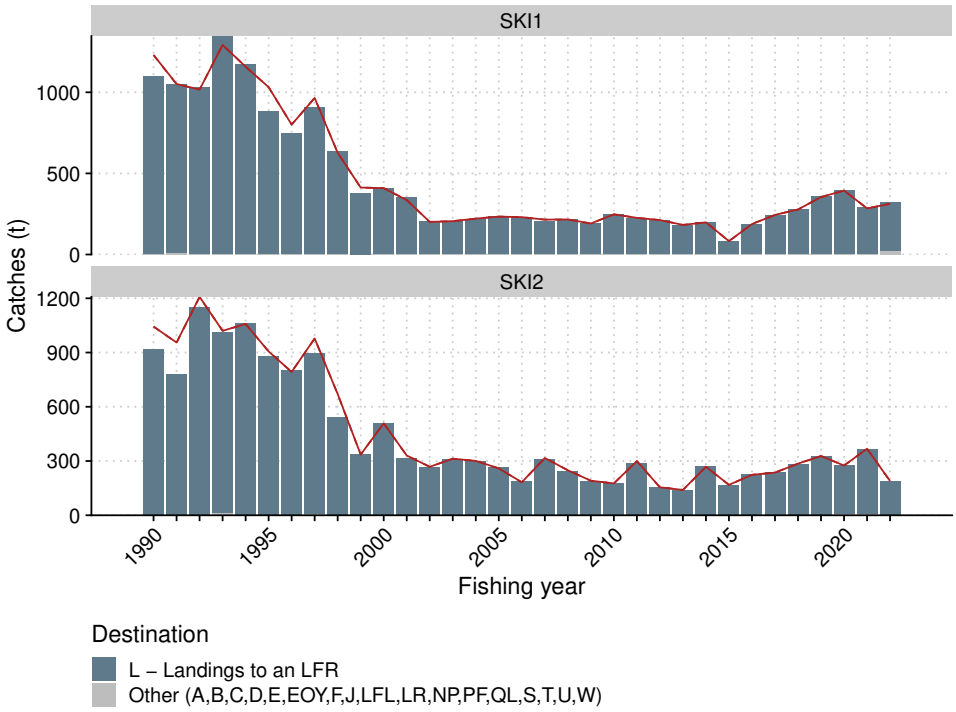


Figure 5: Gemfish catches by destination (bars), compared with Monthly Harvest Return / Quota Monitoring Return (MHR/QMR) totals (line), for Quota Management Areas SKI 1 and SKI 2. Destination codes are defined in Table 2 with tabulated catches in Appendix B.

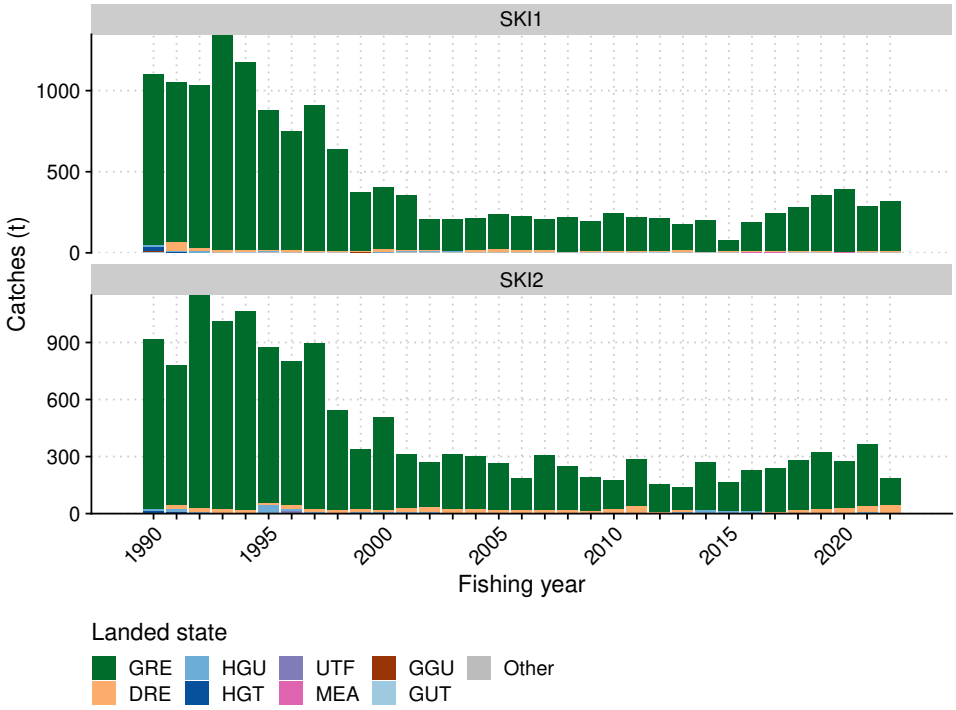


Figure 6: Landed state of gemfish catches for Quota Management Areas SKI 1 and SKI 2. Catches are tabulated in Appendix B, and landed state codes are defined in the glossary Table E.1.

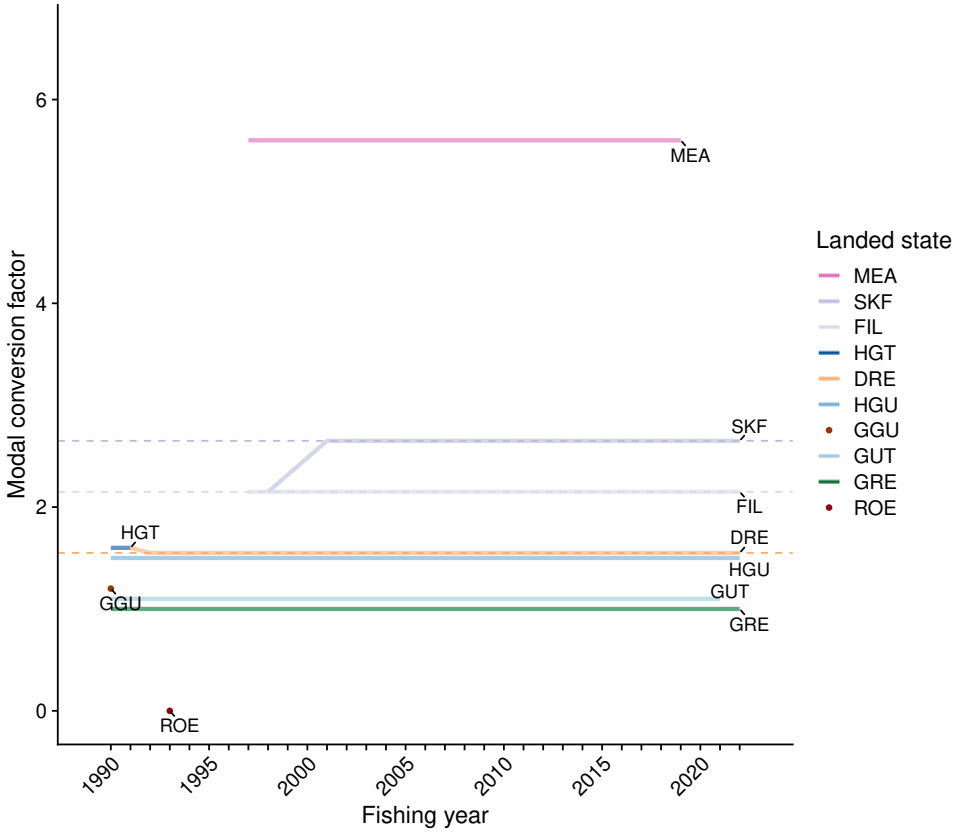


Figure 7: The modal annual conversion factor reported for the product states used in SKI 1 and SKI 2 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table B.8, and landed state codes are defined in the glossary Table E.1.

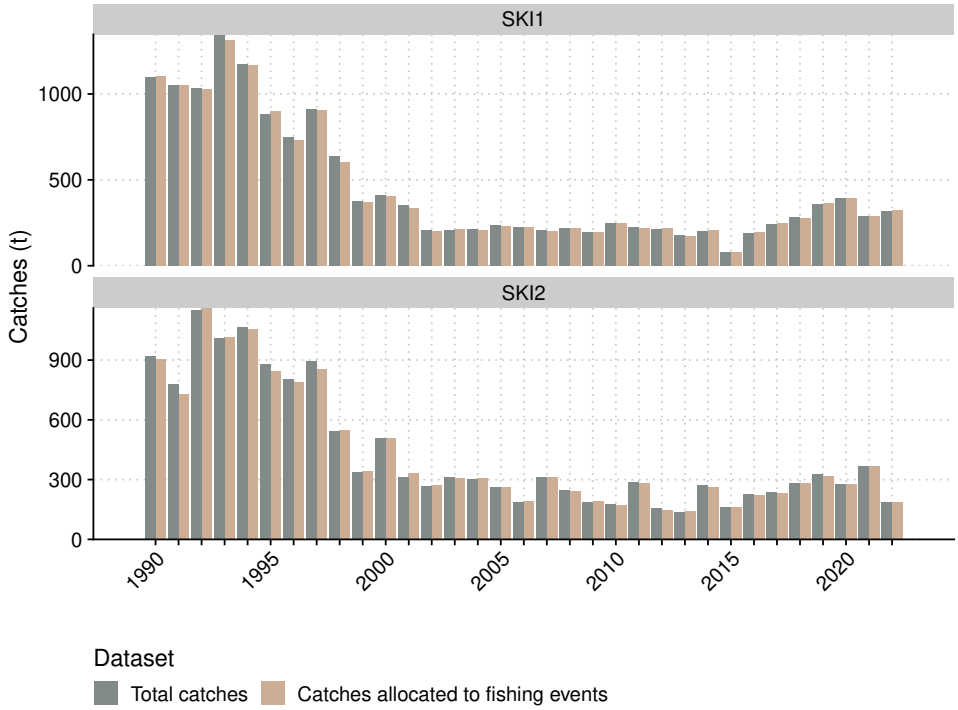


Figure 8: Total catches (t) of gemfish from SKI 1 and SKI 2 in comparison with catches allocated to fishing events in the characterisation dataset.

3.1 The SKI 1 Quota Management Area

In SKI 1, most landings originated from trips which also recorded estimated catches; these estimates were scaled to landings by the allocation procedure (Figure 9a). Since the mid-2000s, there has been slight reduction in the proportion of landings represented in estimated catches (Figure 9b), with estimated catches totalling around 75% of landings in the last decade. The increase in catch of SKI 1 since 2015 has been associated with an increasing proportion of fishing events and fishing days when gemfish was caught (Figure 9c,d).

Prior to 1994, reporting of effort from trips landing SKI 1 was mainly on the CELR form, but from the mid-1990s there was a transition to use of the TCEPR form for trawl effort (Figure 10). Following the introduction of higher resolution forms for inshore fisheries from 1 October 2007, use of the CELR form by trips landing SKI 1 was greatly reduced with effort being recorded on the TCER and LTCER forms instead. The majority of catch continued to be reported by trips using the TCEPR form until the introduction of Electronic Reporting from 2018. Full reporting of catch and effort for the SKI 1 fishery using the Electronic Reporting System was evident by 2020.

The great majority of gemfish caught in SKI 1 is taken by bottom trawl (Figure 11, Table B.2). Bottom trawl catches using the Precision Seafood Harvesting Modular Harvest System (gear code PRB) increased steadily in SKI 1 from 2017 to 2019, dropped in 2020 and 2021, but increased again in 2022.

Catches from gemfish-target trawling predominated until 2014, but dropped substantially in 2015 (Figure 12, Table B.2). The target trawl fishery subsequently continued, at a reduced level, in the following three years, but since 2017 there has been a marked transition, with the majority of the SKI 1 catch from 2018–2022 being taken as bycatch in tarakihi and hoki target trawling. Bycatch of gemfish has consistently occurred in scampi target fishing in SKI 1, but overall quantities have been small. In 2022, 25 t of additional SKI 1 catch was permitted under Special Permit 826 to enable catch sampling in the traditional SKI 1 target fishery.

When gemfish are targeted, they are typically the first or second most abundant species in the catch, by weight (Figure 13). Gemfish taken as bycatch in the hoki and tarakihi fisheries have had an average reporting rank of 3–4 for vessels reporting on the TCEPR form, but the average reporting rank has typically been lower for gemfish bycatch reporting on the TCER forms, or via the Electronic Reporting system, where more species per event can be reported.

Vessels in the bottom trawl fisheries in SKI 1 undertake an average of 2.5–3 trawls per day (Figure 14). There have been some between-form differences in daily effort associated with the fact that different segments of the fleet have historically used different reporting forms, but there are no indications of unusual changes in effort reporting associated with changes in forms, or with the changeover to Electronic Reporting.

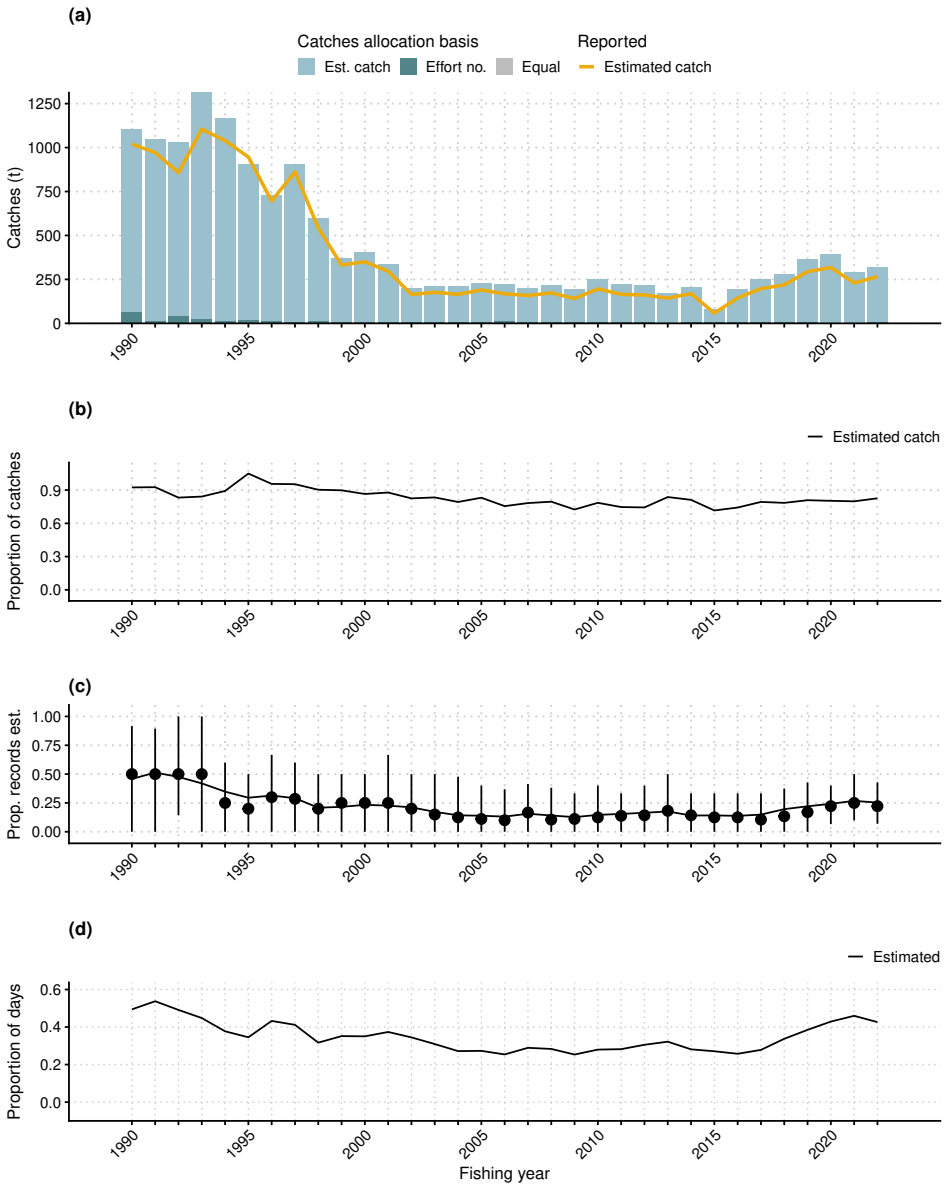


Figure 9: (a) bars: gemfish catches allocated to fishing events in the SKI 1 QMA with allocation method indicated by fill colour (see Section 2.3); line: total estimated catch of SKI; (b) the proportion of SKI 1 catches included in estimated catch data; (c) the proportion of fishing event records with an estimated catch of SKI, with the line showing the overall proportion and the distributions illustrating the median and inter-quartile range by trip; (d) the proportion of vessel-days fished with a reported catch of SKI.

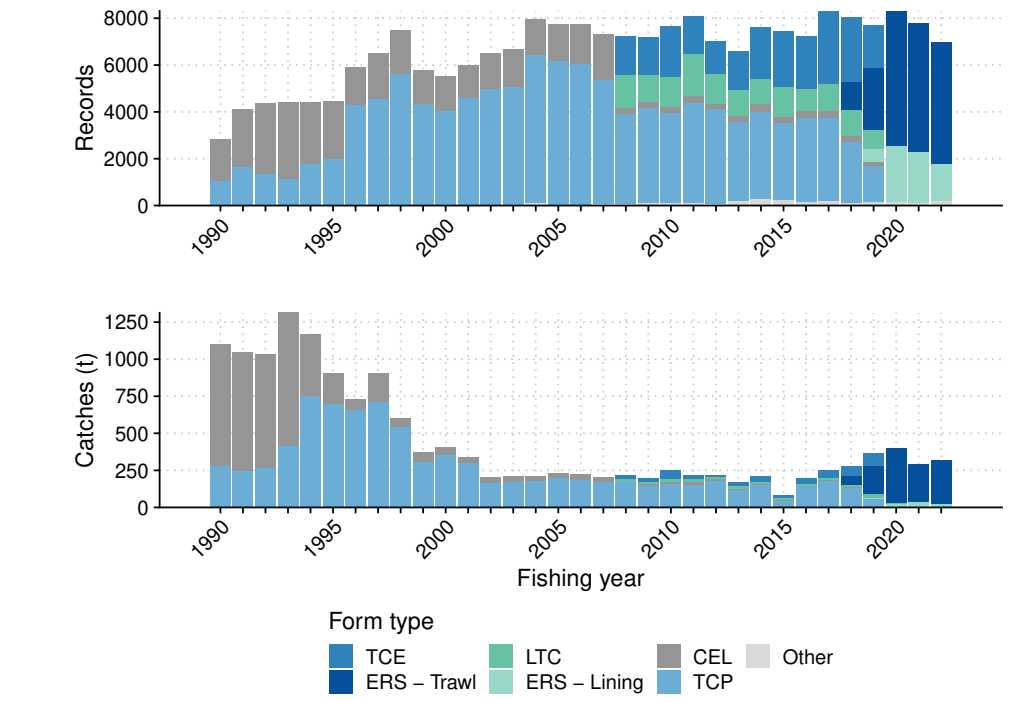


Figure 10: Reporting forms used on trips catching gemfish within the SKI 1 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Netting, ERS - Other Lining, ERS - Potting, ERS - Seining, ERS - Tuna Lining, HLC, HTC, LCE, NCE, TUN. A list of the main form type codes is included in the glossary Table E.2.

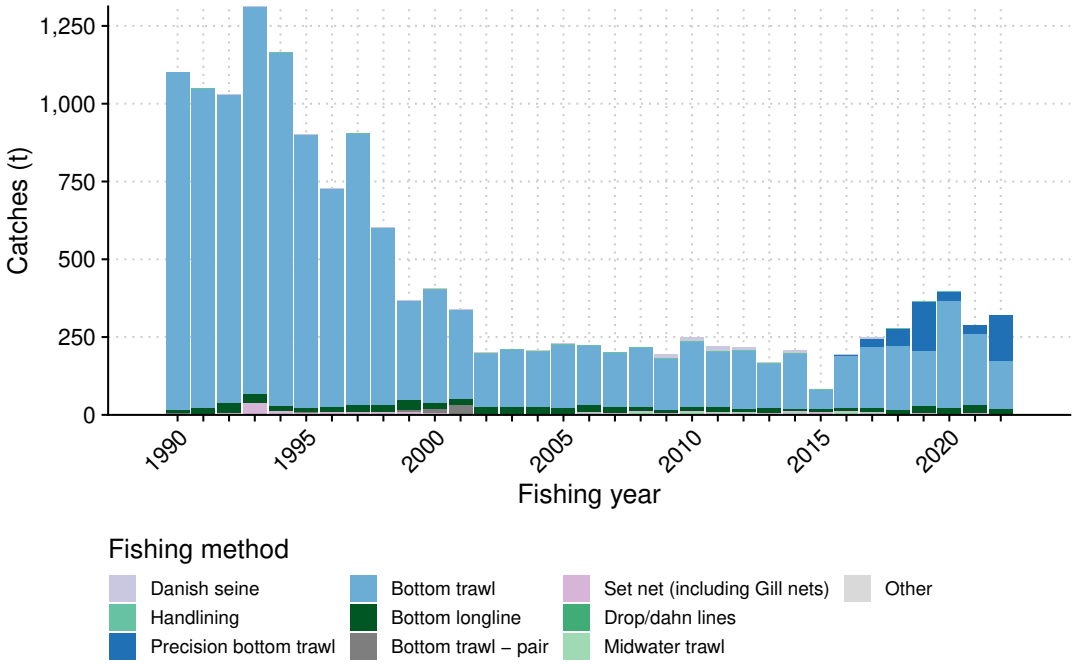


Figure 11: Catches of gemfish by fishing method, for events within the SKI 1 Quota Management Area. Methods grouped as Other include: CP, CRP, D, DN, DPN, FP, PL, PS, PSH, RLP, RN, SCN, SLL, T, TL. Tabulated results are provided in Appendix B, and a list of the main fishing method code types is included in the glossary Table E.3.

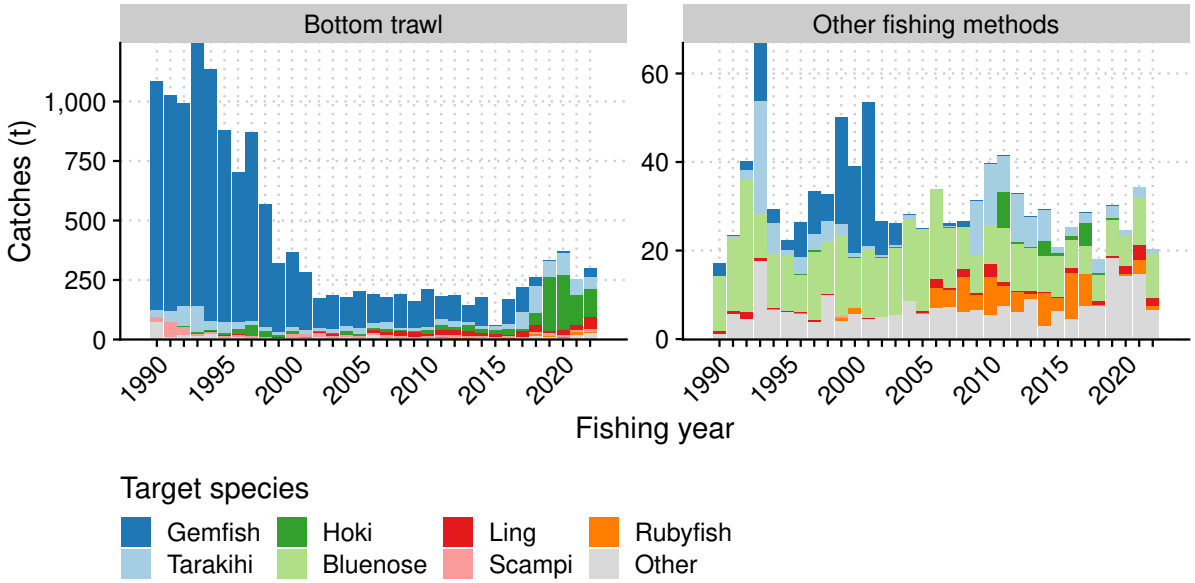


Figure 12: Catches of gemfish by fishing method and declared target species, for events within the SKI 1 Quota Management Area. Fishing Methods grouped as Other include: BLL, BPT, CP, CRP, D, DL, DN, DPN, DS, FP, HL, MW-PRM, PL, PS, PSH, RLP, RN, SCN, SLL, SN, T, TL. Species grouped as Other include target species with less than 8% of the gemfish catch within the SKI 1 Quota Management Area in a fishing year.

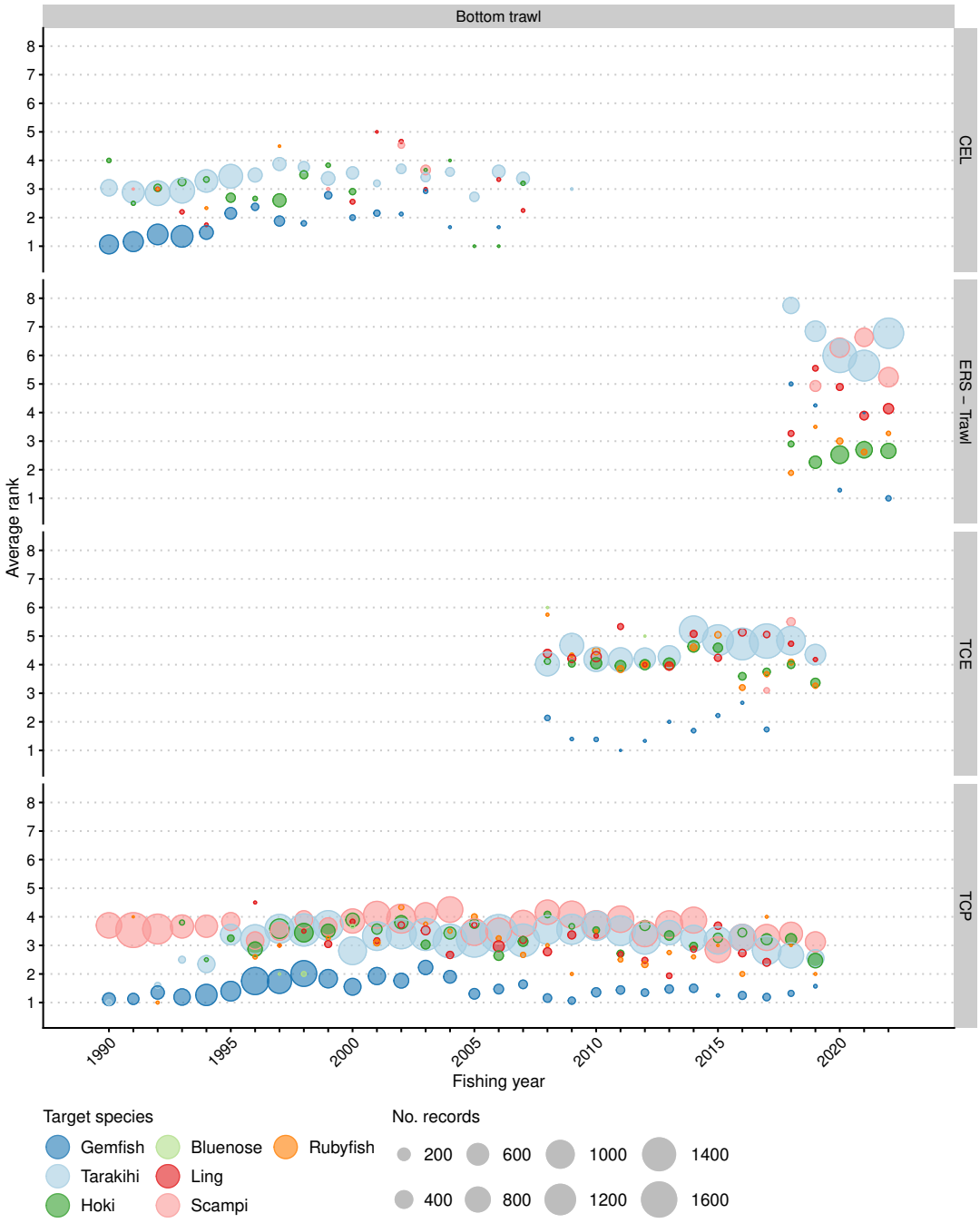


Figure 13: Average rank of gemfish in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the SKI 1 Quota Management Area. The area of the circles scales with the number of records.

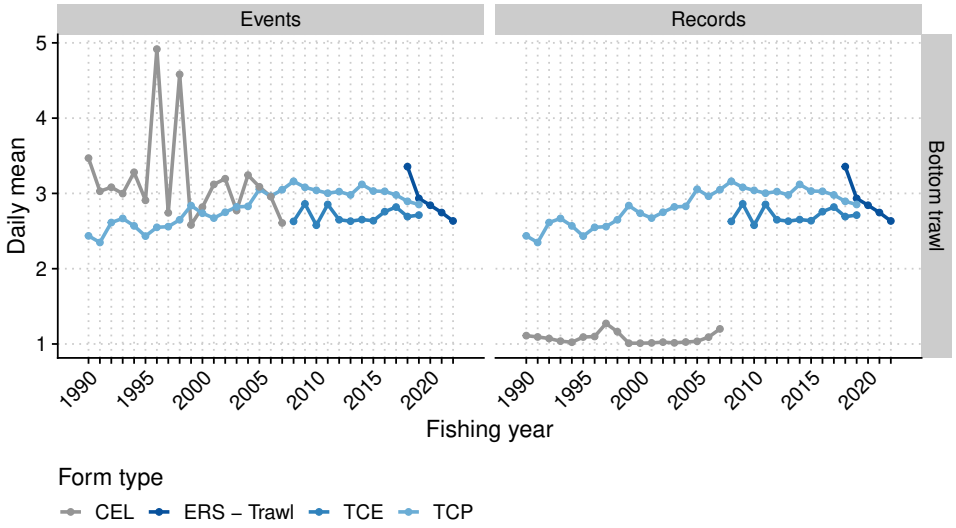


Figure 14: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the SKI 1 QMA on trips landing SKI 1. Data are included for years where a form was used on at least five vessel-days.

3.2 The SKI 2 Quota Management Area

Similarily to SKI 1, most landings to the SKI 2 stock were from trips that recorded estimated catches on at least some fishing events (Figure 15a). While there has also been slight reduction in the proportion of SKI 2 landings represented in estimated catches since the mid-2000s, estimated catches of SKI 2 have totalled more than 75% of landings in all but one year in the series (Figure 15b). As was the case in SKI 1, recent increases in catches of SKI 2 have been associated with an increasing proportion of fishing events and fishing days when gemfish was caught (Figure 15c,d).

Reporting form use for trips landing SKI 2 (Figure 16) has shown similar trends to those noted in SKI 1 (Figure 10), except that a larger proportion of the catch during 2008–2019 was reported on the TCER form. Full Electronic Reporting of catch and effort for the SKI 2 fishery was evident by 2020.

While bottom trawl catches dominate in SKI 2, there has also been a long-term midwater trawl fishery (Figure 17, Table B.3). Catches of gemfish by midwater trawl were particularily evident in the mid-1990s, comprising almost half the catch in 1995 (Table B.3), but typically made up less than 15% of SKI 2 landings. A small amount of set net catch of gemfish was reported in the 1990s.

In the bottom trawl fishery in SKI 2, target catches predominated until the mid-2000s, after which bycatch from tarakihi target trawling made up the majority of the catch in most years (Figure 18). Some gemfish targeting persisted until 2019, but the target catch dropped to less than five tonnes in 2020 (Table B.3). There has been sporadic bycatch of gemfish from hoki target trawling throughout the data series, whereas scampi-target bycatch has reduced since 2010.

The midwater trawl fishery targeted gemfish in the 1990s, but catches since the mid-2000s have been bycatch. From 2006 to 2017 this was primarily from rubyfish target trawling but, from 2018, bycatch in alfonsino and hoki target trawling has also been important (Figure 18).

As was the case in SKI 1, when gemfish are targeted in SKI 2 they are typically the first or second most abundant species in the catch (Figure 19), while gemfish taken as bycatch in the hoki and tarakihi fisheries have had an average reporting rank of 3–4. Vessels in the bottom and midwater trawl fisheries in SKI 2 also undertake an average of 2.5–3 trawls per day (Figure 20) with no indications of changes in effort reporting associated with changes in forms, or with the change to electronic reporting.

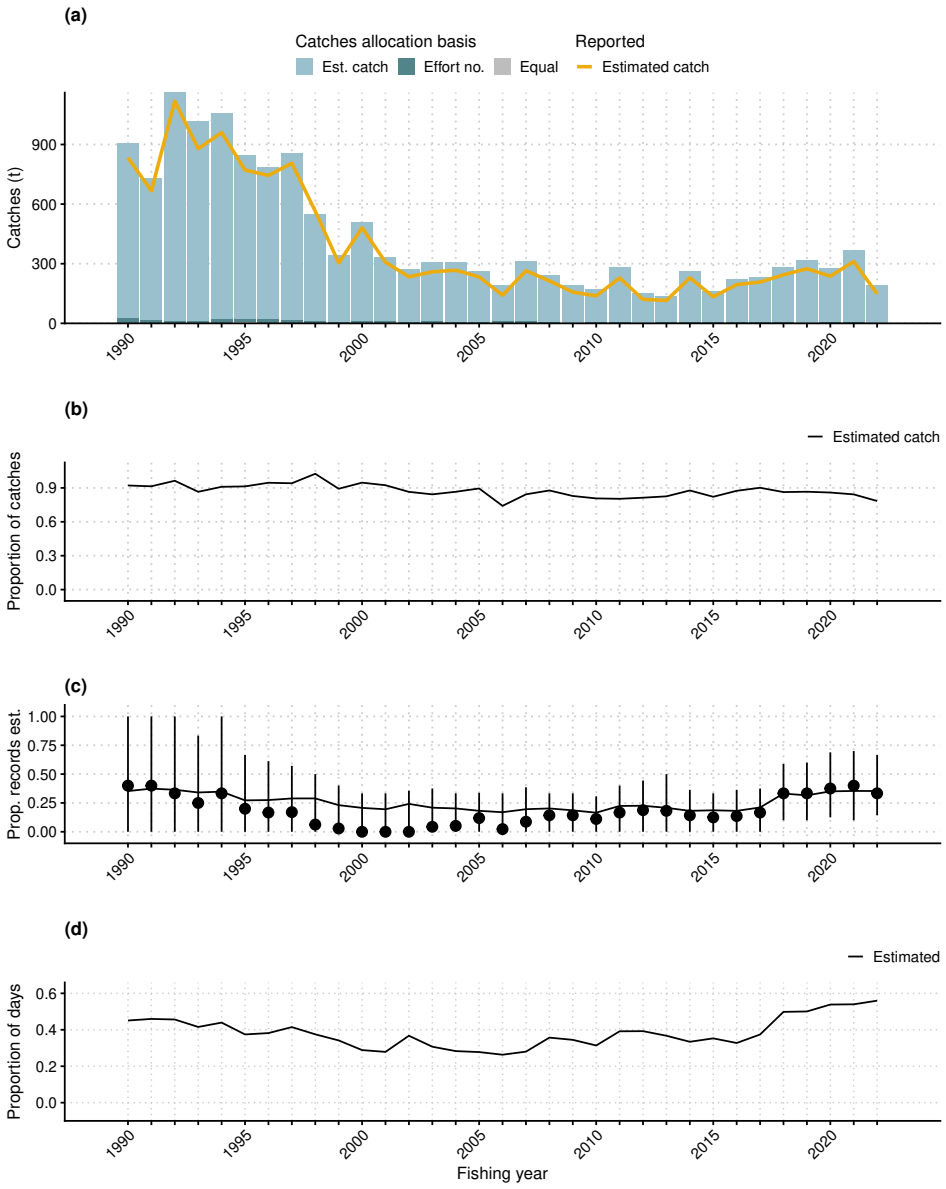


Figure 15: (a) bars: gemfish catches allocated to fishing events in the SKI 2 QMA with allocation method indicated by fill colour (see Section 2.3); line: total estimated catch of SKI; (b) the proportion of SKI 2 catches included in estimated catch data; (c) the proportion of fishing event records with an estimated catch of SKI, with the line showing the overall proportion and the distributions illustrating the median and inter-quartile range by trip; (d) the proportion of vessel-days fished with a reported catch of SKI.

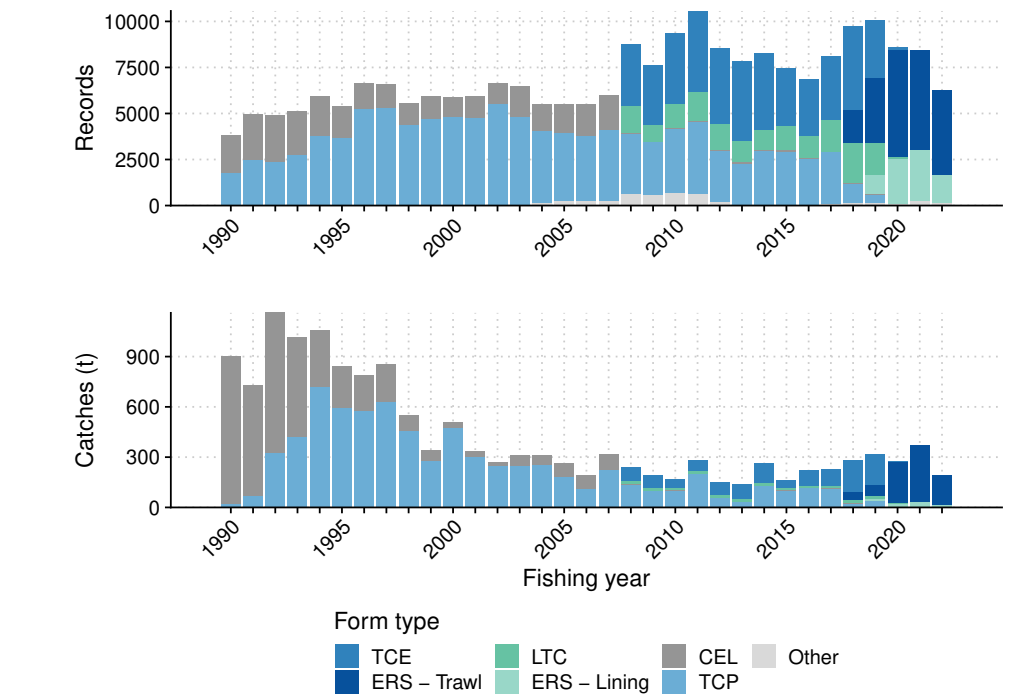


Figure 16: Reporting forms used on trips catching gemfish within the SKI 2 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Netting, ERS - Other Lining, ERS - Potting, ERS - Seining, ERS - Tuna Lining, HTC, LCE, NCE, TUN. A list of the main form type codes is included in the glossary Table E.2.

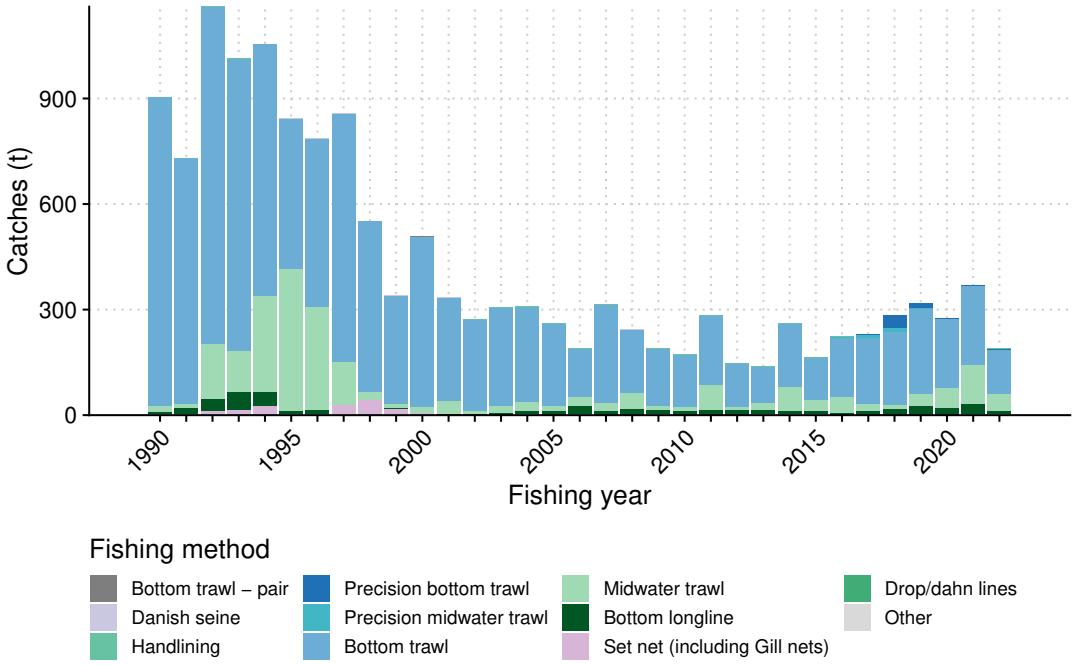


Figure 17: Catches of gemfish by fishing method, for events within the SKI 2 Quota Management Area. Methods grouped as Other include: DI, FP, PS, PSH, RLP, SLL, T, TL. Tabulated results are provided in Appendix B, and a list of the main fishing method code types is included in the glossary Table E.3.

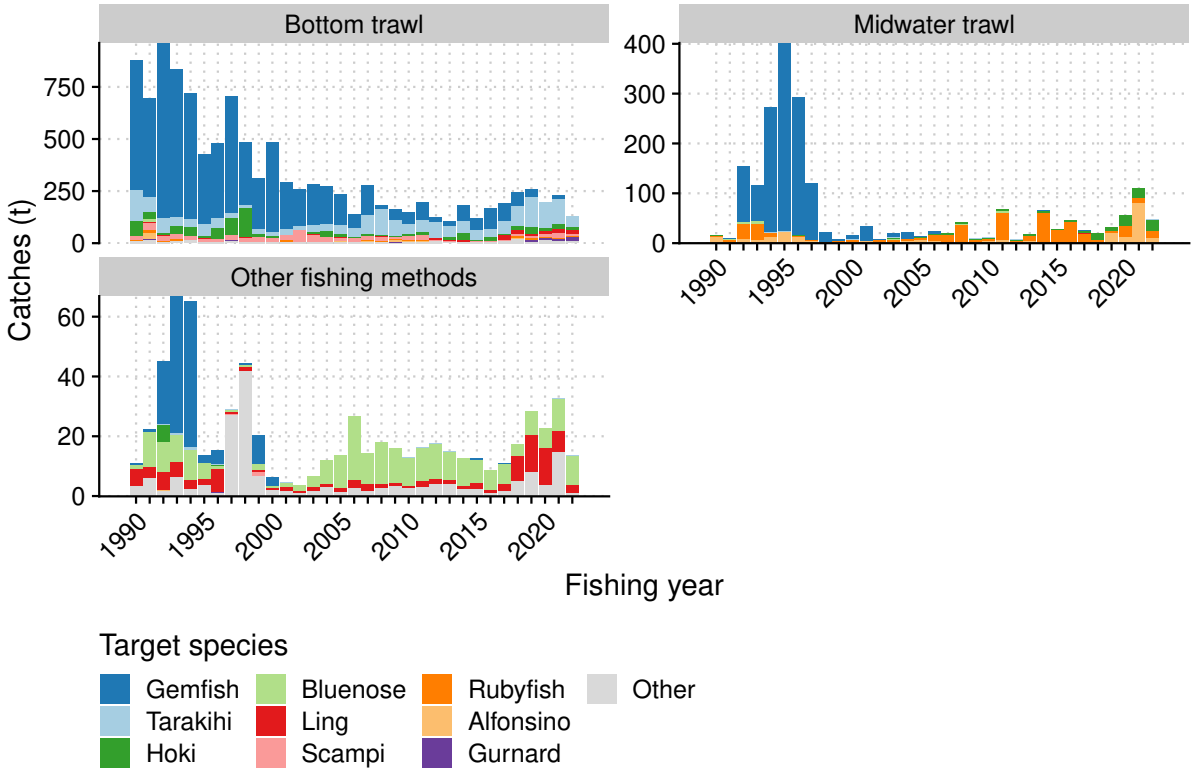


Figure 18: Catches of gemfish by fishing method and declared target species, for events within the SKI 2 Quota Management Area. Fishing Methods grouped as Other include: BLL, BPT, DL, DS, DV, FP, HL, PS, PSH, RLP, SLL, SN, T, TL. Species grouped as Other include target species with less than 8% of the gemfish catch within the SKI 2 Quota Management Area in a fishing year.

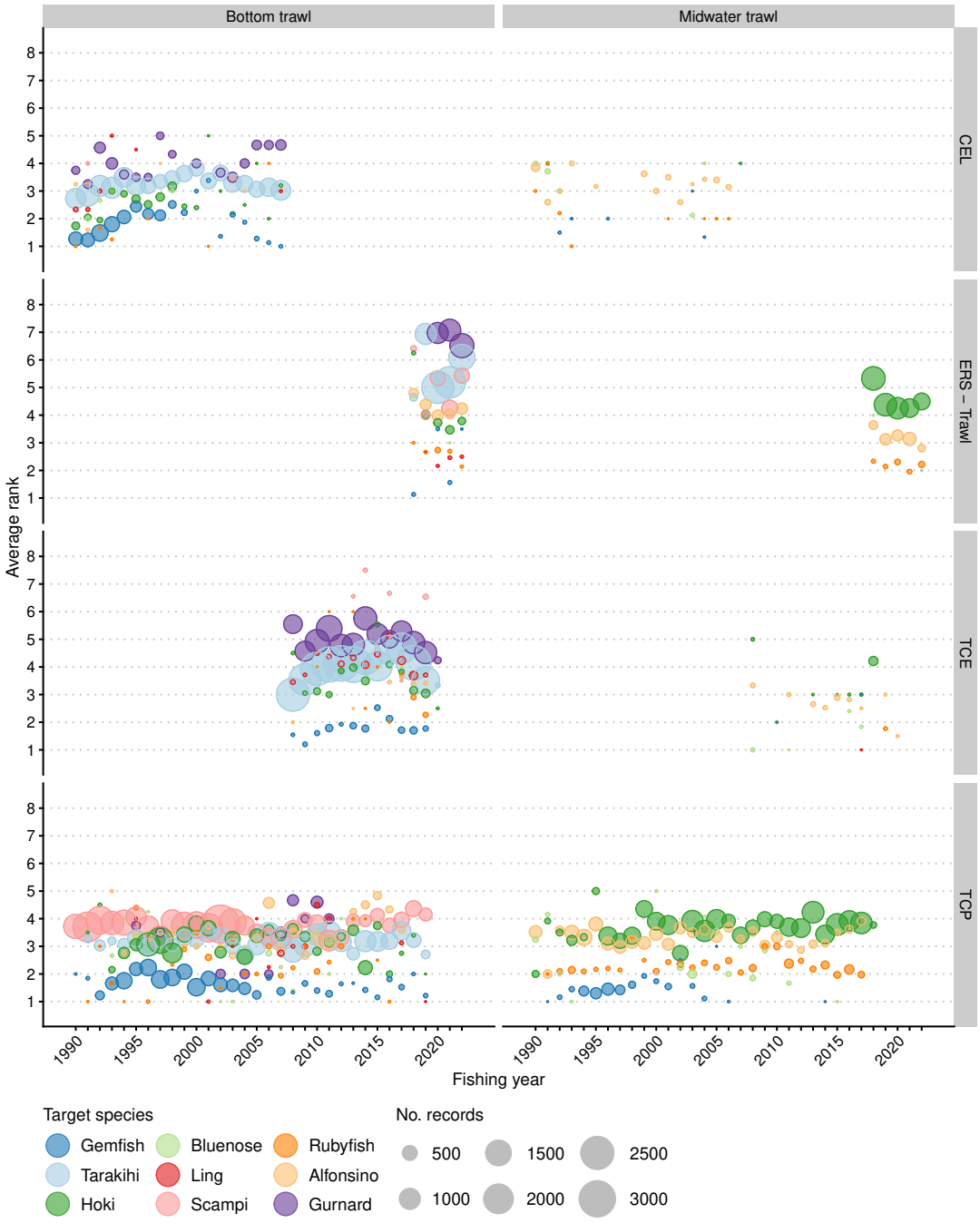


Figure 19: Average rank of gemfish in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the SKI 2 Quota Management Area. The area of the circles scales with the number of records.

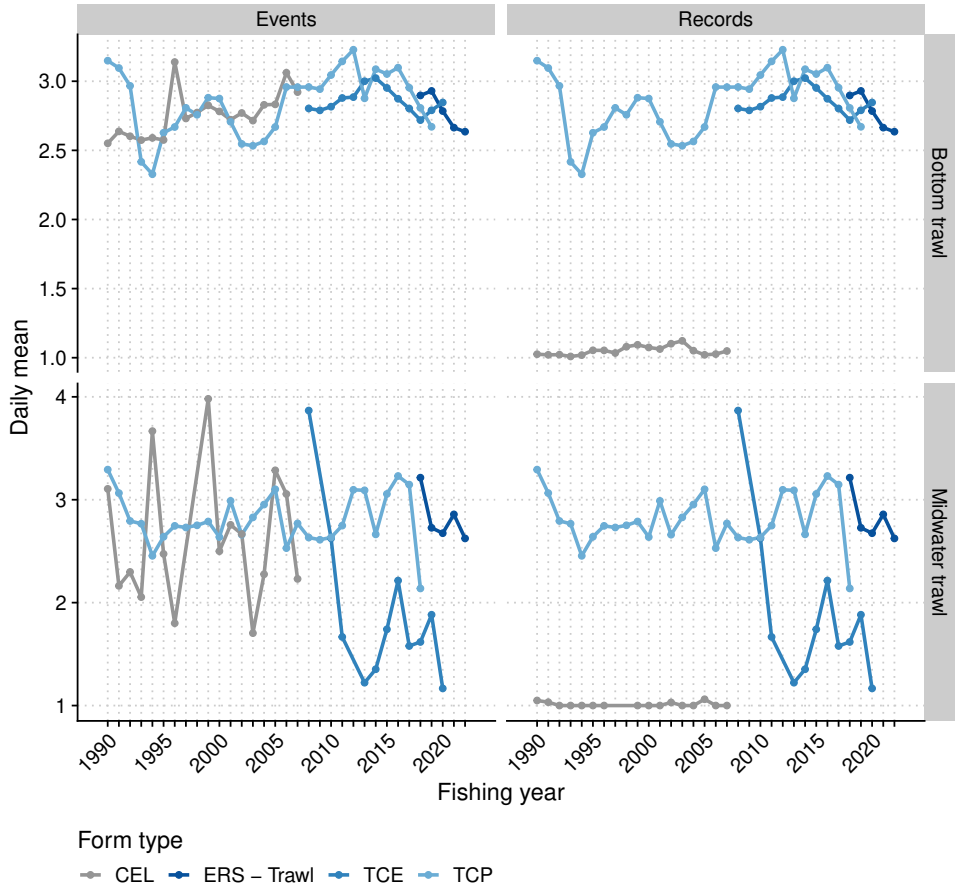


Figure 20: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the SKI 2 QMA on trips landing SKI 2. Data are included for years where a form was used on at least five vessel-days.

3.3 The bottom trawl fishery

The proportion of bottom trawl catches of gemfish in SKI 1 and SKI 2 recorded with fine-scale spatial information (i.e., a latitude and longitude, at least at the start of the fishing event, rather than just a statistical area) increased steadily in the early and mid-1990s due to the increased use of the TCEPR form in North Island inshore fisheries. From the mid-1990s, at least 75% of catch and effort were recorded with fine-scale spatial information, increasing to close to 100% from 2008 following the introduction of the TCER form (Figure 21).

Bottom trawl catches of gemfish are widespread in SKI 1 and SKI 2, from Cook Strait eastwards around the North Island to Raglan, in Statistical Area 041 (Figure 22). In the earliest period (1994–1997), the highest catches were taken off the northern west coast of the North Island; more recently the highest catches have occurred on the east coast from the Bay of Plenty south to the Waiarapa coast. Somewhat higher catch rates (Figure 23) in Statistical Areas 008 and 013, in particular, and also in the far north, are thought to be associated with spawning migrations (Horn & Hurst 1999), but the highest catch rates have been recorded sporadically off the Wairarapa coast.

Gemfish-target trawl fishing (Figure 24) has focussed on the higher-catch rate areas. Following the TACC reductions in the late 1990s, the spatial extent of the target fishery has contracted; in particular, the target fishery off the upper west coast of the North Island ceased to operate. Since then, target fishing has predominantly occurred in the western Bay of Plenty and off the Wairarapa coast. In recent periods, the hoki target fishery has been somewhat more widespread than the gemfish target fishery off the east coast from the Bay of Plenty south, but largely overlaps the areas fished by the gemfish target fishery. Gemfish bycatch from tarakihi target trawling extends throughout the two QMAs. The area responsible for producing 90% of the bottom trawl catch increased in the recent four year period (Figure 25), a feature that is likely to be due to the larger part of the catch now coming from the non-target fisheries (Figure 12, Figure 18).

Statistical Areas 008 and 014 were the key areas where catches remained at higher levels following the TACC cuts in the late 1990s; the harvest from the west coast (Statistical Areas 046 and 047), and the other east coast areas that had previously supported the target fishery, substantially reduced at this time (Figure 26). However, increased catches in the last five years are evident in many areas.

Gemfish catches by the target fishery in SKI 1 were historically focussed in May and June (Figure 27), whereas the target catch in SKI 2 occurred during October–May and was greatly reduced in June–August. Catch rates show a similar pattern, albeit with sporadic high catch rates in some months/years (Figure 28).

Bycatch of gemfish in the SKI 1 fisheries for other target species was traditionally more evenly spread throughout the year (Figure 27). However, recent increases in catch from the hoki target fishery in SKI 1 have primarily occurred in the May–June period, while the tarakihi and scampi bycatch has remained year round. In SKI 2, the reduced gemfish catch in June–August is also apparent in the tarakihi, hoki and alfonsino target fisheries, but less so in scampi and ling target fishing.

Gemfish targeting has focussed on depths of 150 m to 400 m, within the range of the shallower part of the hoki fishery and the deeper part of the tarakihi trawl fishery (Figure 29). Gemfish are caught throughout the depth ranges fished by the scampi and ling target fisheries, but are less frequent in the deeper (> 500 m) parts of the hoki and alfonsino fisheries.

Target gemfish catch rates are highest from 200 m to 400 m (Figure 30). Catch rates in tarakihi target trawling increase with depth, but there is little tarakihi target fishing deeper than 300 m. In SKI 1, gemfish catch rates in the hoki and ling fisheries are higher from 300 m to 400 m, but there is little depth effect evident on bycatch rates in SKI 2.

The gemfish, scampi and tarakihi target fisheries in SKI 1 operate at noticeably deeper depths than those in SKI 2 (Figure 31). In contrast, the hoki fishery in SKI 1 has operated in a narrow depth range, slightly

deeper than the gemfish target fishery, whereas the hoki fishery in SKI 2 has a much broader depth range. For tarakihi, the gemfish-catch weighted depth distribution is deeper than the unweighted distribution of tarakihi target effort, with some indication of a shift to deeper tarakihi target fishing in SKI 1 over the last decade.

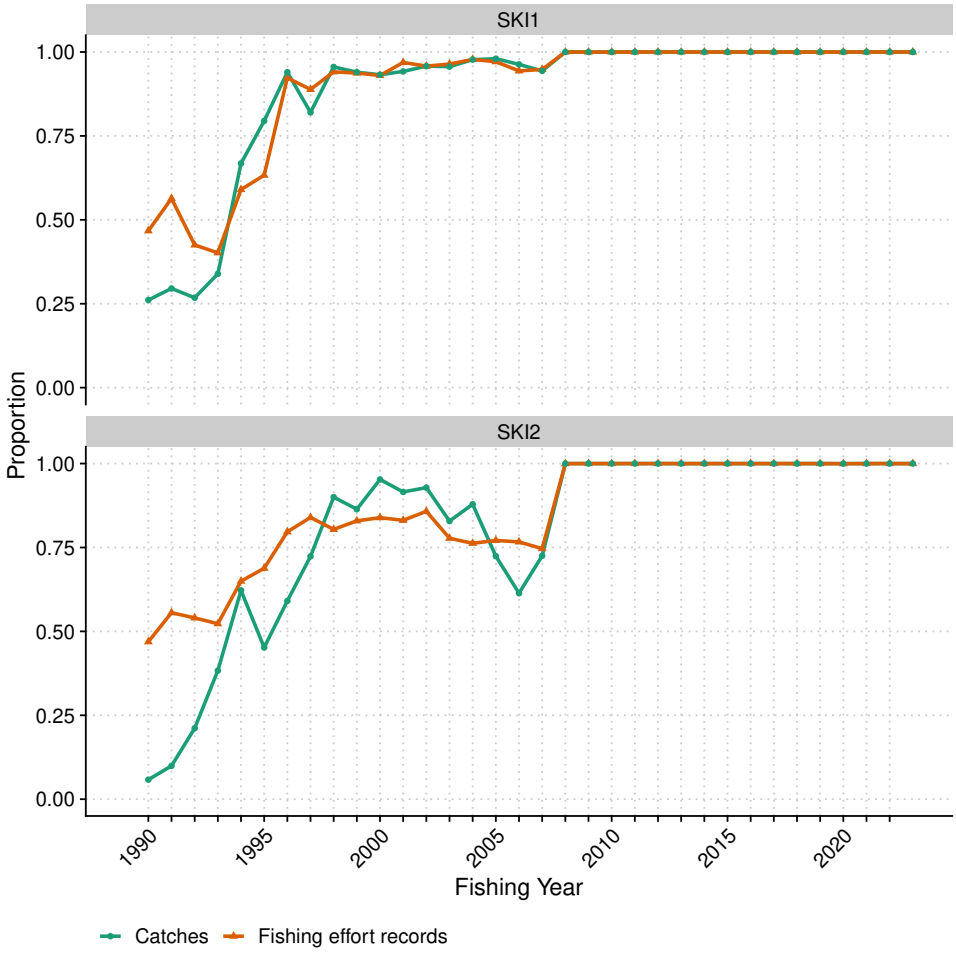


Figure 21: The proportion of records and catches reported with a latitude/longitude for the SKI 1 and SKI 2 bottom trawl fishery.

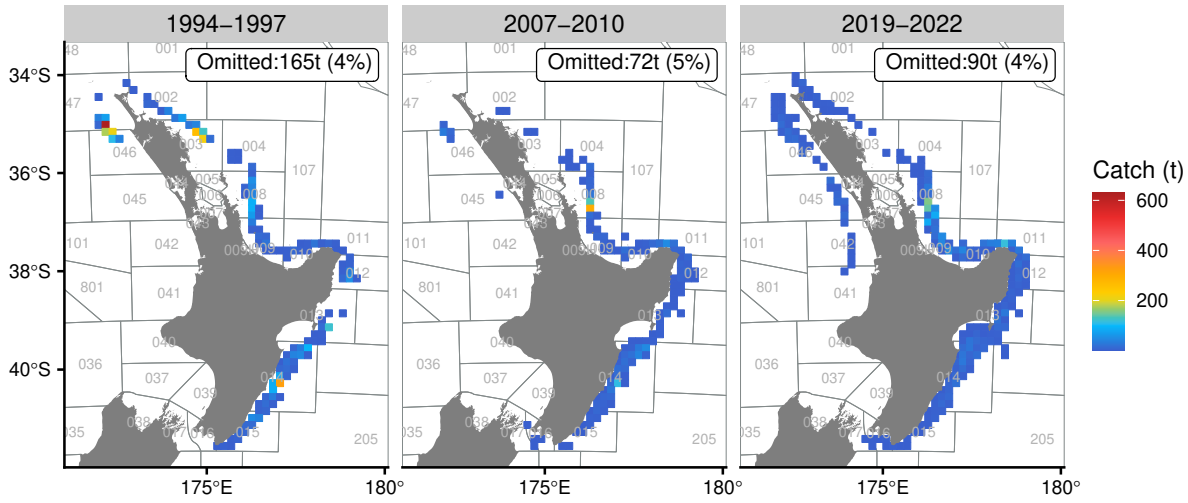


Figure 22: Catches (t) for the SKI 1 and SKI 2 bottom trawl fishery, for four year periods within the era during which at least 70% of catch was reported with spatial information. These plots use a 16 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

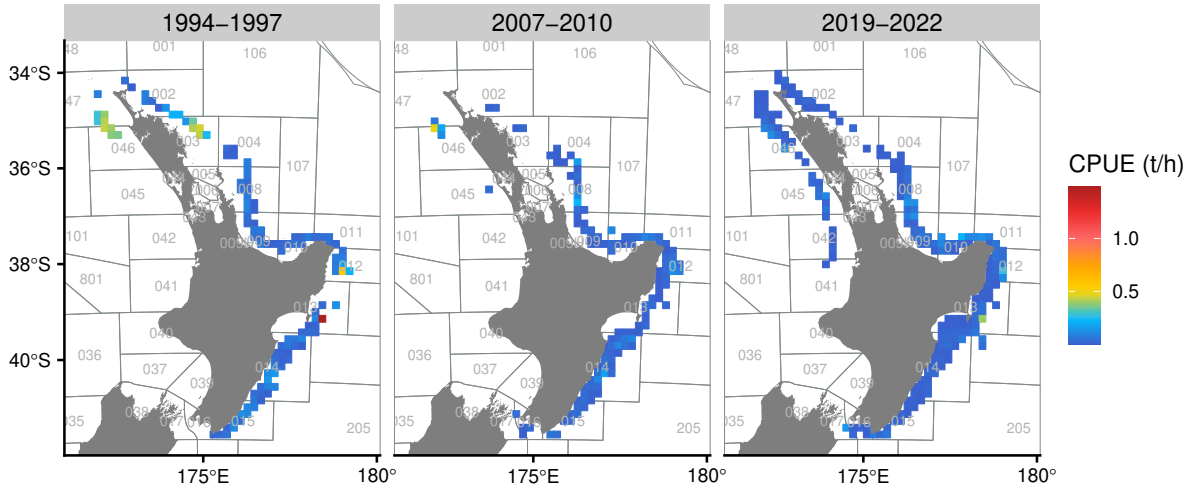


Figure 23: Raw aggregate CPUE (t/h) for the SKI 1 and SKI 2 bottom trawl fishery, for four year periods within the era during which at least 70% of catch was reported with spatial information. These plots use a 16 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted.

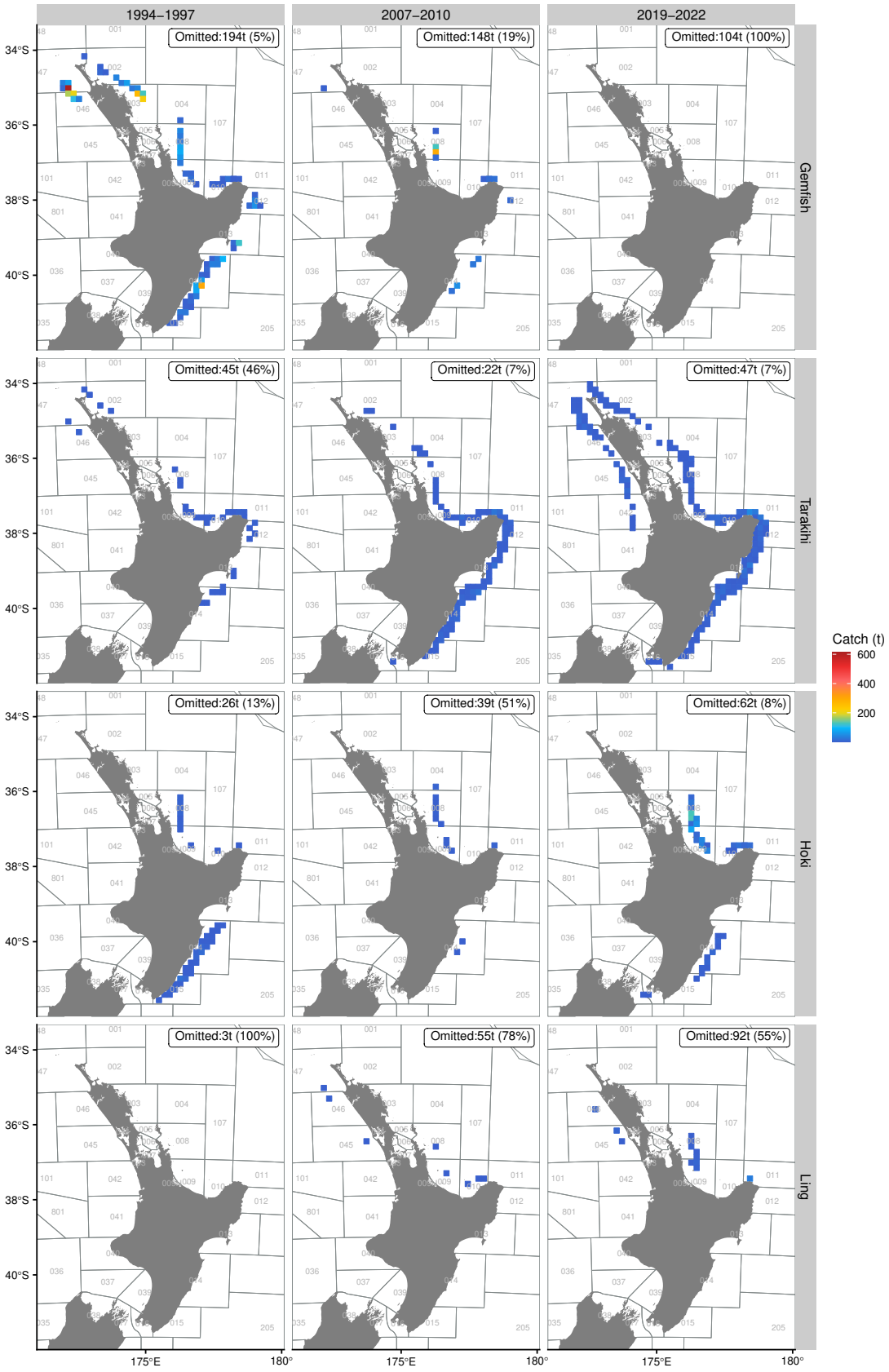


Figure 24: Gemfish catches for the bottom trawl fishery by key target species. These plots use a 16 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

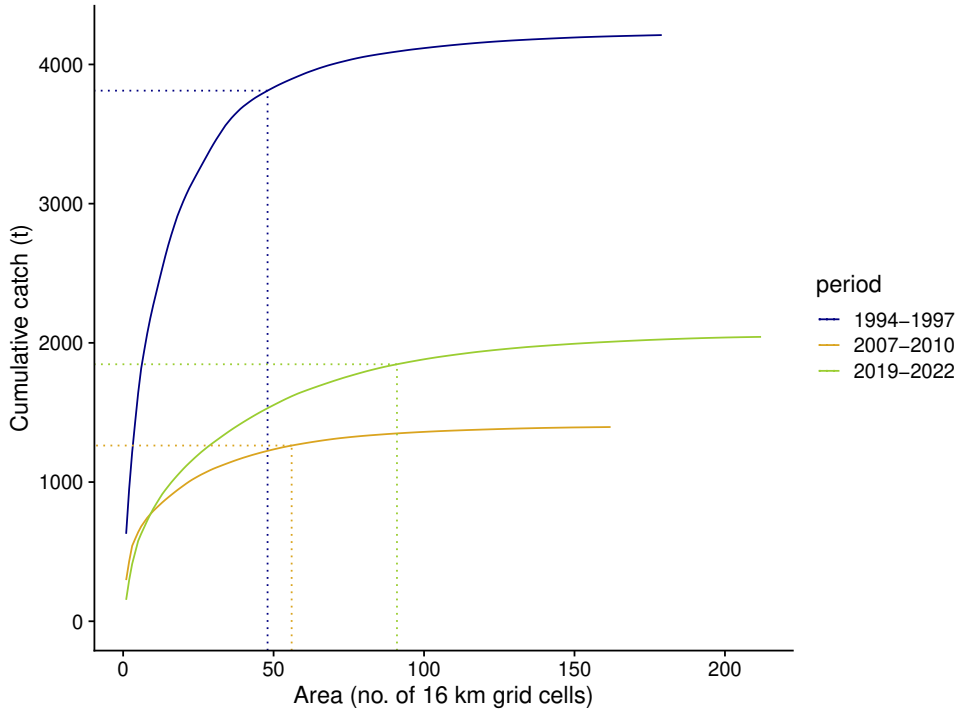


Figure 25: Cumulative SKI 1 and SKI 2 catch by area (grid cells) for the bottom trawl fishery, aggregated for the first, middle, and last 4 year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 4 year period of reporting.

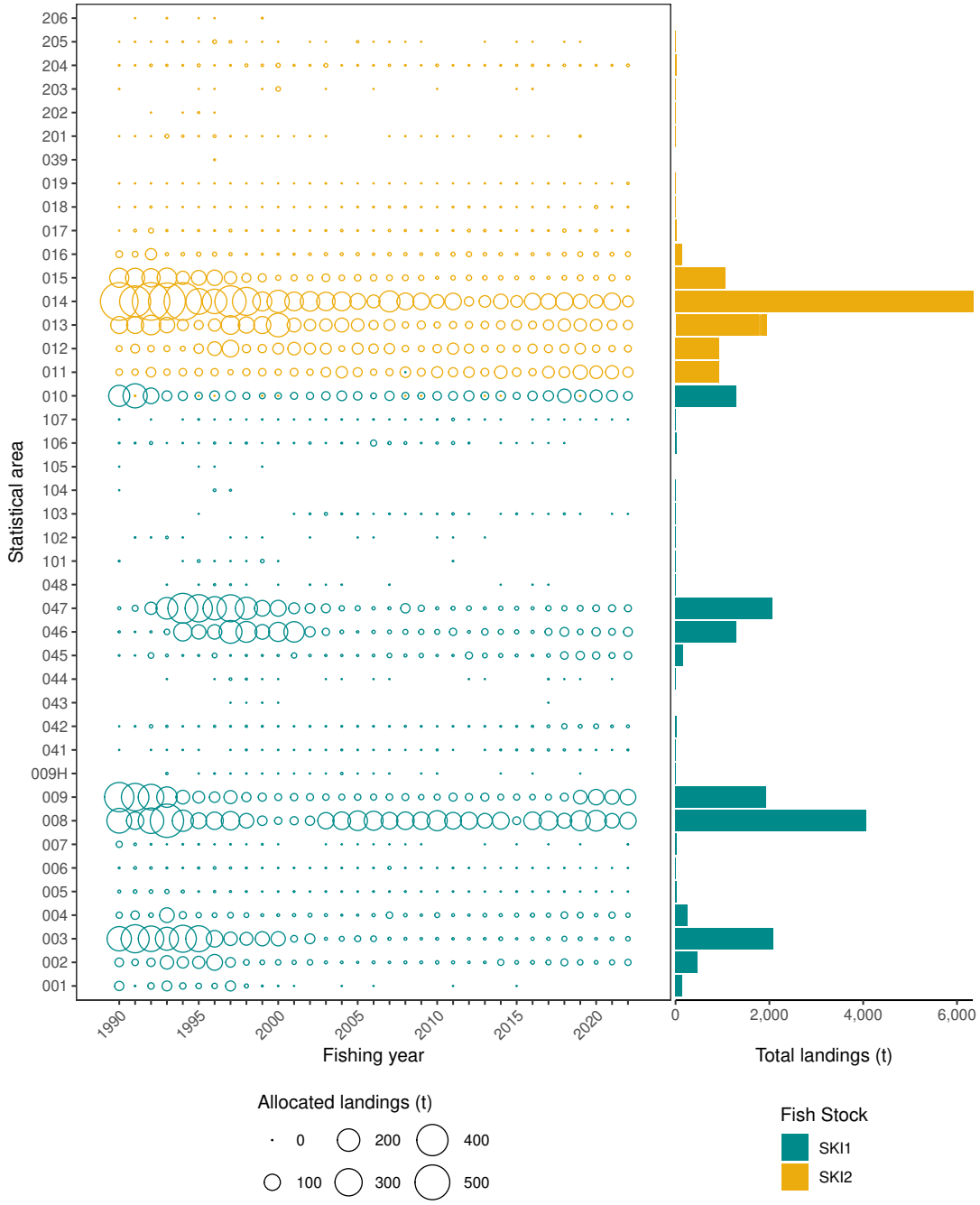


Figure 26: Annual SKI 1 and SKI 2 catches (t) by statistical area for the bottom trawl fishery. The size of the circles scale with the catches by statistical area. The bar plot (right hand side) shows the total catches of SKI 1 and SKI 2 for each statistical area.

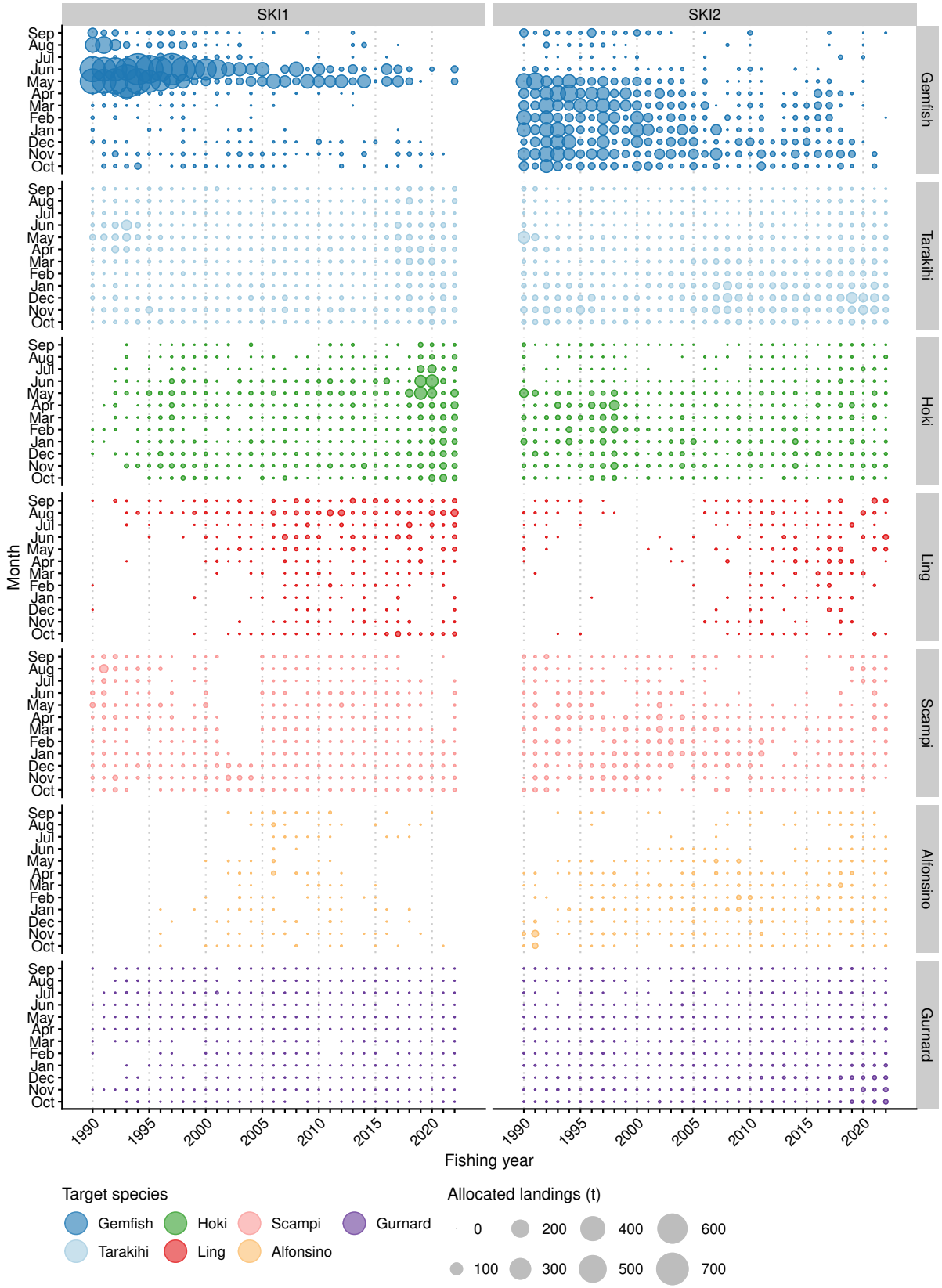


Figure 27: Seasonal distribution of SKI 1 and SKI 2 catches by month and fishing year for the bottom trawl target fisheries. The area of the circle scales with the monthly catches.

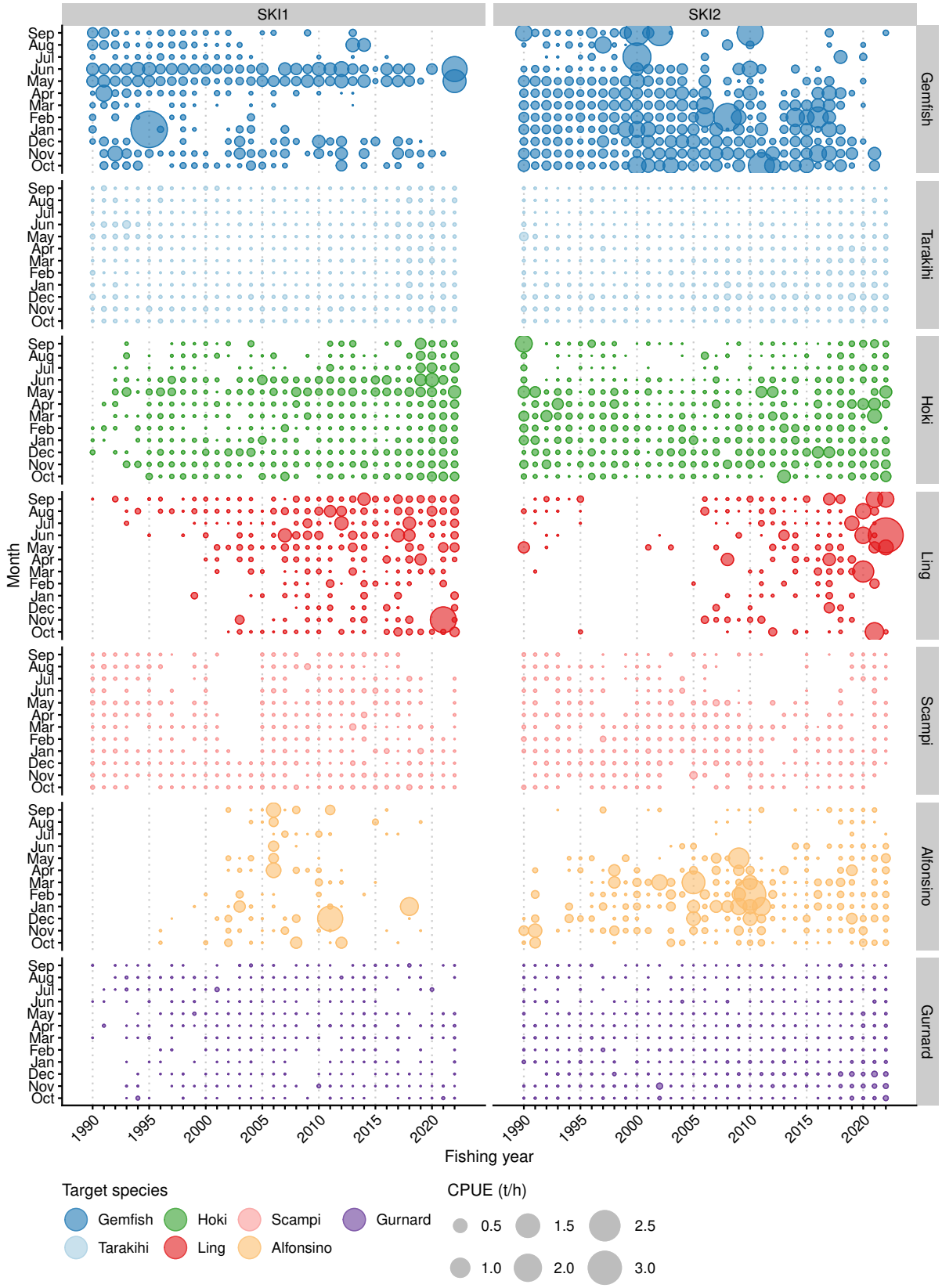


Figure 28: Seasonal distribution of SKI 1 and SKI 2 raw aggregate CPUE (t/h) by month and fishing year for the bottom trawl target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h) .

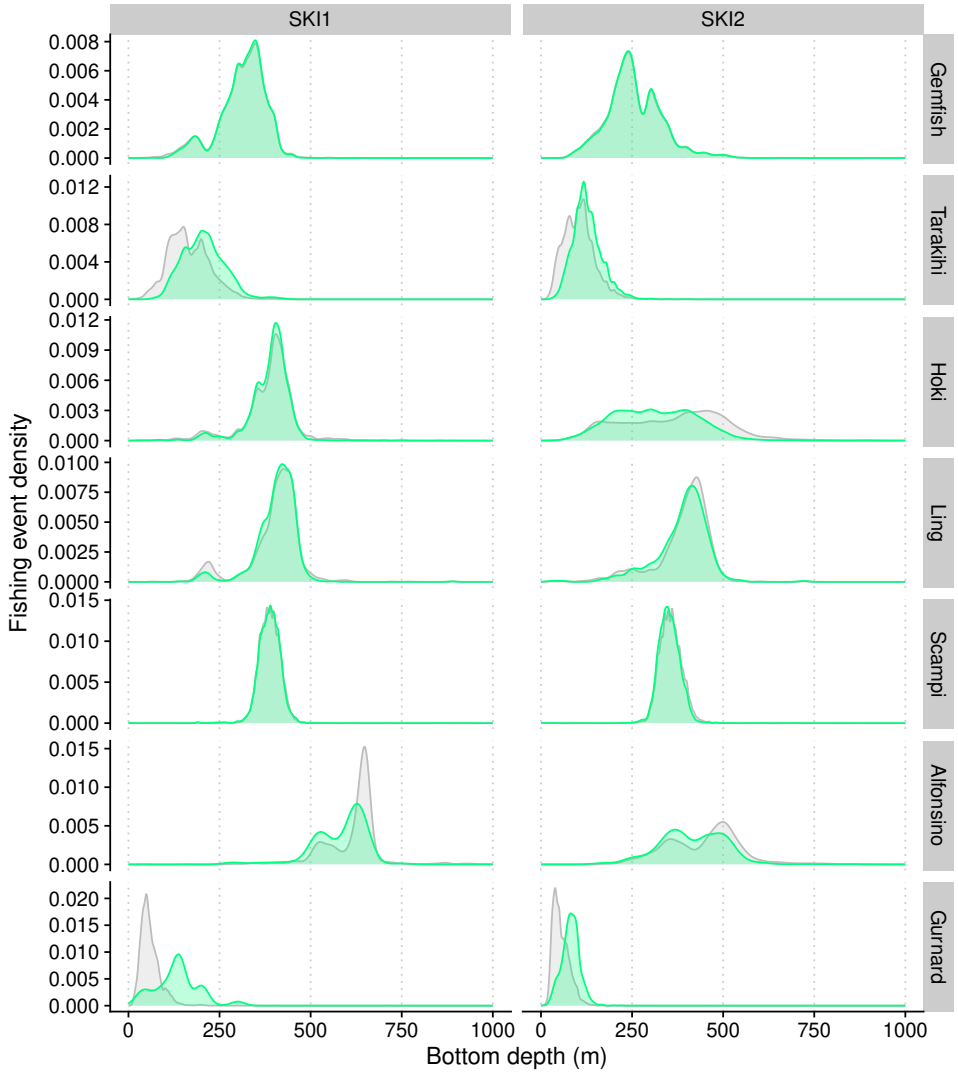


Figure 29: Effort depth distribution by target species for trips landing SKI 1 and SKI 2 from the bottom trawl fishery. Grey fill = total effort, Green fill = positive effort (i.e., estimated catch > 0).

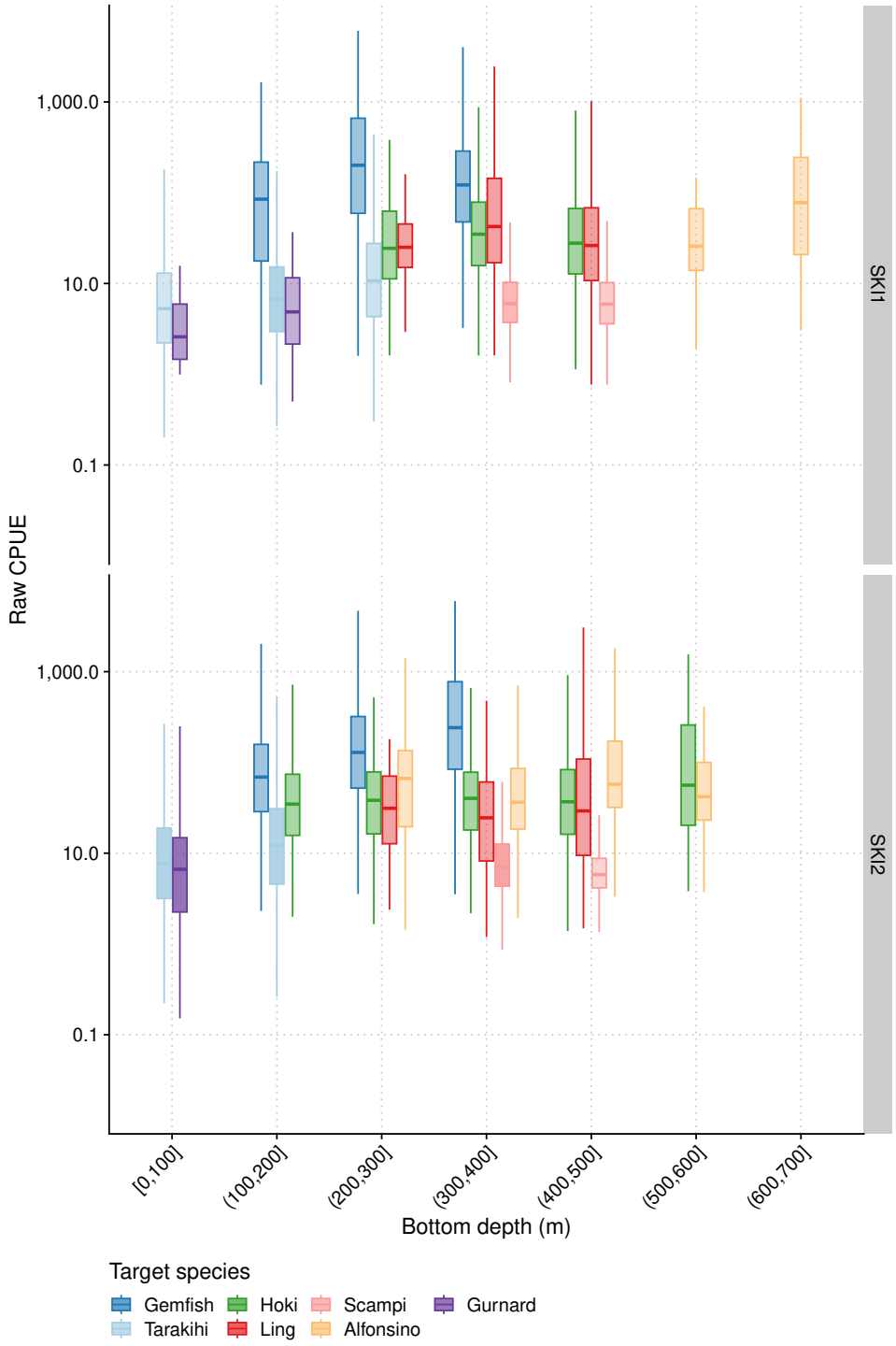


Figure 30: Raw gemfish CPUE (t/h) by depth bin and target species for events catching gemfish from the bottom trawl target fisheries in SKI 1 and SKI 2. Boxplots are included for depth bins that include at least 5% of the events in the dataset for a particular target species, and events with a raw CPUE 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.

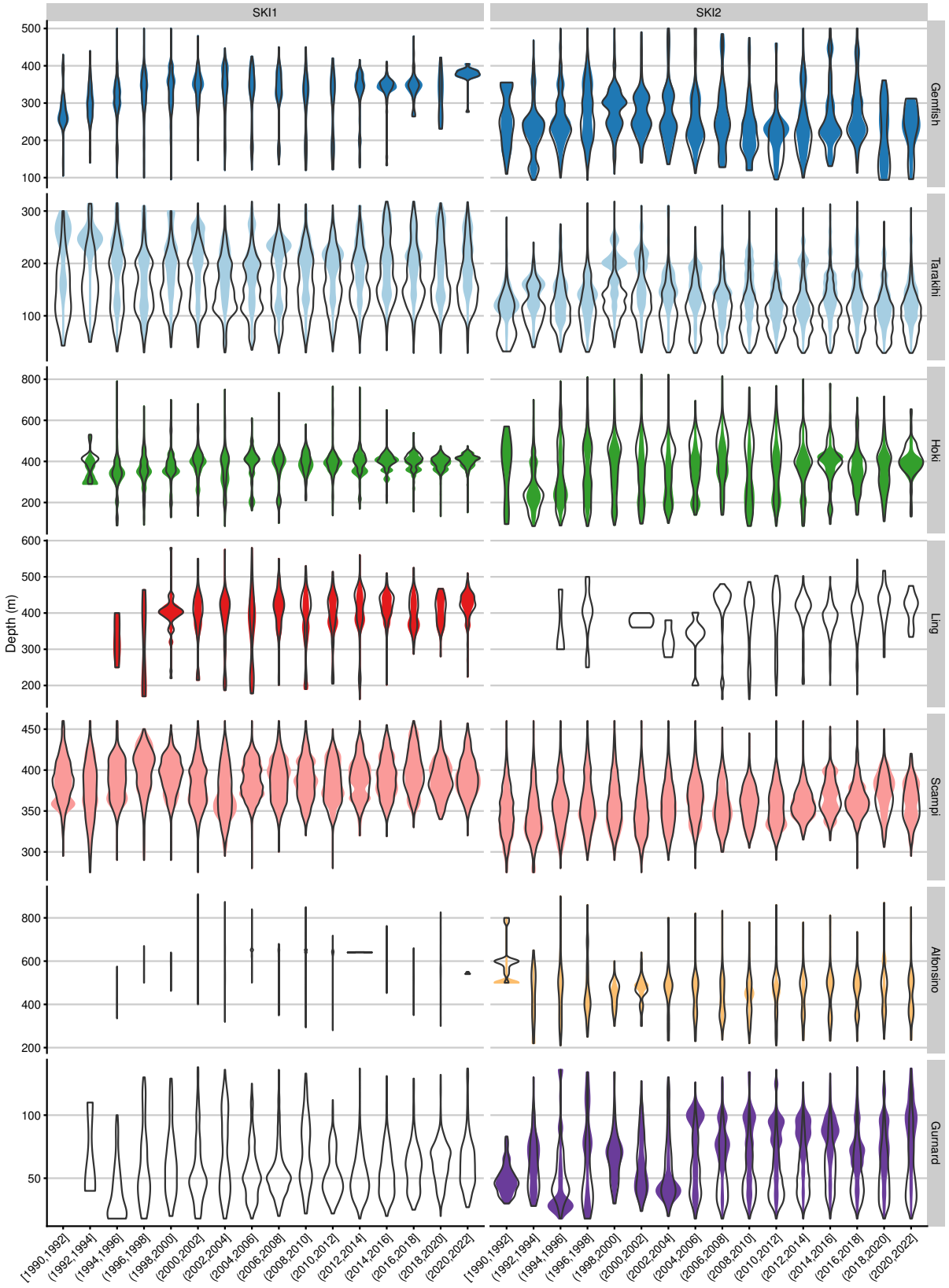


Figure 31: Catch weighted (coloured) and unweighted (unfilled) effort depth distribution by target species for trips landing SKI 1 and SKI 2 from the bottom trawl fishery.

3.4 The midwater trawl fishery

Most midwater trawl catches of gemfish in SKI 1 and SKI 2 have been recorded with fine-scale spatial information since the mid-1990s (Figure 32). Catches by the midwater trawl fishery have been patchy; the fishery has primarily operated in SKI 2, from Cook Strait to East Cape (Figure 33), with the majority of catches from Statistical Area 013 (Figure 34). However, the increase in catch since 2018 has been primarily from Statistical Area 015.

The target midwater trawl fishery largely ceased by the mid-2000s, but a recent increase in the catch of gemfish by midwater trawls targeting hoki and alfonsino in SKI 2 is apparent (Figure 35).

Target midwater trawl catches in SKI 2 were historically high in September and October with catches maintained through to March in a couple of years in the mid-1990s (Figure 36). Lower catches in April to July are consistent with the stock hypothesis where gemfish migrate north from SKI 2 to spawning areas in north of SKI 1, before returning south. However, midwater trawl catch rates have been sporadic and do not show a clear seasonal pattern (Figure 37).

The majority of the midwater trawl effort on trips landing SKI 1 and SKI 2 has been carried out near the sea floor (Figure 38).

Gemfish are caught throughout the depth ranges of the midwater trawl fisheries targeting rubyfish, gemfish and hoki in SKI 2, but have not been reported from hoki or bluenose target midwater trawling in SKI 1 (Figure 39).

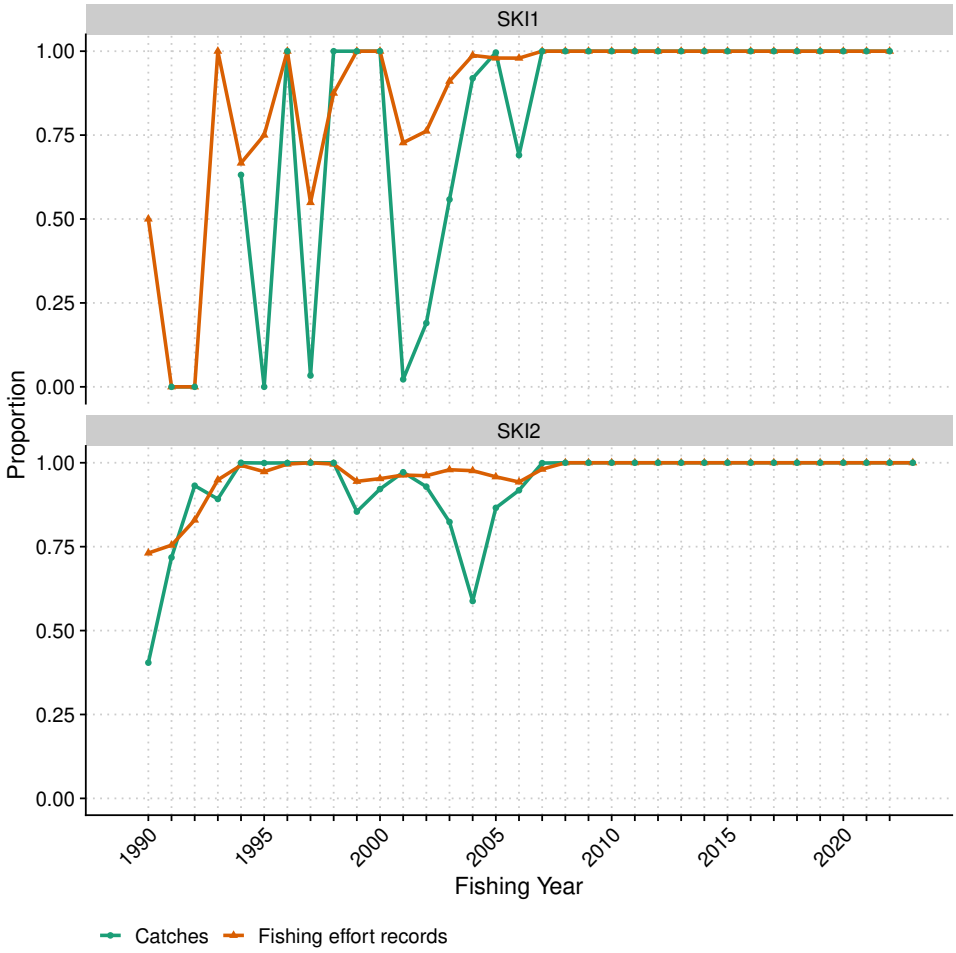


Figure 32: The proportion of records and catches reported with a latitude/longitude for the SKI 1 and SKI 2 midwater trawl fishery.

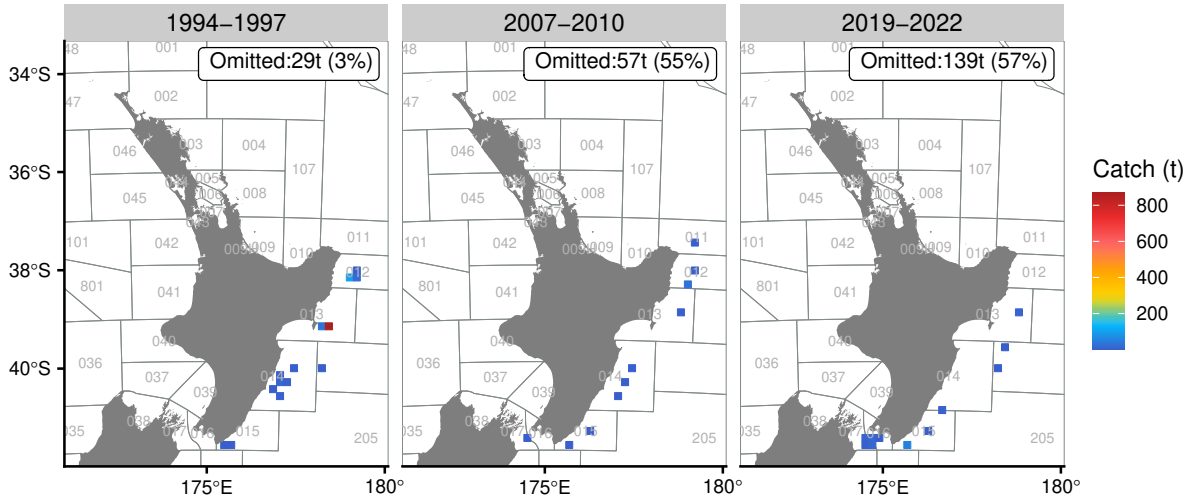


Figure 33: Catches (t) for the SKI 1 and SKI 2 midwater trawl fishery, for four year periods within the era during which at least 70% of catch was reported with spatial information. These plots use a 16 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

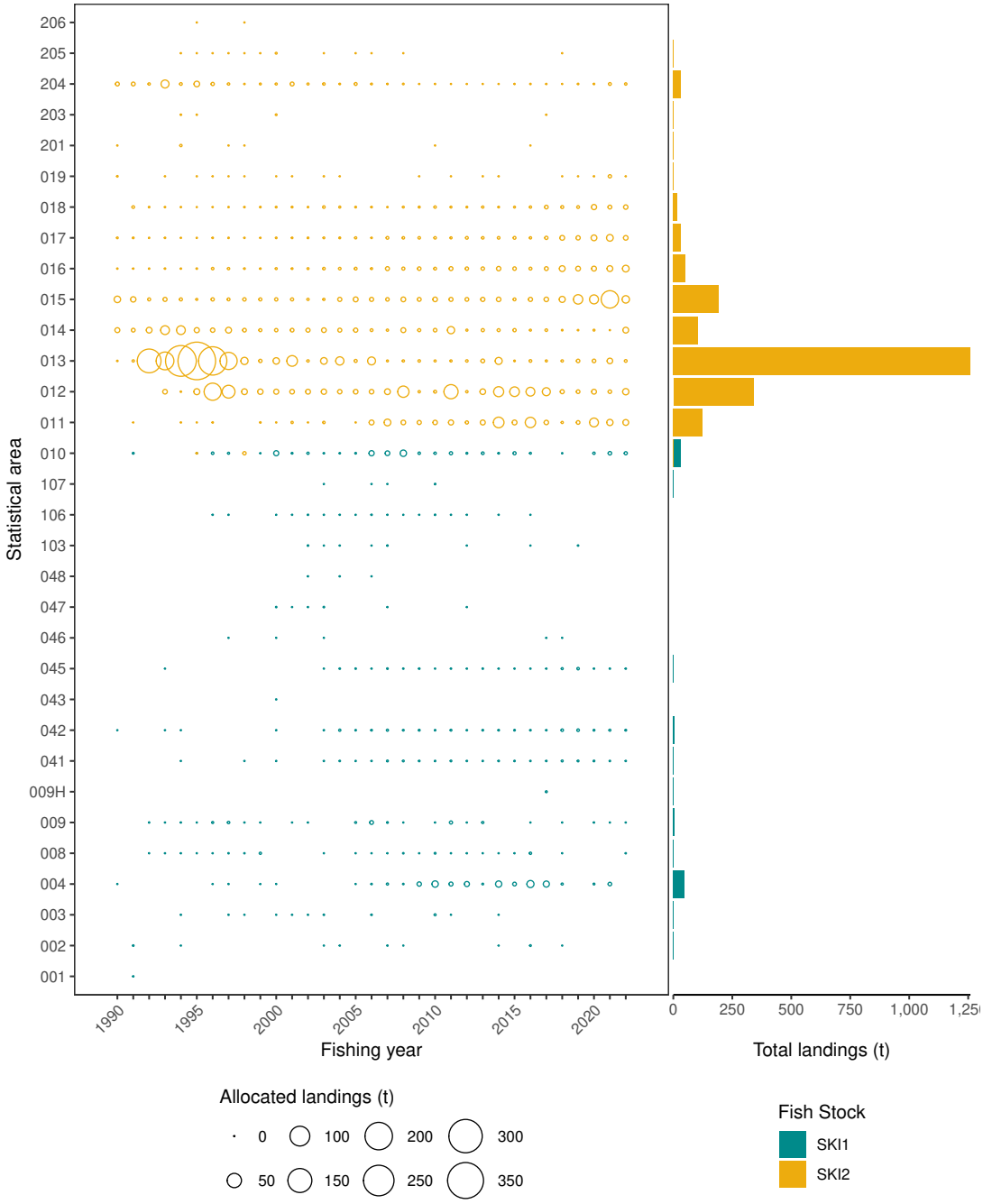


Figure 34: Annual SKI 1 and SKI 2 catches (t) by statistical area for the midwater trawl fishery. The size of the circles scale with the catches by statistical area. The bar plot (right hand side) shows the total catches of SKI 1 and SKI 2 for each statistical area.

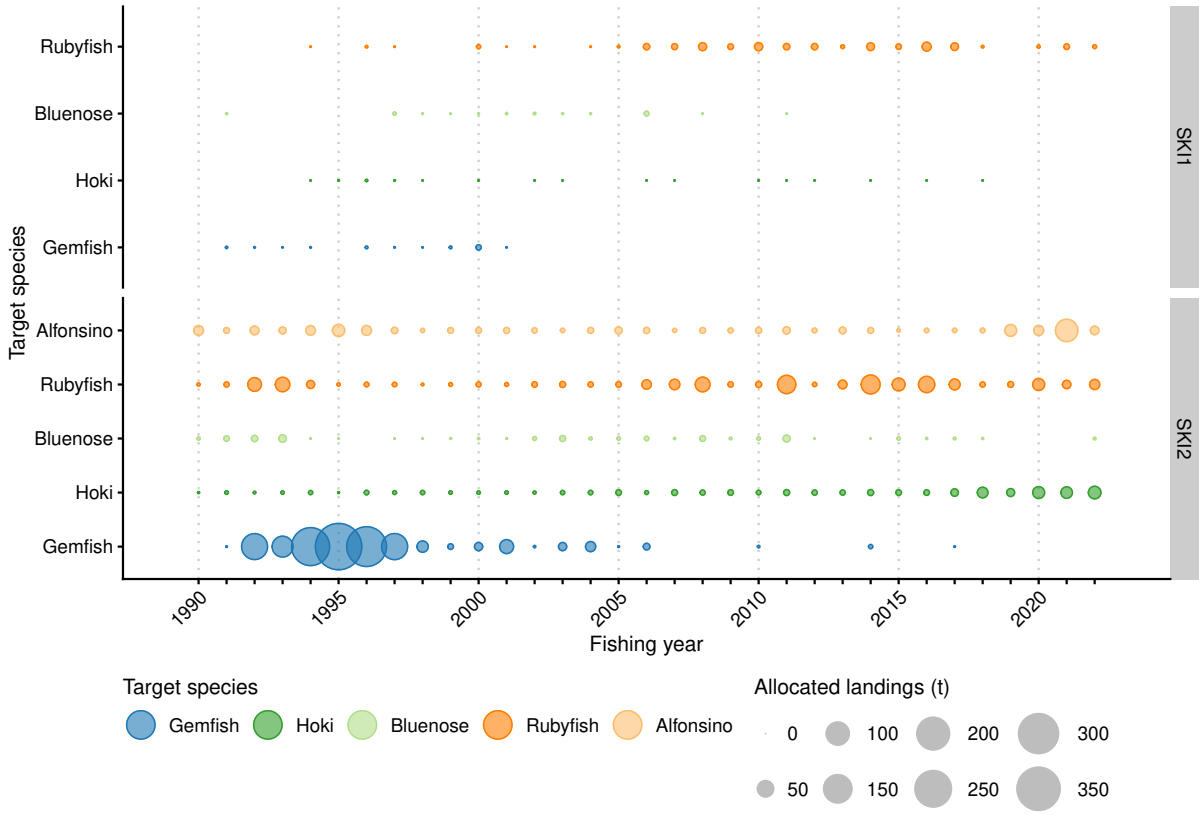


Figure 35: Gemfish catches by fishing year and target species for the midwater trawl fishery. The area of the circle scales with the yearly catches.

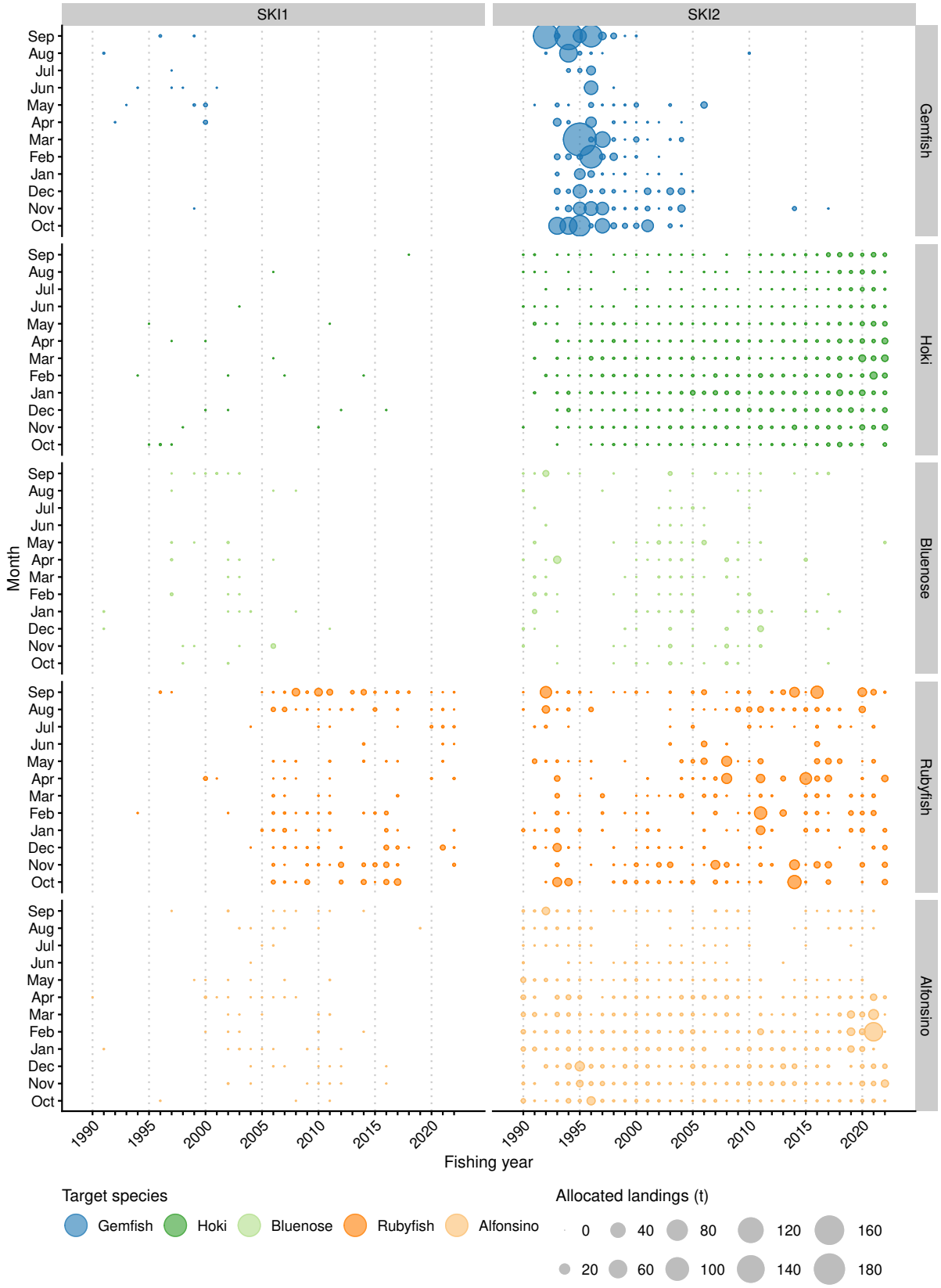


Figure 36: Seasonal distribution of SKI 1 and SKI 2 catches by month and fishing year for the midwater trawl target fisheries. The area of the circle scales with the monthly catches.

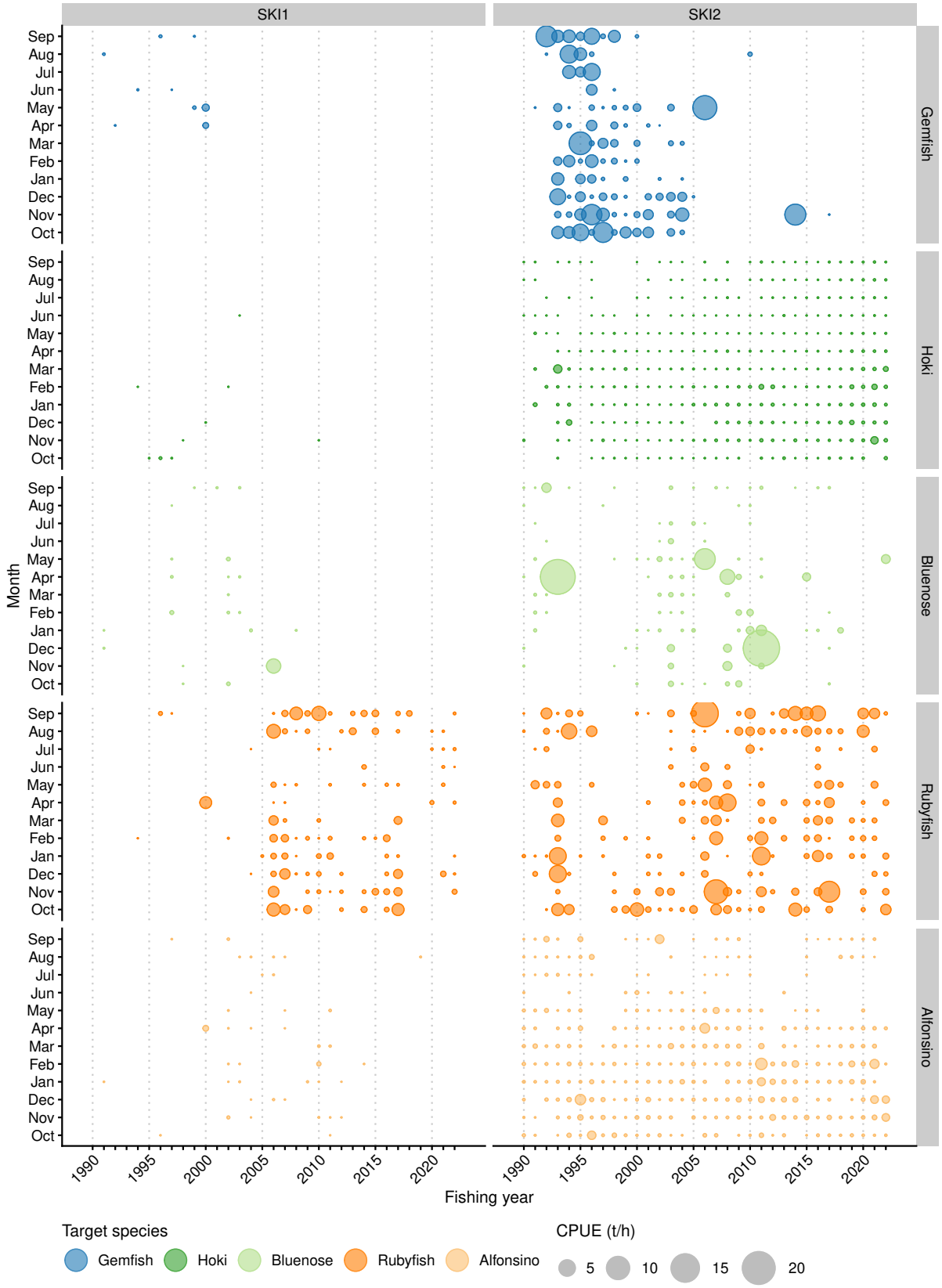


Figure 37: Seasonal distribution of SKI 1 and SKI 2 raw aggregate CPUE (t/h) by month and fishing year for the midwater trawl target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h) .

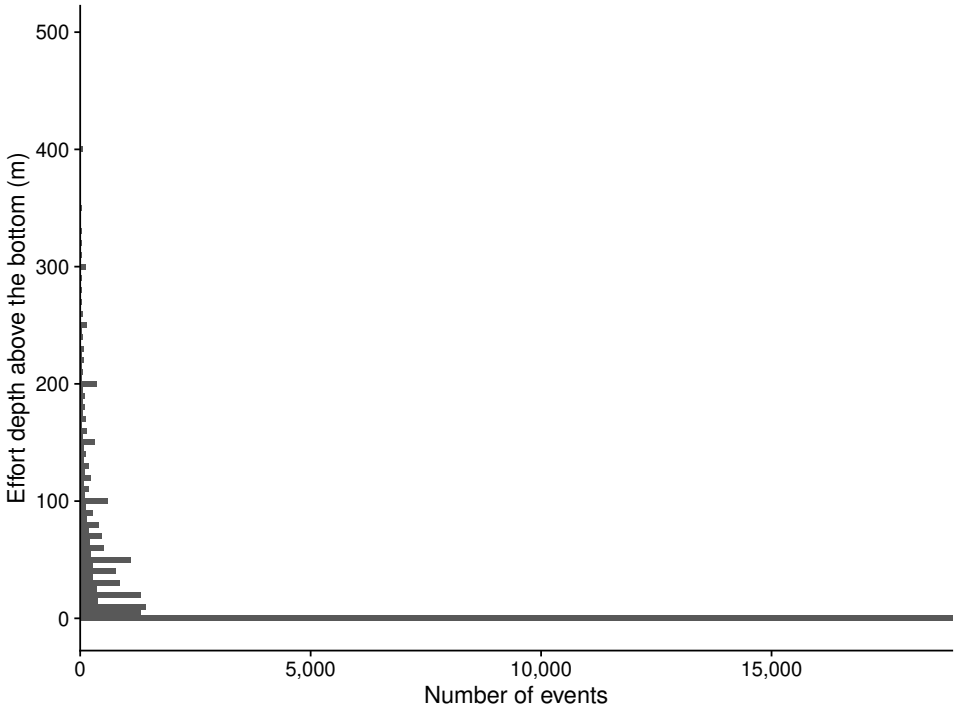


Figure 38: Distribution of the distance of fishing effort from the bottom for trips landing SKI 1 and SKI 2 from the midwater trawl fishery.

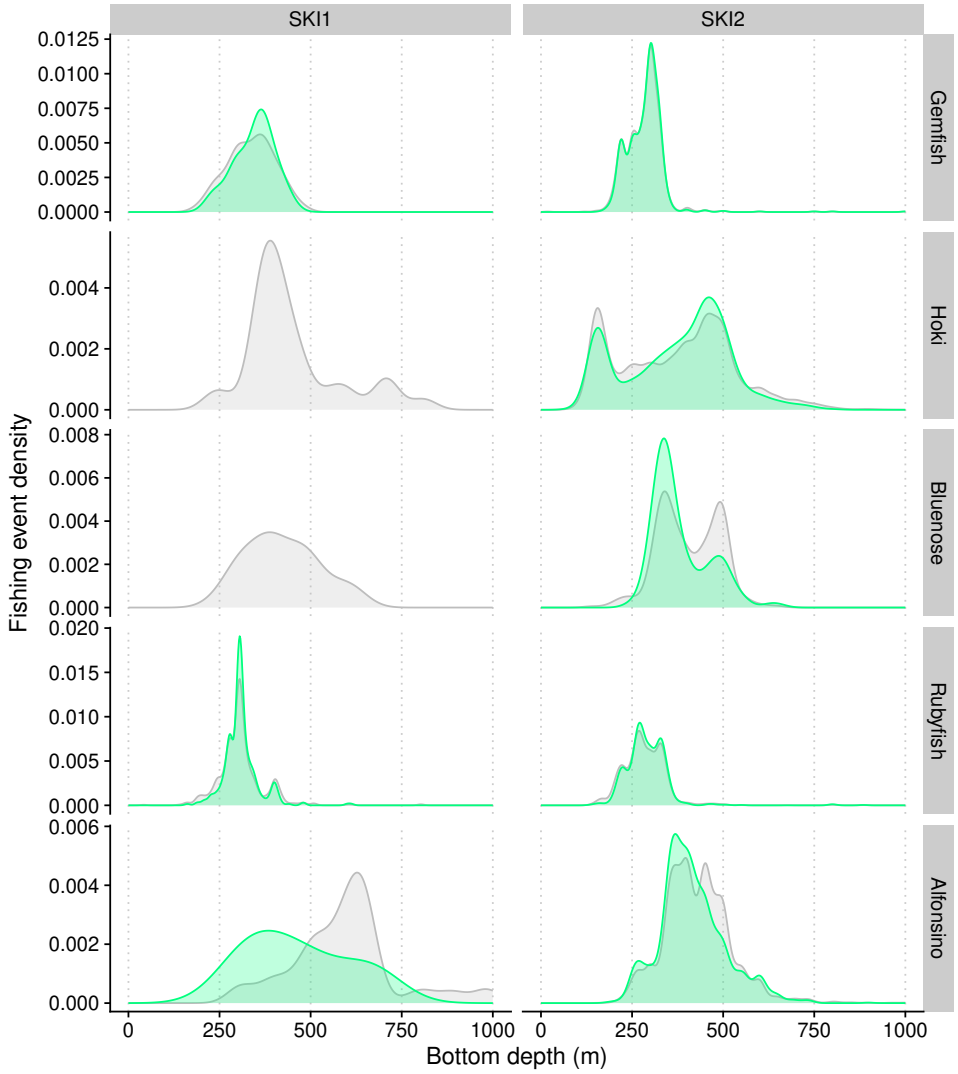


Figure 39: Effort depth distribution by target species for trips landing SKI 1 and SKI 2 from the midwater trawl fishery. Grey fill = total effort, Green fill = positive effort (i.e., estimated catch > 0).

4. CATCH-PER-UNIT-EFFORT

4.1 CPUE series development

The previously published CPUE analysis for northern gemfish (Starr & Kendrick 2016) was for SKI 2 only, and included data up to the 2014 fishing year. That analysis used data from bottom trawling only, aggregated to the daily resolution. Target species was included in the analysis as an explanatory variable. The working group noted that these analyses appeared to be robust, with only small differences in the models that excluded or included gemfish as a target species, but recommended that future CPUE analyses should include data from the Bay of Plenty region of SKI 1.

The current CPUE series for northern gemfish were developed progressively from 2020 to 2022. In 2020, the 2014 CPUE indices were initially updated using the approaches used by Starr & Kendrick (2016) and with the addition of data from the Bay of Plenty. The updated series showed large increases in 2018 and 2019 that were primarily driven by data from the tarakihi target fishery. The tarakihi target fishery generally operates in shallower depths than the gemfish target fishery. Examination of length-frequency data from observers and market sampling (Appendix C) suggested that the tarakihi fishery took a mix of sub-adult and adult gemfish, and that adult gemfish were taken when targeting gemfish. As a result, separate CPUE indices were developed for the tarakihi and gemfish target fisheries. Both included data from SKI 2 and the east and west coast fisheries in SKI 1, on the basis that SKI 1 and SKI 2 are assessed as a single biological stock. This was supported by implied residual plots, which showed consistent trends across all statistical areas for each series.

For the tarakihi target fisheries, a trip-resolution index was developed, to address the fact that gemfish may not be well estimated in event-level data from the tarakihi fishery. The 2020 Fisheries Assessment Plenary accepted the tarakihi-target bottom-trawl (BT-TAR) positive catches trip-based index as an index of abundance for mixed sub-adult and adult gemfish in SKI 1 and SKI 2. The BT-TAR trip-based index was updated in 2021 (and accepted by the Plenary), using a combined binomial-lognormal model, and has subsequently been updated annually. The model with data to the end of the 2022 fishing year is presented below as the 'SKI1 SKI2 BT-TAR trip' series, and referred to in the text as the 'BT-TAR trip' series.

For the gemfish target fisheries, event-based data were available from the mid-1990s in SKI 1. However, the 2020 Fisheries Assessment Plenary concluded that the BT-SKI indices could not be accepted as indexing abundance of SKI 1 and SKI 2 due to sparse data, large changes in distribution of fishing effort and considerably reduced targeting. To address concerns with the gemfish target index, a new event-resolution index was developed in 2021 using data from hoki and gemfish target tows by both bottom trawl and midwater trawl fished within 10 m of the bottom. The index was limited to the Bay of Plenty and SKI 2 where a continuous fishery has operated. Market sampling data indicated that gemfish and hoki target trips caught adult gemfish with a similar size composition, and the event-resolution HOK-SKI target index from the east coast fisheries was therefore accepted as an index of abundance of adult gemfish by the 2021 Fisheries Assessment Plenary. This index, updated with data to the end of the 2022 fishing year, is referred to here as the 'SKI1 SKI2 HOK-SKI event' series.

During the development of these key CPUE indices the Inshore Fisheries Working Group and Fisheries Assessment Plenary also considered a range of additional indices, as sensitivities. A number of these are presented in Appendix D and are discussed below (Section 4.4). In particular, a fishing event level index for the tarakihi target fishery is available from the 2008 fishing year, when the TCER form was introduced for inshore trawl effort ('SKI1 SKI2 TAR event'). In addition, a daily-resolution index for the gemfish and hoki target fishery was produced, with the later event-level data aggregated to match that of the earlier CELR resolution data ('SKI1 SKI2 HOK-SKI daily'). This provides an alternative index beginning in the 1990 fishing year.

4.2 SKI1 SKI2 BT-TAR trip

The BT-TAR trip series is defined in Table 4; in particular, it uses data from inshore areas off the entire east coast of the North Island, and the northern west coast.

The core vessel selection retains 88.7% of the catch while reducing the core fleet in the modelling dataset to 77 vessels (Figure 40). The resulting fleet shows good overlap, with some vessels operating continuously over the period (Figure 41). 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 53 vessels in 1993 and 1994, reducing to 19 vessels by 2022. The fleet has undertaken 250–900 trips, comprising 2400–9000 tows, per annum. The catch of gemfish has been relatively modest, ranging from 25 to 250 tonnes per annum, with lowest catches during the late 1990s and early 2000s, and highest catches since 2015. Over much of the series, gemfish were caught in around half the trips but this has increased to more than 75% of trips in 2017–2022.

Stepwise selection for the binomial model, standardising the probability that a trip catches gemfish, retains vessel, month and area, together with a month:area interaction (Table 7). The number of tows on a trip (`total_effort_num`) is also retained as the key effort term. For much of the series, there is little effect of standardisation (Figure 42). However, during 2017–2022, the standardised index is noticeably higher than the unstandardised series, with the modal month of the trip being the main explanatory variable that drives this change, and the interaction between month and area also contributing (Figure 43).

Increased activity by a couple of vessels with higher probability of catching gemfish generally acted to reduce the standardised index during 2017–2021 (Figure 44). Temporal fishing patterns have remained stable, with little influence from this term (Figure 45). There is a higher probability of gemfish catch in May–June and October–November, likely related to the migrations to and from spawning grounds. Trips by vessels in the core fleet were somewhat longer from the mid-2000s, tending to reduce the index, but there were fewer long trips in 2021 and 2022 (Figure 46). Spatially, the Bay of Plenty (Statistical Areas 009, 010, and 011) and East Northland (Area 002) have a higher probability of gemfish catch (Figure 47); however, in interpreting the monthly and spatial effects it is important to recall that there is also an interaction between area and month.

Stepwise selection for the lognormal model of positive catches results in the same set of explanatory variables that were retained in the occurrence model (Table 8). In particular, the main effort term retained is the total number of tows on a trip. Diagnostics for the lognormal model (Figure 48) are noticeably better than those for alternative error distributions considered (Figure 49).

The effect of standardisation on positive catches is most apparent at the start and end of the series, with the standardised index substantially higher than the unstandardised index during 1990–1993, and somewhat lower during 2019–2021 (Figure 50). Step plots (Figure 51) demonstrate that the vessel effect is primarily responsible for the reduced index in 2019–2021, but the higher values in the standardised series during 1990–1993 is a cumulative effect with contributions from all explanatory variables.

Influence from changes in the fleet has shown a generally increasing trend over time (Figure 52) with a number of vessels that have high catch rates of gemfish showing a higher level of activity in the second half of the series. Catch rates are highest in October–December, and noticeably lower in July–September (Figure 53). The relationship between catch quantity and the number of tows on a trip (Figure 54) is flatter than the relationship with probability of catch (Figure 46); the effect is that the influence of the number of tows on a trip averages around 0.9 during 1990–2004, then around 1.1 during 2005–2021, dropping below 1.0 in 2022. Catch quantities are generally higher in the Bay of Plenty and northern FMA 2 areas, and lowest in the southern FMA 2 areas (i.e., southern Wairarapa Coast and Cook Strait; Figure 55), noting that the positive catch index also has an area:month interaction.

Residual implied coefficients by statistical area do not suggest any particular differences in trend between areas (Figure 56), although data from the North Island west coast are sparse.

The final binomial and lognormal indices, and the resulting combined index, are illustrated in Figure 57 and Figure 58, and tabulated in Table 9. The combined series showed a steep decline from 1990 to 1994, primarily resulting from a drop in positive catch magnitude, with a further decline to 1998 as the probability of catching gemfish also declined. The series then showed a gradually increasing trend to 2016, and then a rapid increase to 2020 with the probability of capture and magnitude of catches both increasing. The series showed a slight drop in 2021, and dropped further in 2022. Uncertainty in the series has been higher during 2018–2022, primarily due to wider confidence intervals for the probability of gemfish catch.

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 SKI1 SKI2 BT-TAR trip CPUE series.

Series	SKI1 SKI2 BT-TAR trip
QMS stock	SKI1, SKI2
Reporting forms	CEL, TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	TAR
Areas	002, 003, 008, 009, 010, 011, 012, 013, 014, 015, 016, 017, 018, 045, 046, 047
Period	1989-10-01, 2022-09-30
Resolution	Trip
Core fleet years	5
Core fleet trips	5
Default model	landkg ~ fyear + vessel_key + ns(log(total_effort_num), 3) + ns(mean_fishing_duration, 3) + modal_stat_area*modal_month + bs(mean_effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

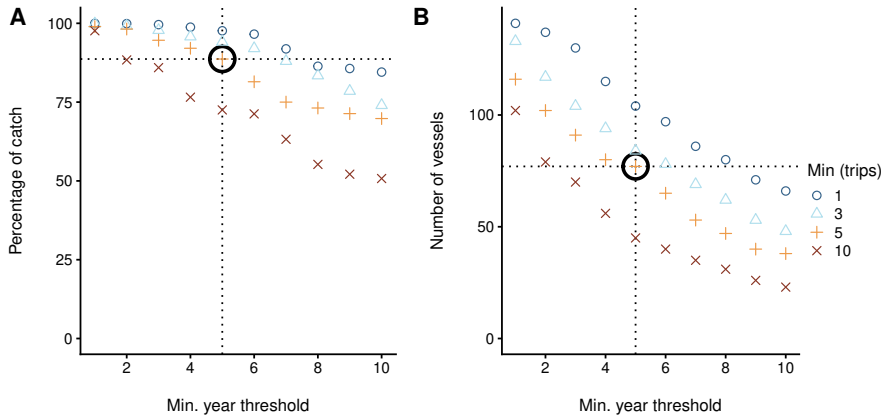


Figure 40: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 BT-TAR trip CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

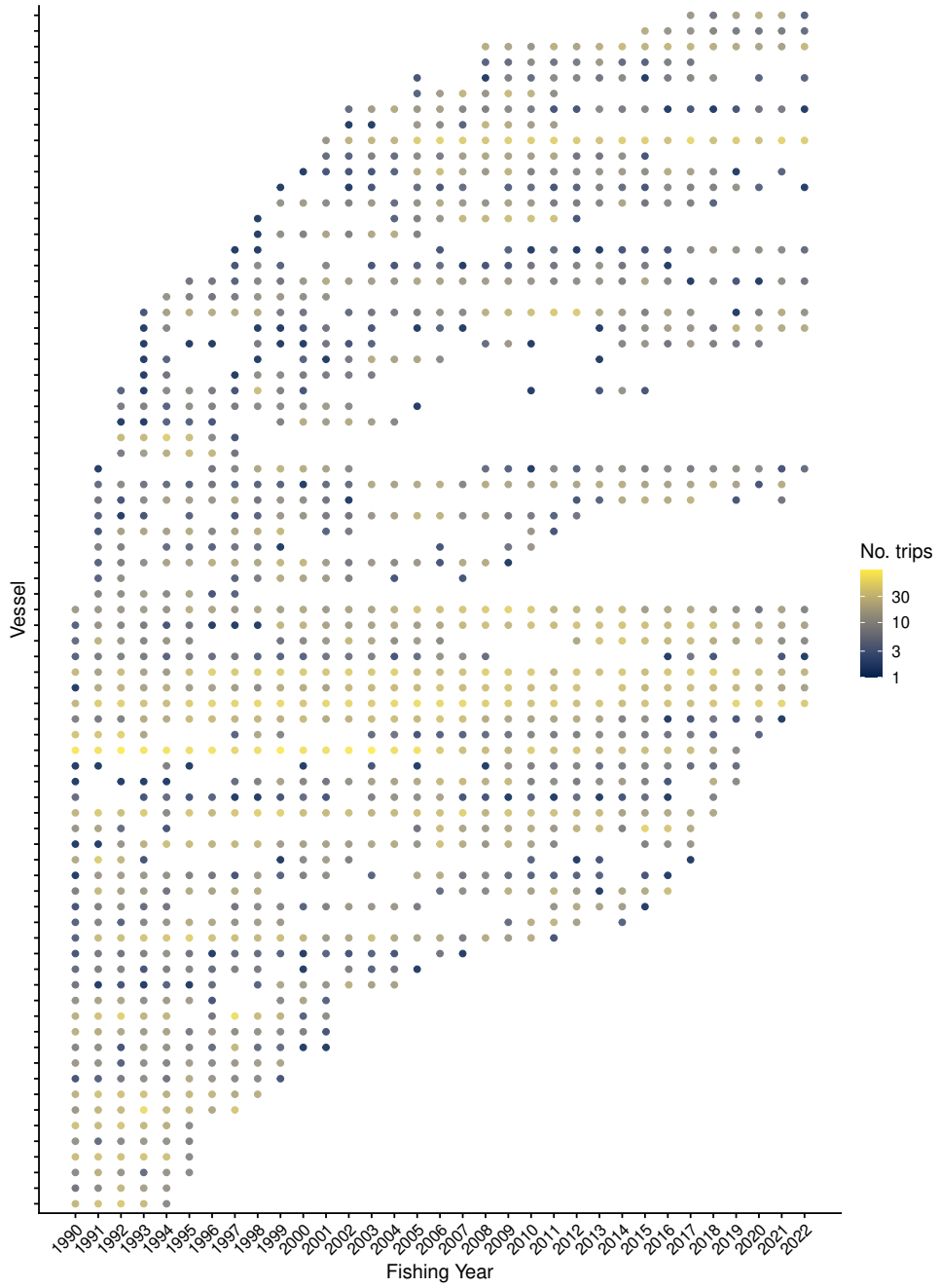


Figure 41: Number of trips by fishing year for core vessels. The colour of the points is proportional to the number of trips undertaken by a vessel in a fishing year.

Table 5: Summary of SKI1 SKI2 BT-TAR trip total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ungroomed data	142 (Percent: 100) (Records: 687)	171 (Percent: 100) (Records: 996)	154 (Percent: 100) (Records: 1132)	162 (Percent: 100) (Records: 978)	101 (Percent: 100) (Records: 951)	123 (Percent: 100) (Records: 972)	116 (Percent: 100) (Records: 745)	50 (Percent: 100) (Records: 835)	32 (Percent: 100) (Records: 813)	59 (Percent: 100) (Records: 873)	49 (Percent: 100) (Records: 719)	38 (Percent: 100) (Records: 659)
Less than 60 tows on trip	142 (Percent: 100) (Records: 687)	171 (Percent: 100) (Records: 996)	154 (Percent: 100) (Records: 1131)	162 (Percent: 100) (Records: 978)	101 (Percent: 100) (Records: 951)	123 (Percent: 100) (Records: 971)	115 (Percent: 100) (Records: 742)	50 (Percent: 100) (Records: 834)	30 (Percent: 100) (Records: 812)	57 (Percent: 100) (Records: 869)	49 (Percent: 100) (Records: 718)	38 (Percent: 100) (Records: 659)
Core fleet selection	100 (Percent: 71) (Records: 543)	132 (Percent: 77) (Records: 810)	118 (Percent: 77) (Records: 933)	120 (Percent: 74) (Records: 850)	81 (Percent: 80) (Records: 812)	114 (Percent: 92) (Records: 800)	92 (Percent: 79) (Records: 627)	47 (Percent: 93) (Records: 694)	26 (Percent: 81) (Records: 724)	51 (Percent: 86) (Records: 747)	46 (Percent: 94) (Records: 604)	32 (Percent: 82) (Records: 572)

Filter	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ungroomed data	38 (Percent: 100) (Records: 695)	101 (Percent: 100) (Records: 707)	82 (Percent: 100) (Records: 687)	138 (Percent: 100) (Records: 723)	163 (Percent: 100) (Records: 843)	152 (Percent: 100) (Records: 716)	201 (Percent: 100) (Records: 725)	162 (Percent: 100) (Records: 791)	110 (Percent: 100) (Records: 744)	196 (Percent: 100) (Records: 652)	132 (Percent: 100) (Records: 619)	88 (Percent: 100) (Records: 613)
Less than 60 tows on trip	38 (Percent: 100) (Records: 695)	101 (Percent: 100) (Records: 707)	82 (Percent: 100) (Records: 687)	138 (Percent: 100) (Records: 723)	163 (Percent: 100) (Records: 843)	152 (Percent: 100) (Records: 716)	201 (Percent: 100) (Records: 725)	162 (Percent: 100) (Records: 791)	110 (Percent: 100) (Records: 744)	196 (Percent: 100) (Records: 652)	132 (Percent: 100) (Records: 619)	88 (Percent: 100) (Records: 613)
Core fleet selection	38 (Percent: 100) (Records: 587)	56 (Percent: 55) (Records: 642)	54 (Percent: 65) (Records: 606)	100 (Percent: 72) (Records: 674)	108 (Percent: 66) (Records: 751)	146 (Percent: 100) (Records: 653)	164 (Percent: 81) (Records: 677)	158 (Percent: 100) (Records: 757)	110 (Percent: 100) (Records: 713)	194 (Percent: 100) (Records: 635)	129 (Percent: 100) (Records: 583)	75 (Percent: 86) (Records: 536)

Filter	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ungroomed data	157 (Percent: 100) (Records: 688)	111 (Percent: 100) (Records: 659)	146 (Percent: 100) (Records: 599)	259 (Percent: 100) (Records: 601)	235 (Percent: 100) (Records: 516)	219 (Percent: 100) (Records: 422)	187 (Percent: 100) (Records: 335)	184 (Percent: 100) (Records: 383)	106 (Percent: 100) (Records: 320)
Less than 60 tows on trip	157 (Percent: 100) (Records: 688)	111 (Percent: 100) (Records: 659)	146 (Percent: 100) (Records: 599)	259 (Percent: 100) (Records: 601)	231 (Percent: 100) (Records: 515)	219 (Percent: 100) (Records: 422)	187 (Percent: 100) (Records: 335)	184 (Percent: 100) (Records: 383)	106 (Percent: 100) (Records: 320)
Core fleet selection	147 (Percent: 94) (Records: 602)	111 (Percent: 100) (Records: 577)	144 (Percent: 100) (Records: 567)	256 (Percent: 100) (Records: 550)	227 (Percent: 100) (Records: 433)	217 (Percent: 100) (Records: 377)	182 (Percent: 100) (Records: 318)	183 (Percent: 100) (Records: 341)	101 (Percent: 100) (Records: 252)

Table 6: Summary of the SKI1 SKI2 BT-TAR trip dataset after core fleet selection. Trips caught represents the percentage of trips with gemfish catch.

Fishing year	Vessels	Trips	Events	Hrs	Catch (t)	Trips caught
1990	39	543	4 414	15 006.68	100.42	53.22
1991	46	810	6 801	23 261.93	131.94	49.38
1992	50	906	6 608	23 444.62	118.09	48.23
1993	53	813	6 781	24 807.67	119.52	56.33
1994	53	775	6 733	24 241.82	80.70	54.97
1995	47	779	6 419	23 685.12	113.51	56.74
1996	42	627	4 964	18 743.43	91.54	46.57
1997	46	694	4 954	17 557.82	46.91	36.74
1998	48	724	5 395	19 239.25	25.58	39.23
1999	48	747	5 831	20 999.08	50.96	42.17
2000	44	604	5 129	19 191.43	46.13	38.74
2001	44	572	4 878	17 703.27	31.66	46.85
2002	40	587	4 777	16 375.75	37.71	54.86
2003	40	642	5 602	19 963.80	56.05	56.23
2004	35	606	5 614	19 537.72	53.82	54.79
2005	40	674	6 604	23 939.14	99.90	43.77
2006	38	751	8 198	29 249.48	107.86	50.20
2007	35	653	7 498	25 809.92	146.33	57.58
2008	37	677	7 933	28 265.80	163.51	55.10
2009	40	757	8 900	31 216.65	157.88	49.93
2010	42	713	8 243	28 891.77	109.55	58.20
2011	39	635	8 017	27 226.23	194.25	67.24
2012	37	583	7 275	24 810.77	129.00	70.33
2013	36	536	6 444	22 188.22	75.17	61.94
2014	36	602	7 480	26 056.25	147.45	64.78
2015	38	577	6 938	24 993.50	111.04	59.79
2016	36	567	6 617	24 612.93	143.71	66.84
2017	33	550	6 579	24 706.13	256.41	75.45
2018	29	433	5 131	18 904.38	226.57	89.84
2019	25	377	4 563	16 753.18	217.31	87.00
2020	22	318	3 912	14 700.00	182.16	85.53
2021	21	341	3 491	13 336.74	182.56	80.94
2022	19	252	2 401	8 803.85	100.89	77.78

Table 7: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	31.00	26 862	4.90	4.90	*
+ vessel_key	77.00	24 408	14.20	9.30	*
+ modal_month	11.00	22 321	21.70	7.50	*
+ ns(log(total_effort_num), 3)	3.00	21 330	25.20	3.50	*
+ modal_stat_area	15.00	21 030	26.40	1.20	*
+ modal_stat_area:modal_month	165.00	20 446	29.60	3.20	*
+ ns(mean_fishing_duration, 3)	3.00	20 339	30.00	0.40	
+ bs(mean_effort_height, 3)	3.00	20 322	30.10	0.10	

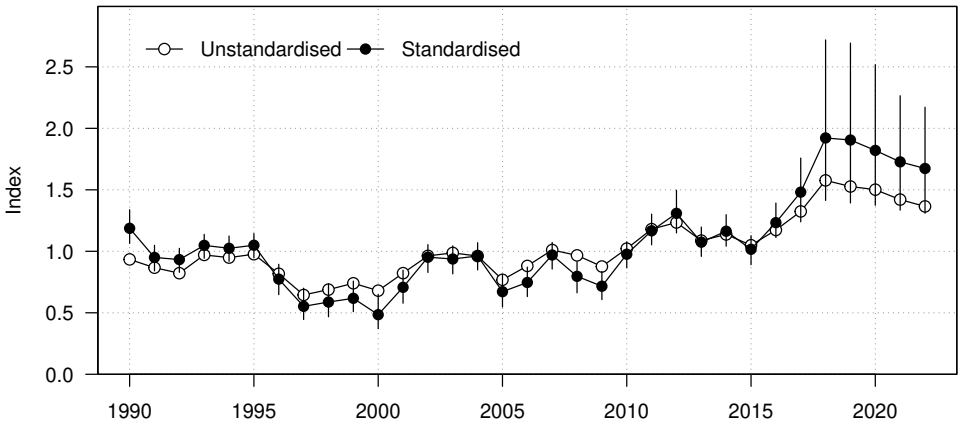


Figure 42: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 BT-TAR trip dataset.

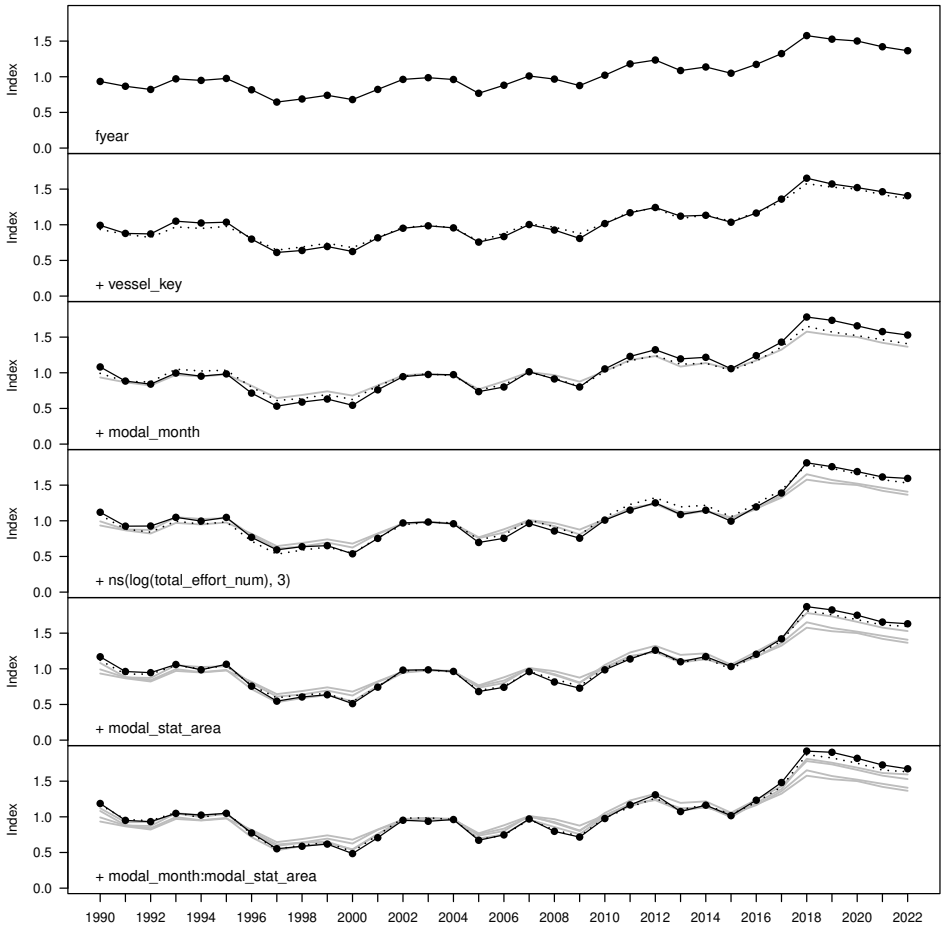


Figure 43: Step plot for occurrence of catch in the SKI1 SKI2 BT-TAR trip dataset.

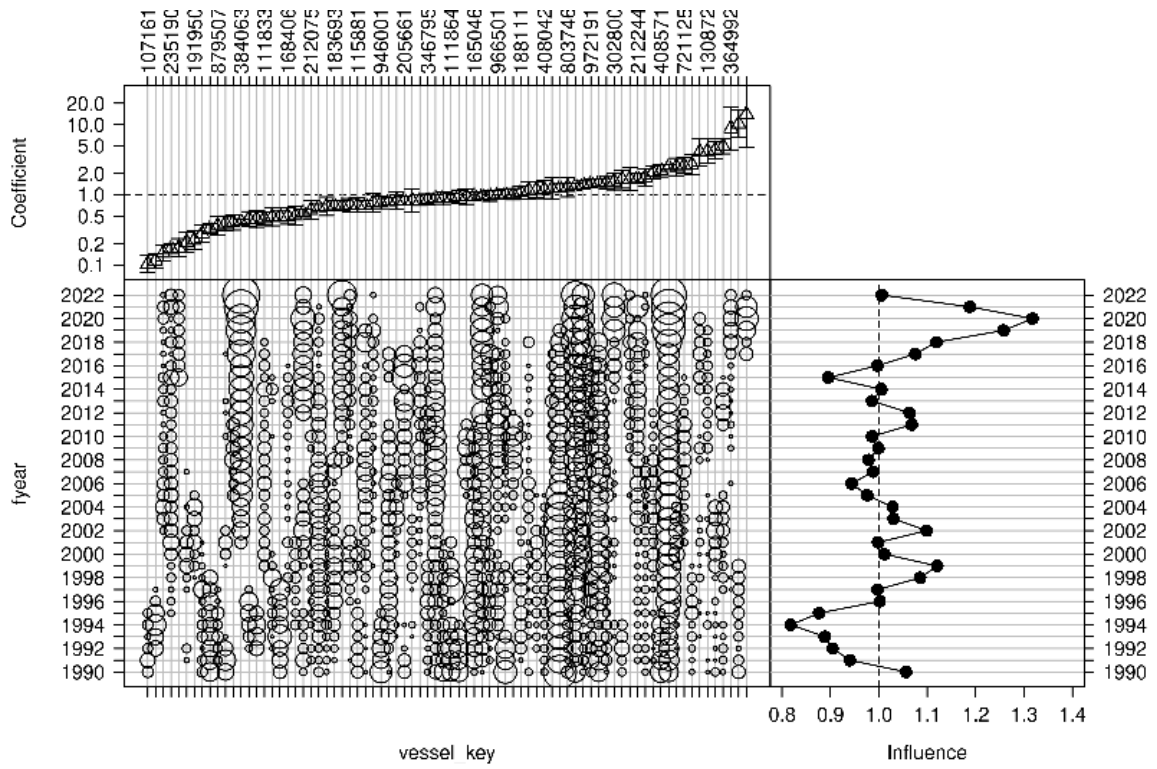


Figure 44: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

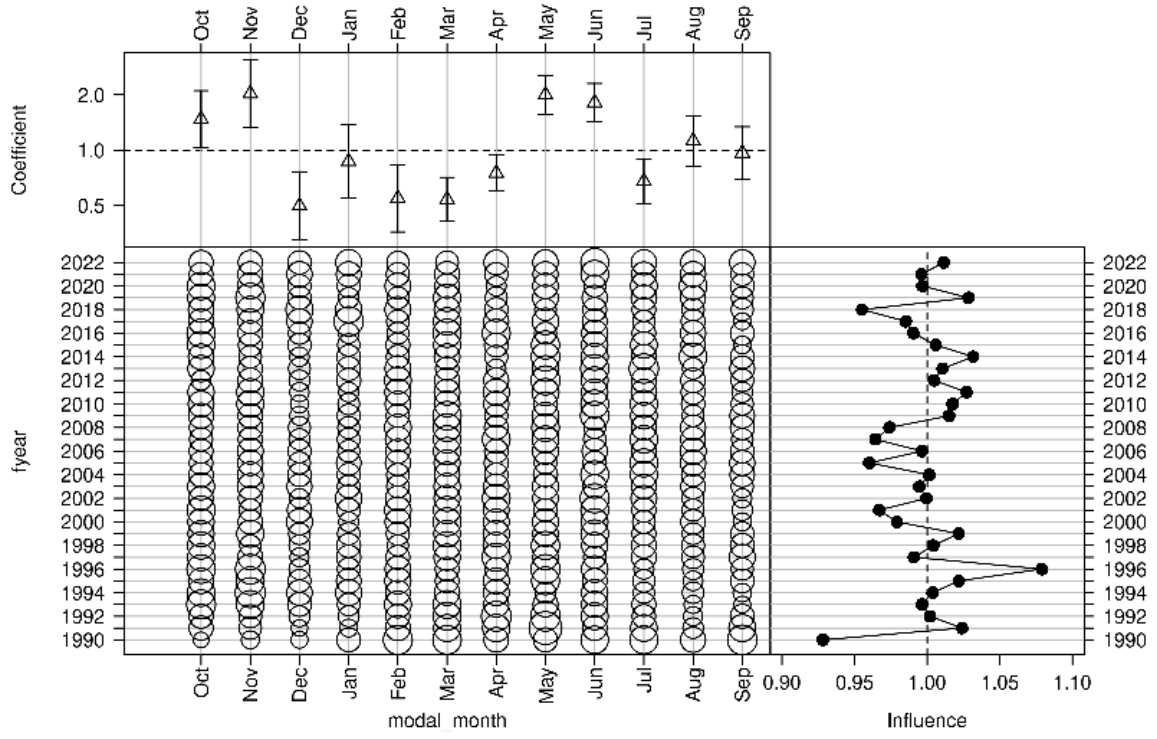


Figure 45: CDI plot for modal month for the occurrence of positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

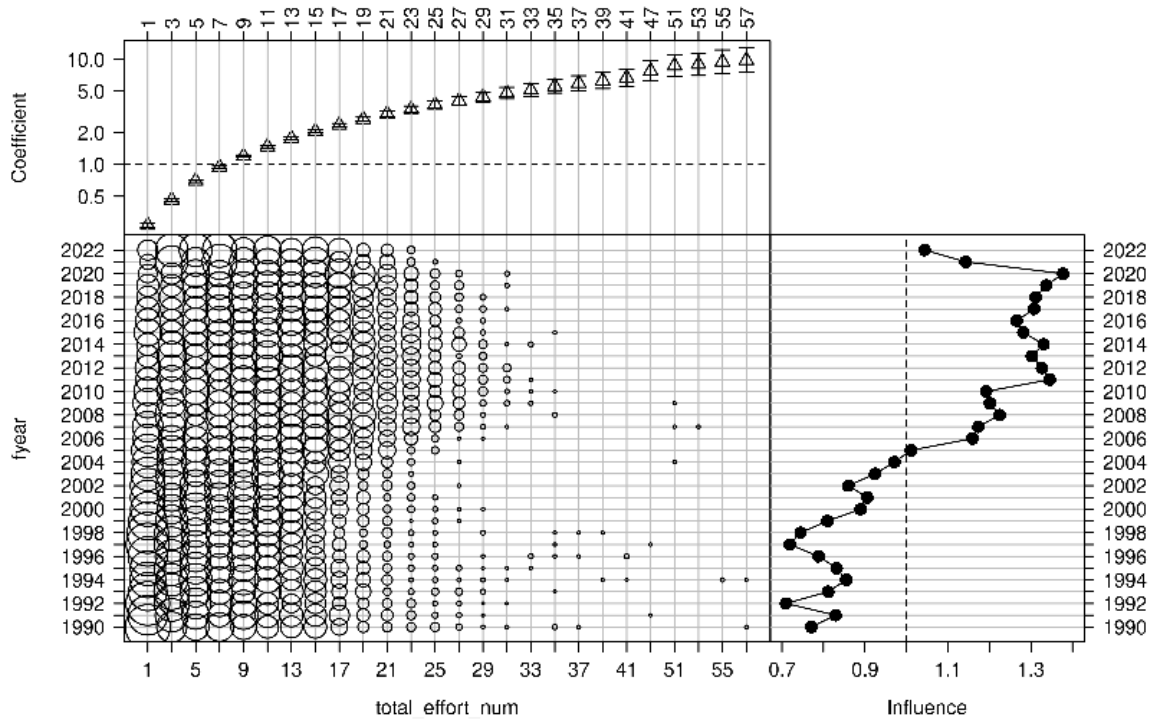


Figure 46: CDI plot for log total effort num for the occurrence of positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

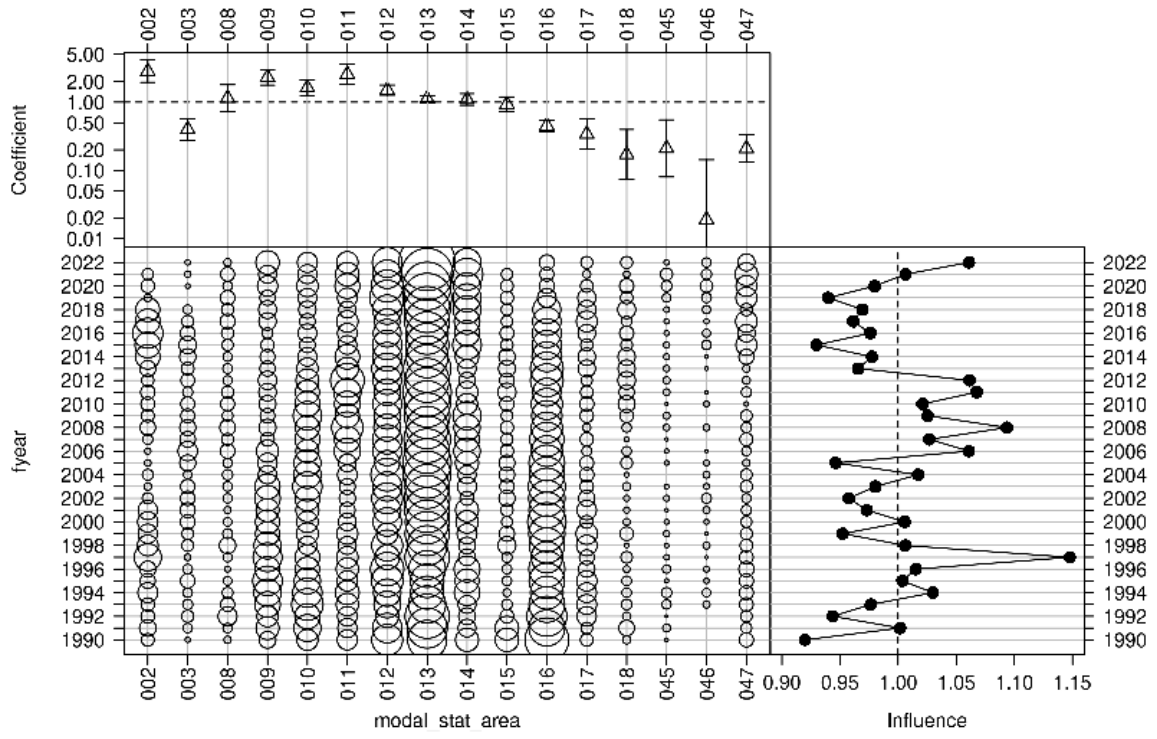


Figure 47: CDI plot for modal statistical area for the occurrence of positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

Table 8: Summary of stepwise selection for the lognormal model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	31	47 864	6.0	6.0	*
+ vessel key	77	45 643	23.5	17.5	*
+ modal month	11	43 996	33.8	10.3	*
+ ns(log(total effort num), 3)	3	43 605	36.0	2.2	*
+ modal stat area	15	43 324	37.8	1.7	*
+ modal stat area:modal month	162	42 379	44.2	6.5	*
+ ns(mean fishing duration, 3)	3	42 268	44.8	0.6	
+ bs(mean effort height, 3)	3	42 242	45.0	0.2	

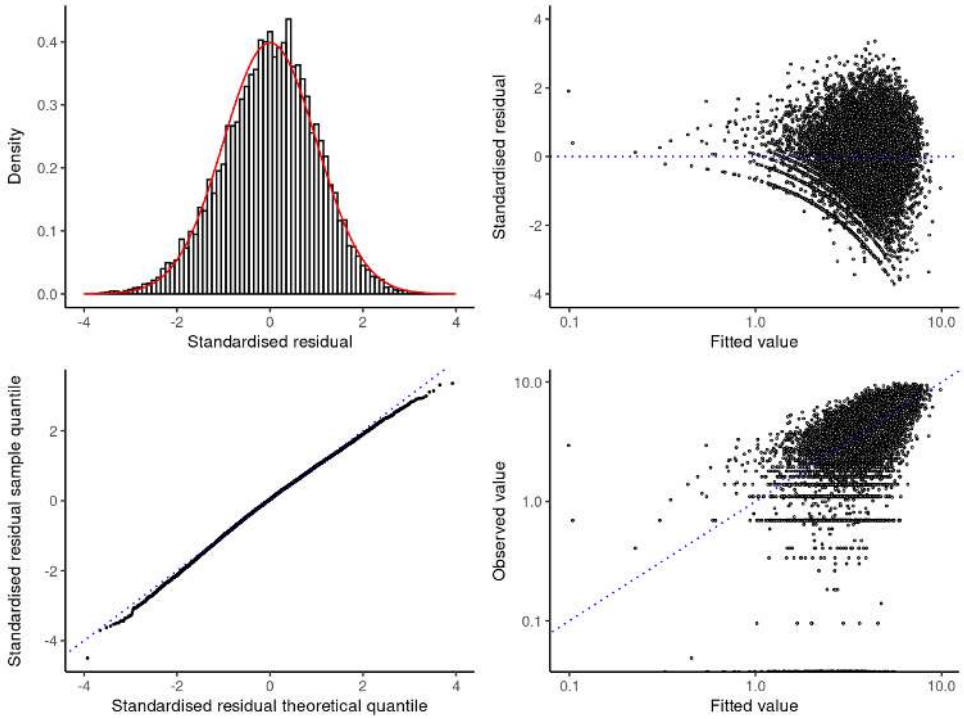


Figure 48: Diagnostic plots for the lognormal model for the SKI1 SKI2 BT-TAR trip dataset.

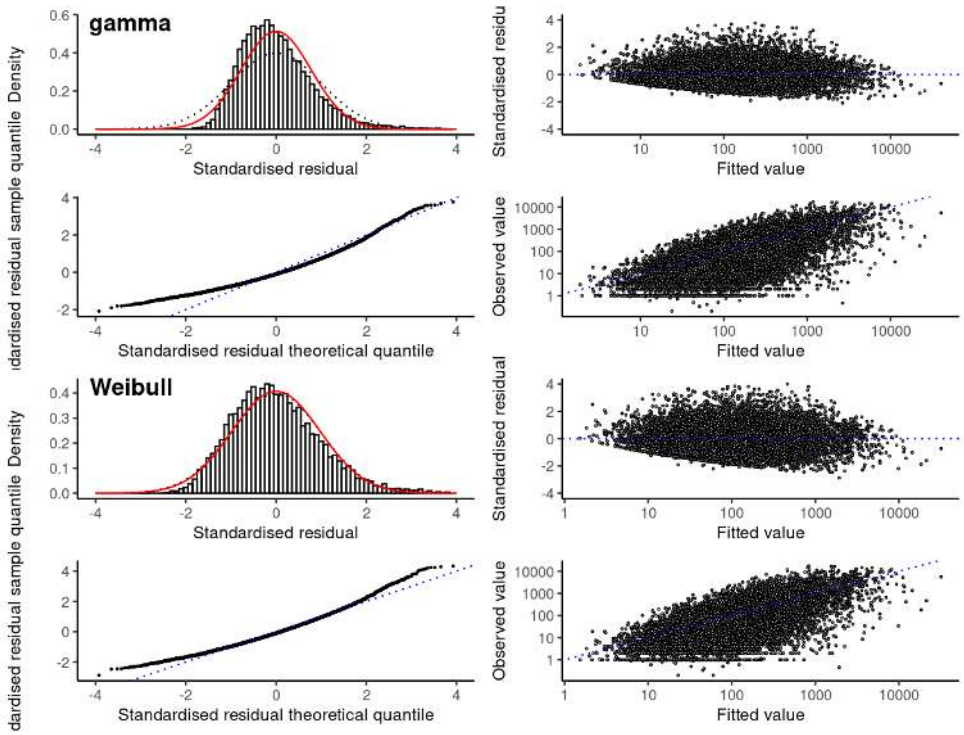


Figure 49: Diagnostic plots for the gamma and Weibull model for the SKI1 SKI2 BT-TAR trip dataset.

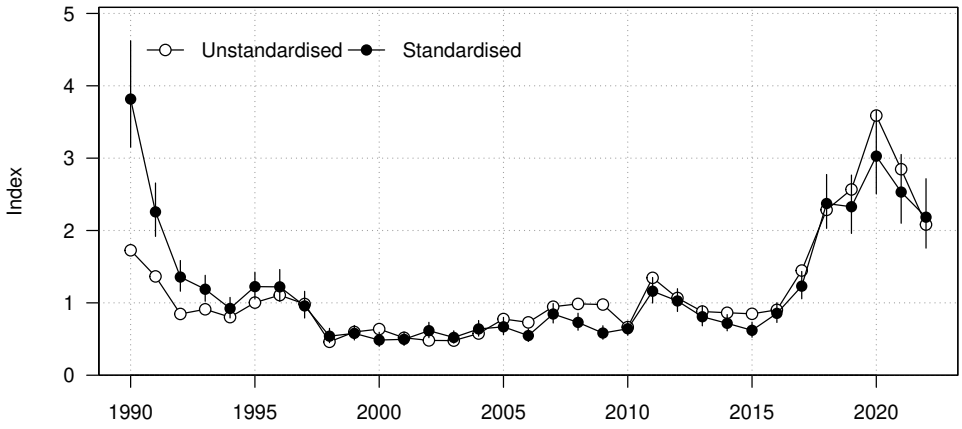


Figure 50: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 BT-TAR trip dataset.

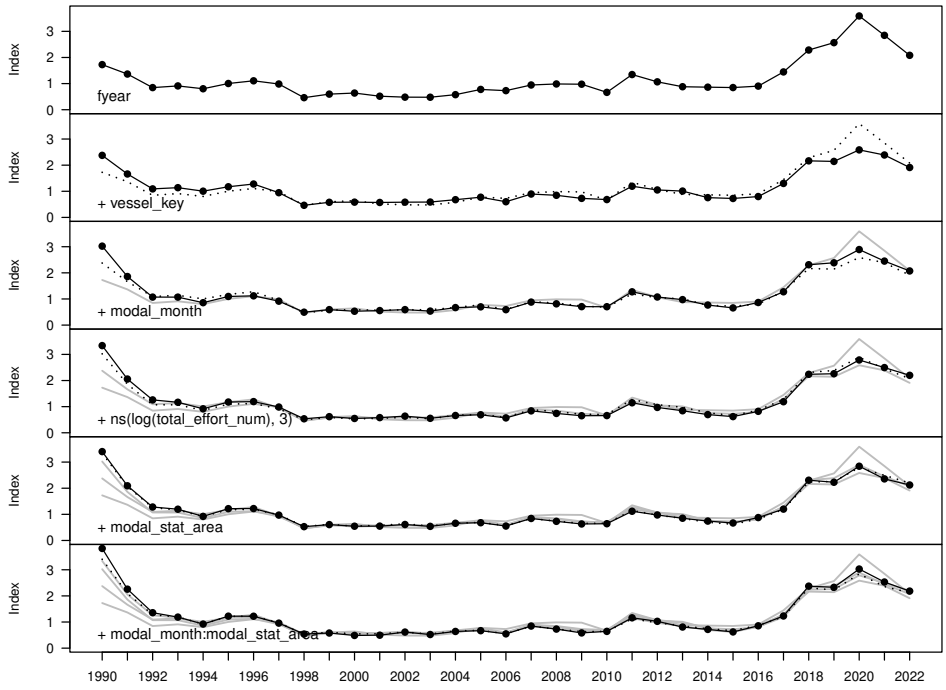


Figure 51: Changes to the SKI1 SKI2 BT-TAR trip positive catch index as terms are successively entered into the model.

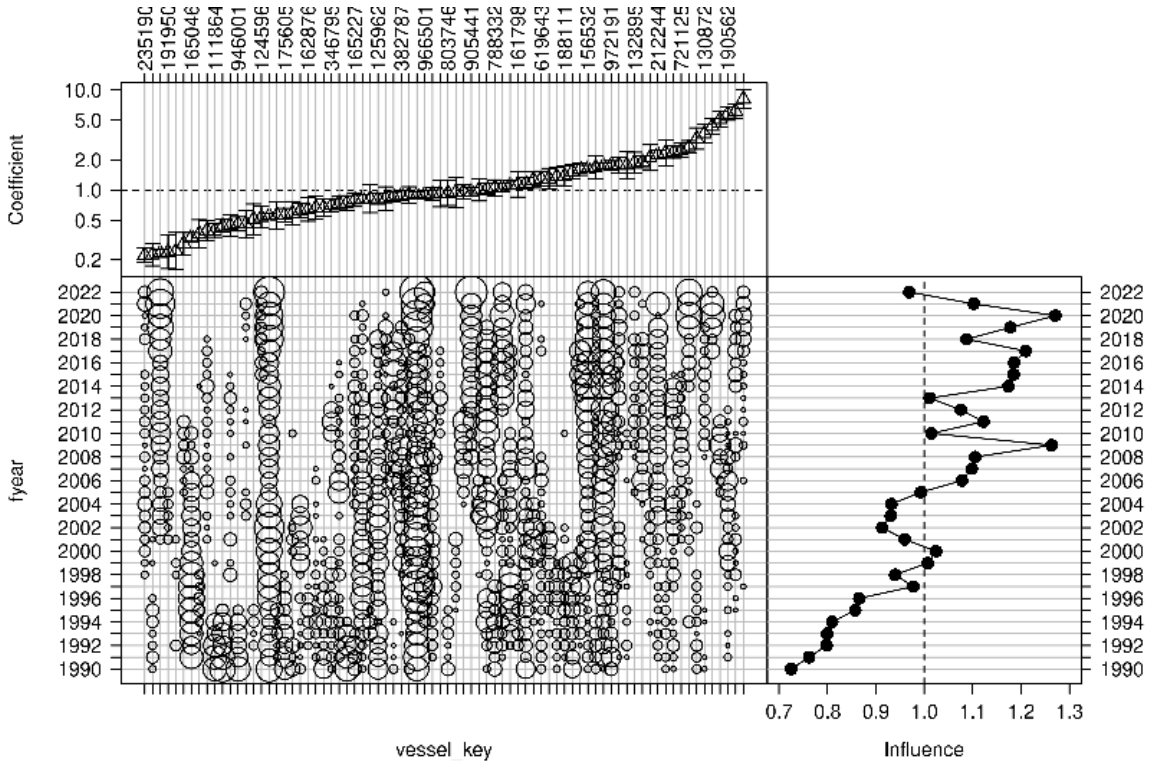


Figure 52: CDI plot for vessel key for the positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

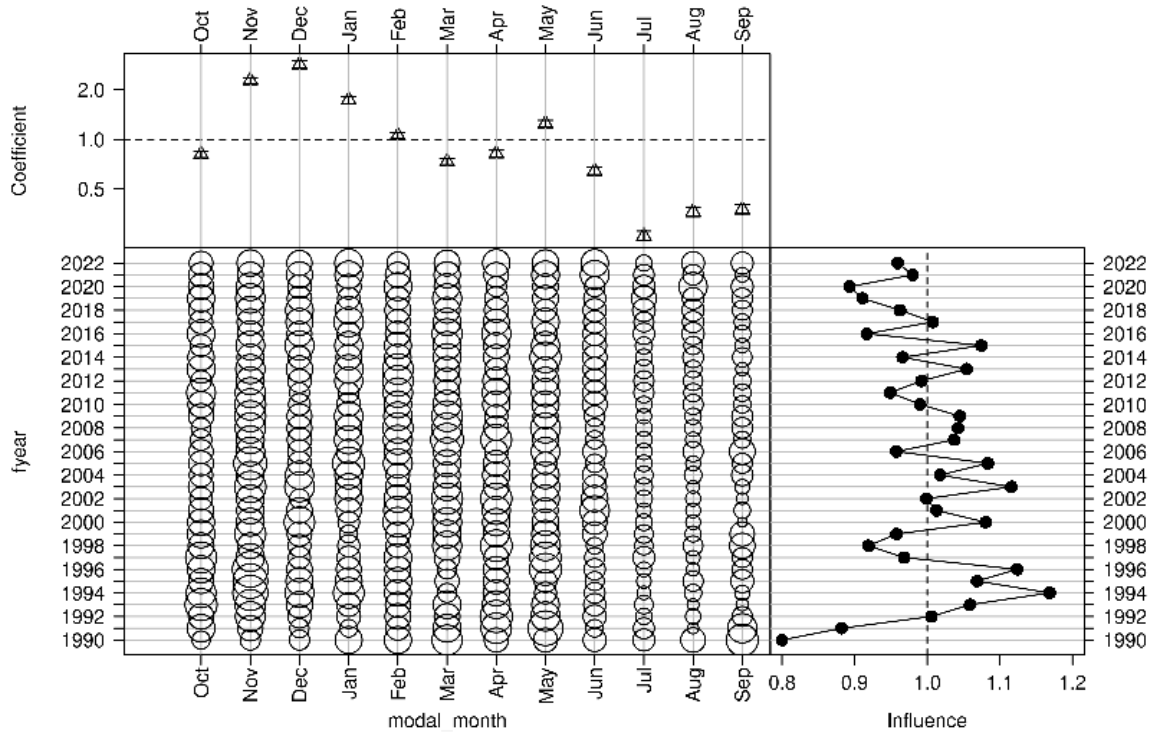


Figure 53: CDI plot for modal month for the positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

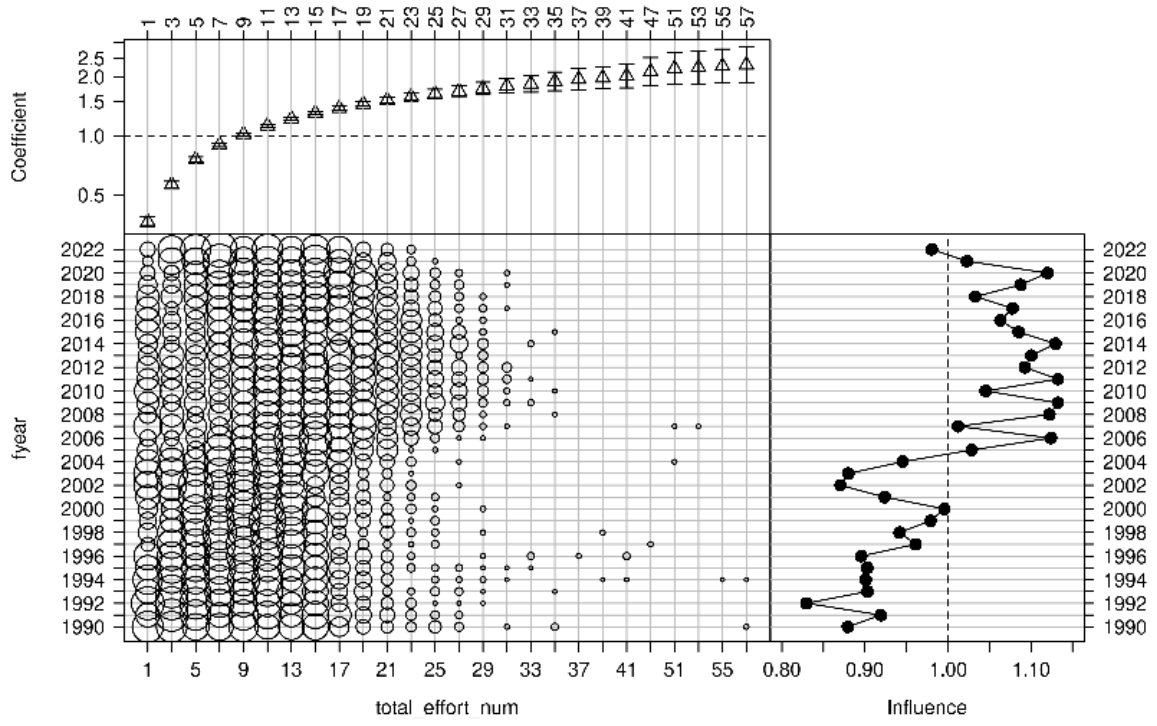


Figure 54: CDI plot for log total effort num for the positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

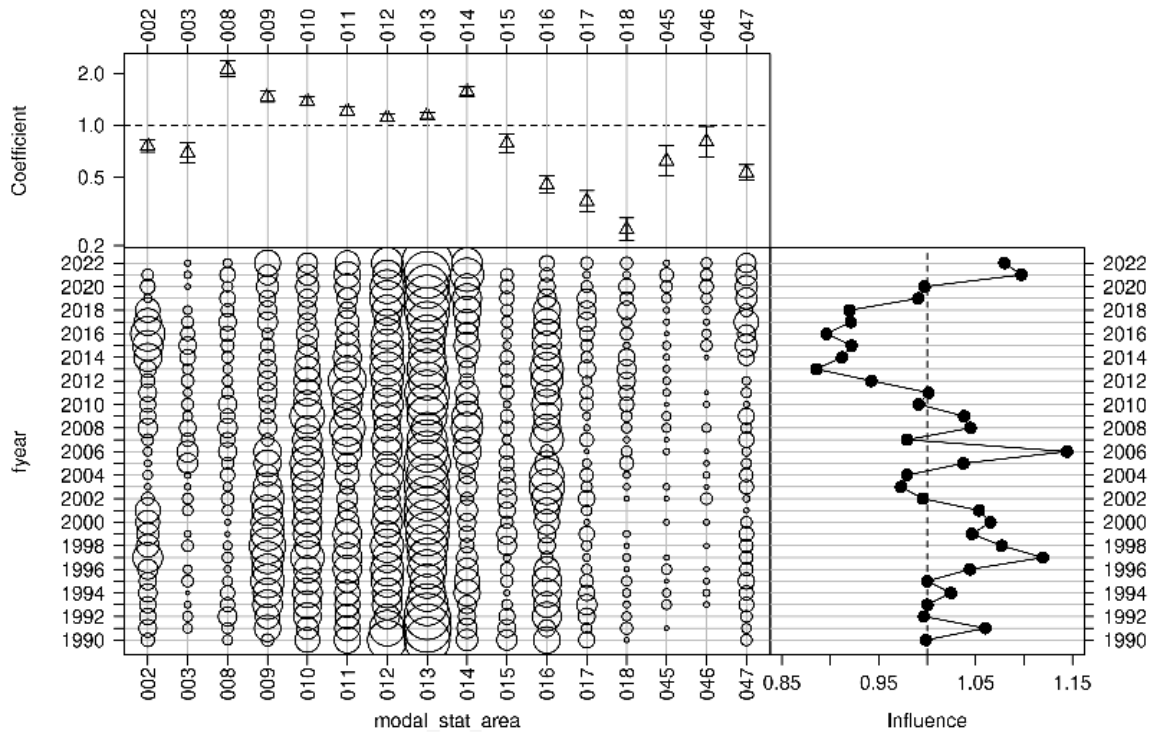


Figure 55: CDI plot for modal statistical area for the positive catch SKI1 SKI2 BT-TAR trip catch-per-unit-effort dataset.

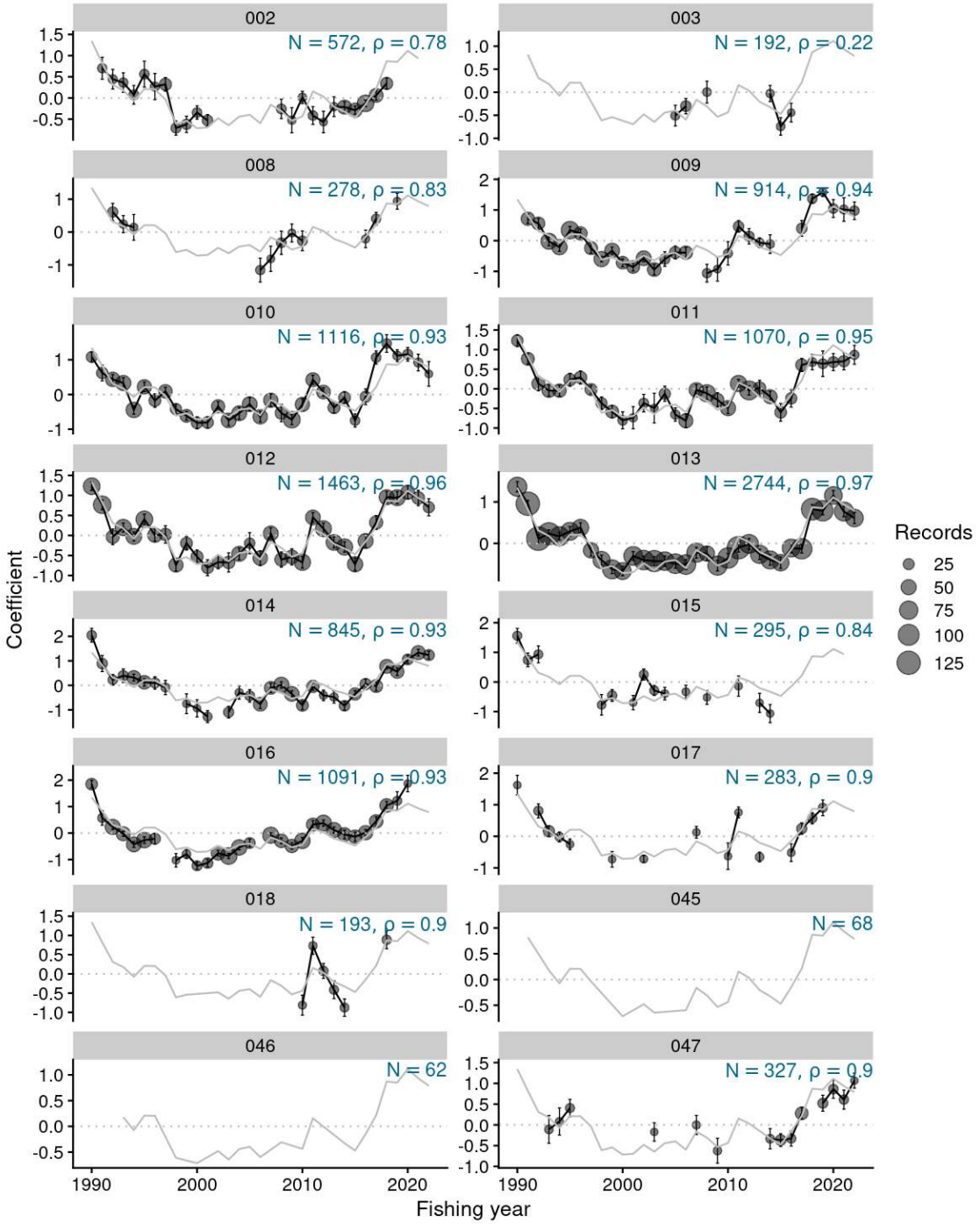


Figure 56: Residual implied coefficients for area-year in the lognormal positive catch model for the SKI1 SKI2 BT-TAR trip dataset.

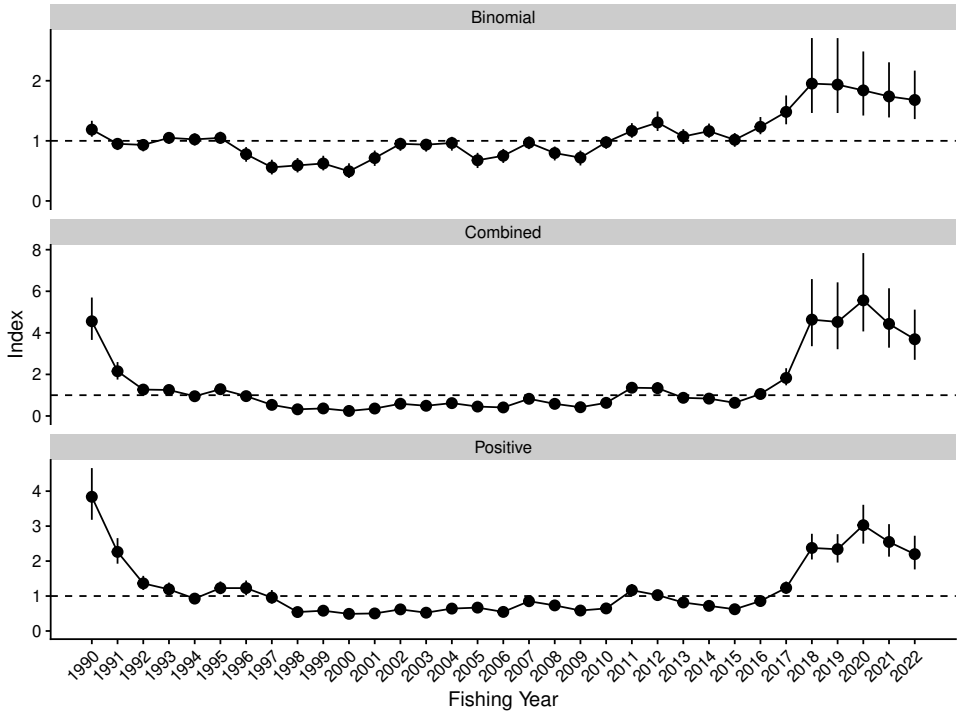


Figure 57: Standardised indices and 95% confidence intervals for the SKI1 SKI2 BT-TAR trip dataset.

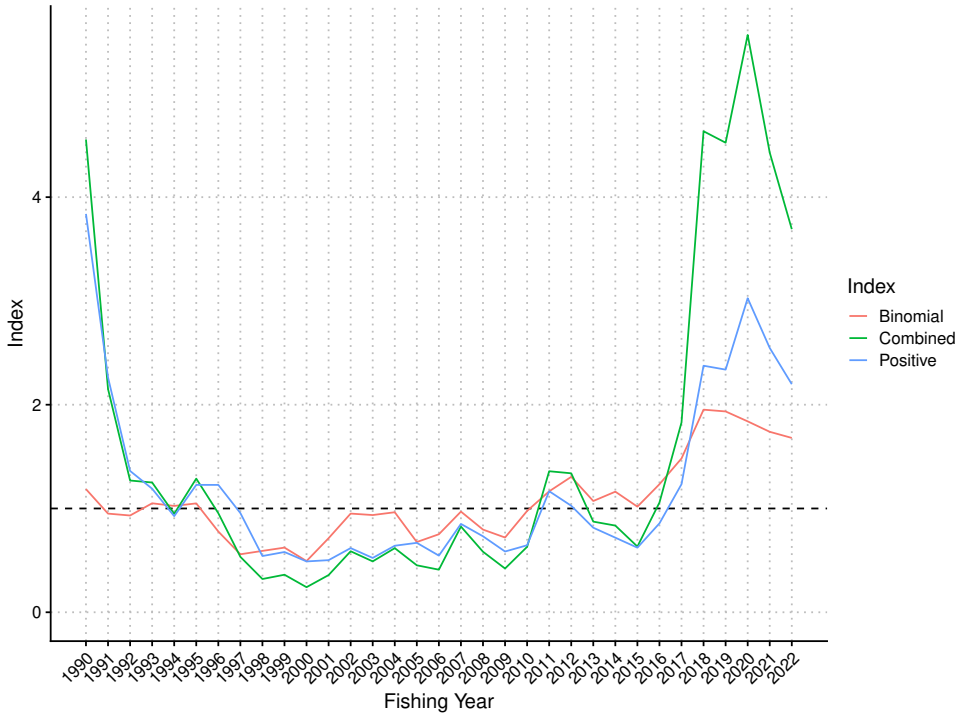


Figure 58: Standardised indices for the SKI1 SKI2 BT-TAR trip dataset.

Table 9: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 BT-TAR trip.

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1990	1.19	1.19	0.068	1.19	4.56	4.56	0.520	4.56	3.84	3.84	0.377	3.84
1991	0.95	0.95	0.051	0.95	2.15	2.15	0.215	2.15	2.26	2.26	0.187	2.26
1992	0.93	0.93	0.051	0.93	1.27	1.27	0.113	1.27	1.36	1.36	0.103	1.36
1993	1.05	1.05	0.048	1.05	1.25	1.25	0.115	1.25	1.19	1.19	0.094	1.19
1994	1.02	1.02	0.052	1.02	0.95	0.95	0.088	0.95	0.93	0.93	0.070	0.93
1995	1.05	1.05	0.051	1.05	1.29	1.29	0.116	1.29	1.23	1.23	0.093	1.23
1996	0.78	0.78	0.062	0.78	0.95	0.95	0.112	0.95	1.23	1.23	0.108	1.23
1997	0.56	0.56	0.063	0.56	0.53	0.53	0.082	0.53	0.96	0.96	0.099	0.96
1998	0.59	0.59	0.061	0.59	0.32	0.32	0.046	0.32	0.54	0.54	0.050	0.54
1999	0.62	0.62	0.062	0.62	0.36	0.36	0.050	0.36	0.58	0.58	0.047	0.58
2000	0.49	0.49	0.062	0.49	0.24	0.24	0.039	0.24	0.49	0.49	0.051	0.49
2001	0.71	0.71	0.065	0.71	0.36	0.36	0.047	0.36	0.50	0.50	0.047	0.50
2002	0.95	0.95	0.055	0.95	0.59	0.59	0.059	0.59	0.62	0.62	0.053	0.62
2003	0.94	0.94	0.054	0.94	0.49	0.49	0.047	0.49	0.52	0.52	0.042	0.52
2004	0.96	0.96	0.059	0.96	0.62	0.62	0.064	0.62	0.64	0.64	0.053	0.64
2005	0.68	0.68	0.064	0.68	0.45	0.45	0.056	0.45	0.67	0.67	0.057	0.67
2006	0.75	0.75	0.059	0.75	0.41	0.41	0.047	0.41	0.55	0.55	0.044	0.55
2007	0.97	0.97	0.053	0.97	0.83	0.83	0.083	0.83	0.85	0.85	0.071	0.85
2008	0.80	0.80	0.059	0.80	0.58	0.58	0.061	0.58	0.73	0.73	0.055	0.73
2009	0.72	0.72	0.063	0.72	0.42	0.42	0.049	0.42	0.59	0.59	0.046	0.59
2010	0.98	0.98	0.053	0.98	0.63	0.63	0.059	0.63	0.65	0.65	0.049	0.65
2011	1.17	1.17	0.062	1.17	1.36	1.36	0.127	1.36	1.17	1.17	0.089	1.17
2012	1.30	1.30	0.083	1.30	1.34	1.34	0.131	1.34	1.03	1.03	0.072	1.03
2013	1.07	1.07	0.063	1.07	0.87	0.87	0.092	0.87	0.81	0.81	0.068	0.81
2014	1.16	1.16	0.060	1.16	0.84	0.84	0.076	0.84	0.72	0.72	0.051	0.72
2015	1.02	1.02	0.058	1.02	0.63	0.63	0.065	0.63	0.62	0.62	0.051	0.62
2016	1.23	1.23	0.073	1.23	1.06	1.06	0.098	1.06	0.86	0.86	0.068	0.86
2017	1.48	1.48	0.122	1.48	1.83	1.83	0.210	1.83	1.23	1.23	0.089	1.23
2018	1.95	1.95	0.318	1.95	4.64	4.64	0.824	4.64	2.38	2.38	0.188	2.38
2019	1.94	1.94	0.318	1.94	4.52	4.52	0.821	4.52	2.34	2.34	0.207	2.34
2020	1.84	1.84	0.272	1.84	5.56	5.56	0.962	5.56	3.03	3.03	0.284	3.03
2021	1.74	1.74	0.234	1.74	4.43	4.43	0.729	4.43	2.55	2.55	0.237	2.55
2022	1.68	1.68	0.206	1.68	3.69	3.69	0.616	3.69	2.20	2.20	0.246	2.20

4.3 SKI1 SKI2 HOK-SKI event

The HOK-SKI event series is defined in Table 10. The data are restricted to the Bay of Plenty area of SKI 1, and SKI 2, because there has been little target fishing for gemfish in the areas off the northern east and west coasts of the North Island since the early 2000s (Figure 26). Gemfish target fishing is supplemented by hoki target events as catch composition is similar (Appendix C), and midwater trawls fished within 10 m of the sea floor are included along with bottom trawl events. Data are included from the 1994 fishing year onwards as this represents the point from which a substantial proportion of gemfish catch and effort was reported at the event level (Figure 21, Figure 32).

The core vessel selection retains 93% of the catch while reducing the core fleet in the modelling dataset to 52 vessels (Figure 59). The resulting fleet shows acceptable overlap, although few vessels have operated continuously over the period and some particularly active vessels left the fishery in the mid-2000s (Figure 60). The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 11.

The core fleet dataset (Table 12) peaks at 35 vessels in 1997, reducing to 10 vessels by 2022. Effort has been quite variable; the fleet undertook over 300 trips, with over 2000 hours of fishing, in 1997 and 1998. However, in 2007 and 2008 less than 100 trips were undertaken. Over the decade to 2021, activity was reasonably consistent with 300–600 tows from 120–180 trips providing 100–200 tonnes of catch, except in 2016 when the core fleet catch dipped to 77 t. There was a further reduction in catch and activity in 2022, despite the research allowance for target catch. Over much of the series, gemfish were caught in at least 60% of events but this has increased to more than 85% of events in 2020–2022. Allocation of trip catch to individual fishing events is exclusively on the basis of estimated catch (Figure 61).

Stepwise selection for the binomial model, standardising the probability that a trip catches gemfish, retains target species, vessel, month, and area, together with a month:area interaction (Table 13). For much of the series, there is little effect of standardisation (Figure 62). However, at the start (1994–1996) and end (2020–2021) of the series the standardised index is somewhat lower than the unstandardised series, with target species and vessel being the main explanatory variables responsible for this change (Figure 63).

The influence of vessels (Figure 64) was dominated by a recent (2020–2021) increase in activity by two vessels with especially high probabilities of catching gemfish, although that activity did not continue in 2022. Gemfish target trawls were much more likely to catch gemfish than hoki target trawls (Figure 65); as a result, a general reduction in gemfish targeting over the course of the series, and a particularly sharp reduction in the final 3–4 years, together with a gradual increase in hoki target trawling led to a generally reducing influence of target species over the course of the series.

In common with the BT-TAR series, there is a higher probability of gemfish catch in May–June and September–November, likely related to the migrations to and from spawning grounds (Figure 66). Statistical Areas 008 and 013 have higher probabilities of catching gemfish, whereas adjoining areas (Statistical Areas 009, 014) have lower probabilities (Figure 67). Spatial and temporal patterns of effort have varied over the series, with neither month or area having especially high influence (and recalling that there is also an interaction between area and month).

Stepwise selection for the Weibull model of positive catches retains all the explanatory variables offered, with the exception of method (Table 14). The duration of the tow is the last variable to enter the model, with the headline height of the trawl (`effort_height`) also retained. Likewise, the depth of fishing (`bottom_depth`) is retained in addition to the statistical area. Diagnostics for the Weibull model (Figure 68) are reasonable, and noticeably better than those for alternative error distributions considered (Figure 69).

The impact of standardisation on positive catches was apparent throughout the series, with the standardised index lower than the unstandardised index from 1994–2000, substantially higher from

2018–2022, and noticeably smoothed from 2001–2015 (Figure 70). Step plots (Figure 71) demonstrate that the vessel effect is primarily responsible for the reduced index for 1994–2000, while the increase in the standardised series during 2018–2022 is primarily due to the change in targeting. The area:month interaction has a particular impact in raising the 2021 and 2022 indices.

Turnover in the fleet resulted in the influence of vessels on positive catch quantities generally decreasing from the mid-1990s to 2013, then generally increasing to 2021 before dropping again in 2022 (Figure 72). The influence of target species has shown an overall decrease over the series (Figure 73). Catch quantities are expected to be higher in Statistical Area 011 (Figure 74) and lower in July–September (Figure 75), with varying influence from these variables over the series due to shifting fishing patterns. Catches are expected to be larger for tows in bottom depths of 200 m to 400 m (Figure 76); with the exception of 1994 where fishing extended to shallower depths, the influence of fishing depth gradually decreased from the mid-1990s to 2014, with a bimodal fishing depth range developing during 2008–2016. Over recent years (2017–2022) the depths fished have become focussed in the 350 m to 450 m range.

The effect of headline height on gemfish catch is rather small for much of the range in observed sizes, but indicates a slight increase for nets with 10 m to 20 m headline heights and reduced catches for nets with larger headline heights (Figure 77). Much of the variation in headline heights used over time relates to the more sporadic use of midwater gear by vessels in the core fleet; for the bottom trawl effort there has been a reduced use of higher opening nets since the mid-2000s. Gemfish catch quantities generally increase with tow duration (Figure 78); tow durations decreased during 1994–2000, but generally increased over the period 2001–2018.

Residual implied coefficients by target species (Figure 79) show similar trends for the hoki and gemfish target effort, but with more variability in the gemfish indices since 2010 as the amount of gemfish target effort has declined. Trends are similar in all of the statistical areas included in the series (Figure 80). Fishing method (i.e., bottom vs. midwater trawling) was not selected in the final model; residual implied coefficients suggest similar trends but with a general lack of midwater trawl effort in recent years (Figure 81).

While there is a slight trend in the final binomial index over the period, with reduced probability of capture in 1997–1999 and increased probability in 2020–2022 (Figure 82), the change in the magnitude of positive catches is considerably larger, and it is this index that dominates the combined series (Figure 82, Figure 83, Table 15). The final combined index drops by more than 50% from 1994 to 2002, but then increases by 2–3 times over the period 2002–2004. The index is then stable or slightly decreasing to 2017 after which a fourfold to fivefold increase is seen over the period to 2022.

Table 10: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 HOK-SKI event CPUE series.

Series	SKI1 SKI2 HOK-SKI event
QMS stock	SKI1, SKI2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW
Target species	SKI, HOK
Areas	008, 009, 010, 011, 012, 013, 014, 015
Period	1993-10-01, 2022-09-30
Resolution	Fishing event
Core fleet years	3
Core fleet trips	3
Default model	allockg_top5 ~ fyear + vessel_key + target_species + primary_method + bs(log(fishing_duration), 3) + stat_area*month + bs(bottom_depth, 3) + bs(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

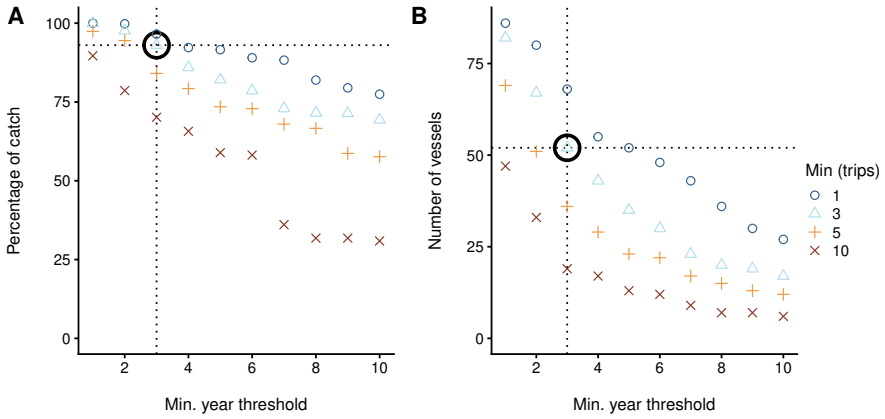


Figure 59: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 HOK-SKI event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

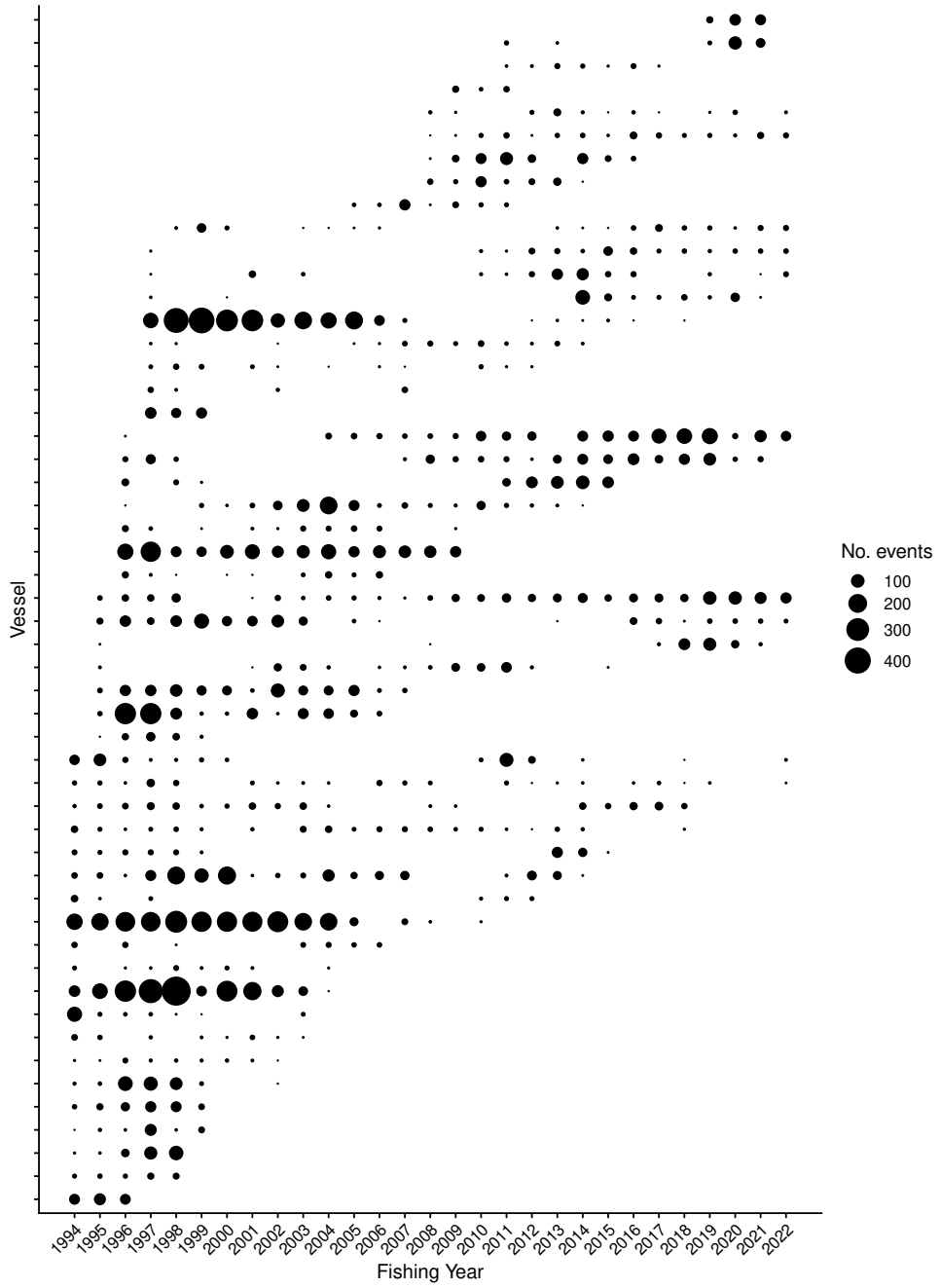


Figure 60: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 11: Summary of SKI1 SKI2 HOK-SKI event total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ungroomed data	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Fishing duration is not NA	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Positive fishing duration	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 917)	(Records: 2108)	(Records: 2823)	(Records: 2609)	(Records: 1372)	(Records: 1347)	(Records: 1228)	(Records: 968)	(Records: 991)	(Records: 1045)	(Records: 626)
Bottom depth >=50	768	650	635	731	502	280	455	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1147)	(Records: 909)	(Records: 2043)	(Records: 2772)	(Records: 2446)	(Records: 1361)	(Records: 1343)	(Records: 1225)	(Records: 968)	(Records: 987)	(Records: 1036)	(Records: 622)
Bottom depth <=600	767	650	634	727	502	280	454	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2023)	(Records: 2654)	(Records: 2383)	(Records: 1340)	(Records: 1308)	(Records: 1182)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Effort height <100	767	650	630	711	498	280	454	277	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2000)	(Records: 2594)	(Records: 2357)	(Records: 1336)	(Records: 1297)	(Records: 1176)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Midwater effort depth <=10 m from bottom	760	641	630	709	498	280	451	277	205	295	331	281
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1123)	(Records: 881)	(Records: 1989)	(Records: 2570)	(Records: 2279)	(Records: 1305)	(Records: 1208)	(Records: 1090)	(Records: 868)	(Records: 892)	(Records: 957)	(Records: 572)
Core fleet selection	482	591	592	666	497	279	451	277	204	295	327	281
	(Percent: 63)	(Percent: 91)	(Percent: 92)	(Percent: 90)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 652)	(Records: 686)	(Records: 1550)	(Records: 2081)	(Records: 2180)	(Records: 1270)	(Records: 1205)	(Records: 1069)	(Records: 859)	(Records: 887)	(Records: 944)	(Records: 570)

Filter	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Fishing duration is not NA	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Positive fishing duration	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth >=50	182 (Percent: 100) (Records: 367)	236 (Percent: 100) (Records: 367)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth <=600	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Effort height <100	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Midwater effort depth <=10 m from bottom	182 (Percent: 100) (Records: 353)	236 (Percent: 100) (Records: 349)	145 (Percent: 100) (Records: 259)	179 (Percent: 100) (Records: 298)	239 (Percent: 100) (Records: 468)	221 (Percent: 100) (Records: 571)	152 (Percent: 100) (Records: 388)	130 (Percent: 100) (Records: 506)	247 (Percent: 100) (Records: 693)	86 (Percent: 100) (Records: 383)	251 (Percent: 100) (Records: 385)	192 (Percent: 91) (Records: 361)
Core fleet selection	182 (Percent: 100) (Records: 352)	235 (Percent: 100) (Records: 345)	143 (Percent: 100) (Records: 248)	178 (Percent: 100) (Records: 291)	235 (Percent: 100) (Records: 412)	206 (Percent: 92) (Records: 527)	103 (Percent: 67) (Records: 376)	121 (Percent: 92) (Records: 494)	238 (Percent: 100) (Records: 671)	77 (Percent: 90) (Records: 362)	243 (Percent: 100) (Records: 370)	174 (Percent: 82) (Records: 337)

Filter	2018	2019	2020	2021	2022
Ungroomed data	181 (Percent: 100) (Records: 493)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Fishing duration is not NA	181 (Percent: 100) (Records: 493)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Positive fishing duration	181 (Percent: 100) (Records: 492)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Bottom depth >=50	181 (Percent: 100) (Records: 492)	295 (Percent: 100) (Records: 777)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 388)	178 (Percent: 100) (Records: 368)
Bottom depth <=600	180 (Percent: 100) (Records: 483)	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Effort height <100	180 (Percent: 100) (Records: 483)	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Midwater effort depth <=10 m from bottom	160 (Percent: 89) (Records: 413)	158 (Percent: 54) (Records: 570)	246 (Percent: 92) (Records: 433)	156 (Percent: 92) (Records: 358)	69 (Percent: 39) (Records: 205)
Core fleet selection	140 (Percent: 78) (Records: 386)	145 (Percent: 49) (Records: 516)	238 (Percent: 89) (Records: 417)	154 (Percent: 91) (Records: 357)	69 (Percent: 39) (Records: 201)

Table 12: Summary of the SKI1 SKI2 HOK-SKI event dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of event with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1994	20	125	652	2 677.07	481.80	86.66
1995	25	137	686	2 117.55	590.70	79.59
1996	30	279	1 550	4 710.60	592.28	71.48
1997	35	341	2 081	6 663.35	665.98	62.18
1998	32	355	2 180	7 361.53	496.94	61.10
1999	26	217	1 270	3 797.65	278.69	60.63
2000	17	173	1 205	2 955.47	450.80	70.95
2001	21	167	1 069	2 573.82	277.06	69.50
2002	20	179	859	2 532.13	203.98	72.18
2003	21	178	887	2 972.67	295.10	74.97
2004	20	188	944	3 387.62	326.76	70.97
2005	17	129	570	2 060.32	281.21	69.65
2006	19	117	352	1 315.00	182.45	62.50
2007	16	94	345	1 396.52	235.28	74.78
2008	17	86	248	1 075.20	142.85	69.35
2009	16	116	291	1 192.07	178.24	71.82
2010	18	147	412	1 852.55	235.27	76.94
2011	22	166	527	2 128.12	205.63	66.22
2012	21	128	376	1 433.35	102.66	67.82
2013	19	178	494	2 051.78	120.61	68.02
2014	22	182	671	2 347.53	237.66	73.17
2015	16	121	362	1 325.65	77.44	61.60
2016	15	128	370	1 643.67	243.12	74.59
2017	13	116	337	1 542.97	174.08	70.92
2018	14	127	386	1 889.25	140.37	79.53
2019	14	135	516	2 516.17	145.27	66.67
2020	12	143	417	1 949.05	237.70	90.17
2021	12	142	357	1 721.65	154.37	90.48
2022	10	80	201	884.80	68.63	86.57

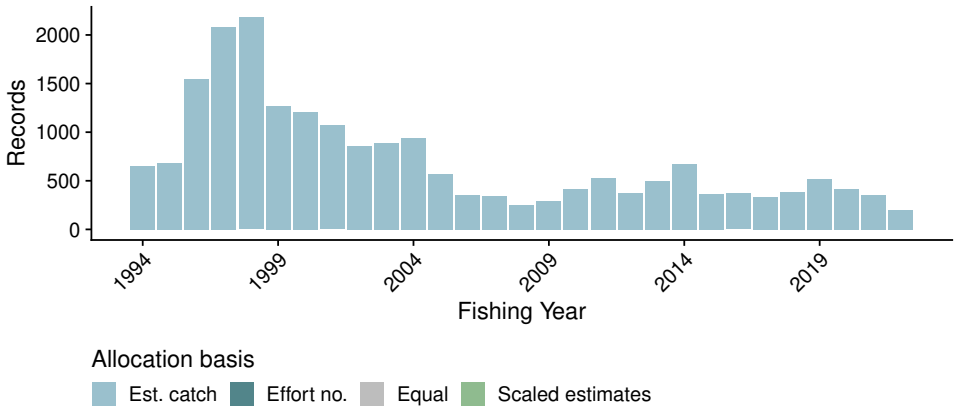


Figure 61: Allocation basis for attributing landings to records in the SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table 13: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	27.00	24 618	2.50	2.50	*
+ vessel_key	51.00	21 922	13.60	11.10	*
+ target_species	1.00	21 085	16.90	3.30	*
+ bs(bottom_depth, 3)	3.00	20 910	17.60	0.70	
+ month	11.00	20 727	18.40	0.80	*
+ bs(log(fishing_duration), 3)	3.00	20 671	18.70	0.20	
+ stat_area	7.00	20 597	19.00	0.40	*
+ stat_area:month	77.00	20 353	20.60	1.60	*
+ bs(effort_height, 3)	3.00	20 339	20.70	0.10	
+ primary_method	1.00	20 331	20.70	0.00	

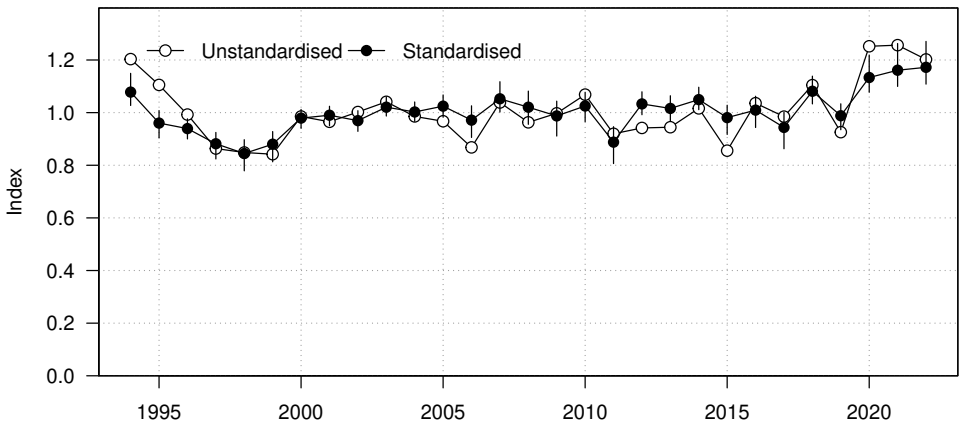


Figure 62: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 HOK-SKI event dataset.

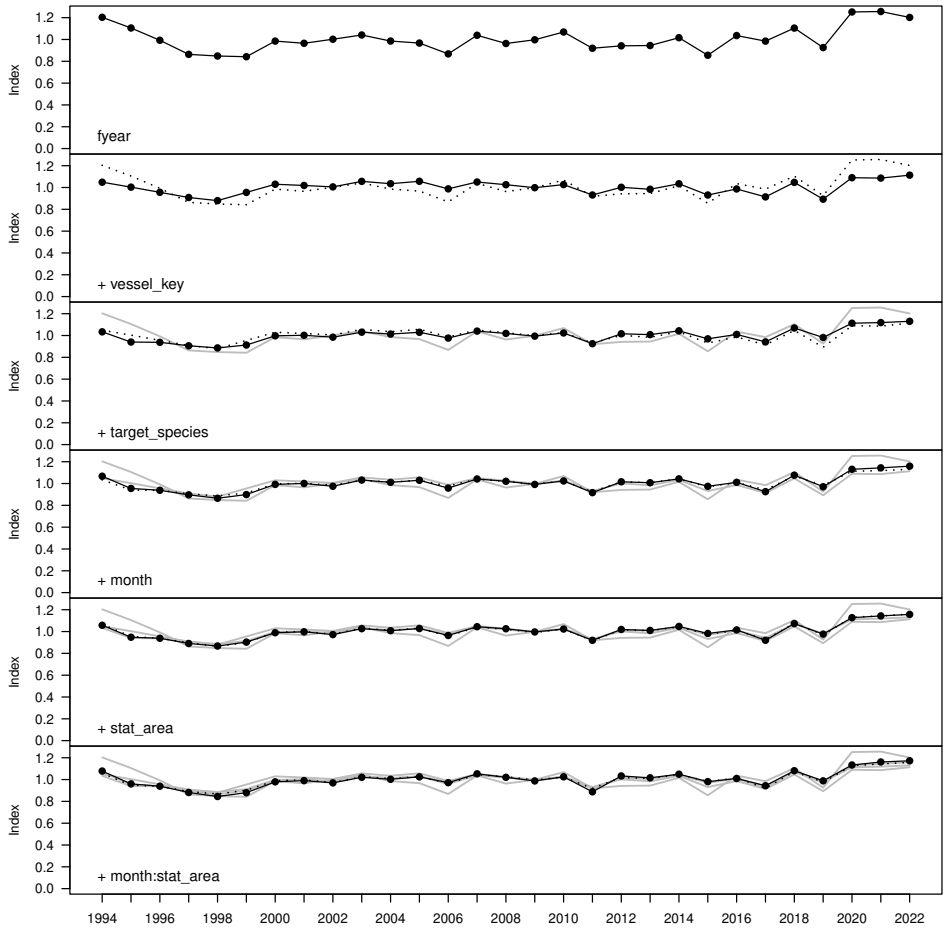


Figure 63: Step plot for occurrence of catch in the SKI1 SKI2 HOK-SKI event dataset.

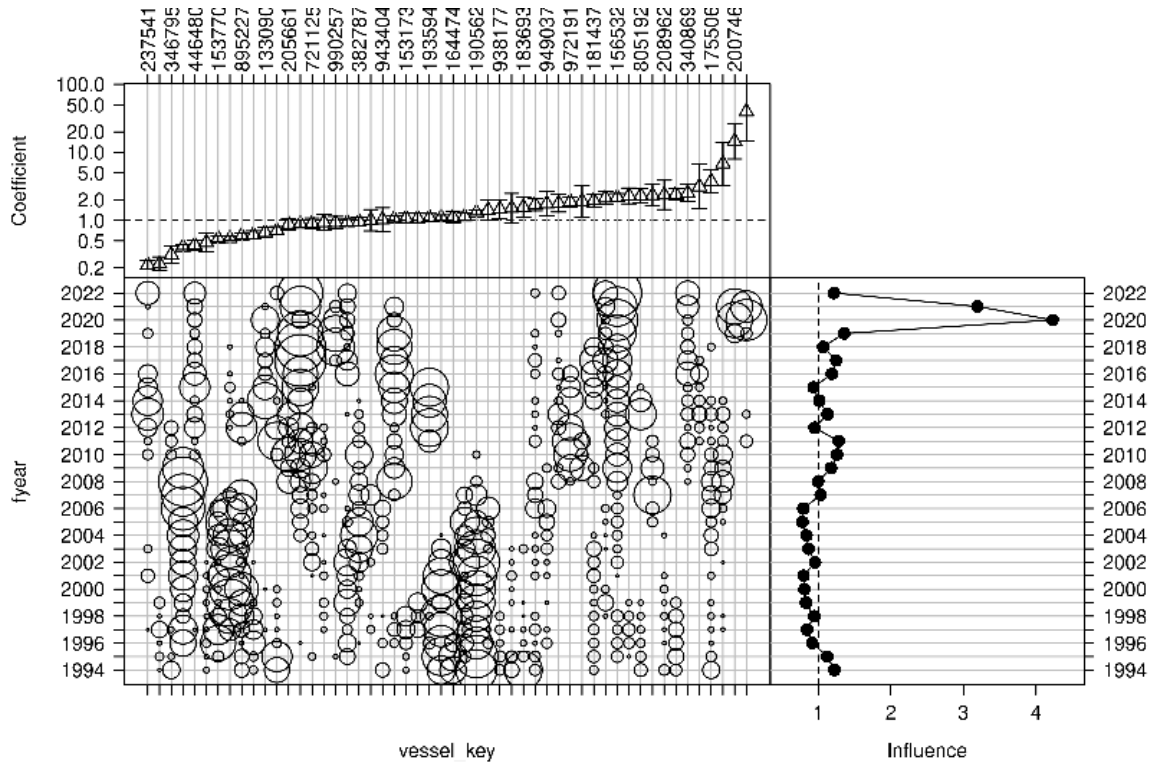


Figure 64: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

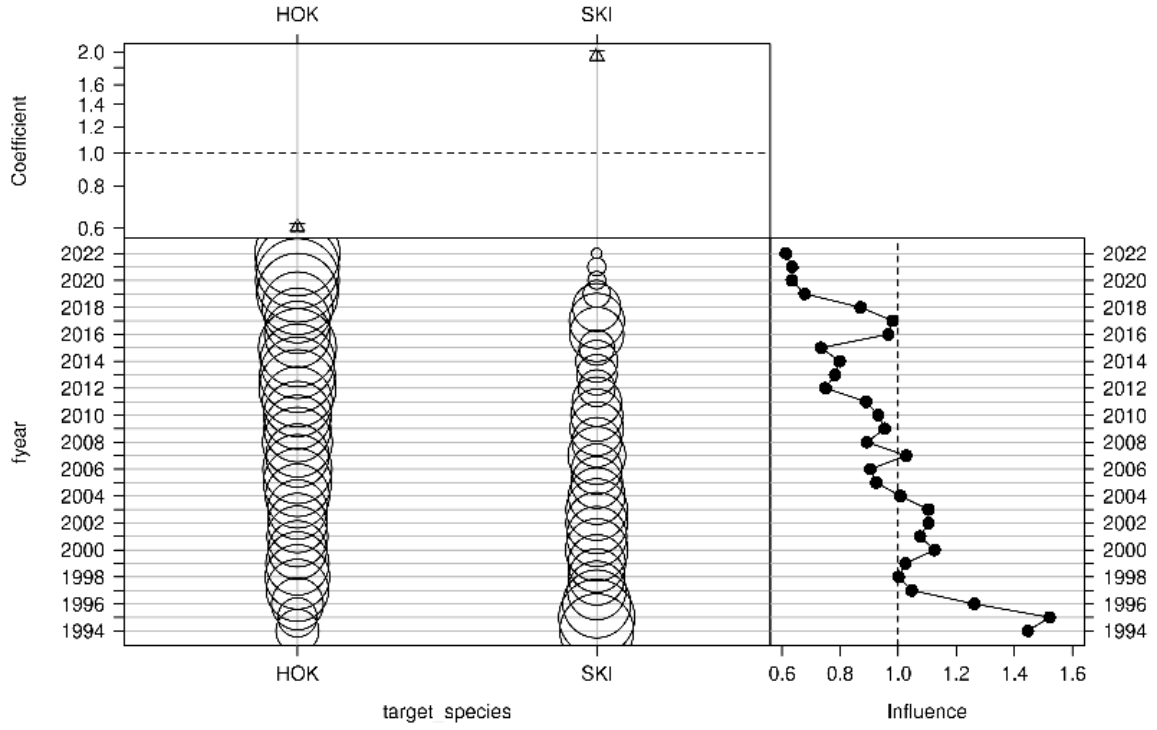


Figure 65: CDI plot for target species for the occurrence of positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

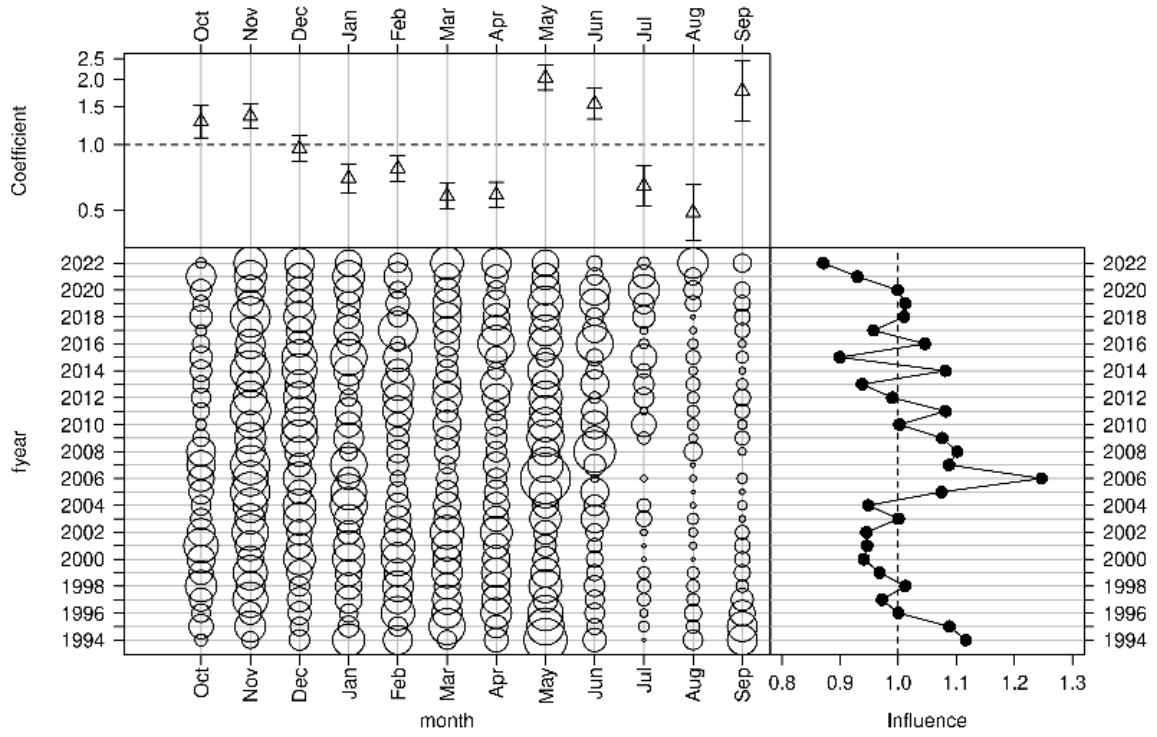


Figure 66: CDI plot for month for the occurrence of positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

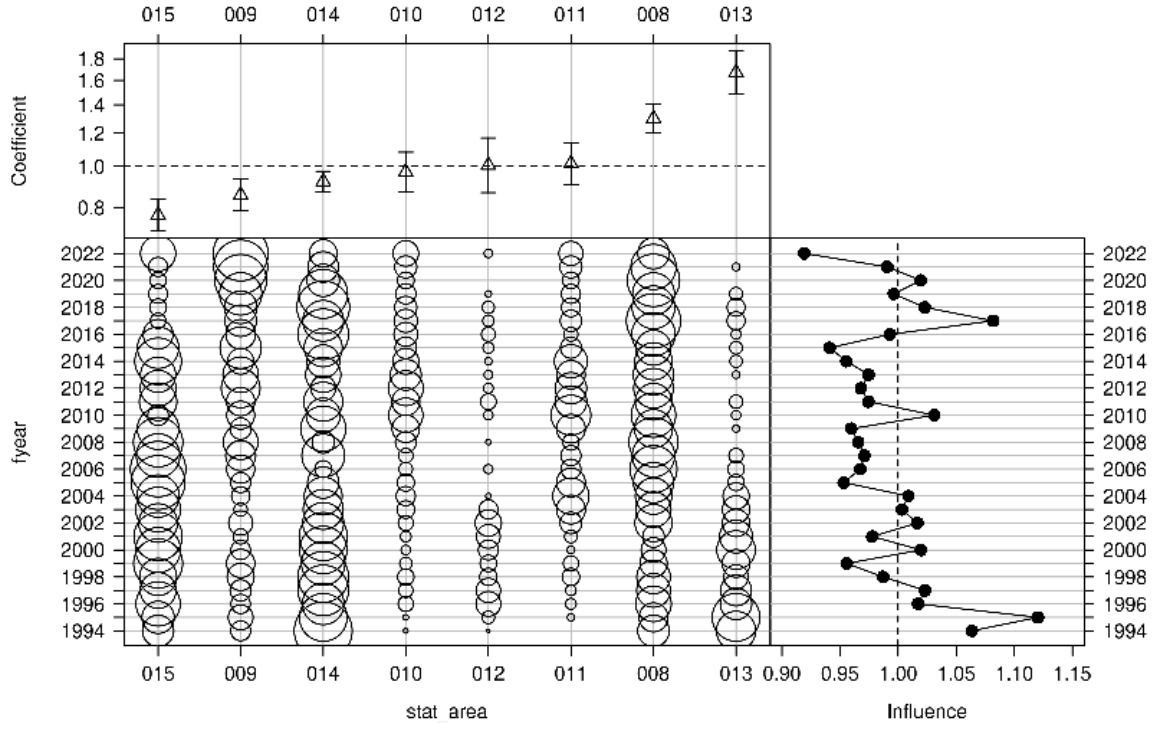


Figure 67: CDI plot for statistical area for the occurrence of positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

Table 14: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30	200 334	3.4	3.4	*
+ vessel key	51	194 703	37.8	34.4	*
+ target species	1	193 424	45.5	7.7	*
+ stat area	7	192 976	48.3	2.8	*
+ month	11	192 606	50.6	2.4	*
+ stat area:month	77	190 952	61.5	10.9	*
+ bs(bottom depth, 3)	3	190 674	63.2	1.7	*
+ bs(effort height, 3)	3	190 426	64.7	1.5	*
+ bs(log(fishing duration), 3)	3	190 233	65.9	1.2	*
+ primary method	1	190 226	65.9	0.1	

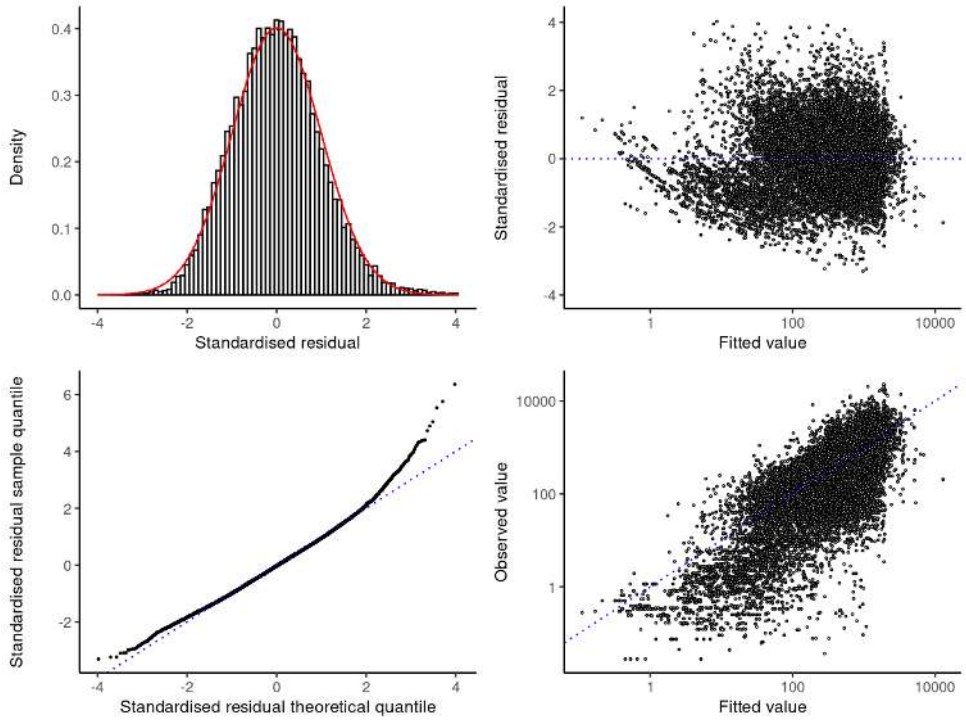


Figure 68: Diagnostic plots for the Weibull model for the SKI1 SKI2 HOK-SKI event dataset.

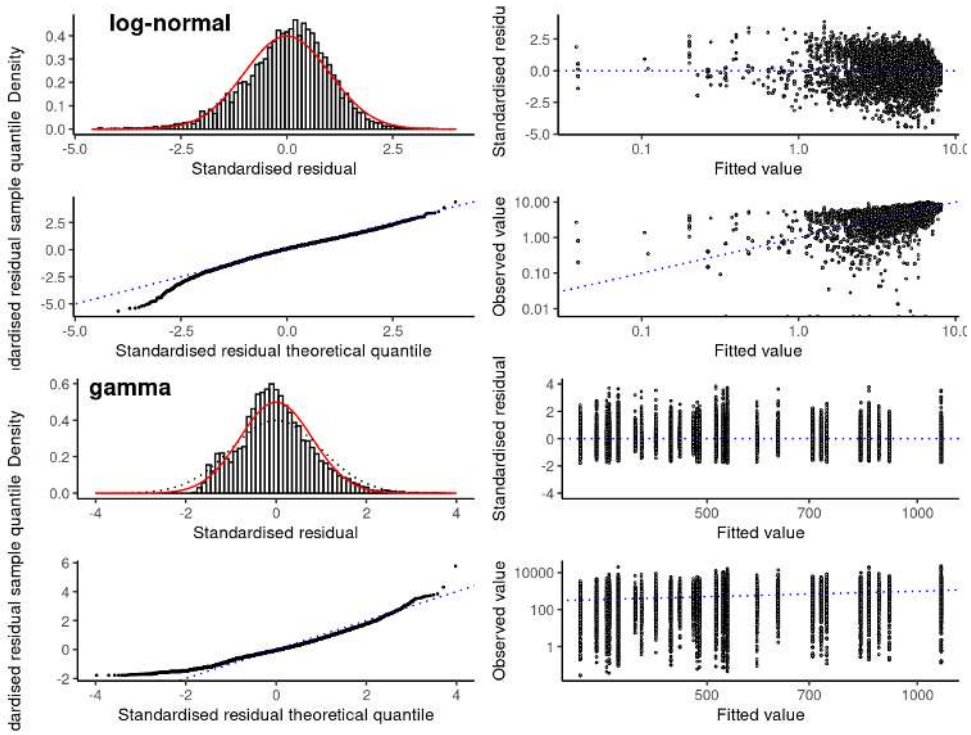


Figure 69: Diagnostic plots for the log-normal and gamma model for the SKI1 SKI2 HOK-SKI event dataset.

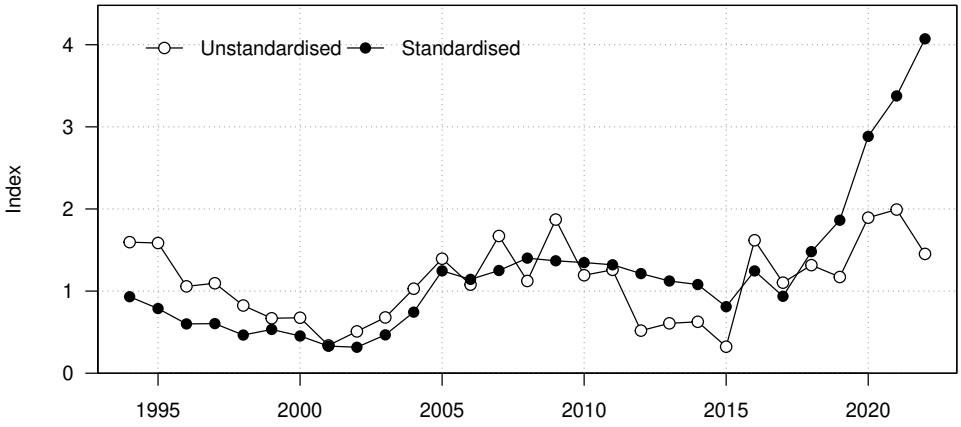


Figure 70: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 HOK-SKI event dataset.

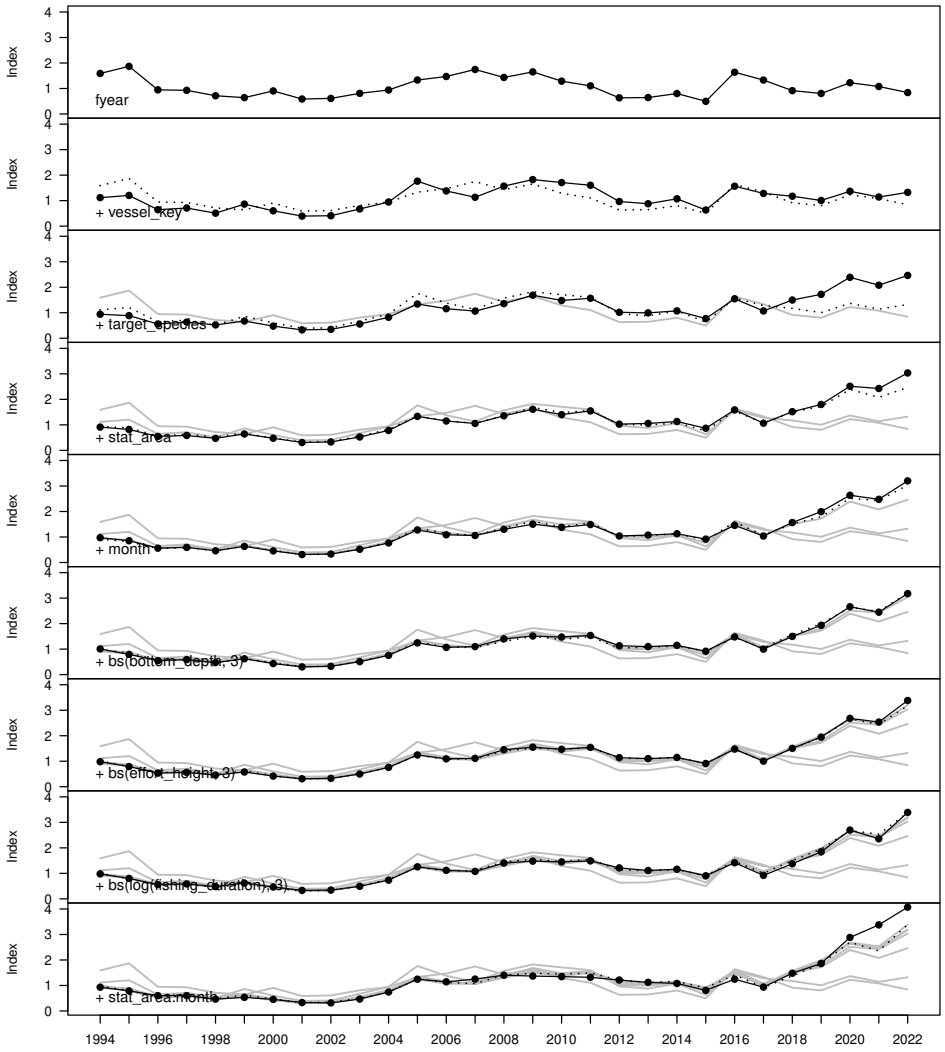


Figure 71: Changes to the SKI1 SKI2 HOK-SKI event positive catch index as terms are successively entered into the model.

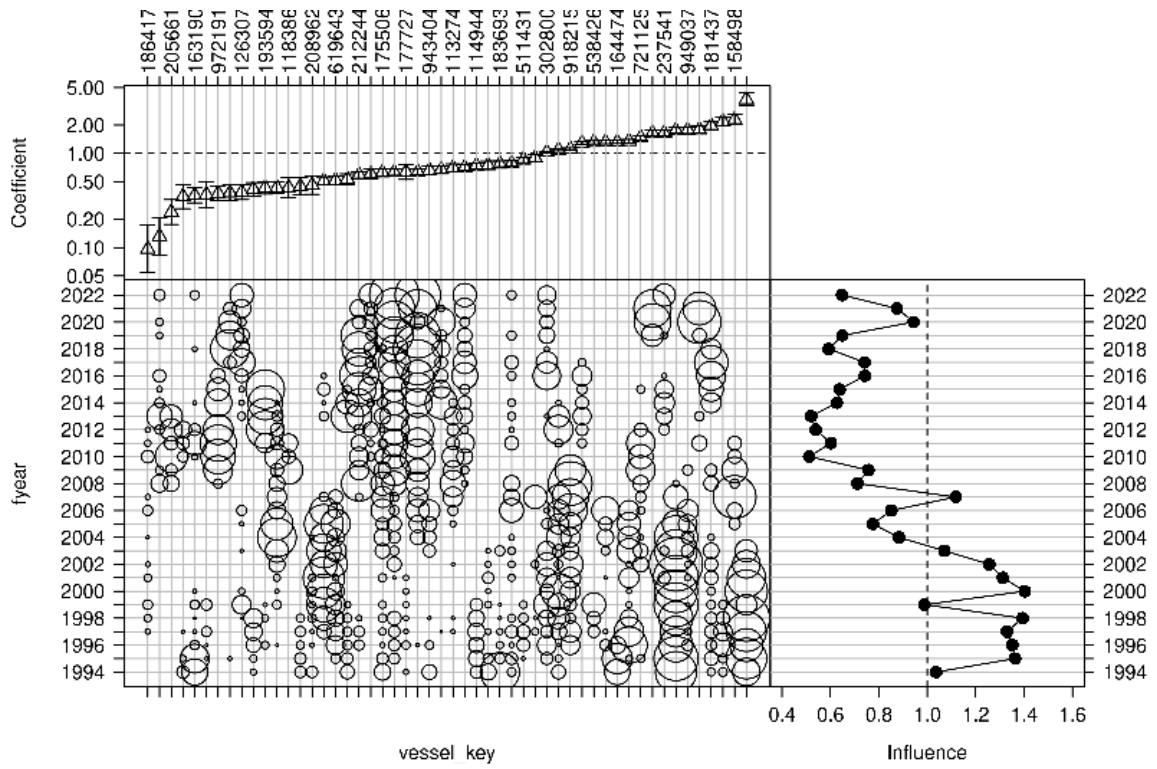


Figure 72: CDI plot for vessel key for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

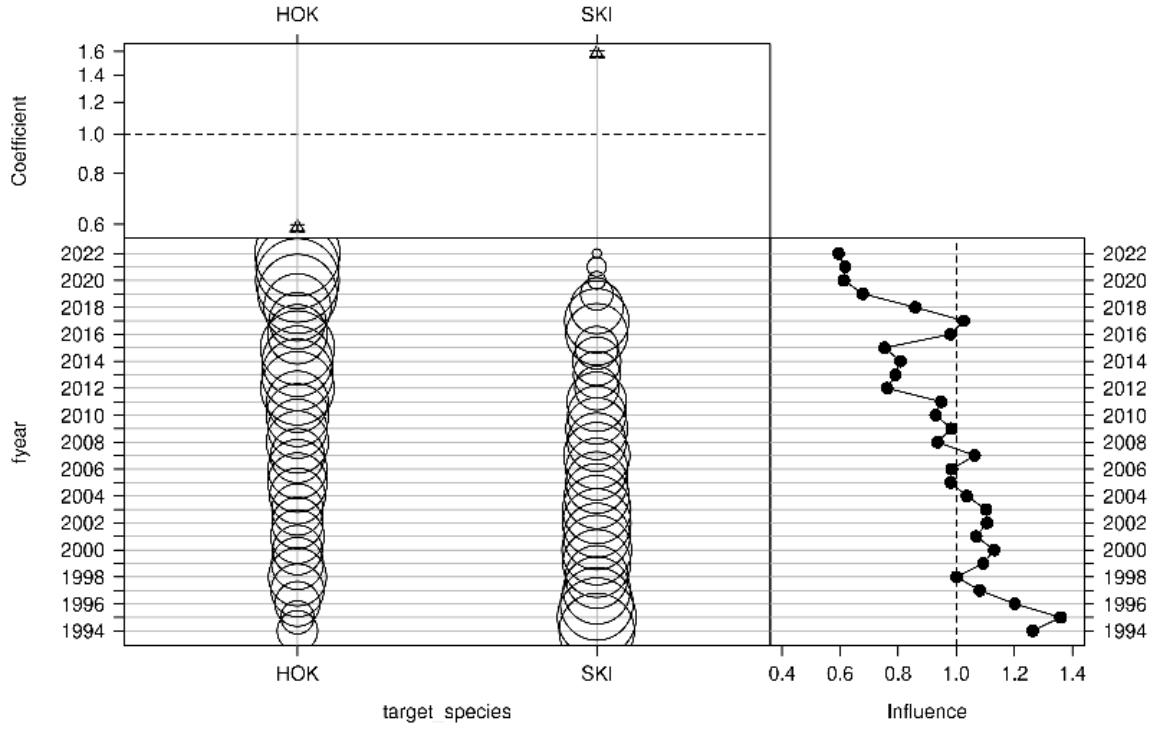


Figure 73: CDI plot for target species for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

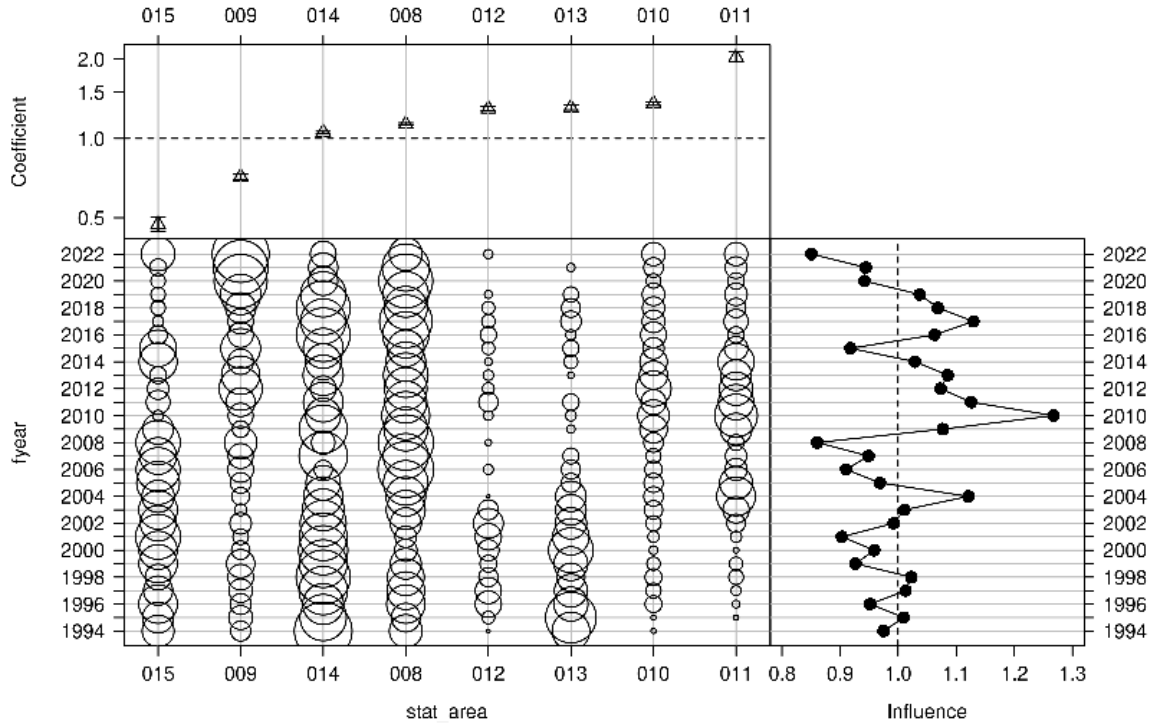


Figure 74: CDI plot for statistical area for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

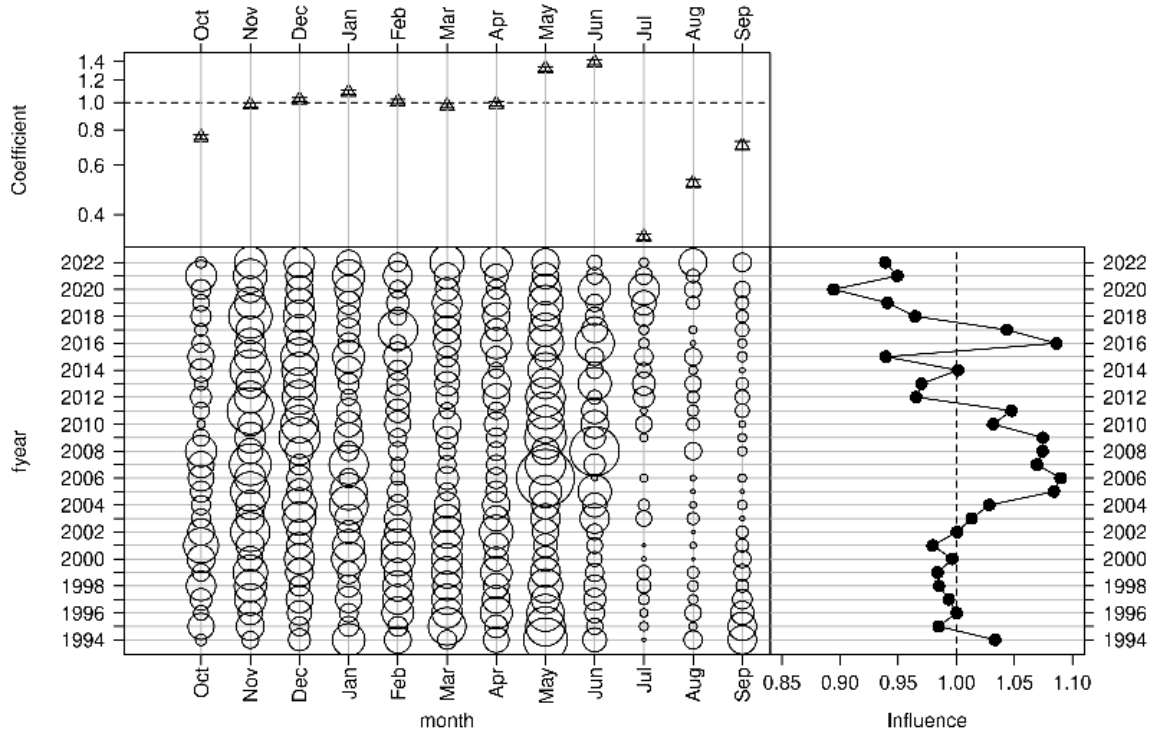


Figure 75: CDI plot for month for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

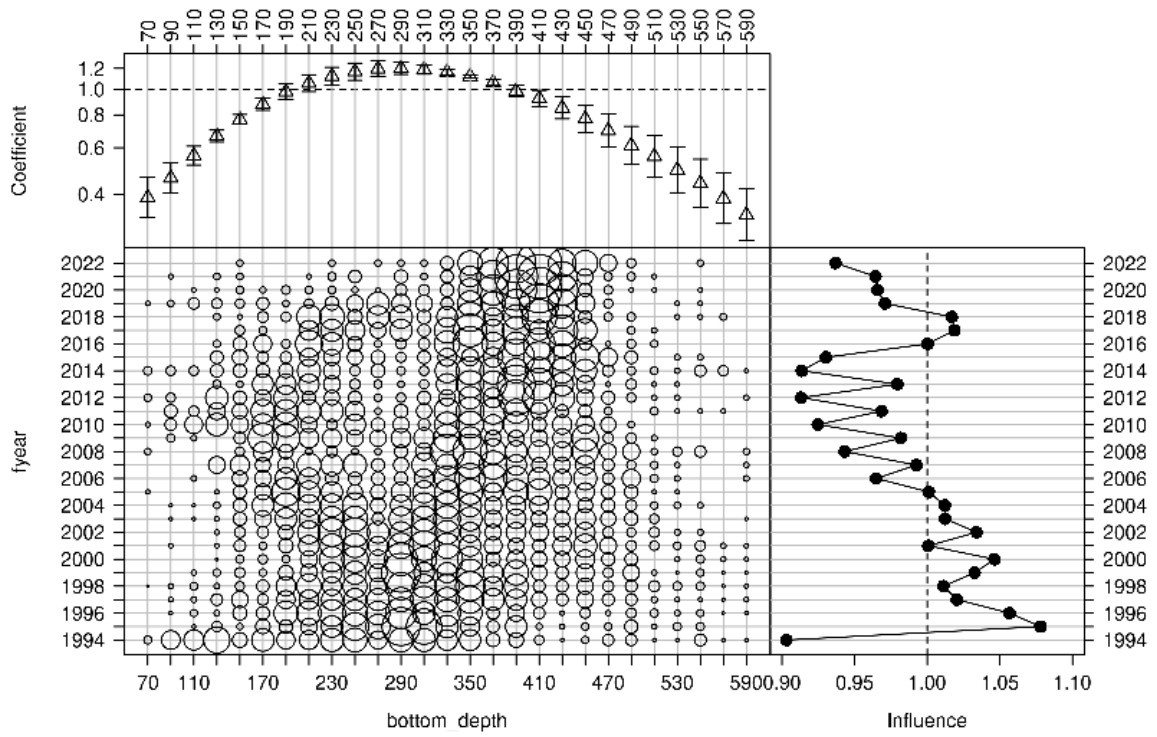


Figure 76: CDI plot for bottom depth for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

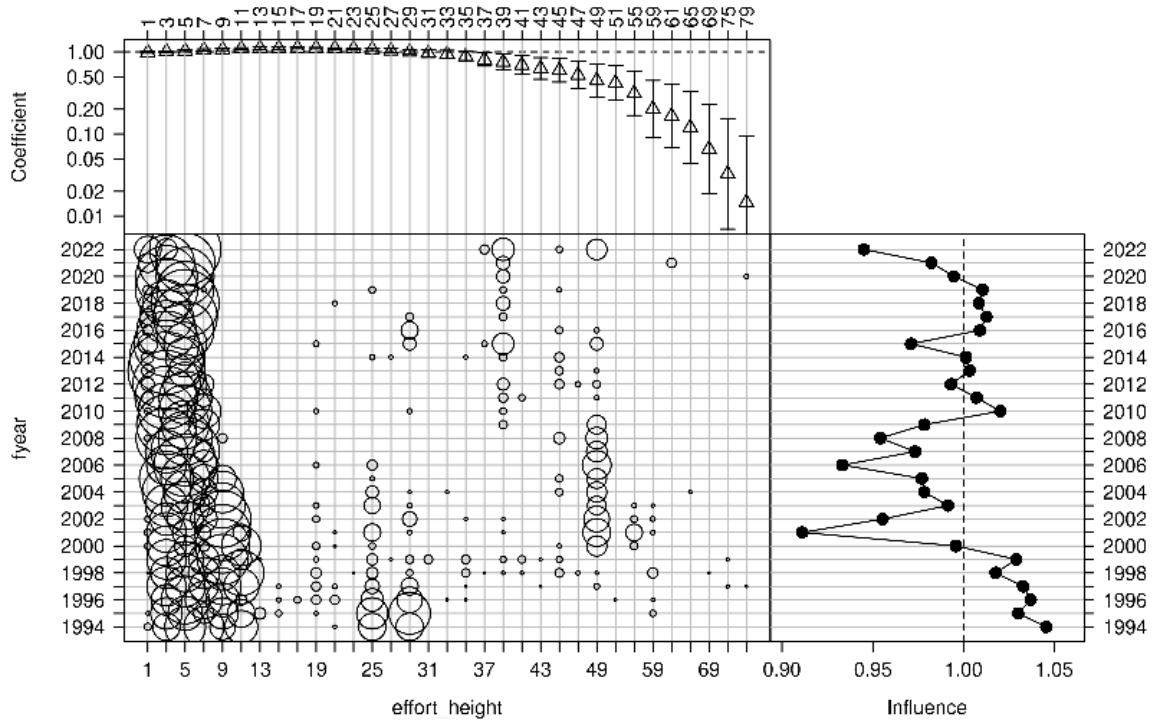


Figure 77: CDI plot for effort height for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

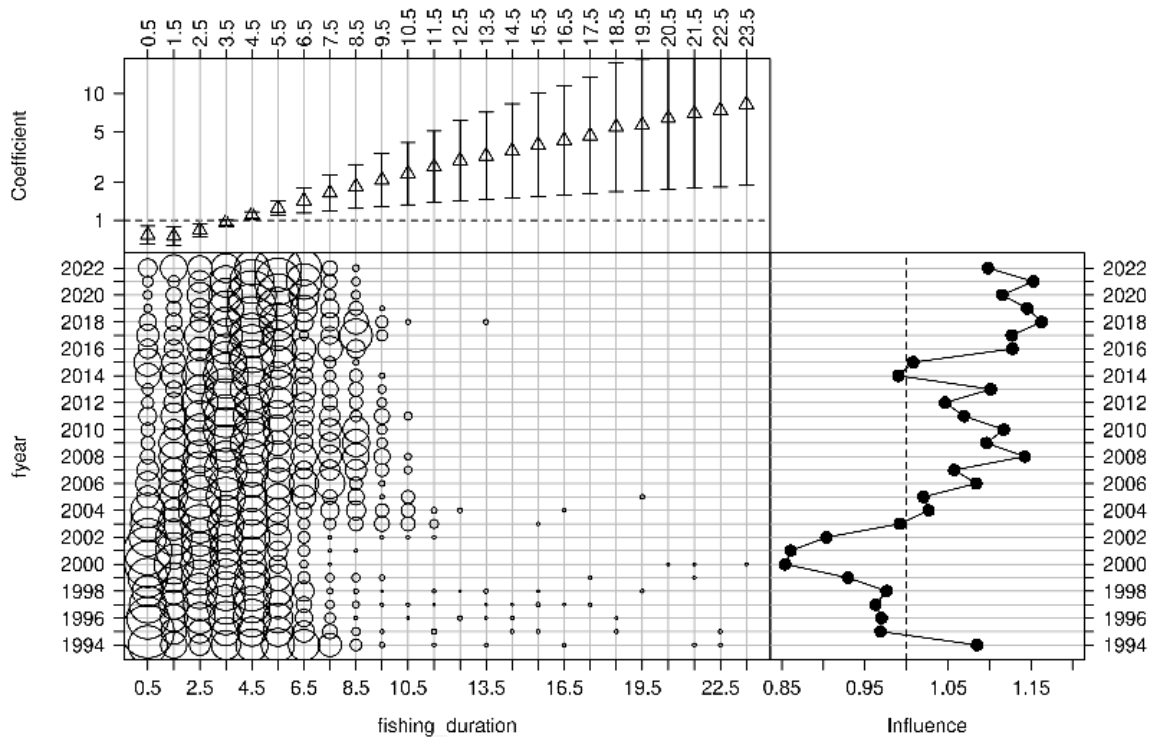


Figure 78: CDI plot for log fishing duration for the positive catch SKI1 SKI2 HOK-SKI event catch-per-unit-effort dataset.

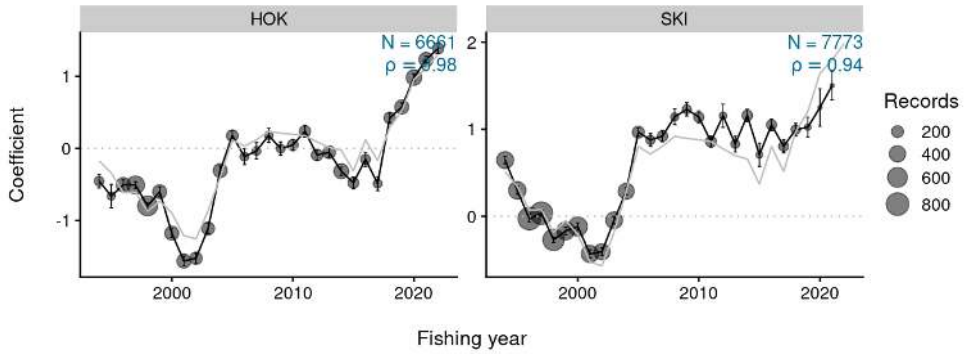


Figure 79: Residual implied coefficients for target-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event dataset.

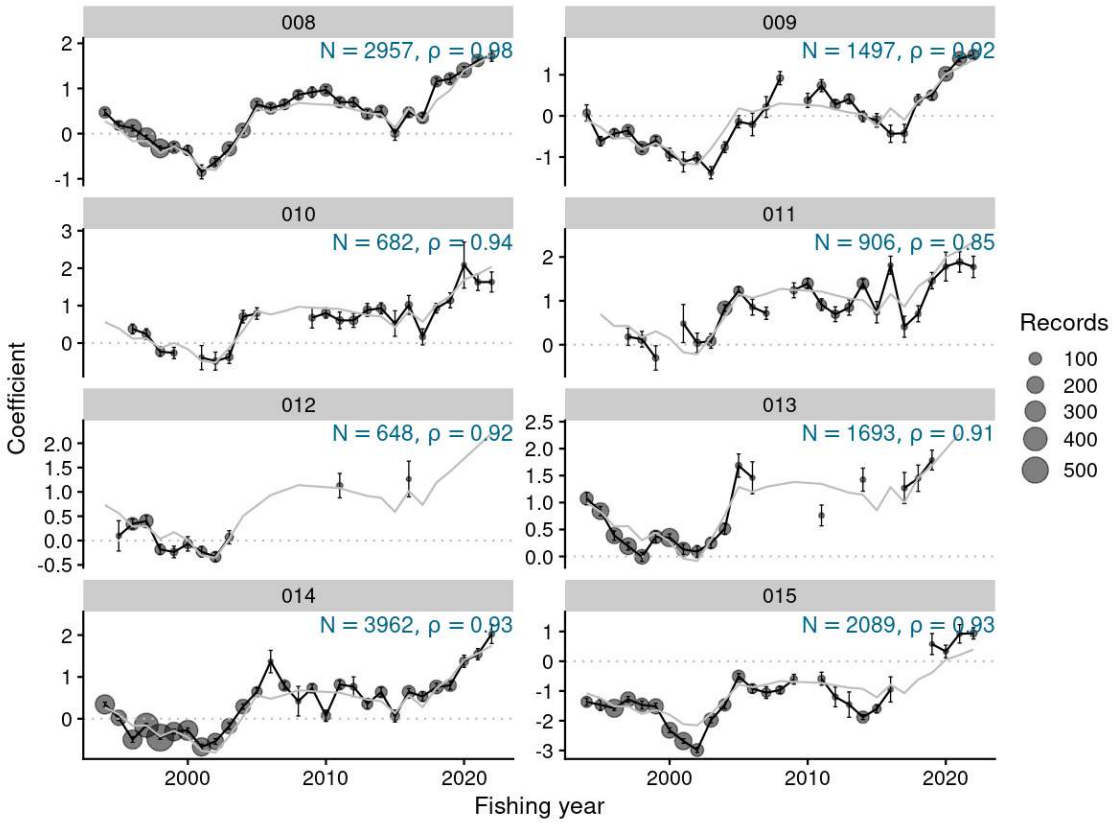


Figure 80: Residual implied coefficients for area-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event dataset.

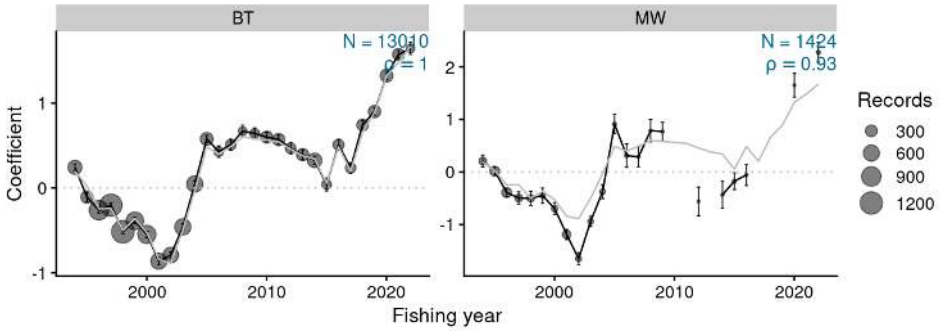


Figure 81: Residual implied coefficients for primary method-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event dataset.

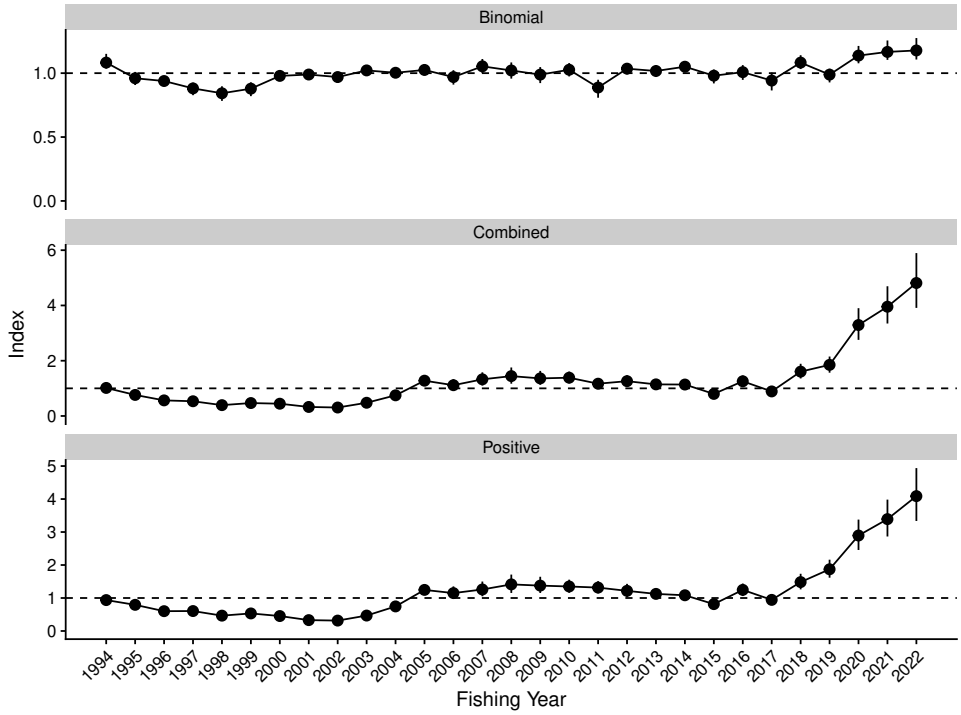


Figure 82: Standardised indices and 95% confidence intervals for the SKI1 SKI2 HOK-SKI event dataset.

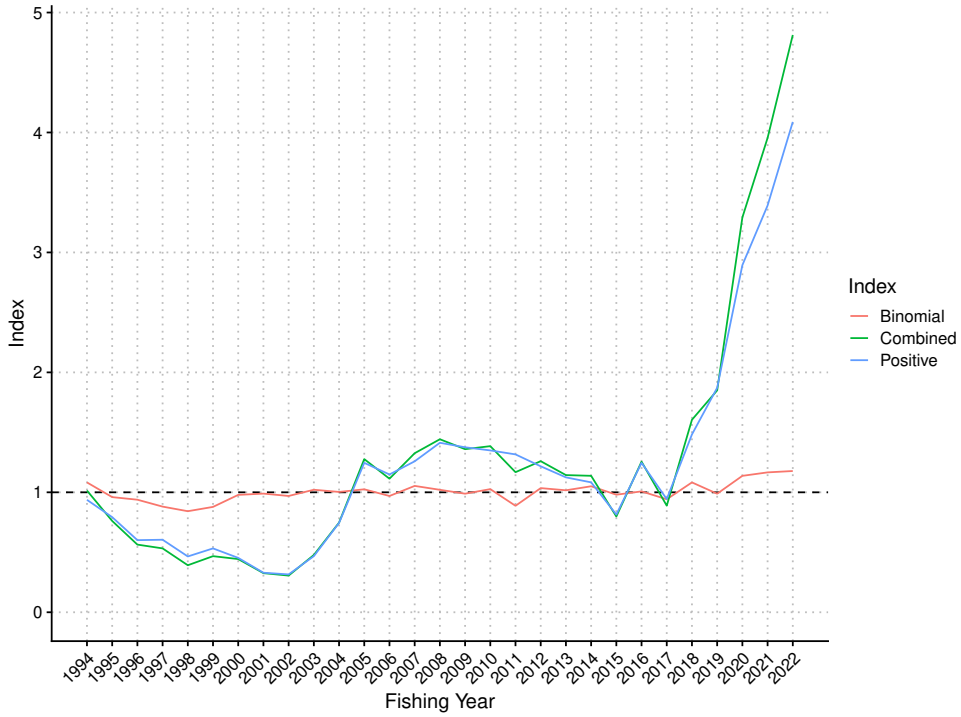


Figure 83: Standardised indices for the SKI1 SKI2 HOK-SKI event dataset.

Table 15: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 HOK-SKI event.

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1994	1.08	1.08	0.030	1.08	1.01	1.01	0.075	1.01	0.94	0.94	0.067	0.94
1995	0.96	0.96	0.026	0.96	0.76	0.76	0.051	0.76	0.79	0.79	0.048	0.79
1996	0.94	0.94	0.019	0.94	0.56	0.56	0.029	0.56	0.60	0.60	0.029	0.60
1997	0.88	0.88	0.025	0.88	0.53	0.53	0.027	0.53	0.60	0.60	0.027	0.60
1998	0.84	0.84	0.029	0.84	0.39	0.39	0.022	0.39	0.47	0.47	0.021	0.47
1999	0.88	0.88	0.028	0.88	0.47	0.47	0.029	0.47	0.53	0.53	0.029	0.53
2000	0.98	0.98	0.019	0.98	0.44	0.44	0.024	0.44	0.45	0.45	0.024	0.45
2001	0.99	0.99	0.019	0.99	0.33	0.33	0.018	0.33	0.33	0.33	0.017	0.33
2002	0.97	0.97	0.021	0.97	0.31	0.31	0.018	0.31	0.32	0.32	0.017	0.32
2003	1.02	1.02	0.019	1.02	0.48	0.48	0.026	0.48	0.47	0.47	0.024	0.47
2004	1.00	1.00	0.018	1.00	0.75	0.75	0.044	0.75	0.75	0.75	0.043	0.75
2005	1.03	1.03	0.022	1.03	1.28	1.28	0.081	1.28	1.25	1.25	0.076	1.25
2006	0.97	0.97	0.029	0.97	1.11	1.11	0.102	1.11	1.15	1.15	0.095	1.15
2007	1.05	1.05	0.028	1.05	1.33	1.33	0.122	1.33	1.26	1.26	0.114	1.26
2008	1.02	1.02	0.032	1.02	1.44	1.44	0.150	1.44	1.41	1.41	0.142	1.41
2009	0.99	0.99	0.032	0.99	1.36	1.36	0.128	1.36	1.38	1.38	0.125	1.38
2010	1.03	1.03	0.027	1.03	1.38	1.38	0.110	1.38	1.35	1.35	0.102	1.35
2011	0.89	0.89	0.036	0.89	1.17	1.17	0.095	1.17	1.32	1.32	0.095	1.32
2012	1.04	1.04	0.022	1.04	1.26	1.26	0.109	1.26	1.22	1.22	0.104	1.22
2013	1.02	1.02	0.024	1.02	1.14	1.14	0.090	1.14	1.12	1.12	0.082	1.12
2014	1.05	1.05	0.021	1.05	1.14	1.14	0.077	1.14	1.08	1.08	0.071	1.08
2015	0.98	0.98	0.028	0.98	0.80	0.80	0.074	0.80	0.81	0.81	0.071	0.81
2016	1.01	1.01	0.029	1.01	1.26	1.26	0.102	1.26	1.25	1.25	0.097	1.25
2017	0.94	0.94	0.036	0.94	0.89	0.89	0.087	0.89	0.94	0.94	0.084	0.94
2018	1.08	1.08	0.028	1.08	1.60	1.60	0.136	1.60	1.48	1.48	0.121	1.48
2019	0.99	0.99	0.027	0.99	1.85	1.85	0.149	1.85	1.87	1.87	0.139	1.87
2020	1.14	1.14	0.035	1.14	3.29	3.29	0.292	3.29	2.89	2.89	0.235	2.89
2021	1.17	1.17	0.039	1.17	3.95	3.95	0.344	3.95	3.39	3.39	0.285	3.39
2022	1.18	1.18	0.043	1.18	4.81	4.81	0.506	4.81	4.09	4.09	0.409	4.09

4.4 CPUE comparisons and sensitivities

4.4.1 Previous analyses

The CPUE indices presented here are updates of indices that were reviewed and accepted, with data to the 2020 fishing year, by the Fisheries Assessment Plenary in May 2021 ('the 2021 analysis'; Fisheries New Zealand 2021). For the years in common, there is good consistency between the previous and updated analysis for both the BT-TAR trip series (Figure 84) and the HOK-SKI event series (Figure 85).

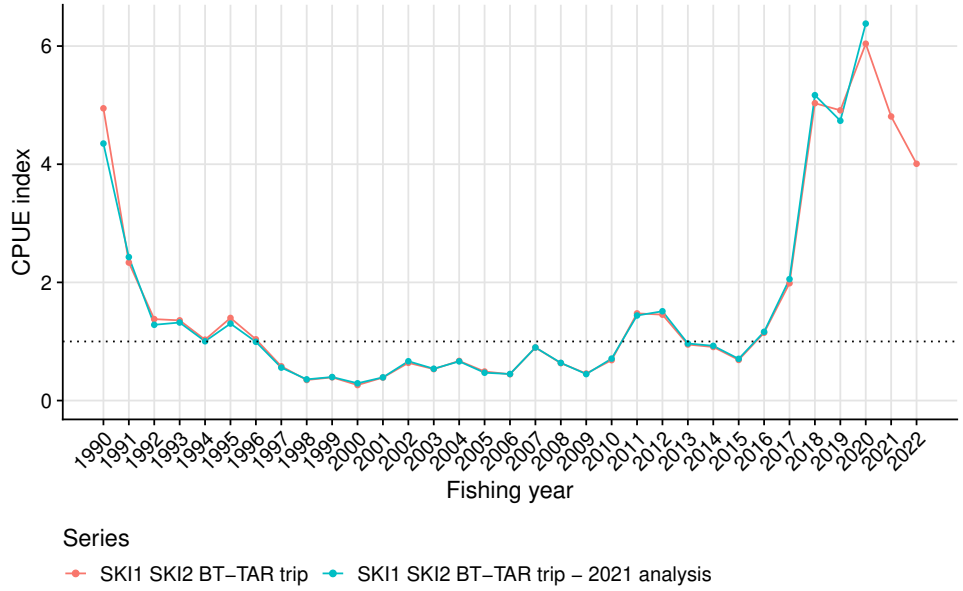


Figure 84: Comparison of the SKI1 SKI2 BT-TAR trip index from 2021, with data to the 2020 fishing year, with the updated indices using data to the 2022 fishing year.

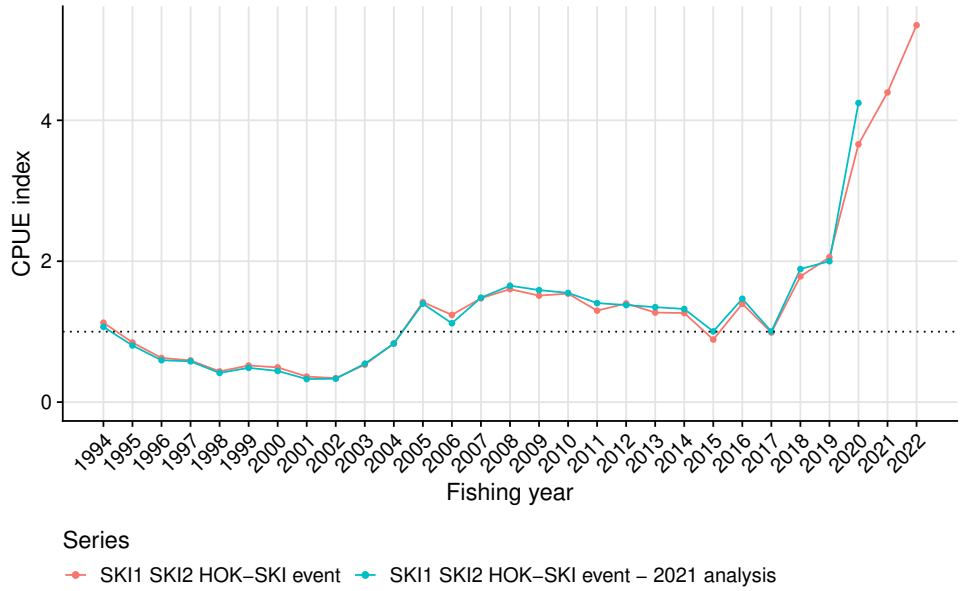


Figure 85: Comparison of the SKI1 SKI2 HOK-SKI event index from 2021, with data to the 2020 fishing year, with the updated indices using data to the 2022 fishing year.

4.4.2 Alternative data resolutions

A tarakihi target event-resolution index from 2008 (Appendix D.1) showed a similar trend to that of the main trip-resolution index for the common years (Figure 86). The daily-resolution index with gemfish and hoki target data (Appendix D.2) showed a similar trend to the event-resolution index from 1994 to 2017 (Figure 87); however, from 2018 to 2022 the event-level index increased more rapidly than the daily-resolution index. The daily-resolution index was developed primarily to provide a longer term index for development of a fully-quantitative stock assessment and it is anticipated that the development of this model will assist in better understanding the contrasting trends between these indices in the recent period.

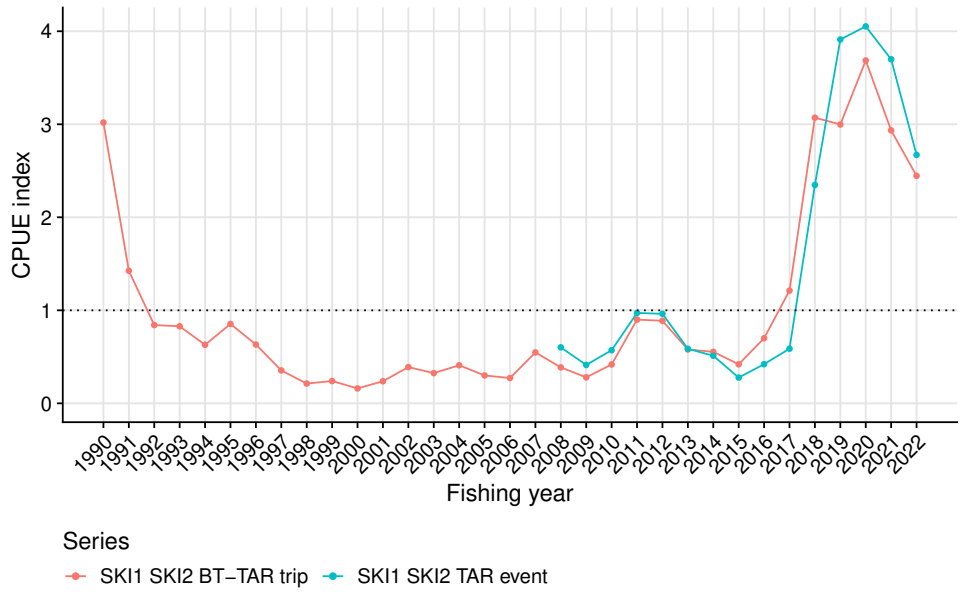


Figure 86: Comparison of the SKI1 SKI2 BT-TAR trip-resolution index index with the SKI1 SKI2 TAR event-resolution index.

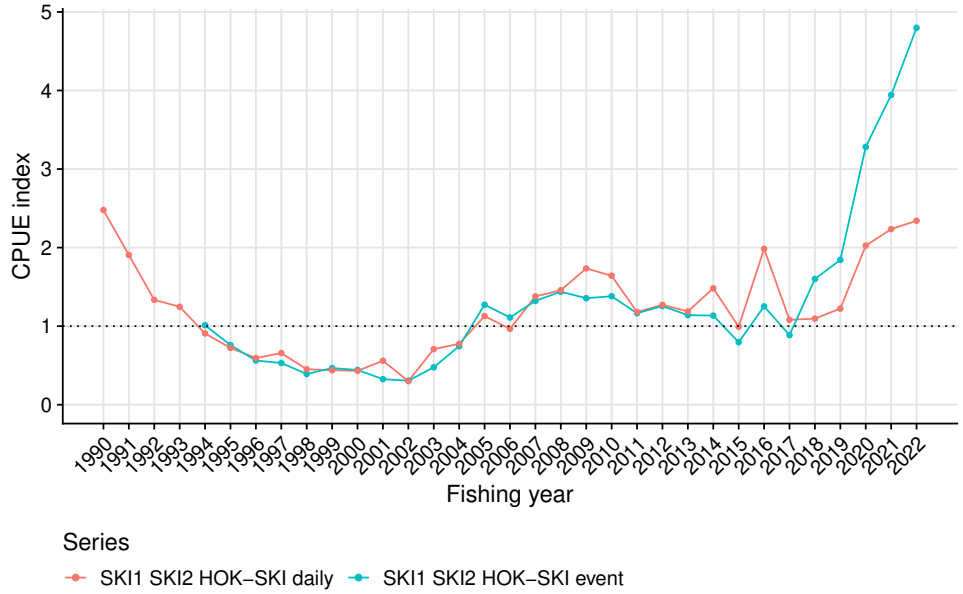


Figure 87: Comparison of the SKI1 SKI2 HOK-SKI event-resolution index with the SKI1 SKI2 HOK-SKI daily-resolution index.

4.4.3 Intermittent vessel participation

During the 2022 update of the CPUE series, a key issue investigated by the Inshore Fisheries Working Group was the treatment of vessels that had intermittent participation in the fishery. In the case of the core fleet developed for the HOK-SKI event index, it was noted that a number of vessels had participated in the fishery in the 1990s but then had not been active in the fishery for a period (potentially over a decade) before they again participated in the fishery, often as quite active vessels (Figure 60). It was noted that the operation of these vessels may have changed during this break. As a result, a range of sensitivities were considered for the HOK-SKI event index.

The first approach considered was to 'split vessels' that had a break in their participation in the core fleet. This was implemented by defining the maximum gap in a vessel's participation, in years. For vessels where any gaps in activity exceeded this threshold, the data from the vessel was split at the gap, and allocated to two new pseudo-vessels. Each of these pseudo-vessels was then assessed against the normal core fleet participation criterion (i.e., a minimum number of trips in a certain number of years) and retained in the data set if these criteria were met. Then, in the CPUE modelling, each of these pseudo-vessels was treated as if it was a different vessel, and a vessel effect was estimated independently. Vessels that did not have gaps in their participation were treated normally; that is, a single vessel effect was estimated using their data over the whole series. A single variant of the HOK-SKI event series, where vessels were split if they had gaps exceeding 5 years, is presented in Appendix D.3. Although quite a number of vessels are split, the core-fleet participation rules mean that the number of 'vessels' in the analysis only increases from 52 to 56; however, early data from some vessels that had only sporadic early participation in the fishery are eliminated (Figure D.44). The impact of this sensitivity is rather small, primarily reducing the index slightly in 2020–2022 (Figure 88).

Two additional sensitivities were developed for the HOK-SKI event index: the first used data only from those vessels that were part of the core fleet in 1994 (the '1994 fleet'; Appendix D.4), and the second required vessels to be part of the core fleet in 2021 (the '2021 fleet'; Appendix D.5). These sensitivities inevitably resulted in reduced data sets, and it proved impossible to fit models that included an interaction between month and statistical area in these cases.

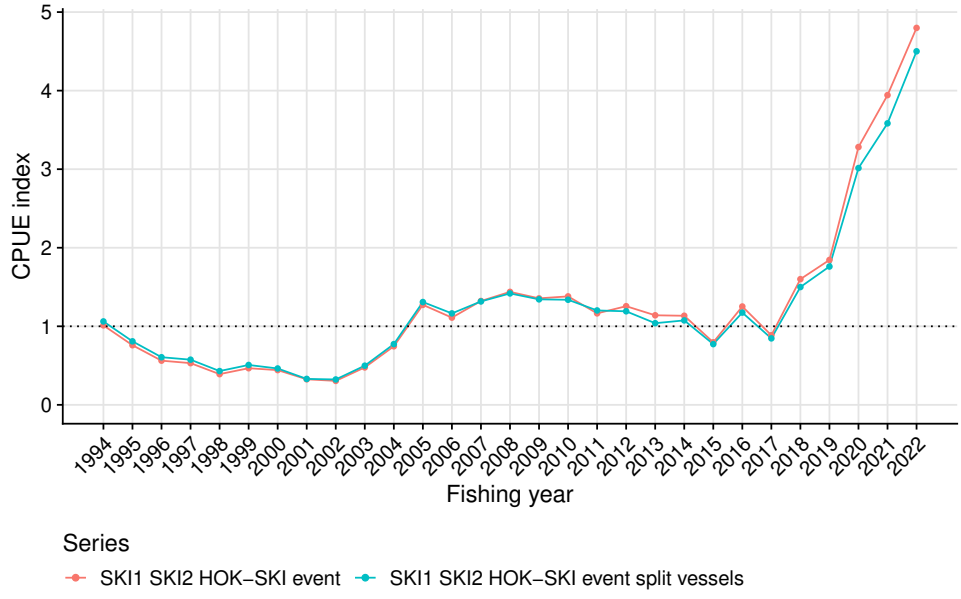


Figure 88: Comparison of the SKI1 SKI2 HOK-SKI event-resolution index with a sensitivity where vessels that had a gap in participation in the fishery of more than five years were split into separate pseudo-vessels.

However, as this interaction has relatively little impact on the binomial model of the base series (Figure 63), and the impact on positive catches is primarily in 2021 and 2022 (Figure 71), there is limited difference between the base HOK-SKI event index and a sensitivity where this interaction is excluded (Figure 89). In general, these two sensitivities provided indices that showed similar trends to the base index (with the interaction excluded), although the sensitivities showed greater variability in the period from 2001 to 2017 (Figure 90). The 2021 fleet provides data back to 1995, with the 1995 index being somewhat lower than the base index, and the 2021 and 2022 indices slightly higher; however these differences in recent years may be primarily due to the lack of the area:month interaction (Figure 89). The 1994 fleet sensitivity provides no data after 2018 and so misses the recent significant increase in abundance.

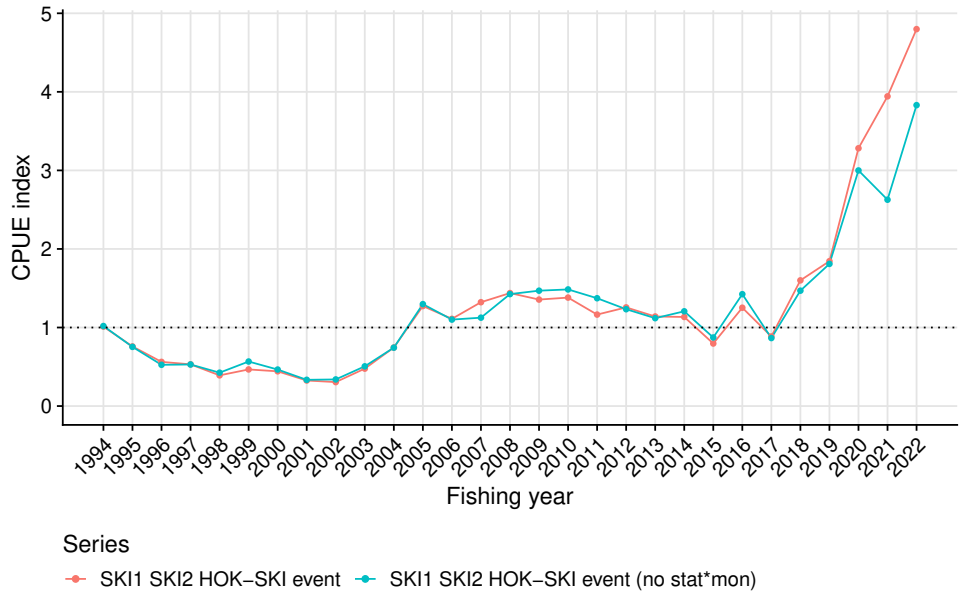


Figure 89: Comparison of the SKI1 SKI2 HOK-SKI event-resolution index with a sensitivity where the interaction between month and statistical area was not included.

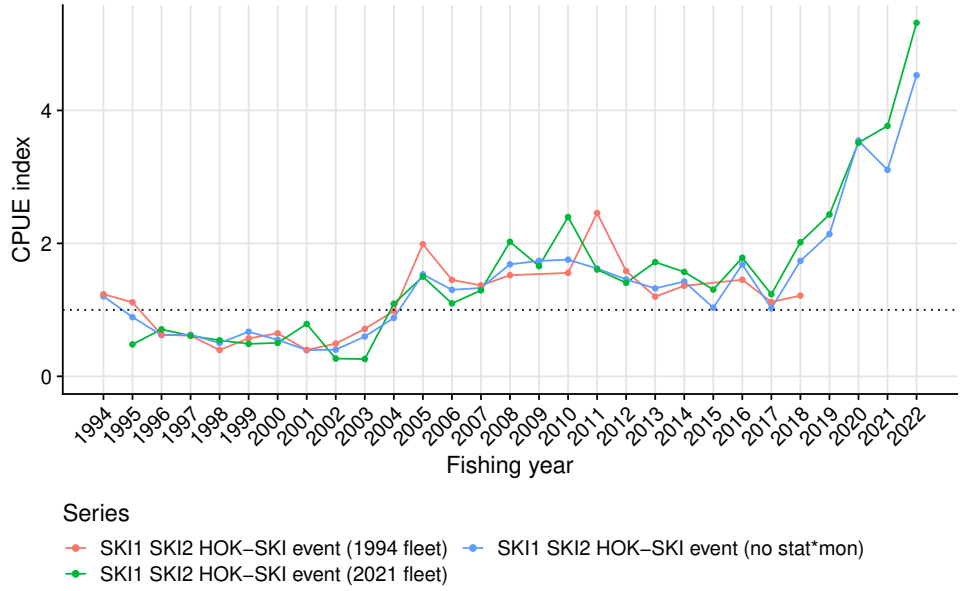


Figure 90: Comparison of the SKI1 SKI2 HOK-SKI event-resolution index with sensitivities where the data were restricted to vessels that were in the fleet at either the beginning of the series (1994) or near the end (2021); in all cases the interaction between month and Statistical Area was excluded.

5. DISCUSSION

Catches of gemfish in Quota Management Areas SKI 1 and SKI 2 are believed to be made up primarily of silver gemfish, *Rexea solandri*, comprising a single biological stock (Fisheries New Zealand 2022) often referred to as 'northern gemfish'. The commercial fisheries for northern gemfish are primarily trawl fisheries, with bottom trawl predominating. Catches by midwater trawling have occurred periodically, mainly in SKI 2.

Historically, the majority of the catch was taken by gemfish target trawling, but target fishing activity was significantly reduced following substantial reductions in catch limits in the late 1990s. In SKI 1, a target fishery in the western Bay of Plenty took the majority of the catch until the mid-2010s. Recent catches have primarily come from non-target fishing, principally for tarakihi and hoki. In SKI 2, non-target catch, primarily from tarakihi target tows, has dominated since the mid-2000s.

Gemfish catches in SKI 1 and SKI 2 have been increasing since the mid-2010s, consistently exceeding the TACC in SKI 1 since 2017 and in SKI 2 during 2018–2021, with indications that recreational catches have also increased (see Section 1). Standardised catch-per-unit-effort from commercial fisheries provides indices of abundance for northern gemfish. A key difference been the indices presented here and the previously published indices (Starr & Kendrick 2016) has been the separation of the tarakihi and gemfish/hoki target fisheries, recognising that these fisheries capture different parts of the gemfish population. Although length composition data are limited, it appears that the tarakihi fishery takes a mix of sub-adult and adult gemfish. The deeper gemfish and hoki target fisheries take primarily adult gemfish.

Comparing the two key CPUE indices accepted by the Fisheries Assessment Plenary demonstrates that the BT-TAR trip index started increasing in 2017, one or two years ahead of the increases subsequently seen in the HOK-SKI event index (Figure 91). While this is consistent with the hypothesis that the tarakihi fishery catches more sub-adult fish than the hoki and gemfish target fishery, and thus provides earlier evidence of incoming recruitment to the stock, it should be noted that similar correlations have not been apparent earlier in the series (although no earlier periods, where abundance indices are available from both fisheries, have the magnitude of increase observed since 2016).

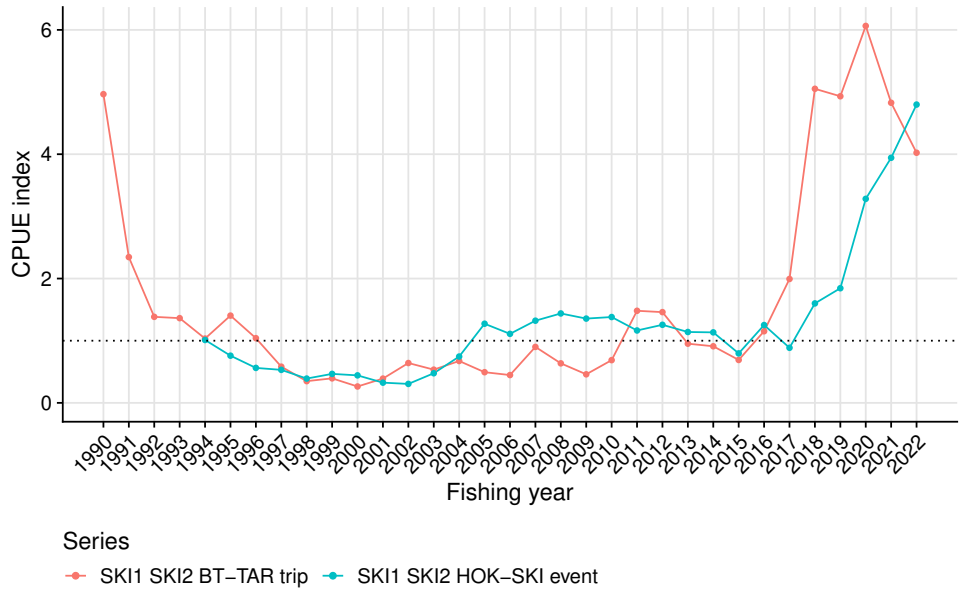


Figure 91: Comparing the SKI 1 and 2 tarakihi (SKI1 SKI2 BT-TAR trip) and hoki-gemfish target CPUE series (SKI1 SKI2 HOK-SKI event).

5.1 Stock status

In 2021, the Fisheries Assessment Plenary agreed that the HOK-SKI event-resolution index provided an index of adult stock abundance and was suitable for use as a partial-quantitative stock assessment using B_{MSY} compatible reference points. Geometric mean CPUE from the HOK-SKI event-resolution model for the period 2004 to 2017 was adopted as the soft limit reference point for SKI 1 and 2, with the default Harvest Strategy Standard definitions used to define the target and hard limit at twice and half the soft limit, respectively. The corresponding overfishing threshold is considered to be half the relative exploitation rate over the reference period.

The Plenary noted that the resulting assessment of stock status in the mid-1990s and early 2000s was poorer than indicated by the 2008 assessment results, which suggested stock status in 2007 was in the range 20–30% B_0 (Fisheries New Zealand 2022). The HOK-SKI event index did not align especially well with the biomass trajectory estimated by the 2008 assessment, but the Plenary noted that the 2008 assessment had not provided a good fit to the increase in CPUE in the mid-2000s. Adopting the period 2004 to 2017 as the soft limit was considered the best option to provide reference points that reflected the assessed status in 2008.

Stock abundance and relative exploitation rate over time are illustrated in Figure 92, and were used to provide the assessment of stock status reported by Fisheries New Zealand (2022); for 2021, the stock was considered likely to be above the target and abundance increased further in 2022.

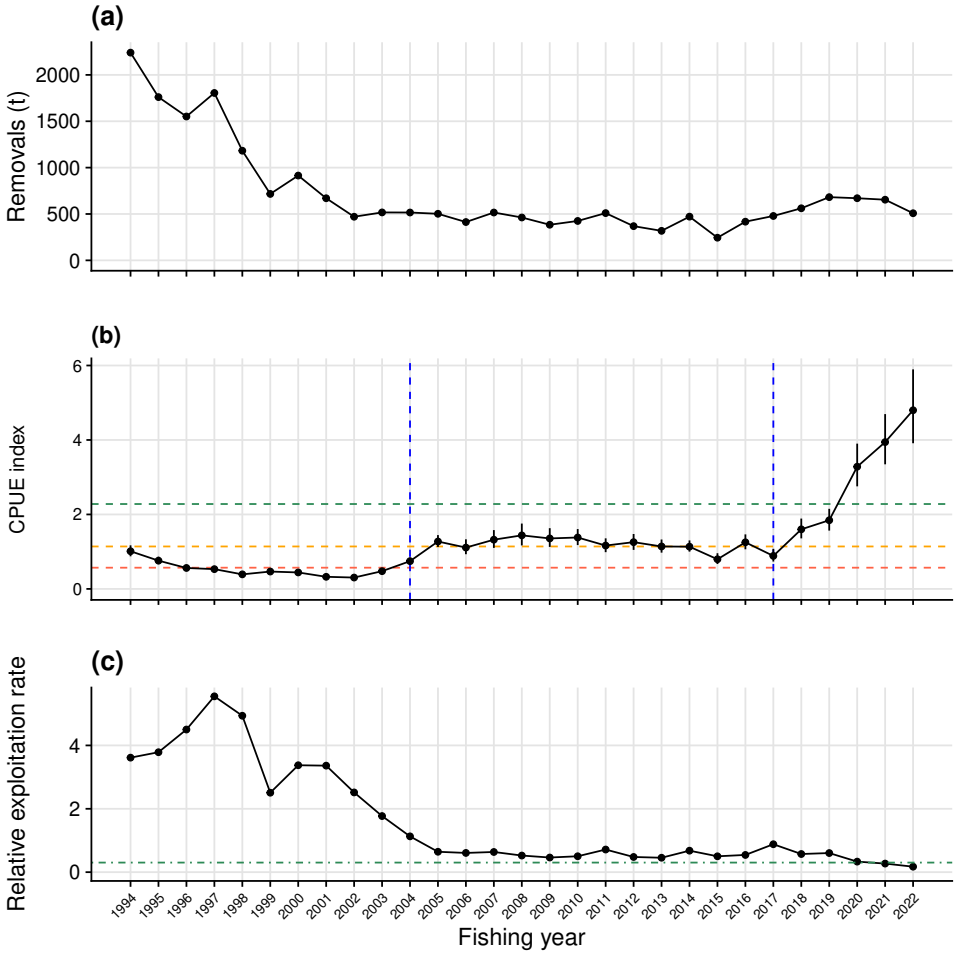


Figure 92: Stock status relative to the reference period (2004-2017, indicated by dashed vertical lines in panel b), with geometric mean CPUE in this period considered to represent the soft limit.

6. ACKNOWLEDGEMENTS

This work was funded by Fisheries Inshore New Zealand. The Inshore Fisheries Working Group provided valuable input on the development of the gemfish CPUE series and their use in a partial-quantitative assessment. Adam Langley provided helpful input on the gemfish fisheries and the series developed. Paul Starr, Nokome Bentley, and McKenzie Tornquist made important contributions to the methods and code used in the analyses reported here. Andrew Stewart of Te Papa Tongarewa, the Museum of New Zealand, kindly answered queries on the records of *Rexea prometheoides* and distribution of *R. antefurcata*.

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APPENDIX A: DATA GROOMING

Grooming of the statutory 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
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 transhippments
LASCF	Fix	Correct some state codes
LASCI	Flag	Landings to invalid state code
LASCD	Drop	Drop landings of secondary product states
LADUP	Drop	Duplicate landings
LACFM	Fix	Replace missing conversion factors with the median over all years
LAGWI	Fix	Estimate missing greenweights
LAGWM	Drop	Missing greenweights that cannot be estimated
LAGWO	Fix	Identify and fix order of magnitude errors in landings

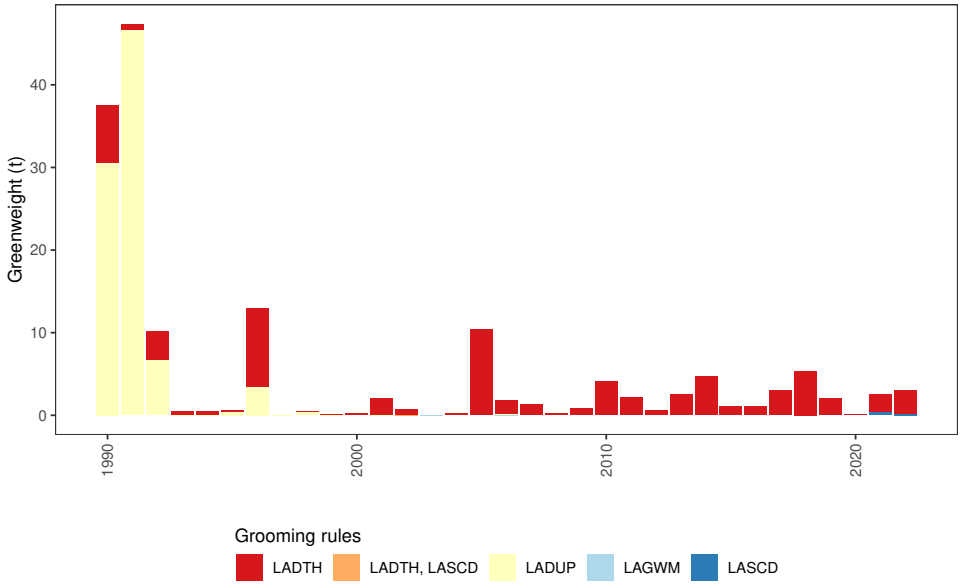

Figure A.1: The quantity of landings dropped, with the relevant grooming rules indicated.

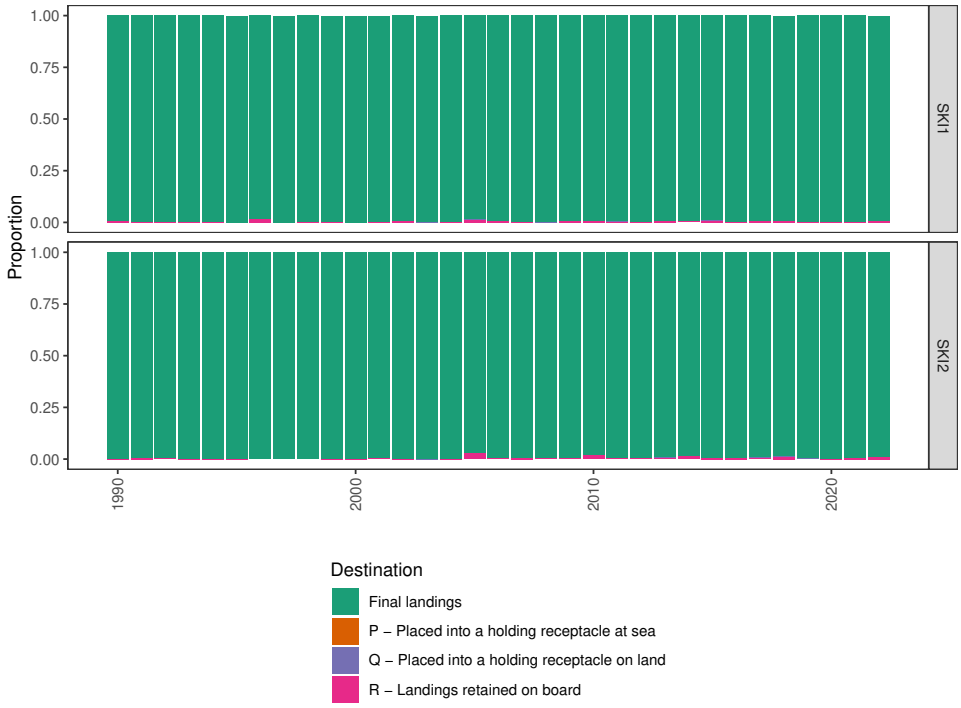

Figure A.2: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

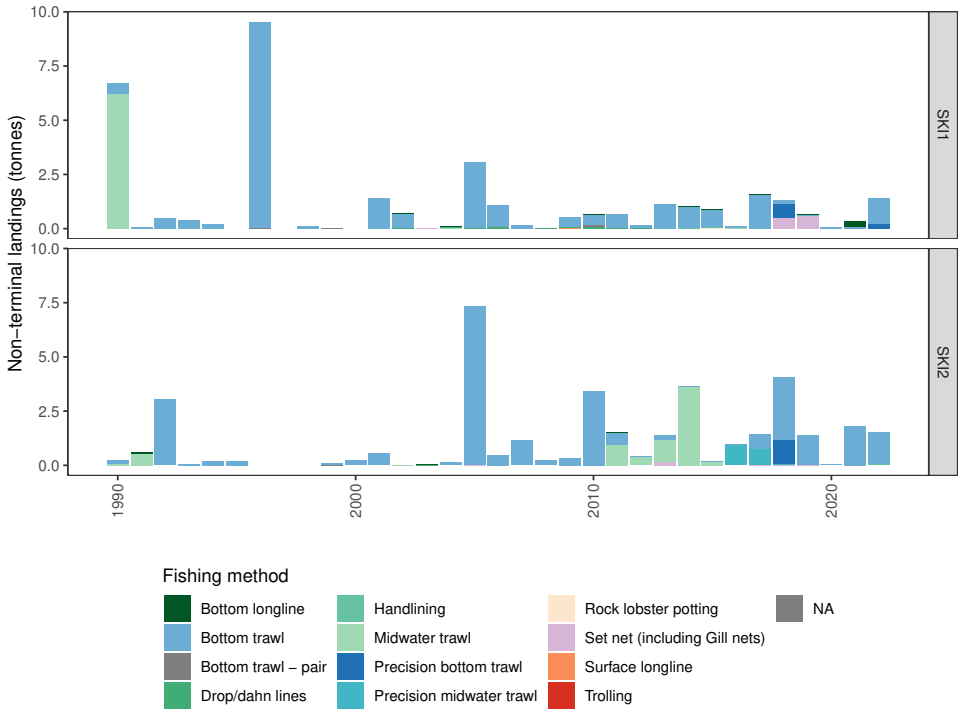

Figure A.3: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

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

			Green weight (kg)	
QMA	Fishing year	Trips	Original	Adjusted
SKI1	1990	1	157218	1572.180
SKI1	1995	2	128563	1285.630
SKI1	1996	1	8000	80.000
SKI1	1997	2	47419	474.190
SKI1	1999	1	33091	330.910
SKI1	2001	1	265	2.650
SKI1	2002	1	107	1.070
SKI1	2003	1	127	1.270
SKI1	2004	1	1128	1.128
SKI1	2013	1	1158	11.580
SKI2	2003	1	100	1.000

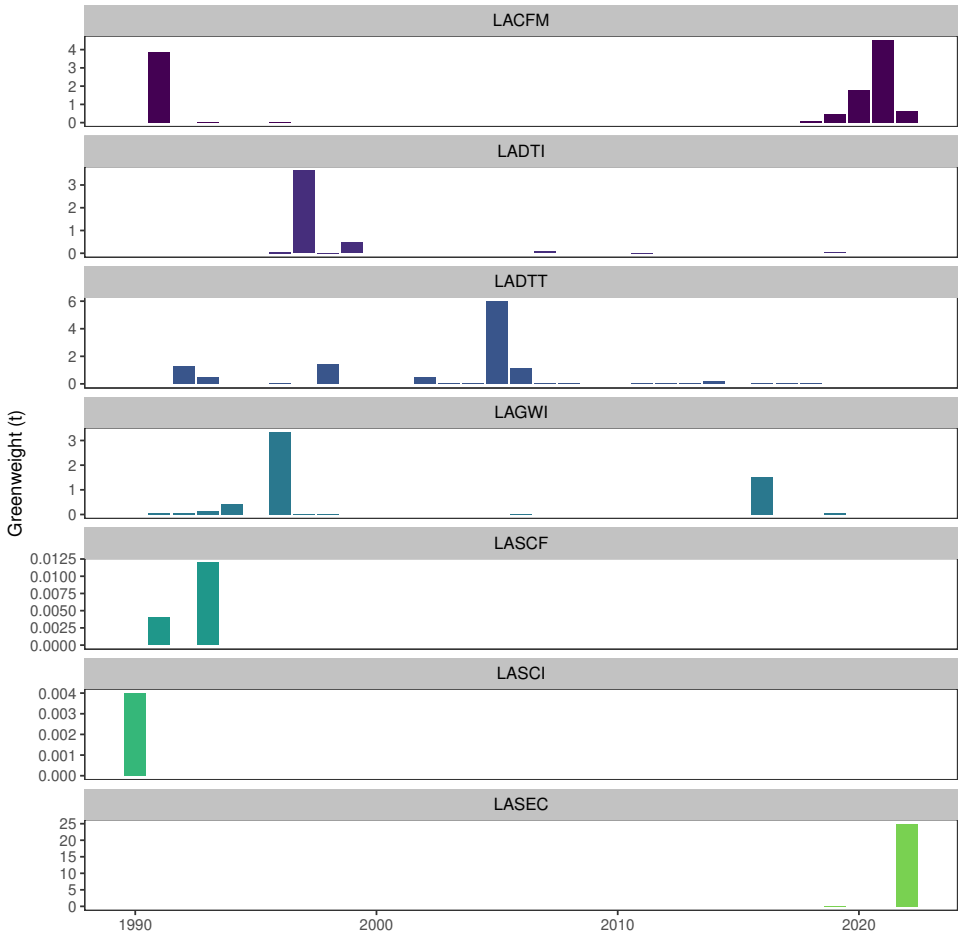

Figure A.4: The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.

A.2 Effort

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

Rule	Effect	Description
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	Substitude 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
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

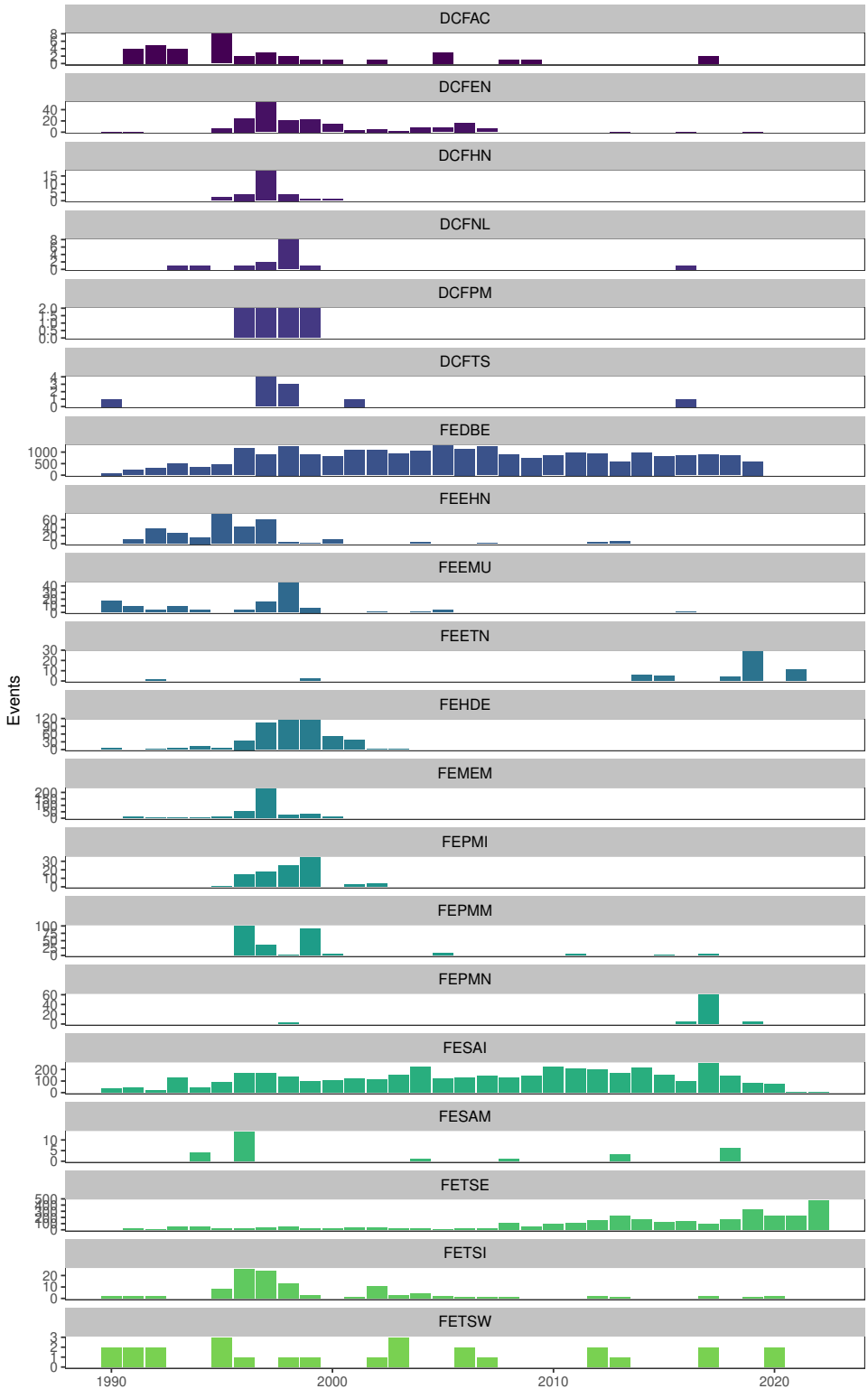

Figure A.5: The number of fishing events flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

APPENDIX B: TABULATED FISHERIES CHARACTERISATION DATA

Table B.1: Annual Total Allowable Commercial Catch (TACC) and Monthly Harvest Return/Quota Management Return totals for SKI 1 and SKI 2 from 1990 to 2022.

Fishing year	SKI1		SKI2	
	TACC	MHR/QMR	TACC	MHR/QMR
1990	1 139.10	1 230.15	1 178.50	1 043.47
1991	1 151.80	1 051.30	1 187.50	955.50
1992	1 151.80	1 016.84	1 188.20	1 207.74
1993	1 151.80	1 292.09	1 196.50	1 020.02
1994	1 151.80	1 157.91	1 230.40	1 057.80
1995	1 151.80	1 031.65	1 299.90	905.92
1996	1 151.80	800.88	1 299.90	792.59
1997	1 151.80	965.08	1 299.90	977.79
1998	752.00	626.88	849.00	670.53
1999	460.00	412.70	520.00	335.58
2000	460.00	409.07	520.00	508.57
2001	460.00	335.44	520.00	330.48
2002	210.00	200.92	240.00	268.04
2003	210.00	205.53	240.00	312.80
2004	210.00	221.05	240.00	300.71
2005	210.00	233.68	240.00	259.25
2006	210.00	230.14	240.00	182.43
2007	210.00	214.88	240.00	316.62
2008	210.00	216.01	240.00	248.91
2009	210.00	190.98	240.00	191.00
2010	210.00	247.44	240.00	176.14
2011	210.00	225.82	240.00	299.57
2012	210.00	212.23	240.00	154.66
2013	210.00	182.33	240.00	140.04
2014	210.00	198.24	240.00	268.41
2015	210.00	82.39	240.00	168.22
2016	210.00	187.70	240.00	223.66
2017	210.00	244.06	240.00	235.86
2018	210.00	277.40	240.00	285.50
2019	210.00	354.12	240.00	327.73
2020	210.00	394.05	240.00	274.96
2021	252.00	284.18	240.00	367.86
2022	252.00	312.78	240.00	189.28

Table B.2: Annual SKI 1 landings (t) from the different sources of catch data used in the fishery characterisation. QMR = Quota Monitoring Returns; MHR = Monthly Harvest Returns. Landings are groomed landings (Appendix A); allocated catch is landings allocated to fishing events in the characterisation dataset. Targeted catch represents the allocated catch taken on fishing events where SKI was targeted. '–': no observations.

Fishing year	QMR/MHR (t)	Landings (t)	Allocated			Allocated target	
			Total Catch (t)	BT-PRB (%)	MW-PRM (%)	Catch (t)	Catch (%)
1990	1 230.15	1 099.44	1 103.22	98.45	<0.01	964.78	87.45
1991	1 051.30	1 049.22	1 049.34	97.77	0.02	904.98	86.24
1992	1 016.84	1 034.14	1 030.51	96.11	<0.01	852.54	82.73
1993	1 292.09	1 346.59	1 312.40	94.91	<0.01	1 116.16	85.05
1994	1 157.91	1 175.46	1 165.52	97.49	<0.01	1 062.57	91.17
1995	1 031.65	882.26	902.20	97.54	<0.01	808.23	89.58
1996	800.88	749.47	728.24	96.39	0.1	636.14	87.35
1997	965.08	909.10	903.66	96.30	0.08	803.30	88.89
1998	626.88	638.95	601.35	94.56	<0.01	524.47	87.22
1999	412.70	377.35	369.01	86.38	0.09	312.55	84.70
2000	409.07	407.58	405.03	90.35	1.08	335.95	82.94
2001	335.44	354.93	337.33	84.18	0.03	278.82	82.66
2002	200.92	203.98	199.21	86.71	0.18	134.52	67.53
2003	205.53	204.26	211.43	87.70	0.05	146.87	69.46
2004	221.05	215.30	208.09	86.44	0.19	125.12	60.13
2005	233.68	238.05	228.27	89.00	0.13	157.31	68.91
2006	230.14	226.25	222.40	84.80	3.1	122.43	55.05
2007	214.88	205.59	201.97	87.00	2.16	101.88	50.44
2008	216.01	216.72	217.91	87.78	3.73	144.10	66.13
2009	190.98	194.66	194.09	83.89	1.86	113.58	58.52
2010	247.44	248.15	249.54	84.08	3.45	158.26	63.42
2011	225.82	222.54	221.10	81.23	2.18	94.30	42.65
2012	212.23	213.24	216.71	84.87	2.11	106.41	49.10
2013	182.33	180.31	170.98	83.81	0.7	69.60	40.71
2014	198.24	200.38	208.06	85.89	3.64	122.70	58.97
2015	82.39	79.91	81.45	74.53	3.78	4.49	5.51
2016	187.70	188.11	194.47	87.06	5.67	108.01	55.54
2017	244.06	243.43	248.44	88.48	2.89	105.94	42.64
2018	277.40	281.06	278.87	93.55	0.42	38.41	13.77
2019	354.12	356.43	363.89	91.68	0.32	3.23	0.89
2020	394.05	395.20	395.27	93.77	0.19	7.45	1.88
2021	284.18	288.60	287.82	88.10	1.23	0.17	0.06
2022	312.78	319.44	321.12	93.70	0.39	40.20	12.52

Table B.3: Annual SKI 2 landings (t) from the different sources of catch data used in the fishery characterisation. QMR = Quota Monitoring Returns; MHR = Monthly Harvest Returns. Landings are groomed landings (Appendix A); allocated catch is landings allocated to fishing events in the characterisation dataset. Targeted catch represents the allocated catch taken on fishing events where SKI was targeted. '–': no observations.

Fishing year	QMR/MHR (t)	Landings (t)	Allocated			Allocated target	
			Total Catch (t)	BT-PRB (%)	MW-PRM (%)	Catch (t)	Catch (%)
1990	1 043.47	919.96	904.05	97.21	1.60	625.09	69.14
1991	955.50	779.56	729.09	95.56	1.39	475.29	65.19
1992	1 207.74	1 148.62	1 160.79	82.76	13.34	973.51	83.87
1993	1 020.02	1 009.25	1 015.01	82.05	11.38	822.08	80.99
1994	1 057.80	1 064.65	1 055.24	68.06	25.76	899.41	85.23
1995	905.92	878.15	844.26	50.83	47.55	715.58	84.76
1996	792.59	801.84	787.17	60.90	37.16	636.73	80.89
1997	977.79	896.14	856.02	82.50	14.11	676.12	78.98
1998	670.53	543.25	550.23	88.03	3.88	323.57	58.81
1999	335.58	339.03	340.72	91.48	2.55	257.58	75.60
2000	508.57	506.87	507.60	95.72	3.05	446.00	87.86
2001	330.48	314.87	333.04	88.16	10.46	254.55	76.43
2002	268.04	266.31	270.49	95.94	2.79	179.13	66.23
2003	312.80	312.62	307.33	91.62	6.27	205.04	66.72
2004	300.71	300.62	308.31	88.67	7.47	196.14	63.62
2005	259.25	264.12	261.07	89.82	5.00	149.38	57.22
2006	182.43	186.78	190.72	73.60	12.49	74.65	39.14
2007	316.62	310.37	314.11	88.99	6.41	147.42	46.93
2008	248.91	245.57	243.42	75.11	17.52	18.59	7.64
2009	191.00	189.21	189.74	86.95	4.61	52.47	27.66
2010	176.14	176.71	171.26	86.18	6.33	58.10	33.92
2011	299.57	287.08	284.18	70.08	24.24	90.41	31.81
2012	154.66	155.63	148.18	83.73	4.32	20.96	14.15
2013	140.04	137.84	139.36	76.42	12.75	26.61	19.10
2014	268.41	270.87	261.03	69.95	25.25	78.65	30.13
2015	168.22	164.34	162.87	74.55	17.71	60.08	36.89
2016	223.66	228.83	222.74	75.44	20.69	102.15	45.86
2017	235.86	235.04	230.36	84.30	11.04	91.16	39.57
2018	285.50	280.47	282.70	86.60	7.32	69.67	24.65
2019	327.73	325.17	317.20	81.19	9.93	35.51	11.20
2020	274.96	274.83	276.16	72.01	19.83	2.94	1.06
2021	367.86	365.40	368.95	61.42	29.71	14.43	3.91
2022	189.28	188.69	188.98	68.05	24.81	0.19	0.10

Table B.4: Annual gemfish catches (t) by main destination codes for the SKI 1 Quota Management Area. L= Landings to an LFR, LFL= Fish landed after being held live on land. A complete list of destination codes is provided in Table 2. '–': no observations.

Fishing year	L	LFL	Other
1990	1096.89	-	2.55
1991	1042.3	-	6.93
1992	1034.05	-	0.09
1993	1345.93	-	0.66
1994	1174.53	-	0.93
1995	882.11	-	0.15
1996	749.33	-	0.14
1997	908.96	-	0.14
1998	638.53	-	0.42
1999	377.35	-	-
2000	407.54	-	0.04
2001	354.74	-	0.19
2002	203.74	-	0.24
2003	204.04	-	0.22
2004	214.74	-	0.56
2005	237.66	-	0.39
2006	225.77	-	0.48
2007	204.74	-	0.85
2008	215.22	-	1.5
2009	194.15	-	0.51
2010	247.5	-	0.65
2011	221.56	-	0.98
2012	212.13	-	1.11
2013	179.5	-	0.81
2014	199.25	-	1.12
2015	79.03	-	0.88
2016	186.77	-	1.33
2017	242.85	-	0.59
2018	280.16	-	0.91
2019	354.37	-	2.06
2020	391.44	0.36	3.4
2021	285.29	0.38	2.92
2022	297.1	20.61	1.73

Table B.5: Annual gemfish catches (t) by main destination codes for the SKI 2 Quota Management Area. L= Landings to an LFR, LFL= Fish landed after being held live on land. A complete list of destination codes is provided in Table 2. '–': no observations.

Fishing year	L	LFL	Other
1990	919.46	-	0.5
1991	777.02	-	2.54
1992	1146.3	-	2.33
1993	995.67	-	13.58
1994	1064.6	-	0.05
1995	878.13	-	0.02
1996	801.8	-	0.03
1997	892.59	-	3.55
1998	543.25	-	<0.01
1999	338.57	-	0.47
2000	506.87	-	<0.01
2001	314.83	-	0.04
2002	266.23	-	0.08
2003	312.58	-	0.04
2004	300.6	-	0.03
2005	264.07	-	0.05
2006	186.76	-	0.02
2007	310.34	-	0.03
2008	245.55	-	0.02
2009	189.14	-	0.07
2010	176.64	-	0.07
2011	286.97	-	0.11
2012	155.5	-	0.13
2013	137.59	-	0.26
2014	270.7	-	0.17
2015	164.08	-	0.26
2016	228.64	-	0.19
2017	234.6	-	0.44
2018	280.18	-	0.3
2019	324.42	-	0.76
2020	266.56	3.56	4.71
2021	359.64	-	5.75
2022	186.66	0.84	1.19

Table B.6: Annual landed states of gemfish landings (t) for the SKI 1 Quota Management Area. Key state codes (in terms of total landed green weight) include: DRE= Dressed, GGU= Gilled and gutted, GRE= Green (or whole), GUT= Gutted, HGT= Headed, gutted, and tailed, HGU= Headed and gutted, MEA= Fish meal, UTF= Fillets: skin-on untrimmed. Remaining codes are grouped into 'Other' throughout this report. A complete list of state codes is provided in the glossary Table E.1. '–': no observations.

Fishing year	GGU	GRE	GUT	HGT	HGU	DRE	ROE	SCT	WIN	FIL	MEA	SKF	HGF	TSK	DSC
1990	0.01	1.05	<0.01	0.03	0.01	-	-	-	-	-	-	-	-	-	-
1991	-	0.98	-	<0.01	0.01	0.06	-	-	-	-	-	-	-	-	-
1992	-	1	-	-	0.01	0.02	-	-	-	-	-	-	-	-	-
1993	-	1.33	<0.01	-	<0.01	0.01	<0.01	-	-	-	-	-	-	-	-
1994	-	1.16	<0.01	-	<0.01	0.01	-	-	-	-	-	-	-	-	-
1995	-	0.87	-	-	0.01	0.01	-	<0.01	-	-	-	-	-	-	-
1996	-	0.73	<0.01	<0.01	<0.01	0.01	-	-	<0.01	-	-	-	-	-	-
1997	-	0.9	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
1998	-	0.63	-	-	<0.01	<0.01	-	-	-	-	<0.01	<0.01	-	-	-
1999	<0.01	0.37	-	-	<0.01	<0.01	-	-	-	-	-	-	-	-	-
2000	-	0.39	-	-	<0.01	0.02	-	-	-	-	-	-	-	-	-
2001	-	0.33	<0.01	-	0.01	0.01	-	-	-	-	-	-	<0.01	-	-
2002	-	0.19	-	<0.01	0.01	0.01	-	-	-	-	<0.01	-	-	<0.01	-
2003	-	0.19	-	<0.01	0.01	<0.01	-	-	-	<0.01	<0.01	-	-	-	-
2004	-	0.2	<0.01	-	<0.01	0.01	-	-	-	-	<0.01	-	-	-	-
2005	-	0.22	<0.01	-	0.01	0.02	-	-	-	-	-	<0.01	-	-	-
2006	-	0.21	-	<0.01	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2007	-	0.19	<0.01	-	<0.01	0.01	-	-	-	<0.01	-	<0.01	-	-	-
2008	-	0.21	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2009	-	0.19	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2010	-	0.24	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2011	-	0.21	-	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2012	-	0.2	<0.01	-	<0.01	0.01	-	-	-	-	<0.01	-	-	-	-
2013	-	0.17	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2014	-	0.19	-	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2015	-	0.07	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	-	-	-	-
2016	-	0.18	-	-	<0.01	0.01	-	-	-	-	<0.01	-	-	-	-
2017	-	0.24	-	-	<0.01	0.01	-	-	-	-	<0.01	-	-	-	-
2018	-	0.27	<0.01	-	<0.01	0.01	-	-	-	<0.01	<0.01	<0.01	-	-	-
2019	-	0.35	-	-	<0.01	0.01	-	-	-	-	<0.01	<0.01	-	-	<0.01
2020	-	0.39	-	-	<0.01	0.01	-	-	-	-	<0.01	-	-	-	-
2021	-	0.28	-	-	<0.01	0.01	-	-	-	<0.01	<0.01	<0.01	-	-	-
2022	-	0.31	-	-	<0.01	0.01	-	-	-	<0.01	<0.01	<0.01	-	-	-

Table B.7: Annual landed states of gemfish landings (t) for the SKI 2 Quota Management Area. Key state codes (in terms of total landed green weight) include: DRE= Dressed, GGU= Gilled and gutted, GRE= Green (or whole), GUT= Gutted, HGT= Headed, gutted, and tailed, HGU= Headed and gutted, MEA= Fish meal, UTF= Fillets: skin-on untrimmed. Remaining codes are grouped into 'Other' throughout this report. A complete list of state codes is provided in the glossary Table E.1. '–': no observations.

Fishing year	GRE	GUT	HGT	HGU	DRE	WIN	UTF	FIL	SKF	FIN	MEA
1990	0.9	<0.01	0.01	0.01	-	-	-	-	-	-	-
1991	0.74	<0.01	0.01	0.02	0.02	-	-	-	-	-	-
1992	1.12	<0.01	-	0.01	0.02	-	-	-	-	-	-
1993	0.99	-	-	<0.01	0.02	-	-	-	-	-	-
1994	1.05	<0.01	-	<0.01	0.02	-	-	-	-	-	-
1995	0.82	<0.01	-	0.04	0.01	<0.01	-	-	-	-	-
1996	0.76	<0.01	-	0.01	0.02	-	0.02	-	-	-	-
1997	0.87	<0.01	-	0.01	0.02	-	-	<0.01	-	-	-
1998	0.53	-	<0.01	<0.01	0.02	-	-	-	-	-	-
1999	0.31	-	<0.01	<0.01	0.02	-	-	-	-	-	-
2000	0.49	-	<0.01	<0.01	0.01	-	-	<0.01	-	-	-
2001	0.29	<0.01	-	<0.01	0.02	-	-	-	<0.01	-	-
2002	0.23	<0.01	<0.01	<0.01	0.03	-	-	-	<0.01	<0.01	<0.01
2003	0.29	<0.01	<0.01	<0.01	0.02	-	-	-	-	-	<0.01
2004	0.28	-	<0.01	<0.01	0.02	-	-	<0.01	-	-	<0.01
2005	0.25	-	-	<0.01	0.01	-	-	<0.01	-	-	<0.01
2006	0.17	-	-	<0.01	0.02	-	-	<0.01	-	-	<0.01
2007	0.29	-	-	<0.01	0.02	-	-	-	-	-	-
2008	0.23	-	-	<0.01	0.02	-	-	-	-	-	<0.01
2009	0.18	<0.01	-	<0.01	0.01	-	-	-	-	-	-
2010	0.15	-	-	<0.01	0.02	-	-	-	-	-	<0.01
2011	0.25	<0.01	-	<0.01	0.03	-	-	-	<0.01	-	<0.01
2012	0.15	<0.01	-	<0.01	0.01	-	-	-	-	-	<0.01
2013	0.12	<0.01	-	0.01	0.01	-	-	-	-	-	<0.01
2014	0.25	-	-	0.01	<0.01	-	-	-	-	-	<0.01
2015	0.15	<0.01	-	0.01	<0.01	-	-	-	-	-	<0.01
2016	0.21	<0.01	-	0.01	<0.01	-	-	<0.01	-	-	<0.01
2017	0.23	<0.01	-	<0.01	0.01	-	-	<0.01	-	-	<0.01
2018	0.26	<0.01	-	<0.01	0.01	-	-	-	-	-	<0.01
2019	0.3	<0.01	-	<0.01	0.02	-	-	<0.01	<0.01	-	<0.01
2020	0.25	-	-	<0.01	0.03	-	-	-	-	-	<0.01
2021	0.33	<0.01	-	0.01	0.03	-	-	-	-	-	<0.01
2022	0.15	-	-	<0.01	0.04	-	-	-	-	-	<0.01

Table B.8: Annual modal conversion factor reported for the product state codes of gemfish for the SKI 1 and SKI 2 Quota Management Areas. DRE= Dressed, FIL= Fillets: skin-on, GGU= Gilled and gutted, GRE= Green (or whole), GUT= Gutted, HGT= Headed, gutted, and tailed, HGU= Headed and gutted, MEA= Fish meal, ROE= Roe, SKF= Fillets: skin-off. A complete list of state codes is provided in the glossary Table E.1. '–': no observations.

Fishing year	GGU	GRE	GUT	HGT	HGU	DRE	ROE	FIL	MEA	SKF
1990	1.20	1.00	1.10	1.60	1.50	-	-	-	-	-
1991	-	1.00	1.10	1.60	1.50	1.60	-	-	-	-
1992	-	1.00	1.10	-	1.50	1.55	-	-	-	-
1993	-	1.00	1.10	-	1.50	1.55	0.00	-	-	-
1994	-	1.00	1.10	-	1.50	1.55	-	-	-	-
1995	-	1.00	1.10	-	1.50	1.55	-	-	-	-
1996	-	1.00	1.10	-	1.50	1.55	-	-	-	-
1997	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
1998	-	1.00	-	-	1.50	1.55	-	-	5.60	2.15
1999	-	1.00	-	-	1.50	1.55	-	-	-	-
2000	-	1.00	-	-	1.50	1.55	-	2.15	-	-
2001	-	1.00	1.10	-	1.50	1.55	-	-	-	2.65
2002	-	1.00	1.10	-	1.50	1.55	-	-	5.60	2.65
2003	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2004	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2005	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	2.65
2006	-	1.00	-	-	1.50	1.55	-	2.15	5.60	-
2007	-	1.00	1.10	-	1.50	1.55	-	2.15	-	2.65
2008	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2009	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2010	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2011	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	2.65
2012	-	1.00	1.10	-	1.50	1.55	-	-	5.60	-
2013	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2014	-	1.00	-	-	1.50	1.55	-	2.15	5.60	-
2015	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2016	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2017	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	-
2018	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	2.65
2019	-	1.00	1.10	-	1.50	1.55	-	2.15	5.60	2.65
2020	-	1.00	-	-	1.50	1.55	-	-	-	-
2021	-	1.00	1.10	-	1.50	1.55	-	2.15	-	2.65
2022	-	1.00	-	-	1.50	1.55	-	2.15	-	2.65

Table B.9: Reporting forms used for effort within the SKI 1 Quota Management Area, on trips landing gemfish in terms of data records and their allocated catch (t) from 1990 to 2020. A complete list of form type codes is provided in the glossary Table E.2. '–': no observations.

Fishing year	Records (N)						Allocated catch (t)					
	TCP	CEL	TCE	LTC	ERS - Trawl	ERS - Lining	TCP	CEL	TCE	LTC	ERS - Trawl	ERS - Lining
1990	1073.00	1754.00	-	-	-	-	280.32	822.91	-	-	-	-
1991	1658.00	2468.00	-	-	-	-	250.03	799.30	-	-	-	-
1992	1351.00	3030.00	-	-	-	-	264.77	765.75	-	-	-	-
1993	1143.00	3285.00	-	-	-	-	414.83	897.56	-	-	-	-
1994	1785.00	2627.00	-	-	-	-	750.56	414.94	-	-	-	-
1995	1978.00	2435.00	-	-	-	-	697.20	204.95	-	-	-	-
1996	4274.00	1611.00	-	-	-	-	660.32	67.82	-	-	-	-
1997	4574.00	1929.00	-	-	-	-	714.06	189.57	-	-	-	-
1998	5627.00	1839.00	-	-	-	-	543.41	57.89	-	-	-	-
1999	4316.00	1437.00	-	-	-	-	304.87	63.99	-	-	-	-
2000	4034.00	1477.00	-	-	-	-	356.50	48.50	-	-	-	-
2001	4564.00	1380.00	-	-	-	-	296.80	40.28	-	-	-	-
2002	4938.00	1526.00	-	-	-	-	164.19	34.96	-	-	-	-
2003	5057.00	1611.00	-	-	-	-	175.89	35.54	-	-	-	-
2004	6360.00	1522.00	-	-	-	-	175.65	31.81	-	-	-	-
2005	6144.00	1574.00	-	-	-	-	199.63	28.62	-	-	-	-
2006	6036.00	1705.00	-	-	-	-	186.35	36.04	-	-	-	-
2007	5292.00	1957.00	-	-	-	-	170.20	31.65	-	-	-	-
2008	3883.00	266.00	1646.00	1388.00	-	-	172.90	3.58	26.74	14.53	-	-
2009	4048.00	270.00	1583.00	1137.00	-	-	142.76	15.84	23.86	10.63	-	-
2010	3851.00	292.00	2174.00	1271.00	-	-	158.64	16.32	60.09	14.37	-	-
2011	4276.00	321.00	1633.00	1767.00	-	-	151.26	20.69	33.18	15.91	-	-
2012	4048.00	207.00	1439.00	1271.00	-	-	174.24	12.61	14.25	13.24	-	-
2013	3399.00	244.00	1671.00	1110.00	-	-	113.97	6.78	30.52	15.36	-	-
2014	3733.00	359.00	2183.00	1053.00	-	-	149.55	10.19	36.74	7.96	-	-
2015	3297.00	264.00	2363.00	1254.00	-	-	41.44	2.00	22.33	11.27	-	-
2016	3599.00	278.00	2301.00	925.00	-	-	143.74	2.61	36.59	9.64	-	-
2017	3571.00	286.00	3129.00	1148.00	-	-	175.66	6.77	51.34	11.62	-	-
2018	2640.00	244.00	2767.00	1087.00	1208.00	-	134.79	2.11	70.16	13.55	57.09	-
2019	1572.00	146.00	1878.00	829.00	2619.00	541.00	56.42	0.84	85.91	21.14	192.44	3.80
2020	-	-	-	17.00	5751.00	2386.00	-	-	-	0.01	371.41	23.50
2021	-	-	-	-	5510.00	2169.00	-	-	-	-	257.12	28.88
2022	-	-	-	-	5195.00	1555.00	-	-	-	-	302.15	16.46

Table B.10: Reporting forms used for effort within the SKI 2 Quota Management Area, on trips landing gemfish in terms of data records and their allocated catch (t) from 1990 to 2020. A complete list of form type codes is provided in the glossary Table E.2. '–': no observations.

Fishing year	Records (N)						Allocated catch (t)					
	TCP	CEL	TCE	LTC	ERS - Trawl	ERS - Lining	TCP	CEL	TCE	LTC	ERS - Trawl	ERS - Lining
1990	1803.00	2023.00	-	-	-	-	23.99	880.06	-	-	-	-
1991	2459.00	2483.00	-	-	-	-	68.47	660.62	-	-	-	-
1992	2392.00	2513.00	-	-	-	-	324.31	836.48	-	-	-	-
1993	2729.00	2374.00	-	-	-	-	420.38	594.64	-	-	-	-
1994	3793.00	2132.00	-	-	-	-	718.65	336.56	-	-	-	-
1995	3700.00	1701.00	-	-	-	-	595.06	249.20	-	-	-	-
1996	5277.00	1359.00	-	-	-	-	576.74	210.42	-	-	-	-
1997	5334.00	1253.00	-	-	-	-	633.09	222.93	-	-	-	-
1998	4374.00	1159.00	-	-	-	-	456.73	93.50	-	-	-	-
1999	4687.00	1229.00	-	-	-	-	277.15	63.55	-	-	-	-
2000	4818.00	1071.00	-	-	-	-	477.13	30.45	-	-	-	-
2001	4733.00	1177.00	-	-	-	-	302.64	30.35	-	-	-	-
2002	5501.00	1131.00	-	-	-	-	247.91	22.53	-	-	-	-
2003	4822.00	1632.00	-	-	-	-	246.87	60.42	-	-	-	-
2004	3907.00	1422.00	-	-	-	-	253.76	54.36	-	-	-	-
2005	3699.00	1543.00	-	-	-	-	181.07	79.92	-	-	-	-
2006	3544.00	1703.00	-	-	-	-	108.01	82.24	-	-	-	-
2007	3850.00	1885.00	-	-	-	-	222.76	91.01	-	-	-	-
2008	3286.00	61.00	3391.00	1421.00	-	-	136.71	0.53	88.77	15.23	-	-
2009	2877.00	22.00	3244.00	882.00	-	-	96.10	0.04	77.63	13.51	-	-
2010	3486.00	24.00	3859.00	1302.00	-	-	100.01	0.01	58.41	11.10	-	-
2011	3972.00	32.00	4416.00	1545.00	-	-	199.12	0.01	68.92	14.70	-	-
2012	2800.00	82.00	4120.00	1385.00	-	-	55.94	2.28	74.52	14.93	-	-
2013	2255.00	113.00	4293.00	1101.00	-	-	34.51	0.64	89.75	13.73	-	-
2014	2943.00	72.00	4158.00	1072.00	-	-	132.24	0.31	116.25	12.17	-	-
2015	2898.00	73.00	3164.00	1270.00	-	-	100.53	0.95	49.74	11.12	-	-
2016	2532.00	72.00	3042.00	1175.00	-	-	115.73	0.36	98.39	8.26	-	-
2017	2815.00	36.00	3456.00	1713.00	-	-	113.36	0.02	106.26	10.26	-	-
2018	1036.00	101.00	4562.00	2123.00	1796.00	-	24.36	0.07	193.83	16.18	47.31	-
2019	470.00	86.00	3165.00	1689.00	3543.00	1000.00	39.89	0.25	186.06	16.55	63.08	11.28
2020	-	-	118.00	74.00	5854.00	2469.00	-	-	7.13	0.89	246.48	21.46
2021	-	-	-	-	5450.00	2736.00	-	-	-	-	336.23	32.18
2022	-	-	-	-	4590.00	1499.00	-	-	-	-	175.48	11.57

Table B.11: Landings (t) of SKI 1 by method of capture and fishing year. A complete list of fishing method codes is provided in the glossary Table E.3. '–': no observations.

Fishing year	BLL	BPT	BT	DL	MW	SN	HL	DS	PRB	Other	Total
1990	12.09	2.69	1086.12	0.14	0.00	0.96	-	-	-	1.21	1103.22
1991	21.18	0.21	1025.94	0.36	0.21	1.13	0.08	-	-	0.23	1049.34
1992	34.21	0.00	990.41	0.77	0.01	4.27	-	0.01	-	0.83	1030.51
1993	28.90	-	1245.61	1.59	0.00	35.66	-	0.08	-	0.56	1312.40
1994	17.38	0.45	1136.21	0.83	0.01	10.14	0.00	0.01	-	0.48	1165.52
1995	15.75	0.37	879.98	0.41	0.01	5.35	-	0.11	-	0.21	902.20
1996	17.03	0.18	701.95	1.36	0.76	6.05	-	0.16	-	0.76	728.24
1997	25.35	-	870.23	0.53	0.69	6.65	0.00	0.11	-	0.09	903.66
1998	22.25	-	568.65	0.58	0.01	9.32	-	0.08	-	0.46	601.35
1999	34.61	7.09	318.76	0.60	0.35	6.37	-	0.73	-	0.51	369.01
2000	21.28	12.51	365.93	0.14	4.37	0.09	0.00	0.65	-	0.05	405.03
2001	22.82	29.28	283.96	0.53	0.11	0.03	-	0.08	-	0.52	337.33
2002	24.27	-	172.73	0.15	0.36	0.03	0.08	0.50	-	1.09	199.21
2003	25.08	0.15	185.43	0.17	0.11	0.14	0.10	0.22	-	0.04	211.43
2004	24.08	0.11	179.87	0.15	0.39	0.01	0.09	3.14	-	0.26	208.09
2005	23.78	0.22	203.17	0.06	0.30	0.03	0.19	0.46	-	0.06	228.27
2006	24.44	0.02	188.59	0.29	6.90	0.06	0.26	0.12	-	1.71	222.40
2007	19.56	0.33	175.71	0.36	4.37	0.09	0.87	0.02	-	0.66	201.97
2008	15.76	0.21	191.29	1.49	8.14	0.06	0.82	0.12	-	0.01	217.91
2009	12.20	0.19	162.83	1.67	3.61	0.06	0.13	13.38	-	0.03	194.09
2010	14.47	0.30	209.82	1.25	8.61	0.08	0.20	14.61	-	0.19	249.54
2011	15.94	0.02	179.60	3.85	4.82	0.02	0.41	16.40	-	0.05	221.10
2012	13.27	-	183.91	1.11	4.57	2.31	0.28	11.18	-	0.07	216.71
2013	15.56	-	143.30	0.28	1.20	4.34	0.35	5.93	-	0.01	170.98
2014	7.99	-	178.71	0.16	7.58	3.59	0.83	9.15	-	0.05	208.06
2015	11.26	-	60.70	0.18	3.08	4.31	0.70	1.08	-	0.15	81.45
2016	9.64	-	168.53	0.15	11.02	1.88	0.36	2.05	0.78	0.06	194.47
2017	12.51	-	195.57	0.13	7.18	2.11	0.06	6.51	24.25	0.13	248.44
2018	13.55	-	206.28	0.21	1.16	1.16	0.37	1.53	54.60	0.00	278.87
2019	24.87	-	178.65	0.03	1.16	3.27	0.24	0.64	154.95	0.08	363.89
2020	23.36	-	344.45	0.15	0.75	0.06	0.02	0.26	26.20	0.01	395.27
2021	28.23	-	227.58	0.65	3.55	0.04	0.15	1.61	25.99	0.02	287.82
2022	16.40	-	153.13	0.07	1.26	1.86	0.03	0.61	147.77	0.00	321.12

Table B.12: Landings (t) of SKI 2 by method of capture and fishing year. A complete list of fishing method codes is provided in the glossary Table E.3. '–': no observations.

Fishing year	BLL	BT	DL	MW	SN	HL	DS	BPT	PRM	PRB	Other	Total
1990	8.96	878.82	0.11	14.43	1.71	-	-	-	-	-	0.02	904.05
1991	21.46	696.71	0.28	10.12	0.35	-	-	-	-	-	0.17	729.09
1992	33.77	960.71	0.00	154.88	10.38	0.01	-	-	-	-	1.04	1160.79
1993	54.39	832.77	0.00	115.47	12.33	0.04	-	-	-	-	0.01	1015.01
1994	41.19	718.18	0.04	271.85	23.88	-	-	-	-	-	0.09	1055.24
1995	10.75	429.13	0.05	401.49	2.68	-	0.00	-	-	-	0.16	844.26
1996	14.23	479.36	0.35	292.51	0.33	-	0.06	-	-	-	0.32	787.17
1997	1.79	706.23	0.30	120.80	24.93	-	0.00	-	-	-	1.97	856.02
1998	3.03	484.37	0.28	21.33	41.21	-	-	-	-	-	0.01	550.23
1999	3.18	311.69	0.02	8.69	16.06	-	0.00	-	-	-	1.07	340.72
2000	2.15	485.87	0.01	15.46	4.06	-	-	0.01	-	-	0.03	507.60
2001	4.37	293.60	0.03	34.85	0.01	-	0.00	-	-	-	0.18	333.04
2002	3.28	259.52	0.01	7.54	0.07	0.00	-	-	-	-	0.07	270.49
2003	6.40	281.57	0.02	19.27	0.01	0.01	-	-	-	-	0.06	307.33
2004	11.45	273.39	0.00	23.03	0.00	0.01	-	-	-	-	0.43	308.31
2005	13.31	234.50	0.03	13.04	0.09	0.05	-	-	-	-	0.05	261.07
2006	25.75	140.36	0.01	23.81	0.73	0.04	-	-	-	-	0.00	190.72
2007	13.97	279.52	0.02	20.14	0.21	0.01	0.23	-	-	-	0.02	314.11
2008	17.31	182.84	0.05	42.65	0.47	-	0.05	-	-	-	0.05	243.42
2009	14.16	164.98	0.00	8.75	1.75	0.01	-	-	-	-	0.08	189.74
2010	12.75	147.59	0.00	10.83	0.08	0.00	0.00	-	-	-	0.01	171.26
2011	16.12	199.14	0.00	68.90	0.01	0.00	0.00	-	-	-	0.00	284.18
2012	15.39	124.06	0.01	6.40	0.04	2.27	0.00	-	-	-	0.00	148.18
2013	13.74	106.50	0.19	17.76	0.71	0.44	0.00	-	-	-	0.02	139.36
2014	12.01	182.58	0.27	65.91	0.06	0.03	-	-	-	-	0.18	261.03
2015	11.12	121.42	0.23	28.85	0.54	0.71	-	-	-	-	0.00	162.87
2016	8.26	168.04	0.13	43.49	0.01	0.21	-	-	2.59	-	0.01	222.74
2017	10.26	191.28	0.01	19.43	0.37	0.01	-	-	5.99	2.91	0.11	230.36
2018	16.90	209.60	0.05	9.85	0.06	0.01	-	-	10.84	35.21	0.18	282.70
2019	27.83	242.94	0.13	31.43	0.08	0.13	-	-	0.08	14.59	0.00	317.20
2020	22.19	196.44	0.16	54.75	0.00	0.00	0.20	-	-	2.41	0.01	276.16
2021	31.84	225.41	0.34	109.61	0.52	-	-	-	-	1.22	0.02	368.95
2022	11.49	126.22	0.08	46.88	1.90	0.03	-	-	-	2.38	0.01	188.98

APPENDIX C: COMPOSITIONAL DATA

Size composition data for gemfish are available from observer and market sampling. Opportunistic observer sampling data (subsection C.1) are available from SKI 1 and SKI 2, primarily from bottom trawl fisheries off the east coast (Table C.1).

Interpretation of aggregated patterns by area and method (Figure C.2, Figure C.3) is complicated by the sporadic nature of the sampling. For bottom trawl fisheries, the widest size range of gemfish has been recorded from scampi target tows on the east coast in SKI 1, while the a small number of samples from tarakihi target tows in SKI 2 exhibit a noticeable deficit of fish over 75 cm (Figure C.4, Figure C.5). Samples from hoki target trawling are primarily unsexed samples collected during a gear comparison trial (Middleton 2021), while sampling of gemfish bycatch from scampi trawls provides the longest time series of samples (Figure C.8).

A small number of samples from midwater fishing contained no fish under 60 cm (Figure C.9).

Directed market sampling was carried out annually from 1990–1994 and 1996–2008 in support of the previous fully quantitative assessments of northern gemfish, and so provides much larger sample sizes (Table C.2) than were available from observer sampling. Aggregated samples suggest that gemfish sampled in SKI 1, off both the east (FMA 1) and west (FMA 9) coasts were predominantly larger than 75 cm while samples from SKI 2 (FMA 2) had a much higher proportion of smaller fish, although fish under 60 cm were noticably fewer in samples from midwater fishing in SKI 2 (Figure C.12).

While market sampling was landings-based, differences between different target fisheries can be investigated on the basis of the modal target of the sampled trips (Figure C.13). The differences are most apparent in cumulative distributions (Figure C.14) with tarakihi-target trips in FMA 2 having the smallest fish, and FMA 2 hoki and gemfish trips showing a wider size range of gemfish than hoki and gemfish target trips in FMA 1 or FMA 9.

Although smaller gemfish were sometimes encountered in SKI 1 samples, samples from both the east and west coast fisheries are unimodal in most years (Figure C.15). Samples from SKI 2, however, often showed multiple modes, with year class progession discernible. Although the market sampling intended to focus on the gemfish target fisheries, later market samples from SKI 2 were from trips with a range of modal target species, with tarakihi target trips sampled during 2003–2008.

Maturity data for female gemfish from market and observer sampling (Figure C.18) suggest that 50% of fish are mature at lengths of around 65 cm.

C.1 Observer length-frequency data

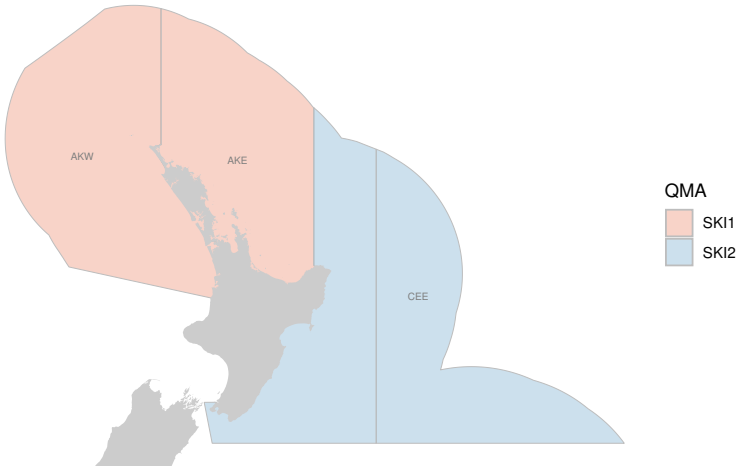

Figure C.1: Observer Fisheries Management Areas in relation to the Quota Management Areas (QMA) for gemfish.

Table C.1: Length frequency samples of gemfish by area and method, sampled by the Observer Programme from fishing years 1991 to 2022. Observer area codes are defined in the glossary.

QMA	Observer FMA	Method	Sampled events	Number of fish
SKI1	AKE	BLL	8	12
SKI1	AKE	BT	245	3 707
SKI1	AKE	MW	4	63
SKI1	AKE	PRB	22	1 342
SKI1	AKW	BLL	1	2
SKI1	AKW	BT	42	218
SKI1	AKW	HAL	1	1
SKI1	AKW	MW	7	37
SKI1	AKW	PRB	2	24
SKI2	CEE	BLL	5	7
SKI2	CEE	BT	477	4 694
SKI2	CEE	MW	57	389
SKI2	CEE	PRB	2	48
SKI2	CEE	PRM	1	7
SKI2	CEE	TWL	1	12

C.1.1 Length composition by area and method

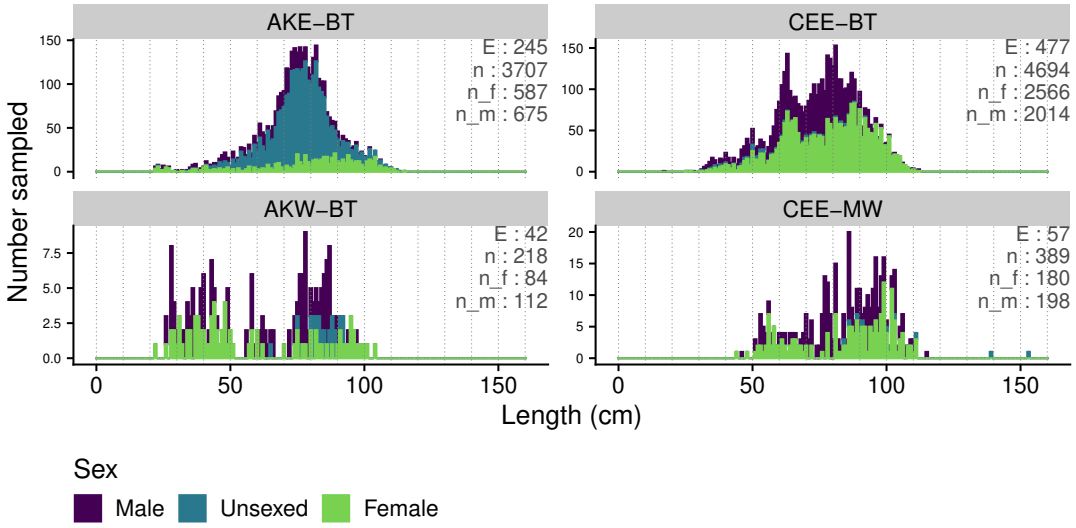

Figure C.2: Raw (unscaled) length-frequency distributions of gemfish for the AKE, AKW, CEE areas by fishing method. Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-method. Only area-methods with at least 100 fish measurements are included. The observer area codes are defined in the glossary.

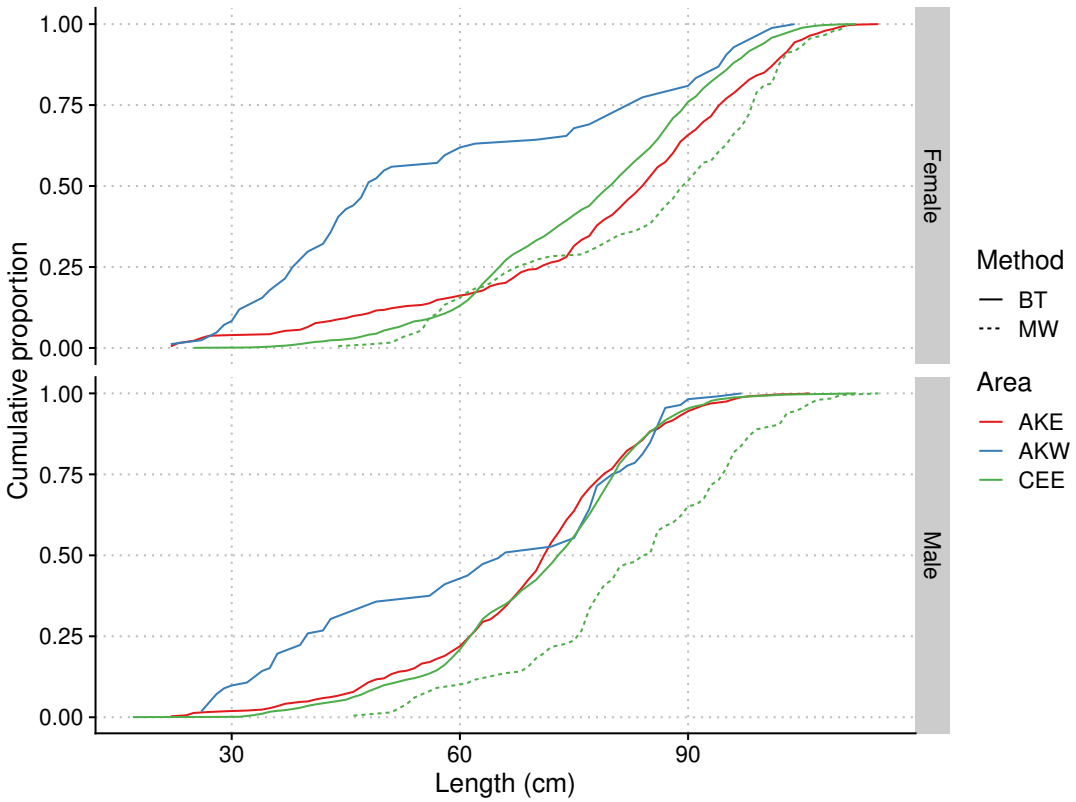

Figure C.3: Cumulative length-frequency distributions of gemfish for the AKE, AKW, CEE area by fishing method, using raw, unscaled observer samples.

C.1.2 The bottom trawl fishery

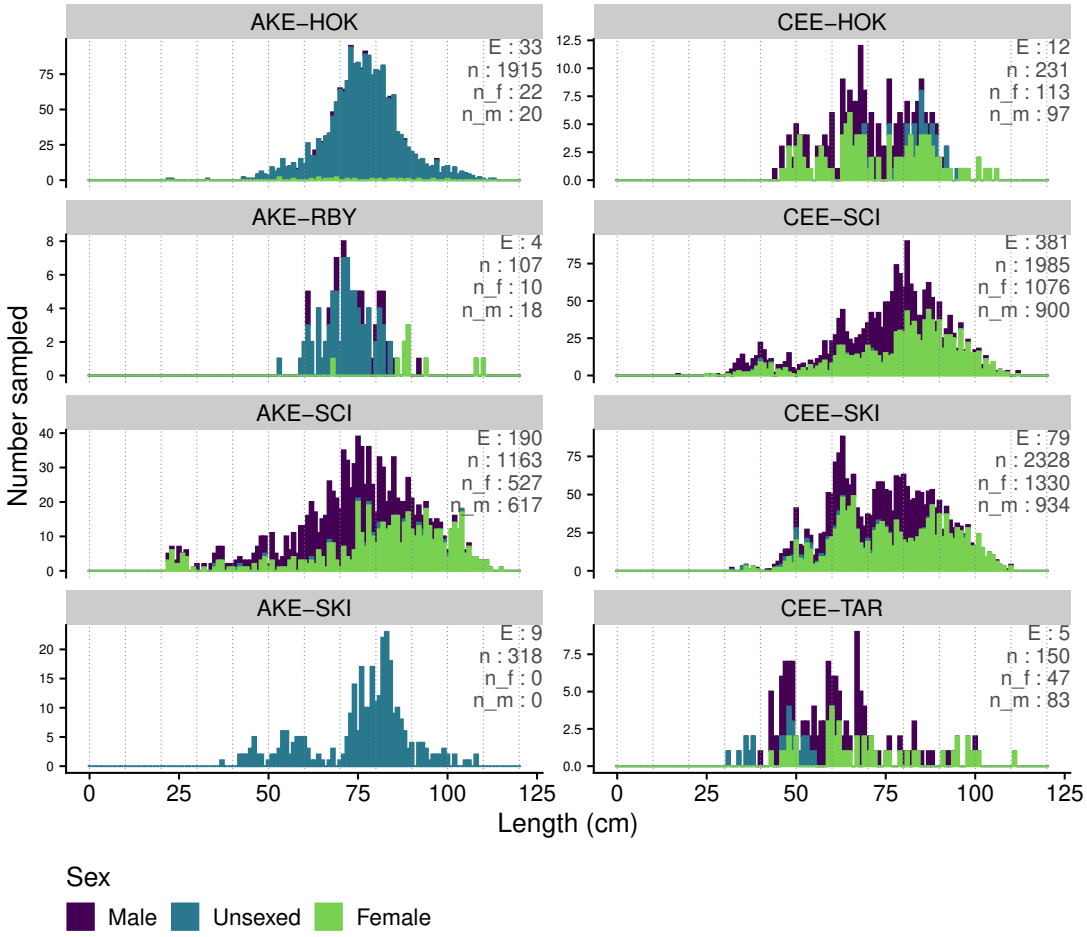

Figure C.4: Raw length-frequency distributions for gemfish caught in the bottom trawl fishery, by area, target species, and sex. Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-target and sex. Only area-targets at least 100 fish measurements are included. Observer area codes are defined in the glossary.

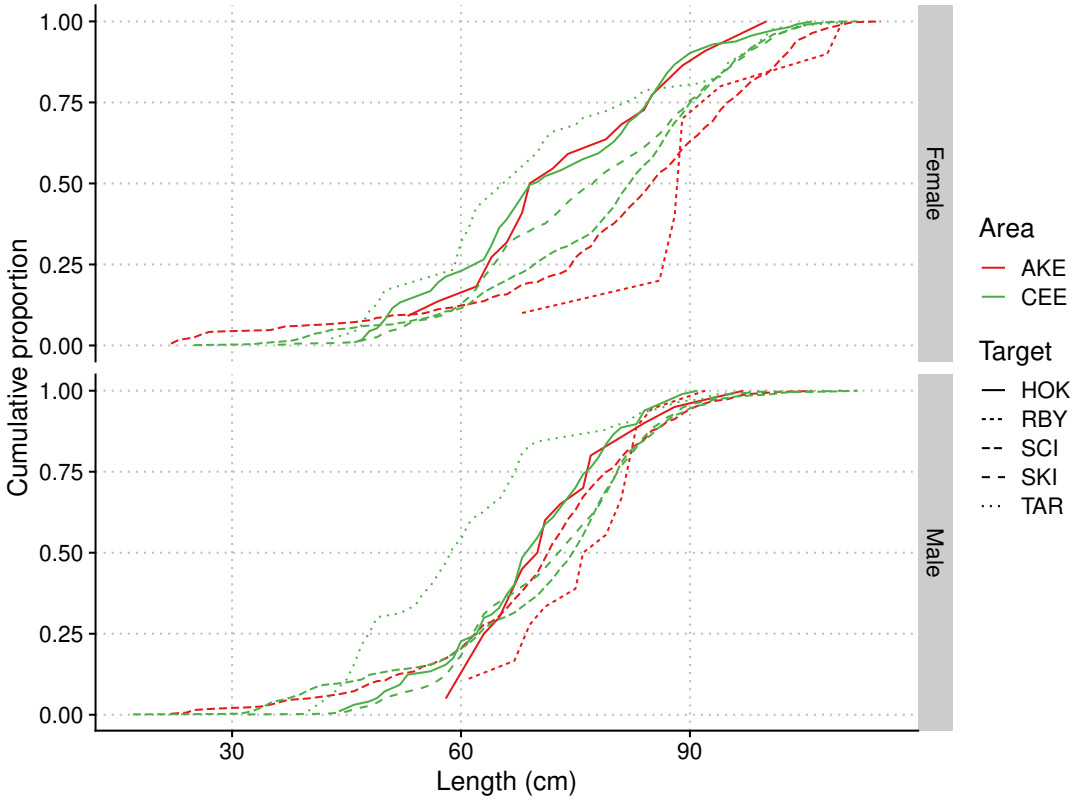

Figure C.5: Cumulative length-frequency distributions for gemfish caught in the bottom trawl fishery, by area and target species. Only area-targets at least 100 fish measurements are included. Observer area codes are defined in the glossary.

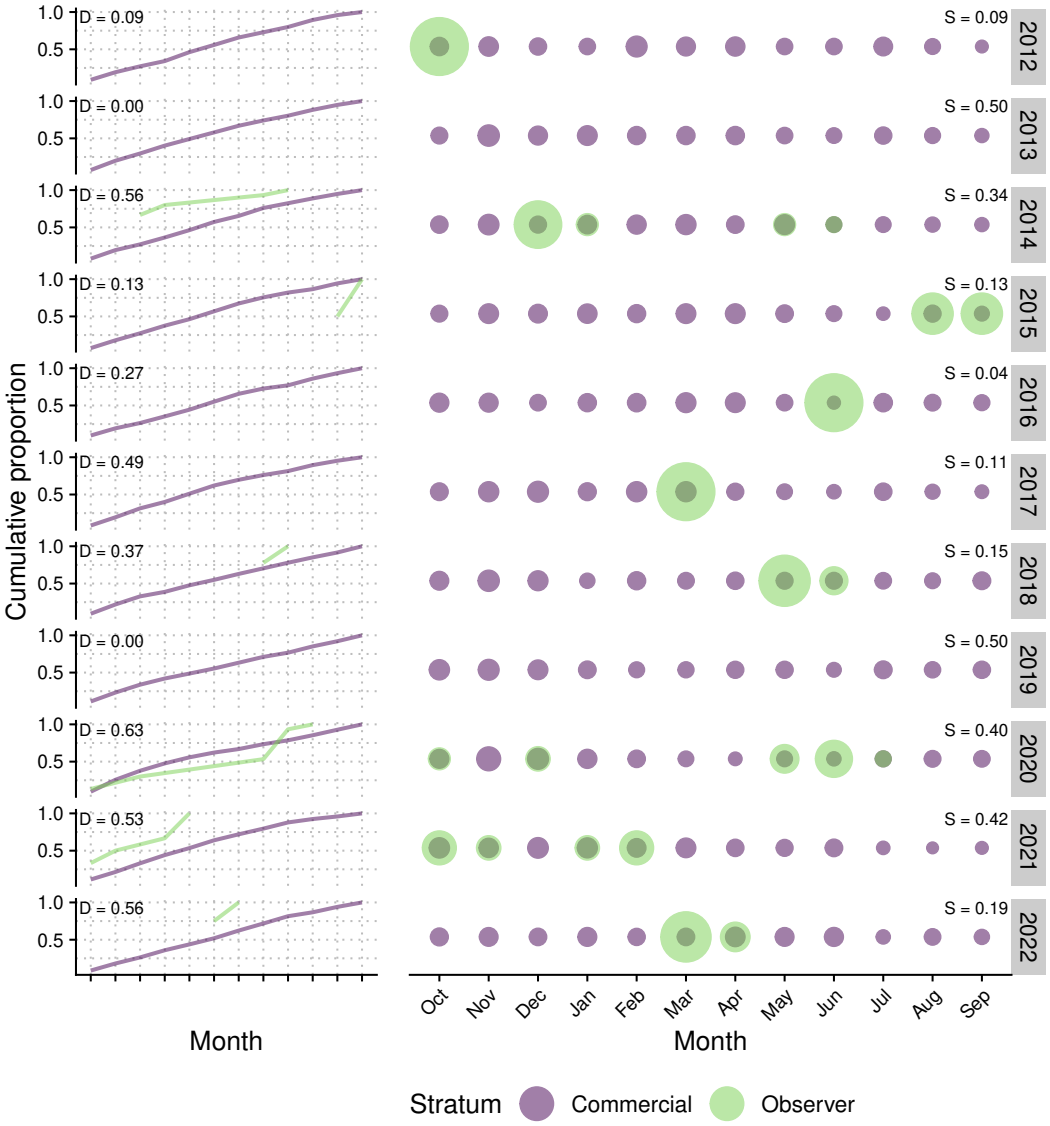

Figure C.6: Representativeness of observer sampling coverage of bottom trawl fishing events that caught gemfish in 2012 to 2022 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

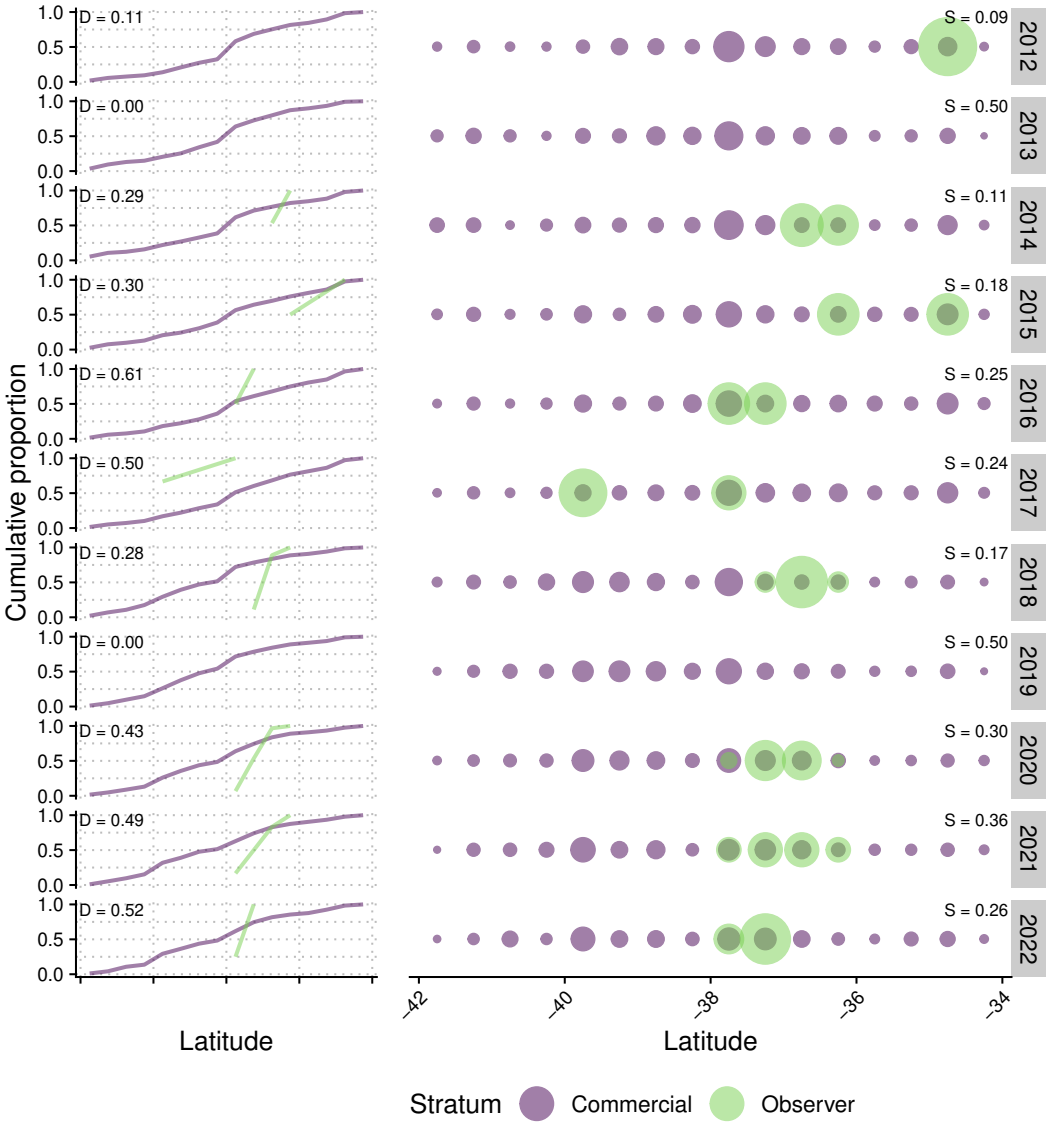

Figure C.7: Representativeness of observer sampling coverage of fishing events that caught gemfish in 2012 to 2022 by fishing year and latitude. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

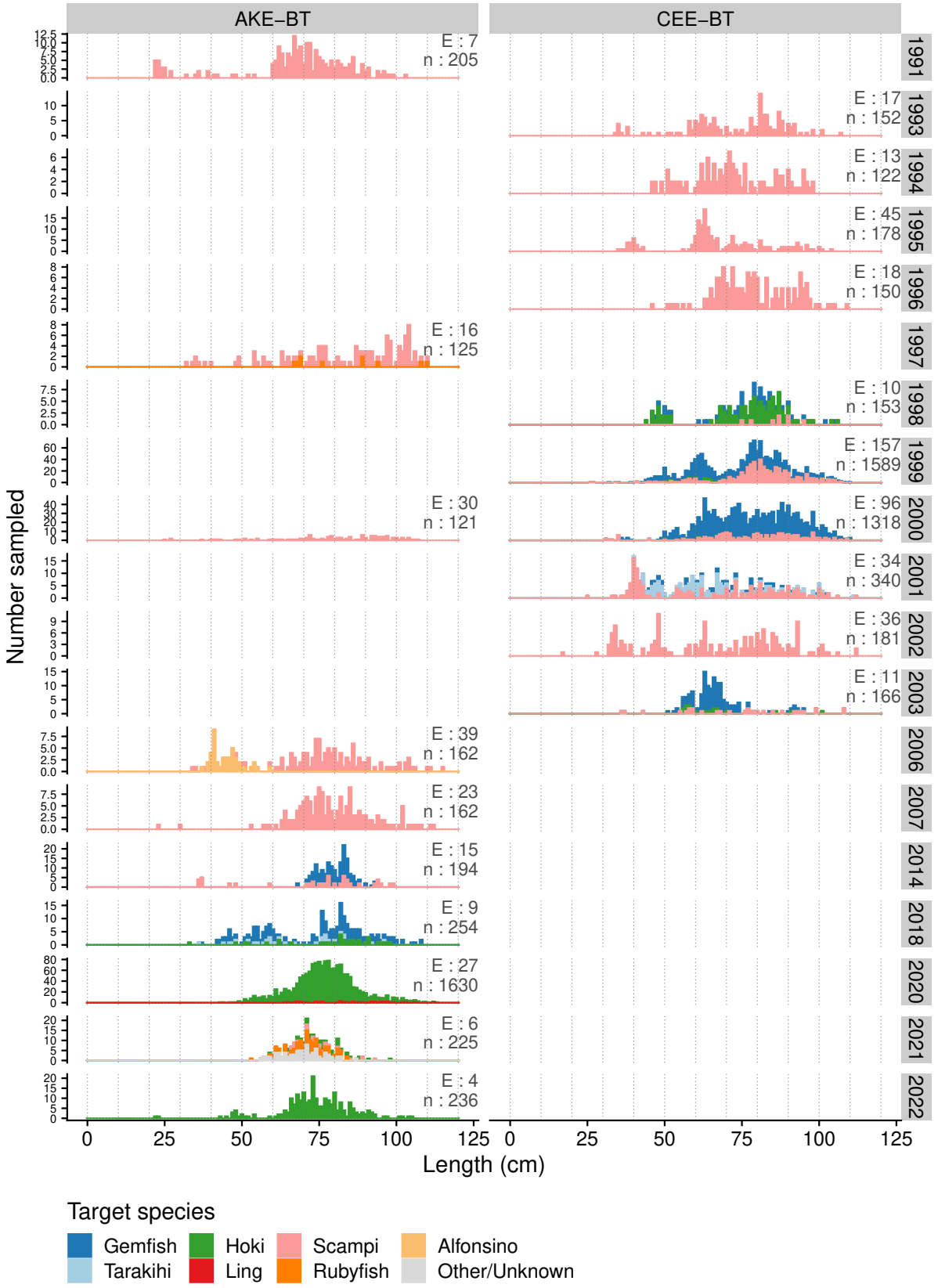

Figure C.8: Raw length-frequency distributions for gemfish caught in the bottom trawl fishery, by area, fishing year, and target species. Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area, target and year. Observer area codes are defined in the glossary. The Other grouping includes both minor target species and events where the target species was not recorded.

C.1.3 The midwater trawl fishery

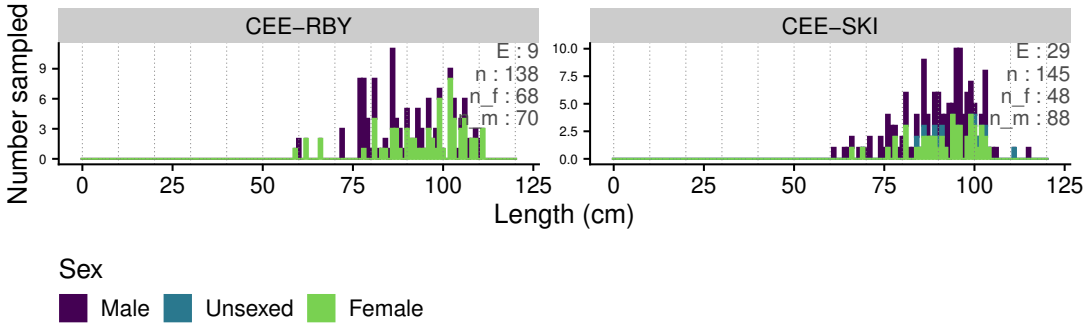

Figure C.9: Raw length-frequency distributions for gemfish caught in the midwater trawl fishery, by area, target species, and sex. Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-target and sex. Only area-targets at least 100 fish measurements are included. Observer area codes are defined in the glossary.

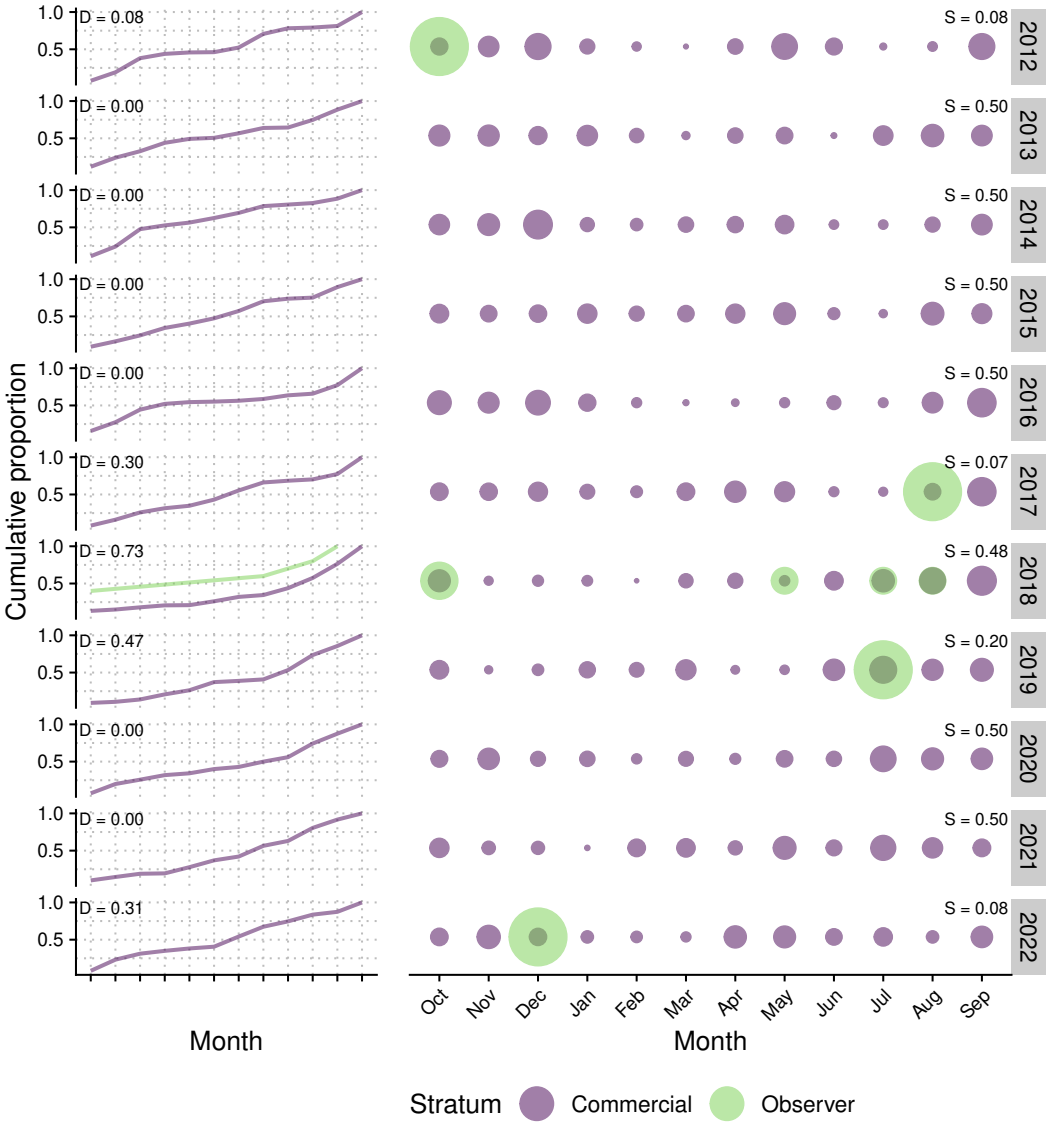

Figure C.10: Representativeness of observer sampling coverage of midwater trawl fishing events that caught gemfish in 2012 to 2022 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

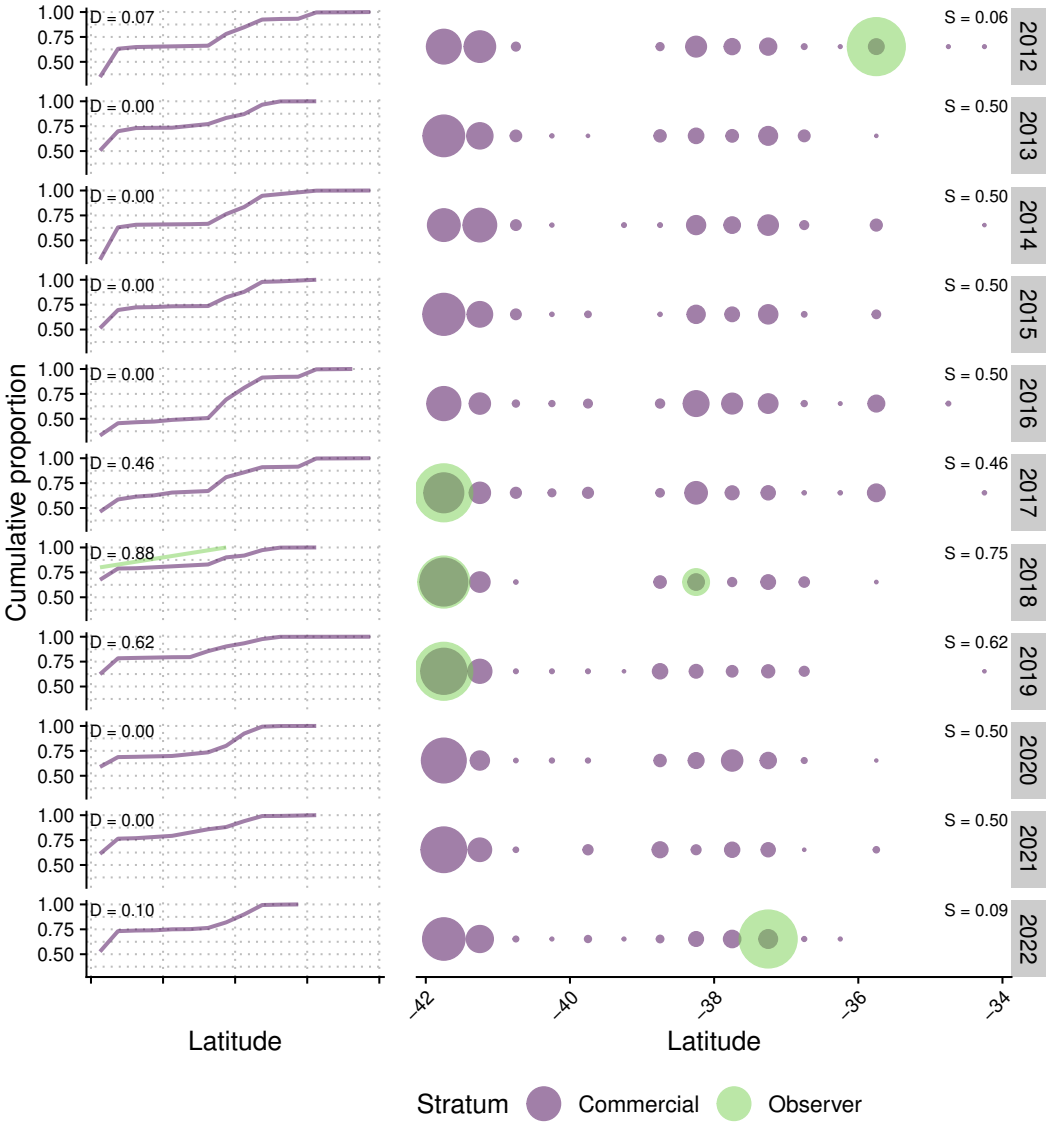

Figure C.11: Representativeness of observer sampling coverage of fishing events that caught gemfish in 2012 to 2022 by fishing year and latitude. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

C.2 Market sampling data

Table C.2: Length frequency samples of gemfish from market sampling.

Area	Method	Sampled landings	Number of fish
FMA1	BT	94	18 027
FMA2	BLL	1	43
FMA2	BT	114	12 104
FMA2	MW	18	2 225
FMA2	SN	1	147
FMA9	BT	54	13 782

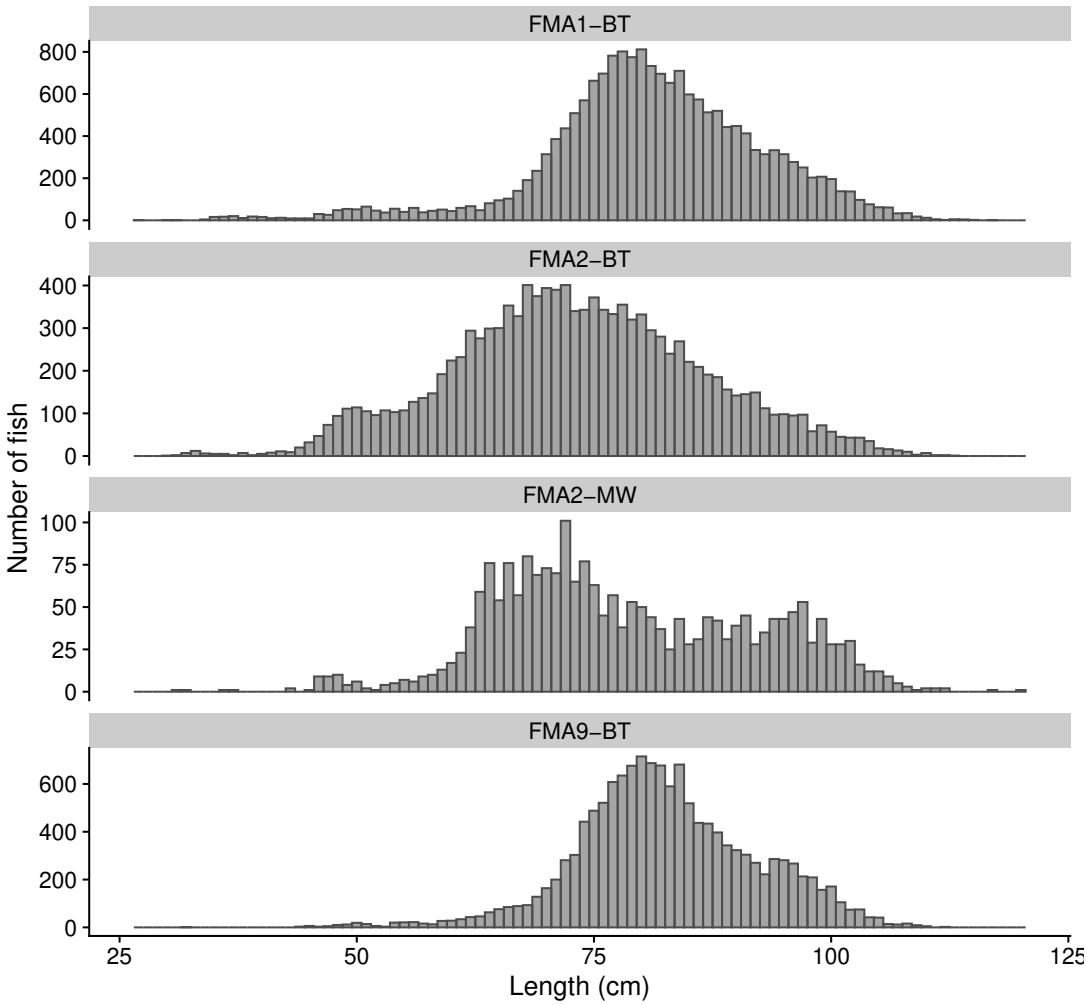

Figure C.12: Raw aggregate market sampling length-frequency distributions by area and method for gemfish for strata with at least 200 fish sampled.

C.2.1 Market samples from the bottom trawl fishery

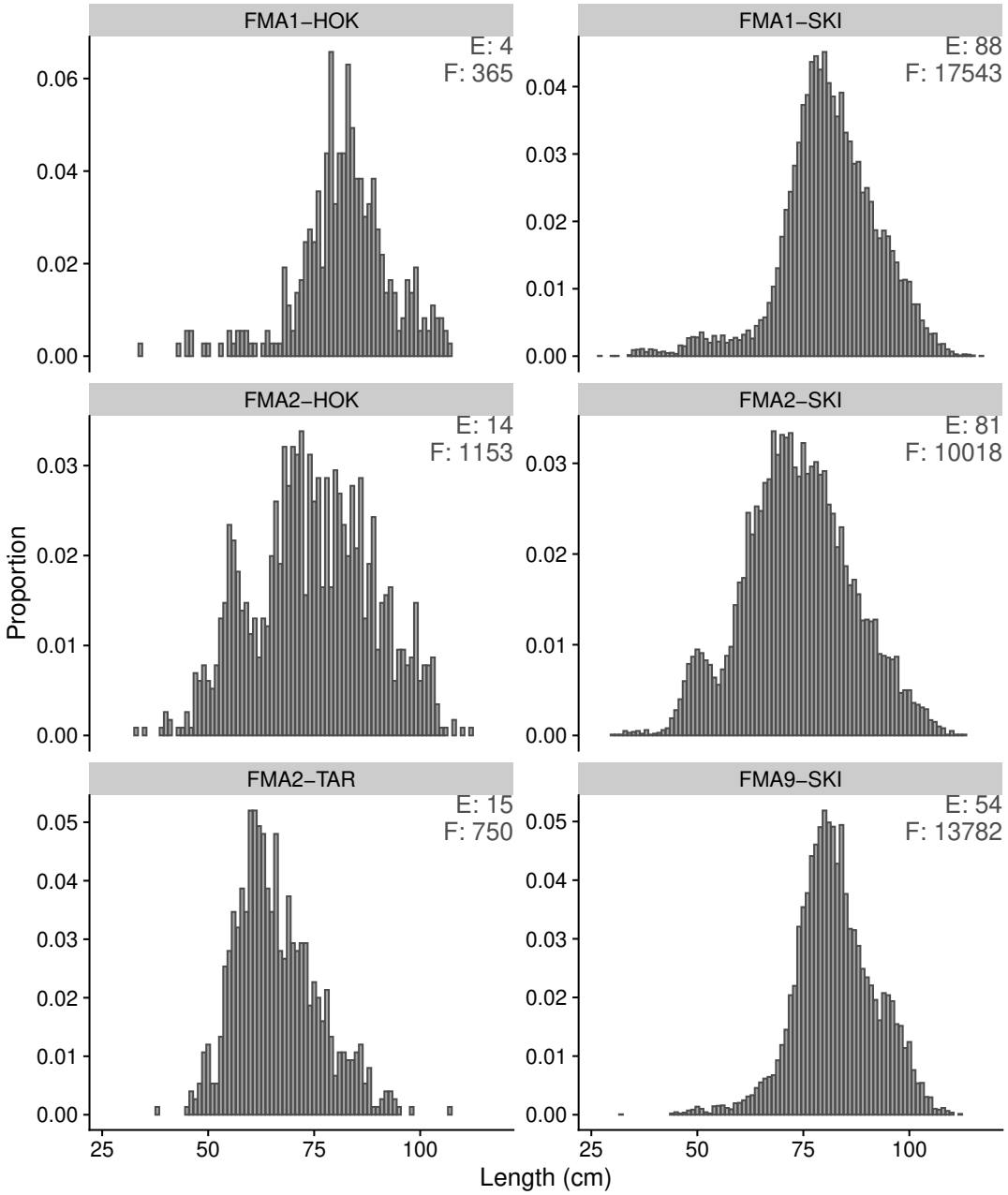

Figure C.13: Raw aggregate market sampling length-frequency distributions for gemfish caught in the bottom trawl fishery, by area and target species. E indicates the number of landings sampled, and F the total number of fish sampled.

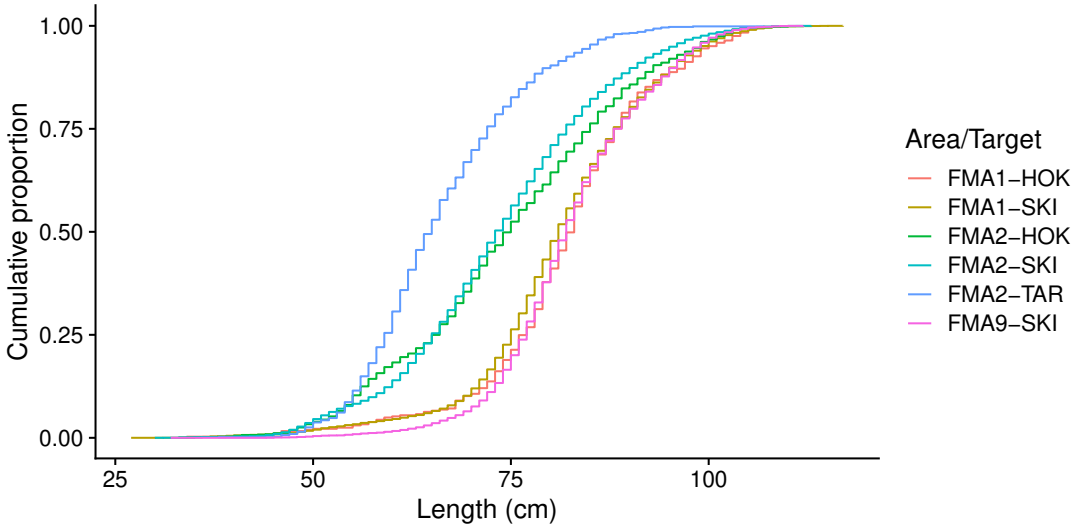

Figure C.14: Cumulative market sampling length-frequency distributions for gemfish caught in the bottom trawl fishery, by area and target species.

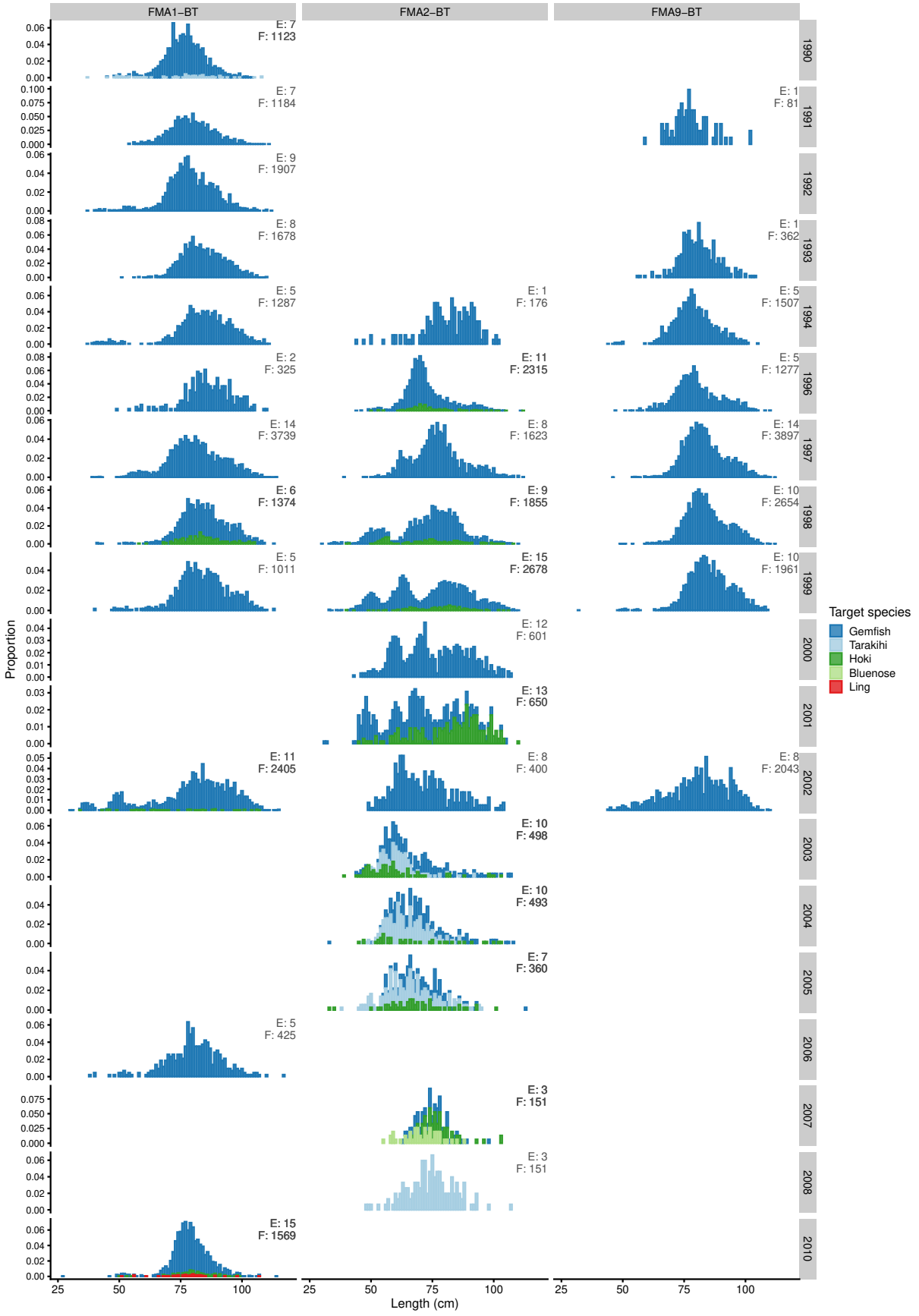

Figure C.15: Raw aggregate market sampling length-frequency distributions for gemfish caught in the bottom trawl fishery, by area, year, and target species, strata with at least 30 fish sampled. E indicates the number of landings sampled, and F the total number of fish sampled.

C.2.2 Market samples from the midwater trawl fishery

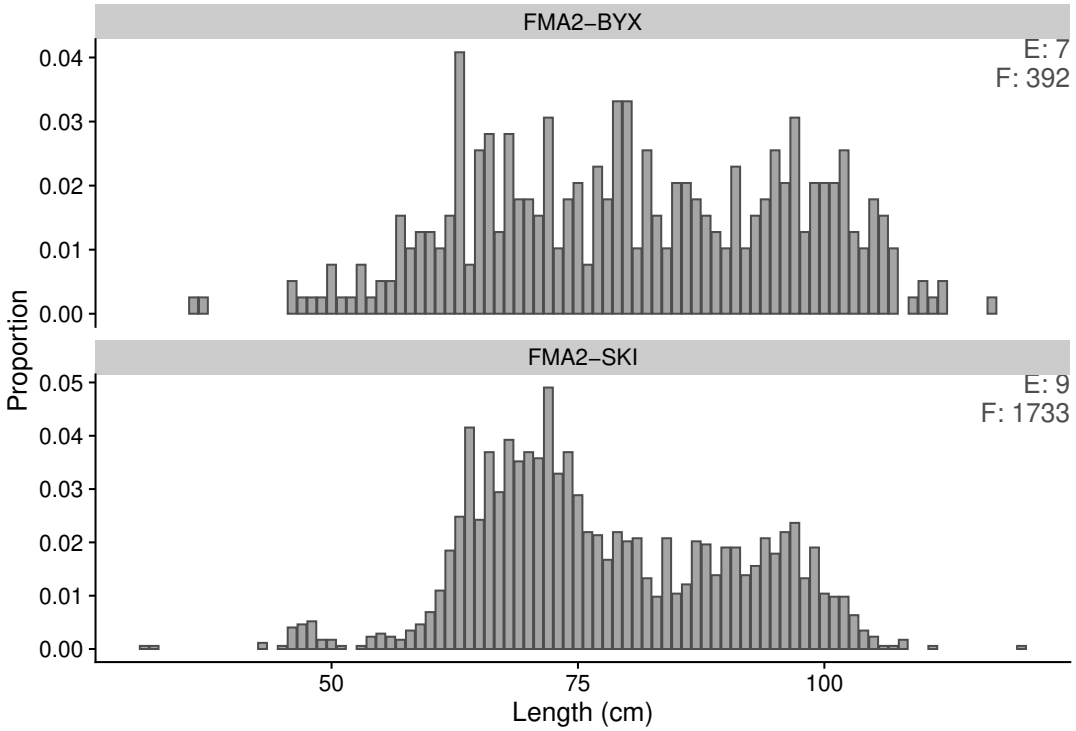

Figure C.16: Raw aggregate market sampling length-frequency distributions for gemfish caught in the midwater trawl fishery, by area and target species. E indicates the number of landings sampled, and F the total number of fish sampled.

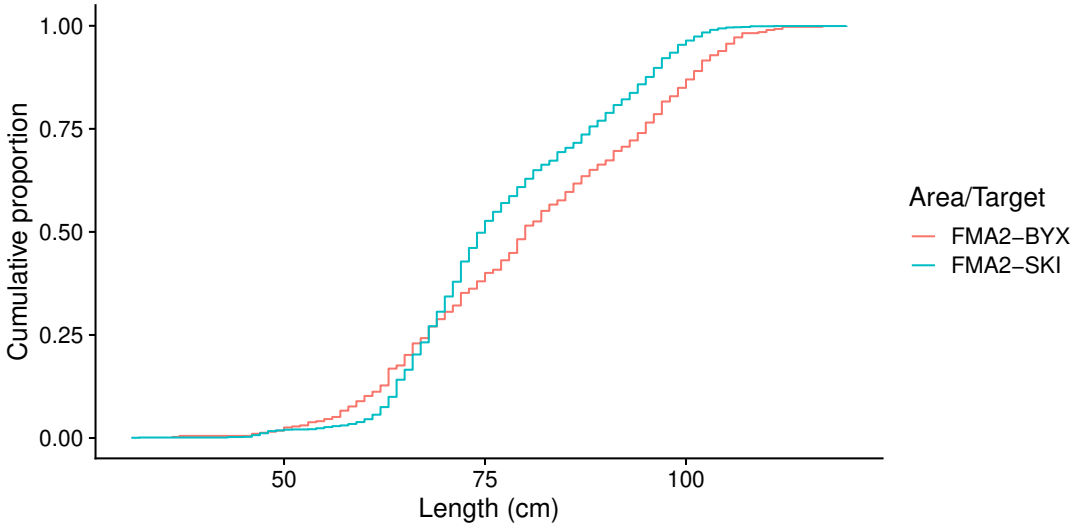

Figure C.17: Cumulative market sampling length-frequency distributions for gemfish caught in the midwater trawl fishery, by area and target species.

C.3 Maturity data

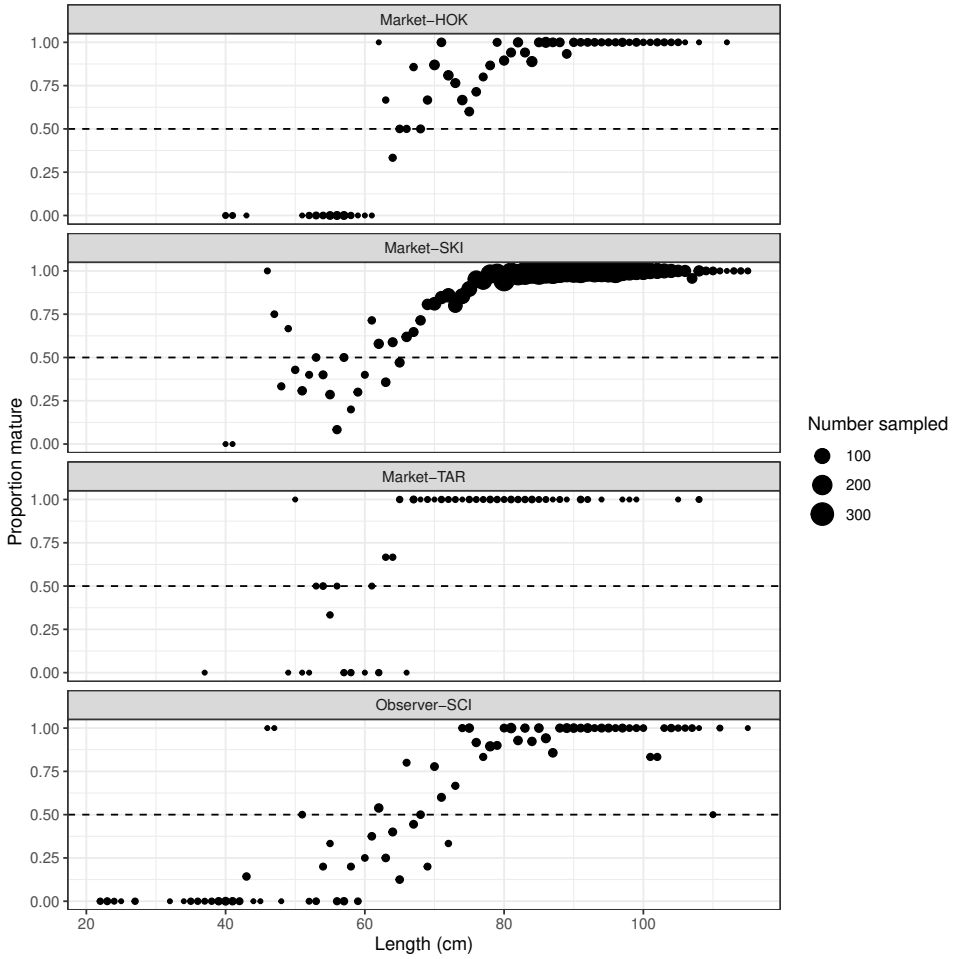

Figure C.18: Maturity at length for female gemfish for sampling sources and target fisheries where at least 100 females have been staged. Mature fish are those with a macroscopic gonad stage of 2 or greater (5 stage scale).

APPENDIX D: ADDITIONAL CPUE SERIES

D.1 SKI1 SKI2 TAR event

Table D.1: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 TAR event CPUE series.

Series	SKI1 SKI2 TAR event
QMS stock	SKI1, SKI2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	TAR
Areas	008, 009, 010, 011, 012, 013, 014, 015
Period	2007-10-01, 2022-09-30
Resolution	Fishing event
Core fleet years	3
Core fleet trips	3
Default model	allockg_top5 ~ fyear + vessel_key + bs(log(fishing_duration), 3) + stat_area*month + bs(bottom_depth, 3) + bs(effort_width, 3) + bs(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

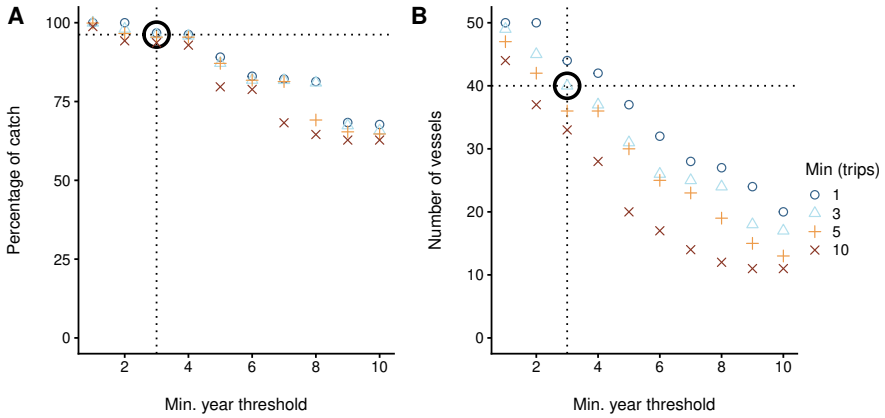

Figure D.1: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 TAR event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

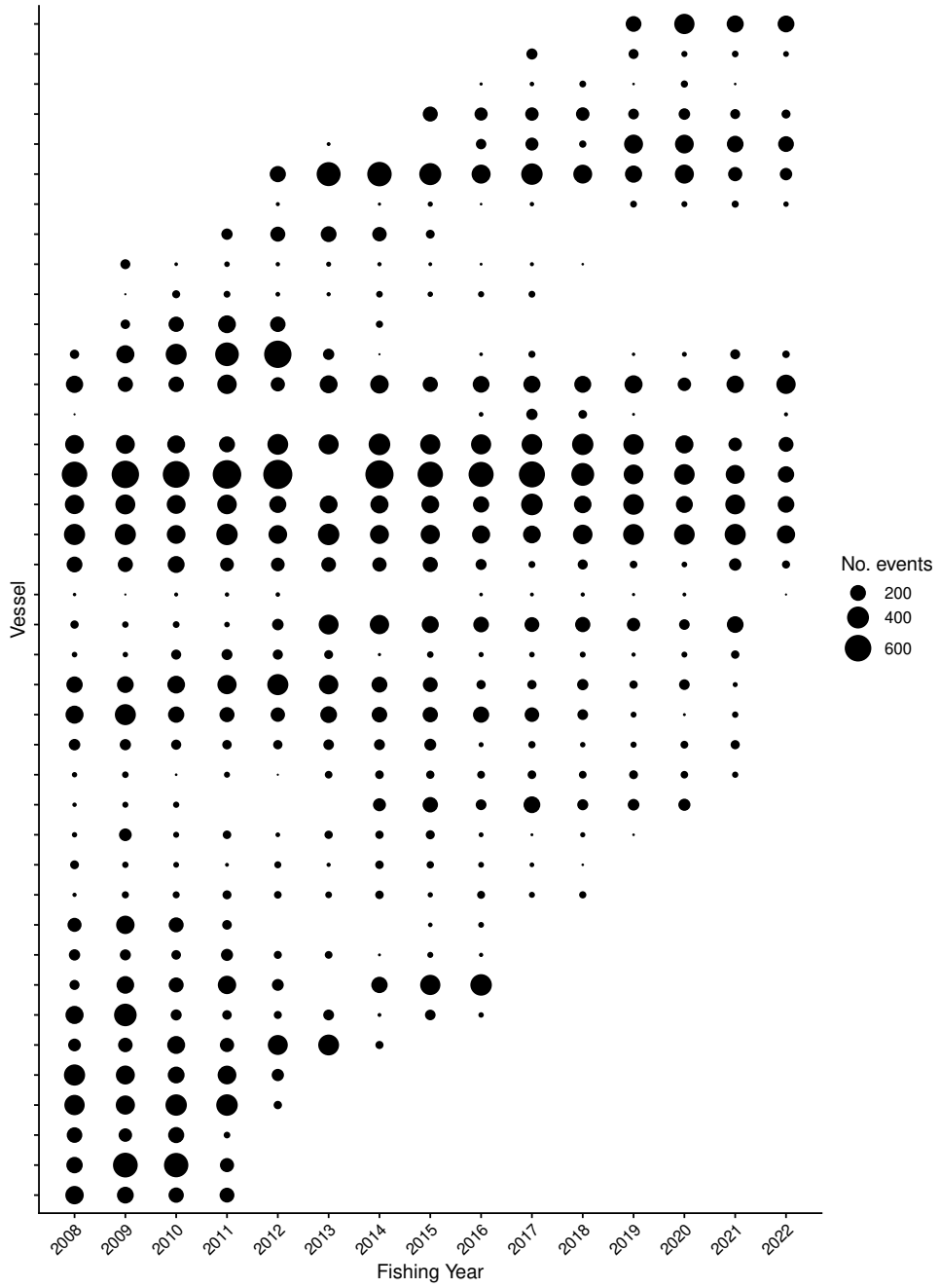

Figure D.2: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.2: Summary of SKI1 SKI2 TAR event total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ungroomed data	128 (Percent: 100) (Records: 6316)	83 (Percent: 100) (Records: 6798)	51 (Percent: 100) (Records: 6553)	73 (Percent: 100) (Records: 6221)	89 (Percent: 100) (Records: 5554)	60 (Percent: 100) (Records: 5050)	58 (Percent: 100) (Records: 5351)	56 (Percent: 100) (Records: 4781)	42 (Percent: 100) (Records: 3848)	108 (Percent: 100) (Records: 4037)	133 (Percent: 100) (Records: 3472)	146 (Percent: 100) (Records: 3182)
Fishing duration is not NA	128 (Percent: 100) (Records: 6316)	83 (Percent: 100) (Records: 6796)	51 (Percent: 100) (Records: 6553)	73 (Percent: 100) (Records: 6220)	89 (Percent: 100) (Records: 5554)	60 (Percent: 100) (Records: 5050)	58 (Percent: 100) (Records: 5351)	56 (Percent: 100) (Records: 4781)	42 (Percent: 100) (Records: 3848)	108 (Percent: 100) (Records: 4036)	133 (Percent: 100) (Records: 3472)	146 (Percent: 100) (Records: 3182)
Positive fishing duration	128 (Percent: 100) (Records: 6315)	83 (Percent: 100) (Records: 6796)	51 (Percent: 100) (Records: 6553)	73 (Percent: 100) (Records: 6220)	89 (Percent: 100) (Records: 5553)	60 (Percent: 100) (Records: 5050)	58 (Percent: 100) (Records: 5351)	56 (Percent: 100) (Records: 4781)	42 (Percent: 100) (Records: 3846)	108 (Percent: 100) (Records: 4035)	133 (Percent: 100) (Records: 3471)	146 (Percent: 100) (Records: 3182)
Bottom depth >=10	128 (Percent: 100) (Records: 6313)	83 (Percent: 100) (Records: 6794)	50 (Percent: 100) (Records: 6552)	73 (Percent: 100) (Records: 6220)	89 (Percent: 100) (Records: 5552)	60 (Percent: 100) (Records: 5049)	58 (Percent: 100) (Records: 5350)	56 (Percent: 100) (Records: 4780)	42 (Percent: 100) (Records: 3846)	108 (Percent: 100) (Records: 4034)	133 (Percent: 100) (Records: 3471)	146 (Percent: 100) (Records: 3181)
Bottom depth <=600	128 (Percent: 100) (Records: 6313)	83 (Percent: 100) (Records: 6794)	50 (Percent: 100) (Records: 6552)	73 (Percent: 100) (Records: 6220)	89 (Percent: 100) (Records: 5552)	60 (Percent: 100) (Records: 5049)	58 (Percent: 100) (Records: 5350)	56 (Percent: 100) (Records: 4780)	42 (Percent: 100) (Records: 3845)	108 (Percent: 100) (Records: 4034)	133 (Percent: 100) (Records: 3471)	146 (Percent: 100) (Records: 3181)
Core fleet selection	90 (Percent: 70) (Records: 4894)	76 (Percent: 92) (Records: 6047)	45 (Percent: 88) (Records: 5490)	60 (Percent: 82) (Records: 5426)	72 (Percent: 81) (Records: 4699)	44 (Percent: 73) (Records: 3827)	50 (Percent: 86) (Records: 4194)	51 (Percent: 91) (Records: 4088)	39 (Percent: 92) (Records: 3355)	84 (Percent: 78) (Records: 3549)	89 (Percent: 67) (Records: 2831)	140 (Percent: 100) (Records: 3008)

Filter	2020	2021	2022
Ungroomed data	153 (Percent: 100) (Records: 2868)	144 (Percent: 100) (Records: 2720)	58 (Percent: 100) (Records: 1920)
Fishing duration is not NA	153 (Percent: 100) (Records: 2868)	144 (Percent: 100) (Records: 2720)	58 (Percent: 100) (Records: 1920)
Positive fishing duration	153 (Percent: 100) (Records: 2867)	144 (Percent: 100) (Records: 2719)	58 (Percent: 100) (Records: 1918)
Bottom depth >=10	153 (Percent: 100) (Records: 2867)	144 (Percent: 100) (Records: 2718)	58 (Percent: 100) (Records: 1918)
Bottom depth <=600	153 (Percent: 100) (Records: 2867)	144 (Percent: 100) (Records: 2717)	58 (Percent: 100) (Records: 1918)
Core fleet selection	153 (Percent: 100) (Records: 2864)	144 (Percent: 100) (Records: 2711)	58 (Percent: 100) (Records: 1918)

Table D.3: Summary of the SKI1 SKI2 TAR event dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of event with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
2008	29	644	4 894	17 694.70	89.78	31.98
2009	31	762	6 047	21 956.20	76.10	27.55
2010	31	732	5 490	19 885.69	44.65	32.90
2011	31	749	5 426	19 298.08	59.99	31.98
2012	29	602	4 694	16 751.30	71.71	39.75
2013	23	509	3 824	14 009.10	43.53	30.47
2014	27	564	4 194	14 933.82	49.52	34.62
2015	26	507	4 013	14 934.41	50.88	31.12
2016	30	492	3 348	13 075.60	38.73	37.69
2017	27	508	3 549	13 833.67	84.10	35.59
2018	23	399	2 831	11 082.50	88.84	43.98
2019	24	417	3 008	11 501.80	140.11	50.07
2020	22	405	2 864	11 172.28	153.39	49.79
2021	20	452	2 711	10 599.82	144.15	41.83
2022	15	331	1 918	7 233.13	57.77	43.74

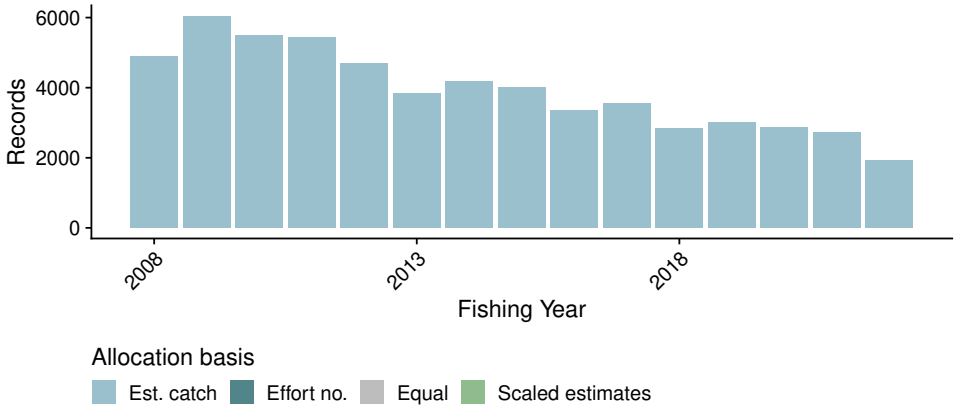

Figure D.3: Allocation basis for attributing landings to records in the SKI1 SKI2 TAR event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.4: Summary of stepwise selection for occurrence of positive catch. 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	13.00	75 929	1.40	1.40	*
+ bs(bottom_depth, 3)	3.00	73 712	4.30	2.90	*
+ vessel_key	40.00	72 814	5.50	1.30	*
+ stat_area	7.00	72 004	6.60	1.10	*
+ month	11.00	71 303	7.60	0.90	*
+ stat_area:month	77.00	70 757	8.50	0.90	*
+ bs(effort_width, 3)	3.00	70 732	8.50	0.00	
+ bs(effort_height, 3)	3.00	70 725	8.50	0.00	
+ bs(log(fishing_duration), 3)	3.00	70 720	8.50	0.00	

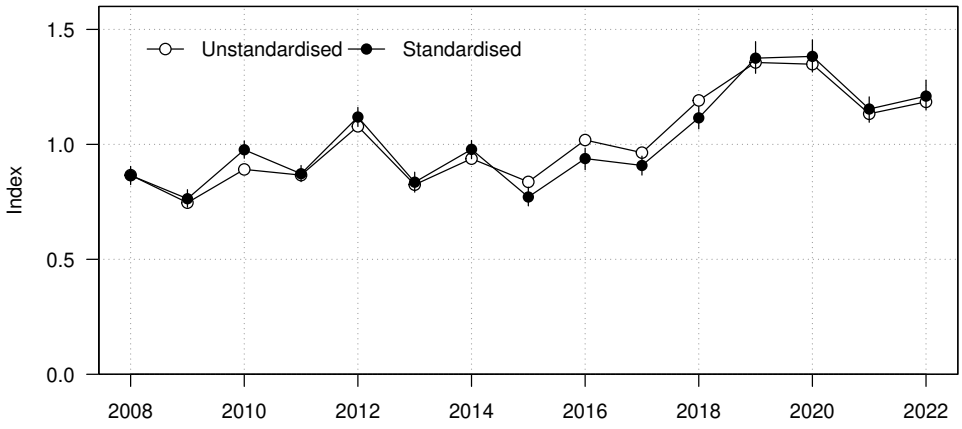

Figure D.4: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 TAR event dataset.

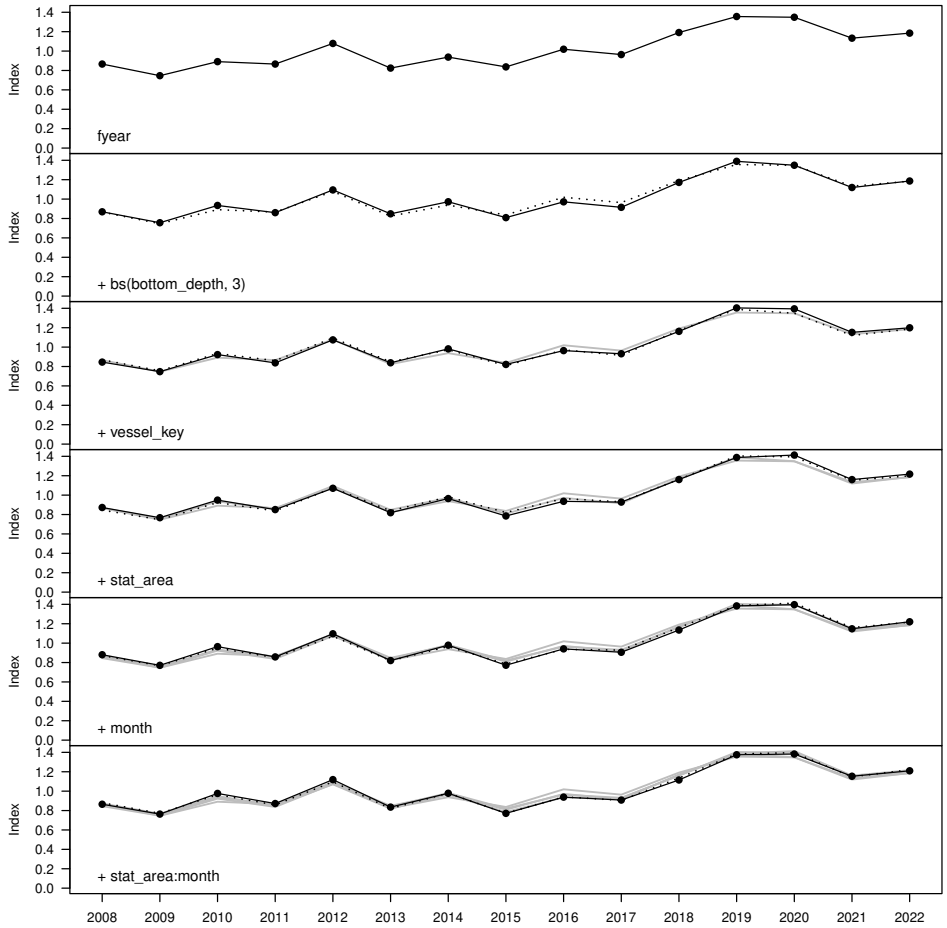

Figure D.5: Step plot for occurrence of catch in the SKI1 SKI2 TAR event dataset.

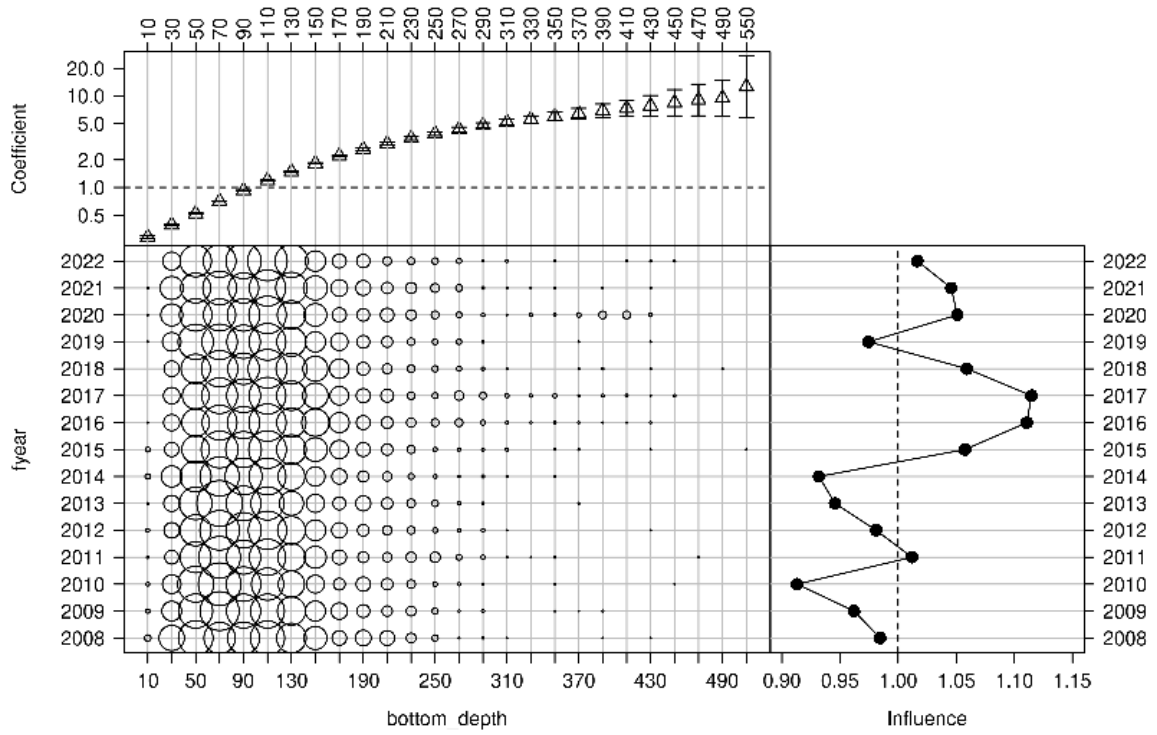

Figure D.6: CDI plot for bottom depth for the occurrence of positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

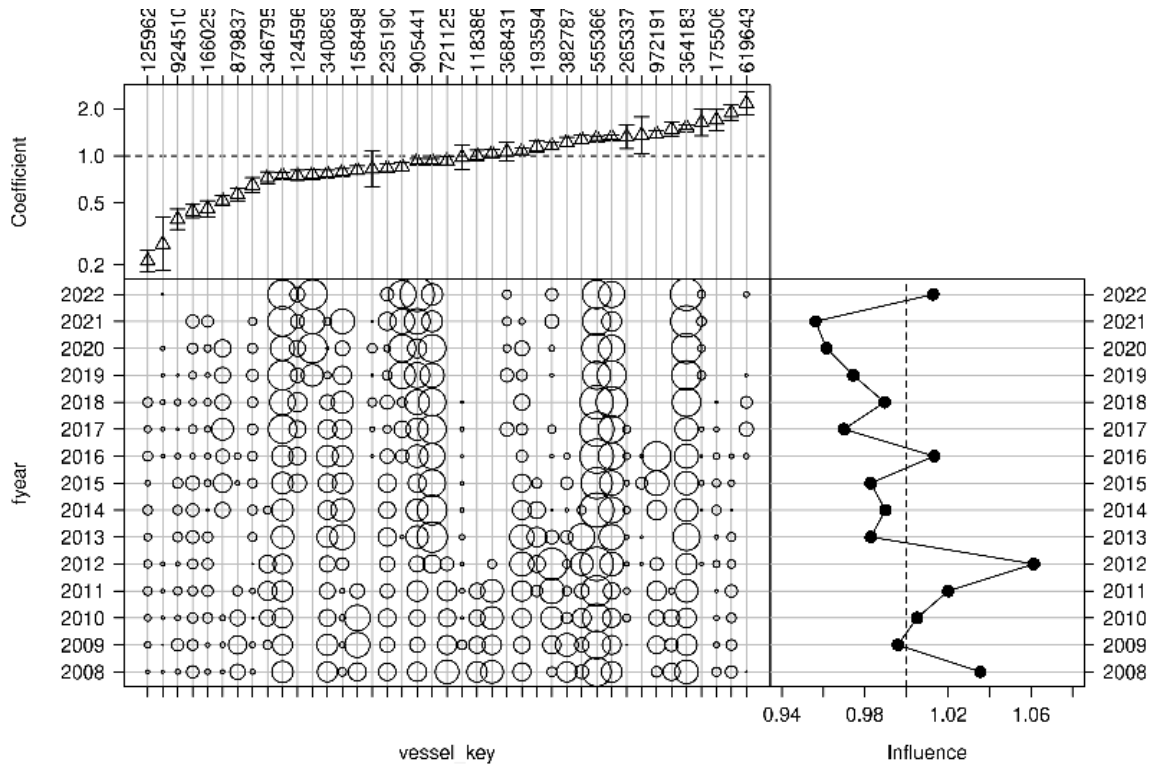

Figure D.7: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

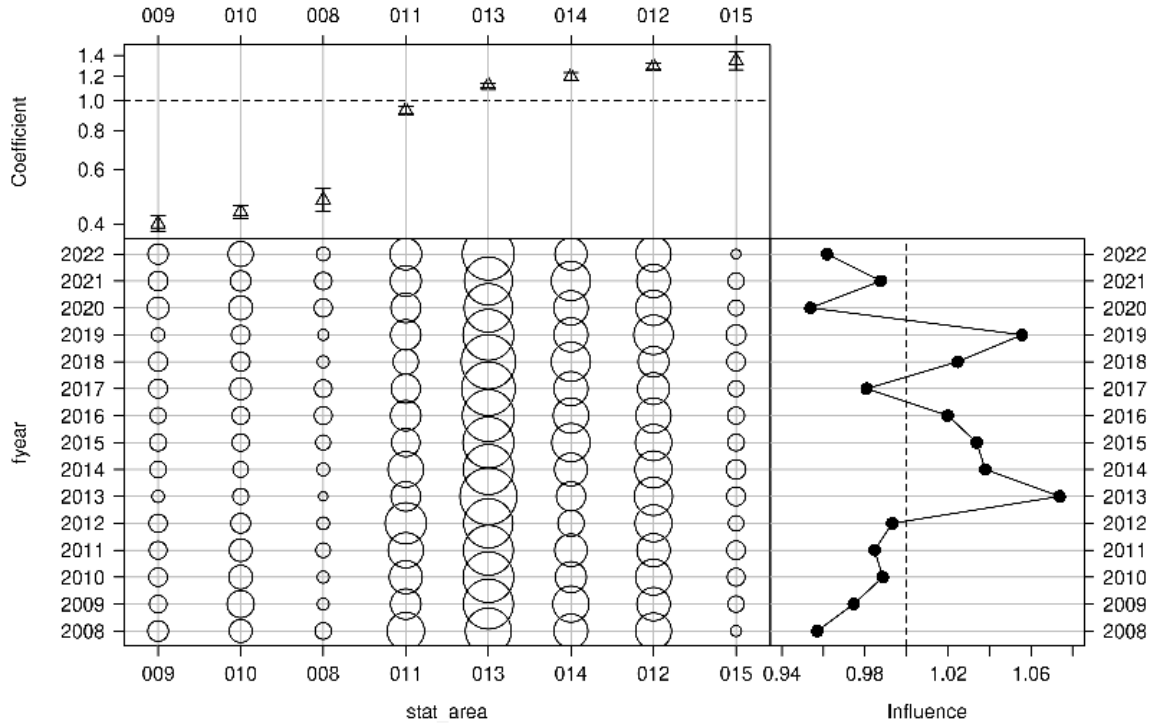

Figure D.8: CDI plot for statistical area for the occurrence of positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

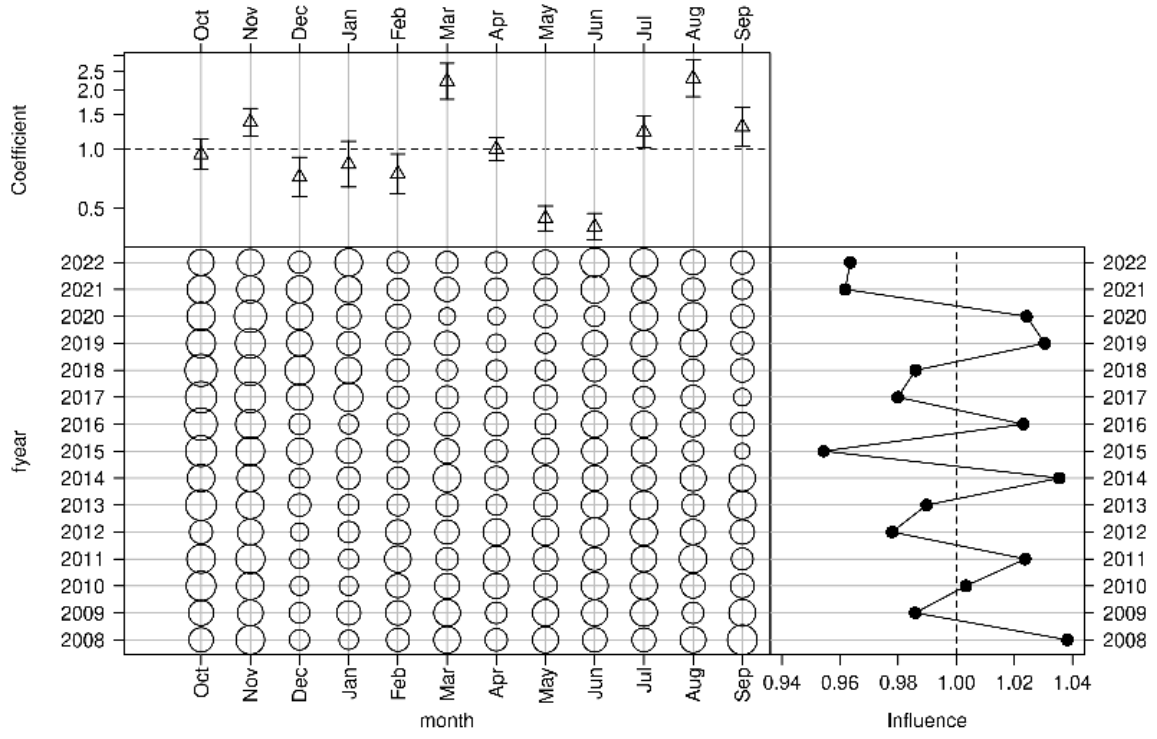

Figure D.9: CDI plot for month for the occurrence of positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

Table D.5: Summary of stepwise selection for the lognormal model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	13	97 336	7.8	7.8	*
+ month	11	90 692	32.7	24.9	*
+ bs(bottom depth, 3)	3	86 891	43.7	11.1	*
+ vessel key	40	83 666	51.9	8.1	*
+ stat area	7	83 215	52.9	1.0	*
+ stat area:month	77	82 233	55.4	2.5	*
+ bs(effort width, 3)	3	82 151	55.5	0.2	
+ bs(effort height, 3)	3	82 119	55.6	0.1	
+ bs(log(fishing duration), 3)	3	82 110	55.6	0.0	

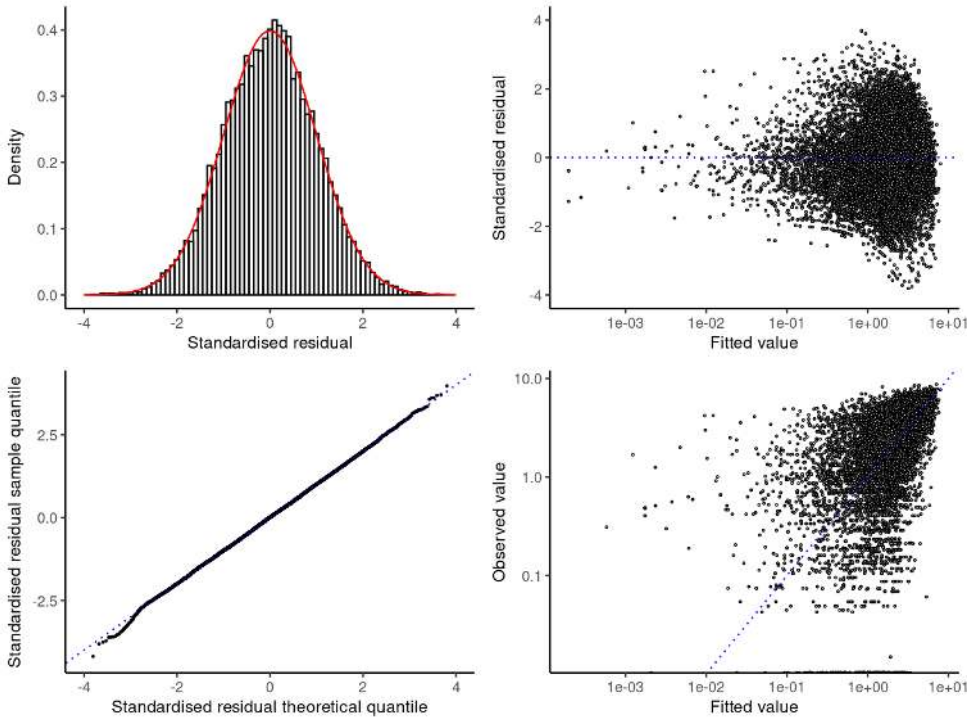

Figure D.10: Diagnostic plots for the lognormal model for the SKI1 SKI2 TAR event dataset.

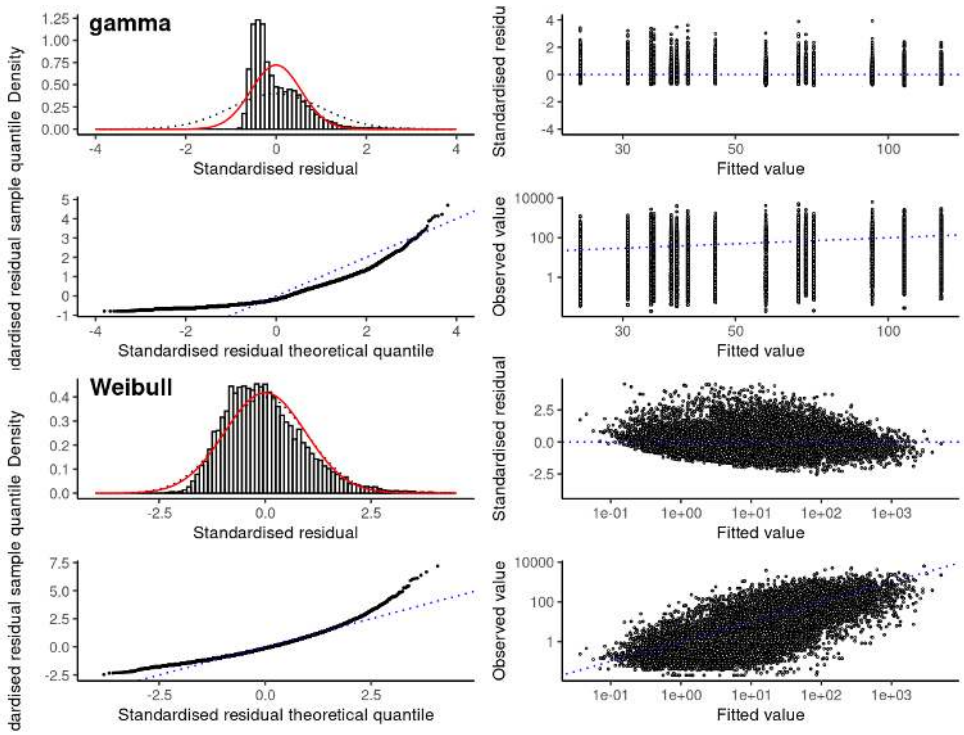

Figure D.11: Diagnostic plots for the gamma and Weibull model for the SKI1 SKI2 TAR event dataset.

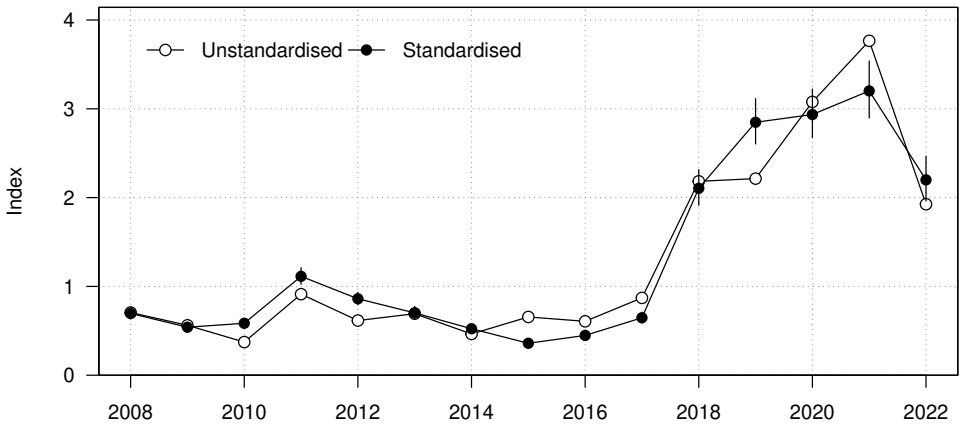

Figure D.12: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 TAR event dataset.

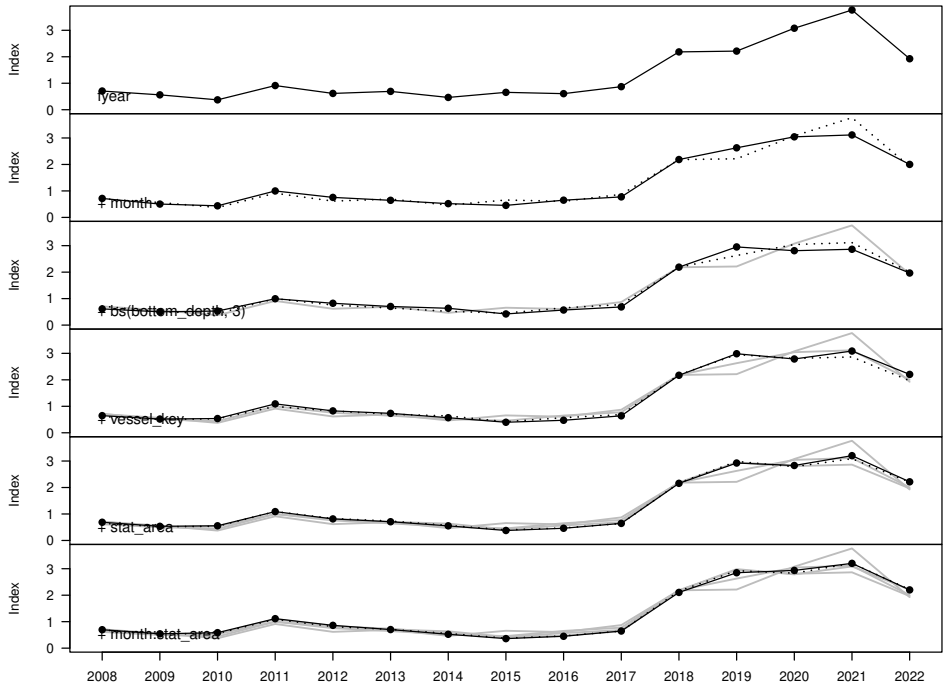

Figure D.13: Changes to the SKI1 SKI2 TAR event positive catch index as terms are successively entered into the model.

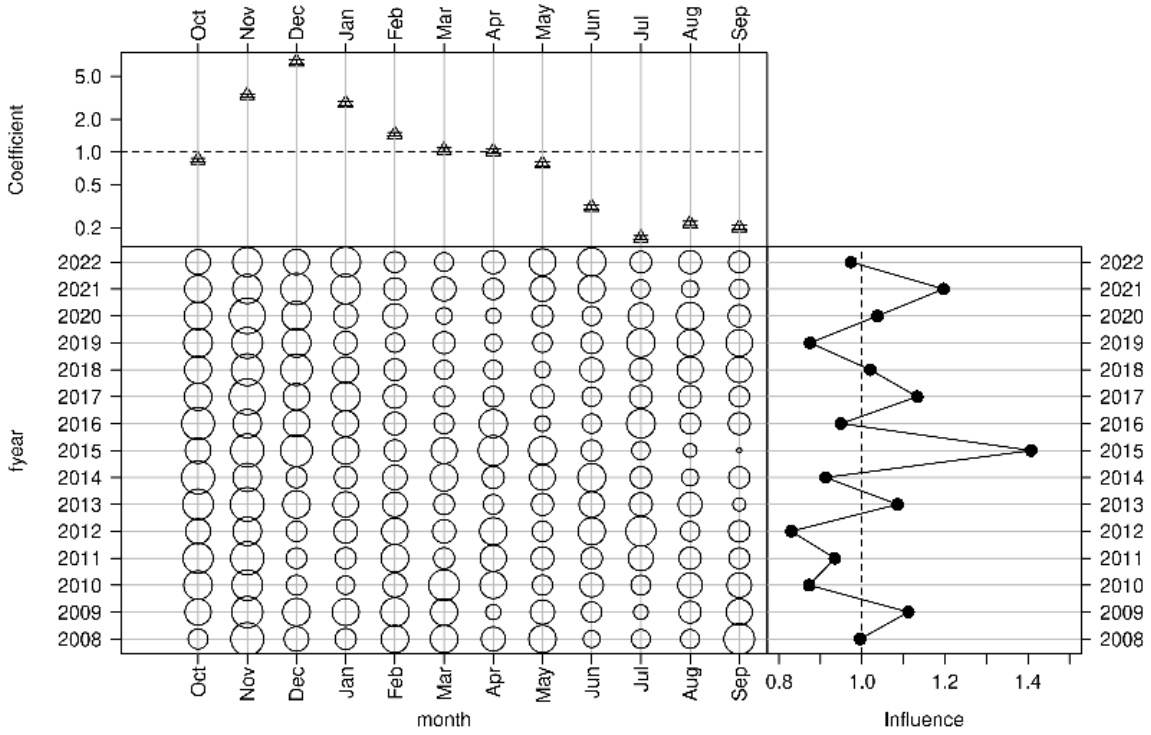

Figure D.14: CDI plot for month for the positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

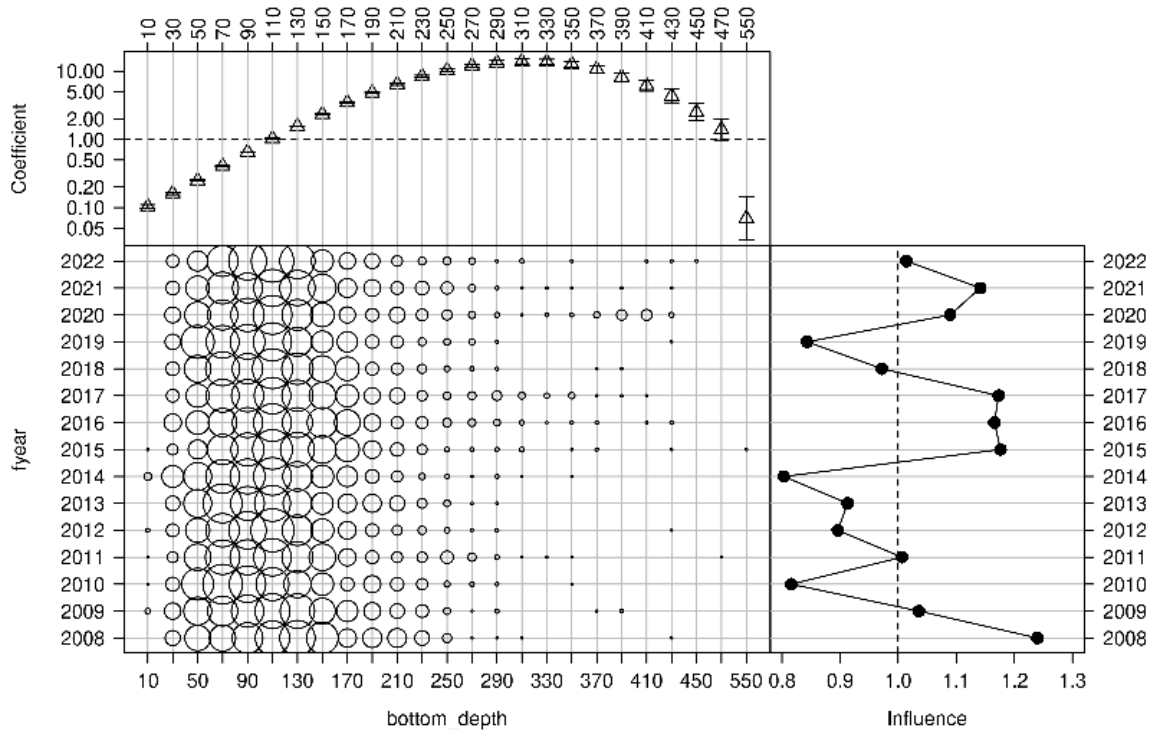

Figure D.15: CDI plot for bottom depth for the positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

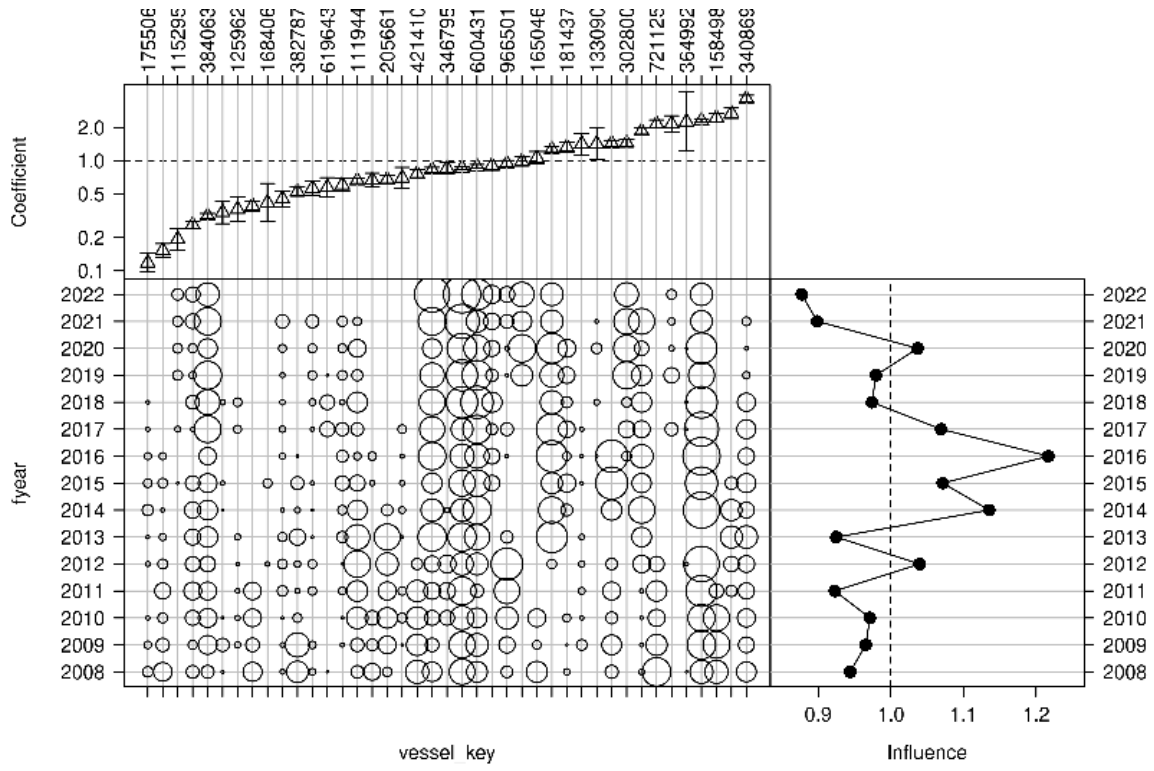

Figure D.16: CDI plot for vessel key for the positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

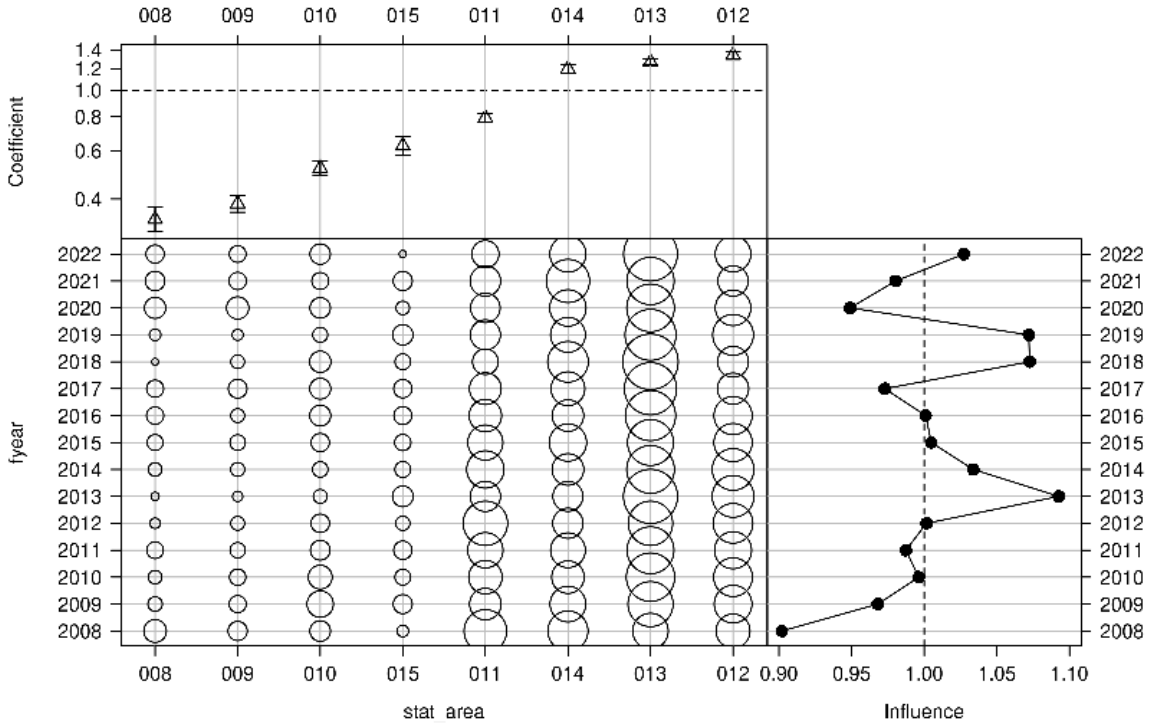

Figure D.17: CDI plot for statistical area for the positive catch SKI1 SKI2 TAR event catch-per-unit-effort dataset.

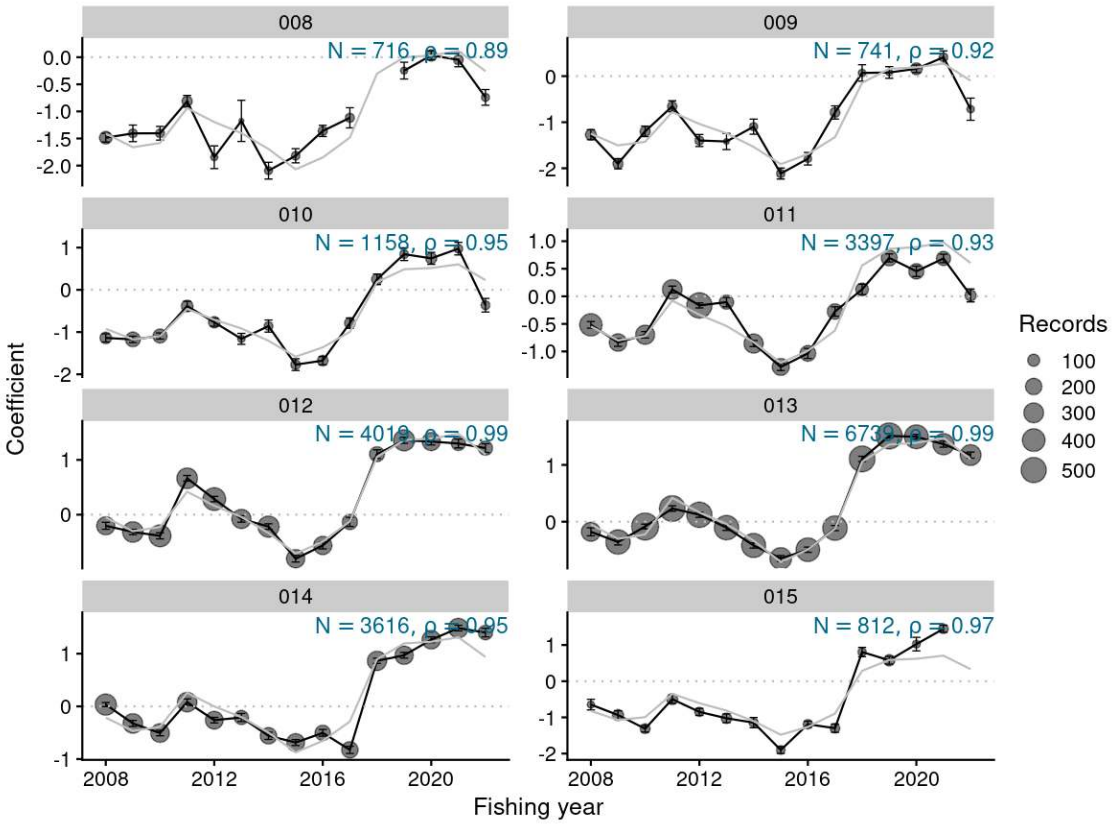

Figure D.18: Residual implied coefficients for area-year in the lognormal positive catch model for the SKI1 SKI2 TAR event dataset.

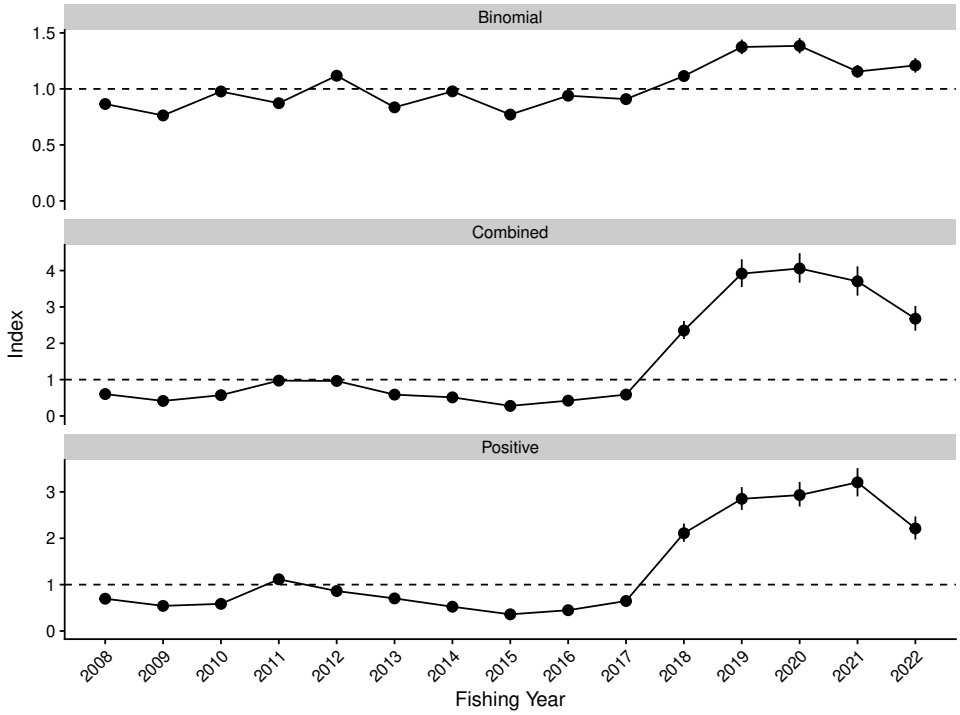

Figure D.19: Standardised indices and 95% confidence intervals for the SKI1 SKI2 TAR event dataset.

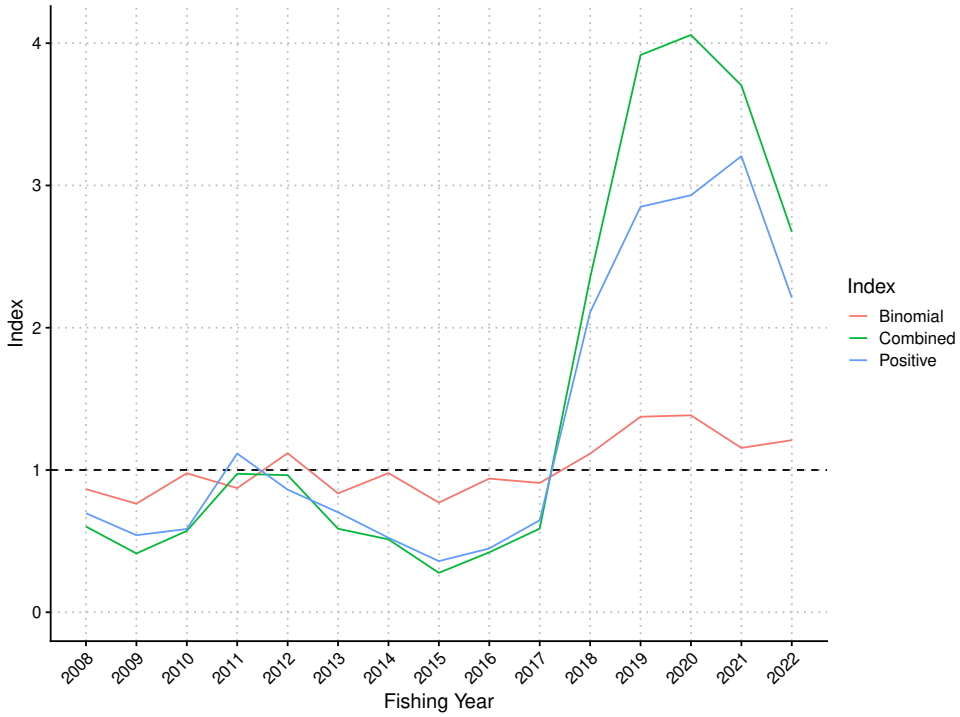

Figure D.20: Standardised indices for the SKI1 SKI2 TAR event dataset.

Table D.6: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 TAR event.

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
2008	0.87	0.87	0.020	0.87	0.60	0.60	0.030	0.60	0.70	0.70	0.031	0.70
2009	0.76	0.76	0.020	0.76	0.41	0.41	0.021	0.41	0.54	0.54	0.024	0.54
2010	0.98	0.98	0.019	0.98	0.57	0.57	0.027	0.57	0.59	0.59	0.024	0.59
2011	0.87	0.87	0.019	0.87	0.97	0.97	0.046	0.97	1.12	1.12	0.048	1.12
2012	1.12	1.12	0.021	1.12	0.96	0.96	0.042	0.96	0.86	0.86	0.034	0.86
2013	0.84	0.84	0.022	0.84	0.59	0.59	0.035	0.59	0.70	0.70	0.037	0.70
2014	0.98	0.98	0.020	0.98	0.51	0.51	0.025	0.51	0.52	0.52	0.023	0.52
2015	0.77	0.77	0.022	0.77	0.28	0.28	0.015	0.28	0.36	0.36	0.017	0.36
2016	0.94	0.94	0.023	0.94	0.42	0.42	0.023	0.42	0.45	0.45	0.021	0.45
2017	0.91	0.91	0.023	0.91	0.59	0.59	0.031	0.59	0.65	0.65	0.030	0.65
2018	1.12	1.12	0.025	1.12	2.35	2.35	0.126	2.35	2.11	2.11	0.101	2.11
2019	1.37	1.37	0.033	1.37	3.92	3.92	0.194	3.92	2.85	2.85	0.126	2.85
2020	1.38	1.38	0.035	1.38	4.06	4.06	0.208	4.06	2.93	2.93	0.135	2.93
2021	1.16	1.16	0.029	1.16	3.70	3.70	0.205	3.70	3.21	3.21	0.156	3.21
2022	1.21	1.21	0.033	1.21	2.68	2.68	0.173	2.68	2.21	2.21	0.127	2.21

D.2 SKI1 SKI2 HOK-SKI daily

Table D.7: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 HOK-SKI daily CPUE series.

Series	SKI1 SKI2 HOK-SKI daily
QMS stock	SKI1, SKI2
Reporting forms	CEL, TCP, TCE, ERS - Trawl
Fishing methods	BT
Target species	SKI, HOK
Areas	008, 009, 010, 011
Period	1989-10-01, 2022-09-30
Resolution	Day
Core fleet years	5
Core fleet trips	3
Default model	allockg ~ fyear + vessel_key + target_species + ns(log(fishing_duration), 3) + stat_area*month + ns(effort_width, 3) + ns(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

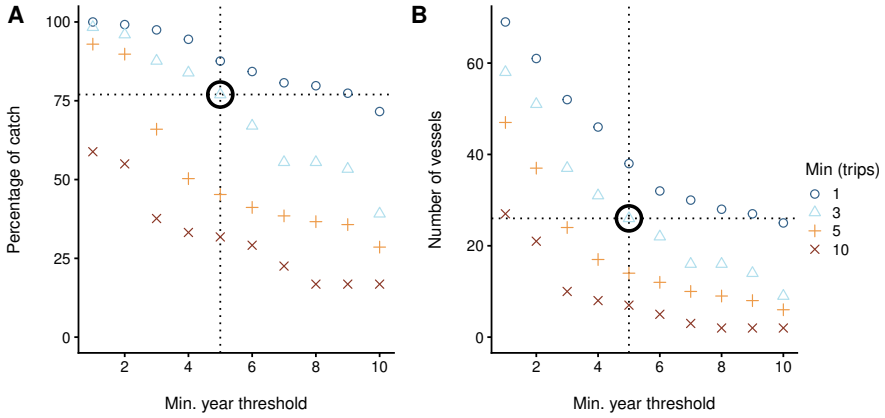

Figure D.21: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 HOK-SKI daily CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

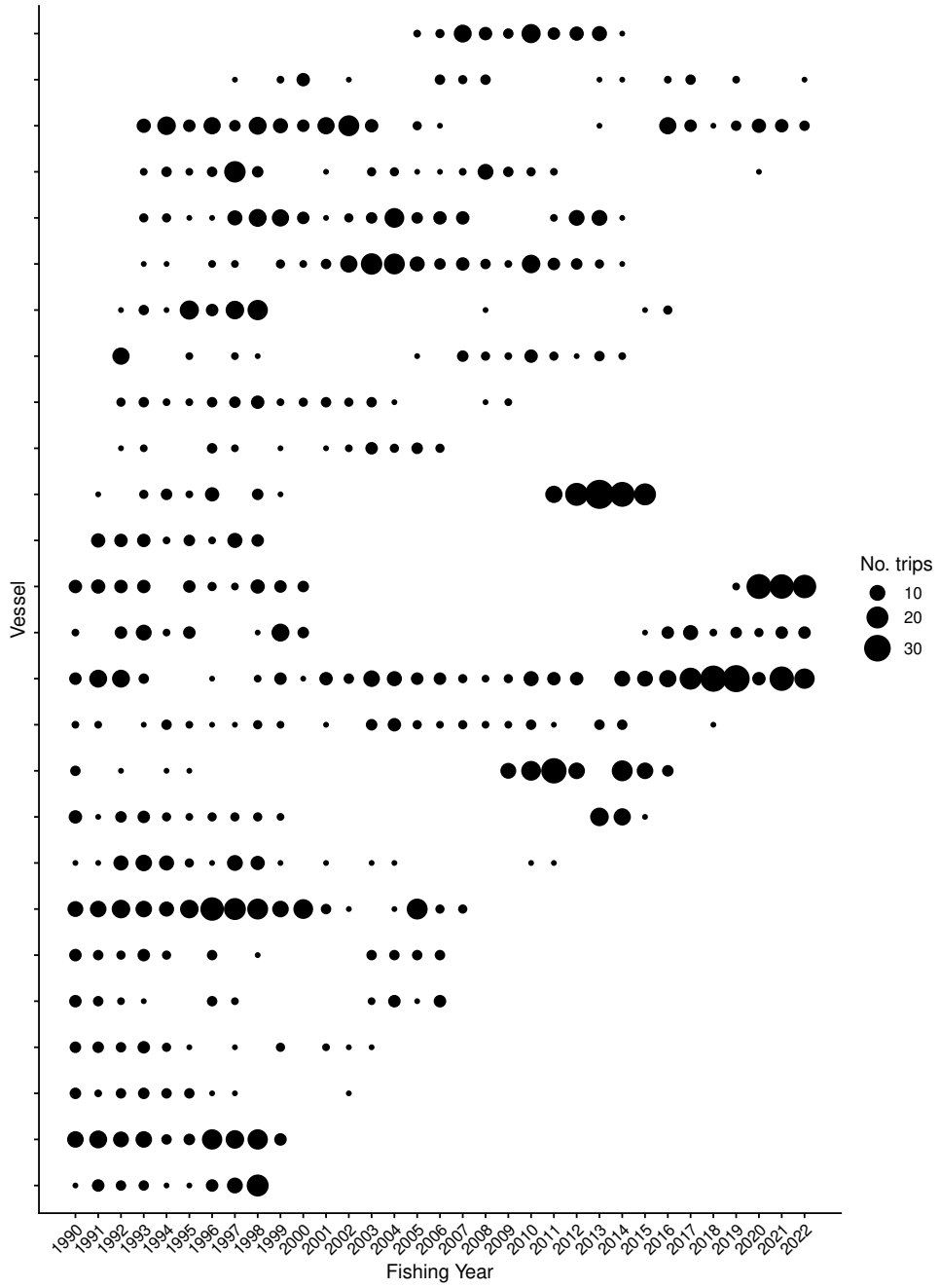

Figure D.22: Number of trips by fishing year for core vessels. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

Table D.8: Summary of SKI1 SKI2 HOK-SKI daily total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ungroomed data	674	580	510	595	236	119	150	200	106	46	18	34
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 347)	(Records: 370)	(Records: 463)	(Records: 550)	(Records: 261)	(Records: 269)	(Records: 325)	(Records: 535)	(Records: 471)	(Records: 181)	(Records: 130)	(Records: 84)
Fishing duration is not NA	656	580	501	595	236	119	150	200	106	45	18	34
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 339)	(Records: 370)	(Records: 458)	(Records: 550)	(Records: 260)	(Records: 267)	(Records: 325)	(Records: 535)	(Records: 469)	(Records: 179)	(Records: 130)	(Records: 84)
Positive fishing duration	656	580	501	592	236	119	150	200	106	45	18	34
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 339)	(Records: 370)	(Records: 458)	(Records: 549)	(Records: 260)	(Records: 267)	(Records: 325)	(Records: 535)	(Records: 469)	(Records: 179)	(Records: 130)	(Records: 84)
Fishing duration under 30hrs	647	580	501	588	236	119	150	194	106	45	18	34
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 337)	(Records: 370)	(Records: 457)	(Records: 548)	(Records: 260)	(Records: 267)	(Records: 321)	(Records: 525)	(Records: 466)	(Records: 179)	(Records: 130)	(Records: 84)
Effort height <100	647	579	501	585	236	119	142	157	105	45	18	34
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 95)	(Percent: 79)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 337)	(Records: 369)	(Records: 457)	(Records: 546)	(Records: 260)	(Records: 267)	(Records: 306)	(Records: 406)	(Records: 458)	(Records: 179)	(Records: 130)	(Records: 84)
Core fleet selection	506	479	379	489	181	84	108	118	76	43	14	33
	(Percent: 75)	(Percent: 83)	(Percent: 74)	(Percent: 82)	(Percent: 76)	(Percent: 70)	(Percent: 72)	(Percent: 59)	(Percent: 72)	(Percent: 100)	(Percent: 79)	(Percent: 100)
	(Records: 247)	(Records: 298)	(Records: 309)	(Records: 393)	(Records: 189)	(Records: 151)	(Records: 216)	(Records: 267)	(Records: 312)	(Records: 166)	(Records: 118)	(Records: 77)

Filter	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Ungroomed data	29	99	113	135	84	84	72	82	139	71	91	67
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 143)	(Records: 173)	(Records: 199)	(Records: 118)	(Records: 92)	(Records: 91)	(Records: 70)	(Records: 68)	(Records: 161)	(Records: 132)	(Records: 128)	(Records: 150)
Fishing duration is not NA	29	99	113	135	84	84	72	82	139	71	91	67
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 143)	(Records: 173)	(Records: 199)	(Records: 118)	(Records: 92)	(Records: 91)	(Records: 70)	(Records: 68)	(Records: 161)	(Records: 132)	(Records: 128)	(Records: 150)
Positive fishing duration	29	99	113	135	84	84	72	82	139	71	91	67
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 143)	(Records: 173)	(Records: 199)	(Records: 118)	(Records: 92)	(Records: 91)	(Records: 70)	(Records: 68)	(Records: 161)	(Records: 132)	(Records: 128)	(Records: 150)
Fishing duration under 30hrs	29	99	112	132	84	84	72	82	139	71	91	67
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 143)	(Records: 173)	(Records: 198)	(Records: 117)	(Records: 92)	(Records: 91)	(Records: 70)	(Records: 68)	(Records: 161)	(Records: 132)	(Records: 128)	(Records: 150)
Effort height <100	29	98	112	132	84	84	72	82	139	71	91	67
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 143)	(Records: 172)	(Records: 198)	(Records: 117)	(Records: 92)	(Records: 91)	(Records: 70)	(Records: 68)	(Records: 161)	(Records: 132)	(Records: 128)	(Records: 150)
Core fleet selection	22	73	96	126	82	44	59	53	126	53	56	41
	(Percent: 75)	(Percent: 74)	(Percent: 85)	(Percent: 93)	(Percent: 100)	(Percent: 52)	(Percent: 82)	(Percent: 64)	(Percent: 90)	(Percent: 75)	(Percent: 62)	(Percent: 61)
	(Records: 82)	(Records: 124)	(Records: 144)	(Records: 110)	(Records: 85)	(Records: 78)	(Records: 59)	(Records: 47)	(Records: 120)	(Records: 105)	(Records: 107)	(Records: 121)

Filter	2014	2015	2016	2017	2018	2019	2020	2021	2022
Ungroomed data	116 (Percent: 100) (Records: 151)	26 (Percent: 100) (Records: 93)	104 (Percent: 100) (Records: 97)	79 (Percent: 100) (Records: 108)	56 (Percent: 100) (Records: 93)	100 (Percent: 100) (Records: 150)	210 (Percent: 100) (Records: 172)	117 (Percent: 100) (Records: 153)	51 (Percent: 100) (Records: 83)
Fishing duration is not NA	116 (Percent: 100) (Records: 151)	26 (Percent: 100) (Records: 93)	104 (Percent: 100) (Records: 97)	79 (Percent: 100) (Records: 108)	56 (Percent: 100) (Records: 93)	100 (Percent: 100) (Records: 150)	210 (Percent: 100) (Records: 172)	117 (Percent: 100) (Records: 153)	51 (Percent: 100) (Records: 83)
Positive fishing duration	116 (Percent: 100) (Records: 151)	26 (Percent: 100) (Records: 93)	104 (Percent: 100) (Records: 97)	79 (Percent: 100) (Records: 108)	56 (Percent: 100) (Records: 93)	100 (Percent: 100) (Records: 150)	210 (Percent: 100) (Records: 172)	117 (Percent: 100) (Records: 153)	51 (Percent: 100) (Records: 83)
Fishing duration under 30hrs	116 (Percent: 100) (Records: 151)	26 (Percent: 100) (Records: 93)	104 (Percent: 100) (Records: 97)	79 (Percent: 100) (Records: 108)	56 (Percent: 100) (Records: 93)	100 (Percent: 100) (Records: 150)	210 (Percent: 100) (Records: 172)	117 (Percent: 100) (Records: 153)	51 (Percent: 100) (Records: 83)
Effort height <100	116 (Percent: 100) (Records: 151)	26 (Percent: 100) (Records: 93)	104 (Percent: 100) (Records: 97)	79 (Percent: 100) (Records: 108)	56 (Percent: 100) (Records: 93)	100 (Percent: 100) (Records: 150)	210 (Percent: 100) (Records: 172)	117 (Percent: 100) (Records: 153)	51 (Percent: 100) (Records: 83)
Core fleet selection	85 (Percent: 73) (Records: 122)	21 (Percent: 81) (Records: 80)	53 (Percent: 51) (Records: 56)	37 (Percent: 47) (Records: 72)	39 (Percent: 71) (Records: 70)	41 (Percent: 41) (Records: 82)	38 (Percent: 18) (Records: 74)	64 (Percent: 55) (Records: 112)	51 (Percent: 100) (Records: 83)

Table D.9: Summary of the SKI1 SKI2 HOK-SKI daily dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of daily with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1990	14	73	232	1 971.00	480.75	93.97
1991	14	79	283	2 588.25	456.08	94.35
1992	18	106	309	3 352.40	379.13	85.44
1993	22	117	373	3 694.33	474.58	88.74
1994	19	75	184	1 693.87	177.53	84.24
1995	19	80	151	1 372.28	84.12	64.24
1996	20	107	215	2 220.07	107.20	79.07
1997	20	132	265	2 439.78	117.46	71.32
1998	18	148	304	2 895.17	73.78	48.68
1999	16	80	165	1 653.97	43.21	57.58
2000	9	51	113	932.65	13.81	43.36
2001	11	38	74	728.10	32.58	71.62
2002	10	46	82	901.33	21.76	46.34
2003	12	68	124	1 196.97	72.96	71.77
2004	11	69	144	1 461.63	95.65	79.17
2005	12	58	110	1 381.85	125.60	79.09
2006	12	45	85	823.53	81.87	68.24
2007	9	46	78	840.50	43.54	66.67
2008	9	34	59	695.60	59.20	66.10
2009	8	29	47	473.35	52.61	63.83
2010	8	69	120	1 367.45	125.66	65.00
2011	10	67	105	1 073.45	53.37	64.76
2012	7	64	107	1 024.43	55.86	51.40
2013	9	82	121	1 279.72	40.88	51.24
2014	10	76	122	1 284.75	84.82	58.20
2015	6	44	80	919.02	20.71	33.75
2016	6	40	56	695.37	53.35	51.79
2017	4	39	72	855.17	36.67	33.33
2018	4	33	70	836.72	39.22	67.14
2019	5	44	82	882.88	41.35	57.32
2020	5	45	74	754.85	37.96	79.73
2021	4	63	112	1 045.05	64.42	83.04
2022	5	51	83	800.15	50.63	80.72

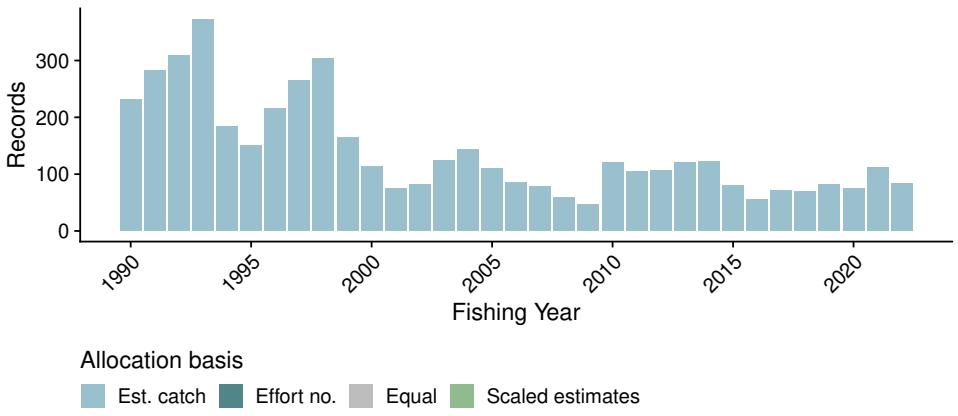

Figure D.23: Allocation basis for attributing landings to records in the SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

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

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	31.00	5 007	11.70	11.70	*
+ target_species	1.00	4 198	26.20	14.50	*
+ month	11.00	3 934	31.30	5.10	*
+ vessel_key	26.00	3 890	33.00	1.70	*
+ ns(log(fishing_duration), 3)	3.00	3 884	33.20	0.20	
+ ns(effort_width, 3)	3.00	3 878	33.50	0.20	
+ stat_area	3.00	3 873	33.70	0.20	*
+ stat_area:month	33.00	3 817	35.80	2.20	*

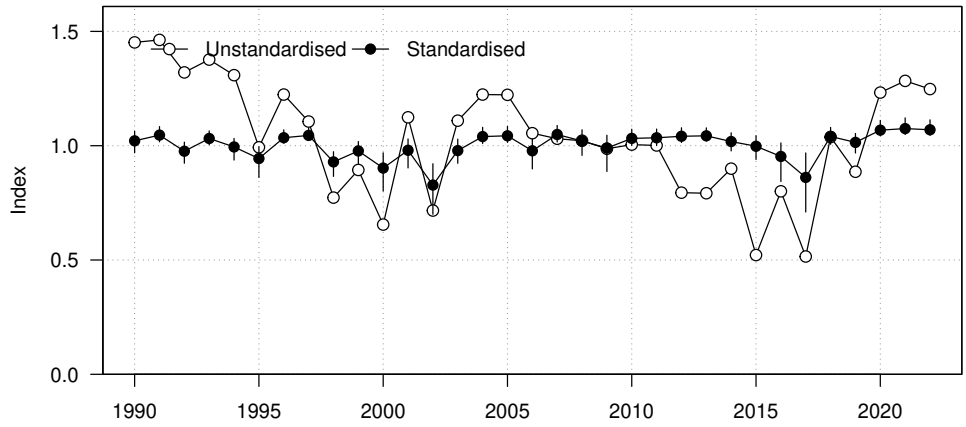

Figure D.24: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 HOK-SKI daily dataset.

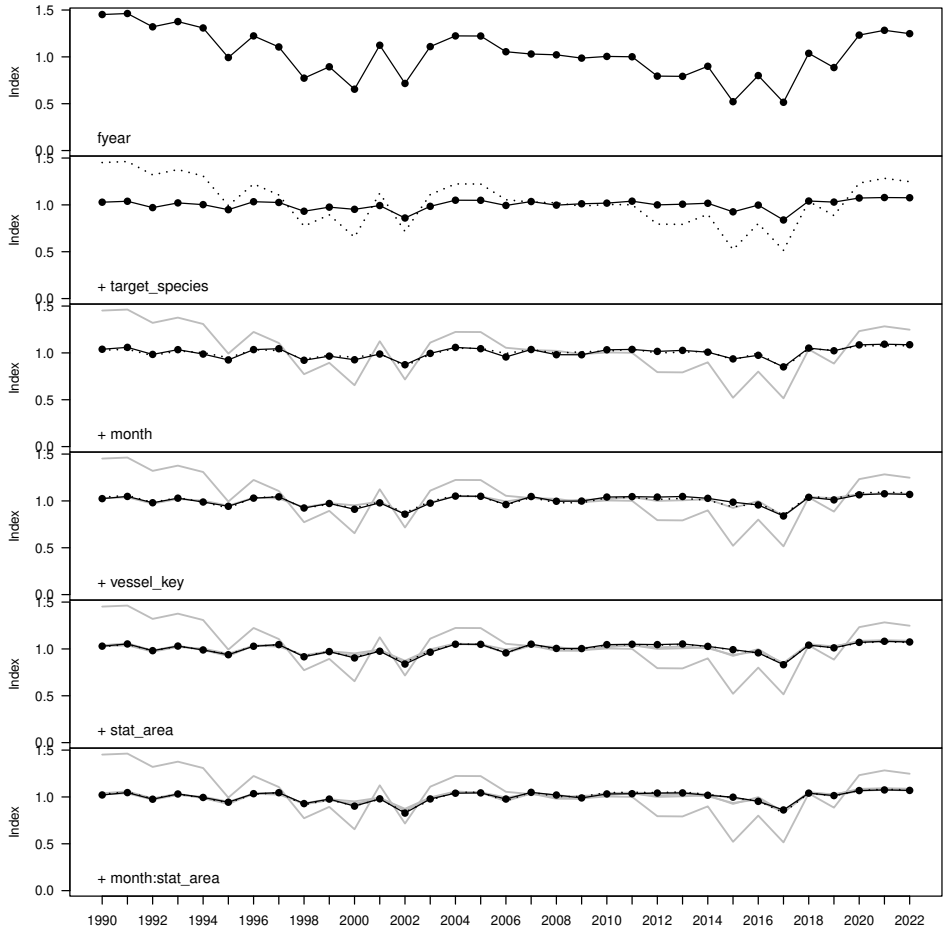

Figure D.25: Step plot for occurrence of catch in the SKI1 SKI2 HOK-SKI daily dataset.

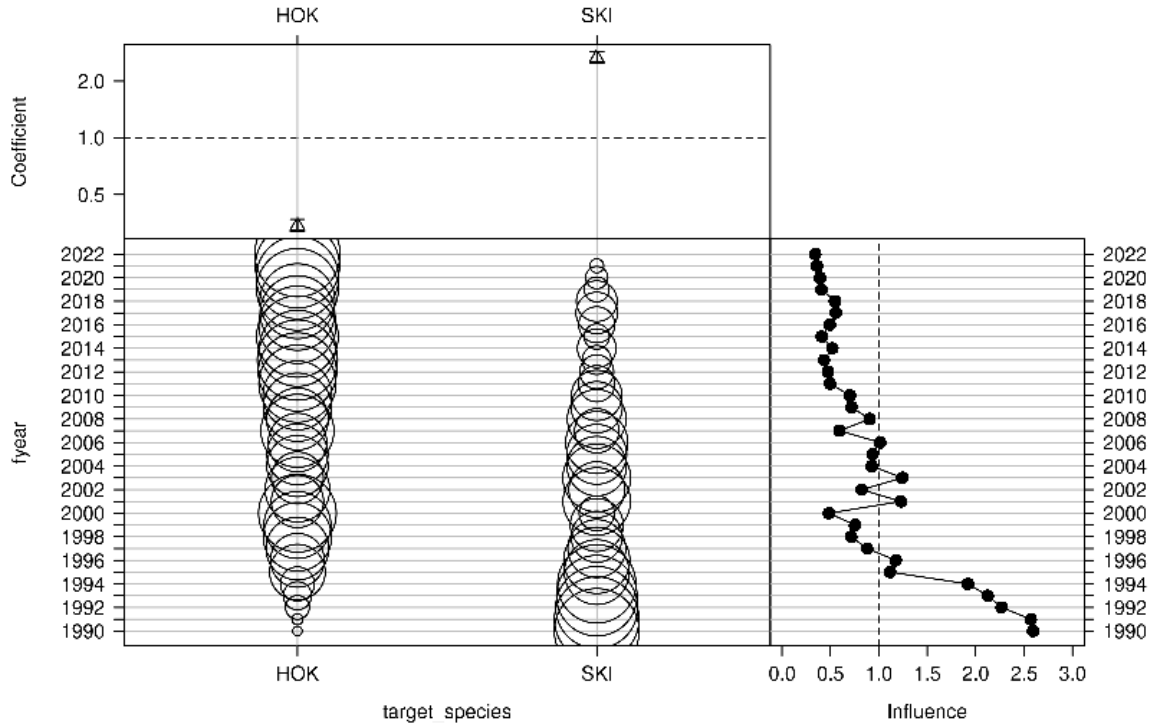

Figure D.26: CDI plot for target species for the occurrence of positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

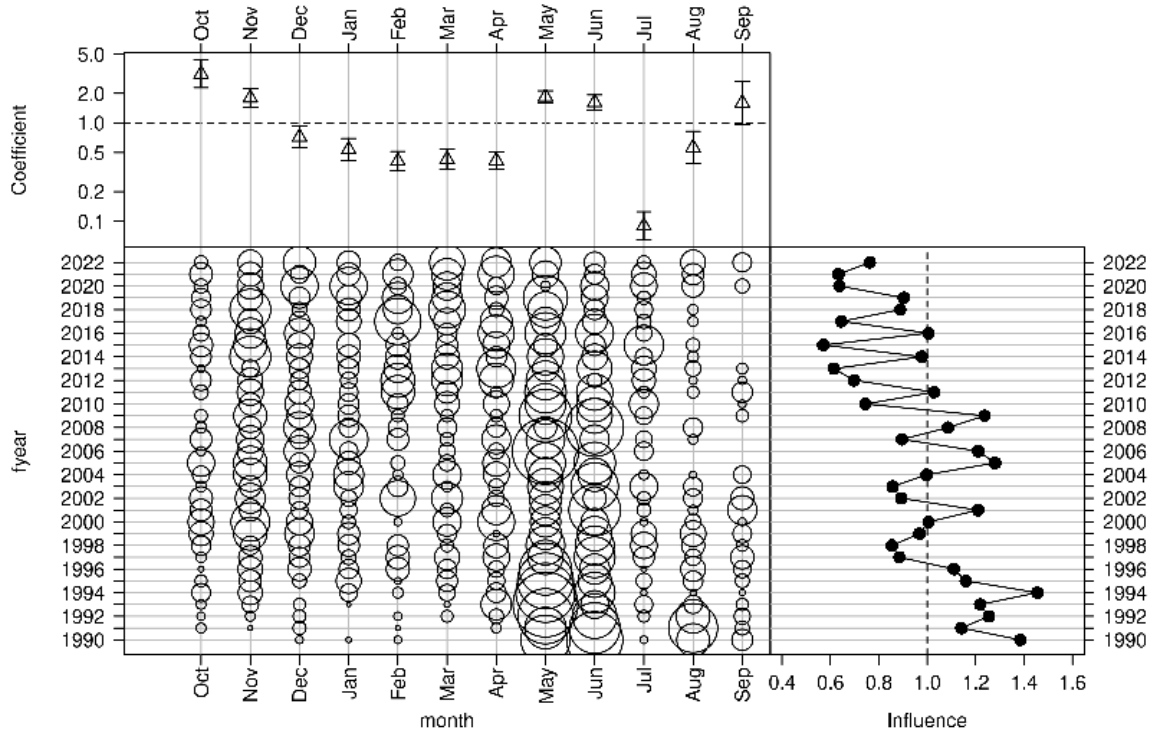

Figure D.27: CDI plot for month for the occurrence of positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

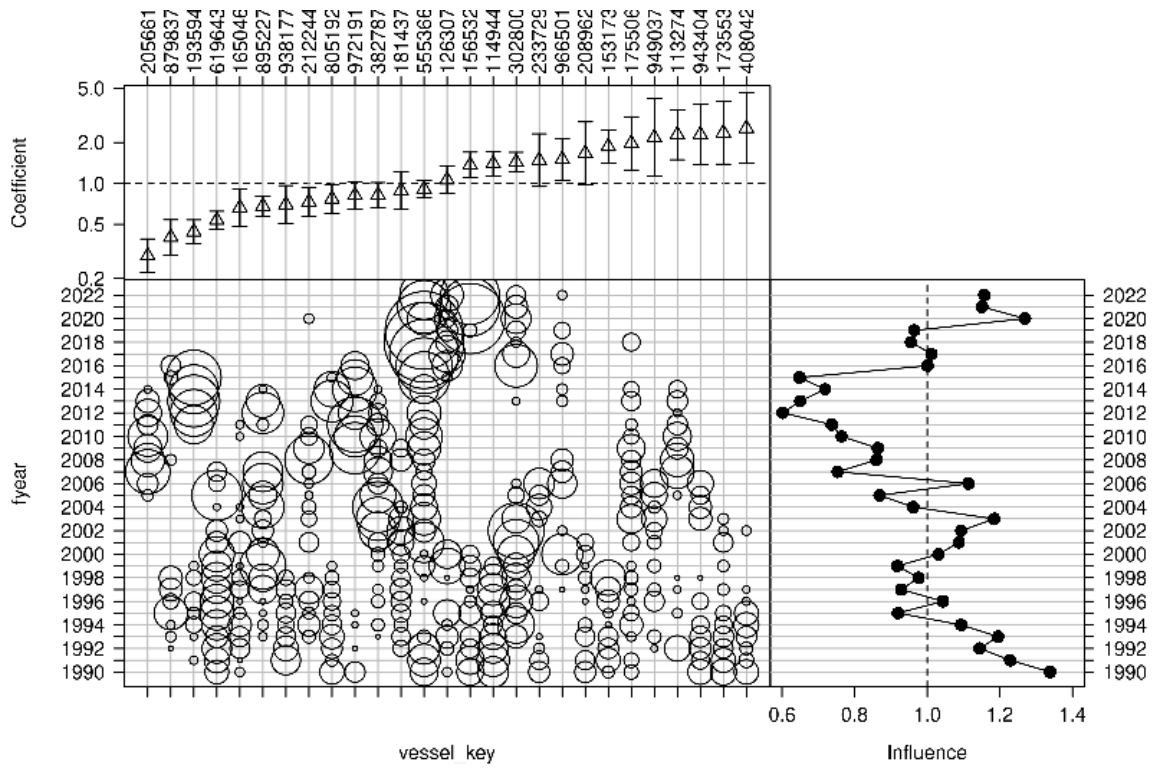

Figure D.28: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

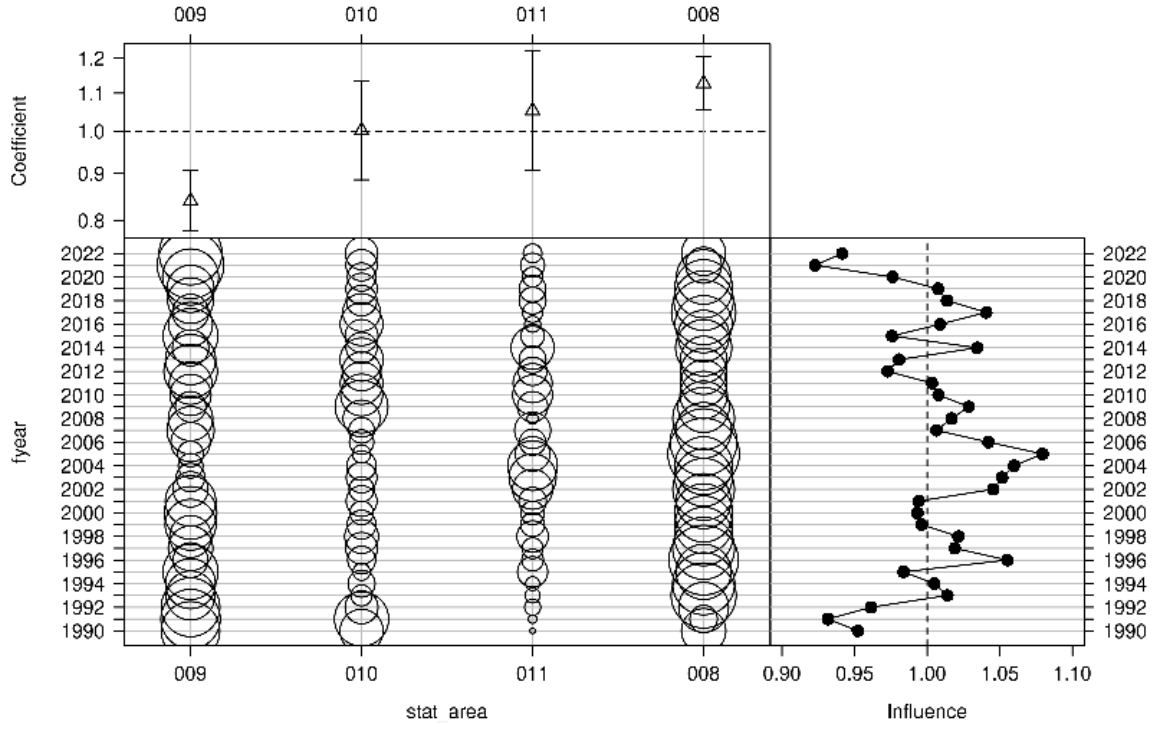

Figure D.29: CDI plot for statistical area for the occurrence of positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

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

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	34	52 975	17.3	17.3	*
+ target species	1	52 428	32.0	14.7	*
+ vessel key	26	52 102	42.1	10.1	*
+ month	11	51 831	50.0	7.9	*
+ stat area	3	51 714	53.3	3.3	*
+ ns(log(fishing duration), 3)	3	51 633	55.6	2.3	*
+ stat area:month	33	51 578	58.8	3.2	*

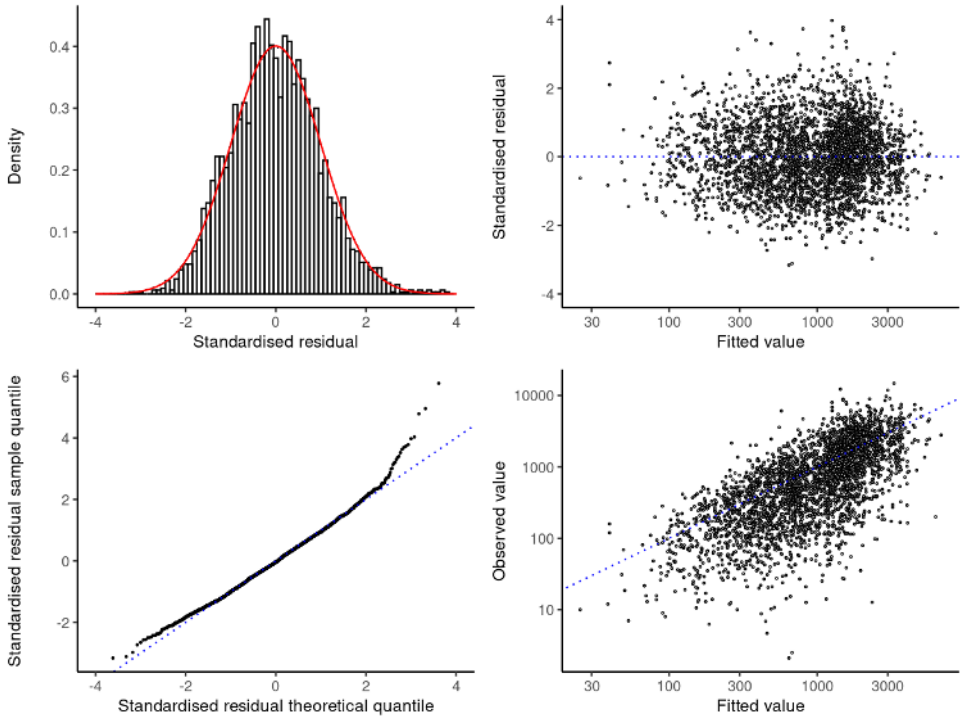

Figure D.30: Diagnostic plots for the Weibull model for the SKI1 SKI2 HOK-SKI daily dataset.

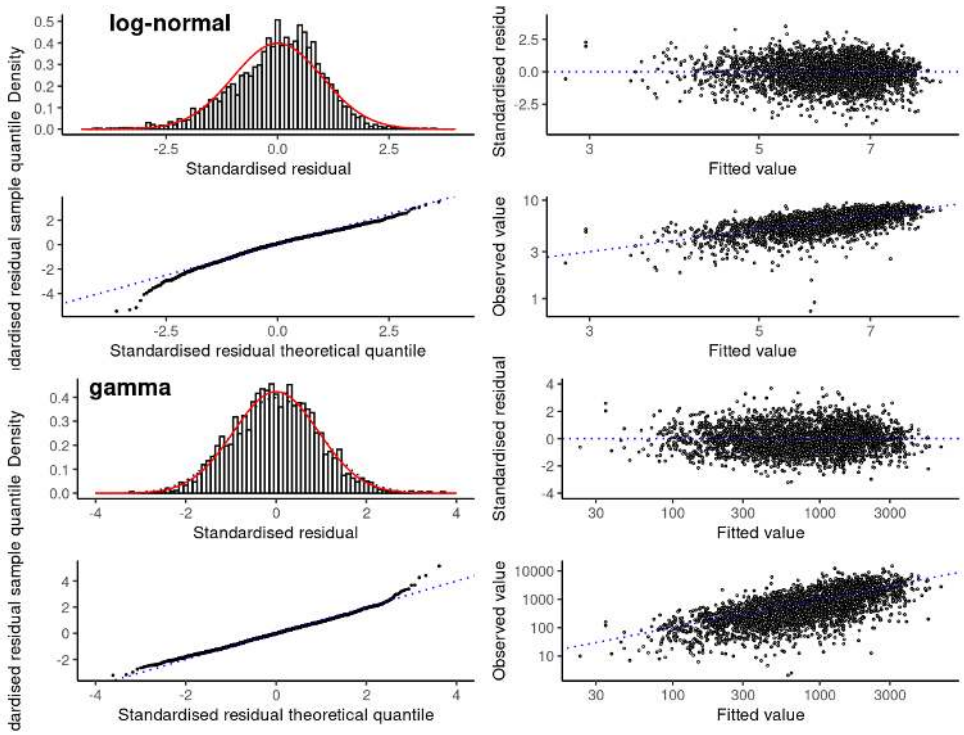

Figure D.31: Diagnostic plots for the log-normal and gamma model for the SKI1 SKI2 HOK-SKI daily dataset.

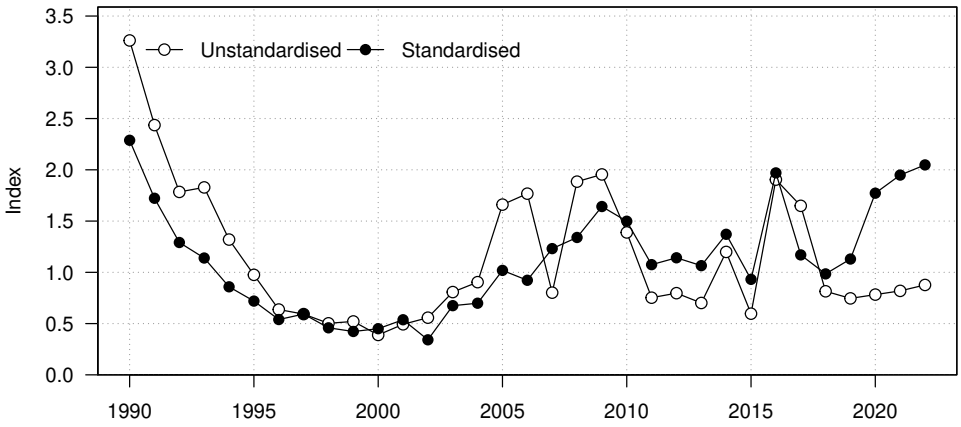

Figure D.32: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 HOK-SKI daily dataset.

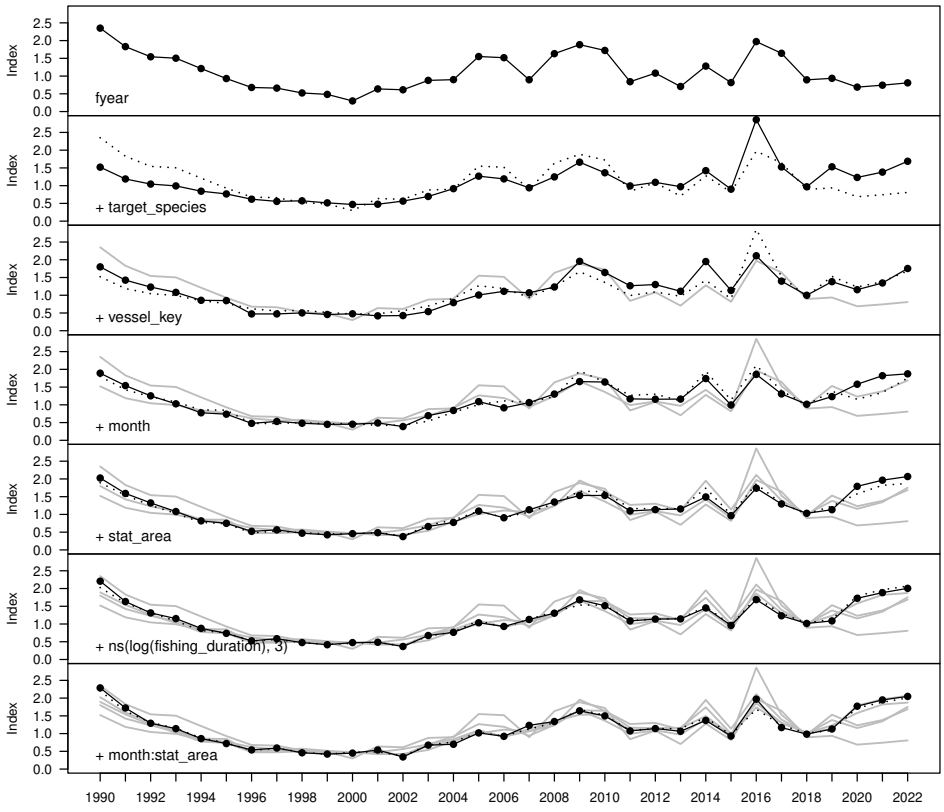

Figure D.33: Changes to the SKI1 SKI2 HOK-SKI daily positive catch index as terms are successively entered into the model.

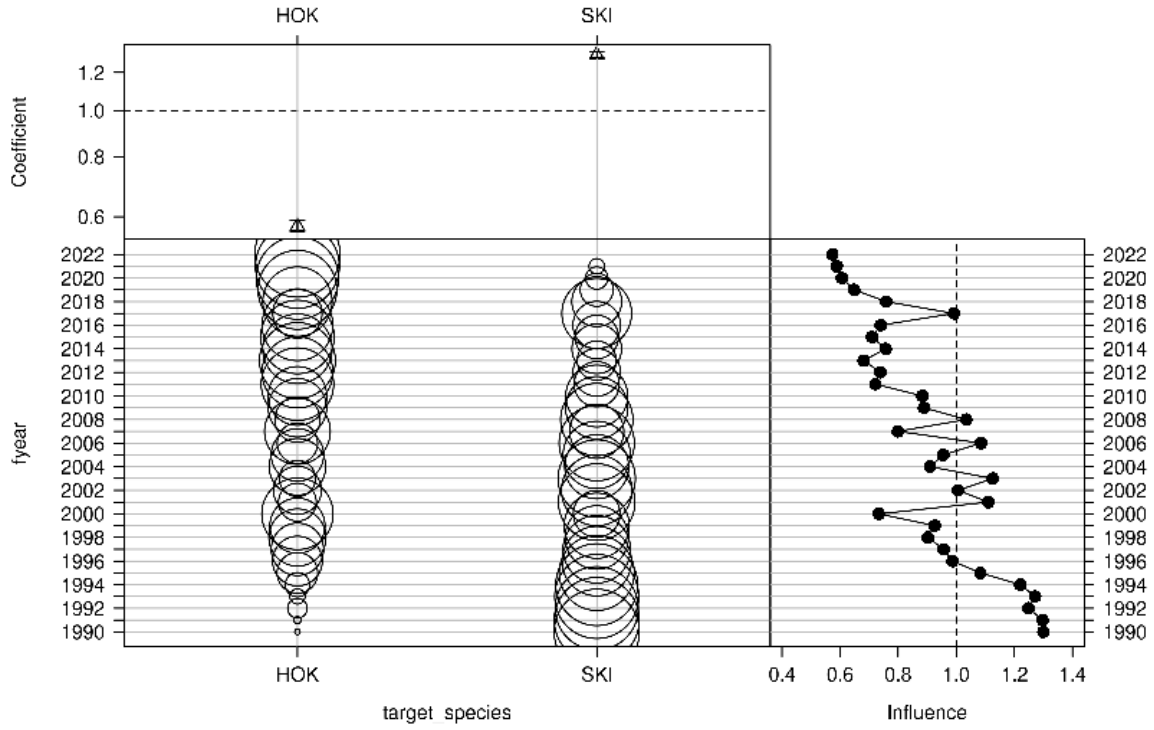

Figure D.34: CDI plot for target species for the positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

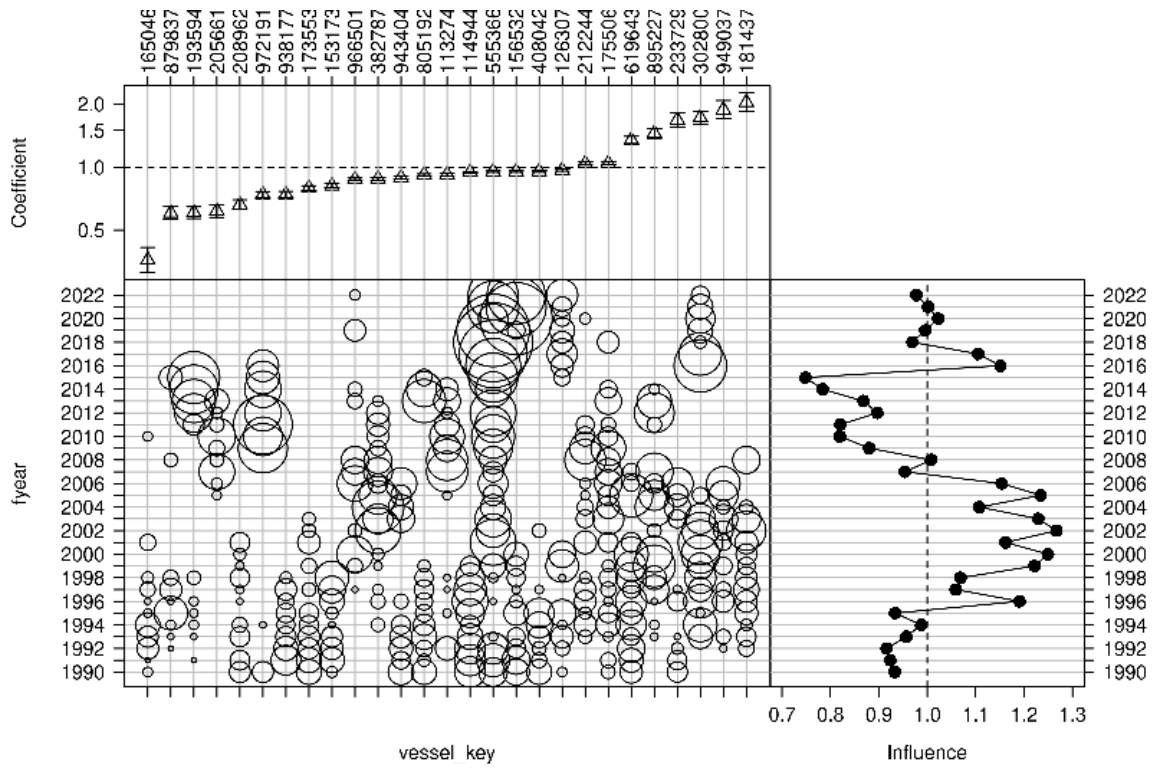

Figure D.35: CDI plot for vessel key for the positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

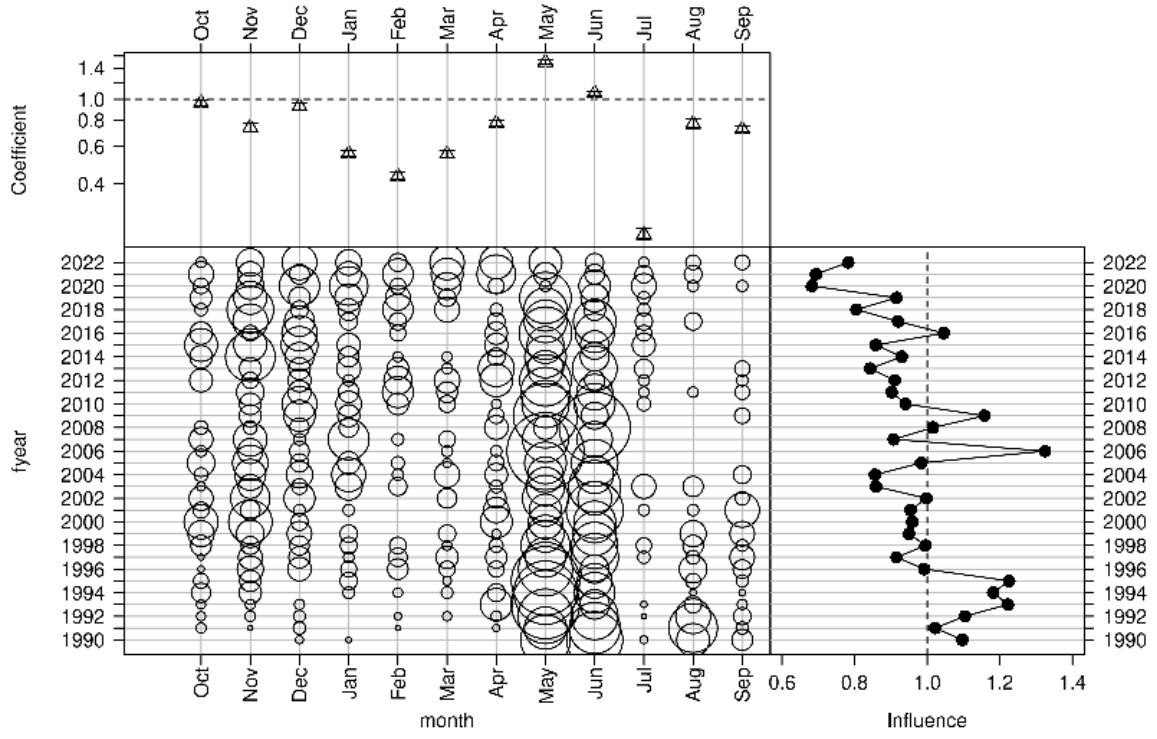

Figure D.36: CDI plot for month for the positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

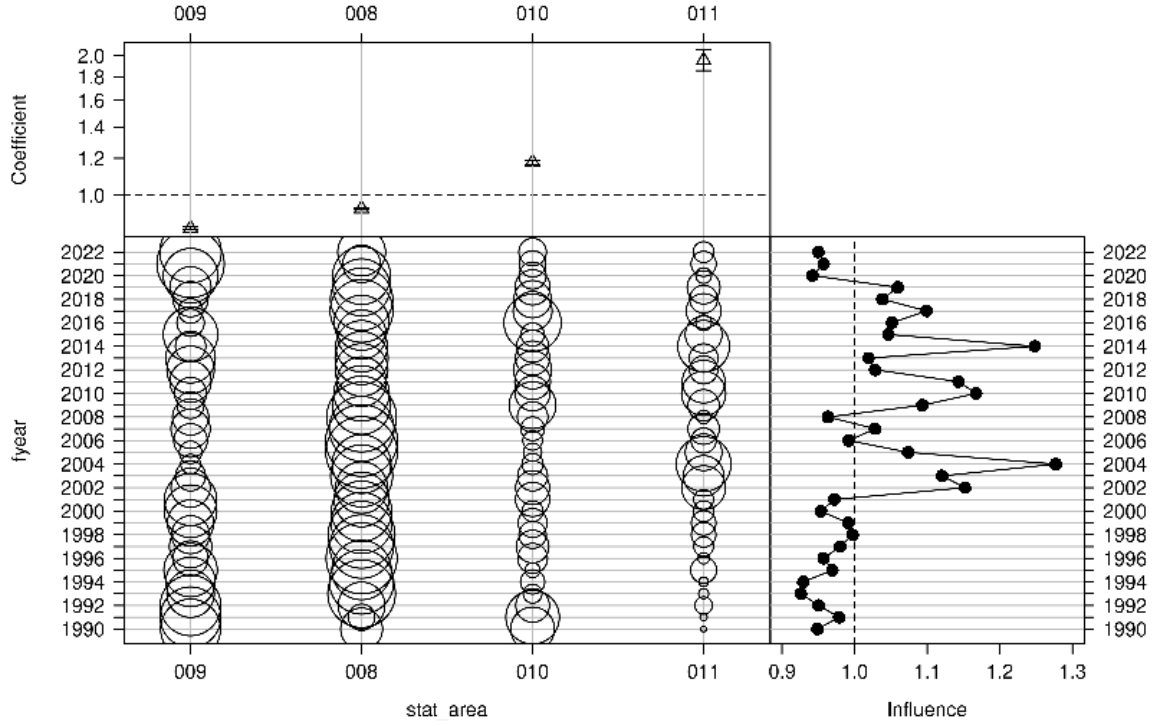

Figure D.37: CDI plot for statistical area for the positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

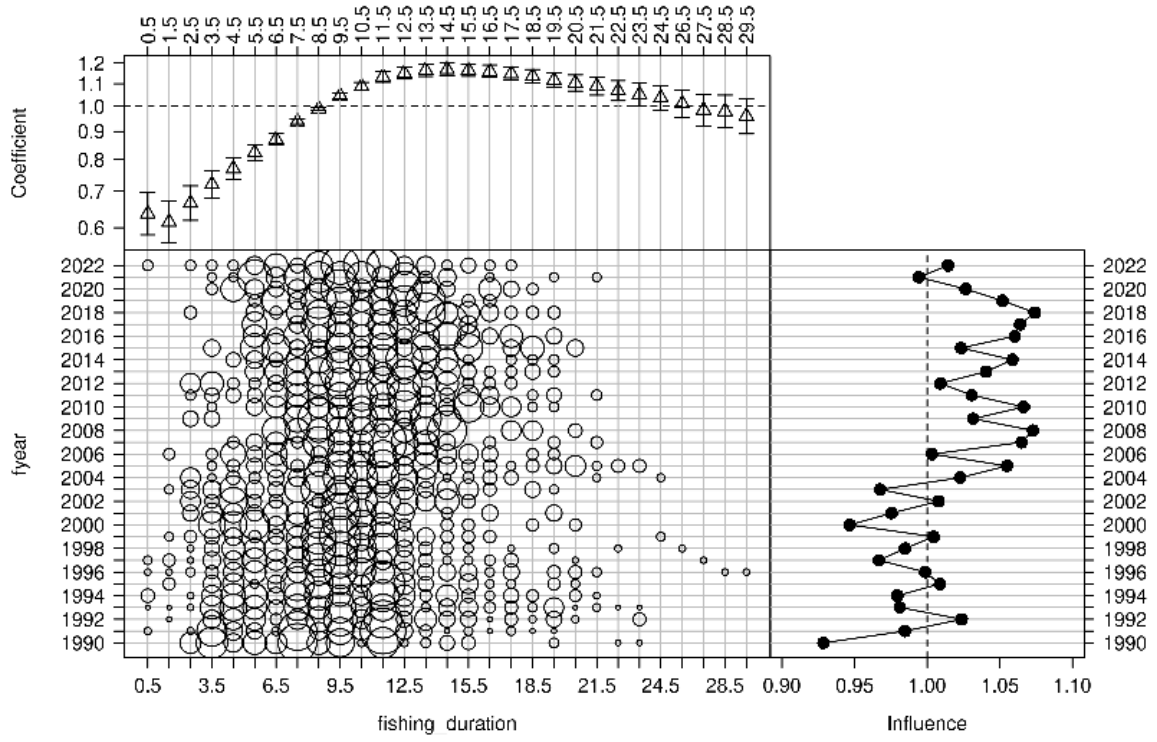

Figure D.38: CDI plot for log fishing duration for the positive catch SKI1 SKI2 HOK-SKI daily catch-per-unit-effort dataset.

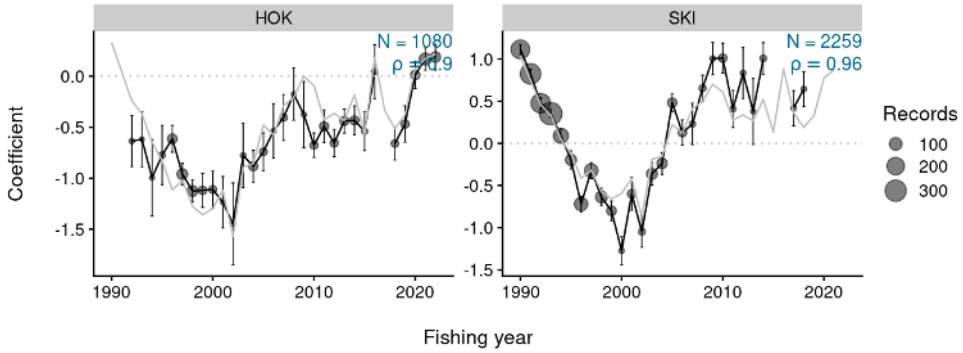

Figure D.39: Residual implied coefficients for target-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI daily dataset.

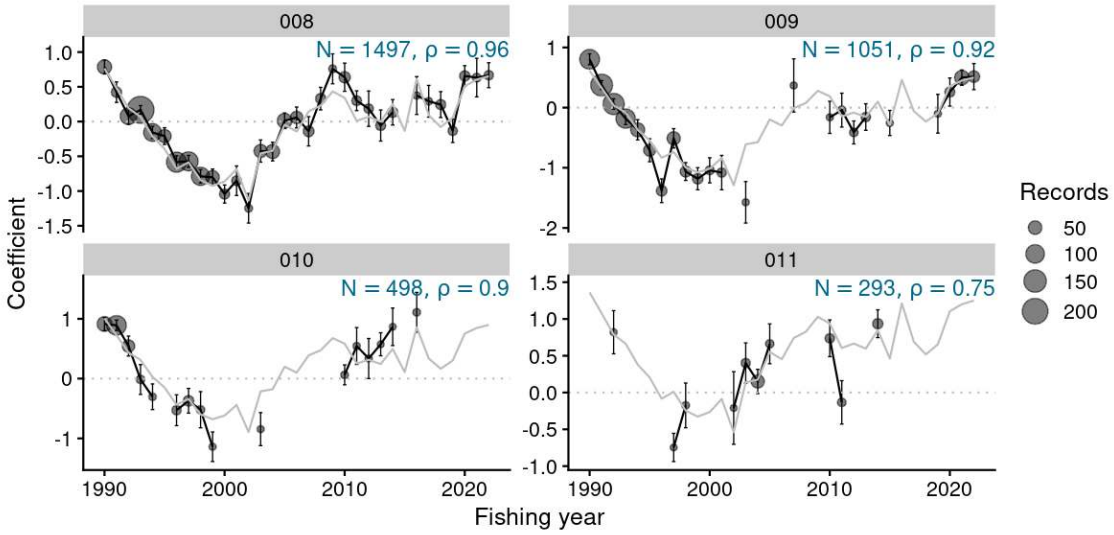

Figure D.40: Residual implied coefficients for area-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI daily dataset.

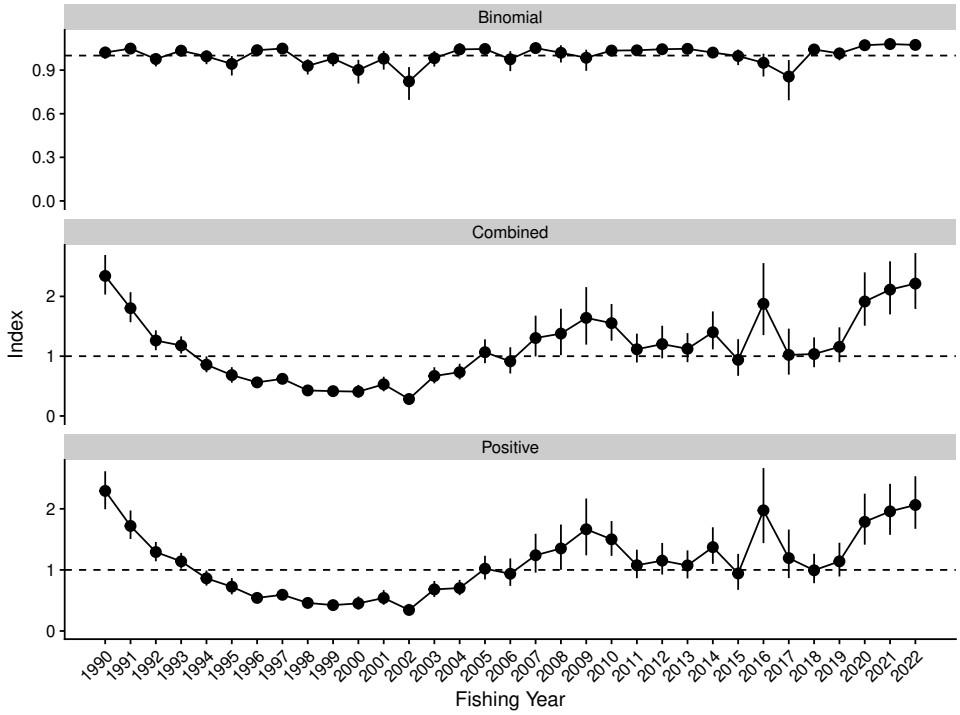

Figure D.41: Standardised indices and 95% confidence intervals for the SKI1 SKI2 HOK-SKI daily dataset.

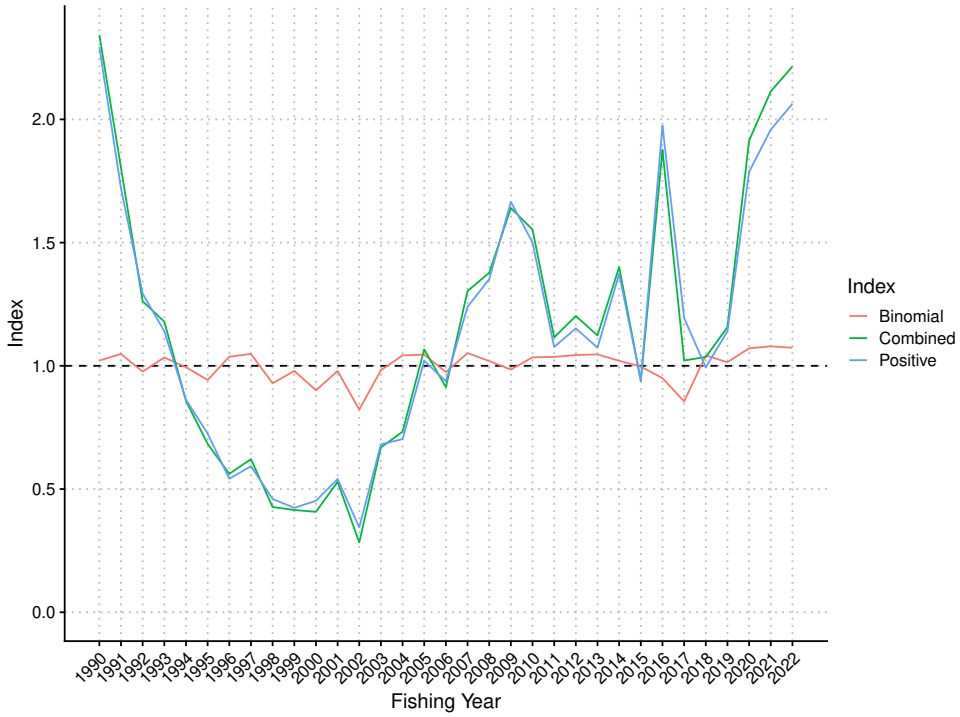

Figure D.42: Standardised indices for the SKI1 SKI2 HOK-SKI daily dataset.

Table D.12: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 HOK-SKI daily.

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1990	1.02	1.02	0.021	1.02	2.34	2.34	0.169	2.34	2.29	2.29	0.158	2.29
1991	1.05	1.05	0.017	1.05	1.80	1.80	0.128	1.80	1.72	1.72	0.119	1.72
1992	0.98	0.98	0.023	0.98	1.26	1.26	0.085	1.26	1.29	1.29	0.081	1.29
1993	1.03	1.03	0.015	1.03	1.18	1.18	0.073	1.18	1.14	1.14	0.066	1.14
1994	0.99	0.99	0.024	0.99	0.86	0.86	0.068	0.86	0.86	0.86	0.063	0.86
1995	0.94	0.94	0.034	0.94	0.68	0.68	0.066	0.68	0.73	0.73	0.068	0.73
1996	1.04	1.04	0.015	1.04	0.56	0.56	0.042	0.56	0.54	0.54	0.040	0.54
1997	1.05	1.05	0.014	1.05	0.62	0.62	0.044	0.62	0.59	0.59	0.041	0.59
1998	0.93	0.93	0.027	0.93	0.43	0.43	0.031	0.43	0.46	0.46	0.032	0.46
1999	0.98	0.98	0.023	0.98	0.42	0.42	0.038	0.42	0.42	0.42	0.037	0.42
2000	0.90	0.90	0.042	0.90	0.41	0.41	0.054	0.41	0.45	0.45	0.055	0.45
2001	0.98	0.98	0.033	0.98	0.53	0.53	0.062	0.53	0.54	0.54	0.061	0.54
2002	0.82	0.82	0.058	0.82	0.28	0.28	0.044	0.28	0.34	0.34	0.047	0.34
2003	0.98	0.98	0.027	0.98	0.67	0.67	0.069	0.67	0.68	0.68	0.067	0.68
2004	1.04	1.04	0.019	1.04	0.73	0.73	0.067	0.73	0.70	0.70	0.064	0.70
2005	1.05	1.05	0.018	1.05	1.07	1.07	0.102	1.07	1.02	1.02	0.099	1.02
2006	0.97	0.97	0.035	0.97	0.91	0.91	0.112	0.91	0.94	0.94	0.115	0.94
2007	1.05	1.05	0.018	1.05	1.30	1.30	0.174	1.30	1.24	1.24	0.162	1.24
2008	1.02	1.02	0.030	1.02	1.38	1.38	0.198	1.38	1.35	1.35	0.189	1.35
2009	0.98	0.98	0.037	0.98	1.64	1.64	0.245	1.64	1.67	1.67	0.237	1.67
2010	1.03	1.03	0.018	1.03	1.55	1.55	0.156	1.55	1.50	1.50	0.145	1.50
2011	1.04	1.04	0.018	1.04	1.12	1.12	0.123	1.12	1.08	1.08	0.119	1.08
2012	1.04	1.04	0.016	1.04	1.20	1.20	0.139	1.20	1.15	1.15	0.132	1.15
2013	1.05	1.05	0.015	1.05	1.12	1.12	0.124	1.12	1.07	1.07	0.117	1.07
2014	1.02	1.02	0.019	1.02	1.40	1.40	0.162	1.40	1.37	1.37	0.153	1.37
2015	1.00	1.00	0.027	1.00	0.94	0.94	0.156	0.94	0.94	0.94	0.150	0.94
2016	0.95	0.95	0.040	0.95	1.88	1.88	0.307	1.88	1.98	1.98	0.313	1.98
2017	0.86	0.86	0.071	0.86	1.02	1.02	0.196	1.02	1.19	1.19	0.203	1.19
2018	1.04	1.04	0.019	1.04	1.04	1.04	0.127	1.04	0.99	0.99	0.123	0.99
2019	1.01	1.01	0.022	1.01	1.16	1.16	0.149	1.16	1.14	1.14	0.141	1.14
2020	1.07	1.07	0.017	1.07	1.91	1.91	0.228	1.91	1.79	1.79	0.213	1.79
2021	1.08	1.08	0.019	1.08	2.11	2.11	0.226	2.11	1.96	1.96	0.213	1.96
2022	1.07	1.07	0.018	1.07	2.21	2.21	0.238	2.21	2.06	2.06	0.220	2.06

D.3 SKI1 SKI2 HOK-SKI event split vessels

Table D.13: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 HOK-SKI event split vessels CPUE series.

Series	SKI1 SKI2 HOK-SKI event split vessels
QMS stock	SKI1, SKI2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW
Target species	SKI, HOK
Areas	008, 009, 010, 011, 012, 013, 014, 015
Period	1993-10-01, 2022-09-30
Resolution	Fishing event
Core fleet years	3
Core fleet trips	3
Default model	allockg_top5 ~ fyear + vessel_key + target_species + primary_method + bs(log(fishing_duration), 3) + stat_area*month + bs(bottom_depth, 3) + bs(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

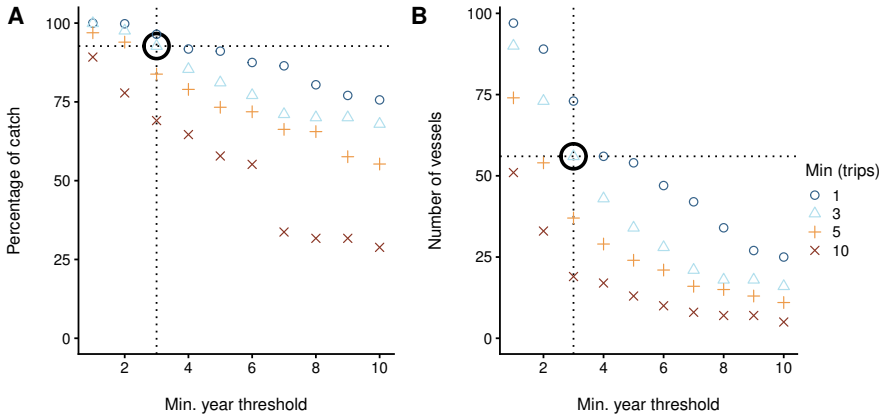

Figure D.43: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 HOK-SKI event split vessels CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

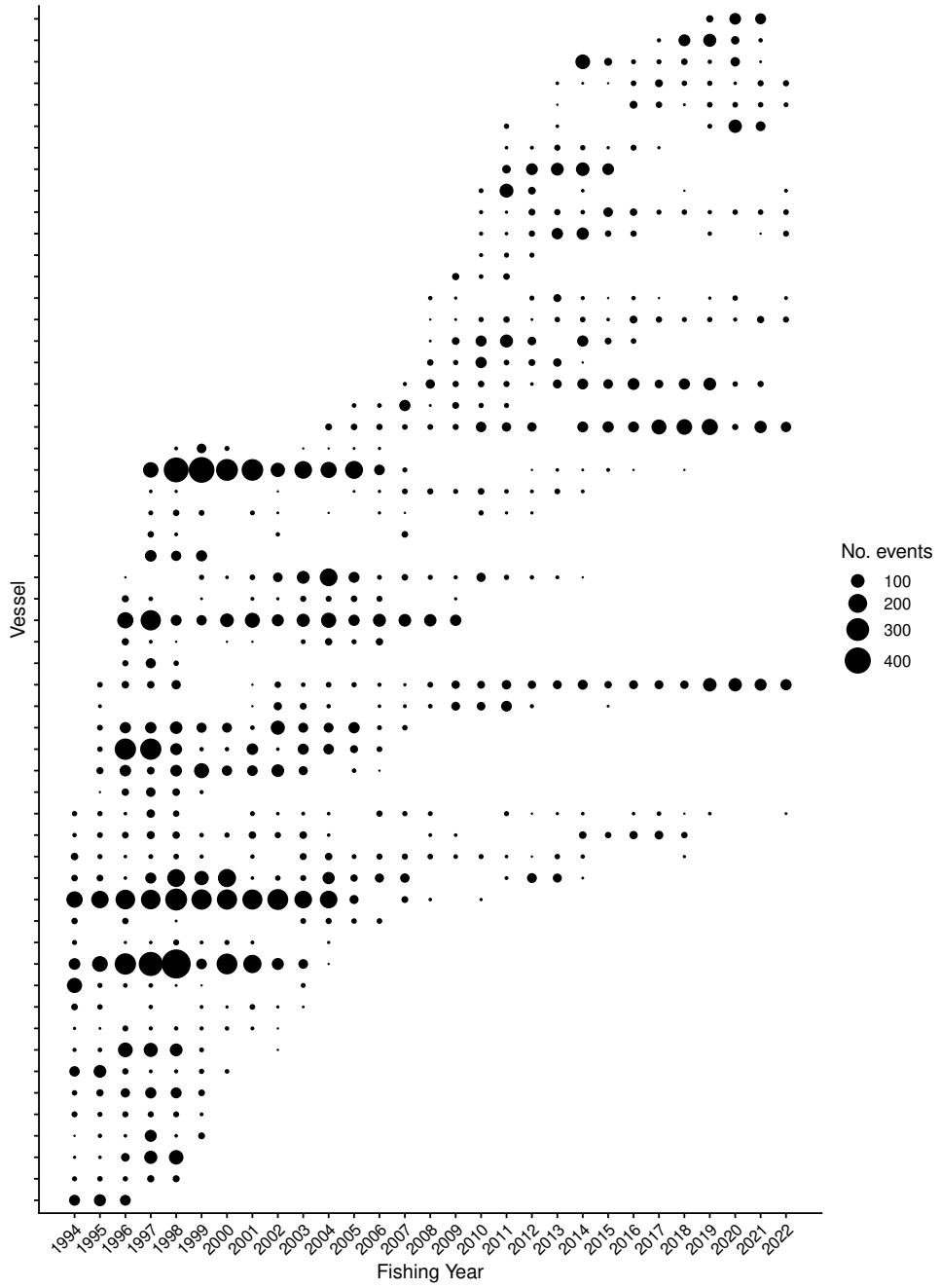

Figure D.44: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.14: Summary of SKI1 SKI2 HOK-SKI event split vessels total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ungroomed data	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Fishing duration is not NA	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Positive fishing duration	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 917)	(Records: 2108)	(Records: 2823)	(Records: 2609)	(Records: 1372)	(Records: 1347)	(Records: 1228)	(Records: 968)	(Records: 991)	(Records: 1045)	(Records: 626)
Bottom depth >=50	768	650	635	731	502	280	455	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1147)	(Records: 909)	(Records: 2043)	(Records: 2772)	(Records: 2446)	(Records: 1361)	(Records: 1343)	(Records: 1225)	(Records: 968)	(Records: 987)	(Records: 1036)	(Records: 622)
Bottom depth <=600	767	650	634	727	502	280	454	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2023)	(Records: 2654)	(Records: 2383)	(Records: 1340)	(Records: 1308)	(Records: 1182)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Effort height <100	767	650	630	711	498	280	454	277	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2000)	(Records: 2594)	(Records: 2357)	(Records: 1336)	(Records: 1297)	(Records: 1176)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Midwater effort depth <=10 m from bottom	760	641	630	709	498	280	451	277	205	295	331	281
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1123)	(Records: 881)	(Records: 1989)	(Records: 2570)	(Records: 2279)	(Records: 1305)	(Records: 1208)	(Records: 1090)	(Records: 868)	(Records: 892)	(Records: 957)	(Records: 572)
Core fleet selection	479	590	592	666	496	279	451	276	204	295	327	281
	(Percent: 62)	(Percent: 91)	(Percent: 92)	(Percent: 90)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 625)	(Records: 680)	(Records: 1519)	(Records: 2063)	(Records: 2165)	(Records: 1267)	(Records: 1204)	(Records: 1043)	(Records: 859)	(Records: 879)	(Records: 944)	(Records: 570)

Filter	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Fishing duration is not NA	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Positive fishing duration	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth >=50	182 (Percent: 100) (Records: 367)	236 (Percent: 100) (Records: 367)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth <=600	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Effort height <100	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Midwater effort depth <=10 m from bottom	182 (Percent: 100) (Records: 353)	236 (Percent: 100) (Records: 349)	145 (Percent: 100) (Records: 259)	179 (Percent: 100) (Records: 298)	239 (Percent: 100) (Records: 468)	221 (Percent: 100) (Records: 571)	152 (Percent: 100) (Records: 388)	130 (Percent: 100) (Records: 506)	247 (Percent: 100) (Records: 693)	86 (Percent: 100) (Records: 383)	251 (Percent: 100) (Records: 385)	192 (Percent: 91) (Records: 361)
Core fleet selection	182 (Percent: 100) (Records: 352)	235 (Percent: 100) (Records: 345)	143 (Percent: 100) (Records: 247)	178 (Percent: 100) (Records: 291)	235 (Percent: 100) (Records: 412)	206 (Percent: 92) (Records: 527)	103 (Percent: 67) (Records: 376)	109 (Percent: 84) (Records: 429)	230 (Percent: 93) (Records: 628)	77 (Percent: 90) (Records: 360)	243 (Percent: 100) (Records: 370)	174 (Percent: 82) (Records: 337)

Filter	2018	2019	2020	2021	2022
Ungroomed data	181 (Percent: 100) (Records: 493)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Fishing duration is not NA	181 (Percent: 100) (Records: 493)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Positive fishing duration	181 (Percent: 100) (Records: 492)	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Bottom depth >=50	181 (Percent: 100) (Records: 492)	295 (Percent: 100) (Records: 777)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 388)	178 (Percent: 100) (Records: 368)
Bottom depth <=600	180 (Percent: 100) (Records: 483)	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Effort height <100	180 (Percent: 100) (Records: 483)	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Midwater effort depth <=10 m from bottom	160 (Percent: 89) (Records: 413)	158 (Percent: 54) (Records: 570)	246 (Percent: 92) (Records: 433)	156 (Percent: 92) (Records: 358)	69 (Percent: 39) (Records: 205)
Core fleet selection	140 (Percent: 78) (Records: 386)	145 (Percent: 49) (Records: 516)	238 (Percent: 89) (Records: 417)	154 (Percent: 91) (Records: 357)	69 (Percent: 39) (Records: 201)

Table D.15: Summary of the SKI1 SKI2 HOK-SKI event split vessels dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of event with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1994	19	120	625	2 481.58	479.23	88.48
1995	23	133	680	2 085.80	589.95	79.71
1996	28	266	1 519	4 600.27	592.01	72.22
1997	31	336	2 063	6 604.32	665.67	62.58
1998	31	350	2 165	7 279.53	495.74	61.11
1999	25	215	1 267	3 785.15	278.68	60.62
2000	16	172	1 204	2 954.47	450.80	71.01
2001	20	165	1 043	2 479.85	275.53	69.80
2002	20	179	859	2 532.13	203.98	72.18
2003	20	177	879	2 947.88	295.07	74.74
2004	20	188	944	3 387.62	326.76	70.97
2005	17	129	570	2 060.32	281.21	69.65
2006	19	117	352	1 315.00	182.45	62.50
2007	16	94	345	1 396.52	235.28	74.78
2008	16	85	247	1 068.28	142.85	69.64
2009	16	116	291	1 192.07	178.24	71.82
2010	18	147	412	1 852.55	235.27	76.94
2011	22	166	527	2 128.12	205.63	66.22
2012	21	128	376	1 433.35	102.66	67.82
2013	18	161	429	1 750.90	109.16	66.90
2014	21	169	628	2 181.77	229.59	72.77
2015	15	120	360	1 316.65	77.33	61.39
2016	15	128	370	1 643.67	243.12	74.59
2017	13	116	337	1 542.97	174.08	70.92
2018	14	127	386	1 889.25	140.37	79.53
2019	14	135	516	2 516.17	145.27	66.67
2020	12	143	417	1 949.05	237.70	90.17
2021	12	142	357	1 721.65	154.37	90.48
2022	10	80	201	884.80	68.63	86.57

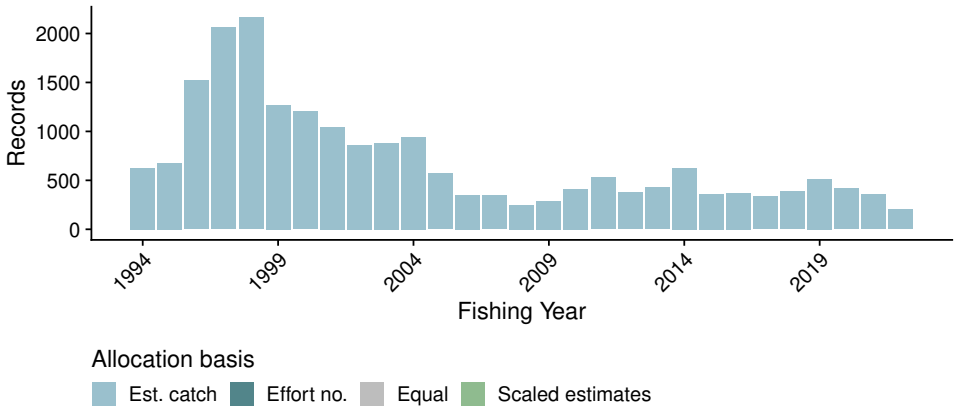

Figure D.45: Allocation basis for attributing landings to records in the SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.16: Summary of stepwise selection for occurrence of positive catch. 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	27.00	24 262	2.60	2.60	*
+ vessel_key	55.00	21 440	14.40	11.80	*
+ target_species	1.00	20 621	17.70	3.30	*
+ bs(bottom_depth, 3)	3.00	20 434	18.40	0.80	
+ month	11.00	20 257	19.20	0.80	*
+ bs(log(fishing_duration), 3)	3.00	20 196	19.50	0.30	
+ stat_area	7.00	20 106	19.90	0.40	*
+ stat_area:month	77.00	19 883	21.50	1.50	*
+ primary_method	1.00	19 875	21.50	0.00	
+ bs(effort_height, 3)	3.00	19 863	21.60	0.10	

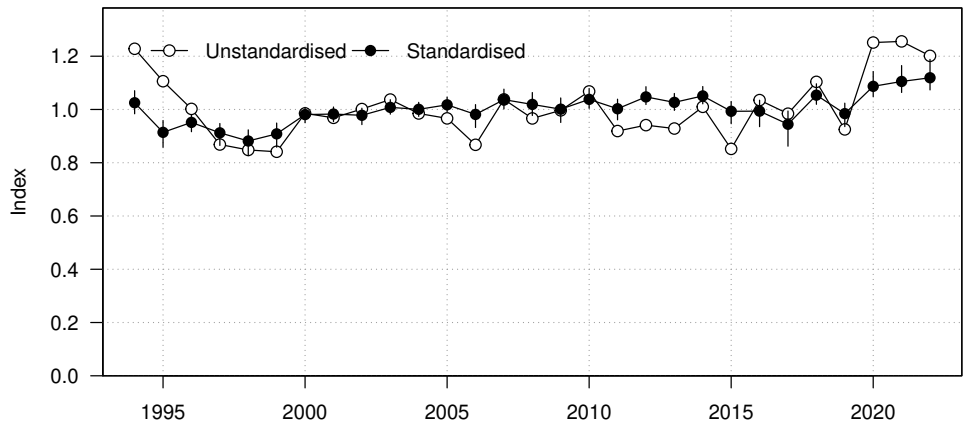

Figure D.46: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 HOK-SKI event split vessels dataset.

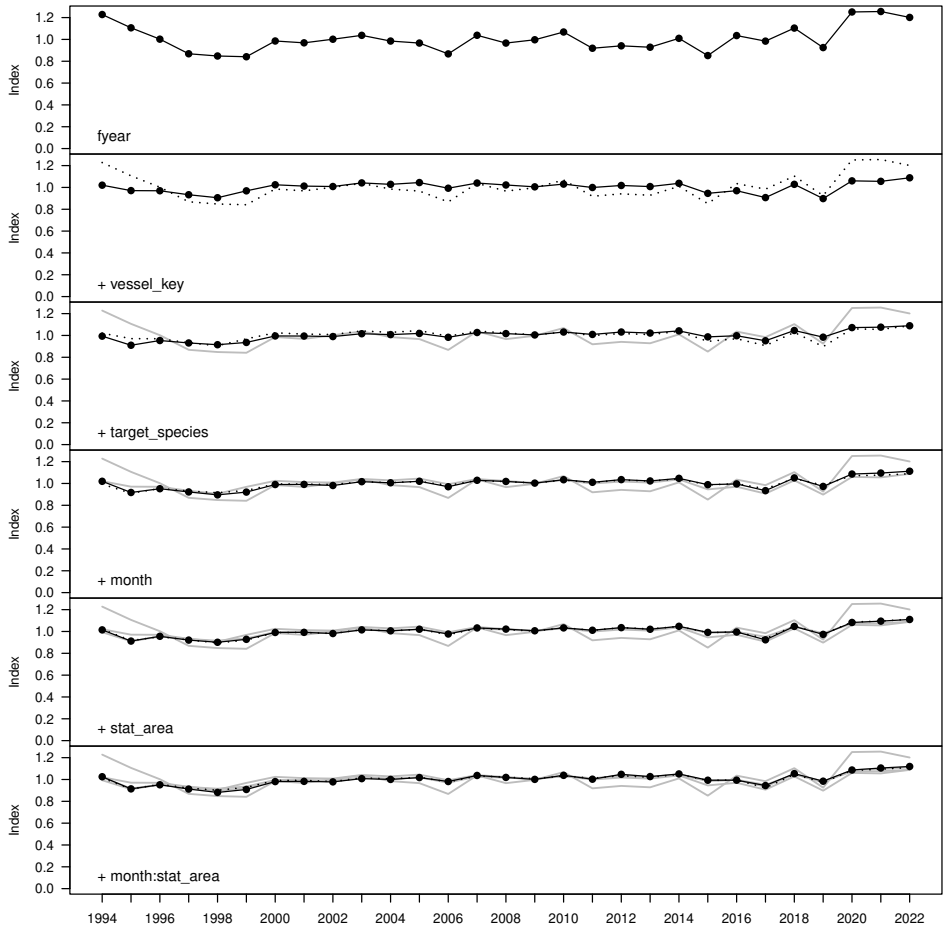

Figure D.47: Step plot for occurrence of catch in the SKI1 SKI2 HOK-SKI event split vessels dataset.

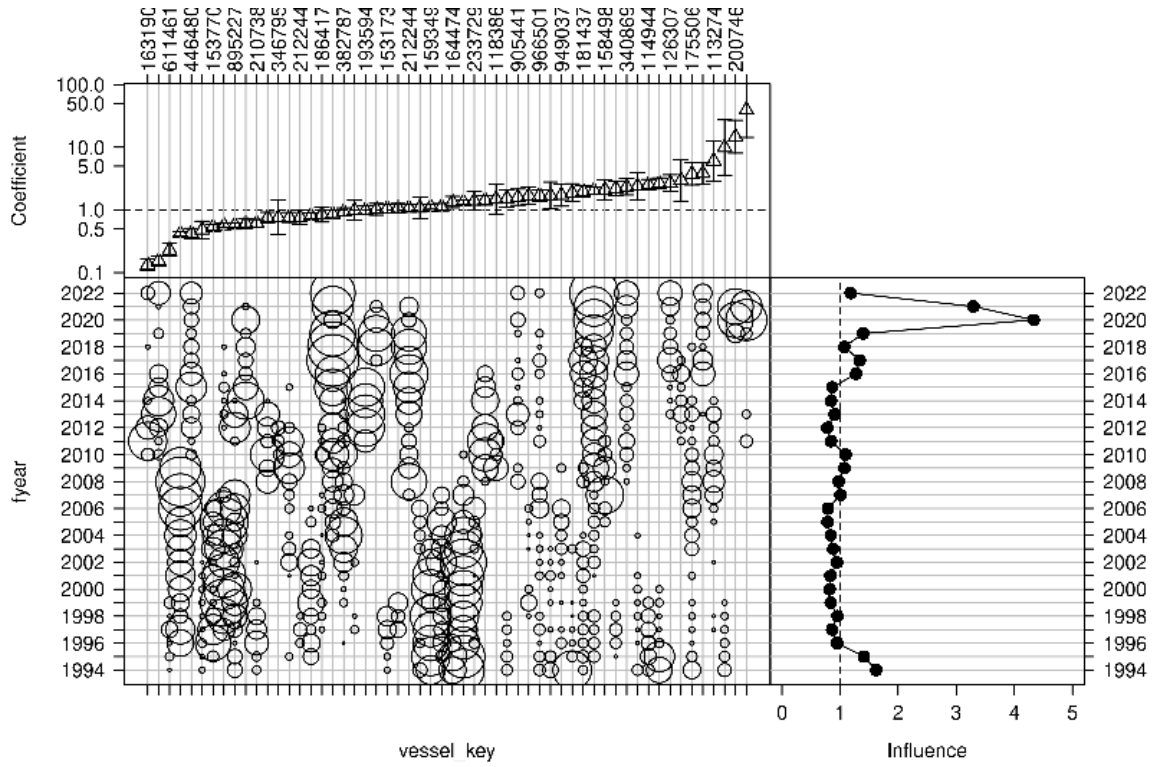

Figure D.48: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

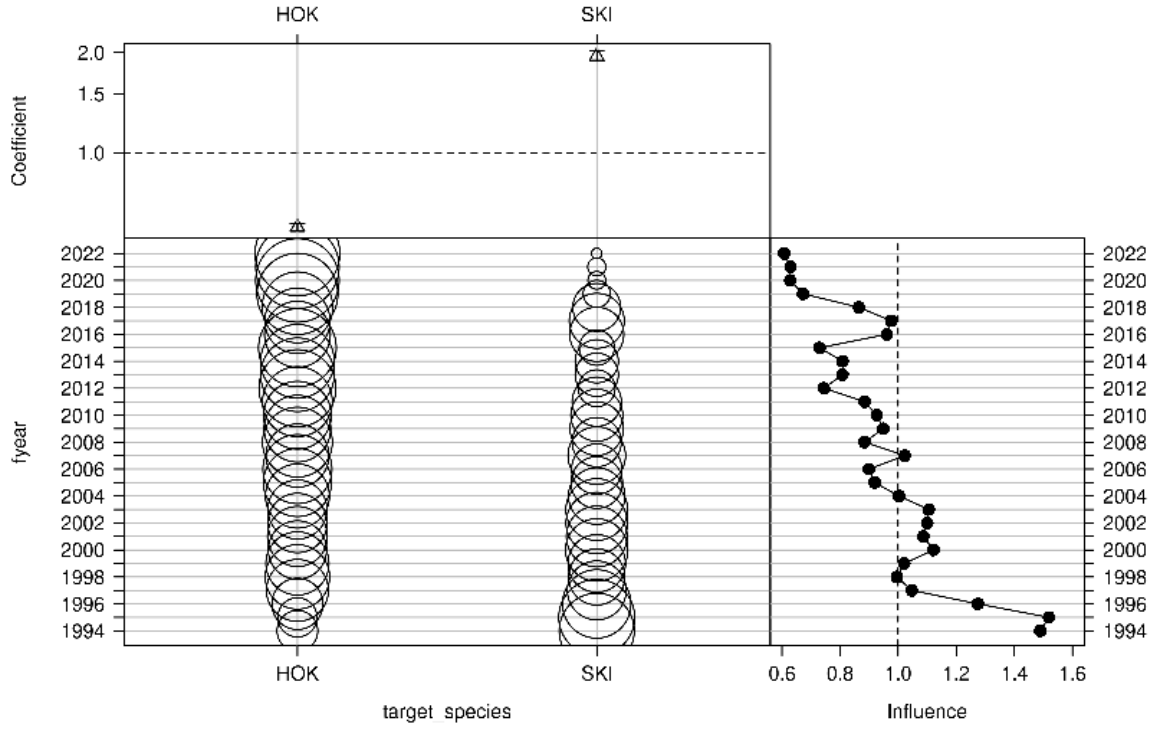

Figure D.49: CDI plot for target species for the occurrence of positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

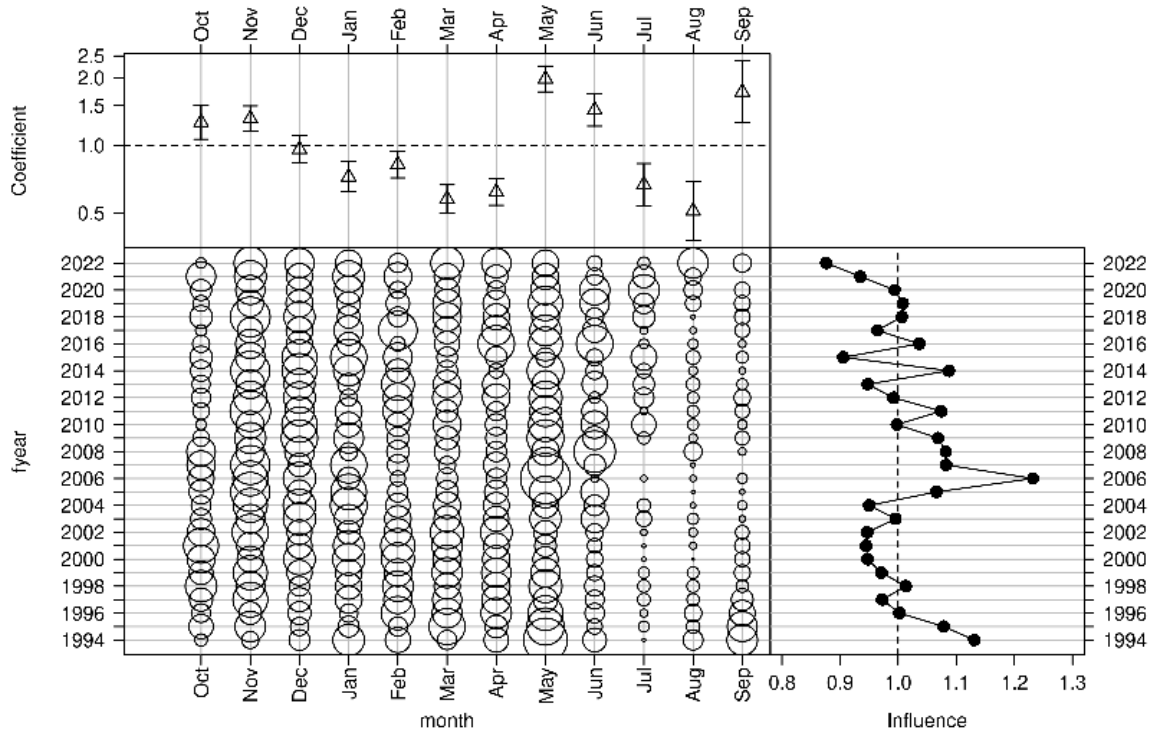

Figure D.50: CDI plot for month for the occurrence of positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

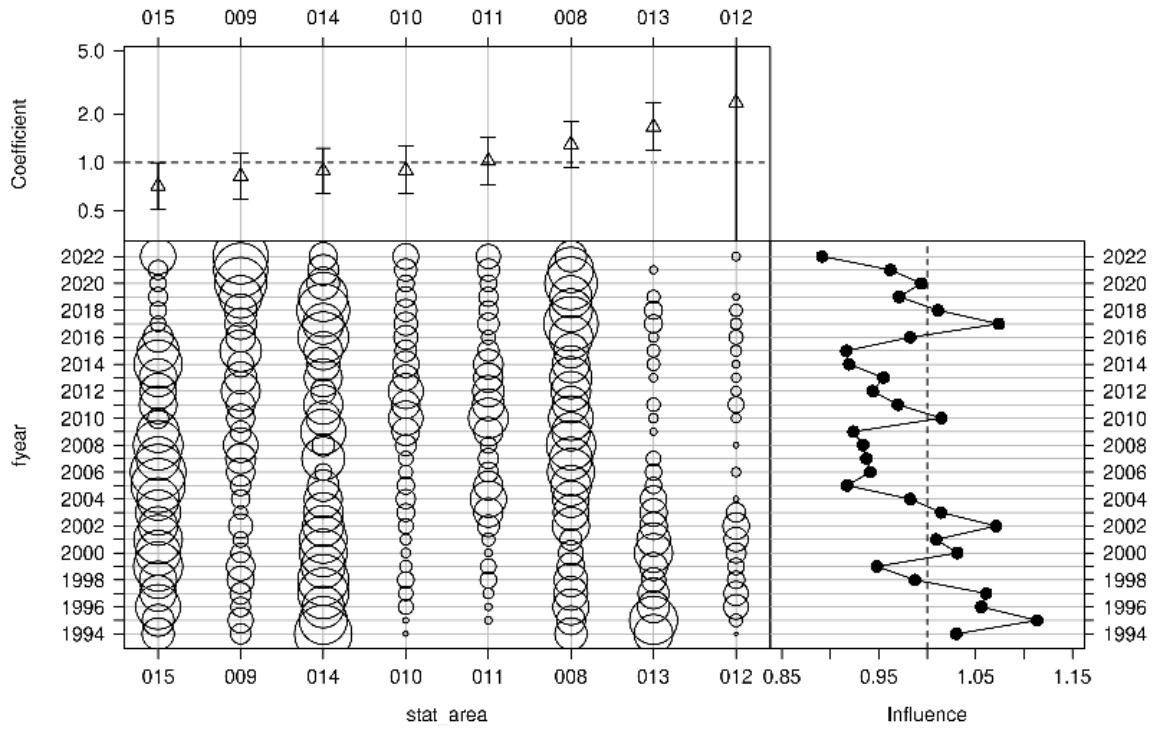

Figure D.51: CDI plot for statistical area for the occurrence of positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

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

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30	198 489	3.3	3.3	*
+ vessel key	55	192 806	38.4	35.1	*
+ target species	1	191 543	46.1	7.7	*
+ stat area	7	191 105	48.9	2.7	*
+ month	11	190 750	51.1	2.3	*
+ stat area:month	77	189 146	61.8	10.7	*
+ bs(bottom depth, 3)	3	188 854	63.6	1.8	*
+ bs(effort height, 3)	3	188 598	65.2	1.6	*
+ bs(log(fishing duration), 3)	3	188 419	66.3	1.1	*
+ primary method	1	188 409	66.4	0.1	

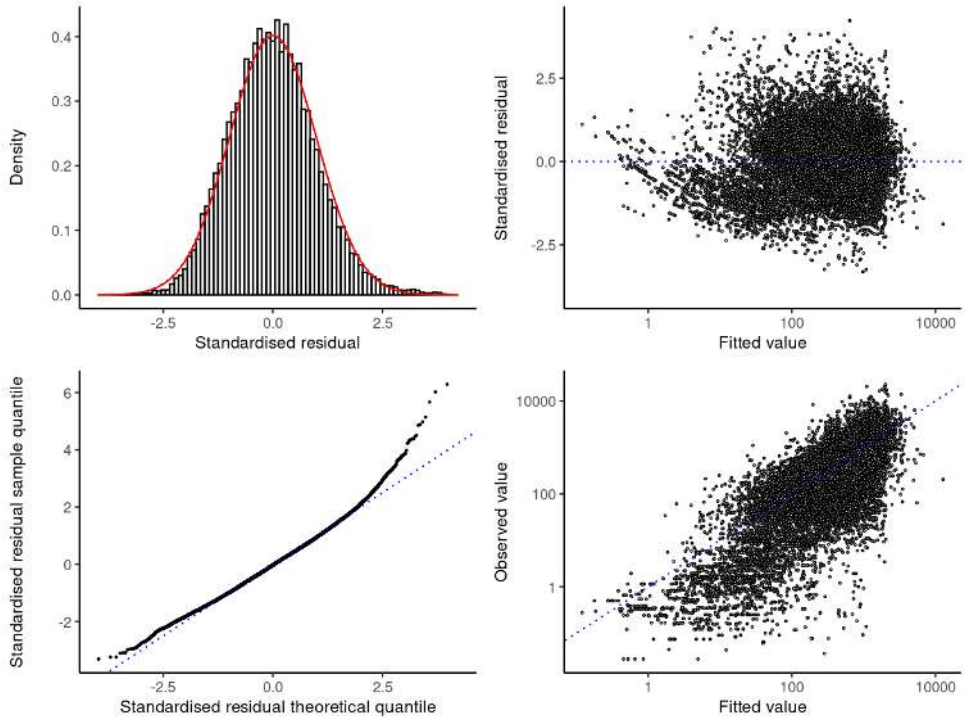

Figure D.52: Diagnostic plots for the Weibull model for the SKI1 SKI2 HOK-SKI event split vessels dataset.

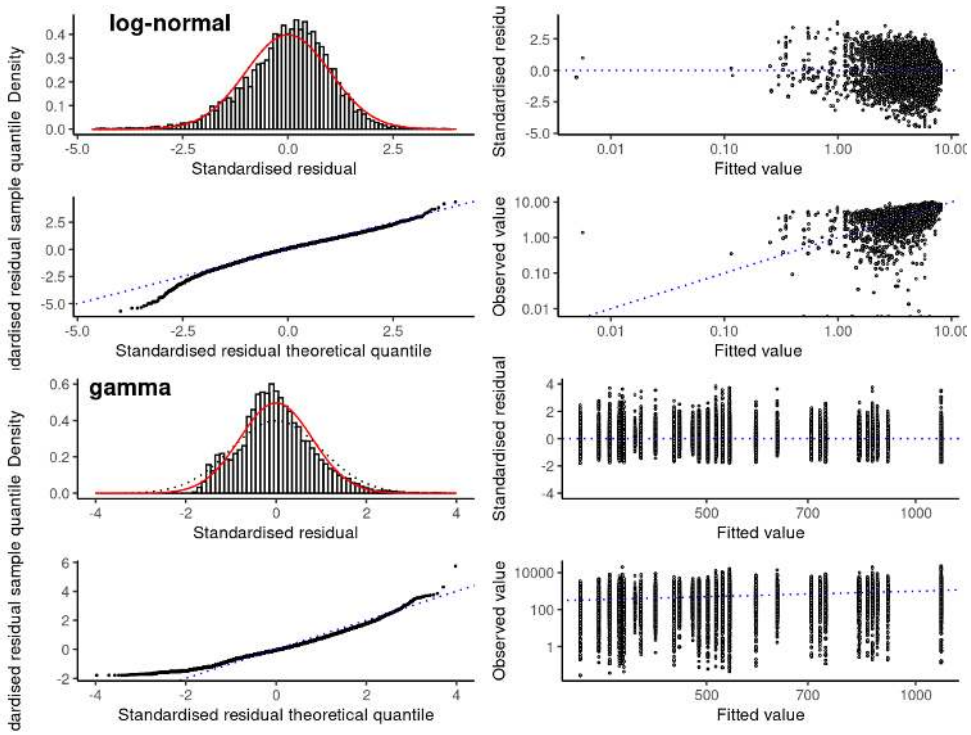

Figure D.53: Diagnostic plots for the log-normal and gamma model for the SKI1 SKI2 HOK-SKI event split vessels dataset.

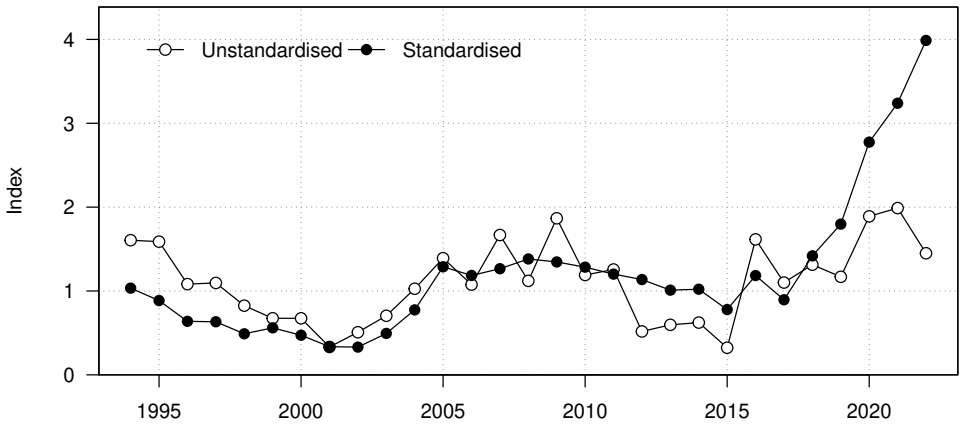

Figure D.54: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 HOK-SKI event split vessels dataset.

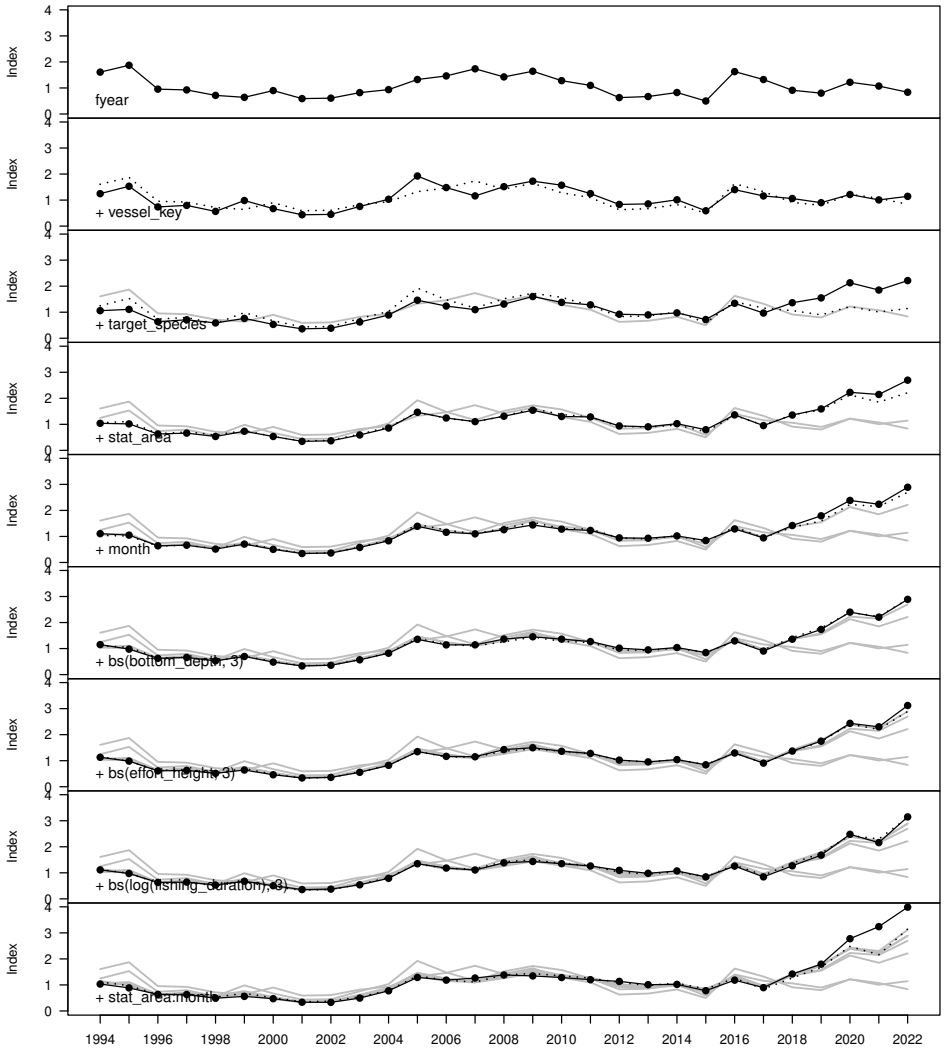

Figure D.55: Changes to the SKI1 SKI2 HOK-SKI event split vessels positive catch index as terms are successively entered into the model.

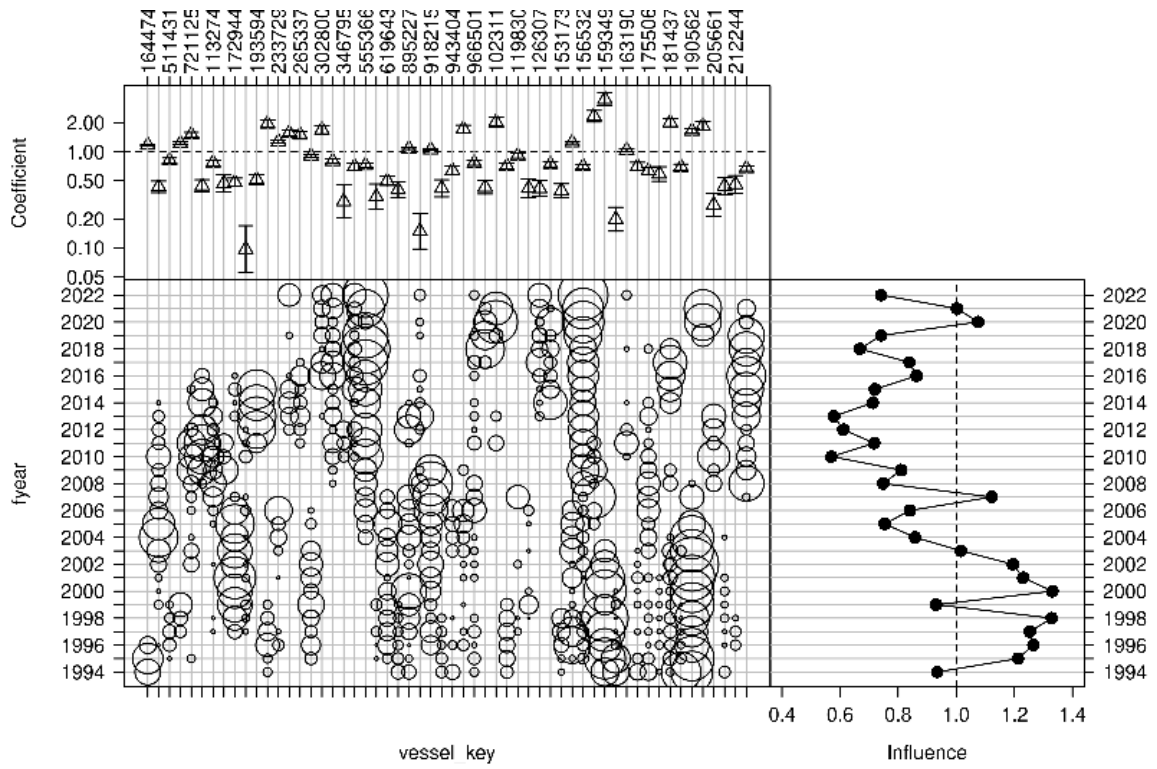

Figure D.56: CDI plot for vessel key for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

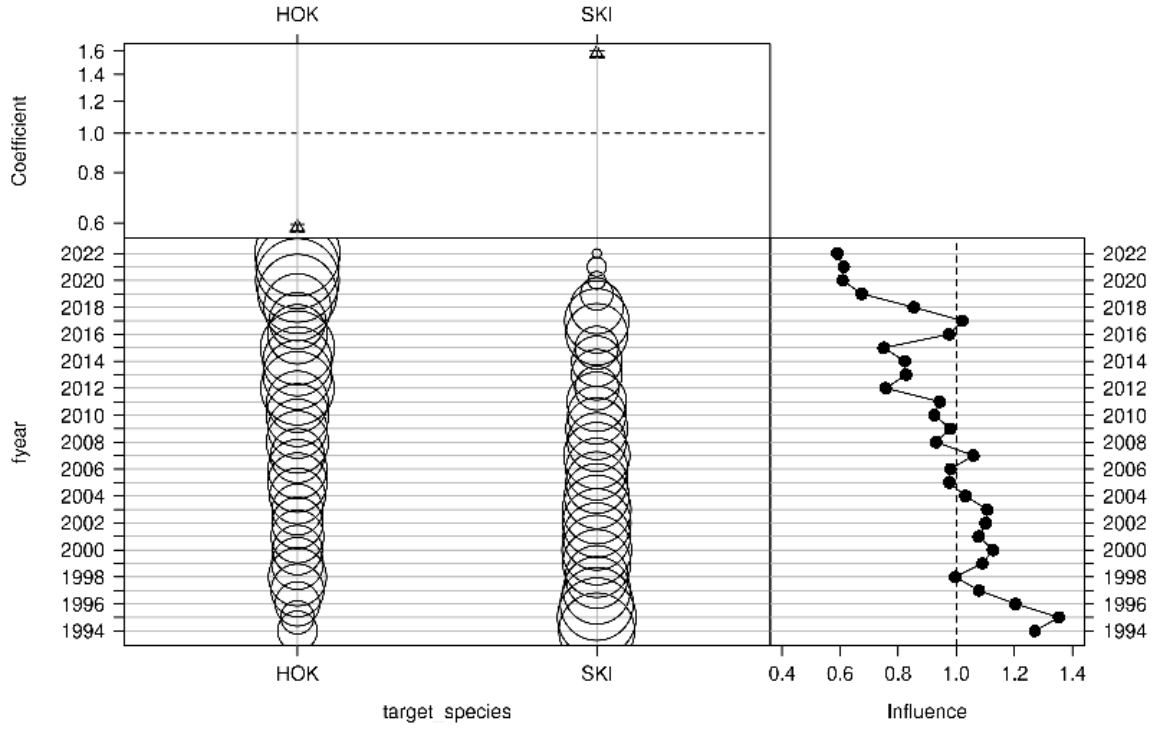

Figure D.57: CDI plot for target species for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

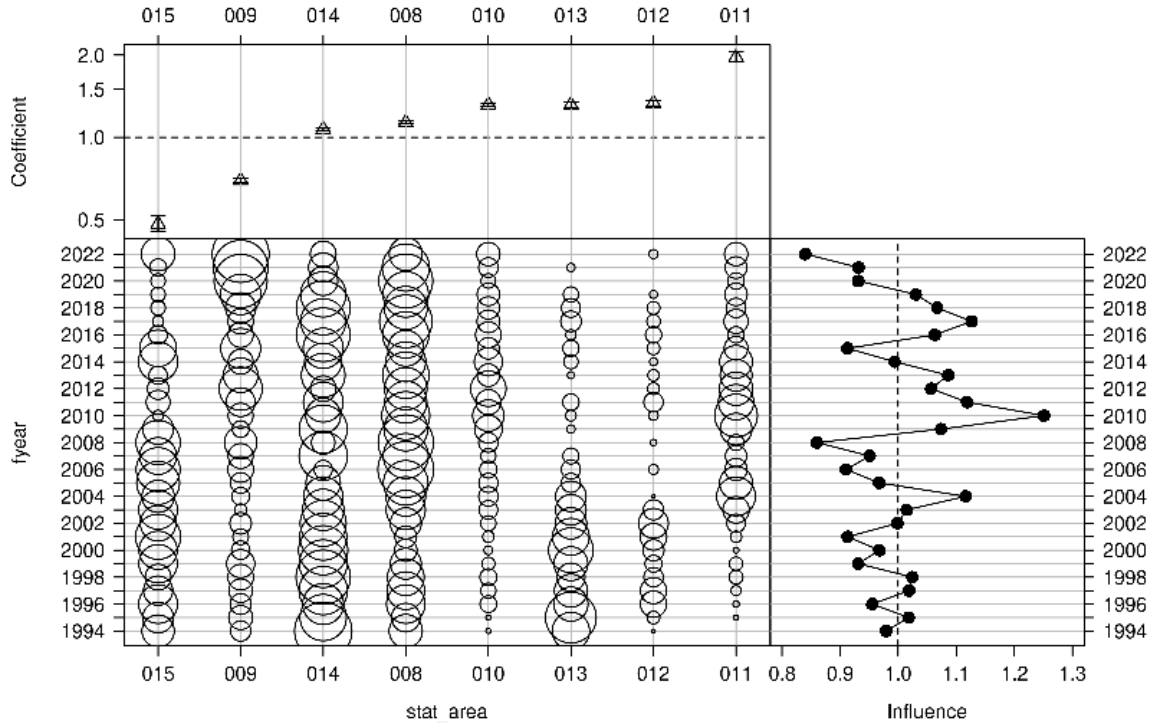

Figure D.58: CDI plot for statistical area for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

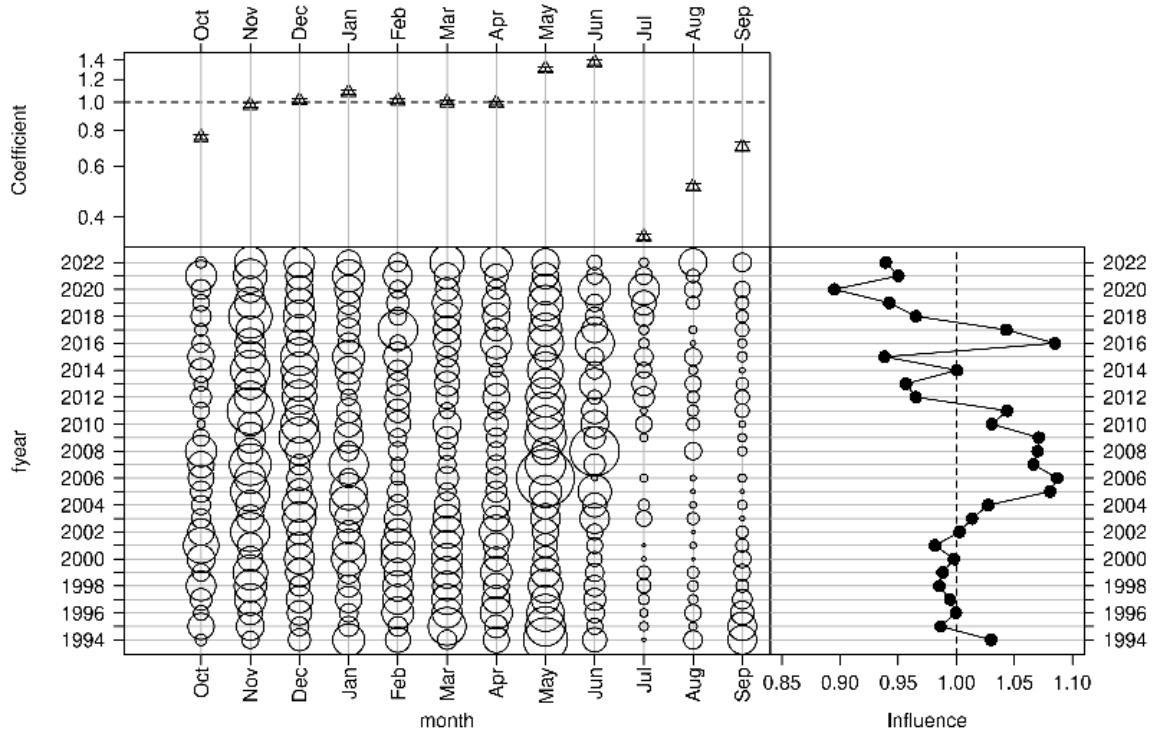

Figure D.59: CDI plot for month for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

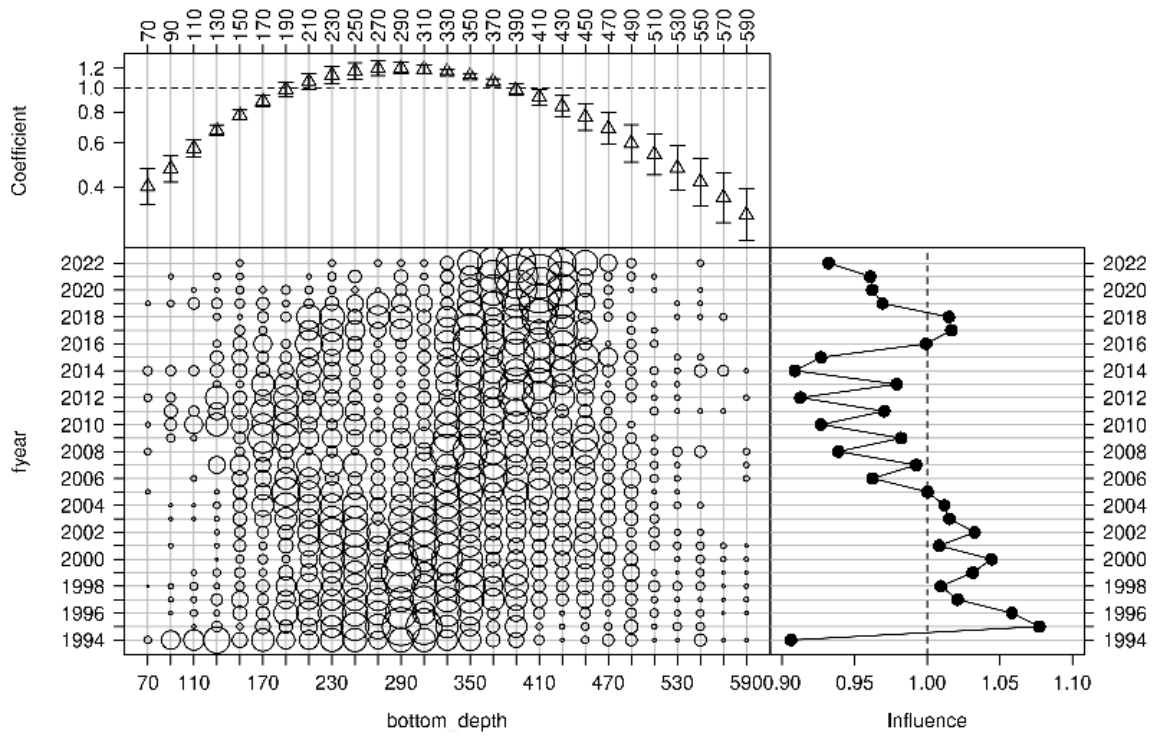

Figure D.60: CDI plot for bottom depth for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

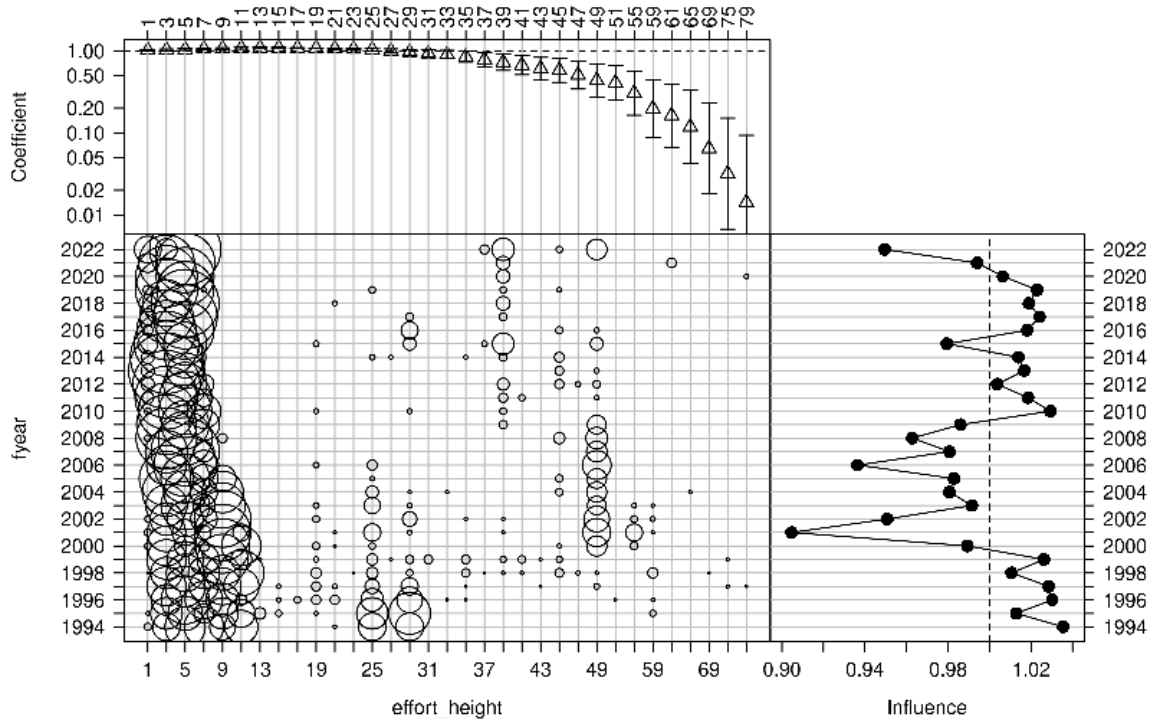

Figure D.61: CDI plot for effort height for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

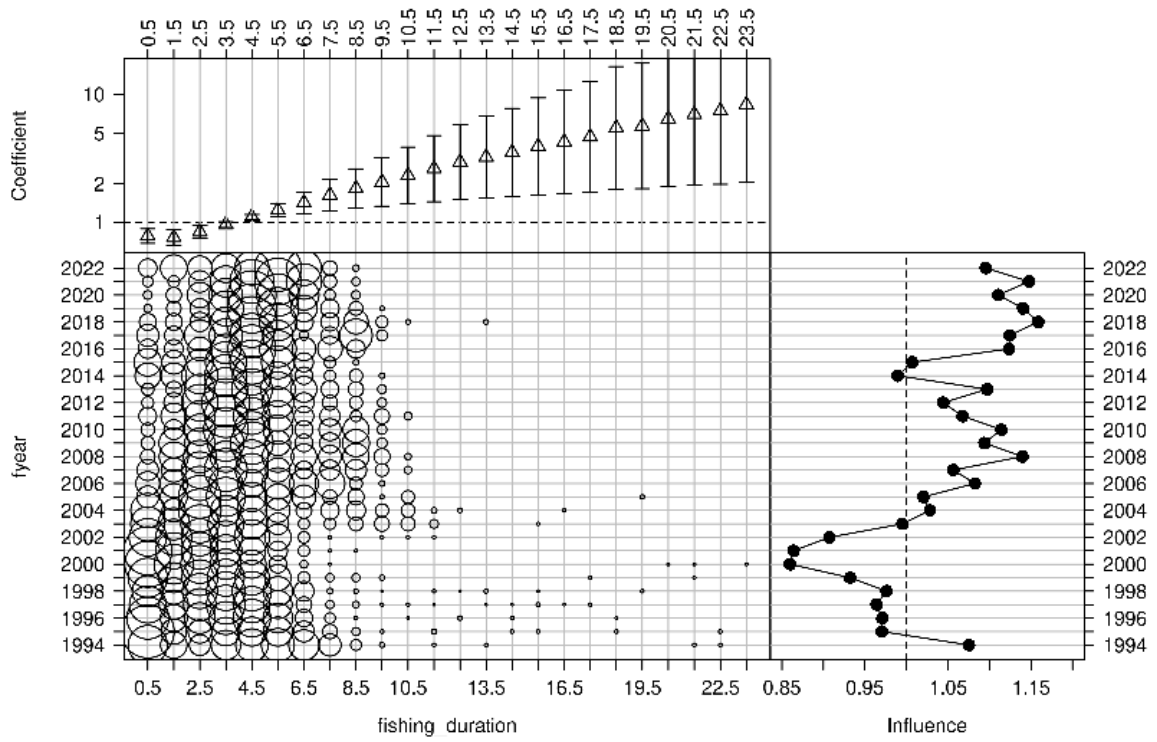

Figure D.62: CDI plot for log fishing duration for the positive catch SKI1 SKI2 HOK-SKI event split vessels catch-per-unit-effort dataset.

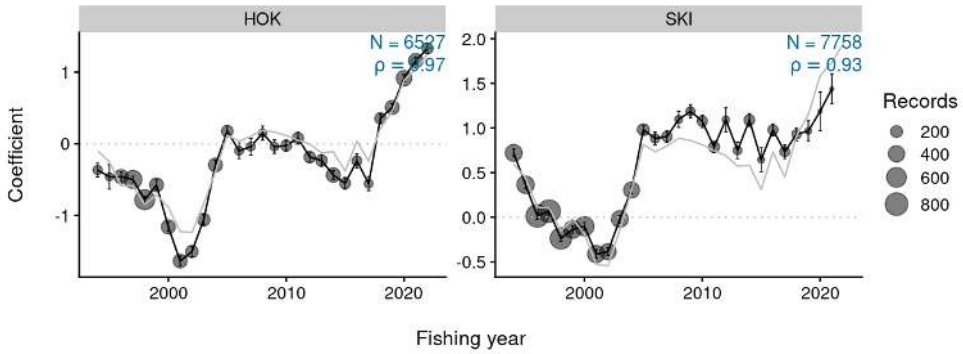

Figure D.63: Residual implied coefficients for target-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event split vessels dataset.

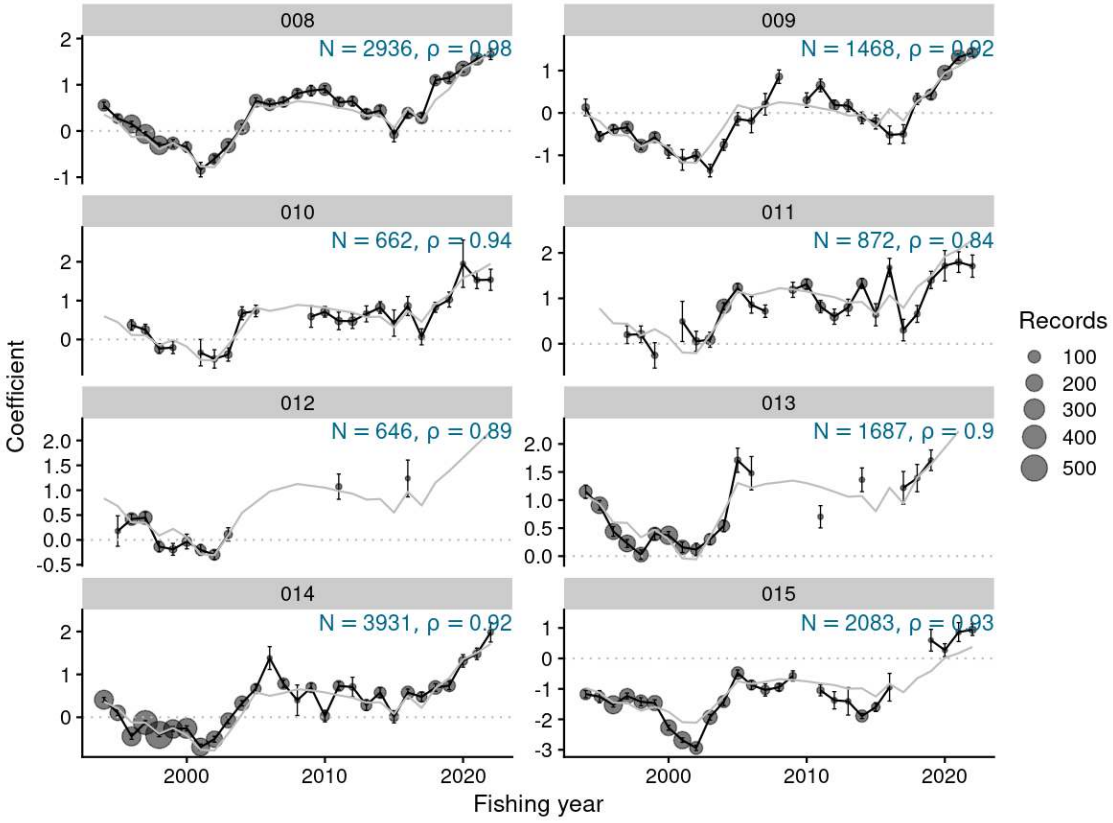

Figure D.64: Residual implied coefficients for area-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event split vessels dataset.

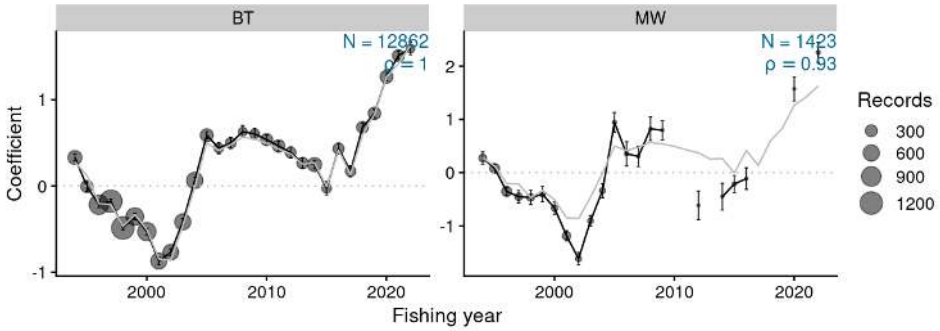

Figure D.65: Residual implied coefficients for primary method-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event split vessels dataset.

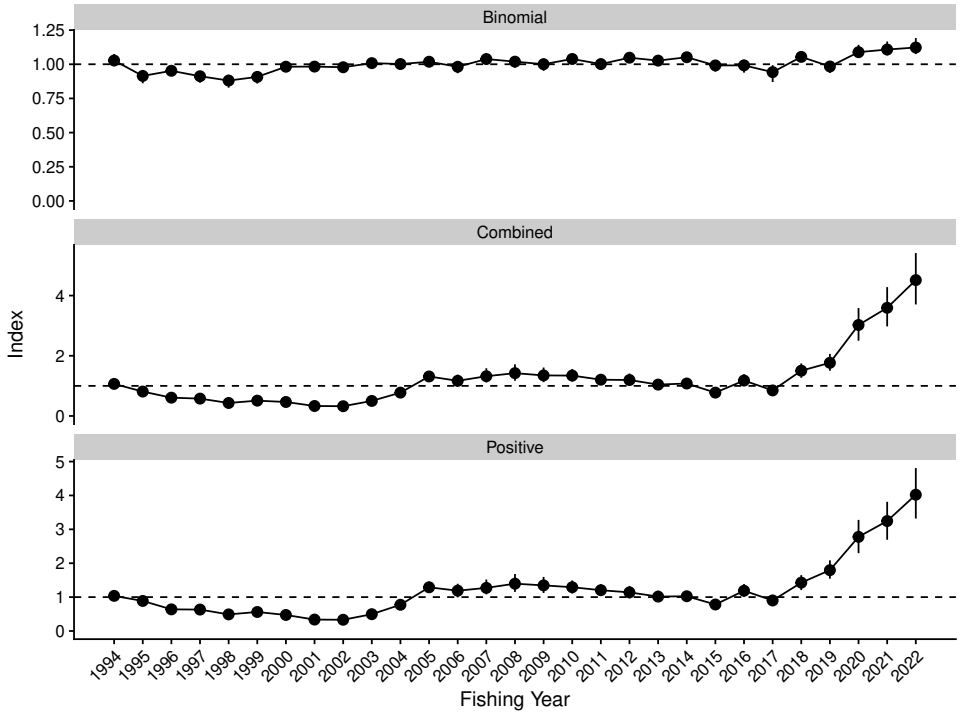

Figure D.66: Standardised indices and 95% confidence intervals for the SKI1 SKI2 HOK-SKI event split vessels dataset.

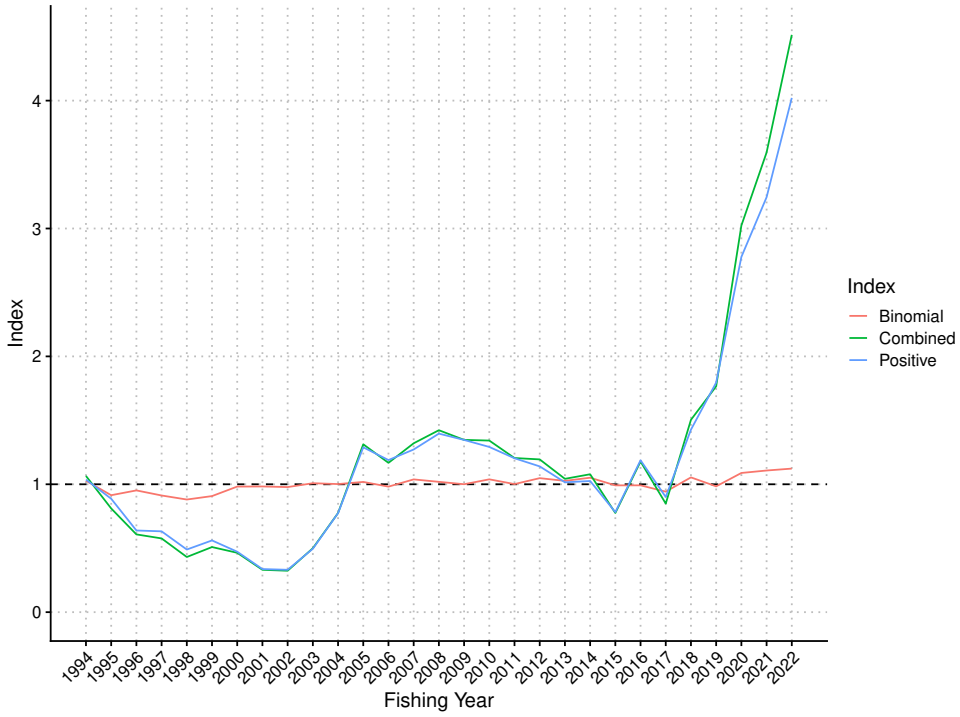

Figure D.67: Standardised indices for the SKI1 SKI2 HOK-SKI event split vessels dataset.

Table D.18: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 HOK-SKI event split vessels.

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1994	1.03	1.03	0.023	1.03	1.07	1.07	0.084	1.07	1.04	1.04	0.076	1.04
1995	0.91	0.91	0.025	0.91	0.81	0.81	0.061	0.81	0.89	0.89	0.060	0.89
1996	0.95	0.95	0.016	0.95	0.61	0.61	0.033	0.61	0.64	0.64	0.034	0.64
1997	0.91	0.91	0.020	0.91	0.58	0.58	0.030	0.58	0.63	0.63	0.030	0.63
1998	0.88	0.88	0.024	0.88	0.43	0.43	0.024	0.43	0.49	0.49	0.024	0.49
1999	0.91	0.91	0.022	0.91	0.51	0.51	0.034	0.51	0.56	0.56	0.033	0.56
2000	0.98	0.98	0.014	0.98	0.46	0.46	0.027	0.46	0.47	0.47	0.027	0.47
2001	0.98	0.98	0.014	0.98	0.33	0.33	0.019	0.33	0.34	0.34	0.019	0.34
2002	0.98	0.98	0.015	0.98	0.32	0.32	0.020	0.32	0.33	0.33	0.019	0.33
2003	1.01	1.01	0.014	1.01	0.50	0.50	0.030	0.50	0.50	0.50	0.029	0.50
2004	1.00	1.00	0.013	1.00	0.78	0.78	0.045	0.78	0.77	0.77	0.045	0.77
2005	1.02	1.02	0.016	1.02	1.31	1.31	0.089	1.31	1.29	1.29	0.085	1.29
2006	0.98	0.98	0.022	0.98	1.17	1.17	0.102	1.17	1.19	1.19	0.103	1.19
2007	1.04	1.04	0.019	1.04	1.32	1.32	0.120	1.32	1.27	1.27	0.112	1.27
2008	1.02	1.02	0.021	1.02	1.42	1.42	0.139	1.42	1.40	1.40	0.135	1.40
2009	1.00	1.00	0.023	1.00	1.35	1.35	0.124	1.35	1.35	1.35	0.121	1.35
2010	1.04	1.04	0.019	1.04	1.34	1.34	0.107	1.34	1.29	1.29	0.098	1.29
2011	1.00	1.00	0.021	1.00	1.21	1.21	0.090	1.21	1.20	1.20	0.086	1.20
2012	1.05	1.05	0.017	1.05	1.19	1.19	0.103	1.19	1.14	1.14	0.093	1.14
2013	1.03	1.03	0.017	1.03	1.04	1.04	0.084	1.04	1.02	1.02	0.081	1.02
2014	1.05	1.05	0.017	1.05	1.08	1.08	0.074	1.08	1.03	1.03	0.067	1.03
2015	0.99	0.99	0.021	0.99	0.78	0.78	0.070	0.78	0.78	0.78	0.070	0.78
2016	0.99	0.99	0.024	0.99	1.18	1.18	0.101	1.18	1.19	1.19	0.097	1.19
2017	0.94	0.94	0.031	0.94	0.85	0.85	0.082	0.85	0.90	0.90	0.078	0.90
2018	1.05	1.05	0.019	1.05	1.50	1.50	0.121	1.50	1.43	1.43	0.112	1.43
2019	0.98	0.98	0.021	0.98	1.77	1.77	0.143	1.77	1.80	1.80	0.138	1.80
2020	1.09	1.09	0.023	1.09	3.02	3.02	0.277	3.02	2.78	2.78	0.250	2.78
2021	1.11	1.11	0.026	1.11	3.59	3.59	0.333	3.59	3.24	3.24	0.285	3.24
2022	1.12	1.12	0.030	1.12	4.51	4.51	0.435	4.51	4.02	4.02	0.380	4.02

D.4 SKI1 SKI2 HOK-SKI event (1994 fleet)

Table D.19: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 HOK-SKI event (1994 fleet) CPUE series.

Series	SKI1 SKI2 HOK-SKI event (1994 fleet)
QMS stock	SKI1, SKI2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW
Target species	SKI, HOK
Areas	008, 009, 010, 011, 012, 013, 014, 015
Period	1993-10-01, 2018-09-30
Resolution	Fishing event
Core fleet years	3
Core fleet trips	3
Default model	allockg_top5 ~ fyear + vessel_key + target_species + primary_method + bs(log(fishing_duration), 3) + stat_area + month + bs(bottom_depth, 3) + bs(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

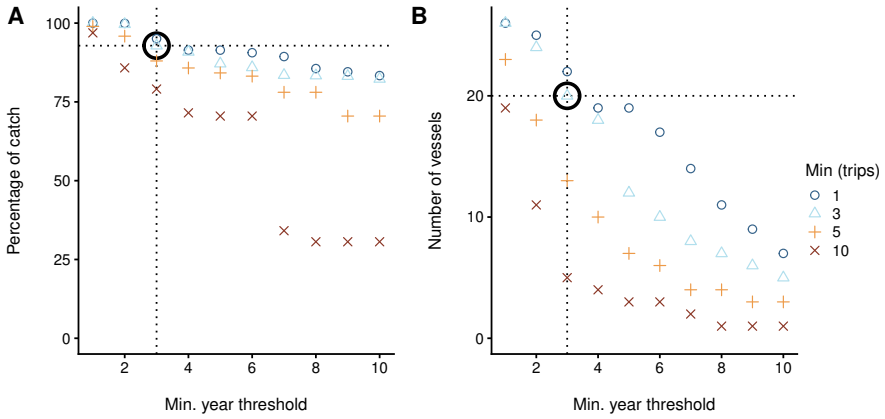

Figure D.68: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 HOK-SKI event (1994 fleet) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

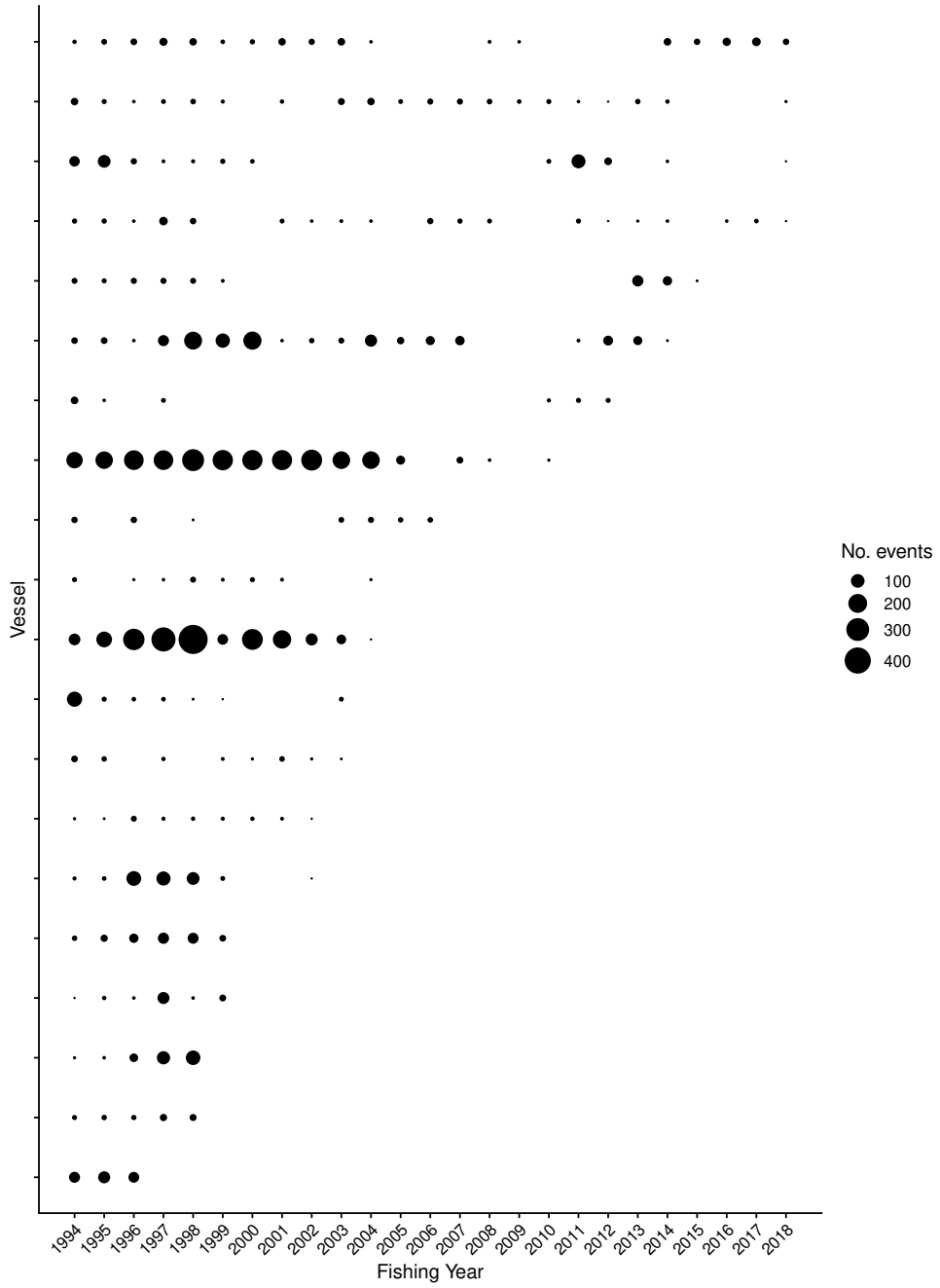

Figure D.69: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.20: Summary of SKI1 SKI2 HOK-SKI event (1994 fleet) total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Ungroomed data	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Fishing duration is not NA	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)
Positive fishing duration	768	650	645	740	535	282	456	278	205	295	332	283
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1149)	(Records: 917)	(Records: 2108)	(Records: 2823)	(Records: 2609)	(Records: 1372)	(Records: 1347)	(Records: 1228)	(Records: 968)	(Records: 991)	(Records: 1045)	(Records: 626)
Bottom depth >=50	768	650	635	731	502	280	455	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1147)	(Records: 909)	(Records: 2043)	(Records: 2772)	(Records: 2446)	(Records: 1361)	(Records: 1343)	(Records: 1225)	(Records: 968)	(Records: 987)	(Records: 1036)	(Records: 622)
Bottom depth <=600	767	650	634	727	502	280	454	278	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2023)	(Records: 2654)	(Records: 2383)	(Records: 1340)	(Records: 1308)	(Records: 1182)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Effort height <100	767	650	630	711	498	280	454	277	205	295	331	282
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1140)	(Records: 901)	(Records: 2000)	(Records: 2594)	(Records: 2357)	(Records: 1336)	(Records: 1297)	(Records: 1176)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)
Midwater effort depth <=10 m from bottom	760	641	630	709	498	280	451	277	205	295	331	281
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 1123)	(Records: 881)	(Records: 1989)	(Records: 2570)	(Records: 2279)	(Records: 1305)	(Records: 1208)	(Records: 1090)	(Records: 868)	(Records: 892)	(Records: 957)	(Records: 572)
Fished in 1994	760	618	435	537	430	216	440	243	171	188	185	103
	(Percent: 100)	(Percent: 95)	(Percent: 67)	(Percent: 73)	(Percent: 80)	(Percent: 77)	(Percent: 100)	(Percent: 87)	(Percent: 84)	(Percent: 64)	(Percent: 56)	(Percent: 36)
	(Records: 1123)	(Records: 780)	(Records: 877)	(Records: 1205)	(Records: 1351)	(Records: 501)	(Records: 704)	(Records: 486)	(Records: 363)	(Records: 317)	(Records: 306)	(Records: 86)
Core fleet selection	482	568	434	522	430	216	440	243	171	188	185	103
	(Percent: 63)	(Percent: 87)	(Percent: 67)	(Percent: 71)	(Percent: 80)	(Percent: 77)	(Percent: 100)	(Percent: 87)	(Percent: 84)	(Percent: 64)	(Percent: 56)	(Percent: 36)
	(Records: 652)	(Records: 616)	(Records: 862)	(Records: 1113)	(Records: 1349)	(Records: 501)	(Records: 704)	(Records: 486)	(Records: 363)	(Records: 315)	(Records: 306)	(Records: 86)

Filter	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Fishing duration is not NA	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Positive fishing duration	182 (Percent: 100) (Records: 367)	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth >=50	182 (Percent: 100) (Records: 367)	236 (Percent: 100) (Records: 367)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)
Bottom depth <=600	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Effort height <100	182 (Percent: 100) (Records: 365)	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)
Midwater effort depth <=10 m from bottom	182 (Percent: 100) (Records: 353)	236 (Percent: 100) (Records: 349)	145 (Percent: 100) (Records: 259)	179 (Percent: 100) (Records: 298)	239 (Percent: 100) (Records: 468)	221 (Percent: 100) (Records: 571)	152 (Percent: 100) (Records: 388)	130 (Percent: 100) (Records: 506)	247 (Percent: 100) (Records: 693)	86 (Percent: 100) (Records: 383)	251 (Percent: 100) (Records: 385)	192 (Percent: 91) (Records: 361)
Fished in 1994	49 (Percent: 27) (Records: 87)	55 (Percent: 23) (Records: 92)	46 (Percent: 31) (Records: 31)	23 (Percent: 13) (Records: 12)	21 (Percent: 9) (Records: 28)	17 (Percent: 8) (Records: 135)	11 (Percent: 7) (Records: 89)	31 (Percent: 24) (Records: 120)	45 (Percent: 18) (Records: 87)	37 (Percent: 43) (Records: 20)	59 (Percent: 24) (Records: 38)	54 (Percent: 25) (Records: 45)
Core fleet selection	49 (Percent: 27) (Records: 87)	55 (Percent: 23) (Records: 92)	46 (Percent: 31) (Records: 31)	23 (Percent: 13) (Records: 12)	21 (Percent: 9) (Records: 28)	17 (Percent: 8) (Records: 134)	11 (Percent: 7) (Records: 89)	31 (Percent: 24) (Records: 120)	45 (Percent: 18) (Records: 87)	37 (Percent: 43) (Records: 20)	59 (Percent: 24) (Records: 37)	54 (Percent: 25) (Records: 45)

Filter	2018
Ungroomed data	181 (Percent: 100) (Records: 493)
Fishing duration is not NA	181 (Percent: 100) (Records: 493)
Positive fishing duration	181 (Percent: 100) (Records: 492)
Bottom depth >=50	181 (Percent: 100) (Records: 492)
Bottom depth <=600	180 (Percent: 100) (Records: 483)
Effort height <100	180 (Percent: 100) (Records: 483)
Midwater effort depth <=10 m from bottom	160 (Percent: 89) (Records: 413)
Fished in 1994	24 (Percent: 13) (Records: 23)
Core fleet selection	24 (Percent: 13) (Records: 23)

Table D.21: Summary of the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of event with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1994	20	125	652	2 677.07	481.80	86.66
1995	18	109	616	1 816.37	567.66	82.63
1996	18	152	862	2 545.37	434.36	73.32
1997	18	168	1 113	3 616.82	522.40	72.51
1998	17	214	1 349	4 560.68	430.06	69.46
1999	14	91	501	1 475.10	215.98	76.45
2000	8	87	704	1 554.47	439.85	85.09
2001	9	68	486	1 119.53	243.26	84.36
2002	8	50	363	973.55	171.45	92.29
2003	9	57	315	1 121.47	187.97	93.33
2004	8	61	306	1 232.43	185.33	90.52
2005	4	22	86	353.22	103.07	96.51
2006	4	25	87	491.80	48.52	68.97
2007	4	19	92	474.35	54.58	72.83
2008	4	12	31	192.25	45.79	80.65
2009	2	4	12	88.58	22.62	100.00
2010	4	13	28	116.77	20.96	60.71
2011	5	24	134	429.92	17.36	38.06
2012	5	20	89	307.08	10.66	51.69
2013	4	35	120	571.82	31.03	71.67
2014	6	32	87	289.95	44.98	86.21
2015	2	12	20	42.70	36.91	100.00
2016	2	11	37	90.25	59.12	94.59
2017	2	19	45	114.10	53.81	95.56
2018	4	9	23	66.00	23.59	91.30

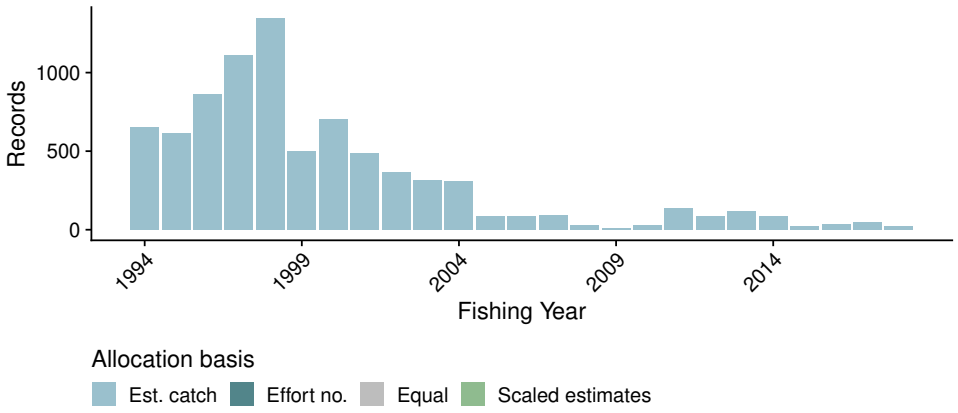

Figure D.70: Allocation basis for attributing landings to records in the SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

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

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	23.00	8075	5.90	5.90	*
+ target_species	1.00	7482	12.90	7.00	*
+ vessel_key	19.00	7258	16.00	3.10	*
+ bs(bottom_depth, 3)	3.00	7111	17.80	1.80	*
+ month	11.00	7042	18.80	1.10	*
+ stat_area	7.00	7014	19.30	0.50	
+ primary_method	1.00	6964	19.90	0.60	
+ bs(log(fishing_duration), 3)	3.00	6957	20.10	0.10	

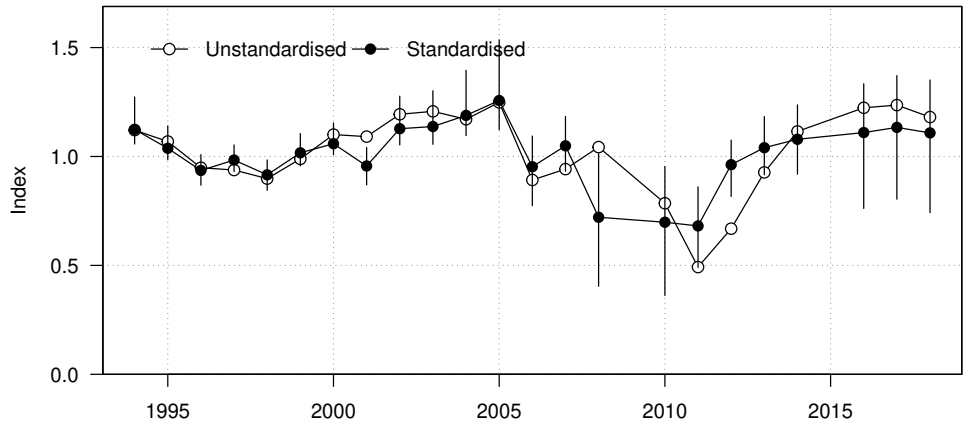

Figure D.71: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

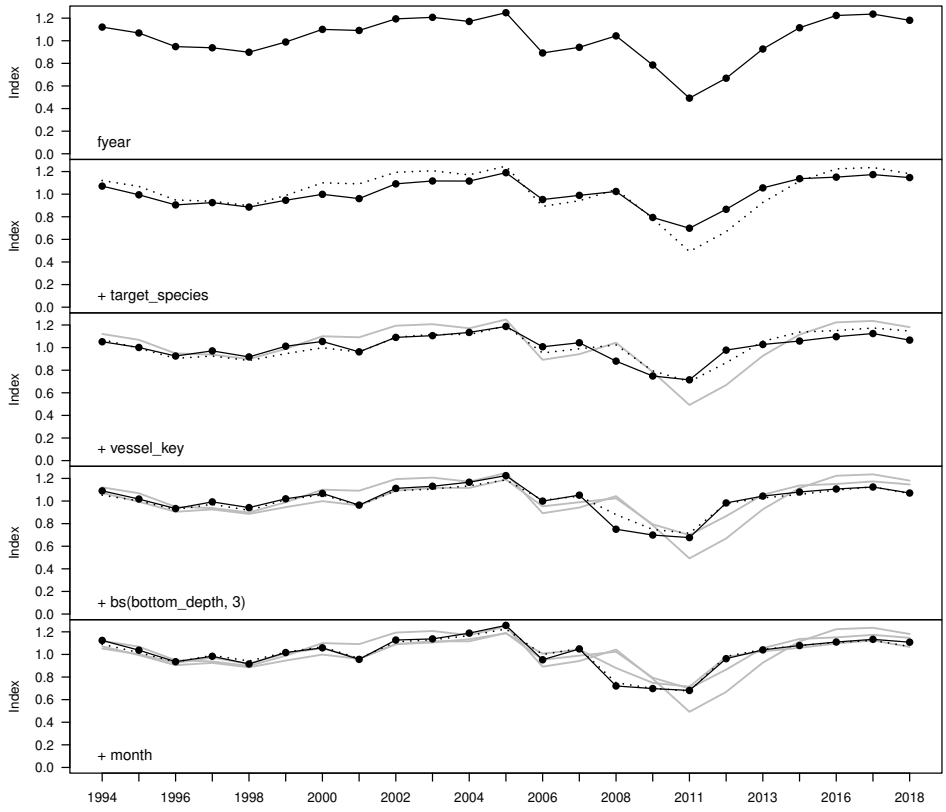

Figure D.72: Step plot for occurrence of catch in the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

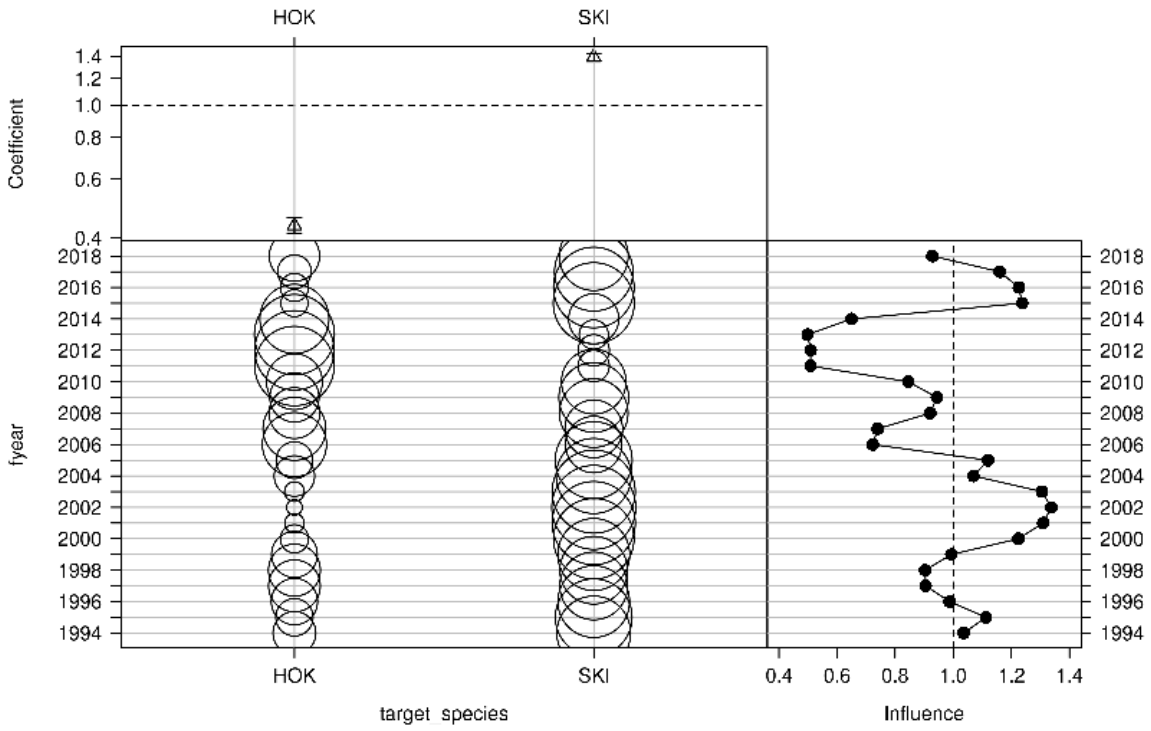

Figure D.73: CDI plot for target species for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

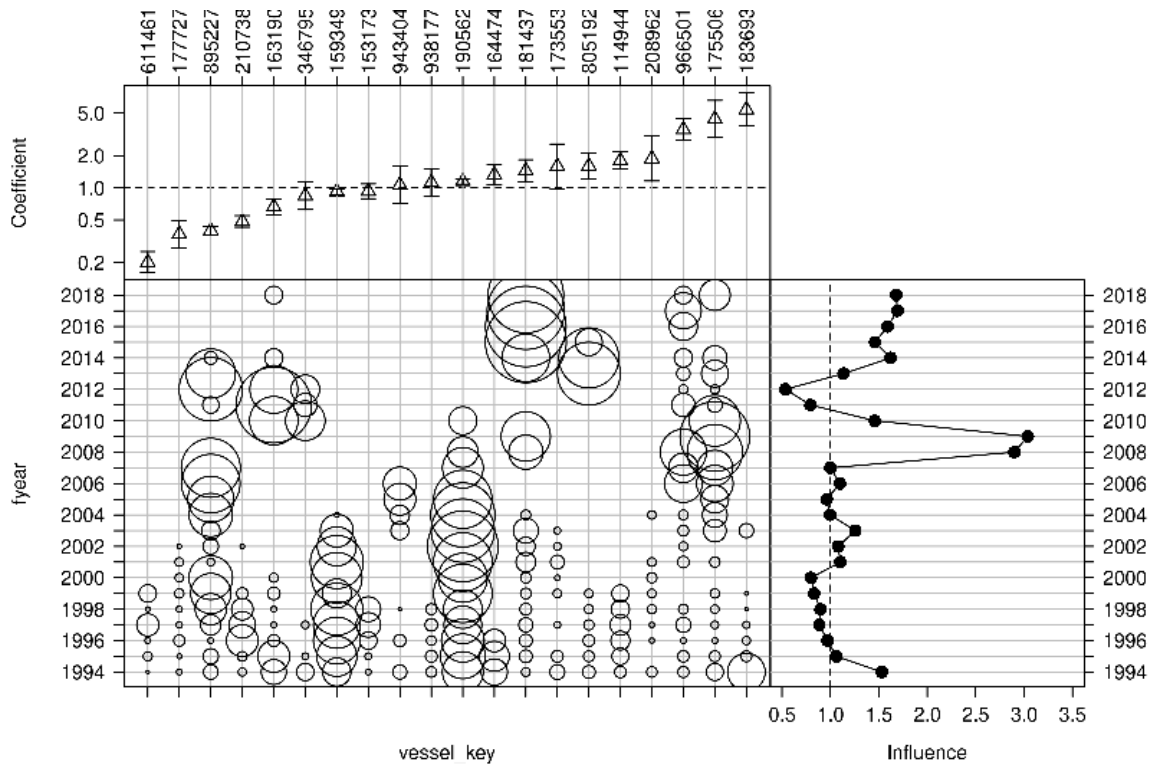

Figure D.74: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

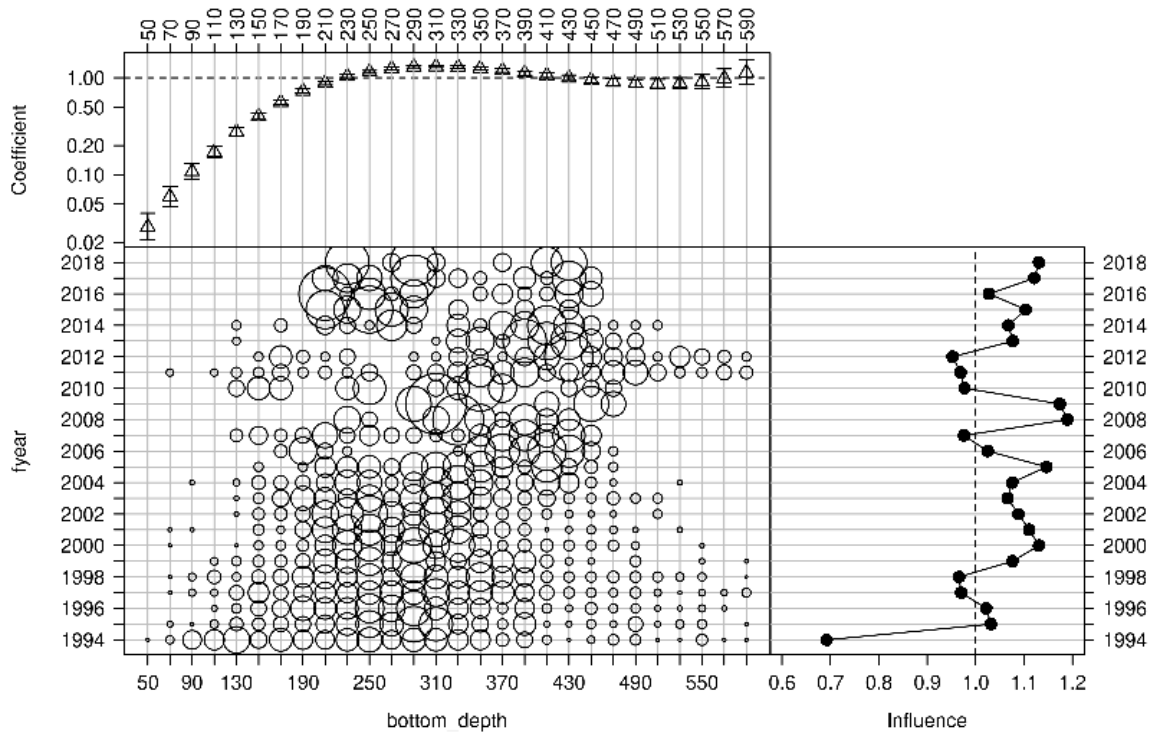

Figure D.75: CDI plot for bottom depth for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

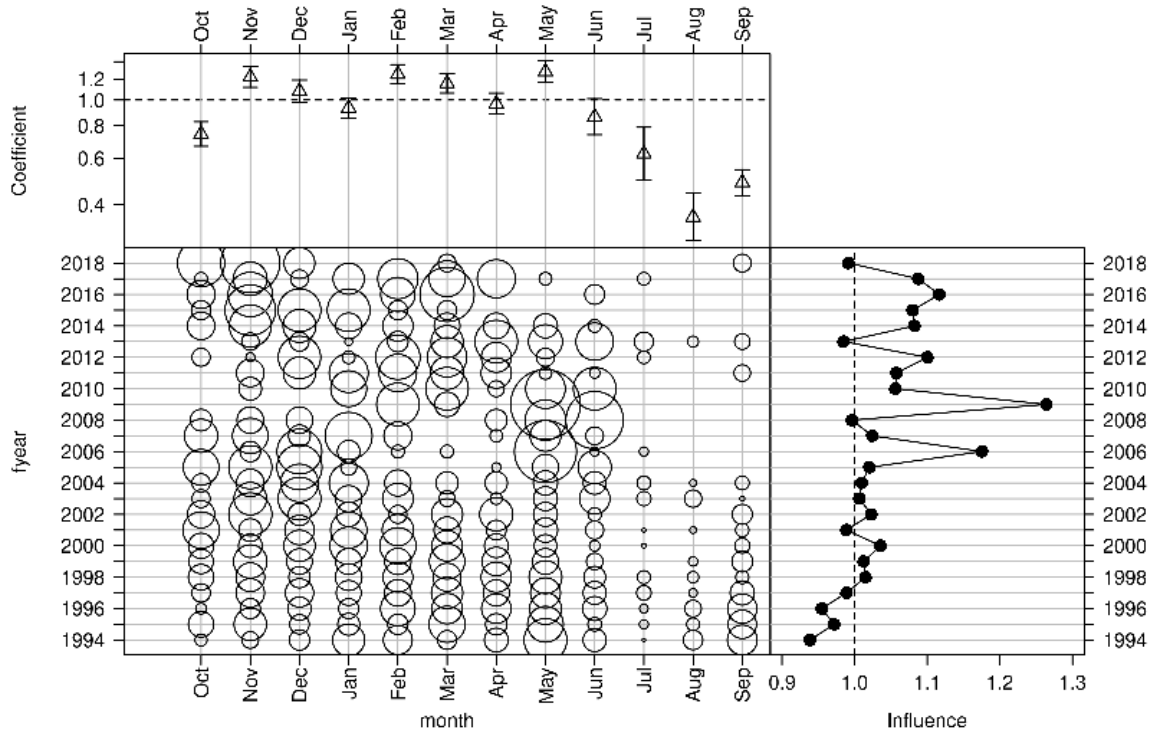

Figure D.76: CDI plot for month for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

Table D.23: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	26	94 103	3.9	3.9	*
+ vessel key	19	92 559	26.0	22.1	*
+ target species	1	92 234	30.5	4.6	*
+ month	11	92 140	32.2	1.6	*
+ bs(log(fishing duration), 3)	3	92 086	33.0	0.8	
+ stat area	7	92 056	33.6	0.6	
+ bs(bottom depth, 3)	3	92 022	34.2	0.6	
+ bs(effort height, 3)	3	91 996	34.6	0.4	
+ primary method	1	91 996	34.6	0.0	

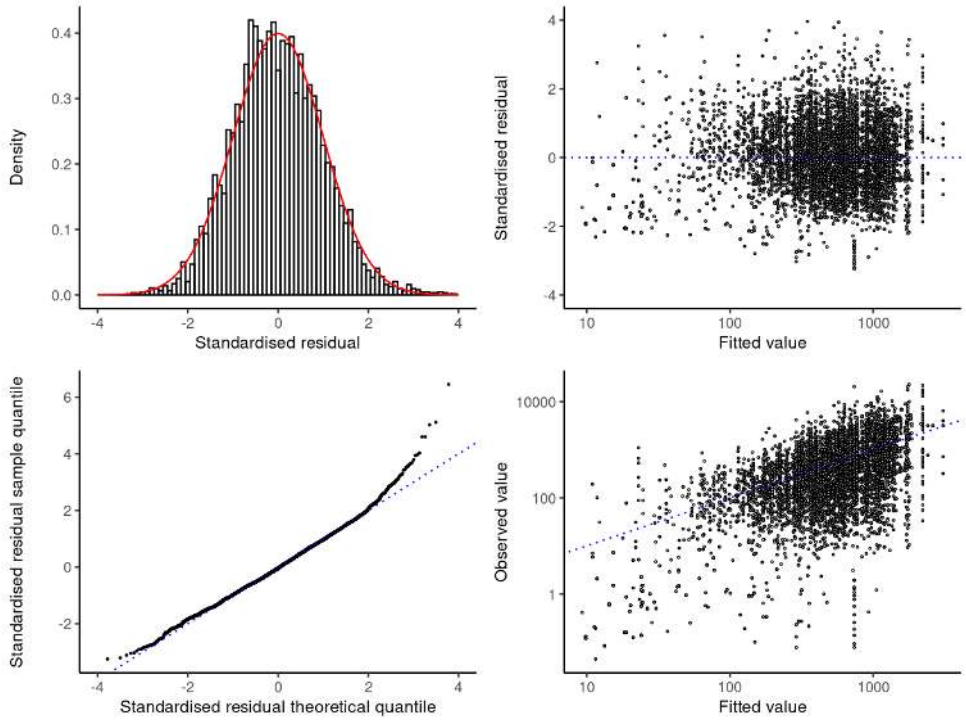

Figure D.77: Diagnostic plots for the Weibull model for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

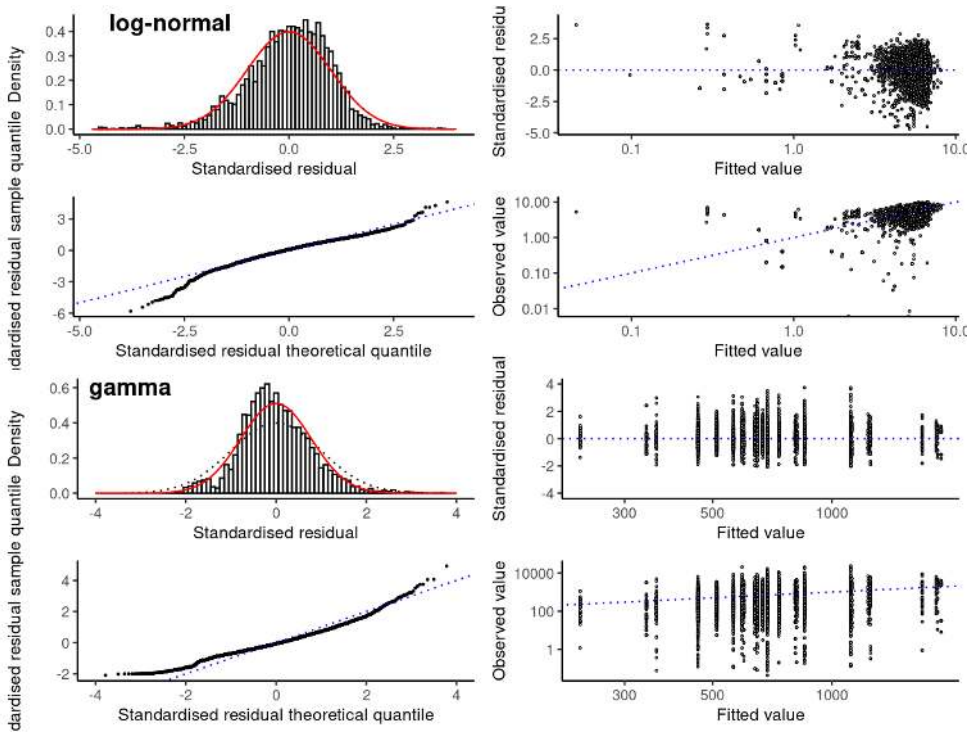

Figure D.78: Diagnostic plots for the log-normal and gamma model for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

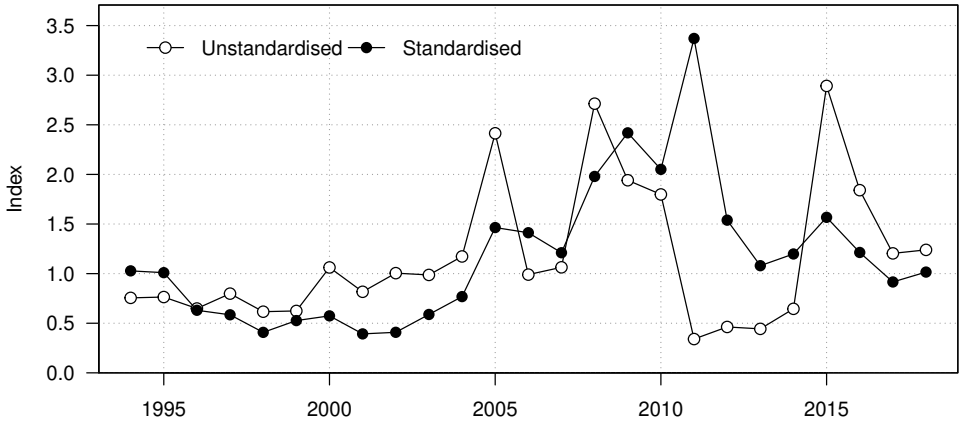

Figure D.79: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

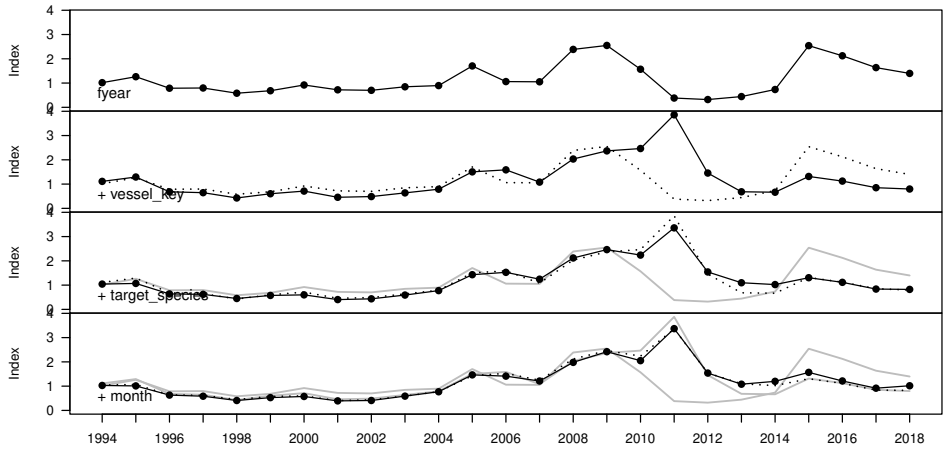

Figure D.80: Changes to the SKI1 SKI2 HOK-SKI event (1994 fleet) positive catch index as terms are successively entered into the model.

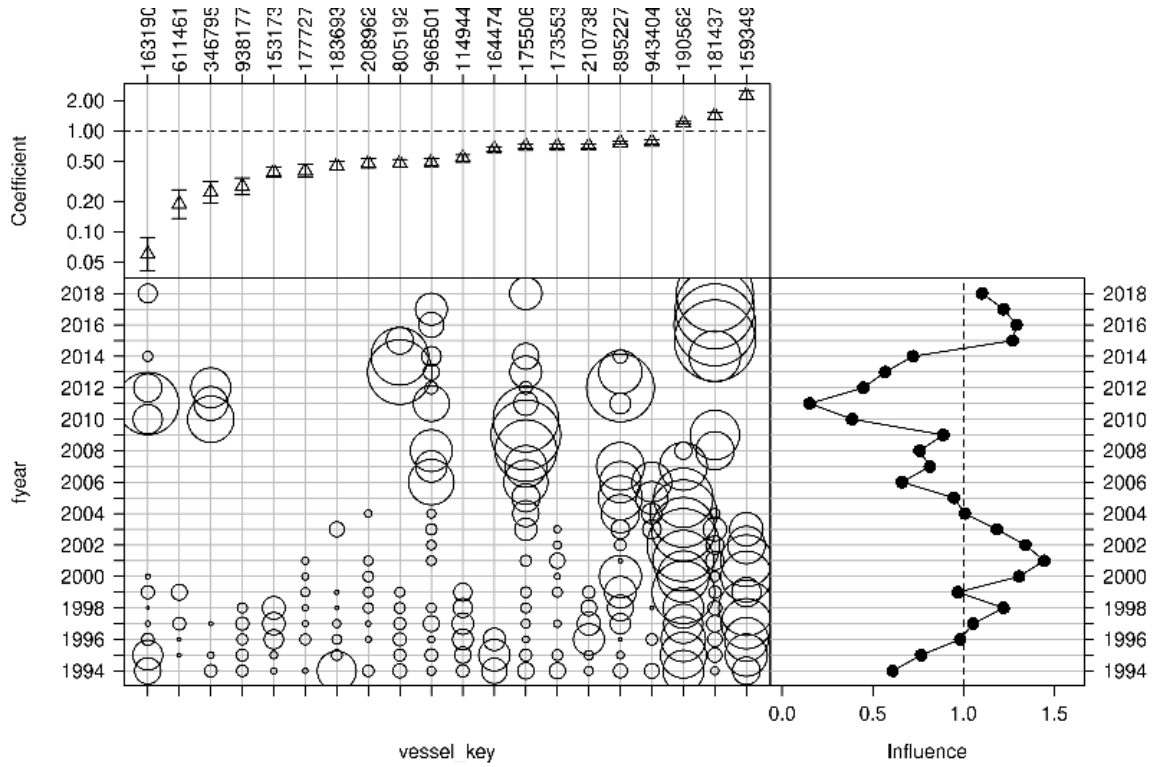

Figure D.81: CDI plot for vessel key for the positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

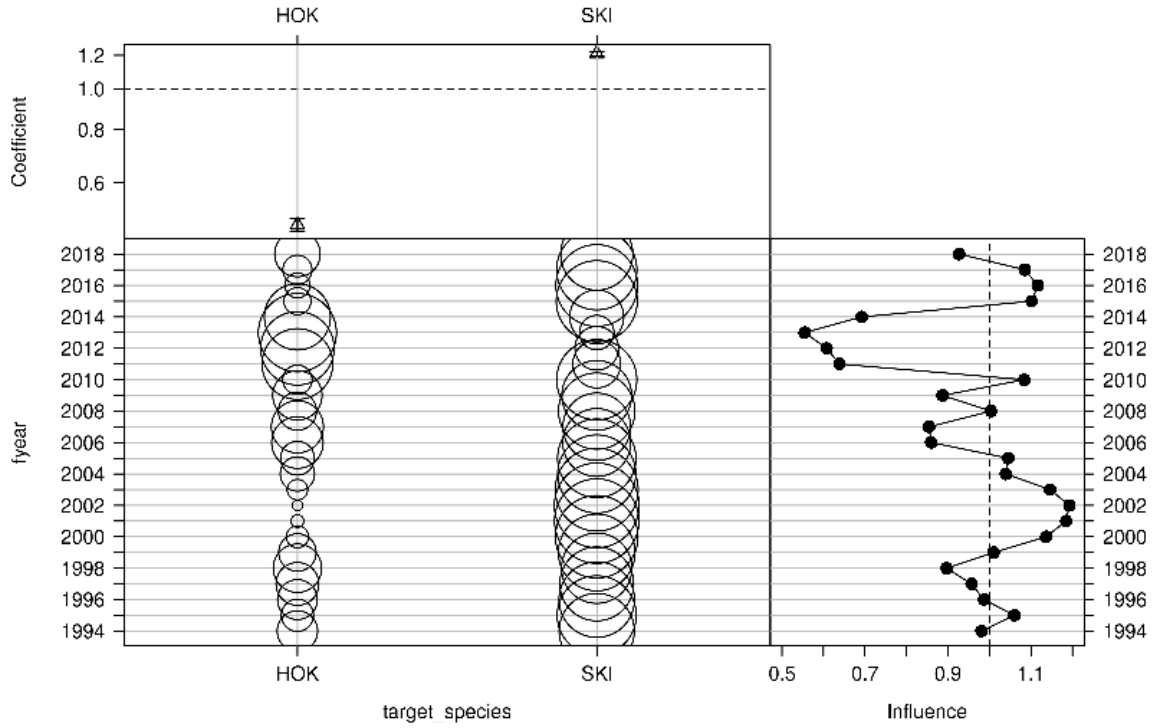

Figure D.82: CDI plot for target species for the positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

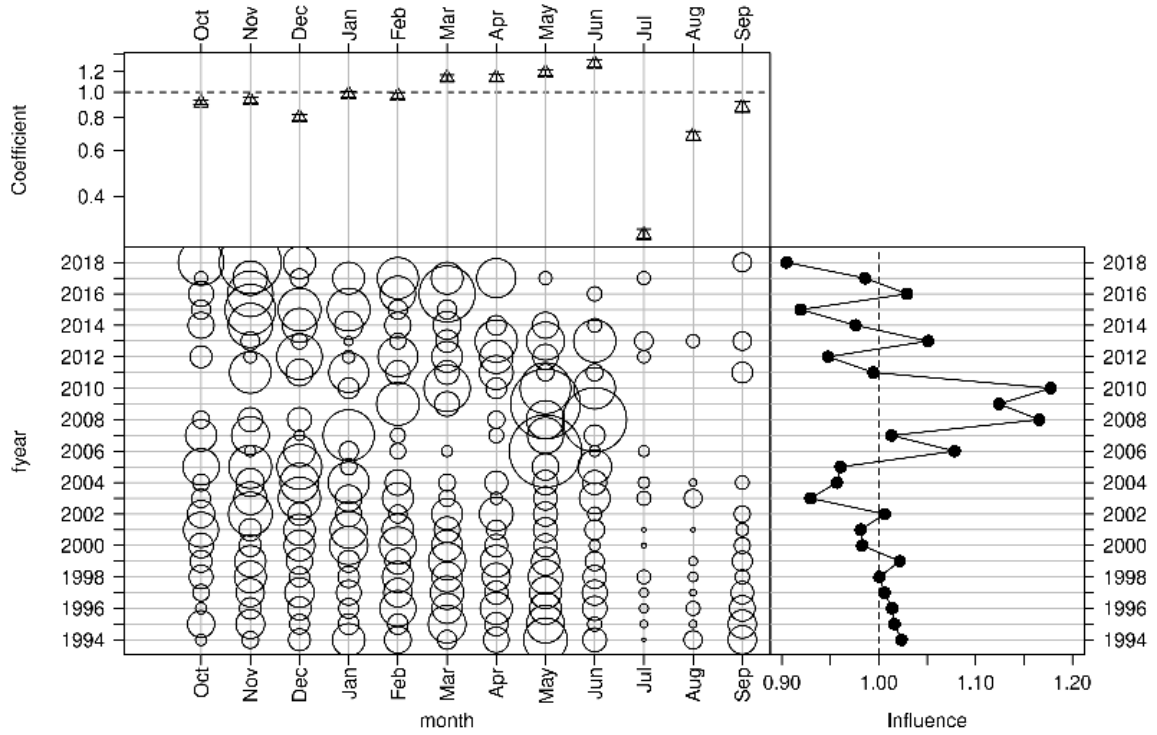

Figure D.83: CDI plot for month for the positive catch SKI1 SKI2 HOK-SKI event (1994 fleet) catch-per-unit-effort dataset.

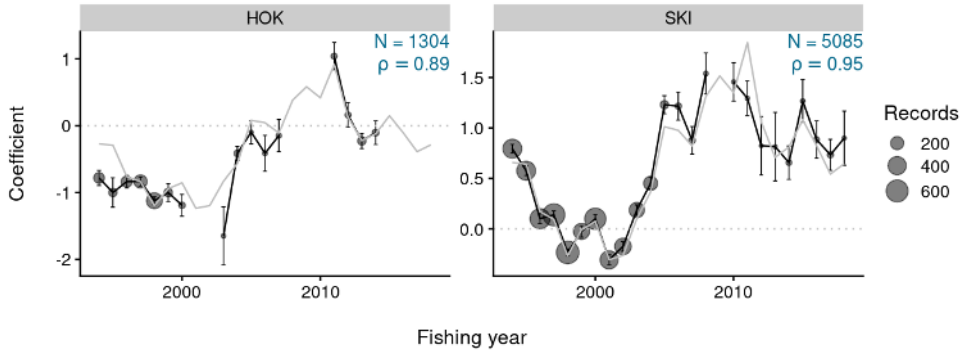

Figure D.84: Residual implied coefficients for target-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

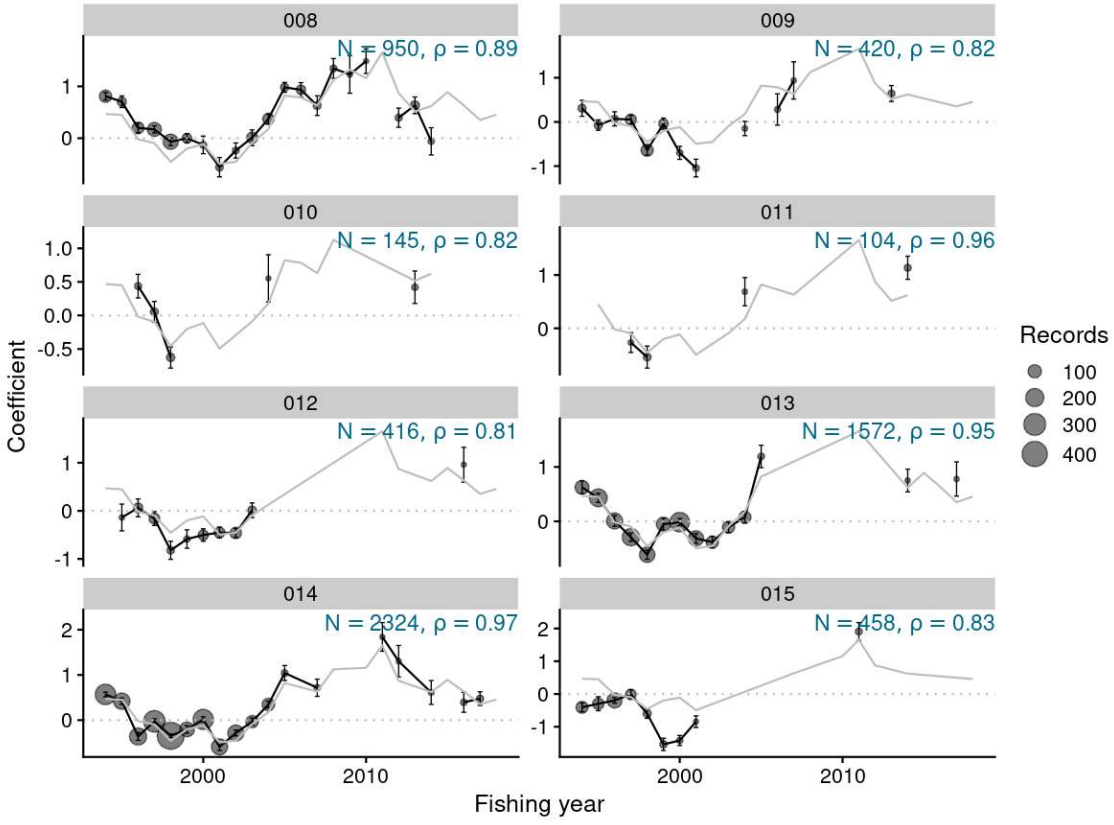

Figure D.85: Residual implied coefficients for area-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

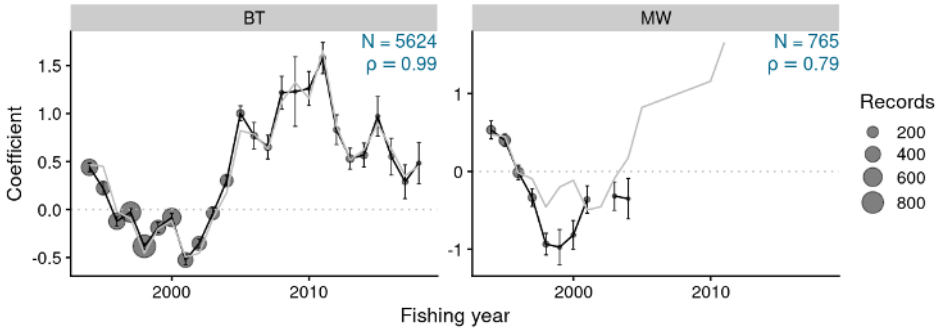

Figure D.86: Residual implied coefficients for primary method-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

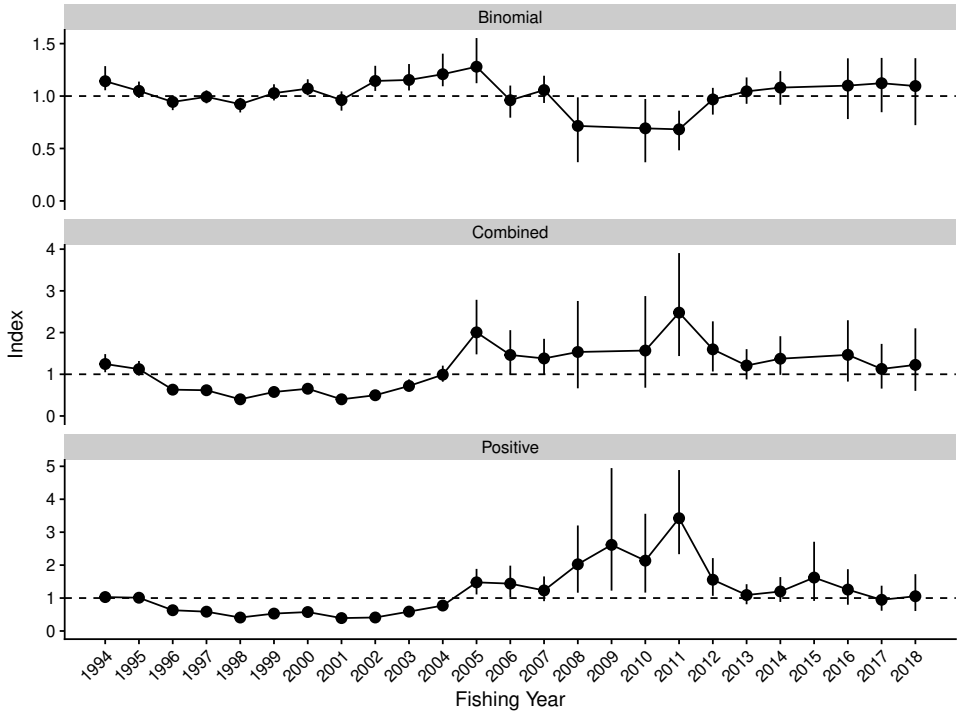

Figure D.87: Standardised indices and 95% confidence intervals for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

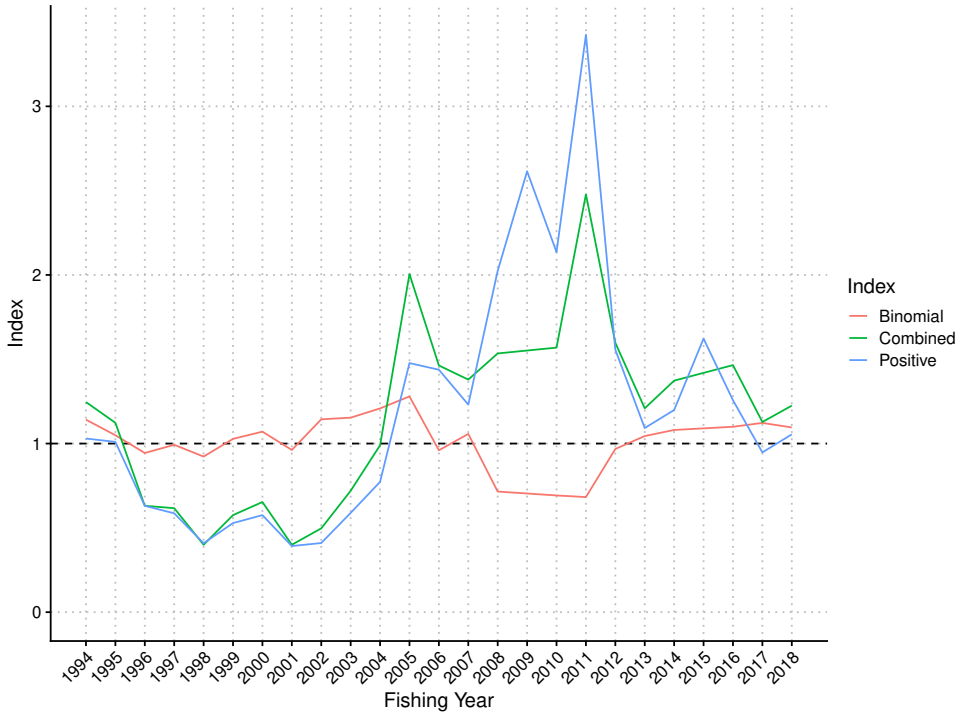

Figure D.88: Standardised indices for the SKI1 SKI2 HOK-SKI event (1994 fleet) dataset.

Table D.24: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 HOK-SKI event (1994 fleet).

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1994	1.14	1.14	0.059	1.14	1.25	1.25	0.111	1.25	1.03	1.03	0.081	1.03
1995	1.05	1.05	0.040	1.05	1.12	1.12	0.089	1.12	1.01	1.01	0.071	1.01
1996	0.94	0.94	0.036	0.94	0.63	0.63	0.047	0.63	0.63	0.63	0.043	0.63
1997	0.99	0.99	0.031	0.99	0.62	0.62	0.042	0.62	0.59	0.59	0.035	0.59
1998	0.92	0.92	0.036	0.92	0.40	0.40	0.027	0.40	0.41	0.41	0.025	0.41
1999	1.03	1.03	0.039	1.03	0.58	0.58	0.046	0.58	0.53	0.53	0.042	0.53
2000	1.07	1.07	0.039	1.07	0.65	0.65	0.047	0.65	0.58	0.58	0.038	0.58
2001	0.96	0.96	0.047	0.96	0.40	0.40	0.035	0.40	0.39	0.39	0.030	0.39
2002	1.14	1.14	0.061	1.14	0.50	0.50	0.046	0.50	0.41	0.41	0.032	0.41
2003	1.15	1.15	0.064	1.15	0.72	0.72	0.072	0.72	0.59	0.59	0.050	0.59
2004	1.21	1.21	0.079	1.21	0.99	0.99	0.098	0.99	0.77	0.77	0.063	0.77
2005	1.28	1.28	0.110	1.28	2.00	2.00	0.334	2.00	1.48	1.48	0.198	1.48
2006	0.96	0.96	0.078	0.96	1.46	1.46	0.271	1.46	1.44	1.44	0.243	1.44
2007	1.06	1.06	0.066	1.06	1.38	1.38	0.219	1.38	1.23	1.23	0.192	1.23
2008	0.72	0.72	0.158	0.72	1.53	1.53	0.534	1.53	2.02	2.02	0.521	2.02
2010	0.69	0.69	0.154	0.69	1.57	1.57	0.561	1.57	2.14	2.14	0.611	2.14
2011	0.68	0.68	0.096	0.68	2.48	2.48	0.630	2.48	3.42	3.42	0.652	3.42
2012	0.97	0.97	0.065	0.97	1.60	1.60	0.307	1.60	1.56	1.56	0.292	1.56
2013	1.04	1.04	0.064	1.04	1.21	1.21	0.185	1.21	1.09	1.09	0.155	1.09
2014	1.08	1.08	0.082	1.08	1.37	1.37	0.236	1.37	1.20	1.20	0.192	1.20
2016	1.10	1.10	0.148	1.10	1.47	1.47	0.375	1.47	1.26	1.26	0.275	1.26
2017	1.12	1.12	0.132	1.12	1.13	1.13	0.273	1.13	0.95	0.95	0.194	0.95
2018	1.10	1.10	0.163	1.10	1.22	1.22	0.383	1.22	1.05	1.05	0.285	1.05
2009									2.61	2.61	0.949	2.61
2015									1.62	1.62	0.458	1.62

D.5 SKI1 SKI2 HOK-SKI event (2021 fleet)

Table D.25: Definition for the dataset, core fleet criteria and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the SKI1 SKI2 HOK-SKI event (2021 fleet) CPUE series.

Series	SKI1 SKI2 HOK-SKI event (2021 fleet)
QMS stock	SKI1, SKI2
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW
Target species	SKI, HOK
Areas	008, 009, 010, 011, 012, 013, 014, 015
Period	1994-10-01, 2022-09-30
Resolution	Fishing event
Core fleet years	3
Core fleet trips	3
Default model	allockg_top5 ~ fyear + vessel_key + target_species + primary_method + bs(log(fishing_duration), 3) + stat_area + month + bs(bottom_depth, 3) + bs(effort_height, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

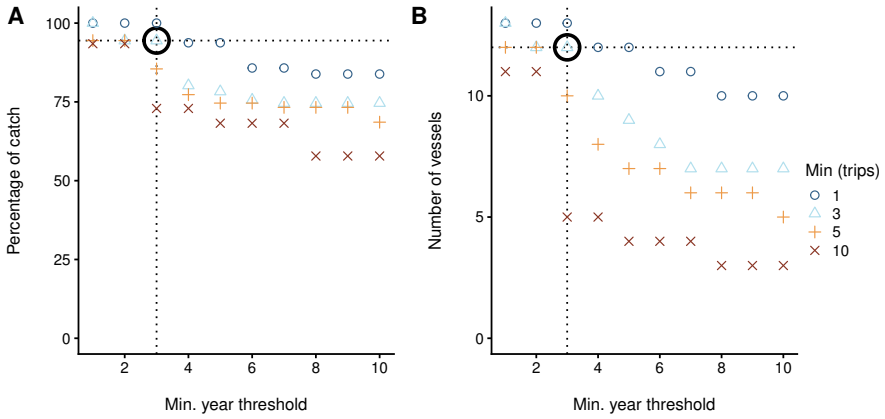

Figure D.89: Percentage of catch and number of vessels for different core vessel selection criteria for the SKI1 SKI2 HOK-SKI event (2021 fleet) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

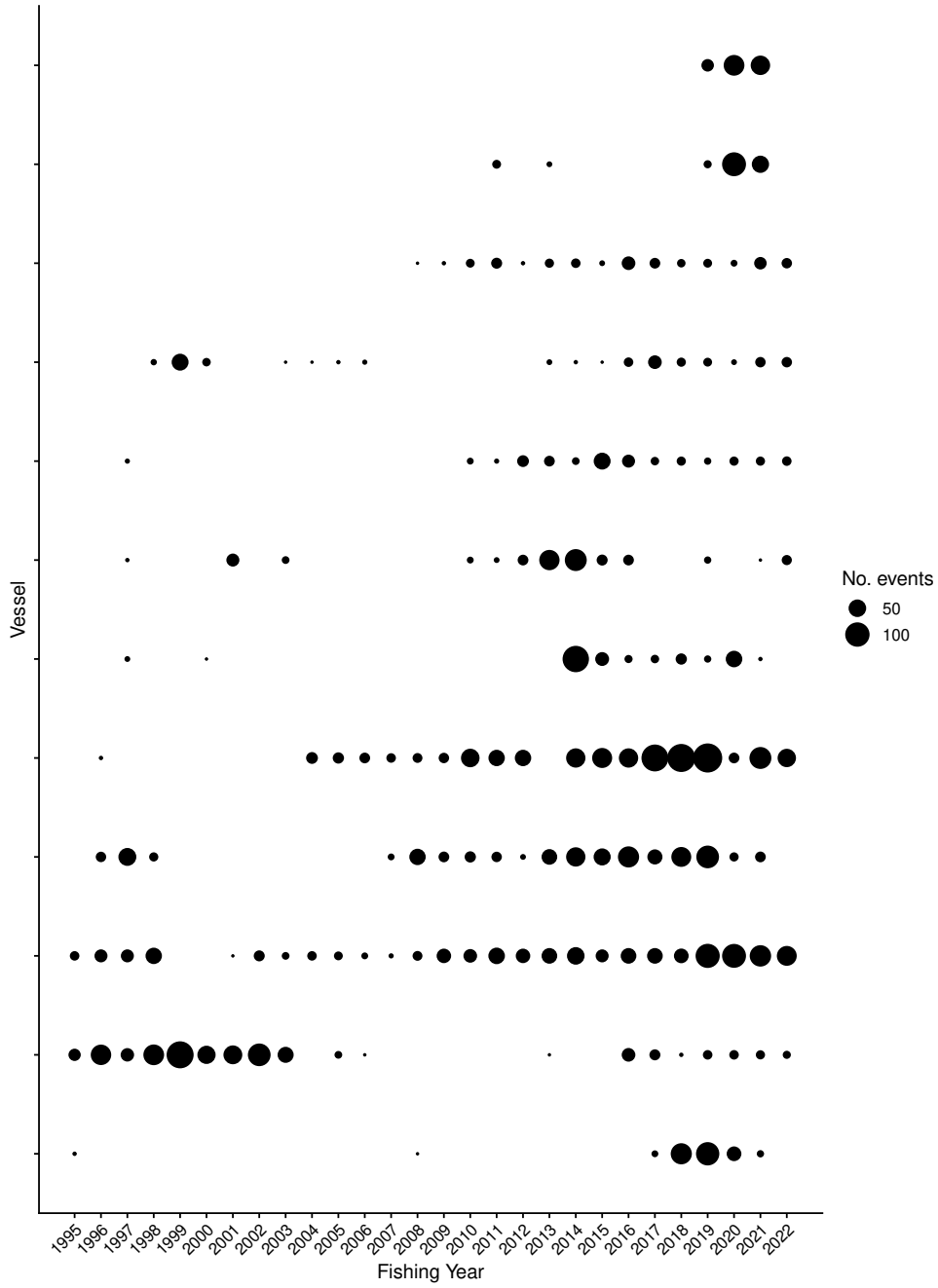

Figure D.90: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.26: Summary of SKI1 SKI2 HOK-SKI event (2021 fleet) total catch (t) subset by fishing year after the data was groomed by various filters. First row (Ungroomed data) shows catch before filters were applied. Subsequent rows below total catch display the percent of catch, and the total number of records.

Filter	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Ungroomed data	650	645	740	535	282	456	278	205	295	332	283	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)	(Records: 367)
Fishing duration is not NA	650	645	740	535	282	456	278	205	295	332	283	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 918)	(Records: 2112)	(Records: 2834)	(Records: 2612)	(Records: 1372)	(Records: 1348)	(Records: 1229)	(Records: 968)	(Records: 992)	(Records: 1046)	(Records: 626)	(Records: 367)
Positive fishing duration	650	645	740	535	282	456	278	205	295	332	283	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 917)	(Records: 2108)	(Records: 2823)	(Records: 2609)	(Records: 1372)	(Records: 1347)	(Records: 1228)	(Records: 968)	(Records: 991)	(Records: 1045)	(Records: 626)	(Records: 367)
Bottom depth >=50	650	635	731	502	280	455	278	205	295	331	282	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 909)	(Records: 2043)	(Records: 2772)	(Records: 2446)	(Records: 1361)	(Records: 1343)	(Records: 1225)	(Records: 968)	(Records: 987)	(Records: 1036)	(Records: 622)	(Records: 367)
Bottom depth <=600	650	634	727	502	280	454	278	205	295	331	282	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 94)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 901)	(Records: 2023)	(Records: 2654)	(Records: 2383)	(Records: 1340)	(Records: 1308)	(Records: 1182)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)	(Records: 365)
Effort height <100	650	630	711	498	280	454	277	205	295	331	282	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 901)	(Records: 2000)	(Records: 2594)	(Records: 2357)	(Records: 1336)	(Records: 1297)	(Records: 1176)	(Records: 934)	(Records: 979)	(Records: 1030)	(Records: 616)	(Records: 365)
Midwater effort depth <=10 m from bottom	641	630	709	498	280	451	277	205	295	331	281	182
	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 93)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)	(Percent: 100)
	(Records: 881)	(Records: 1989)	(Records: 2570)	(Records: 2279)	(Records: 1305)	(Records: 1208)	(Records: 1090)	(Records: 868)	(Records: 892)	(Records: 957)	(Records: 572)	(Records: 353)
Fished in 2021	8.3	21	24	20	35	3.2	19	9.3	7.3	19	21	14
	(Percent: 1)	(Percent: 3)	(Percent: 3)	(Percent: 4)	(Percent: 13)	(Percent: 0.7)	(Percent: 7)	(Percent: 5)	(Percent: 2)	(Percent: 6)	(Percent: 7)	(Percent: 8)
	(Records: 38)	(Records: 113)	(Records: 132)	(Records: 142)	(Records: 170)	(Records: 65)	(Records: 85)	(Records: 106)	(Records: 58)	(Records: 46)	(Records: 40)	(Records: 28)
Core fleet selection	8.3	21	17	19	35	3.2	19	8.9	7.3	15	21	14
	(Percent: 1)	(Percent: 3)	(Percent: 2)	(Percent: 4)	(Percent: 13)	(Percent: 0.7)	(Percent: 7)	(Percent: 4)	(Percent: 2)	(Percent: 4)	(Percent: 7)	(Percent: 8)
	(Records: 38)	(Records: 113)	(Records: 115)	(Records: 131)	(Records: 170)	(Records: 65)	(Records: 85)	(Records: 104)	(Records: 58)	(Records: 35)	(Records: 40)	(Records: 27)

Filter	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ungroomed data	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)	181 (Percent: 100) (Records: 493)
Fishing duration is not NA	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 420)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)	181 (Percent: 100) (Records: 493)
Positive fishing duration	237 (Percent: 100) (Records: 369)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)	181 (Percent: 100) (Records: 492)
Bottom depth >=50	236 (Percent: 100) (Records: 367)	146 (Percent: 100) (Records: 287)	180 (Percent: 100) (Records: 316)	240 (Percent: 100) (Records: 482)	222 (Percent: 100) (Records: 645)	153 (Percent: 100) (Records: 434)	131 (Percent: 100) (Records: 531)	247 (Percent: 100) (Records: 708)	86 (Percent: 100) (Records: 419)	251 (Percent: 100) (Records: 395)	212 (Percent: 100) (Records: 383)	181 (Percent: 100) (Records: 492)
Bottom depth <=600	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)	180 (Percent: 100) (Records: 483)
Effort height <100	236 (Percent: 100) (Records: 361)	146 (Percent: 100) (Records: 284)	180 (Percent: 100) (Records: 314)	239 (Percent: 100) (Records: 474)	222 (Percent: 100) (Records: 637)	153 (Percent: 100) (Records: 413)	131 (Percent: 100) (Records: 518)	247 (Percent: 100) (Records: 702)	86 (Percent: 100) (Records: 413)	251 (Percent: 100) (Records: 391)	212 (Percent: 100) (Records: 382)	180 (Percent: 100) (Records: 483)
Midwater effort depth <=10 m from bottom	236 (Percent: 100) (Records: 349)	145 (Percent: 100) (Records: 259)	179 (Percent: 100) (Records: 298)	239 (Percent: 100) (Records: 468)	221 (Percent: 100) (Records: 571)	152 (Percent: 100) (Records: 388)	130 (Percent: 100) (Records: 506)	247 (Percent: 100) (Records: 693)	86 (Percent: 100) (Records: 383)	251 (Percent: 100) (Records: 385)	192 (Percent: 91) (Records: 361)	160 (Percent: 89) (Records: 413)
Fished in 2021	14 (Percent: 6) (Records: 22)	49 (Percent: 34) (Records: 73)	67 (Percent: 37) (Records: 68)	131 (Percent: 55) (Records: 127)	94 (Percent: 42) (Records: 145)	98 (Percent: 64) (Records: 129)	47 (Percent: 36) (Records: 186)	97 (Percent: 39) (Records: 393)	29 (Percent: 33) (Records: 238)	139 (Percent: 55) (Records: 297)	120 (Percent: 57) (Records: 288)	128 (Percent: 71) (Records: 370)
Core fleet selection	14 (Percent: 6) (Records: 22)	49 (Percent: 34) (Records: 73)	67 (Percent: 37) (Records: 68)	131 (Percent: 55) (Records: 127)	82 (Percent: 37) (Records: 139)	51 (Percent: 33) (Records: 120)	43 (Percent: 33) (Records: 184)	97 (Percent: 39) (Records: 393)	29 (Percent: 33) (Records: 238)	139 (Percent: 55) (Records: 297)	120 (Percent: 57) (Records: 288)	117 (Percent: 65) (Records: 362)

Filter	2019	2020	2021	2022
Ungroomed data	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Fishing duration is not NA	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Positive fishing duration	295 (Percent: 100) (Records: 785)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 389)	178 (Percent: 100) (Records: 369)
Bottom depth >=50	295 (Percent: 100) (Records: 777)	267 (Percent: 100) (Records: 508)	169 (Percent: 100) (Records: 388)	178 (Percent: 100) (Records: 368)
Bottom depth <=600	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Effort height <100	295 (Percent: 100) (Records: 771)	266 (Percent: 100) (Records: 489)	169 (Percent: 100) (Records: 386)	177 (Percent: 100) (Records: 360)
Midwater effort depth <=10 m from bottom	158 (Percent: 54) (Records: 570)	246 (Percent: 92) (Records: 433)	156 (Percent: 92) (Records: 358)	69 (Percent: 39) (Records: 205)
Fished in 2021	153 (Percent: 52) (Records: 513)	243 (Percent: 91) (Records: 410)	156 (Percent: 92) (Records: 358)	66 (Percent: 37) (Records: 189)
Core fleet selection	144 (Percent: 49) (Records: 509)	237 (Percent: 89) (Records: 405)	154 (Percent: 91) (Records: 357)	66 (Percent: 37) (Records: 189)

Table D.27: Summary of the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset after core fleet selection. Records represent a row in the dataset, and records caught represents the percentage of event with gemfish catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1995	3	13	38	147.12	8.26	55.26
1996	4	28	113	529.13	20.74	82.30
1997	6	39	115	573.53	17.41	63.48
1998	4	37	131	661.32	19.34	69.47
1999	2	33	170	689.80	35.32	65.88
2000	3	11	65	249.50	3.17	47.69
2001	3	20	85	301.78	19.18	64.71
2002	2	30	104	448.17	8.91	59.62
2003	4	11	58	222.82	7.33	86.21
2004	3	16	35	219.50	14.79	94.29
2005	4	18	40	193.83	21.04	85.00
2006	4	17	27	102.50	13.96	85.19
2007	3	10	22	108.42	14.06	81.82
2008	5	25	73	384.35	49.25	78.08
2009	4	25	68	361.18	67.40	82.35
2010	6	37	127	580.60	131.12	85.04
2011	7	43	139	666.50	81.53	87.77
2012	6	37	120	468.48	51.05	71.67
2013	8	48	184	648.72	43.35	54.35
2014	8	82	393	1 230.72	97.17	66.92
2015	8	68	238	808.53	28.60	54.62
2016	9	101	297	1 343.23	138.54	71.04
2017	9	94	288	1 402.87	120.25	67.36
2018	9	117	362	1 819.85	116.78	79.01
2019	12	131	509	2 471.58	143.70	66.40
2020	11	141	405	1 886.17	236.84	92.10
2021	12	142	357	1 721.65	154.37	90.48
2022	7	74	189	847.30	66.32	88.36

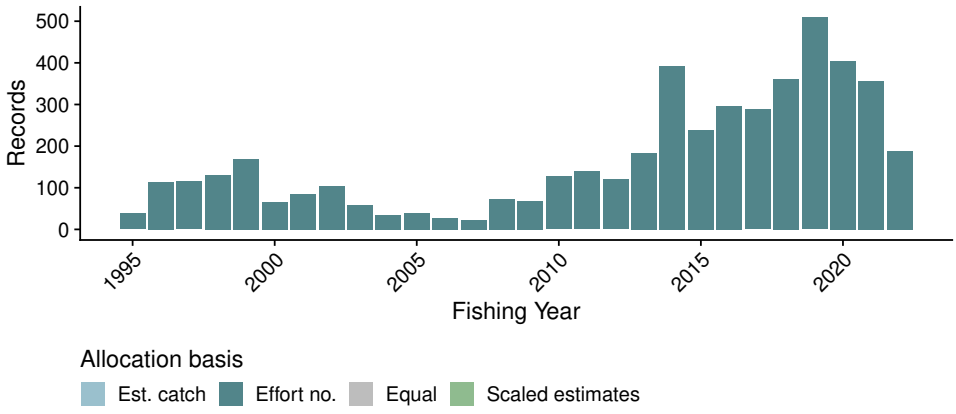

Figure D.91: Allocation basis for attributing landings to records in the SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.28: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	26.00	5 126	7.10	7.10	*
+ target_species	1.00	4 676	15.40	8.30	*
+ vessel_key	11.00	4 422	20.50	5.10	*
+ month	11.00	4 368	21.90	1.40	*
+ bs(log(fishing_duration), 3)	3.00	4 329	22.70	0.80	
+ stat_area	7.00	4 304	23.40	0.70	
+ bs(effort_height, 3)	3.00	4 299	23.60	0.20	

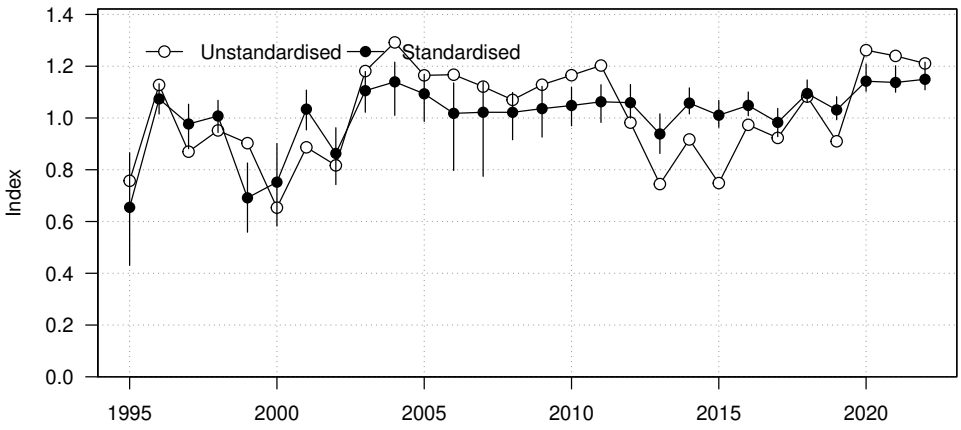

Figure D.92: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

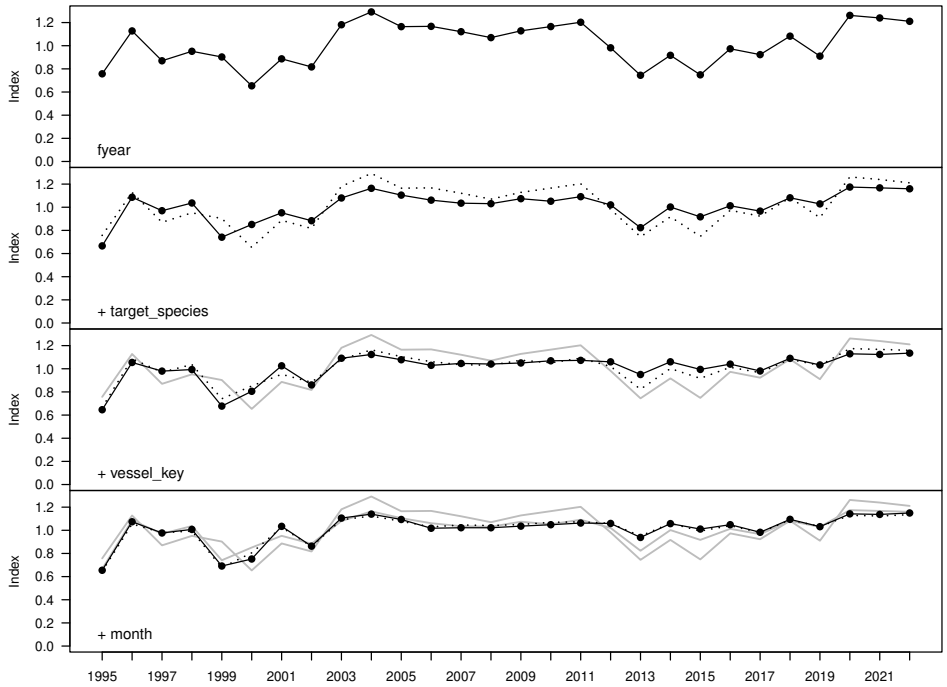

Figure D.93: Step plot for occurrence of catch in the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

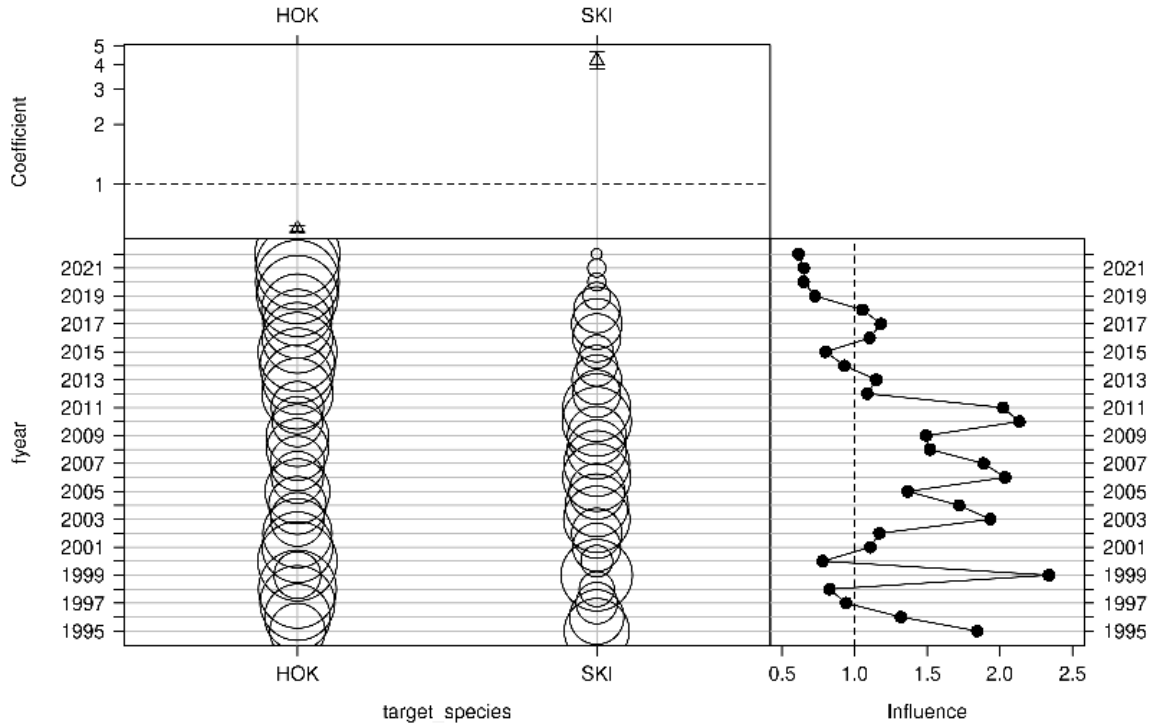

Figure D.94: CDI plot for target species for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

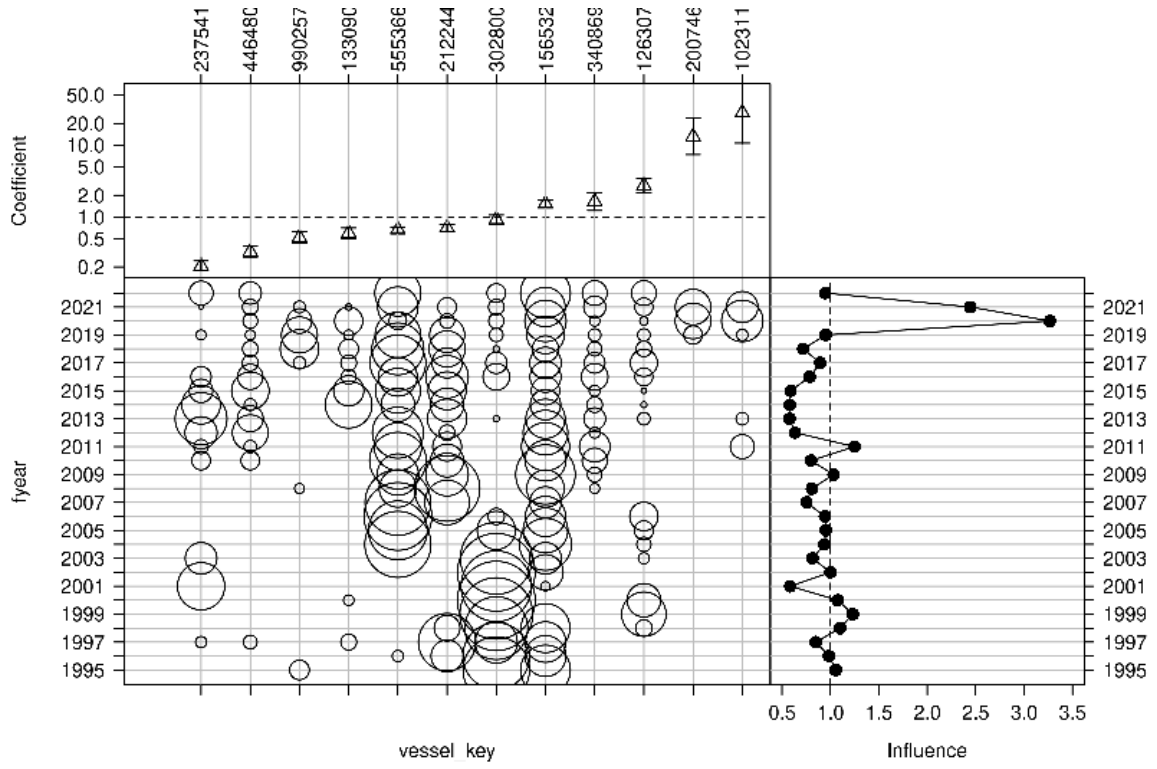

Figure D.95: CDI plot for vessel key for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

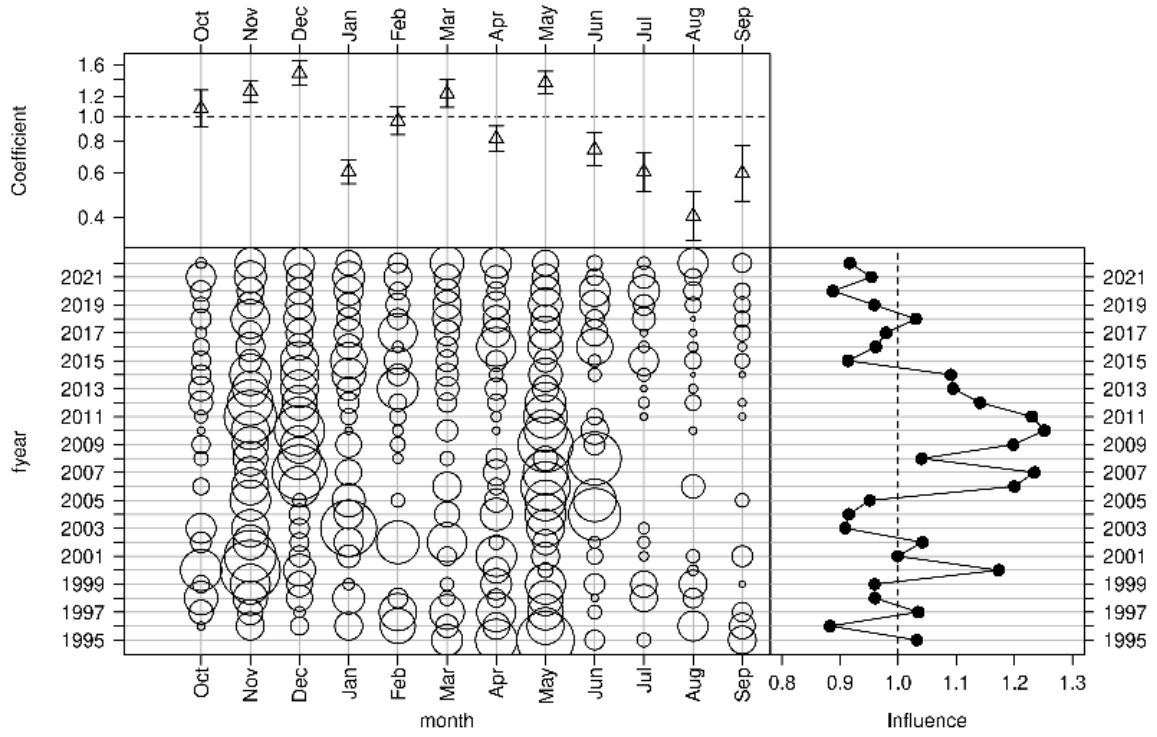

Figure D.96: CDI plot for month for the occurrence of positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

Table D.29: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	29	48 979	9.0	9.0	*
+ target species	1	48 376	24.5	15.5	*
+ bs(log(fishing duration), 3)	3	48 005	34.1	9.6	*
+ vessel key	11	47 732	41.7	7.6	*
+ stat area	7	47 518	47.5	5.8	*
+ month	11	47 355	52.2	4.7	*
+ bs(bottom depth, 3)	3	47 245	55.2	3.0	*
+ bs(effort height, 3)	3	47 234	55.6	0.4	
+ primary method	1	47 232	55.7	0.1	

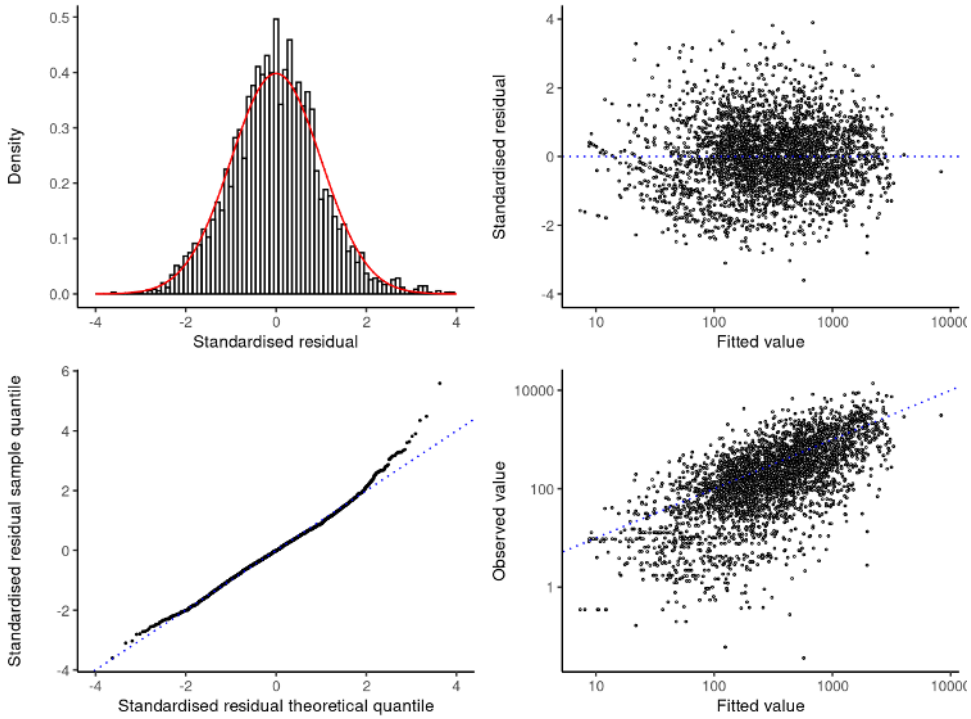

Figure D.97: Diagnostic plots for the Weibull model for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

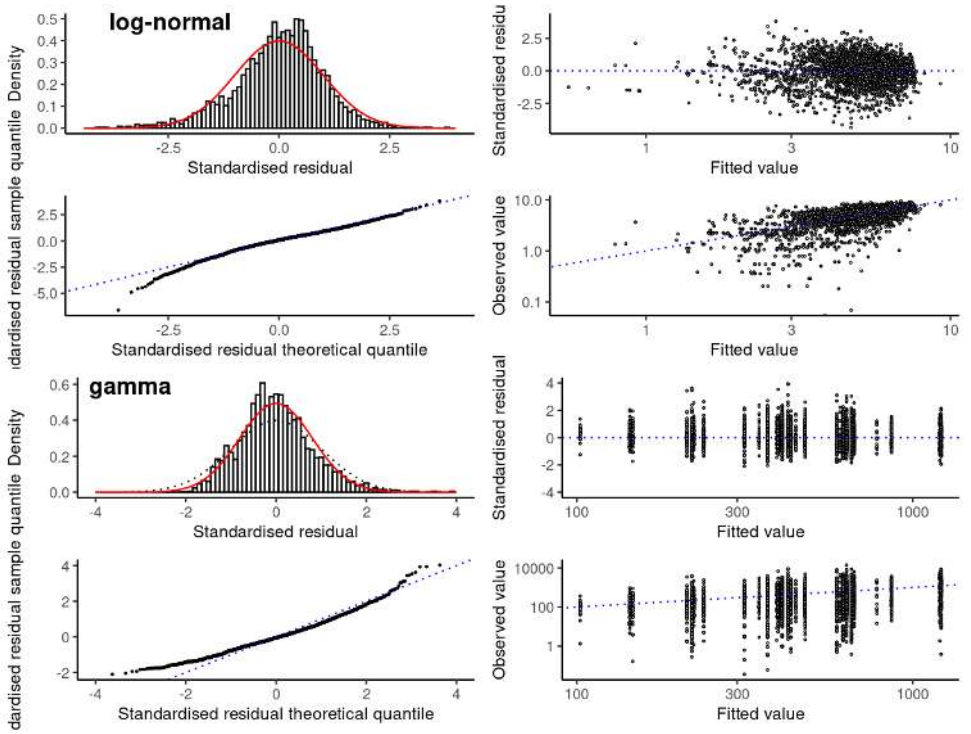

Figure D.98: Diagnostic plots for the log-normal and gamma model for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

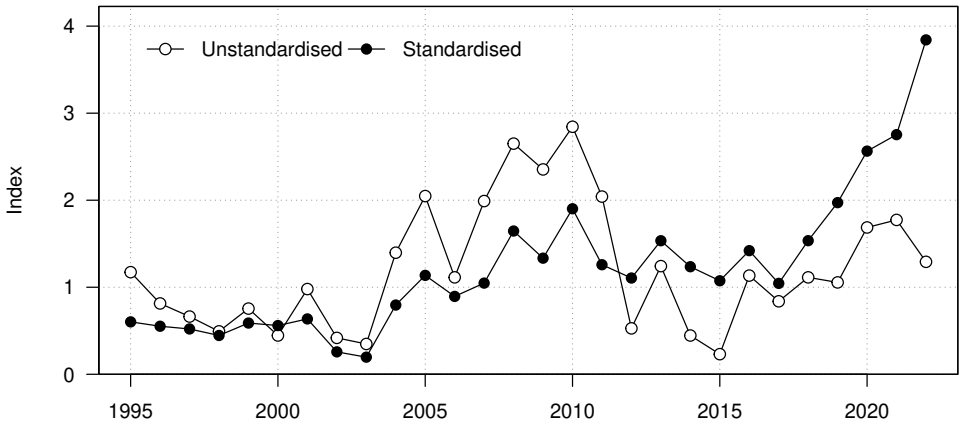

Figure D.99: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

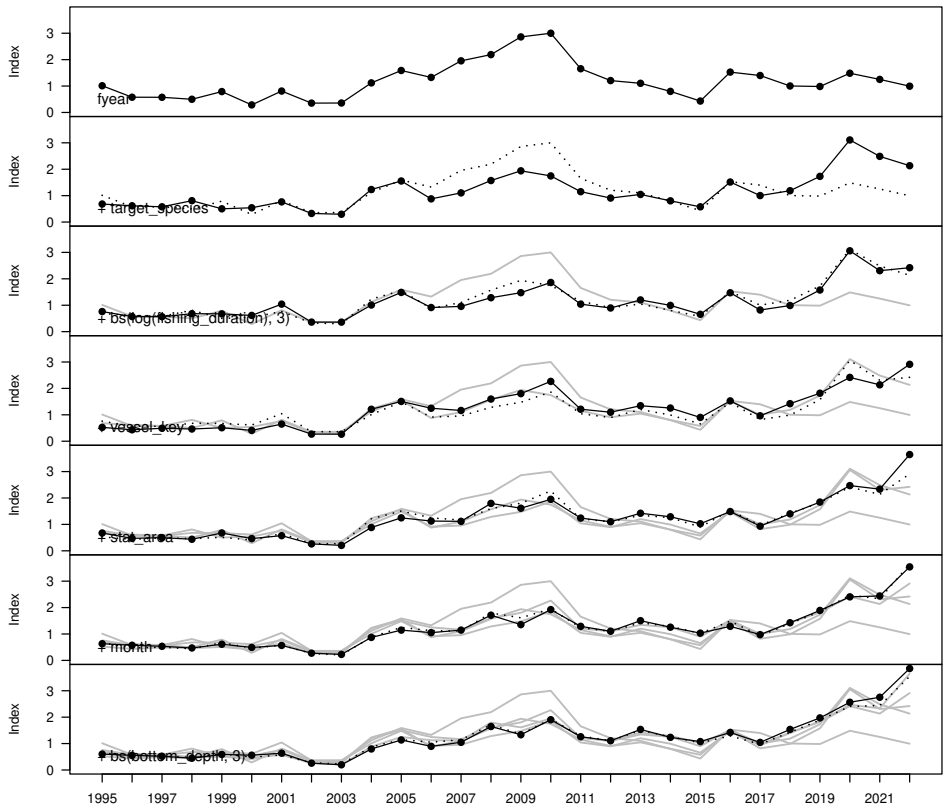

Figure D.100: Changes to the SKI1 SKI2 HOK-SKI event (2021 fleet) positive catch index as terms are successively entered into the model.

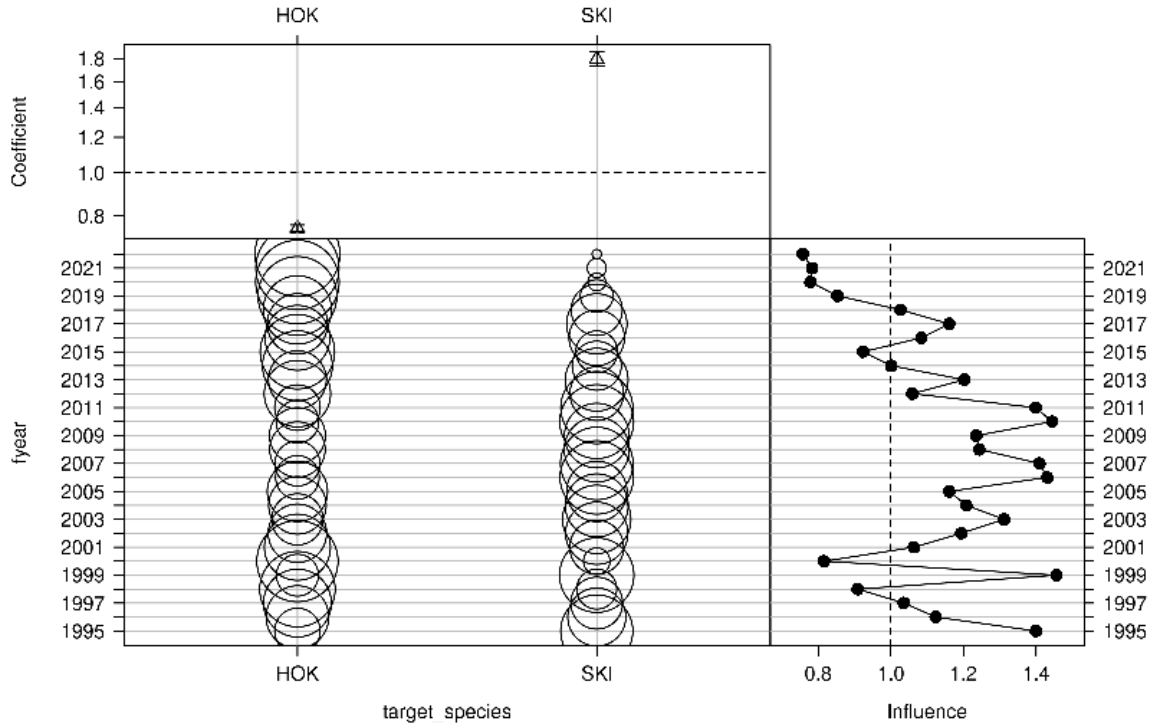

Figure D.101: CDI plot for target species for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

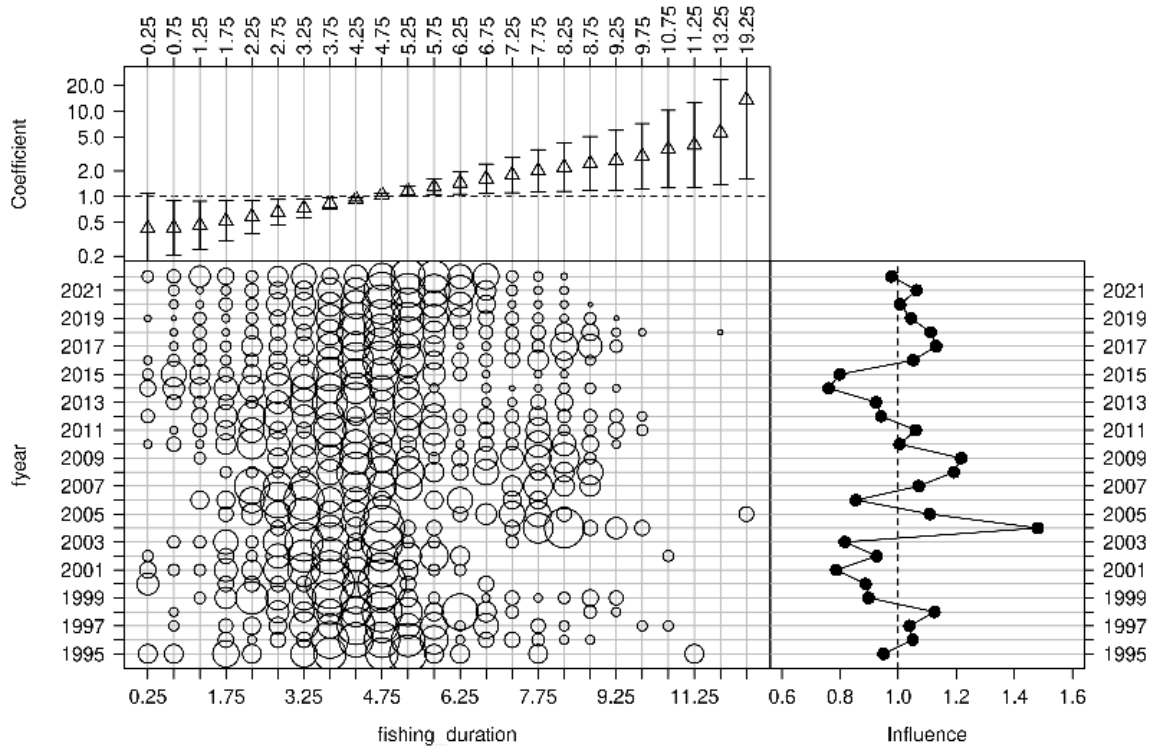

Figure D.102: CDI plot for log fishing duration for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

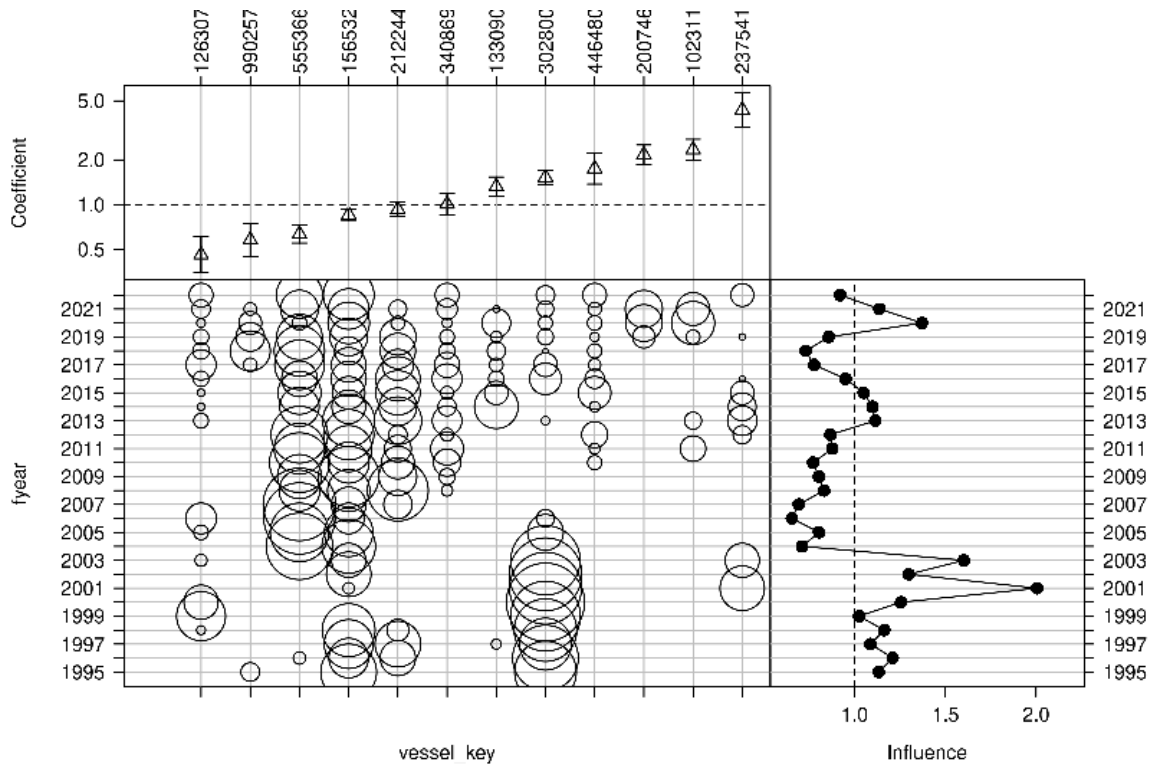

Figure D.103: CDI plot for vessel key for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

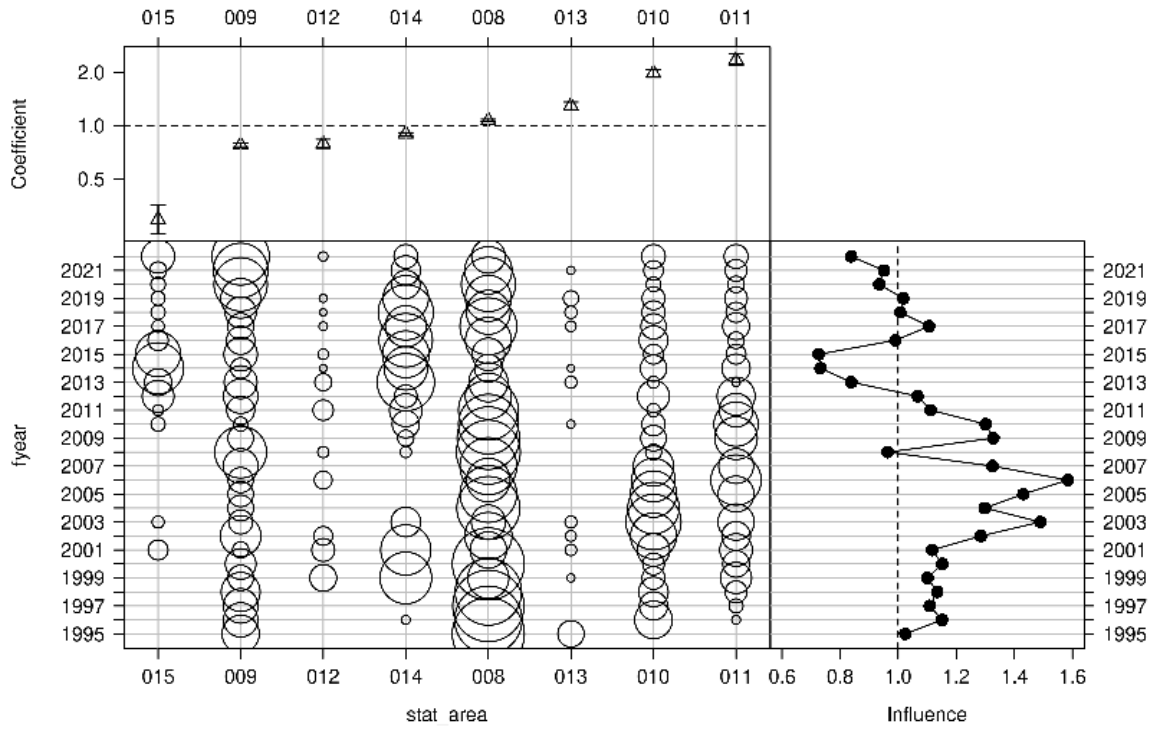

Figure D.104: CDI plot for statistical area for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

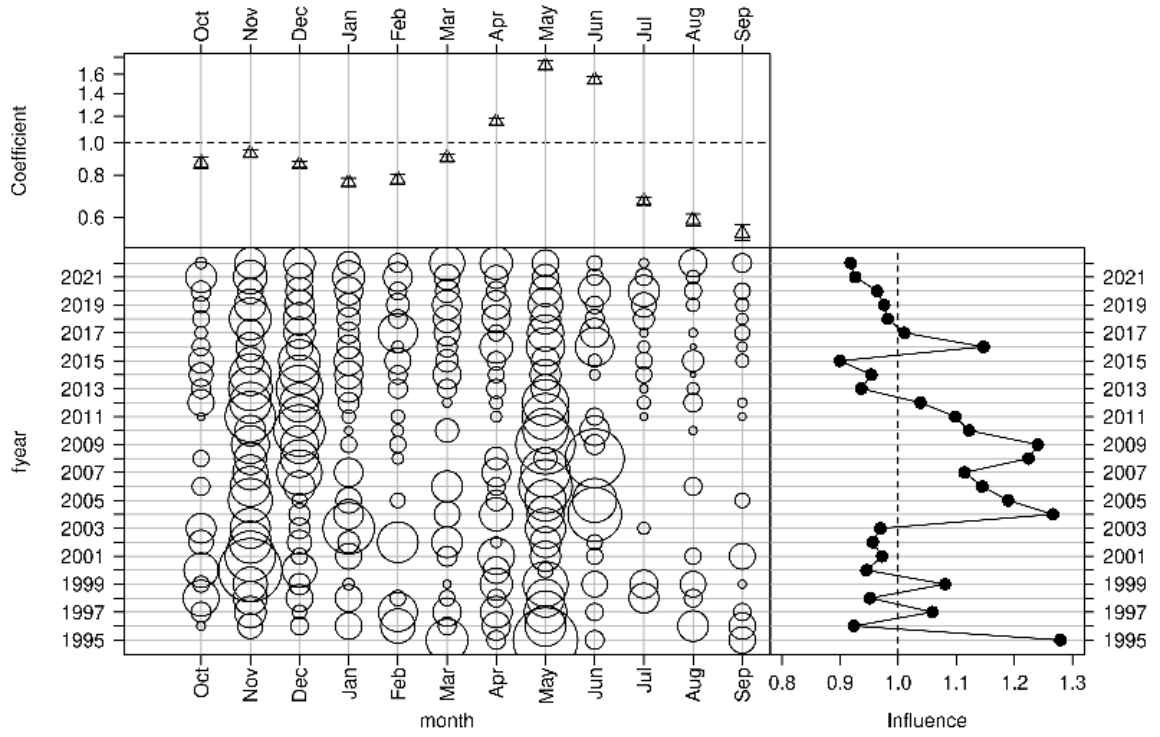

Figure D.105: CDI plot for month for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

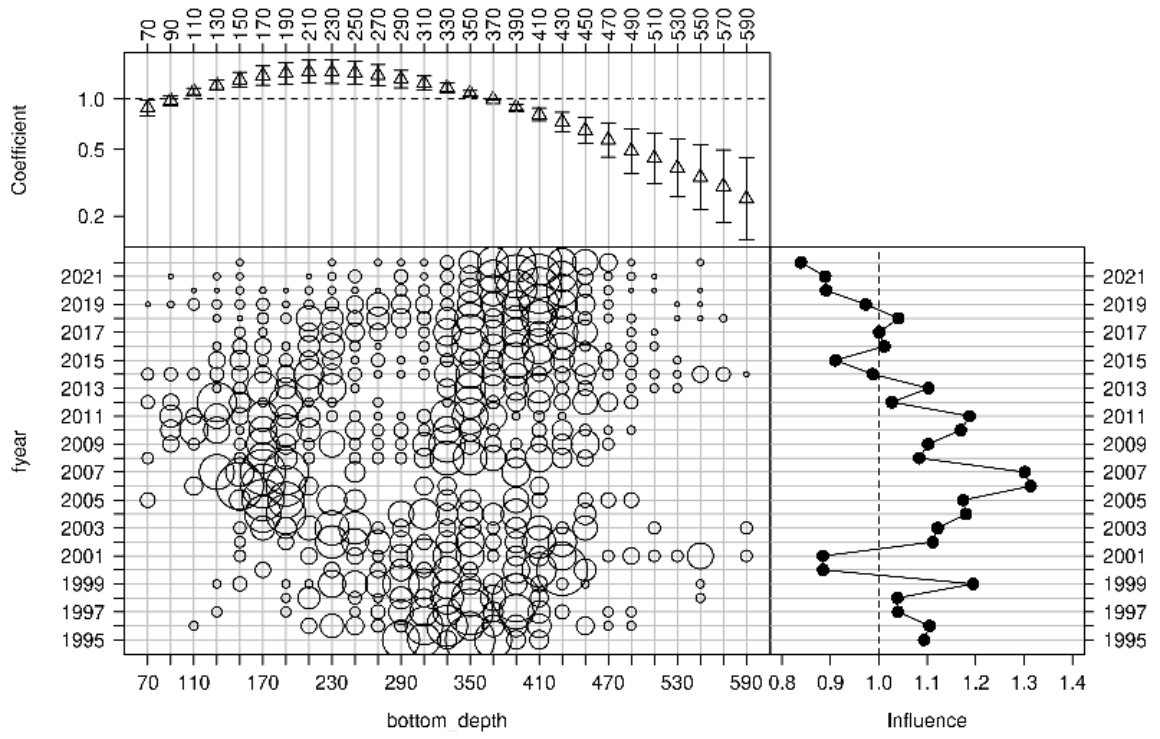

Figure D.106: CDI plot for bottom depth for the positive catch SKI1 SKI2 HOK-SKI event (2021 fleet) catch-per-unit-effort dataset.

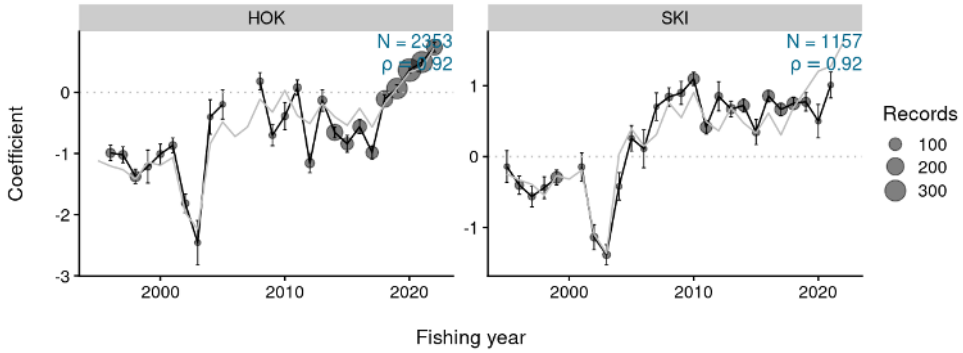

Figure D.107: Residual implied coefficients for target-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

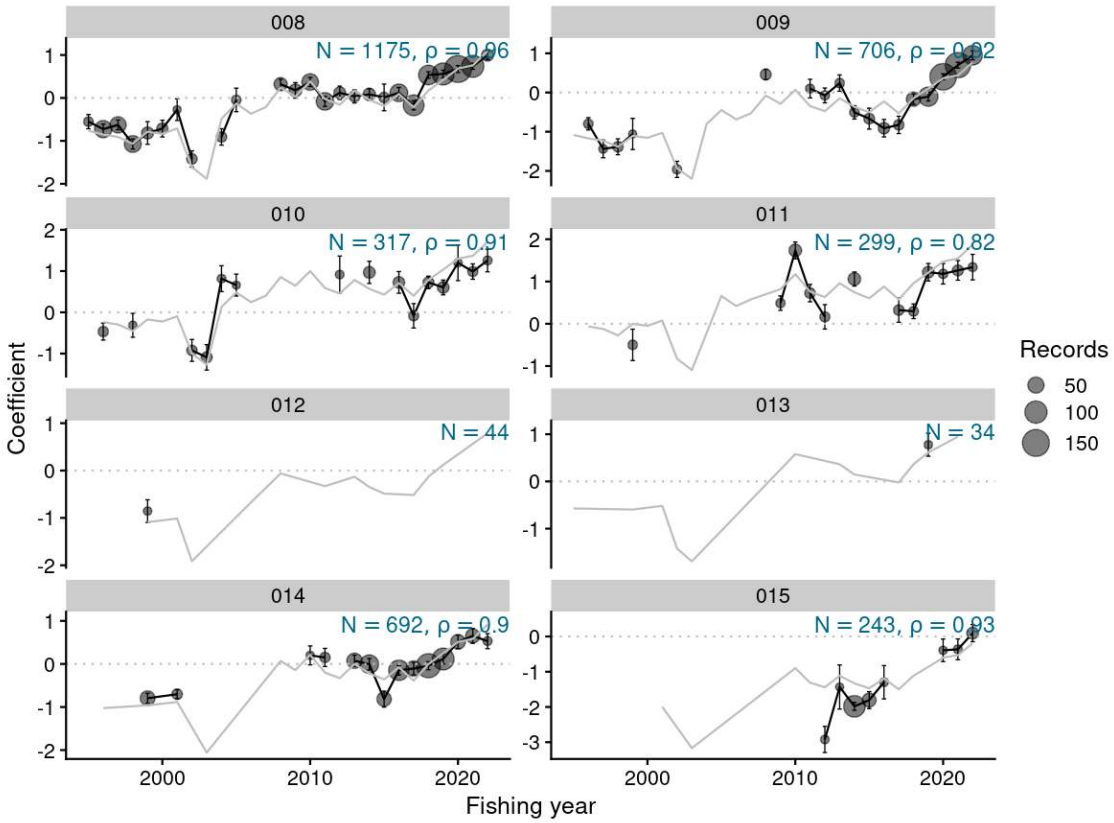

Figure D.108: Residual implied coefficients for area-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

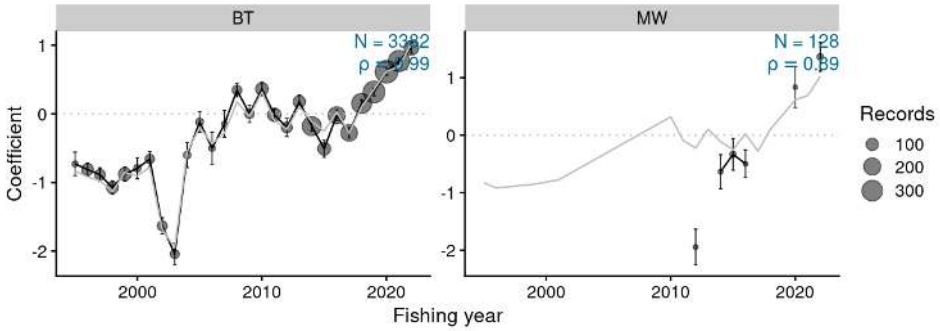

Figure D.109: Residual implied coefficients for primary method-year in the Weibull positive catch model for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

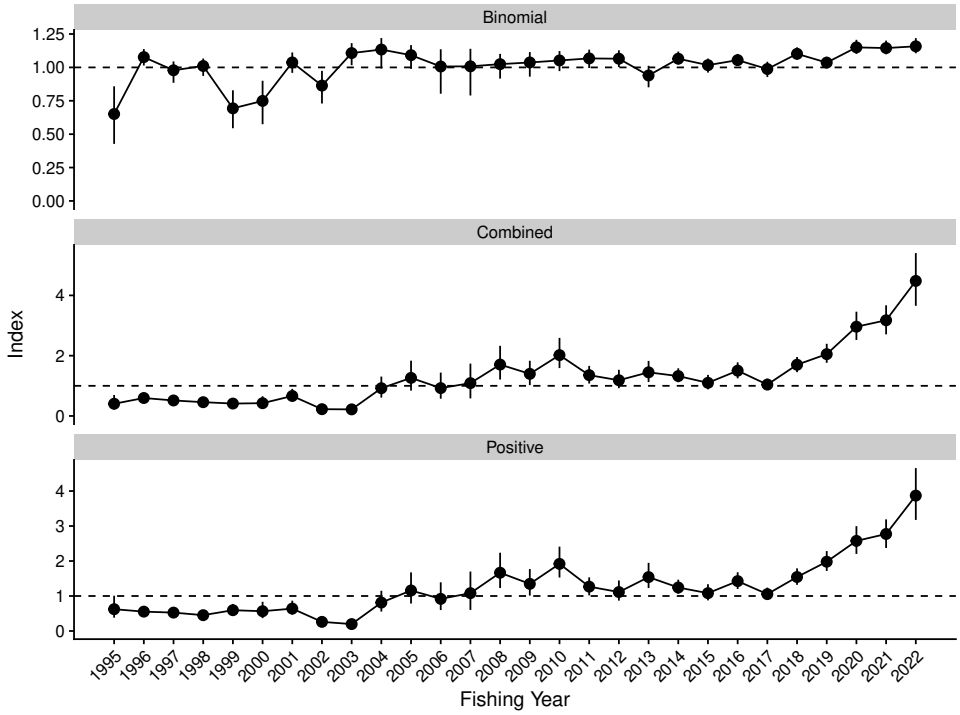

Figure D.110: Standardised indices and 95% confidence intervals for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

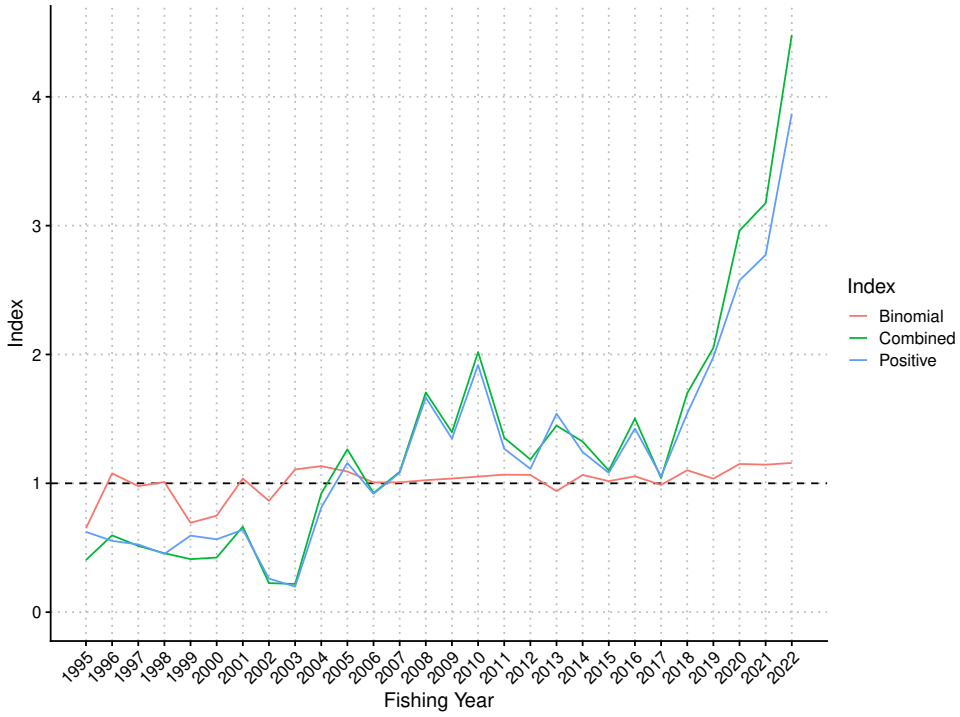

Figure D.111: Standardised indices for the SKI1 SKI2 HOK-SKI event (2021 fleet) dataset.

Table D.30: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5 %, UCI: 97.5 %) for each model in SKI1 SKI2 HOK-SKI event (2021 fleet).

Fishing year	Binomial	Binomial LCI	Binomial SE	Binomial UCI	Combined	Combined LCI	Combined SE	Combined UCI	Positive	Positive LCI	Positive SE	Positive UCI
1995	0.65	0.65	0.110	0.65	0.40	0.40	0.122	0.40	0.62	0.62	0.160	0.62
1996	1.08	1.08	0.031	1.08	0.60	0.60	0.074	0.60	0.55	0.55	0.065	0.55
1997	0.98	0.98	0.041	0.98	0.51	0.51	0.074	0.51	0.53	0.53	0.070	0.53
1998	1.01	1.01	0.033	1.01	0.46	0.46	0.059	0.46	0.45	0.45	0.055	0.45
1999	0.69	0.69	0.072	0.69	0.41	0.41	0.067	0.41	0.59	0.59	0.082	0.59
2000	0.75	0.75	0.083	0.75	0.42	0.42	0.102	0.42	0.57	0.57	0.119	0.57
2001	1.04	1.04	0.039	1.04	0.66	0.66	0.106	0.66	0.64	0.64	0.102	0.64
2002	0.86	0.86	0.062	0.86	0.23	0.23	0.034	0.23	0.26	0.26	0.035	0.26
2003	1.11	1.11	0.042	1.11	0.22	0.22	0.036	0.22	0.20	0.20	0.032	0.20
2004	1.13	1.13	0.058	1.13	0.92	0.92	0.178	0.92	0.81	0.81	0.152	0.81
2005	1.09	1.09	0.045	1.09	1.26	1.26	0.253	1.26	1.16	1.16	0.227	1.16
2006	1.01	1.01	0.085	1.01	0.92	0.92	0.221	0.92	0.92	0.92	0.203	0.92
2007	1.01	1.01	0.089	1.01	1.09	1.09	0.294	1.09	1.08	1.08	0.280	1.08
2008	1.02	1.02	0.047	1.02	1.71	1.71	0.285	1.71	1.67	1.67	0.258	1.67
2009	1.04	1.04	0.047	1.04	1.40	1.40	0.206	1.40	1.35	1.35	0.194	1.35
2010	1.05	1.05	0.038	1.05	2.02	2.02	0.256	2.02	1.92	1.92	0.225	1.92
2011	1.07	1.07	0.035	1.07	1.35	1.35	0.150	1.35	1.27	1.27	0.131	1.27
2012	1.07	1.07	0.032	1.07	1.19	1.19	0.155	1.19	1.11	1.11	0.147	1.11
2013	0.94	0.94	0.041	0.94	1.45	1.45	0.179	1.45	1.54	1.54	0.184	1.54
2014	1.07	1.07	0.025	1.07	1.32	1.32	0.118	1.32	1.24	1.24	0.103	1.24
2015	1.02	1.02	0.027	1.02	1.10	1.10	0.122	1.10	1.08	1.08	0.118	1.08
2016	1.05	1.05	0.023	1.05	1.50	1.50	0.135	1.50	1.43	1.43	0.122	1.43
2017	0.99	0.99	0.029	0.99	1.04	1.04	0.094	1.04	1.05	1.05	0.090	1.05
2018	1.10	1.10	0.023	1.10	1.70	1.70	0.128	1.70	1.54	1.54	0.120	1.54
2019	1.04	1.04	0.022	1.04	2.05	2.05	0.161	2.05	1.98	1.98	0.145	1.98
2020	1.15	1.15	0.027	1.15	2.96	2.96	0.239	2.96	2.57	2.57	0.202	2.57
2021	1.14	1.14	0.026	1.14	3.17	3.17	0.246	3.17	2.77	2.77	0.209	2.77
2022	1.16	1.16	0.029	1.16	4.48	4.48	0.446	4.48	3.87	3.87	0.378	3.87

APPENDIX E: GLOSSARY

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

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

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

Code	Description
CEL	Catch, Effort and Landing Return
ERS - Trawl	Electronic Reporting System - Trawl
ERS - Lining	Electronic Reporting System - Lining
TCE	Trawl Catch Effort Return
TCP	Trawl Catch, Effort and Processing Return
LTC	Lining Trip Catch Effort Return

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

Code	Description
BT	Bottom trawl
BPT	Bottom trawl - pair
MW	Midwater trawl
PRB	Precision bottom trawl
PRM	Precision midwater trawl
SN	Set net (including Gill nets)
BLL	Bottom longline
DL	Drop/dahn lines
DS	Danish seine
HL	Handlining

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

Code	Common name	Scientific name
BNS	Bluenose	*Hyperoglyphe antarctica*
BYX	Alfonsino and long-finned beryx	*Beryx splendens, Beryx decadactylus*
GUR	Gurnard	*Chelidonichthys kumu*
HOK	Hoki	*Macruronus novaezelandiae*
LIN	Ling	*Genypterus blacodes*
RBY	Rubyfish	*Plagiogeneion rubiginosum*
SCI	Scampi	*Metanephrops challengeri*
SKI	Gemfish	*Rexea spp.*
TAR	Tarakihi	*Nemadactylus macropterus, Nemadactylus sp. (King tarakihi)*

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

Code	Description
AKE	Auckland East (from North Cape to Cape Runaway)
AKW	Auckland West (from Tirua Point to North Cape)
CEE	Central East (from Cape Runaway to Titahi Bay)