Ministry for Primary Industries
Manatū Ahu Matua

GUR 7 Fishery Characterisation and CPUE Report

New Zealand Government

Growing and Protecting New Zealand

Requests for further copies should be directed to:

Publications Logistics Officer
Ministry for Primary Industries
PO Box 2526
WELLINGTON 6140

Email: brand@mpi.govt.nz
Telephone: 0800 00 83 33
Facsimile: 04-894 0300

This publication is also available on the Ministry for Primary Industries websites at:
http://www.mpi.govt.nz/news-and-resources/publications
http://fs.fish.govt.nz go to Document library/Research reports

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Starr, P.J.; Kendrick, T.H. (2017). GUR 7 Fishery Characterisation and CPUE Report.

The fisheries taking red gurnard (*Chelidonichthys kumu*) in GUR 7, located on the west coast of the New Zealand South Island and in the lower part of Cook Strait and operating from 1989–90 to 2015–16, are described using compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI). This species is almost exclusively captured by bottom trawl, accounting for over 97% of the accumulated landings over the 27 year period. Only 13% of the bottom trawl landings in GUR 7 were targeted at red gurnard, but that percentage has increased to 33% in the most recent five years (2011–12 to 2015–16). Other important target species are flatfish, barracouta, red cod and tarakihi. Detailed characteristics of the landing data associated with GUR 7, as well as the spatial, temporal, target species and depth distributions relative to the catch of red gurnard in the bottom trawl fishery are presented.

Fine scale positional information from catch and effort records are available from 2007–08, when the new event based catch reporting form (TCER) was introduced by MPI. Previously, almost all of the GUR 7 catch was reported on the daily summary forms (CELR) which do not require positional information. These positional data show that bottom trawl catches of red gurnard extend all along the west coast of the South Island, from Haast to Cape Farewell and extend into Tasman and Golden Bays across Cook Strait to the Marlborough Sounds. These catches are distributed fairly evenly across all months, with no apparent seasonal pattern in any of the sub-areas investigated. Reported depth information shows that gurnard are taken in shallow depths (less than 20 m) up to 160–170 m, depending on the species being targeted. The preferred depth distribution for GUR target fishing lies between 20 and 70 m.

Commercial Catch Per Unit Effort (CPUE) analyses have been used to monitor GUR 7 since 2011 (MPI 2016). These analyses tracked the WCSI separately from the western Cook Strait and stratified the catch and effort data into shallow flatfish target fisheries and put the remaining catch and effort into mixed target species fisheries operated at deeper depths. These analyses were updated in 2014 and this paper represents a further update, extending each series to 2015–16. This paper also reviewed the fishery definitions and recommended some relatively minor changes which were accepted by the Southern Inshore Working Group (SINSWG). The resulting analyses all corroborate an apparent strong upturn in the GUR 7 red gurnard population, beginning around 2010–11.

There also exists a biannual bottom trawl survey which operates off the WCSI and in Tasman/Golden Bays. The red gurnard indices from this survey also show an upturn in relative biomass beginning in 2011, with the 2015 survey index three times the geometric mean of the 12 survey indices covering the period 1991 to 2015. The 2017 review agreed to use this survey to monitor GUR 7 and to use the WCSI(FLA) and WCSI(MIX) CPUE indices as corroboration of the survey trends.
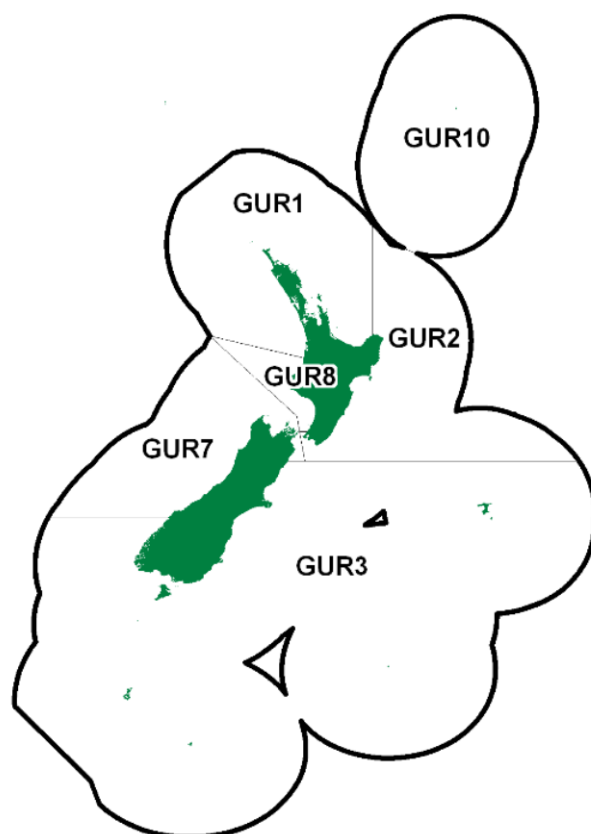
Figure 1:   **Map of GUR QMAs.**

1.   INTRODUCTION

This document describes work conducted under contract for Southern Inshore Fisheries Ltd.

Overall Objective:
1.   To characterise the gurnard (*Chelidonichthys kumu*) fishery in GUR 7 and to update the existing CPUE analysis.

Specific Objectives:
1.   To characterise the GUR 7 fishery.
2.   To analyse existing commercial catch and effort data to the end of 2015/16 fishing year to update the existing GUR 7 bottom trawl CPUE abundance series.

This project extends the following previous projects:

Reference	Last fishing year in analysis
Kendrick et al. (2011)	2009–10
Langley (2014)	2012–13

This report summarises fishery and landings characterisations for GUR 7, as well as presenting CPUE standardisations derived from bottom trawl data originating from GUR 7.

Abbreviations and definitions of terms used in this report are presented in Appendix A. A map showing the red gurnard QMAs is presented in Figure 1. Appendix B presents the MPI FMAs in the context of the contributing statistical reporting areas.

GUR 7

Figure 2: Plot of GUR 7 landings and TACCs from 1986–87 to 2015–16. Landings and TACCs are reported in Table 1.

Table 1: Reported landings (t) and TACC (t) of gurnard in GUR 7 from 1986–87 to 2015–16 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2015–16].

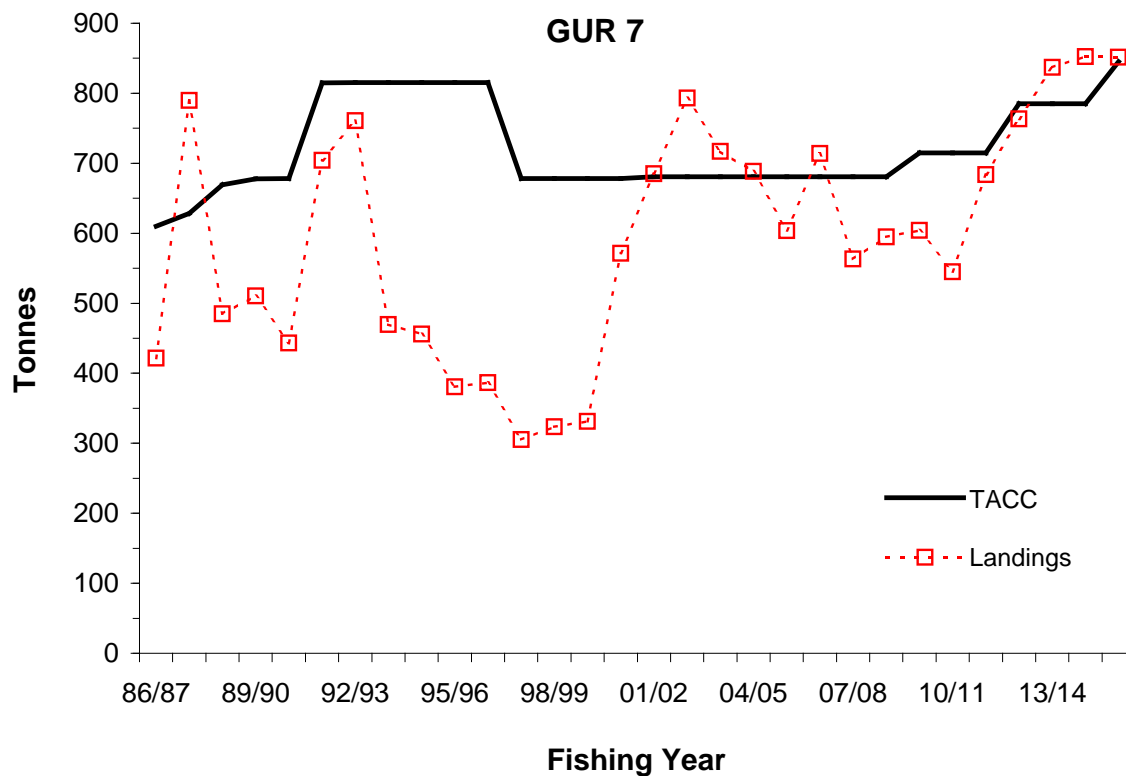| Fishing Year	Landings	TACC	Fishing Year	Landings	TACC
1986–87	421	610	2001–02	685	681
1987–88	790	629	2002–03	793	681
1988–89	485	669	2003–04	717	681
1989–90	511	678	2004–05	688	681
1990–91	443	678	2005–06	604	681
1991–92	704	815	2006–07	714	681
1992–93	761	815	2007–08	563	681
1993–94	469	815	2008–09	595	681
1994–95	456	815	2009–10	604	715
1995–96	380	815	2010–11	545	715
1996–97	387	815	2011–12	684	715
1997–98	305	678	2012–13	763	785
1998–99	324	678	2013–14	837	785
1999–00	331	678	2014–15	852	785
2000–01	571	678	2015–16	852	845

2. INFORMATION ABOUT THE STOCK/FISHERY

2.1 Catches

The TACC for GUR 7 started near 600 t when introduced into the QMS in 1986–87, but increased over the first few years to 678 t through the provisions of quota appeals (Figure 2; Table 1). There was a 20% TACC increase in 1991–92 to 815 t when GUR 7 was introduced into the AMP, but this was reversed back to the pre-AMP TACC in 1997–98 when the programme was reviewed and rationalised. There have since been three TACC increases in response to abundance increases: 5% to 715 t in 2009–10, 10% to 785 t in

2012–13 and 7.6% to 845 t in 2015–16, which is the highest in the series. Landings were generally below the TACC until the early 2000s, never quite reaching the increased AMP TACC and then dropping to near 300 t/year in the mid- to late-1990s. Landings exceeded the 678 t TACC for five of six years from 2001– 02 to 2006–07, but then dropped to below 600 t/year (Figure 2; Table 1). Landings progressively increased from a nadir of 545 t in 2010–11 to 852 t in 2015–16, the highest annual total in the series (Table 1; Figure 2).

2.2 Regulations Affecting the Fishery

2.2.1 Deemed values

Gurnard are primarily landed green (or whole), so there are no conversion factor issues for this species (see Section 2.3.2).

2.3 Analysis of GUR 7 catch and effort data

2.3.1 Methods used for 2017 analysis of MPI catch and effort data

Two data extracts were obtained from the Ministry for Primary Industries (MPI) Warehou database (Ministry of Fisheries 2010). One extract consisted of the complete data set (all fishing event information along with all gurnard landing information) from every trip which recorded landing gurnard in GUR 7, starting from 1 October 1989 and extending to 30 September 2016. A further extract was obtained consisting of all trips which fished in one of the valid statistical areas for GUR 7 (016 to 018, 032–040) using the method BT (bottom trawl), and which excluded the following list of target species: 'ORH', 'OEO', 'SOE', 'SOR', 'SSO', 'BOE', 'WOE', 'CDL', 'BYX', 'HOK', 'SBW', 'SCI', 'SQU', 'HAK'. Once these trips were identified, all fishing event data and gurnard landing data from the entire trip, regardless of method of capture (or the target species), were obtained. These data extracts (MPI replog 10957) were received 16 February 2017. The first data extract was used to characterise and understand the fisheries taking gurnard in GUR 7. These characterisations are reported in Sections 2.3.2 and 2.3.3, plus detailed summary tables with greater spatial resolution in Appendix C. The BT extract was used to calculate standardised CPUE series (see Section 4).

Data were prepared by linking the effort ("fishing event") section of each trip to the landing section, based on trip identification numbers supplied in the database. Effort and landing data were groomed to remove "out-of-range" outliers. The method used to groom the landings data is documented in Appendix D, with 150 t of landings removed which achieved a very close correspondence to the QMR/MHR landing data (see Table D.2 and Figure D.1). The procedures used to prepare the effort data are documented in Starr (2007).

The original level of time stratification for a trip is either by tow, or day of fishing, depending on the type of form used to report the trip information. The data were amalgamated into a common level of stratification known as a "trip stratum" (see table of definitions: Appendix A) for the characterisation part of this report. Depending on how frequently an operator changed areas, method of capture or target species, a trip could consist of one to several "trip strata". This amalgamation was required so that these data could be analysed at a common level of stratification across all reporting form types. Landed catches of gurnard by trip were allocated to the "trip strata" in proportion to the estimated gurnard catches in each "trip stratum". In situations when trips recorded landings of gurnard without any associated estimates of catch in any of the "trip strata" (operators were only required to report the top five species in any fishing event), the gurnard landings were allocated proportionally to effort (tows for trawl data and length of net set for setnet data) in each "trip stratum". Trips which fished within an ambiguous statistical area and landed to multiple GUR QMAs were dropped entirely from the characterisation data set. This "Fishstock" expansion is done to maintain the integrity of the data to characterise a specific QMA. This procedure only resulted in the loss of just over 12% of the landings in the data set. This loss was considered acceptable for the characterisation data set, which intends to

focus on the data from only GUR 7. It also assumes that the characteristics of the dropped data are adequately represented by the remaining data.

Estimated catches were scaled to the level of landings for the CPUE analyses described in Section 4 and Appendix F (and following) by statistical area, without regard to the reported QMA, to minimise the loss of landings, particularly in Cook Strait. This modification resulted in much better retention of the landings but at the cost of losing the capacity to link captures and effort to a specific QMA, thus requiring that QMA-specific CPUE analyses be defined on the basis of statistical area rather than QMA.

Table 2: **Comparison of the total GUR 7 QMR/MHR catch (t) with the sum of the landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data ('Analysis' data set) and the sum of the estimated catches from the Analysis data set. Data source: MPI replog 10956: 1989–90 to 2015–16.**

Fishing Year	QMR/MHR (t)	Total landed catch (t)	% landed/ QMR/MHR	Total Analysis catch (t)	% Analysis /Landed	Total Estimated Catch (t)	% Estimated /Analysis
89/90	511	447	88	430	96	411	95
90/91	443	428	96	418	98	377	90
91/92	704	685	97	674	98	584	87
92/93	761	780	103	733	94	650	89
93/94	469	471	100	450	95	396	88
94/95	456	450	99	428	95	371	87
95/96	380	363	95	316	87	285	90
96/97	387	403	104	335	83	272	81
97/98	305	318	104	275	86	234	85
98/99	324	330	102	302	92	241	80
99/00	331	341	103	319	94	274	86
00/01	571	571	100	541	95	464	86
01/02	685	691	101	634	92	576	91
02/03	793	792	100	750	95	663	88
03/04	717	738	103	696	94	602	86
04/05	688	685	99	645	94	586	91
05/06	604	606	100	569	94	488	86
06/07	714	713	100	658	92	567	86
07/08	563	565	100	534	95	482	90
08/09	595	588	99	561	95	507	90
09/10	604	599	99	553	92	513	93
10/11	545	532	98	477	90	461	97
11/12	684	676	99	626	93	605	97
12/13	763	748	98	695	93	641	92
13/14	837	822	98	772	94	721	93
14/15	852	850	100	813	96	759	93
15/16	852	849	100	823	97	777	94
Total	16 138	16 038	99	15 027	94	13 506	90

Catch totals in the fishery characterisation tables have been scaled to the QMR/MHR totals reported in Table 1 by calculating the ratio of these catches with the total annual landed catch in the analysis dataset and scaling all the landed catch observations (*i*) within a trip using this ratio:

Eq. 1
$$L'_{i,y} = L_{i,y} \frac{\mathbf{QMR}_y}{AL_y}$$

where $\mathbf{QMR}_y$ is the annual QMR/MHR landings, AL_y is the corresponding total annual landings from the analysis data set and $L_{i,y}$ are the landings for record *i* in year *y*.
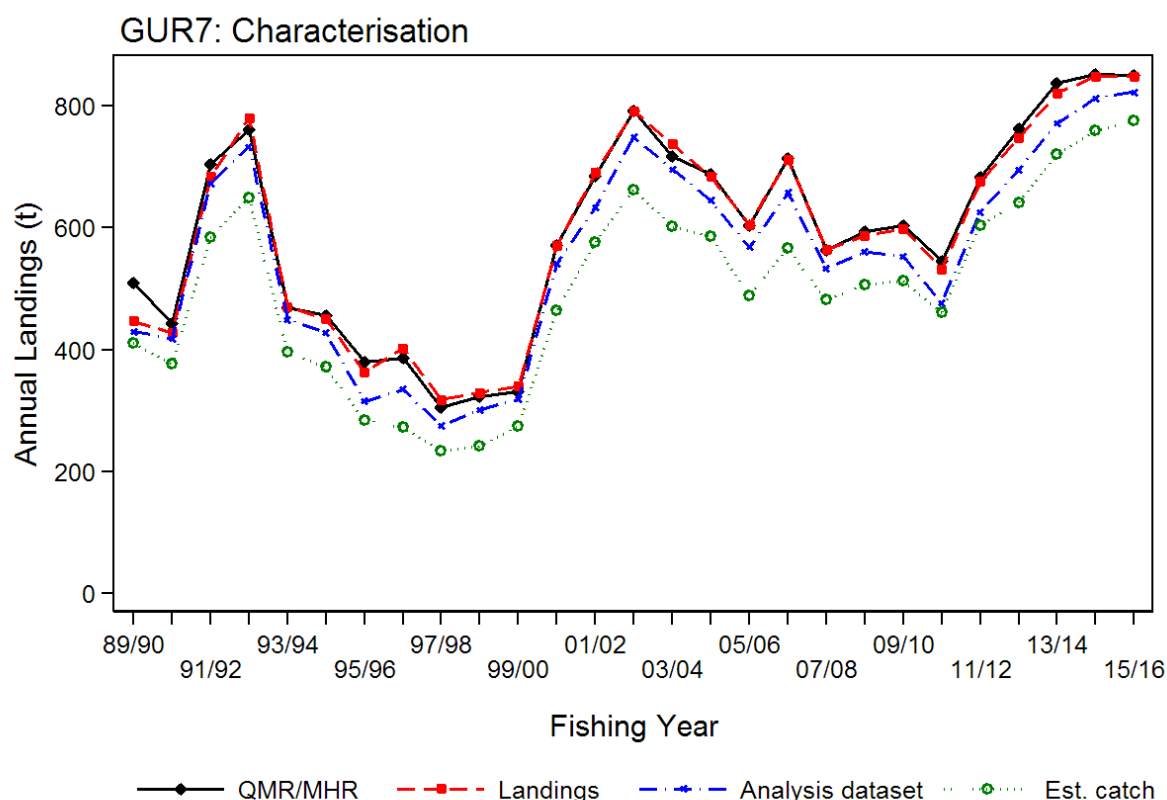
Figure 3: Plot of the GUR 7 catch dataset for totals presented in Table 2.
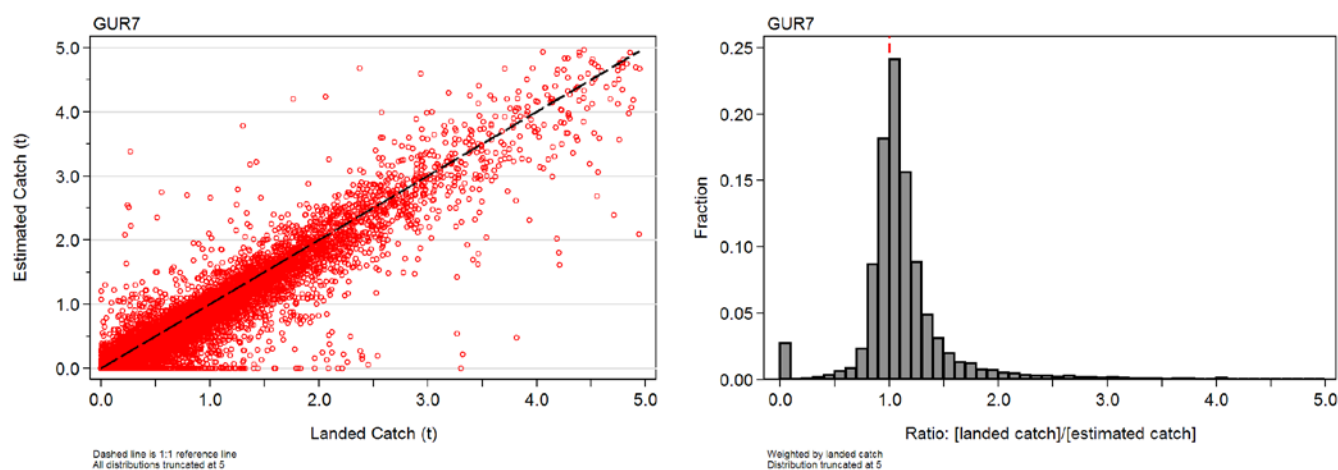

Figure 4: [left panel]: Scatter plot of the sum of landed and estimated gurnard catch for each trip in the GUR 7 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

Table 3: Summary statistics pertaining to the reporting of estimated catch from the GUR 7 analysis dataset.

| Fishing year | Trips with landed catch but which report no estimated catch | | | Statistics (excluding 0s) for the ratio of landed/estimated catch by trip | | | |
	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	9	3	16	0.55	1.00	1.11	1.72
90/91	9	3	15	0.69	1.01	1.16	1.89
91/92	11	5	33	0.71	1.01	1.21	2.00
92/93	13	7	53	0.66	1.01	1.19	2.19
93/94	15	6	29	0.60	1.01	1.26	2.13
94/95	17	6	28	0.52	1.04	1.33	2.57
95/96	17	8	29	0.45	1.05	1.28	2.60
96/97	18	9	36	0.60	1.07	1.32	2.61
97/98	18	7	21	0.53	1.06	1.26	2.47
98/99	21	9	30	0.60	1.09	1.33	2.72
99/00	20	4	15	0.67	1.08	1.43	2.87
00/01	19	4	24	0.73	1.08	1.30	2.40
01/02	12	1	9	0.63	1.05	1.27	2.10
02/03	10	3	21	0.56	1.05	1.27	2.45
03/04	9	4	26	0.70	1.08	1.26	2.40
04/05	8	2	12	0.62	1.08	1.27	2.34
05/06	7	1	6	0.75	1.11	1.32	2.33
06/07	8	1	7	0.72	1.13	1.30	2.33
07/08	4	0	2	0.73	1.12	1.31	2.29
08/09	5	0	3	0.63	1.12	1.75	2.13
09/10	4	0	2	0.72	1.11	1.30	2.27
10/11	5	0	1	0.74	1.10	1.33	2.21
11/12	6	1	4	0.77	1.08	1.22	1.96
12/13	4	0	4	0.78	1.10	1.30	2.15
13/14	5	0	2	0.79	1.08	1.19	1.91
14/15	7	0	4	0.79	1.09	1.28	1.88
15/16	6	0	2	0.80	1.08	1.18	1.82
Total	11	3	433	0.65	1.06	1.28	2.26

The annual totals at different stages of the data preparation procedure are presented in Table 2 and Figure 3. Total landings in the data set are very close to the landings in the QMR/MHR system, except for a 12% shortfall in landings in the first year of data (1989–90: see Table 2). Landings by year in the subsequent fishing years vary from –5% to +4% relative to the QMR/MHR annual totals (Table 2). The shortfall between landed and estimated catch by trip varies from –20% to –5% by fishing year and has averaged at -7% over the most recent 10 years (Table 2). A scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip (Figure 4 [left panel]). The distribution of the ratios of the landed relative to estimated catch shows a skewed distribution with a long tail of ratios greater than 1.0, a mode and median slightly above 1.0 and a mean near 1.3 (Figure 4 [right panel]).

For the GUR 7 dataset across all years, 11% of all trips which landed gurnard estimated no catch of gurnard but reported GUR in the landings (Table 3). This occurred because operators using the CELR form were only required to estimate the catch of the top five species in any single day (8 species by fishing event since the introduction of the TCER forms in 2007–08). These landings represented 3% of the total GUR 7 landings over the period, for a total of 433 tonnes (Table 3). The introduction of the new inshore trawling form (TCER), which records fishing activity at the level of a fishing event (or tow) and reports more species, has dropped the proportion of trips which estimated nil gurnard while landing this species, and has reduced the proportion of GUR landings in this category which now account for less than 1% of the GUR 7 landings since the introduction of the new forms (Table 3).

Data used for CPUE analysis were prepared using the "daily stratum" (Appendix A) procedure proposed by Langley (2014). As noted above, catch/effort data must be summarised to a common

level of stratification in order to construct a time series of CPUE indices that spans the change in reporting forms instituted in the late 2000s. Although the "trip-stratum" procedure proposed by Starr (2007) addresses the nominal instructions provided to fishers using the daily-effort CELR forms, Langley (2014) showed that the actual realised stratification in the earlier form types was daily, with the fisher tending to report the "predominant" statistical area of capture and target species rather than explicitly following the instructions. He showed this by noting that the frequency of changes in statistical area of fishing or target species within a day of fishing was much higher for comparable tow-by-tow event-based forms than in the earlier daily forms. Consequently, we have adopted Langley's (2014) recommendation to use the "daily-stratum" method for preparing data for CPUE analysis. The following steps were used to "rollup" the event-based data (tow-by-tow TCER forms or a single setnet set in the NCELR forms) to a "daily-stratum":

- discard trips that used more than one method in the trip (except for rock lobster potting, cod potting and fyke nets where just these methods were dropped) or used more than one form type;

- sum effort for each day of fishing in the trip;

- sum estimated catch for each day of fishing in the trip and only use the estimated catch from the top five species sorted by weight in descending order;

- calculate the modal statistical area and target species for each day of fishing, each weighted by the number of fishing events: these are the values assigned to the effort and catch for that day of fishing;

- create a list of "most relevant" target species by summing the landings in the GUR 7 characterisation data set across all years to identify the main target fisheries which capture gurnard. A second list of target species, consisting of species which were thought to be very unlikely to interact with gurnard (e.g., orange roughy, hake, arrow squid), was matched with the first list with the intent of dropping all matches. Twenty-four of the 66 target species in the initial list fell into this category (Table 4). After this step, the target species list was re-ranked, resulting in 42 species which accounted for 99.6% of the total GUR 7 landings (Table 4). Finally, a further 24 species, each with less than 1.5 t of accumulated catches over 27 years, were dropped, leaving 18 species in the "most relevant" target species list and still accounting for 99.6% of the merged landed catches in the GUR 7 characterisation data set (Table 4). This list was used to screen daily effort, discarding entire trips which reported target species that were not in this list because it was felt that the effort from the discarded species was not relevant to gurnard CPUE analysis. The decision to discard the entire trip rather than just the effort with the non-relevant target species because analysis showed that there was potential for bias when linking gurnard landings by trip with the remaining partial trip – it is safer to drop the entire trip;

- distribute landings proportionately to each day of the trip based on the gurnard estimated catch or to the daily effort for trips with no estimated gurnard catch.

Note that the above procedure was also applied to the daily effort (CELR) forms to ensure that each of these trips was also reduced to "daily strata" if fishers report more than one statistical area or target species in a day of fishing. Although the expansion from estimated to landed catches was done by statistical area rather than QMA (see discussion at the bottom of page 5), the above procedure resulted in the overall loss of about 7.5% of the landings in the data set due to the practice of dropping entire trips with mixed form types, multiple fishing methods and "out-of-range" target species.

Table 4: Table of target species fisheries which take GUR 7, summed over the period 1989–90 to 2015–16. The "original rank" column shows the relative rank of all 66 target species in this table. The "final rank" column shows the rank of the remaining 42 target species after 24 species (coloured orange), deemed unlikely to capture GUR 7, were dropped. The "Revised cum. %" column calculates the contribution of the 42 remaining target species relative to the total catch in the data set, including catch from the 24 dropped target species. A further 24 target species (coloured light blue) were dropped from the "most relevant" list because there was less than 1.5 t of accumulated landings over the 27 years of data.

Final rank	Original rank	Target species	Common Name	Total GUR 7 landings (t)	Revised cum. %	Original cum. %
1	1	FLA	Flats	7 646.94	52.28	52.28
2	2	GUR	Gurnard	1 898.18	65.26	65.26
3	3	BAR	Barracouta	1 878.49	78.11	78.11
4	4	RCO	Red Cod	1 454.34	88.05	88.05
5	5	TAR	Tarakihi	820.50	93.66	93.66
6	6	WAR	Common Warehou	355.35	96.09	96.09
7	7	SNA	Snapper	142.84	97.07	97.07
8	8	STA	Giant Stargazer	137.94	98.01	98.01
9	9	TRE	Trevally	53.55	98.37	98.37
10	10	JDO	John Dory	48.16	98.70	98.70
11	11	GSH	Ghost Shark	42.87	99.00	99.00
12	13	LEA	Leatherjacket	30.21	99.20	99.44
13	14	SPD	Spiny Dogfish	16.92	99.32	99.55
14	15	ELE	Elephantfish	15.12	99.42	99.66
15	17	SPO	Rig	8.23	99.48	99.78
16	18	BCO	Blue Cod	7.90	99.53	99.83
17	19	SCH	School Shark	4.85	99.57	99.86
18	20	LIN	Ling	4.23	99.60	99.89
19	24	RSK	Rough Skate	1.39	99.60	99.96
20	25	SKI	Gemfish	1.10	99.61	99.96
21	26	MOK	Moki	0.99	99.62	99.97
22	27	SWA	Silver Warehou	0.79	99.62	99.98
23	29	HPB	Hapuku & Bass	0.37	99.63	99.98
24	31	ALB	Albacore Tuna	0.28	99.63	99.99
25	32	KAH	Kahawai	0.22	99.63	99.99
26	33	SPF	Scarlet Wrasse	0.20	99.63	99.99
27	34	SPZ	Spotted Stargazer	0.16	99.63	99.99
28	36	SSK	Smooth Skate	0.15	99.63	99.99
29	37	SKA	Skate	0.13	99.63	99.99
30	38	SCA	Scallop	0.13	99.64	100.00
31	41	FRO	Frostfish	0.10	99.64	100.00
32	43	CAR	Carpet Shark	0.04	99.64	100.00
33	46	ROC	Rock Cod	0.03	99.64	100.00
34	47	SPE	Sea Perch	0.03	99.64	100.00
35	48	THR	Thresher Shark	0.03	99.64	100.00
36	49	BRA	Short-tailed Black Ray	0.02	99.64	100.00
37	50	PAU	Black Paua & Yellowfoot Paua	0.02	99.64	100.00
38	53	STR	Stingray	0.01	99.64	100.00
39	55	TRA	Roughies	0.01	99.64	100.00
40	57	PAD	Paddle Crab	0.00	99.64	100.00
41	58	SCM	Roughskin Dogfish	0.00	99.64	100.00
42	60	LIM	Limpets	0.00	99.64	100.00
–	12	JMA	Jack Mackerel	34.30	–	99.23
–	16	HOK	Hoki	9.10	–	99.72
–	21	ORH	Orange Roughy	3.22	–	99.91
–	22	HAK	Hake	2.74	–	99.93
–	23	SQU	Arrow Squid	2.12	–	99.95
–	28	GSP	Pale Ghost Shark	0.63	–	99.98
–	30	BAT	Large Headed Slickhead	0.35	–	99.99
–	35	LDO	Lookdown Dory	0.16	–	99.99
–	39	SUR	Kina	0.13	–	100.00
–	40	CRA	Rock Lobster	0.12	–	100.00
–	42	SSO	Smooth Oreo	0.05	–	100.00
–	44	RLA	Resania lanceolata	0.04	–	100.00
–	45	CDL	Cardinal Fish	0.03	–	100.00
–	51	WWA	White Warehou	0.02	–	100.00
–	52	BYX	Alfonsino & Long-finned Beryx	0.01	–	100.00
–	54	OEO	Oreos	0.01	–	100.00
–	56	SDO	Silver Dory	0.00	–	100.00
–	59	RBY	Ruby Fish	0.00	–	100.00
–	62	WRA	Whiptail Ray	0.00	–	100.00
–	65	BNS	Bluenose	0.00	–	100.00
–	64	TRU	Trumpeter	0.00	–	100.00
–	63	BSH	Seal Shark	0.00	–	100.00
–	66	OYS	Oysters Dredge	0.00	–	100.00
–	61	RIB	Ribaldo	0.00	–	100.00

2.3.2 Description of landing information for GUR 7

2.3.2.1 Destination codes in the GUR landing data

Landing data for gurnard were provided for every trip which landed GUR 7 at least once, with one record for every reported GUR landing from the trip. Each of these records contained a reported green weight (in kilograms), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a "destination code" (Table 5), which indicated the category under which the landing occurred. The majority of the landings were made using destination code "L" (landed to a Licensed Fish Receiver; Table 5). However, other codes (e.g., A, C or W; Table 5) also potentially described valid landings and were included in this analysis but these are all minor compared to code "L". A number of other codes (notably Q, P and R; Table 5) were not included because it was felt that these landings would be reported at a later date under the "L" destination category. The use of these holding codes can be seen to be minor in GUR 7. Two other codes (D and NULL) represented errors which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Table 5: Destination codes in the unedited landing data received for GUR 7. The "how used" column indicates which destination codes were included in the characterisation analysis. These data summaries have been restricted to GUR 7 over the period 1989–90 to 2015–16.

Destination code	Number events	Green weight (t)	Description	How used
L	54 441	16 244.1	Landed in NZ (to LFR)	keep
E	356	7.4	Eaten	keep
U	26	5.7	Bait used on board	keep
A	340	4.5	Accidental loss	keep
C	18	3.0	Disposed to Crown	keep
W	378	2.7	Sold at wharf	keep
O	8	1.6	Conveyed outside NZ	keep
F	221	1.0	Section 111 Recreational Catch	keep
J	16	0.6	Returned to sea [Section 72(5)(2)]	keep
S	5	0.2	Seized by Crown	keep
H	1	0.0	Loss from holding pot	keep
R	341	33.6	Retained on board	drop
T	125	18.6	Transferred to another vessel	drop
[NULL]	30	6.2	Missing	drop
B	43	2.7	Bait stored for later use	drop
Q	44	0.3	Holding receptacle on land	drop
D	12	0.3	Discarded (non-ITQ)	drop
P	1	0.1	Holding receptacle in water	drop

Table 6: Total greenweight reported and number of events by state code in the landing file used to process the GUR 7 characterisation and CPUE data, arranged in descending landed weight (only for destination codes indicated as "Keep" in Table 5). These data summaries have been restricted to GUR 7 from 1989–90 to 2015–16.

State Code	Number Events	Total reported green weight (t)	Description
GRE	54 848	16 104.2	Green (or whole)
DRE	286	75.4	Dressed
GUT	436	73.8	Gutted
MEA	558	54.6	Fish meal
HGU	124	19.3	Headed and gutted
SKF	91	2.0	Fillets: skin-off
Other	55	2.1	Other (misc) [1]

[1] includes (in descending order): missing, Fillets:skin-off trimmed, Fillets:skin-on.

Table 7: Median conversion factor for the five most important state codes reported in (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process GUR 7 landing data. '–': no observations; 'unk': conversion factor not reported in the database.

Fishing Year	Landed State Code					
	GRE	GUT	DRE	MEA	HGU	Other
Median Conversion Factor						
89/90	1	1.1	–	–	1.5	–
90/91	1	1.05	1.8	–	1.65	2.05
91/92	1	1.05	1.8	–	1.65	–
92/93	1	1.05	–	–	1.65	2.05
93/94	1	1.05	1.8	5.6	1.65	–
94/95	1	1.05	1.8	5.6	1.65	–
95/96	1	1.05	1.8	5.6	1.65	–
96/97	1	1.05	1.8	5.6	1.65	–
97/98	1	1.05	1.8	5.6	1.65	2.05
98/99	1	1.05	1.8	5.6	1.65	–
99/00	1	1.05	1.8	5.6	1.65	–
00/01	1	1.05	1.8	5.6	1.65	–
01/02	1	1.05	1.8	5.6	–	–
02/03	1	1.05	1.8	5.6	1.65	–
03/04	1	1.05	1.8	5.6	–	–
04/05	1	1.05	1.8	5.6	1.65	2.05
05/06	1	1.05	1.8	5.6	1.65	2.6
06/07	1	1.05	1.8	5.6	1.65	2.6
07/08	1	1.05	1.8	5.6	–	2.6
08/09	1	1.05	1.8	5.6	1.65	2.6
09/10	1	1.05	1.8	5.6	–	2.6
10/11	1	1.05	1.8	5.6	1.65	2.6
11/12	1	1.05	1.8	5.6	1.65	2.6
12/13	1	1.05	1.8	5.6	–	2.05
13/14	1	1.05	1.8	5.6	–	2.05
14/15	1	1.05	1.8	5.6	–	2.05
15/16	1	1.05	1.8	5.6	–	2.05
Total Landings (t)						
89/90	447.9	1.1	–	–	1.5	0.0
90/91	426.7	2.0	0.1	–	0.6	0.0
91/92	681.1	2.3	0.8	–	0.6	–
92/93	775.7	1.0	–	–	3.7	0.0
93/94	468.1	0.3	3.3	0.1	0.4	–
94/95	446.2	1.1	0.6	0.4	2.3	–
95/96	353.8	3.4	6.3	1.2	0.8	0.7
96/97	399.7	2.3	2.0	0.4	0.1	0.7
97/98	310.6	3.3	3.2	0.5	0.1	0.4
98/99	326.1	2.2	0.2	1.5	0.0	–
99/00	334.9	3.3	1.4	1.6	0.7	–
00/01	561.3	6.4	1.3	2.3	0.0	–
01/02	676.7	4.3	4.2	5.1	–	0.4
02/03	782.6	3.8	2.3	5.4	0.2	–
03/04	734.1	3.7	0.7	0.8	–	–
04/05	681.4	0.8	1.8	0.7	0.0	0.0
05/06	592.5	2.4	8.6	1.7	0.2	0.5
06/07	701.7	3.9	2.9	3.2	0.1	0.7
07/08	560.6	3.2	1.3	2.7	–	0.1
08/09	582.8	4.5	1.5	2.5	0.5	0.0
09/10	597.5	1.2	1.0	2.7	–	0.0
10/11	531.6	1.4	0.8	1.7	0.2	0.2
11/12	669.9	2.0	1.6	3.6	0.0	0.3
12/13	757.2	2.3	2.1	2.9	–	0.1
13/14	824.6	5.6	2.5	3.8	–	0.0
14/15	848.7	1.6	6.1	5.1	–	0.1
15/16	845.0	4.5	1.7	3.5	–	0.0
Total	15 919.0	73.7	58.3	53.3	12.2	4.4

Table 8: Distribution by form type for landed catch by weight for each fishing year in the GUR 7 landings dataset. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data in the GUR 7 dataset. See Appendix A for definitions of abbreviations used in this table.

	Landings (%)[1]			Days Fishing (%)[2]				Days Fishing				
	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	CELR	TCEPR	TCER	NCELR	Total
89/90	99	1	–	91	9	–	–	5 394	519	–	–	5 913
90/91	99	1	–	94	6	–	–	5 784	370	–	–	6 154
91/92	99	1	–	94	6	–	–	5 997	409	–	–	6 406
92/93	98	2	–	94	6	–	–	7 696	454	–	–	8 150
93/94	98	2	–	93	7	–	–	6 084	433	–	–	6 517
94/95	94	6	–	94	6	–	–	6 797	437	–	–	7 234
95/96	89	11	–	91	9	–	–	6 600	620	–	–	7 220
96/97	91	9	–	96	4	–	–	7 288	296	–	–	7 584
97/98	92	8	–	94	6	–	–	5 992	403	–	–	6 395
98/99	93	7	–	92	8	–	–	6 089	502	–	–	6 591
99/00	97	3	–	95	5	–	–	5 156	280	–	–	5 436
00/01	93	7	–	86	14	–	–	5 456	856	–	–	6 312
01/02	87	13	–	82	18	–	–	5 003	1 065	–	–	6 068
02/03	94	6	–	82	18	–	–	5 325	1 141	–	–	6 466
03/04	95	5	–	89	11	–	–	6 206	769	–	–	6 975
04/05	93	7	–	89	11	–	–	6 437	778	–	–	7 215
05/06	93	7	–	90	10	–	–	6 078	689	–	–	6 767
06/07	93	7	0.29	80	14	–	6	6 034	1 059	–	418	7 511
07/08	6	94	0.19	9	14	72	4	625	956	4 807	266	6 705
08/09	10	90	0.19	10	12	74	4	702	807	5 041	248	6 845
09/10	4	96	0.15	7	10	79	4	490	738	5 788	261	7 296
10/11	4	96	0.14	4	11	81	3	251	696	5 056	196	6 272
11/12	6	94	0.17	6	12	78	4	388	767	5 076	236	6 516
12/13	6	94	0.12	6	12	78	3	392	758	5 109	227	6 553
13/14	5	95	0.12	5	16	75	3	293	962	4 593	212	6 136
14/15	2	97	0.13	5	14	75	4	302	872	4 537	241	6 083
15/16	2	98	0.10	4	15	75	4	256	905	4 516	239	6 003
Average or Total	59	41	0.07	63	10	25	1	113 115	18 541	44 523	2 544	179323[3]

[1] percentages of landed greenweight
[2] percentages of number of days fishing
[3] includes 600 days of longline effort

2.3.2.2 State codes in the GUR landing data

Ninety-nine percent of the valid landing data for GUR 7 were reported using state code GRE (green or whole), with negligible amounts of alternative codes used (Table 6). As this code represents no processing before landing (with a conversion factor equal to 1.0), there have been no changes to conversion factors for this species over the 27 years of record (Table 7).

2.3.2.3 Form types used in the GUR landing and effort data

Most (over 90%) of the GUR 7 landings were reported on CELR forms up to 2006–07, with only minor amounts on the CLR form (Table 8). However, reporting on the CELR form disappeared after the TCER form was introduced in 2007–08. The NCELR form, used exclusively to report setnet effort and landings from 2006–07, is used very little in this fishery because this species is not taken by this gear type. The CLR form is used to report landings forms other than the CELR and NCELR forms, particularly the TCER and TCEPR trawl effort forms. There was a corresponding drop in the usage of the CELR form in the effort data, beginning from 2007–08 (calculated as days fishing, Table 8).

2.3.3   Description of the GUR 7 fishery

2.3.3.1 Introduction

As discussed in Section 2.3.1, landings were matched with effort for every trip while maintaining the integrity of the QMA-specific information for the characterisation data set. This procedure works well for the characterisation step because it gives a better indication of how the QMA-specific catch is distributed spatially and temporally. However, a statistical area expansion procedure was followed when preparing the CPUE data set so that no catch was lost to trips which fished in shared statistical areas and reported landings from more than one QMA. This is a problem in Cook Strait where the QMA boundaries are not well aligned with the geography of the actual fishery. In addition, just over 8% of the landing data are lost even when using the statistical area expansion procedure because these are trips lost from grooming the effort data. Dropped trips also include those that use multiple form types, use more than one gear type and which recorded an unlikely target species (see discussion on Table 4).

The characterisation information in this section is presented using six statistical area groupings due to the large and diverse area encompassed by the GUR 7 fishery. Six groups were chosen because more groups would make the plots difficult to decipher (see Appendix B for the locations of these Areas):

N	Code	Statistical Areas included
1	032–033	Areas 032, 033, 706
2	034	Areas 034, 705
3	035	Areas 035, 704
4	036	Areas 036, 703, 702, 701
5	016-018, 037-038	Areas 016, 017, 018, 037, 038
6	039–040	Areas 039, 040

Note that Groups 5 and 6 have been selected to match the statistical area choices made for the Cook Strait CPUE series (see Section 3).

2.3.3.2 Distribution of landings and effort by method of capture and QMA

Gurnard in GUR 7 are primarily (97%) taken by the bottom trawl method, with the remaining catch taken Danish seine, bottom pair trawl and setnet (Figure 5; Table 9). All capture methods in GUR 7 other than bottom trawl are negligible, accounting for less than 3% of the landings over the 27 years (Table 9). Unsurprisingly, bottom trawl predominates in each of the Statistical Area Groups, with Figure 6 showing that the small amounts of Danish seine and bottom pair trawl landings primarily originate from Area 038. All further tables (Table 10 to Table 13) in Section 2.3.3 will be restricted to bottom trawl landings.

The WCSI fishery accounts for about 60% of the overall GUR 7 bottom trawl catch when areas 032 to 036 are combined, with the remaining 40% coming from the Cook Strait statistical areas (016–018, 037–038) (Table 10).

Table 9: **Distribution of fishing methods, listed in descending order of importance, taking GUR 7 from 1989–90 to 2015–16. '–': no data.**

Fishing year	Method (t)						Method (%)				
	BT	DS	BPT	SN	OTH	Total	BT	DS	BPT	SN	OTH
89/90	495.9	–	10.1	1.5	3.0	510.6	97.1	–	2.0	0.3	0.6
90/91	431.2	–	7.9	3.5	0.5	443.0	97.3	–	1.8	0.8	0.1
91/92	696.3	–	0.1	3.4	4.3	704.1	98.9	–	0.0	0.5	0.6
92/93	756.6	–	0.1	2.4	1.7	760.8	99.5	–	0.0	0.3	0.2
93/94	465.8	–	0.2	2.6	0.9	469.5	99.2	–	0.0	0.5	0.2
94/95	450.2	–	0.3	3.6	1.8	455.9	98.7	–	0.1	0.8	0.4
95/96	374.1	–	0.2	5.2	0.9	380.4	98.3	–	0.1	1.4	0.2
96/97	379.7	–	0.0	1.9	4.9	386.6	98.2	–	0.0	0.5	1.3
97/98	296.2	–	0.1	1.0	7.8	305.0	97.1	–	0.0	0.3	2.6
98/99	318.4	–	0.0	0.8	4.5	323.7	98.4	–	0.0	0.3	1.4
99/00	322.2	–	3.0	1.3	4.7	331.2	97.3	–	0.9	0.4	1.4
00/01	562.2	–	4.1	1.7	3.1	571.2	98.4	–	0.7	0.3	0.6
01/02	674.8	–	6.3	2.1	2.0	685.2	98.5	–	0.9	0.3	0.3
02/03	780.4	–	7.3	3.0	2.3	793.0	98.4	–	0.9	0.4	0.3
03/04	707.3	–	3.3	4.7	1.7	717.0	98.7	–	0.5	0.7	0.2
04/05	682.1	0.5	1.0	3.7	1.0	688.3	99.1	0.1	0.1	0.5	0.1
05/06	596.2	2.5	0.6	3.5	0.8	603.7	98.8	0.4	0.1	0.6	0.1
06/07	707.3	3.6	0.1	2.3	0.6	713.9	99.1	0.5	0.0	0.3	0.1
07/08	539.5	22.0	0.1	1.1	0.5	563.2	95.8	3.9	0.0	0.2	0.1
08/09	567.0	25.6	0.1	1.1	0.9	594.7	95.3	4.3	0.0	0.2	0.1
09/10	582.7	19.6	0.3	0.8	0.6	604.0	96.5	3.2	0.0	0.1	0.1
10/11	529.1	14.5	0.5	0.6	0.1	544.9	97.1	2.7	0.1	0.1	0.0
11/12	649.6	31.4	0.2	1.1	1.2	683.6	95.0	4.6	0.0	0.2	0.2
12/13	736.0	25.8	–	0.9	0.6	763.4	96.4	3.4	–	0.1	0.1
13/14	803.6	32.1	–	1.0	0.6	837.2	96.0	3.8	–	0.1	0.1
14/15	772.3	21.8	55.4	1.0	1.8	852.2	90.6	2.6	6.5	0.1	0.2
15/16	830.3	19.4	–	0.7	1.1	851.5	97.5	2.3	–	0.1	0.1
Total	15 706.9	218.7	101.5	56.5	54.1[1]	16 137.7	97.3	1.4	0.6	0.4	0.3

[1] includes 27 t for troll (coded 'T',which may have meant "trawl"), 13 t for midwater trawl, 6 t for bottom longline and 4 t for dredging.

2.3.3.3   Fine scale distribution of landings for bottom trawl

Fine scale landings and effort data are available for the inshore bottom trawl fleet from 1 Oct 2007. A plot (Figure 7) of bottom trawl landings of gurnard, gridded into 0.1×0.1° cells and summed over nine years from 2007–08 to 2015–16, shows that gurnard are taken all along the west coast of the South Island (WCSI). High levels of catch continue into Cook Strait where there are catch concentrations in the outer portions of Tasman/Golden Bays, extending north of Farewell Spit. Catches of gurnard are also recorded in the outer parts of Marlborough Sounds and around D'Urville Island. Landings of gurnard seem less concentrated in the eastern sections of Cook Strait. Figure 7 also shows concentrated landings of gurnard along the coast of South Taranaki Bight and around Cape Egmont into the North Taranaki Bight. Table 10 shows that there are few landings of GUR 7 in Areas 039 and 040, so the landings shown in Figure 7 in Areas 039 and 040 are either from GUR 8 or from trips which have been discarded because of the ambiguity in reporting catch from trips which land more than one gurnard Fishstock and fish in statistical areas that are valid for several QMAs.
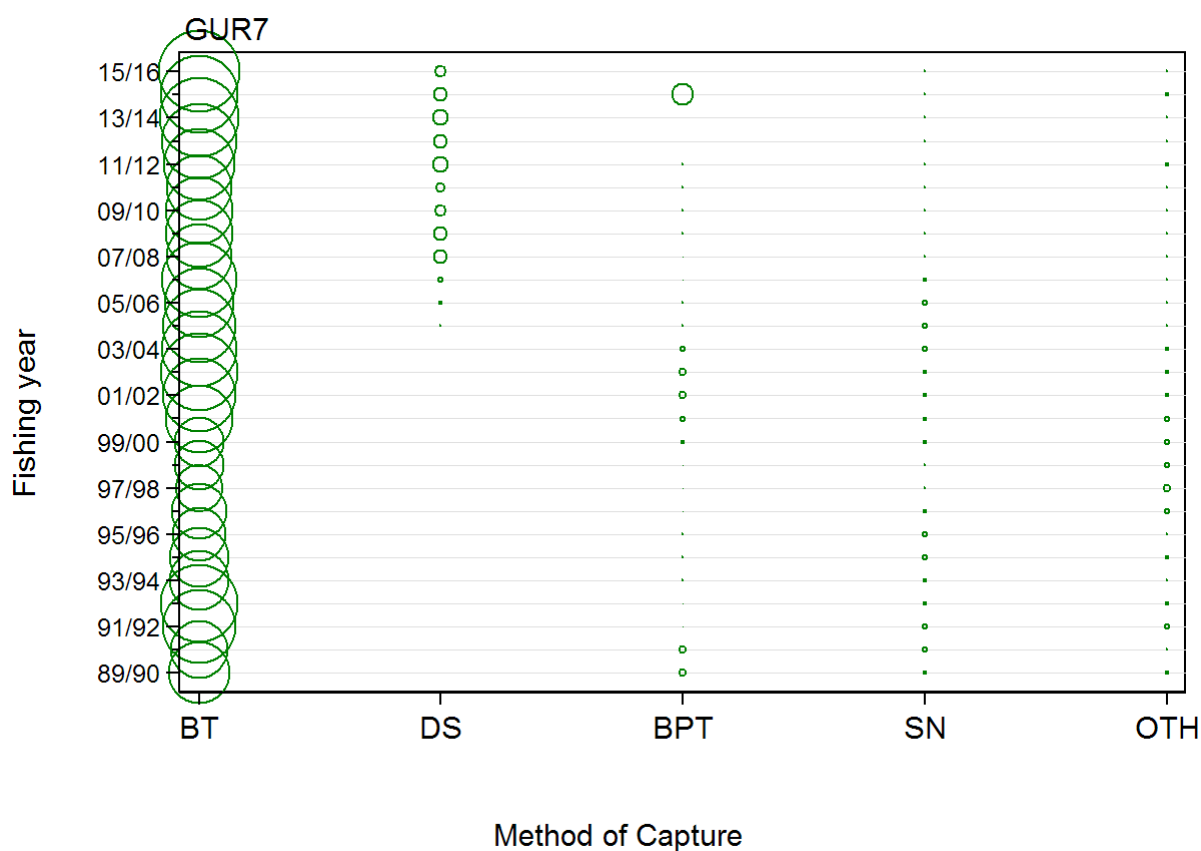
Figure 5:   **Distribution of landings by fishing methods and fishing year from trips which landed GUR 7. Circles are proportional to the catch totals by method and fishing year, with the largest circle representing 830 t (in 2015–16 for BT).**
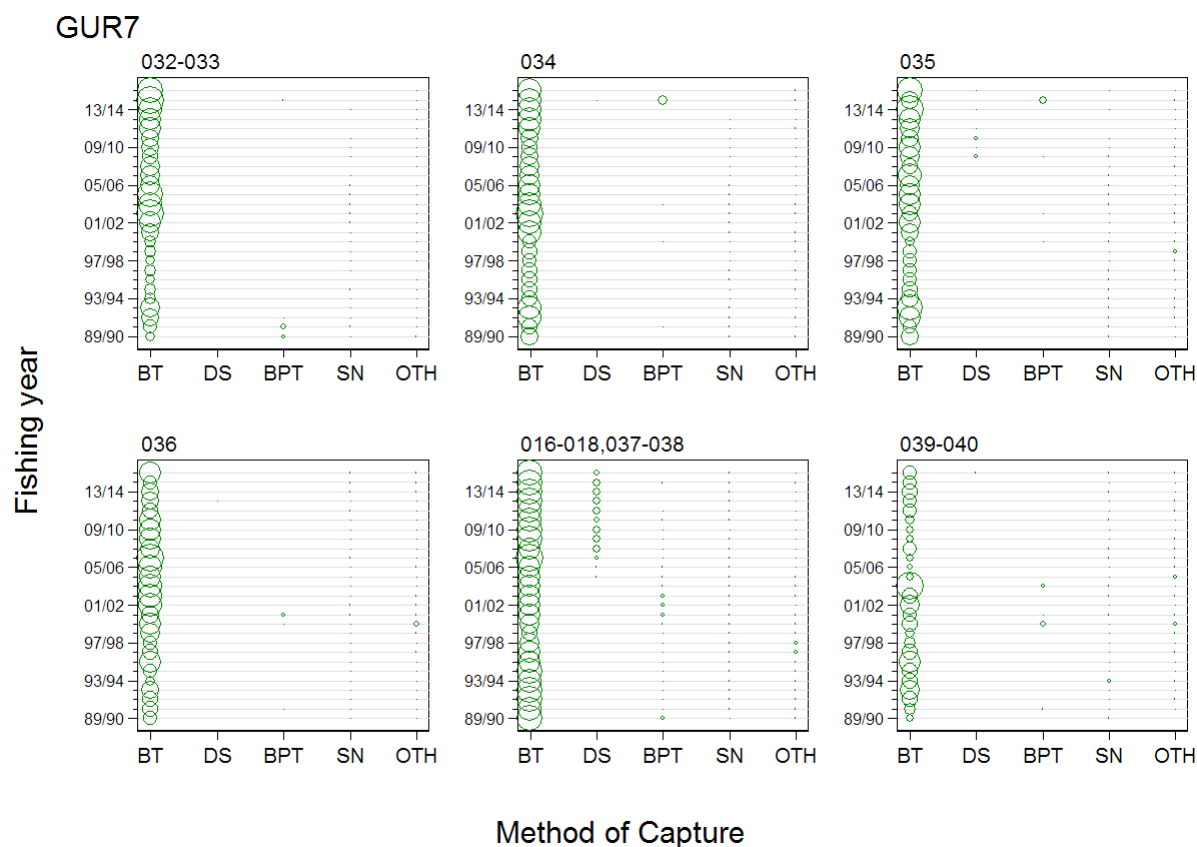
Figure 6: Distribution of gurnard landings for the major fishing methods by fishing year by GUR 7 statistical area grouping from 1989–90 to 2015–16. Circles are proportional to the catch totals by method and fishing year within each sub-graph: [032-033]: largest circle= 168 t in 02/03 for BT; [034]: largest circle= 318 t in 02/03 for BT; [035]: largest circle= 148 t in 13/14 for BT; [036]: largest circle= 34 t in 06/07 for BT; [016-018,037-038]: largest circle= 298 t in 06/07 for BT; [039-040]: largest circle= 12 t in 03/04 for BT.

Table 10: Total landings (t) of GUR 7 by fishing year and Statistical Area Group for bottom trawl from trips which landed gurnard, for the period from 1989–90 to 2015–16.

Fishing Year	Annual bottom trawl catch (t)							Annual bottom trawl catch (%)					
	032-033	034	035	036	016-018, 037-038	039-040	Total	032-033	034	035	036	016-018, 037-038	039-040
89/90	21.4	130.2	68.1	8.4	266.7	1.2	495.9	4.3	26.2	13.7	1.7	53.8	0.2
90/91	45.0	110.5	42.6	10.9	219.6	2.6	431.2	10.4	25.6	9.9	2.5	50.9	0.6
91/92	67.1	235.1	96.9	11.7	281.2	4.4	696.3	9.6	33.8	13.9	1.7	40.4	0.6
92/93	87.8	259.9	140.1	13.7	249.1	6.1	756.6	11.6	34.3	18.5	1.8	32.9	0.8
93/94	36.5	112.8	64.5	4.6	243.8	3.6	465.8	7.8	24.2	13.9	1.0	52.3	0.8
94/95	29.1	100.8	46.4	8.5	261.5	3.9	450.2	6.5	22.4	10.3	1.9	58.1	0.9
95/96	23.0	111.4	34.5	20.7	177.5	7.0	374.1	6.1	29.8	9.2	5.5	47.5	1.9
96/97	29.2	101.8	41.3	11.3	192.2	4.0	379.7	7.7	26.8	10.9	3.0	50.6	1.0
97/98	23.1	75.3	34.8	8.5	151.7	2.6	296.2	7.8	25.4	11.8	2.9	51.2	0.9
98/99	34.6	113.6	41.3	19.1	107.9	1.9	318.4	10.9	35.7	13.0	6.0	33.9	0.6
99/00	36.8	79.6	23.1	20.4	158.1	4.3	322.2	11.4	24.7	7.2	6.3	49.1	1.3
00/01	70.3	228.5	58.1	15.8	186.7	2.8	562.2	12.5	40.6	10.3	2.8	33.2	0.5
01/02	111.4	237.8	93.2	26.1	199.5	6.8	674.8	16.5	35.2	13.8	3.9	29.6	1.0
02/03	167.9	317.6	55.4	26.4	209.4	3.6	780.4	21.5	40.7	7.1	3.4	26.8	0.5
03/04	133.4	245.0	87.6	26.2	203.2	11.9	707.3	18.9	34.6	12.4	3.7	28.7	1.7
04/05	155.7	220.7	88.0	20.3	196.3	1.1	682.1	22.8	32.4	12.9	3.0	28.8	0.2
05/06	90.4	207.3	72.3	28.2	197.5	0.5	596.2	15.2	34.8	12.1	4.7	33.1	0.1
06/07	95.8	169.3	108.9	34.2	298.2	0.9	707.3	13.5	23.9	15.4	4.8	42.2	0.1
07/08	85.3	184.3	54.8	16.9	195.4	2.7	539.5	15.8	34.2	10.2	3.1	36.2	0.5
08/09	64.6	133.7	86.1	20.0	261.2	1.3	567.0	11.4	23.6	15.2	3.5	46.1	0.2
09/10	65.9	114.4	96.5	20.9	283.8	1.3	582.7	11.3	19.6	16.6	3.6	48.7	0.2
10/11	66.7	131.8	62.9	20.8	245.6	1.3	529.1	12.6	24.9	11.9	3.9	46.4	0.3
11/12	101.6	211.7	81.1	12.1	240.3	2.8	649.6	15.6	32.6	12.5	1.9	37.0	0.4
12/13	100.6	232.8	104.0	14.4	281.4	2.8	736.0	13.7	31.6	14.1	2.0	38.2	0.4
13/14	121.7	262.4	148.2	14.6	252.8	3.9	803.6	15.1	32.6	18.4	1.8	31.5	0.5
14/15	163.0	255.7	69.0	8.6	272.5	3.5	772.3	21.1	33.1	8.9	1.1	35.3	0.5
15/16	159.7	227.5	131.6	21.9	286.6	3.0	830.3	19.2	27.4	15.8	2.6	34.5	0.4
Total or Average	2 187.5	4 811.2	2 031.2	465.4	6 119.9	91.7	15 706.9	13.9	30.6	12.9	3.0	39.0	0.6

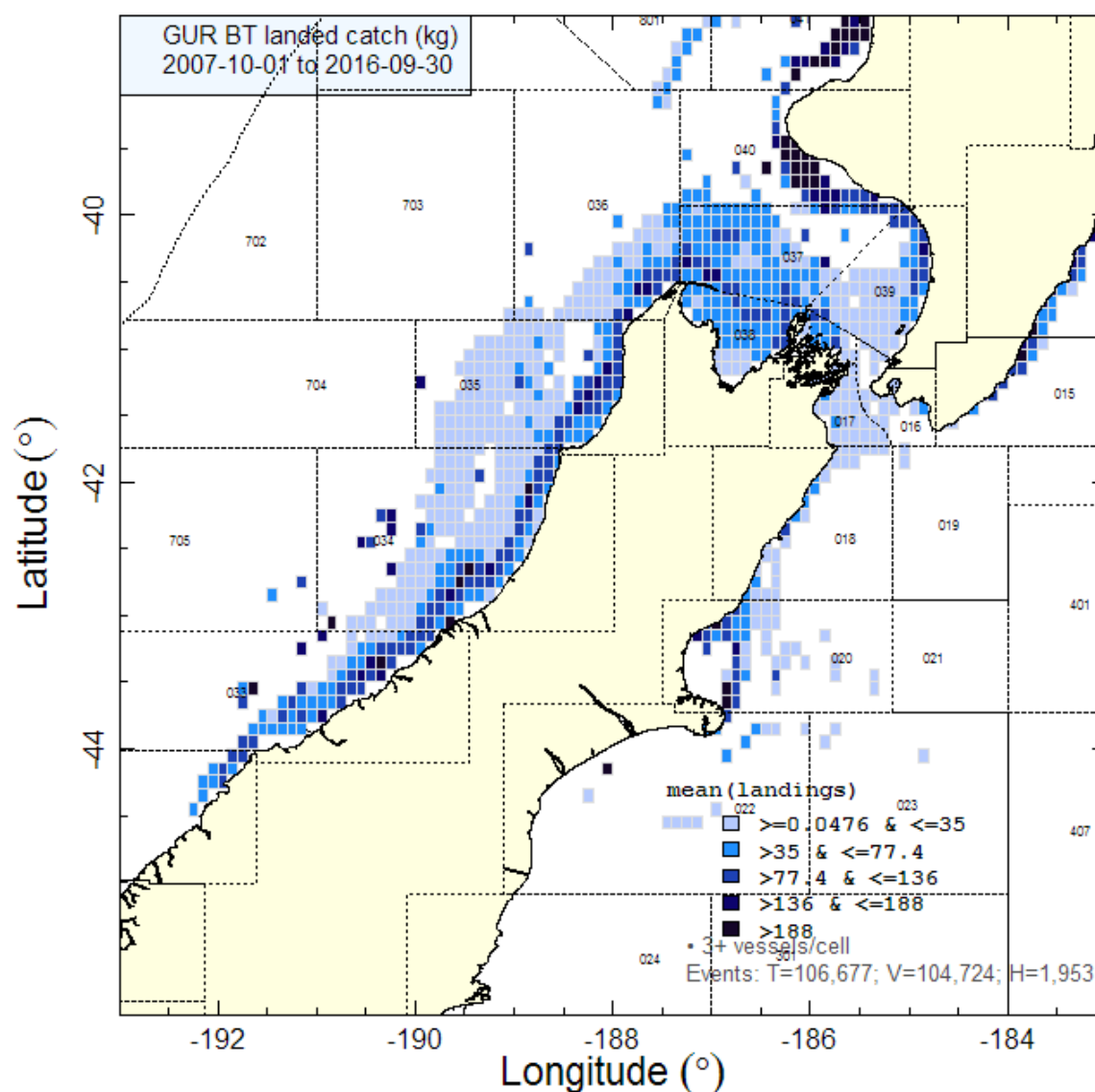**Figure 7:** Spatial distribution of gurnard bottom trawl landings (t) in Cook Strait and the west coast South Island, arranged in 0.1° × 0.1° grids, summed from 2007–08 to 2015–16. Legend colours divide the distribution of total landings into 25%, 50%, 75%, 90% and 95% quantiles. Only grids which have at least three reporting vessels are plotted. Note that this requirement has dropped 1953 of 106 677 events. Boundaries are shown for the general statistical areas plotted in Appendix B. These catch distributions are generated from the bottom trawl CPUE data set which contains all gurnard captured in the plotted statistical areas, regardless of the QMA landed.
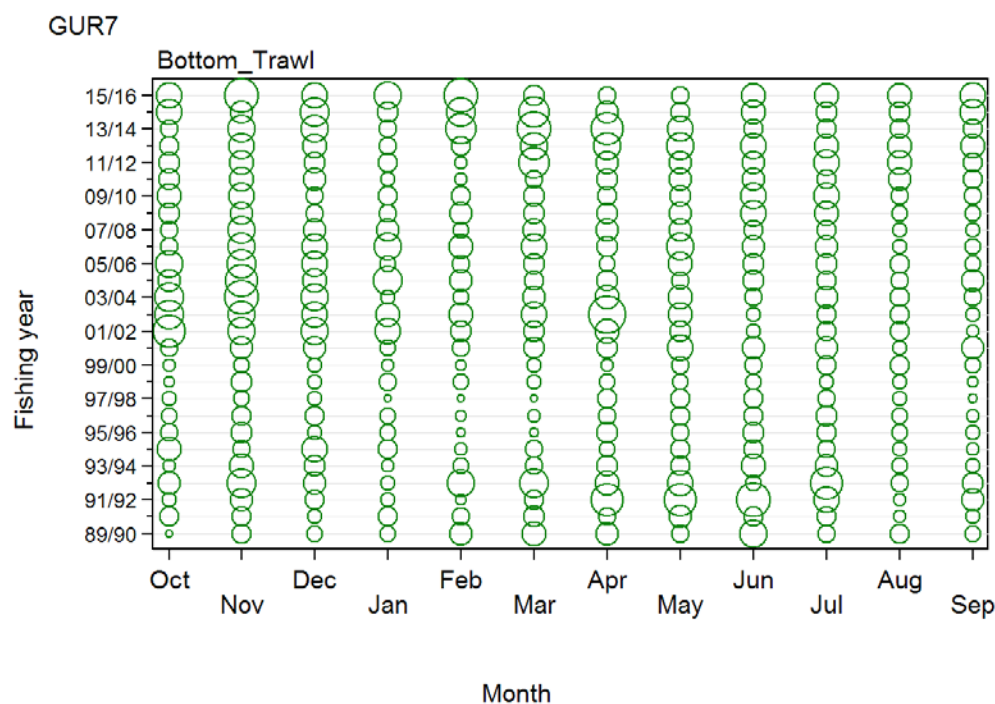
Figure 8: **Distribution of landings by month and fishing year from bottom trawl trips which landed GUR 7. Circles are proportional to the catch totals by month and fishing year: largest circle= 152 t in 02/03 for Apr.**
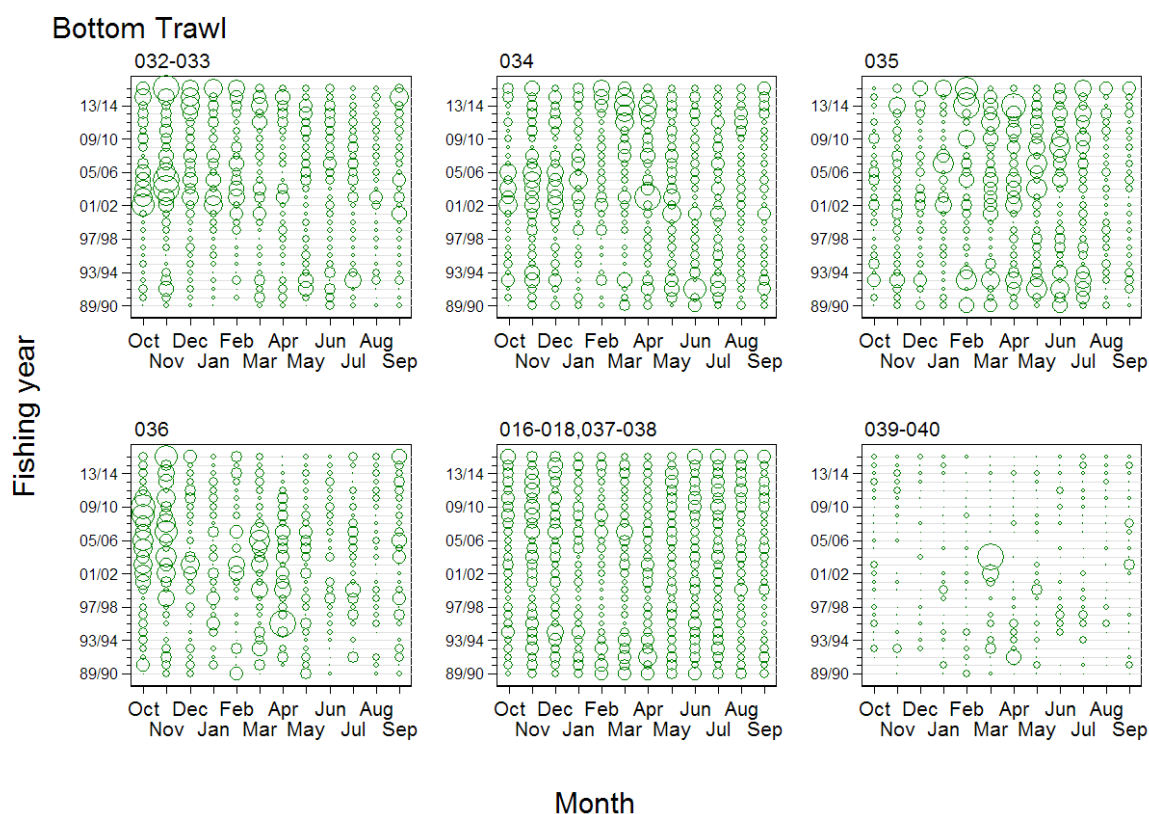
Figure 9: **Distribution of gurnard landings for bottom trawl by month and fishing year by GUR 7 statistical area grouping from 1989–90 to 2015–16. Circles are proportional to the catch totals by month and fishing year within each sub-graph: [032-033]: largest circle= 49 t in 04/05 for Nov; [034]: largest circle= 96 t in 02/03 for Apr; [035]: largest circle= 42 t in 13/14 for Feb; [036]: largest circle= 11 t in 95/96 for Apr; [016-018,037-038]: largest circle= 60 t in 91/92 for Apr; [039-040]: largest circle= 11 t in 03/04 for Mar. These plot data are tabulated in Table C.1A-C.**

2.3.3.4 Seasonal distribution of landings

Landings of GUR 7 in the bottom trawl fishery do not show strong seasonality, with fairly uniform landings across all months of the fishing year, particularly from the late 1990s and early 2000s (Figure 8; Table 11). Bottom trawl landings by statistical area region show similar seasonal distribution patterns in the regions with high levels of catch, with these regions encompassing the full year from the early 2000s (Figure 9).

2.3.3.5 Distribution of landings by declared target species

The majority of the landings from the GUR 7 bottom trawl fishery taking gurnard were targeted at FLA, with GUR being the second most important target species in terms of accumulated catch (Figure 10; Table 12). Targeting GUR is relatively recent, with increased levels of targeting starting from about 2009–10, probably coinciding with an increase in the abundance of this species in GUR 7. Gurnard were also taken when targeting BAR with bottom trawl, but this target category has waned in importance with the increase in GUR targeting. The remaining target fisheries taking gurnard include RCO, TAR and BAR. The spatial pattern of targeting among the Statistical Regions in the GUR 7 bottom trawl catch differs somewhat between the WCSI and Cook Strait (Figure 11). FLA dominates in both areas but the increase in GUR targeting appears to be relatively more important on the WCSI (Table C.2A-D, Figure 11).
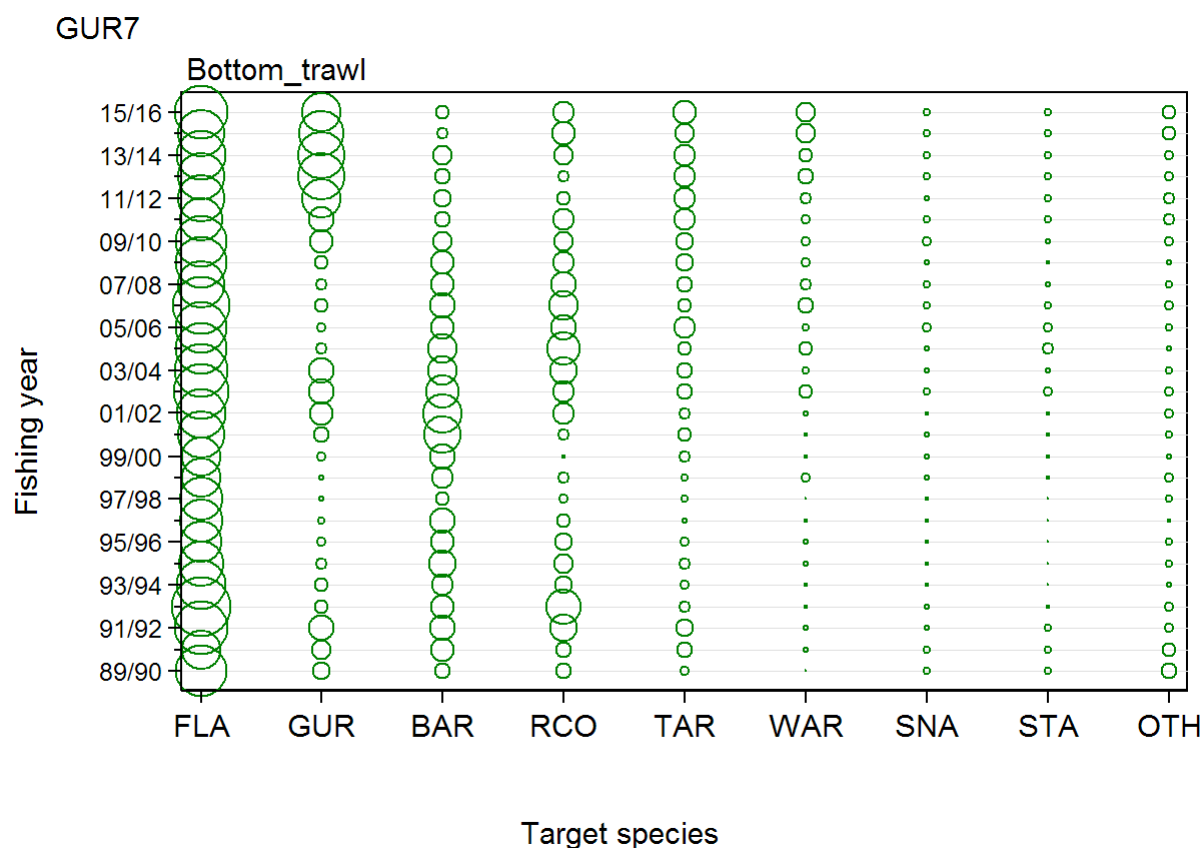

Figure 10:   **Distribution of bottom trawl landings by target species and fishing year from trips which landed GUR 7. Circles are proportional to the catch totals by target species and fishing year: largest circle= 463 t in 92/93 for FLA.**

Table 11: Distribution of bottom trawl landings (%) for gurnard by month and fishing year from trips which landed GUR 7, from 1989–90 to 2015–16. The final column shows the total GUR 7 BT landings by fishing year.

| Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89/90	1.2	8.1	6.0	6.0	11.6	13.0	10.4	6.9	15.6	7.4	8.4	5.5
90/91	8.7	10.1	5.3	8.8	8.4	10.9	8.4	11.8	9.5	8.7	4.5	4.8
91/92	3.4	8.4	6.1	3.6	2.0	6.2	16.0	15.5	18.1	10.2	2.8	7.7
92/93	7.4	12.4	7.3	2.7	10.6	12.1	8.5	9.5	4.0	14.2	4.8	6.6
93/94	4.1	13.9	9.4	3.7	6.1	7.9	9.7	8.7	14.3	11.3	5.7	5.2
94/95	13.6	7.2	16.8	9.1	3.7	6.9	6.4	9.5	9.6	8.0	5.2	3.8
95/96	8.5	11.8	5.4	8.1	2.7	3.0	13.5	9.9	12.7	11.6	7.2	5.6
96/97	7.1	10.2	11.3	6.8	3.2	4.3	8.5	11.3	11.3	13.0	7.8	5.0
97/98	8.2	10.2	8.2	2.7	2.4	2.4	13.7	14.3	14.5	12.1	7.6	3.8
98/99	4.3	14.7	7.6	10.1	9.1	7.6	8.3	9.5	9.5	7.6	6.7	4.9
99/00	6.0	8.5	6.9	5.0	4.3	6.6	6.1	11.1	10.4	12.4	13.3	9.3
00/01	5.7	10.3	9.9	5.2	5.8	8.7	8.7	12.2	10.0	10.0	3.8	9.8
01/02	16.6	12.4	11.8	10.5	7.4	7.0	9.7	6.5	3.7	6.0	5.7	2.8
02/03	11.2	10.6	9.7	7.8	7.5	9.5	19.5	8.3	2.6	5.0	5.2	3.2
03/04	12.2	17.8	11.7	3.2	4.2	7.9	9.5	9.4	5.1	8.1	5.8	5.2
04/05	8.4	16.7	9.3	13.8	7.8	6.3	6.5	5.4	7.3	6.2	4.5	7.8
05/06	12.8	15.4	11.4	4.6	5.5	8.4	5.1	10.2	7.3	7.4	7.1	4.7
06/07	5.1	11.6	10.0	11.4	9.5	10.3	7.1	11.6	8.0	8.2	3.3	3.9
07/08	5.7	14.2	10.6	10.7	5.6	9.6	10.0	9.6	7.6	7.5	4.6	4.3
08/09	8.1	9.0	6.0	6.0	9.2	8.5	8.7	10.0	12.8	11.5	5.3	5.0
09/10	10.2	12.0	5.6	6.4	6.7	7.7	7.5	8.4	11.5	12.3	5.6	6.0
10/11	9.1	12.7	10.1	4.5	3.6	5.9	8.5	10.9	9.9	7.7	9.7	7.5
11/12	7.0	9.8	7.0	5.7	3.1	15.8	8.4	8.1	8.4	11.3	9.6	5.7
12/13	5.4	10.1	8.1	4.3	5.2	11.0	10.7	10.3	9.8	8.3	8.6	8.1
13/14	4.4	9.7	10.2	4.1	12.1	15.5	14.3	9.0	5.4	5.2	5.0	5.1
14/15	9.3	7.2	11.9	6.4	11.3	12.6	6.9	5.6	7.9	6.2	6.1	8.8
15/16	9.0	14.2	8.4	9.9	14.2	5.4	3.8	3.7	7.2	7.8	7.5	8.9
Average	8.0	11.5	9.1	6.7	7.2	9.0	9.5	9.2	8.9	8.8	6.1	6.0
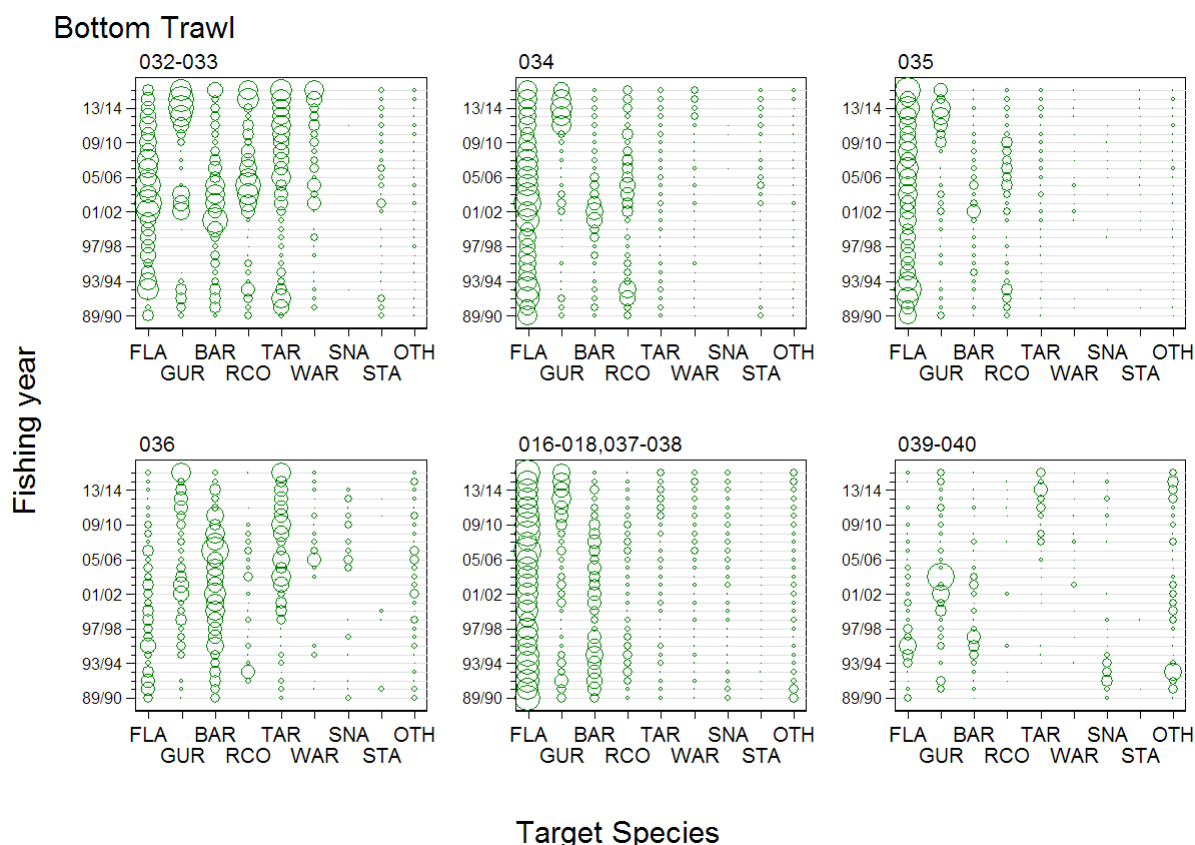
Figure 11: **Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for bottom trawl in the six statistical area groups based on trips which caught GUR 7. Circle sizes are proportional within each panel: [032-033]: largest circle= 56 t in 02/03 for FLA; [034]: largest circle= 184 t in 02/03 for FLA; [035]: largest circle= 111 t in 92/93 for FLA; [036]: largest circle= 19 t in 06/07 for BAR; [016-018,037-038]: largest circle= 185 t in 06/07 for FLA; [039-040]: largest circle= 10 t in 03/04 for GUR. These plot data are tabulated in Table C.2A-C.**

2.3.3.6 Preferred bottom trawl fishing depths for gurnard

Depth information is available from TCEPR and TCER forms which report bottom trawl catches pertaining to gurnard (either recording an estimated catch of gurnard or declaring gurnard as the target species). These data come either from the recently introduced (1 October 2007) TECR forms or the longstanding TCEPR forms, which are primarily used by the larger offshore vessels but have been in operation since the first year of data in this report (1989–90). Ninety-five percent of the depth observations reported in Table 13 originate from the TCER forms, accumulated over nine years. The remaining 5% of the trawl returns are on the older TCEPR forms. This predominance of TCER reports reflects the inshore nature of the gurnard bottom trawl fisheries.

Reported depth observations, summarised over both form types, show that target gurnard bottom trawl fishing tends to be shallow for all target species, ranging from a minimum 5% quantile of 10 m for FLA and SNA to a maximum upper 95% quantile of 173 m for TAR (Table 13). The distribution of tows which caught or targeted gurnard varies about a median of 31 m, with the depth range for TAR, BAR, JDO and STA being somewhat deeper than the other target species (Figure 12).

Table 12: Distribution (%) for bottom trawl gurnard landings by target species and fishing year from trips which landed GUR 7, from 1989–90 to 2015–16.

Year	FLA	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	67.4	7.9	6.6	6.3	2.1	0.1	1.8	1.7	5.9
90/91	48.1	11.2	17.0	6.7	7.1	1.2	1.6	1.5	5.6
91/92	51.6	11.4	12.5	14.9	5.8	0.7	0.7	0.9	1.5
92/93	61.2	3.4	9.5	20.4	2.4	0.4	0.7	0.2	1.8
93/94	67.9	5.7	12.6	8.6	3.2	0.3	0.5	0.1	1.0
94/95	59.0	3.5	20.2	10.4	3.7	1.3	0.4	0.1	1.4
95/96	59.8	3.8	18.7	11.0	3.2	1.1	0.4	0.1	1.9
96/97	65.5	2.7	21.3	6.9	1.5	0.8	0.5	0.1	0.7
97/98	79.5	1.2	8.7	5.0	2.2	0.3	0.4	0.2	2.3
98/99	61.8	1.5	19.0	5.9	2.9	3.5	1.1	0.4	4.0
99/00	60.5	3.2	26.4	0.7	5.2	0.7	1.2	0.7	1.4
00/01	53.0	5.8	31.5	3.0	4.0	0.5	0.8	0.3	1.1
01/02	45.7	10.5	29.4	8.7	2.6	0.6	0.2	0.3	2.0
02/03	51.4	10.6	17.8	7.7	4.6	3.3	0.8	1.9	1.9
03/04	51.6	11.2	15.6	13.2	4.7	1.3	0.7	0.7	1.0
04/05	49.4	2.3	17.6	20.0	3.6	3.3	0.7	2.3	0.9
05/06	55.0	2.3	11.9	14.4	9.8	1.6	1.8	2.2	1.2
06/07	57.6	3.6	11.5	15.0	3.9	4.4	1.1	1.3	1.6
07/08	54.2	3.4	13.7	16.0	5.8	3.2	1.6	0.7	1.4
08/09	60.7	4.0	12.1	11.4	7.1	2.6	0.7	0.5	0.9
09/10	56.6	12.6	8.0	8.6	7.1	2.3	2.1	0.6	2.1
10/11	45.4	17.2	5.9	12.5	10.4	2.6	1.8	1.1	3.0
11/12	43.9	29.4	5.7	4.1	9.1	3.2	0.7	1.6	2.4
12/13	37.8	39.6	4.2	2.4	8.5	3.9	1.0	0.9	1.7
13/14	38.1	36.1	5.8	5.7	7.8	2.8	1.2	1.2	1.5
14/15	36.3	33.2	2.7	9.0	6.8	6.7	1.2	1.0	3.2
15/16	45.0	24.9	3.1	7.7	8.9	6.0	0.8	1.0	2.6
Average	52.3	13.0	12.8	9.9	5.6	2.4	1.0	0.9	2.0
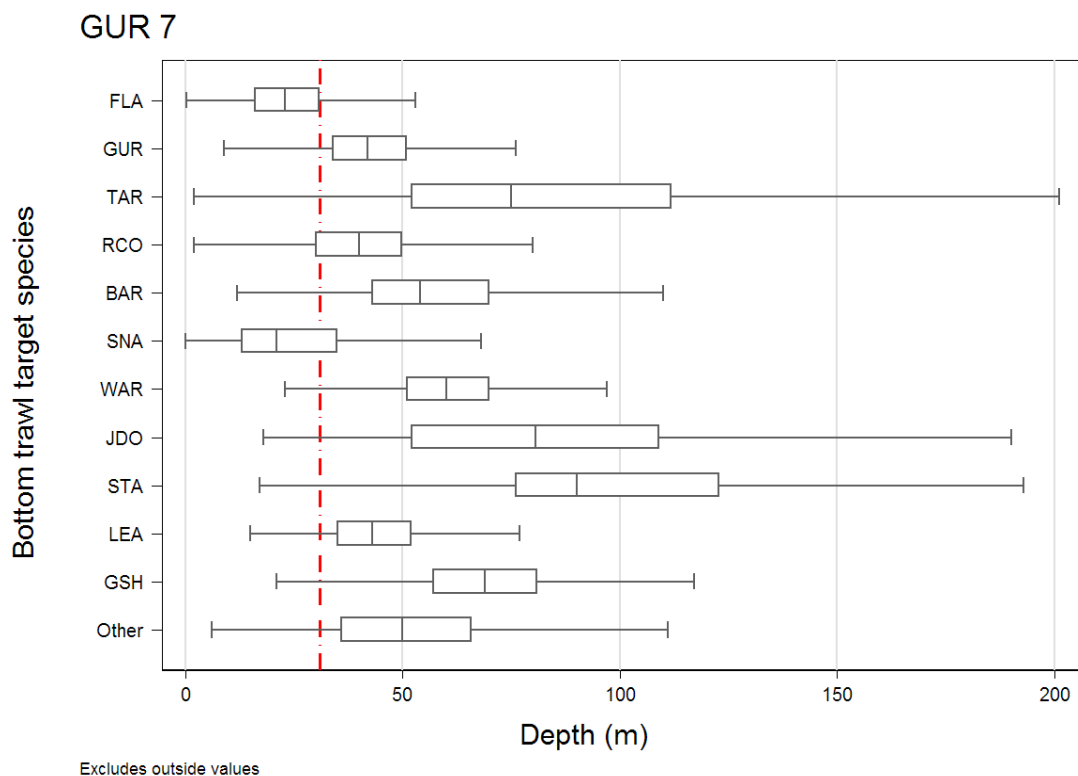
Figure 12: Box plot distributions for GUR 7 of bottom depth from combined TCER and TCEPR form types for effort that targeted or caught gurnard by target species category for the period 2007–08 to 2015–16. Vertical line indicates the median depth from all tows which caught or targeted gurnard.

Table 13: Summary statistics for GUR 7 from distributions from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught gurnard by target species category. Data are summarised by QMA from 2007–08 to 2015–16.

Target species category	Number observations	Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Depth (m) Upper 95% of distribution
FLA	50 943	10	24	23	44
GUR	10 291	20	44	42	73
TAR	9 856	30	86	75	173
RCO	4 852	17	44	40	86
BAR	4 174	30	63	54	136
SNA	2 561	10	28	21	71
WAR	2 467	35	68	60	146
JDO	1 402	35	83	81	137
STA	1 101	52	100	90	158
LEA	791	27	45	43	70
GSH	608	30	70	69	105
Other	953	15	57	50	117
Total	89 999	10	40	31	107

3. WEST COAST SOUTH ISLAND SURVEY

A research trawl survey has operated off the west coast of the South Island and in Tasman/Golden Bays since 1992 (Table 14; Figure 13). It operates from the Haast River in the south to Cape Farewell at the northern end of the South Island west coast. The depths covered in the west coast strata range from 20 m to 400 m south of Cape Foulwind, 25–400 m from Cape Foulwind to Karamea and 20–200 m from Karamea to Cape Farewell. The survey also covers strata in the Tasman/Golden Bays inside a line drawn from Farewell Spit to Stephens Island in the outer Marlborough Sounds. These strata cover a depth range of 20–70 m. Gurnard is one of the six target species considered in the design of this survey. Note that the outer limit of the Tasman/Golden Bays survey strata approximates the line between Areas 038 and 037 shown in Figure 7 and Appendix B. Figure 7 also shows a considerable amount of catch success for gurnard on the outside of this line in Area 037, indicating that this survey is probably not indexing all of the gurnard population in western Cook Strait.

Gurnard biomass estimates from this survey have been relatively elevated for the last three surveys (2011, 2013 and 2015), with the 2015 survey recording a biomass nearly three times the geometric mean of the 12 biomass estimates from 1991 to 2015 (Table 14; Figure 13). The preliminary estimate for gurnard from the recently completed 2017 survey was almost the same as the 2015 estimate (Table 14). Gurnard biomass estimates are much larger on the WCSI than in Tasman/Golden Bays, which is unsurprising, given the much larger size of the west coast strata and the deeper depths being monitored. However, apart from two years, the relative index in the two regions of this survey are not that different when they are put on the same scale (Figure 14). It can be seen that the 1995 and 2007 surveys diverge between the WCSI and Tasman/Golden Bays strata, with each region going in the opposite direction in those years. The remaining years all move in a similar direction and the overall trend is very similar between the two regions (Figure 14). A comparison of recruited with total gurnard biomass trends shows no difference on the WCSI when each series is given a consistent mean (Figure 15, left panel). There is more difference between total and recruited biomass in the Tasman/Golden Bays strata (Figure 15, right panel), but these differences can be attributed to the greater sampling variation in the smaller region which does not sample the full depth range for gurnard.

Previously, the SINSWG has chosen to use only the WCSI strata from this survey (see Section 4 following and MPI 2016). However, when the plots in Figure 14 and Figure 15 were reviewed in 2017, the SINSWG agreed to use the total recruited biomass index from all surveyed strata, given that there is little contradiction between the survey indices when treated as relative indices (MPI 2017).

Stevenson & MacGibbon (2015) reviewed all WCSI biomass estimates for outliers in catchability using the method of Francis et al. (2001). They concluded that the 2003 WCSI estimate was an outlier showing extreme low catchability, but that all other survey estimates were within the expected tolerance. On the basis of this analysis, the 2017 Plenary agreed to exclude the 2003 biomass estimate from the series (MPI 2017).
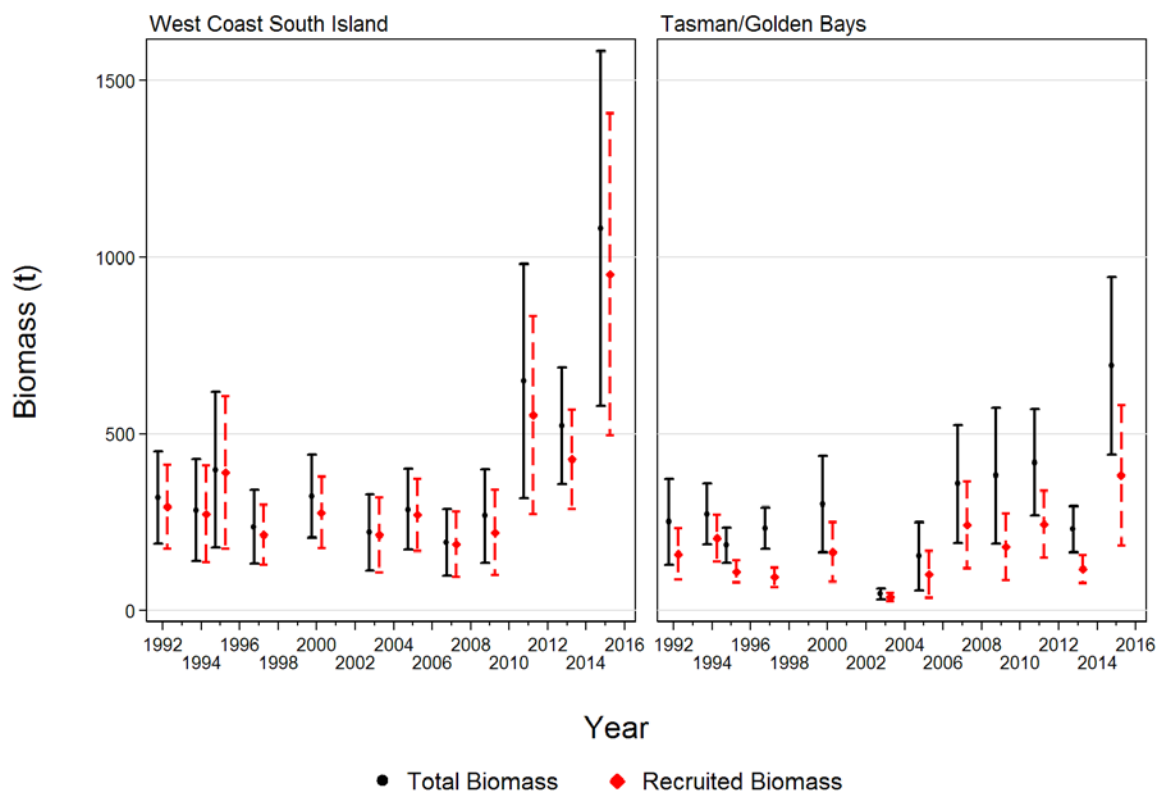

Figure 13: **Plots of the total and recruited (>30 cm) biomass of gurnard for two sections of the west coast South Island survey: [left panel]: the west coast of the South Island strata; [right panel]: the Tasman/Golden Bays strata. Plotted data are presented in Table 14.**

Table 14: **Biomass and CV estimates for the MPI West Coast South Island survey, showing estimates for the west coast only (WCSI), the combined Tasman-Golden Bays strata (TBGB) and the total survey, using all strata from 30–400 m. 'Rec': recruited biomass (>30 cm).**

	Biomass (t)						CV (%)					
	WCSI		TBGB		Total Survey		WCSI		TBGB		Total Survey	
Year	Total	Rec	Total	Rec	Total	Rec	Total	Rec	Total	Rec	Total	Rec
1992	320.7	294.0	251.8	160.0	572.5	454.0	20.4	20.4	24.3	22.7	15.6	15.4
1994	284.9	273.6	273.9	204.7	558.7	478.3	25.2	25.1	15.7	16.3	15.0	16.0
1995	398.7	390.3	184.9	111.3	583.6	501.6	27.6	27.6	13.7	14.2	19.4	21.7
1997	237.0	214.9	233.5	94.9	470.5	309.8	21.9	19.9	12.5	14.6	12.7	14.5
2000	323.7	278.0	301.1	166.0	624.7	444.0	18.1	18.3	22.7	25.5	14.4	14.9
2003#	222.6	215.0	47.0	38.7	269.6	253.7	24.2	24.6	16.1	13.9	20.2	20.9
2005	286.7	271.8	154.9	102.9	441.6	374.7	20.0	18.8	31.2	31.8	17.0	16.2
2007	193.8	188.8	359.1	242.8	552.9	431.6	24.6	24.6	23.2	25.4	17.4	17.9
2009	268.2	220.5	382.4	179.8	650.6	400.4	24.7	27.3	25.1	26.3	17.9	19.1
2011	650.2	553.7	419.4	244.8	1069.5	798.6	25.5	25.4	18.0	19.4	17.0	18.6
2013	523.5	428.4	230.3	118.0	753.8	546.5	15.8	16.4	14.2	17.0	11.8	13.4
2015	1082.3	952.1	693.5	383.1	1775.8	1335.2	23.2	24.0	18.1	25.9	15.8	18.6
2017[1]	–	–	–	–	1705.3	1349.4	–	–	–	–	12.4	11.9

[1] These are preliminary estimates (sub-region estimates not available)
this survey index has been excluded due to a large negative change in catchability (Stevenson & MacGibbon 2015)
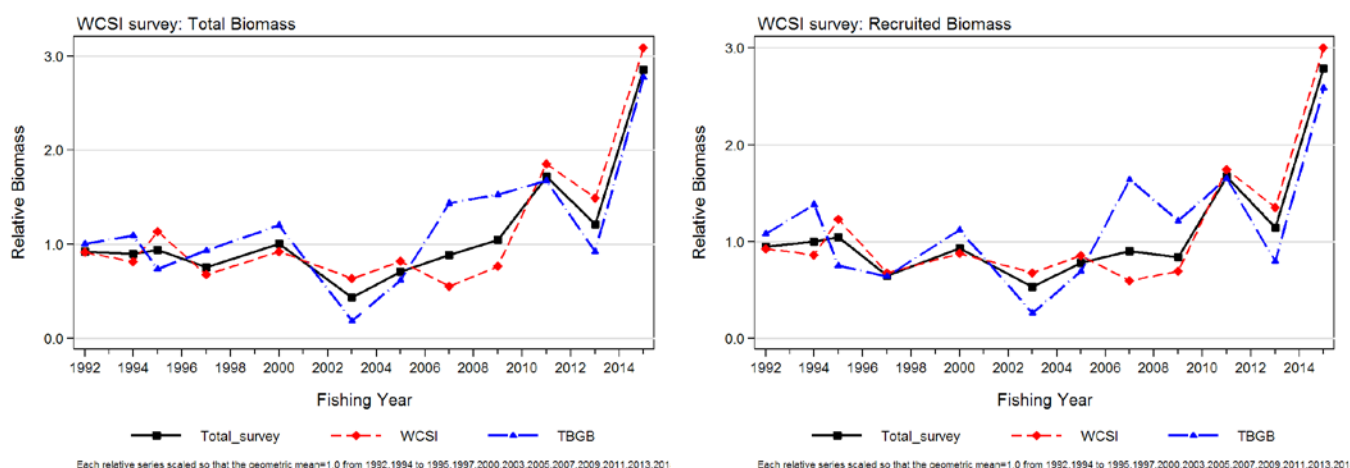

Figure 14: Comparative plots of three sets of WCSI survey estimates: a) total survey; b) WCSI strata; c) Tasman/Golden Bays strata: [left panel]: total biomass estimates; [right panel]: recruited biomass estimates. Each series has been standardised to a common geometric mean.
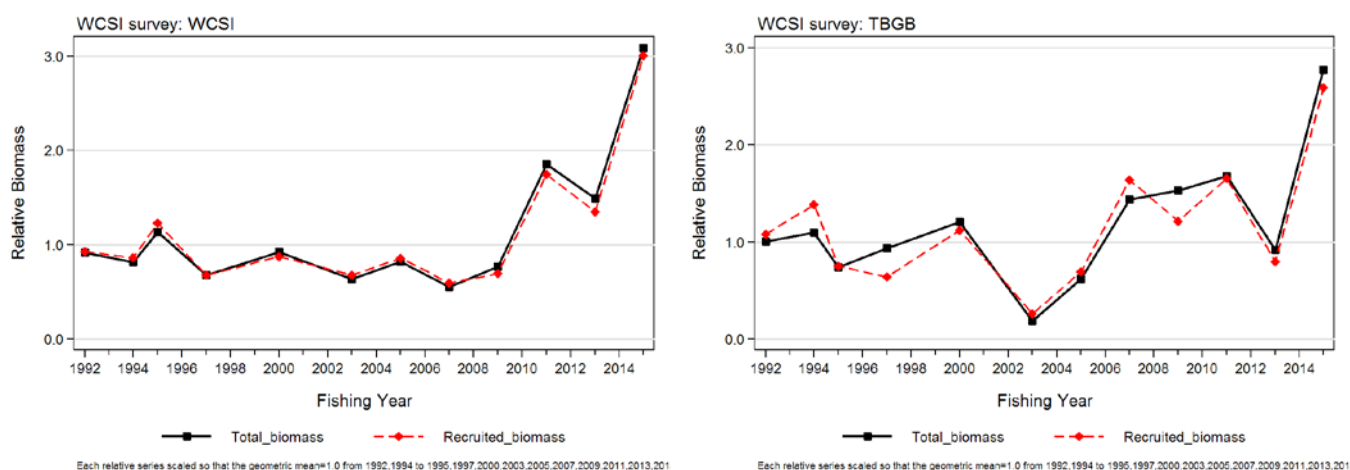

Figure 15: Comparative plots of total and recruited biomass for two regions of the WCSI trawl survey: [left panel]: WCSI strata; [right panel]: Tasman/Golden Bays strata. Each series has been standardised to a common geometric mean.

4. STANDARDISED CPUE ANALYSIS

4.1 GUR 7 Plenary report

The following quotation, taken from the 2016 MPI Plenary Report (MPI 2016), summarises the SINSWG interpretation of the four GUR 7 CPUE series, as they stood after the 2014 review (Langley 2014):

> *In 2011, the Working Group accepted four standardised CPUE series for GUR 7 based on the bycatch of red gurnard in bottom trawl fisheries defined by different target species combinations in two different sub-areas: west coast South Island (Statistical Areas 033, 034, 035, 036) and Tasman Bay/Golden Bay and Cook Strait (038, 017, 018 and 039) (Kendrick et al. 2011). The four CPUE data sets are defined in Table 8* [reproduced in Appendix E].
>
> *In 2014, these four CPUE analyses were updated with data from 1989–90 to 2012–13 (Langley 2014). These analyses also included several refinements to improve the comparability between the data collected from two statutory reporting forms (CELR and TCER) which collect data at different levels of detail (daily and by tow), including the approach used to apportion red gurnard landed catches from individual fishing trips to the associated fishing effort records and the daily aggregation of fishing effort. These refinements*

in data processing resulted in no appreciable change in the resulting CPUE indices for the corresponding period.

The 2014 CPUE analyses used the equivalent model formulations to the previous analyses (dependent and explanatory variables and error structure) (Kendrick et al 2011).

The two sets of CPUE indices from the west coast South Island fisheries show similar cyclical trends with relatively high CPUE indices during 1990–91 to 1991–92 and 2001–02 to 2003–04 and relatively low CPUE indices in 1993–94 to 1999–2000 and 2006–07 to 2010–11. The CPUE indices steadily increased from 2009–10 to a relatively high level in 2012–13.

The trawl survey biomass estimates of recruited (at least 30 cm T.L.) red gurnard from the west coast component of the WCSI Trawl Survey do not exhibit the same cyclical trends as seen in the CPUE indices; however, the high biomass estimates from the two recent trawl surveys (2011 and 2013) are consistent with the recent increase in the CPUE.

The trends in CPUE indices from the northern areas (TB/GB and Cook Strait) of GUR 7 are considerably different from the WCSI CPUE. For the northern areas, the TBCS_BT_MIX CPUE indices during 1989–90 to 2005–06 tended to follow the trend in the TBGB_BT_FLA CPUE indices with a lag of about 2 years. However, in the subsequent years (2006–07 to 2012–13) the two sets of indices have shown divergent trends. There was a marked decline in the level of red gurnard catch from the TBCS mixed trawl fishery between 2006–07 and 2012–13. In 2010–11 to 2012–13 that mixed fishery accounted for a very small proportion of the total GUR 7 catch. Since 2007–08, there was also a marked shift in the spatial distribution of fishing effort in the TBCS fishery with a reduction in the proportion of fishing effort within the areas of higher red gurnard catch rates and a shift towards trawling in deeper waters. On that basis, the 2014 Working Group rejected the TBCS_BT_MIX CPUE index as an index of abundance for GUR 7.

The TBGB_BT_FLA CPUE indices were relatively low during 1995–96 to 1998–99, increased in 1999–2000 and remained relatively stable at about that level until 2007–2008. From 2007–08 to 2012–13, the CPUE indices have tended to increase, although the recent increase may be partly attributable to an increase in the proportion of fishing effort within the shallower areas of TB/GB that tend to have a higher catch rate of red gurnard. Because of this effect and the lack of correspondence with the TBGB WCSI trawl survey results (see next paragraph), the 2014 WG discounted the utility of this CPUE series.

The time series of trawl biomass estimates of recruited (at least 30 cm T.L.) red gurnard from the Tasman Bay/Golden Bay strata of the west coast South Island inshore trawl survey time series varies considerably among surveys and the biomass estimates are not well correlated with the corresponding CPUE indices (TBGB_BT_FLA). There is no persistent trend in the trawl survey biomass estimates and recent (2011 and 2013) biomass estimates are at about the average level for the time series.

4.2   Review of existing GUR 7 CPUE series

The GUR 7 CPUE series described in the 2016 Plenary Report (MPI 2016 and quoted above) were reviewed before repeating the analyses (Appendix E). This review indicated that there were some problematic aspects to the existing series which should be corrected before proceeding with fresh analyses. Appendix E describes these issues, suggests likely improvements and offers information in support of making these improvements, all of which were accepted by the SINSWG. However, none of these changes appreciably changed the interpretation of the original analyses (see Sections 4.3.1 to 4.3.4 and Figure 16 to Figure 20).

4.3 Revised GUR 7 CPUE series

The following selection criteria were used for defining the six bottom trawl fisheries described in this report:

Model	Target species	Statistical Areas	Core Fleet Definition	Document Reference
WCSI(FLA)	FLA	033–036	5 years with 5+ trips	Appendix G
WCSI(MIX)	GUR, RCO, BAR, TAR, WAR, STA	033–036	5 years with 5+ trips	Appendix H
TBGB(FLA)	FLA	017, 037–038	5 years with 10+ trips	Appendix I
TBGB(MIX)	GUR, BAR, TAR, WAR, RCO, SNA	017, 037–038	5 years with 5+ trips	Appendix J
CookSt(FLA)	FLA	017, 037–040	5 years with 10+ trips	Appendix K
CookSt(MIX)	GUR, BAR, TAR, TRE, WAR, SNA	017, 037–040	5 years with 5+ trips	Appendix L

All series used the lognormal distribution for the positive catch model. A binomial model based on the presence/absence of gurnard in each data set was also calculated, with the two models combined using the delta-lognormal method (Eq. F.4) to provide the final series. Each of the indicated Appendices in the above table provide detailed tables and figures with statistics and diagnostics, along with final tables giving the estimated indices with the lognormal standard error.

4.3.1 WCSI(FLA)

Almost all trips and daily strata in the core vessel data set for this fishery captured gurnard (Table G.1). There was a strong increase in the number of events per stratum after the introduction of the new TCER forms in 2007–08 (lower right panel, Figure G.2) but there was a reasonably consistent mean number of tows and mean duration per day of fishing across the 27 years of data (upper right panel, Figure G.2). The lognormal positive catch model explained 46% of the deviance (Table G.2), with vessel and number tows entering the model after fishing year. The standardisation effect is strong in recent years, with the rising CPUE in recent years downgraded because of the high catch rates estimated for the remaining vessels in the fleet (Figure G.6). The model fits the lognormal distribution well (Figure G.5), with the series showing a peak in the early 2000s, followed by a nadir in 2009–10 and an increasing trend since then (Figure G.3). The explanatory variable [*area*] did not meet the 1% R^2-improvement threshold for the lognormal model. Consequently there is no implied residual plot for areaxyear. The binomial model accepted vessel, number of tows and month into the model but only explained 14% of the deviance (Table G.3). The standardisation effect for this model is smaller than for the lognormal model, with the recent vessel effect showing a relative drop for the presence/absence of GUR, possibly compensating for avoidance behaviour (Figure G.9, Figure G.10).
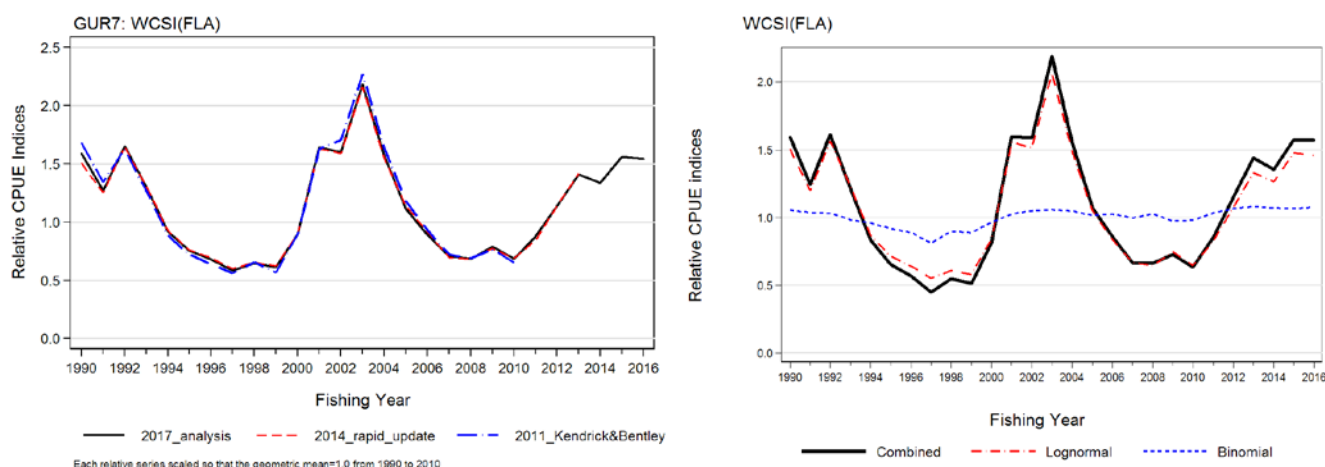

Figure 16: [left panel]: comparison of the standardised lognormal CPUE analysis prepared for this report with the equivalent WCSI(FLA) series prepared by Langley(2014) and Kendrick et al. (2011); [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(FLA) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).

There is nearly perfect correspondence between the updated lognormal series and the equivalent series presented by Langley (2014) and Kendrick et al. (2011) (left panel, Figure 16). This is likely to be because no changes were proposed in Appendix E to the selection criteria used to define this analysis. The effect of combining the lognormal model with the binomial model is small (right panel, Figure 16) because of the very high proportion of trips which landed gurnard and the consequent flat trend in the binomial series (see Table G.1).

4.3.2   WCSI(MIX)

Most trips and daily strata in the WCSI(MIX) core vessel data set captured gurnard. While the percentage of trips with gurnard are lower than for the WCSI(FLA) fishery, there is no apparent trend in capture success (Table H.1). There was a strong increase in the number of events per stratum after the introduction of the new TCER forms in 2007–08 (lower right panel, Figure H.2) but the mean number of tows/day are relatively constant over the 27 years of data while there is an increasing trend in the mean duration/day of fishing (upper right panel, Figure H.2). The lognormal positive catch model explained 38% of the deviance (Table H.2), with target species, month, number tows and vessel entering the model after fishing year. The standardisation effect is relatively strong in recent years, with the rising CPUE in recent years downgraded because of the switch to GUR target fishing (Figure H.6). The model fits the lognormal distribution reasonably well (Figure H.5), with the series showing a peak in the early 2000s, followed by a nadir in 2009–10 and an increasing trend to 2011–12 (Figure H.3). The explanatory variable [area] did not meet the 1% R^2-improvement threshold for the lognormal model. Consequently there is no implied residual plot for area × year. There is good correspondence with the model year effect for the implied residuals among all of the target species categories (Figure H.10). The binomial model accepted target, vessel and month into the model but only explained 17% of the deviance (Table H.3). As seen in the WCSI(FLA) model, the standardisation effect for this model is smaller than for the lognormal model (Figure H.12). The model appears to adjust the presence/absence trend downward in recent years because of the increasing targeting of GUR (Figure H.13), while there is a slight upward adjustment with the addition of the [vessel] explanatory variable, similar to what was observed for the WCSI(FLA) model (Figure H.14). As seen in the lognormal model, there is good correspondence with the model year effect for the implied residuals among all of the target species categories (Figure H.16).
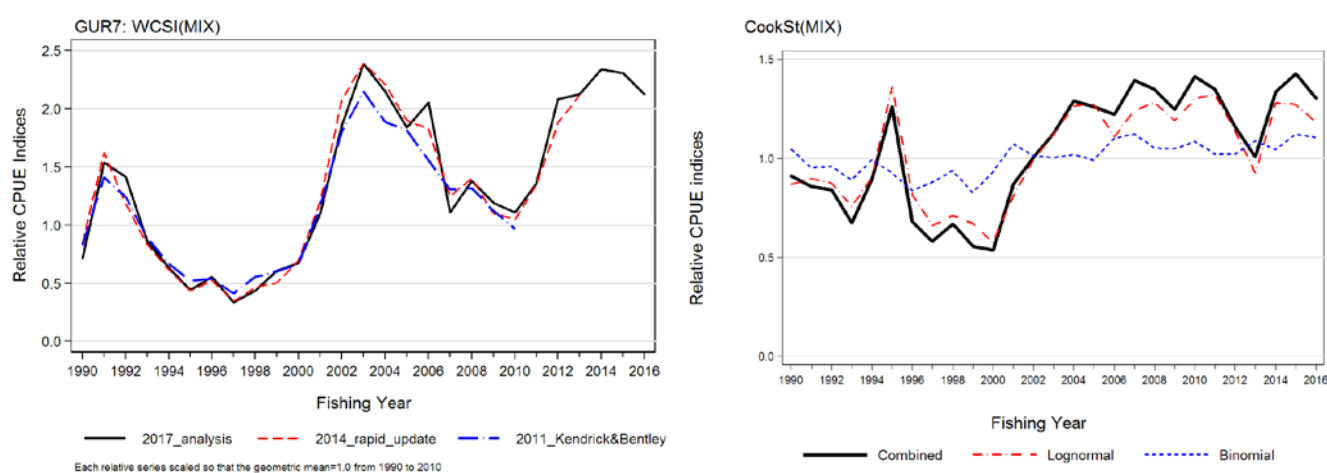

Figure 17:   **[left panel]: comparison of the standardised lognormal CPUE analysis prepared for this report with the equivalent WCSI(MIX) series prepared by Langley(2014) and Kendrick et al. (2011); [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(MIX) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).**

The updated lognormal series compares well with the equivalent series presented by Langley (2014) and Kendrick et al. (2011) (left panel, Figure 17). The only change in the selection criteria for this

analysis proposed in Appendix E was the addition of GUR to the list of target species which only appears to affect the more recent indices, as it compensates for the recent increase in GUR targeting (see Figure H.13). The effect of combining the lognormal model with the binomial model is to slightly lift the CPUE indices from the mid-2000s (right panel, Figure 17), probably resulting from the gradual increasing trend in the binomial series.

4.3.3   TBGB(FLA)

There is a relatively high percentage of trips and daily strata which capture gurnard in this fishery, with values over 90% in every year from 2001–02 (Table I.1). However, there are years in the mid-1990s where the percentage of trips with gurnard drops to below 80%. As in the previous two fisheries, there was a strong increase in the number of events per stratum after the introduction of the new TCER forms in 2007–08 (lower right panel, Figure I.2) but there was a reasonably consistent mean duration per day of fishing and a declining number of tows per stratum across the 27 years of data (upper right panel, Figure I.2). The lognormal positive catch model explained 43% of the deviance (Table I.2), with vessel and number tows entering the model after fishing year. The standardisation effect is moderate in recent years, with the rising CPUE in recent years upgraded with the addition of number tows to the model because of apparently shorter tows (Figure I.7). The model fits the lognormal distribution well (Figure I.5), with the series showing a minor peak in the early 2000s, followed by an increasing trend since then (Figure I.3). The implied residual plot for area × year is dominated by Area 038, where most of the data lie (Figure I.8). Area 017 also shows a similar year effect but Area 037 is less convincing. The binomial model accepted vessel and area into the model and explained 31% of the deviance (Table I.3).

The updated lognormal series compares reasonably well with the equivalent series presented by Langley (2014) and Kendrick et al. (2011) (left panel, Figure 18), except it is lower in the early 1990s and higher in the early 2000s. There were several changes in the selection criteria for this analysis proposed in Appendix E, with the dropping of RCO in the target species definition and the addition of Area 037. The effect of combining the lognormal model with the binomial model is to lift the CPUE indices from the late-2000s (right panel, Figure 18), which is likely to be resulting from the gradual increase in the binomial series. This analysis was not accepted for monitoring GUR 7 in 2017.
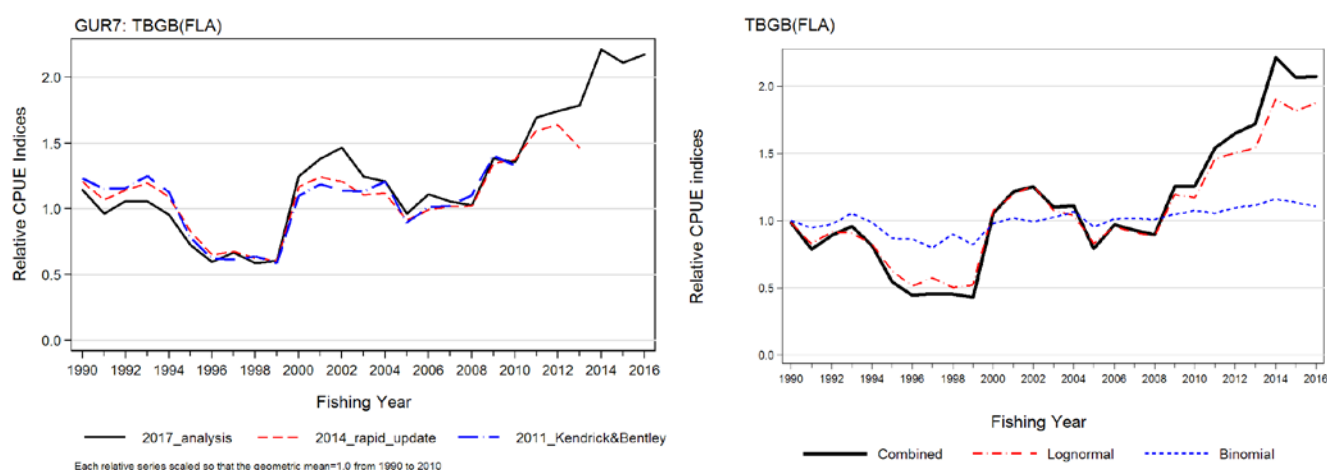

Figure 18:   **[left panel]: comparison of the standardised lognormal CPUE analysis prepared for this report with the equivalent TBGB(FLA) series prepared by Langley(2014) and Kendrick et al. (2011); [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(FLA) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).**

4.3.4 TBGB(MIX)

Sixty to eighty percent of trips and daily strata in the core vessel data set for this fishery captured gurnard, but there is no apparent trend (Table J.1). There was a strong increase in the number of events per stratum after the introduction of the new TCER forms in 2007–08 (lower right panel, Figure J.2) but there was a reasonably consistent mean number of tows and mean duration per day of fishing across the 27 years of data (upper right panel, Figure J.2). The lognormal positive catch model explained 45% of the deviance (Table J.2), with area, target, duration and vessel entering the model after fishing year. The standardisation effect is relatively strong in the mid-2000s, with the peak CPUE in those years downgraded because of an even greater predominance of fishing in Area 038 (Figure J.6). The model fits the lognormal distribution reasonably well (Figure J.5), with the series showing a rising trend from the early 2000s up to a peak in 2009–10, followed by a strong drop to 2012–13 and no change since then (Figure J.3). The implied residual plot for area×year is dominated by Area 038, with the other areas showing only moderate similarity to the overall year trend (Figure J.10). The residual implied coefficients for the six target species categories show poor correspondence to the overall year effect for TAR and WAR, species with relatively few observations (Figure J.11). The other species are more credible in their correspondence with the overall year trend. The binomial model accepted target, area and vessel into the model and explained 26% of the deviance (Table J.3).

The updated lognormal series has the same form as the equivalent series presented by Langley (2014) and Kendrick et al. (2011) (left panel, Figure 19), but seems less variable on a year-to-year basis. There were several changes in the selection criteria for this analysis proposed in Appendix E, with the addition of three species (RCO, GUR and SNA) to the target species definition, the addition of Area 037 and the dropping of Area 018. The effect of combining the lognormal model with the binomial model is to lift the CPUE indices from the early-2000s (right panel, Figure 19), which is likely to be resulting from the gradual increasing trend in the binomial series. This analysis was not accepted for monitoring GUR 7 in 2017.
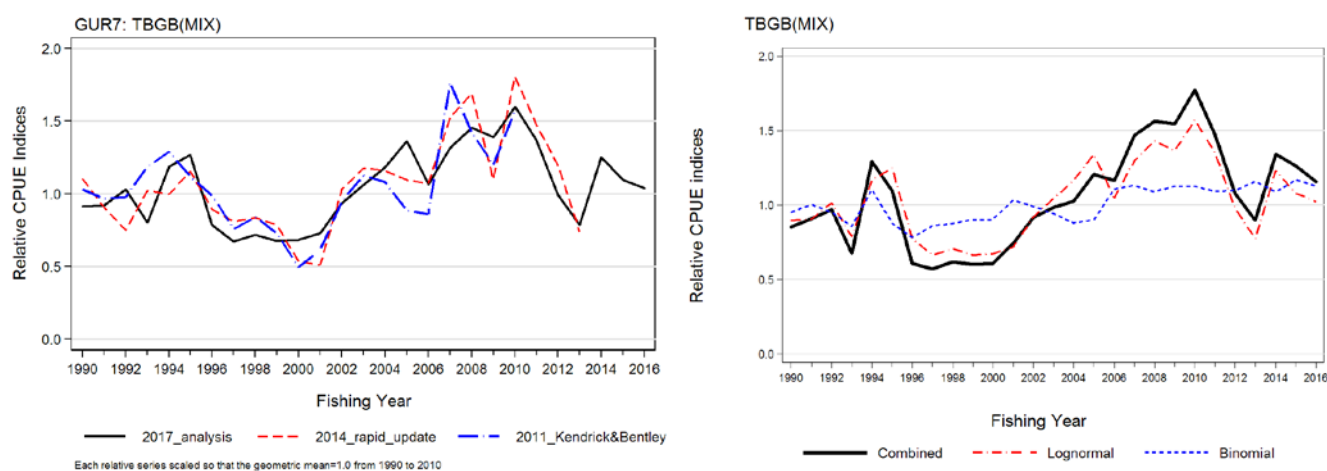

Figure 19: [left panel]: comparison of the standardised lognormal CPUE analysis prepared for this report with the equivalent TBGB(MIX) series prepared by Langley(2014) and Kendrick et al. (2011); [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(MIX) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).

4.3.5 COOKST(FLA)

This CPUE analysis is a new analysis intended to include information from the northwestern part of Cook Strait and is presented as a sensitivity analysis to the TBGB(FLA) series, with the only

difference being the addition of two statistical areas with catch from the Lower Taranaki Bight. Figure K.8 shows that very little data were added to the analysis from Area 039 and almost none from Area 040. Consequently this analysis is almost unchanged from the TBGB(FLA) analysis (left panel, Figure 20). Similarly, the combined model is also almost unchanged from the TBGB(FLA) analysis (right panel, Figure 20).

There is almost no difference between this series and the TBGB(FLA) series. Consequently the description of this series has been omitted because it would be nearly identical to TBGB(FLA) description. This analysis was not accepted for monitoring GUR 7 in 2017.
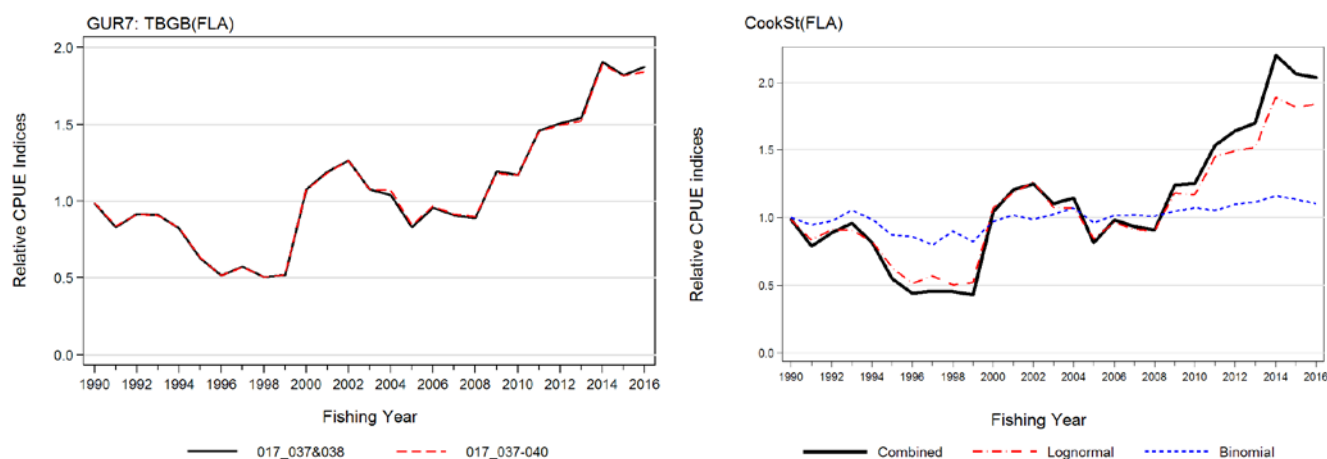

Figure 20: **[left panel]: comparison of the CookSt(FLA) lognormal series with the TBGB(FLA) lognormal series, both prepared for this report; [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the CookSt(FLA) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).**

4.3.6 COOKST(MIX)

This CPUE analysis is a new analysis intended to include information from the northwestern part of Cook Strait, and is presented as a sensitivity analysis to the TBGB(MIX) series, with the main difference being the addition of two statistical areas with catch from the Lower Taranaki Bight. The suite of target species has changed slightly from that used by the TBGB(MIX) model, by dropping RCO and adding TRE (because of the relative unimportance of RCO after extending the model to the North Island. Figure L.10 shows that Area 039 and Area 040 have added over 3600 observations to the model and this has had the effect of smoothing the series from the mid-2000s compared to the TBGB(MIX) analysis (left panel, Figure 21). The combined model is slightly lifted relative to the lognormal analysis (right panel, Figure 21).

The lognormal positive catch model explained 49% of the deviance (Table L.2), with area, target, vessel and duration entering the model after fishing year. The standardisation effect is only moderate with the final lognormal series resembling the unstandardised geometric series (Figure L.4). The model fits the lognormal distribution moderately well (Figure L.5), with the series showing a rising trend from the early 2000s up to a peak in the mid-2000s, after which there is no trend (Figure L.3). The implied residual plot for area×year is dominated by Area 038, followed by Area 037 (Figure L.10). The additional areas (039 and 040) have only moderate correspondence with the overall year trend and the correspondence for Area 017 is low (Figure L.10). The residual implied coefficients for the six target species categories show poor correspondence to the overall year effect for TAR and WAR, and only moderate correspondence for the four remaining target species categories (Figure L.11). The binomial model accepted target, area and vessel into the model and explained 31% of the deviance (Table L.3). This analysis was not accepted for monitoring GUR 7 in 2017.
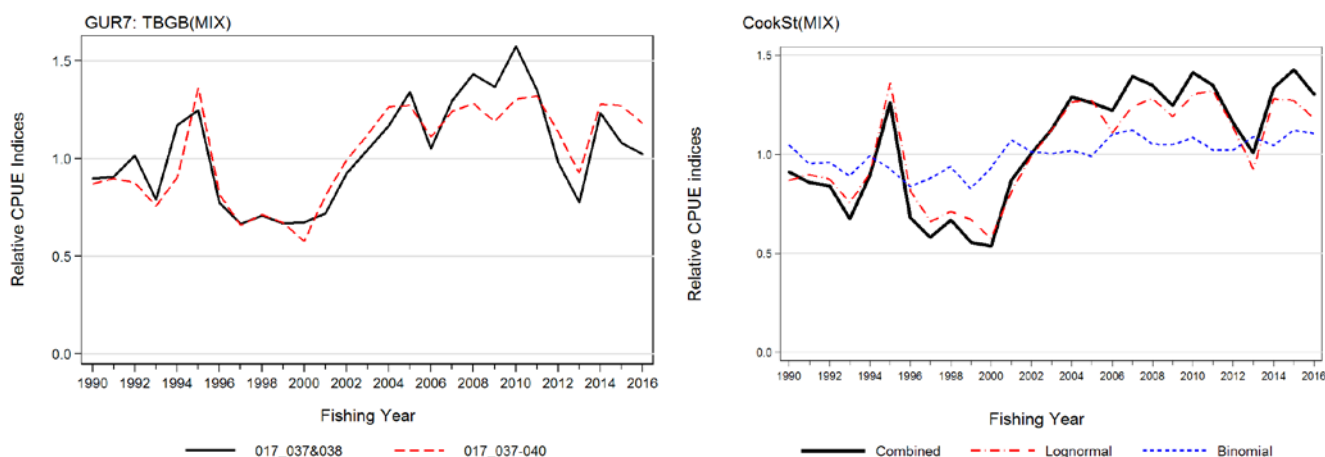
Figure 21: [left panel]: comparison of the CookSt(MIX) lognormal series with the TBGB(MIX) lognormal series, both prepared for this report; [right panel]: relative CPUE indices for gurnard using the lognormal non-zero model based on the CookSt(MIX) fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. F.4).

4.4 Comparisons with WCSI trawl survey indices

The following comparisons are made with the recruited biomass for the total WCSI survey (combined WCSI and Tasman/Golden Bays strata). This was done because the comparison plots in Figure 14 showed that the total series was consistent with both strata groupings of the WCSI survey. Using the indices based on the total survey result in a lower CV and a less variable trend.

The 2017 Plenary agreed, as noted in Section 3, that the 2003 WCSI survey index was likely to be biased low because low catchability, as reported by Stevenson & MacGibbon (2015) using the method of Francis et al (2001). Unfortunately, this is the year when the bottom trawl CPUE peaked for both WCSI(FLA) and the WCSI(MIX) (Figure 22). Figure 22 shows a reasonable degree of overlap between either of the two WCSI CPUE series and the survey biomass indices, with the exception of the 2005 and 2013 indices.
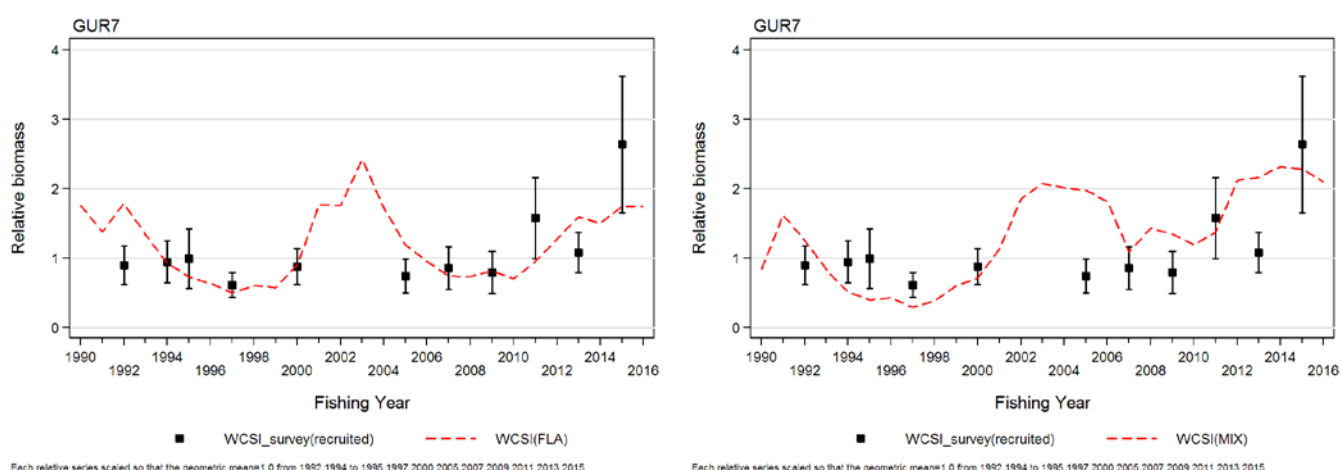

Figure 22: [left panel]: comparison of total WCSI survey (recruited biomass) with the WCSI(FLA) CPUE series (combined index); [right panel]: comparison of total WCSI survey (recruited biomass) with the WCSI(MIX) CPUE series (combined index). The 2003 WCSI recruited index has been dropped from this comparison (see discussion in Section 3).

The TBGB(FLA) CPUE series comes the closest to matching the WCSI trawl survey indices, although the recent indices are not as strong as the those from the survey (left panel, Figure 23). Conversely, the TBGB(MIX) index does not match the recent indices from the WCSI trawl survey indices (right panel, Figure 23).
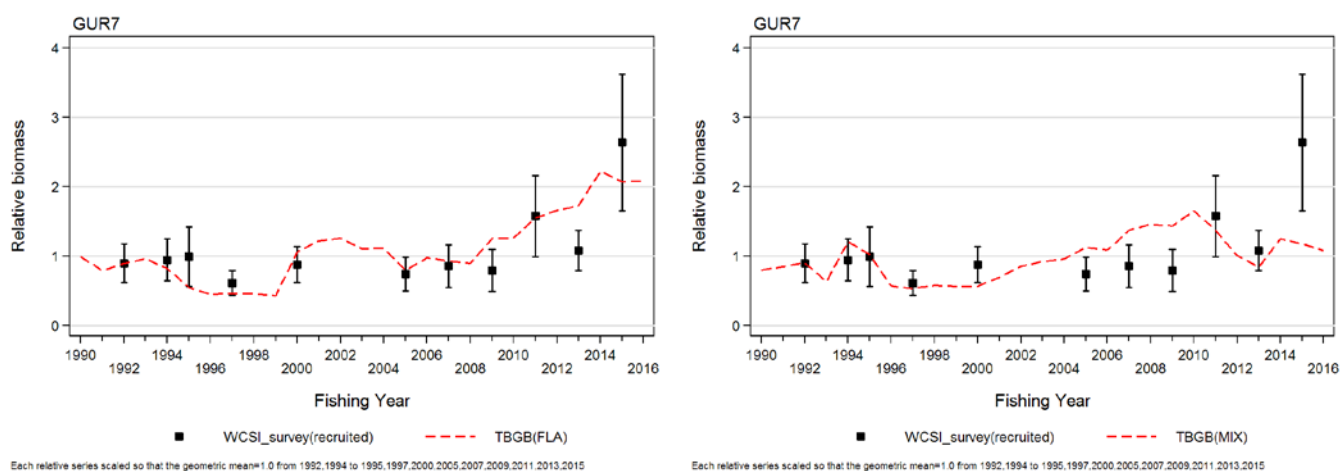

Figure 23: **[left panel]: comparison of total WCSI survey (recruited biomass) with the TBGB(FLA) CPUE series (combined index); [right panel]: comparison of total WCSI survey (recruited biomass) with the TBGB(MIX) CPUE series (combined index). The 2003 WCSI recruited index has been dropped from this comparison (see discussion in Section 3).**
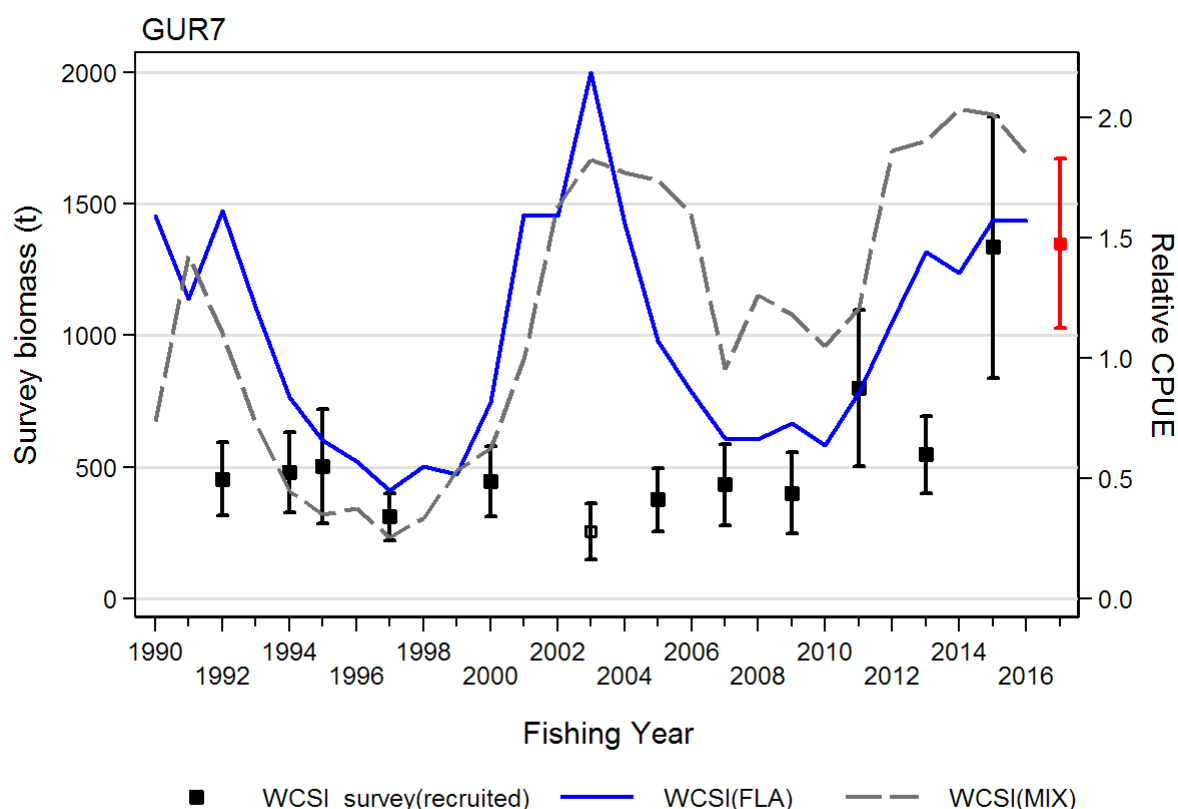

Figure 24: **Comparison of total WCSI survey (recruited biomass) with the WCSI(FLA) and WCSI(MIX) CPUE series (combined indices). The excluded 2003 WCSI recruited index has been plotted with a hollow square symbol and the preliminary 2017 WCSI recruited index is plotted in red.**

The 2017 Plenary accepted the WCSI recruited biomass series as the preferred index for monitoring GUR 7. The 2017 Plenary also agreed that the WCSI(FLA) and WCSI(MIX) series were best used to corroborate the survey index series, particularly in the years when the survey is not operative. A plot which compares all three series shows a good level of corroboration between the three series, once the 2003 WCSI index is discounted (Figure 24). The 2017 Plenary did not accept either of the TBGB CPUE series or the two COOKST CPUE series.

5.   ACKNOWLEDGEMENTS

6.   REFERENCES

Bentley, N.; Kendrick, T.H.; Starr, P.J.; Breen, P.A. (2012). Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardisations. *ICES Journal of Marine Science 69(1):*84–88, doi:10.1093/icesjms/fsr174

Francis, R.I.C.C. (1999). The impact of correlations in standardised CPUE indices. New Zealand Fisheries Assessment Research Document 99/42. 30 p. (Unpublished report held in NIWA library, Wellington.)

Francis, R.I.C.C. (2001). Orange roughy CPUE on the South and East Chatham Rise. *New Zealand Fisheries Assessment Report 2001/26.* 30 p.

Francis, R.I.C.C.; Hurst, R.J.; Renwick, J.A. (2001). An evaluation of catchability assumptions in New Zealand stock assessments. *New Zealand Fisheries Assessment Report 2001/1.* 37 p.

Kendrick, T.H.; Bentley, N.; Langley, A. (2011). Report to the Challenger Fishfish Company: CPUE analyses for FMA 7 Fishstocks of gurnard, tarakihi, blue warehou, and ghost shark. (Unpublished client report held by Trophia Limited, Kaikoura).

Langley, A.D. (2014). Updated CPUE analyses for selected South Island inshore finfish stocks. *New Zealand Fisheries Assessment Report 2014/40.* 116 p.

Ministry for Primary Industries (2016). Fisheries Assessment Plenary, May 2016: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1556 p. (Red Gurnard found in Chapter 73 of Volume 3: http://cs.fish.govt.nz/forums/thread/12485.aspx)

Ministry for Primary Industries (2017). Fisheries Assessment Plenary, May 2017: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1596 p. (Red Gurnard found in Chapter 73 of Volume 3: http://fs.fish.govt.nz/Doc/24476/May_Plenary_2017_Volume_3_FINAL.pdf.ashx)

Ministry of Fisheries. (2010). WAREHOU Database Documentation Catch Effort Base Views and Fields. Version 9. 80 p. (Unpublished report held by the Ministry of Fisheries, Wellington. Obtainable from mailto:RDM.Shared@mpi.govt.nz)

Quinn, T.R.; Deriso, R.B. (1999). Quantitative Fish Dynamics. Oxford University Press. 542 p.

Starr, P.J. (2007). Procedure for merging MFish landing and effort data, version 2.0. Report to the Adaptive Management Programme Fishery Assessment Working Group: AMP WG/07/04. 17 p. (Unpublished document held by the Ministry for Primary Industries, Wellington, N.Z: http://cs.fish.govt.nz/forums/194/PostAttachment.aspx)

Stevenson, M.L.; MacGibbon, D.J. (2015). Inshore trawl survey of the west coast South Island and Tasman and Golden Bays, March-April 2015 (KAH1503). *New Zealand Fisheries Assessment Report 2015/67*. 94 p.

Vignaux, M. (1994). Catch per unit effort (CPUE) analysis of west coast South Island and Cook Strait spawning hoki fisheries, 1987–93. New Zealand Fisheries Assessment Research Document 94/11. 29 p. (Unpublished report held in NIWA library, Wellington, New Zealand)

Appendix A.   GLOSSARY OF ABBREVIATIONS, CODES, AND DEFINITIONS OF TERMS

Table A.1:   Table of abbreviations and definitions of terms

Term/Abbreviation	Definition
AIC	Akaike Information Criterion: used to select between different models (lower is better)
AMP	Adaptive Management Programme: suspended by the Ministry of Fisheries in 2009–10
AMPWG	Ministry of Fisheries AMP Working Group: provided scientific oversight of the AMP when it was active
analysis dataset	data set available after completion of grooming procedure (Starr 2007)
arithmetic CPUE	Sum of catch/sum of effort, usually summed over a year within the stratum of interest (Eq. F.1)
CDI plot	Coefficient-distribution-influence plot (Bentley et al. 2012)
CELR	Catch/Effort Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels less than 28 m. Fishing events are reported on a daily basis on this form
CLR	Catch Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels not using the CELR or NCELR forms to report landings
CPUE	Catch Per Unit Effort
daily-stratum	summarisation within a trip by day of fishing with the modal statistical area of occupancy and modal declared target species assigned to the day of fishing; only trips which used a single capture method are used
destination code	code indicating how each landing was directed after leaving vessel (see Table 5)
EEZ	Exclusive Economic Zone: marine waters under control of New Zealand
estimated catch	an estimate made by the operator of the vessel of the weight of gurnard captured, which is then recorded as part of the "fishing event". Only the top 5 species are required for any fishing event in the CELR and TCEPR data (expanded to 8 for the TCER form type)
fishing event	a "fishing event" is a record of activity in trip. It is a day of fishing within a single statistical area, using one method of capture and one declared target species (CELR data) or a unit of fishing effort (usually a tow or a line set) for fishing methods using other reporting forms
fishing year	1 October – 30 September for gurnard
FMA	MPI Fishery Management Areas: 10 legal areas used by MPI to define large scale stock management units; QMAs consist of one or more of these regions
landing event	weight of gurnard off-loaded from a vessel at the end of a trip. Every landing has an associated destination code and there can be multiple landing events with the same or different destination codes for a trip
LCER	Lining Catch Effort Return (Ministry of Fisheries 2010): active since October 2003 for lining vessels larger than 28 m and reports set-by-set fishing events
LFR	Licensed Fish Receiver: processors legally allowed to receive commercially caught species
LTCER	Lining Trip Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for lining vessels between 6 and 28 m and reports individual set-by-set fishing events
MHR	Monthly Harvest Return: monthly returns used after 1 October 2001. Replaced QMRs but have same definition and utility
MPI	New Zealand Ministry for Primary Industries
NCELR	Netting Catch Effort Landing Return (Ministry of Fisheries 2010): active since October 2006 for inshore vessels using setnet gear between 6 and 28 m and reports individual fishing events
NINSWG	Northern Inshore Fisheries Assessment Working Group: MPI Working Group overseeing North Island inshore fisheries stock assessment work
QMA	Quota Management Area: legally defined unit area used for gurnard management (Figure 1)
QMR	Quota Management Report: monthly harvest reports submitted by commercial fishermen to MPI. Considered to be best estimates of commercial harvest. In use from 1986 to 2001.
QMS	Quota Management System: name of the management system used in New Zealand to control commercial and non-commercial catches
replog	data extract identifier issued by MPI data unit
residual implied coefficient plots	plots which mimic interaction effects between the year coefficients and a categorical variable by adding the mean of the categorical variable residuals in each fishing year to the year coefficient, creating a plot of the "year effect" for each value of the categorical variable
rollup	a term describing the average number of records per "trip-stratum" or "daily stratum"
RTWG	MPI Recreational Technical Working Group

Term/Abbreviation	Definition
SINSWG	Southern Inshore Fisheries Assessment Working Group: MPI Working Group overseeing South Island inshore fisheries stock assessment work and consequently the work presented in this report
standardised CPUE	procedure used to remove the effects of explanatory variables such as vessel, statistical area and month of capture from a data set of catch/effort data for a species; annual abundance is usually modelled as an explanatory variable representing the year of capture and, after removing the effects of the other explanatory variables, the resulting year coefficients represent the relative change in species abundance (Eq. F.3)
statistical area	sub-areas (Appendix B) within an FMA which are identified in catch/effort returns. The boundaries for these statistical areas do not always coincide with the QMA/FMA boundaries, leading to ambiguity in the assignment of effort to a QMA.
TACC	Total Allowable Commercial Catch: catch limit set by the Minister of Fisheries for a QMA that applies to commercial fishing
TCEPR	Trawl Catch Effort Processing Return (Ministry of Fisheries 2010): active since July 1989 for deepwater vessels larger than 28 m and reports tow-by-tow fishing events
TCER	Trawl Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for inshore vessels between 6 and 28 m and reports tow-by-tow fishing events
Trip	a unit of fishing activity by a vessel consisting of "fishing events" and "landing events", which are activities assigned to the trip. MPI generates a unique database code to identify each trip, using the trip start and end dates and the vessel code (Ministry of Fisheries 2010)
trip-stratum	summarisation within a trip by fishing method used, the statistical area of occupancy and the declared target species
unstandardised CPUE	geometric mean of all individual CPUE observations, usually summarised over a year within the stratum of interest (Eq. F.2)

Table A.2:   Code definitions used in the body of the main report and in Appendix C.

Code	Definition	Code	Description
BLL	Bottom longlining	BAR	Barracouta
BPT	Bottom trawl—pair	BNS	Bluenose
BS	Beach seine/drag nets	BUT	Butterfish
BT	Bottom trawl—single	GUR	Elephant Fish
CP	Cod potting	FLA	Flatfish (mixed species)
DL	Drop/dahn lines	GMU	Grey mullet
DS	Danish seining—single	GSH	Ghost shark
HL	Handlining	GUR	Red gurnard
MW	Midwater trawl—single	HOK	Hoki
RLP	Rock lobster potting	HPB	Hapuku & Bass
SLL	Surface longlining	JDO	John Dory
SN	Set netting (includes gill nets)	JMA	Jack mackerel
T	Trolling	KAH	Kahawai
TL	Trot lines	KIN	Kingfish
		LEA	Leatherjacket
		LIN	Ling
		MOK	Moki
		POR	Porae
		RCO	Red cod
		SCH	School shark
		SCI	Scampi
		SKI	Gemfish
		SNA	Snapper
		SPD	Spiny dogfish
		SPE	Sea perch
		GUR	Elephantfish
		SQU	Arrow squid
		STA	Giant stargazer
		SWA	Silver warehou
		TAR	Tarakihi
		TRE	Trevally
		WAR	Blue warehou

Appendix B. MAP OF MPI STATISTICAL AND MANAGEMENT AREAS

NEW ZEALAND FISHERY MANAGEMENT AREAS AND STATISTICAL AREAS
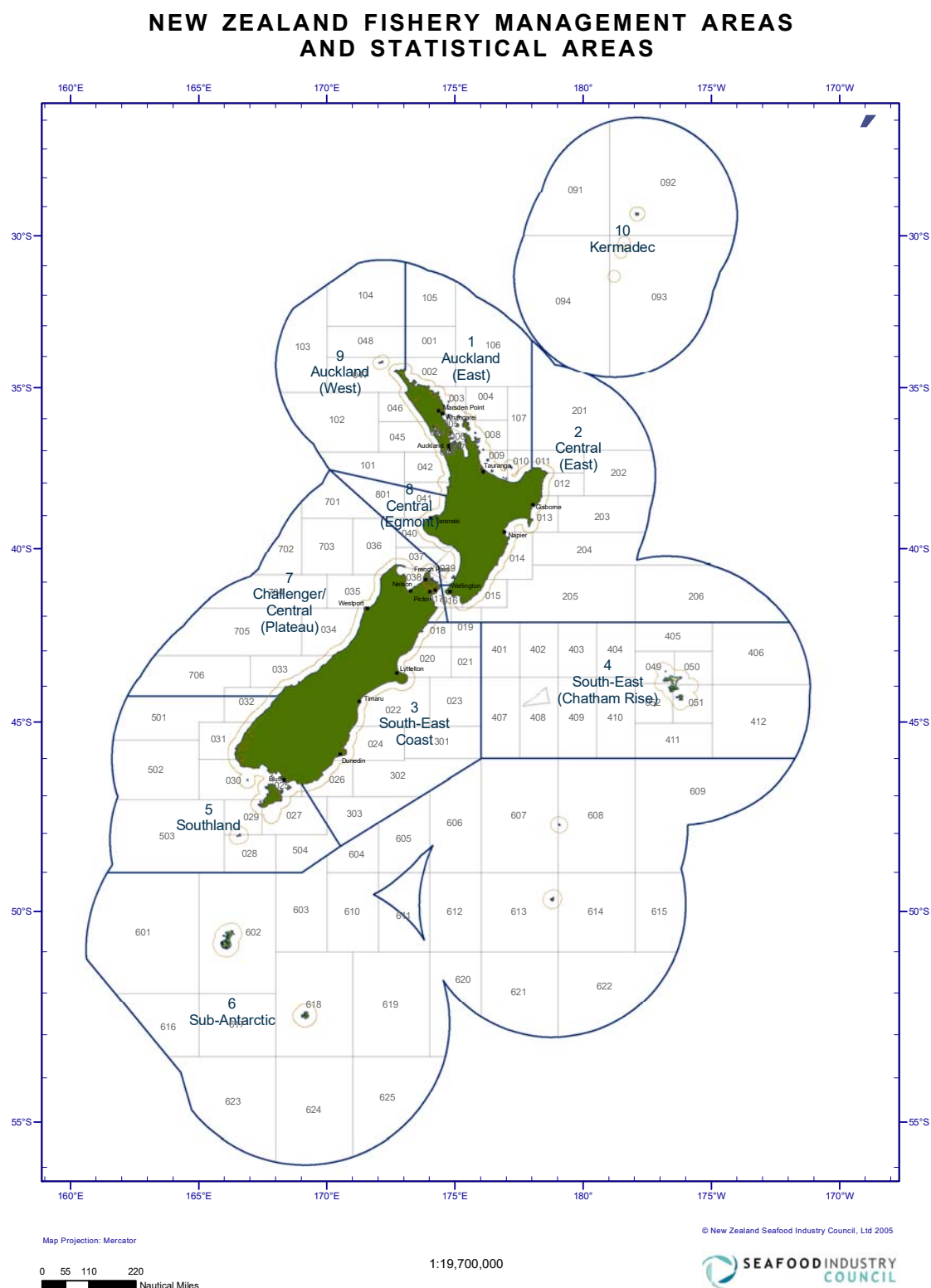

Figure B.1: Map of Ministry for Primary Industries statistical areas and Fishery Management Area (FMA) boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries.

Appendix C. DATA SUMMARIES BY GUR 7 STATISTICAL AREA GROUP FOR BOTTOM TRAWL

Table C.1A: **Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [032-033] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [032-033] are available in Table 10. These values are plotted in Figure 9.**

Fishing Year	Oct [032-033] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
89/90	2.2	12.3	2.9	1.7	–	9.4	13.9	0.0	32.5	8.4	6.9	9.8
90/91	10.9	16.7	3.6	2.5	5.1	18.9	12.4	10.5	13.4	3.7	0.1	2.1
91/92	11.5	25.1	7.6	1.3	0.1	6.6	9.7	23.8	11.9	1.5	0.5	0.4
92/93	3.2	10.9	2.8	2.2	6.3	11.9	5.7	20.3	0.7	21.6	7.0	7.6
93/94	3.7	15.9	6.7	1.4	0.7	4.5	1.3	13.2	22.0	16.7	11.4	2.5
94/95	13.0	3.0	11.2	10.4	4.5	3.1	4.2	13.6	14.5	8.3	5.5	8.8
95/96	6.3	2.0	11.0	17.5	3.6	7.4	7.8	23.3	12.1	5.9	0.5	2.6
96/97	5.9	12.2	26.4	7.8	3.3	7.6	8.4	7.9	10.6	2.5	4.2	3.2
97/98	3.9	12.9	10.6	3.4	2.1	1.3	15.9	13.9	10.7	8.7	9.2	7.3
98/99	6.0	14.1	2.5	10.7	19.3	3.9	15.8	3.8	7.0	6.9	4.7	5.3
99/00	3.8	20.6	8.5	8.7	11.3	8.8	5.1	14.3	5.2	8.0	1.8	3.9
00/01	7.0	6.8	11.1	5.6	15.7	18.9	3.9	1.6	5.0	2.0	0.3	22.2
01/02	31.6	14.4	6.7	22.0	3.9	0.9	2.5	2.8	6.0	2.3	5.1	1.9
02/03	16.6	13.3	12.9	12.1	11.9	5.8	6.6	0.5	1.3	6.4	7.9	4.8
03/04	16.8	36.6	6.9	3.8	12.7	8.3	7.3	2.8	0.6	1.3	0.9	1.9
04/05	12.1	31.5	11.4	11.9	6.3	2.3	0.9	5.2	4.1	5.7	1.3	7.4
05/06	16.5	26.3	10.7	4.4	8.4	1.9	0.4	9.0	7.8	6.7	5.3	2.7
06/07	8.6	12.2	10.5	8.9	19.0	1.8	3.7	6.8	12.9	9.6	1.9	4.3
07/08	1.1	18.8	15.1	14.4	5.3	7.5	5.1	7.0	7.7	5.1	5.0	7.9
08/09	9.1	8.9	8.8	4.9	13.3	7.1	4.3	7.1	9.4	13.0	7.2	7.0
09/10	16.4	15.2	8.9	11.8	3.4	7.6	4.6	7.2	9.4	8.8	3.3	3.3
10/11	7.9	17.0	8.5	3.4	5.3	4.2	4.9	12.2	11.1	7.9	6.2	11.4
11/12	9.6	8.5	6.4	8.5	3.1	17.0	10.7	7.5	10.1	6.3	6.7	5.8
12/13	9.4	8.9	16.2	6.6	5.6	7.3	10.7	11.3	10.7	4.9	3.0	5.4
13/14	4.5	5.2	21.9	6.6	8.9	17.2	6.8	9.7	8.7	3.5	2.4	4.5
14/15	13.0	13.2	15.4	4.2	7.9	8.1	10.0	3.0	2.9	1.2	3.6	17.4
15/16	8.1	30.0	13.1	15.3	12.5	3.5	2.5	2.9	3.9	1.6	1.8	4.8
Average	11.1	17.2	11.0	8.5	8.3	7.4	6.0	7.3	7.0	5.8	3.9	6.4

Table C.1B: Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [034] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [034] are available in Table 10. These values are plotted in Figure 9.

Fishing Year	Oct [034] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
89/90	0.1	11.7	8.4	7.4	3.6	12.5	10.0	2.1	21.3	5.2	9.9	7.8
90/91	6.7	9.9	2.3	9.7	2.4	6.3	8.9	15.1	14.0	14.0	2.4	8.4
91/92	1.2	6.1	3.9	1.3	–	1.9	11.8	15.5	32.1	13.0	2.7	10.5
92/93	10.5	13.6	9.2	1.9	7.0	13.2	7.3	10.1	0.9	13.8	4.2	8.2
93/94	3.7	31.5	7.7	0.2	4.0	0.9	2.7	7.8	17.2	8.8	8.9	6.7
94/95	12.5	7.3	10.9	6.6	0.6	1.8	6.2	15.3	11.2	10.6	9.9	7.1
95/96	8.5	10.4	5.5	8.1	1.4	4.0	12.3	5.2	10.2	15.6	9.7	9.1
96/97	4.0	9.8	14.2	3.9	1.2	4.3	7.2	14.8	10.2	13.7	7.6	9.1
97/98	6.9	8.8	4.2	1.1	1.3	0.1	18.2	13.2	19.0	16.9	6.0	4.3
98/99	3.2	15.8	4.8	13.7	13.8	6.3	8.4	12.2	7.8	4.8	4.7	4.4
99/00	6.8	13.9	13.7	3.7	5.0	4.2	2.9	5.4	8.6	16.7	12.6	6.4
00/01	3.5	9.3	9.2	3.3	2.8	4.5	5.6	21.0	11.2	14.3	3.5	11.6
01/02	20.4	12.5	18.1	7.1	10.4	5.2	5.7	5.6	1.8	5.2	5.7	2.4
02/03	8.3	8.8	9.7	7.1	5.7	7.4	30.2	13.2	1.3	2.2	4.6	1.5
03/04	17.4	15.0	18.4	3.8	3.1	1.4	8.8	7.7	3.9	9.0	6.0	5.5
04/05	6.6	17.0	10.0	22.1	5.7	4.6	8.0	5.5	6.3	3.0	5.4	5.8
05/06	17.8	23.7	19.3	3.3	4.1	3.3	2.7	7.7	5.9	6.9	3.2	2.2
06/07	3.6	11.7	8.8	13.6	5.4	5.4	8.9	12.5	6.9	14.2	4.6	4.5
07/08	2.7	12.8	10.1	13.4	4.5	11.9	15.8	14.2	3.9	3.7	3.9	3.1
08/09	2.3	1.2	2.0	5.4	9.4	16.5	15.5	10.5	11.5	13.9	4.6	7.0
09/10	5.6	7.7	5.1	2.8	7.1	9.3	14.5	11.1	10.8	11.3	6.4	8.3
10/11	2.3	13.7	11.7	8.9	3.0	10.5	6.2	12.8	3.6	7.0	15.1	5.2
11/12	5.5	6.5	10.6	5.6	2.3	24.3	11.6	3.8	6.0	10.6	10.9	2.3
12/13	1.3	6.8	7.0	2.1	6.1	19.8	16.6	8.9	8.1	3.8	11.0	8.6
13/14	1.9	6.8	5.7	4.6	9.8	25.3	20.7	6.1	3.2	3.5	5.9	6.6
14/15	7.1	5.2	9.9	6.1	11.9	19.9	8.8	6.2	7.9	4.7	5.4	6.9
15/16	8.9	13.4	4.0	9.5	19.5	12.4	5.4	3.4	4.1	2.8	6.4	10.2
Average	7.1	11.2	9.4	6.5	6.1	9.8	11.1	9.7	8.2	8.3	6.3	6.3

Table C.1C: **Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [035] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [035] are available in Table 10. These values are plotted in Figure 9.**

Fishing Year	Oct [035] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
89/90	0.1	4.1	7.5	4.0	20.7	17.4	8.7	3.6	19.8	6.6	6.7	0.8
90/91	8.1	7.3	0.9	6.6	0.7	8.1	8.5	11.7	20.2	24.7	2.7	0.6
91/92	0.1	6.8	3.8	0.9	1.3	3.2	11.1	27.8	23.4	15.7	0.4	5.6
92/93	7.6	10.0	7.1	0.9	19.0	14.7	11.7	7.9	1.6	12.2	3.2	4.1
93/94	0.8	4.6	0.9	0.9	15.4	2.4	13.1	13.9	20.1	14.9	5.3	7.7
94/95	16.2	8.3	8.4	3.3	2.8	14.9	7.1	13.0	9.8	2.9	10.1	3.2
95/96	12.1	10.6	4.8	9.4	1.7	2.9	10.3	11.8	12.1	15.5	2.2	6.6
96/97	3.6	4.2	2.4	9.0	7.0	1.7	6.1	13.0	20.5	17.5	10.2	4.8
97/98	3.1	7.5	1.5	1.8	3.4	3.2	13.3	22.9	20.2	11.7	8.0	3.4
98/99	0.8	15.2	8.9	10.3	7.4	5.7	7.1	7.1	15.2	5.8	11.9	4.5
99/00	12.2	13.6	4.8	11.2	6.1	7.5	0.3	4.3	8.9	16.2	12.5	2.4
00/01	4.4	16.2	7.0	4.0	11.2	27.9	7.1	4.8	4.3	9.3	1.1	2.8
01/02	9.7	7.9	8.2	19.0	7.4	11.8	21.4	6.6	1.5	4.2	1.4	0.9
02/03	6.0	5.9	13.3	15.9	5.5	21.8	17.7	7.0	0.8	2.3	3.0	0.8
03/04	2.7	4.4	7.5	3.0	0.3	13.3	16.7	32.9	4.2	6.2	5.0	3.8
04/05	8.5	4.9	0.2	6.7	16.4	16.9	15.7	3.9	14.7	4.2	1.2	6.8
05/06	11.5	7.1	8.8	0.8	7.4	12.0	9.2	17.0	7.3	8.1	7.1	3.7
06/07	3.1	5.2	1.7	23.8	6.9	5.7	6.0	25.2	11.5	6.5	1.6	2.9
07/08	3.3	13.4	8.5	17.9	8.1	6.5	6.5	7.0	19.0	5.0	2.9	1.9
08/09	0.9	2.6	1.2	1.8	1.1	7.6	13.2	21.5	32.3	12.5	1.8	3.4
09/10	8.1	4.1	1.6	2.4	16.9	16.5	5.9	9.0	17.9	13.9	1.7	2.1
10/11	2.2	9.4	1.8	1.9	0.7	8.2	24.6	19.4	9.4	7.2	10.1	5.1
11/12	4.3	2.9	2.9	1.4	5.3	28.3	10.1	14.1	8.9	15.0	5.3	1.7
12/13	0.5	4.7	6.0	2.9	5.9	10.8	13.9	7.6	15.5	17.8	7.9	6.5
13/14	1.2	11.5	6.3	1.8	28.4	9.1	24.6	6.2	3.2	4.4	0.5	2.9
14/15	5.1	0.7	0.4	2.8	34.8	16.8	0.2	7.0	15.8	8.4	2.2	5.6
15/16	0.8	4.4	10.6	15.2	26.2	1.2	3.4	2.2	5.5	13.0	8.6	8.8
Average	4.5	6.9	5.2	6.5	11.8	11.2	11.7	12.1	11.8	10.1	4.3	4.0

Table C.1D: Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [036] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [036] are available in Table 10. These values are plotted in Figure 9. '–': no data.

Fishing Year	Oct [036] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
89/90	0.1	14.2	13.0	–	29.9	0.1	–	29.4	3.0	–	2.3	8.0
90/91	24.8	11.2	15.4	13.4	0.6	18.9	3.3	7.6	0.3	–	3.7	0.7
91/92	3.3	19.5	4.0	1.2	0.9	–	21.0	11.6	0.0	15.5	9.3	13.5
92/93	7.4	9.4	10.8	4.7	17.0	29.2	5.8	4.3	1.0	0.1	–	10.5
93/94	27.0	8.4	3.5	–	0.0	32.0	–	7.4	4.1	10.4	–	7.3
94/95	18.3	0.0	4.1	16.0	1.3	24.8	21.7	9.2	4.5	–	0.1	–
95/96	6.1	2.7	0.0	13.9	0.9	1.3	53.7	12.0	2.0	1.8	3.5	2.0
96/97	13.6	9.6	4.0	3.5	2.9	4.4	14.7	0.7	3.8	16.9	5.0	20.8
97/98	13.7	5.8	17.1	4.6	–	12.5	17.4	10.7	4.5	7.5	5.4	0.8
98/99	0.8	27.4	–	13.6	1.0	3.3	5.6	6.7	12.5	10.6	4.5	14.0
99/00	6.5	2.6	6.0	3.3	3.1	22.2	22.8	3.2	4.2	16.9	4.4	4.8
00/01	24.3	15.6	3.5	5.1	6.1	5.1	19.7	2.3	10.3	4.4	1.7	1.8
01/02	20.4	22.4	10.5	7.6	14.8	3.0	10.1	8.2	–	1.8	0.0	1.2
02/03	21.8	11.8	24.0	0.4	16.6	19.3	2.4	1.2	–	1.8	0.3	0.4
03/04	12.3	27.3	6.9	6.3	–	9.2	10.3	6.4	5.2	3.3	2.6	10.2
04/05	28.6	4.5	0.7	4.0	8.0	18.8	10.9	10.5	0.9	6.5	1.4	5.3
05/06	23.6	9.1	2.6	0.5	0.0	25.6	7.1	7.4	1.3	5.8	2.9	14.2
06/07	10.3	23.7	0.7	5.5	8.7	18.5	10.6	7.5	3.2	5.7	0.5	5.0
07/08	21.5	37.0	2.5	1.0	–	8.9	6.9	6.2	3.8	7.3	1.2	3.7
08/09	41.6	16.4	4.3	4.1	3.8	2.4	9.2	6.8	5.1	1.3	0.6	4.4
09/10	48.1	11.1	4.4	3.9	2.2	5.0	6.7	2.2	6.1	4.9	2.2	3.1
10/11	24.9	29.8	10.3	7.2	2.0	1.2	10.0	1.3	3.1	1.4	3.7	5.0
11/12	12.7	4.3	17.7	7.5	1.9	9.3	8.4	3.9	4.7	8.4	7.1	14.2
12/13	5.0	25.0	7.2	9.5	7.4	11.8	2.0	2.7	8.5	0.5	4.7	15.6
13/14	11.2	30.7	5.0	4.1	13.6	9.0	1.6	8.0	3.6	0.8	6.0	6.4
14/15	14.6	27.9	8.0	3.9	6.1	7.2	0.7	1.7	5.4	4.7	5.2	14.6
15/16	5.5	36.7	13.9	2.2	8.3	3.5	0.2	2.0	0.6	6.9	3.7	16.4
Average	17.2	17.5	7.1	5.3	5.9	11.2	10.9	6.2	3.6	5.2	2.8	7.2

Table C.1E: Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [016-018, 037-038] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [016-018, 037-038] are available in Table 10. These values are plotted in Figure 9.

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
	[016-018, 037-038] (%)											
89/90	1.9	6.8	4.5	6.3	13.3	12.8	11.1	9.9	10.8	8.9	8.5	5.2
90/91	8.7	9.4	7.6	9.7	14.1	11.9	7.6	10.5	4.9	4.4	7.0	4.2
91/92	4.6	6.5	8.4	7.0	4.3	11.1	21.5	9.6	7.2	8.0	4.2	7.6
92/93	5.3	12.8	6.9	4.7	10.9	8.1	9.0	6.3	10.1	14.1	5.8	6.0
93/94	4.8	8.1	13.0	6.4	5.5	12.5	13.3	7.0	10.6	10.7	3.6	4.3
94/95	13.7	7.7	21.8	10.7	4.9	7.3	5.9	6.4	8.3	8.2	2.8	2.3
95/96	8.3	15.6	5.4	6.2	3.8	1.5	10.6	10.5	15.7	10.3	7.6	4.3
96/97	9.3	11.7	10.0	8.1	3.6	4.2	9.5	10.5	9.9	12.6	8.3	2.3
97/98	10.0	11.6	10.9	3.6	2.9	3.0	11.1	13.3	11.8	10.6	7.9	3.3
98/99	7.1	11.6	13.2	5.1	3.0	11.5	6.6	9.8	9.3	10.8	7.9	4.0
99/00	5.2	3.2	3.8	3.4	2.2	5.3	6.7	14.1	13.8	10.4	18.0	13.9
00/01	6.6	10.6	11.9	7.7	4.0	3.6	13.8	8.5	12.1	8.5	6.7	6.0
01/02	6.7	12.2	9.4	4.9	5.0	8.5	13.1	9.6	6.3	10.3	9.1	4.8
02/03	11.0	12.6	4.6	4.3	6.2	11.3	16.5	8.2	6.5	9.2	5.3	4.4
03/04	7.6	14.3	9.7	1.9	2.5	7.8	9.0	6.7	10.2	13.4	9.9	7.1
04/05	5.5	11.3	12.1	10.0	7.4	5.2	4.6	5.7	8.1	11.2	7.9	11.1
05/06	4.6	5.6	5.6	8.0	5.8	13.0	8.0	11.4	9.6	8.4	12.5	7.4
06/07	4.9	12.3	14.8	7.0	9.7	16.5	7.3	8.2	6.5	5.3	4.0	3.4
07/08	10.1	11.9	10.4	5.5	6.6	9.3	7.7	7.3	8.2	12.8	6.0	4.1
08/09	10.6	14.5	9.1	8.2	10.9	5.6	4.7	7.0	8.5	10.4	6.7	4.0
09/10	8.5	15.8	6.5	8.1	4.2	4.3	5.9	7.9	10.4	13.5	7.4	7.3
10/11	13.6	10.3	11.8	2.8	4.4	3.6	6.6	8.2	13.7	8.6	8.1	8.4
11/12	7.7	15.7	4.9	6.1	3.1	4.2	4.2	10.4	9.5	12.9	11.5	9.7
12/13	8.9	14.5	7.1	5.6	4.0	5.1	5.2	12.6	9.1	10.0	8.9	9.0
13/14	8.5	12.4	11.8	3.8	6.6	8.6	6.0	13.2	7.6	8.5	7.9	5.0
14/15	9.9	6.5	14.9	8.7	7.1	7.6	5.3	6.3	8.9	9.8	9.1	5.8
15/16	13.3	9.0	7.6	5.4	5.9	3.1	3.6	5.4	13.0	12.7	11.4	9.7
Average	8.1	10.9	9.6	6.4	6.3	7.8	8.6	8.9	9.5	10.1	7.7	6.1

Table C.1F: **Distribution of GUR 7 landings (%) by fishing year and by month for bottom trawl in statistical area group [039-040] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [039-040] are available in Table 10. These values are plotted in Figure 9. '−': no data.**

Fishing Year	Oct [039-040] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Month Sep
89/90	−	5.1	−	5.7	64.1	17.6	0.0	7.0	0.0	0.0	−	0.5
90/91	−	0.0	−	27.9	1.0	0.0	0.1	28.7	0.0	5.5	0.0	36.8
91/92	0.0	2.1	−	0.0	13.0	1.2	80.0	0.6	−	0.0	0.0	3.1
92/93	12.2	26.8	8.0	1.8	11.0	30.7	7.8	1.2	−	−	−	0.6
93/94	1.1	0.3	7.1	8.8	1.5	25.3	21.5	12.8	−	21.7	−	−
94/95	1.4	9.5	0.1	12.3	18.7	0.3	23.9	1.0	31.0	−	0.1	1.8
95/96	10.4	0.0	4.2	0.4	0.0	16.7	21.7	7.4	13.2	11.5	12.9	1.5
96/97	5.6	2.0	2.5	0.0	0.0	13.8	0.5	1.6	37.9	32.5	−	3.6
97/98	25.9	0.0	8.1	−	1.0	−	7.6	2.7	26.5	7.0	21.2	0.0
98/99	0.0	−	0.0	27.3	2.6	8.2	15.9	14.4	8.2	21.8	1.3	0.3
99/00	5.9	2.0	0.0	32.8	2.2	−	0.9	49.1	0.1	7.0	0.1	−
00/01	5.8	10.0	−	6.4	6.6	46.7	1.0	15.4	8.2	0.0	0.0	0.0
01/02	7.3	1.0	0.0	2.9	3.2	69.9	−	3.4	0.0	7.0	−	5.1
02/03	22.3	−	−	−	0.1	3.2	−	16.8	−	−	3.6	54.0
03/04	−	−	4.6	−	0.7	93.7	0.8	0.0	0.0	0.0	−	0.2
04/05	4.6	−	0.1	25.4	12.2	−	−	−	23.7	0.0	20.2	13.7
05/06	66.5	28.1	0.3	0.1	1.6	−	−	0.0	−	−	0.0	3.5
06/07	5.4	0.0	0.0	0.0	3.9	3.8	0.0	20.3	−	2.4	0.0	64.3
07/08	2.8	3.0	7.3	0.0	0.0	0.0	17.7	6.9	8.6	1.7	4.7	47.3
08/09	3.3	27.5	−	6.7	42.2	2.4	1.9	11.0	1.3	2.7	0.9	0.1
09/10	0.4	17.0	0.0	0.6	2.5	1.4	1.5	0.0	35.2	26.4	6.1	9.0
10/11	16.0	20.2	3.0	−	4.0	0.0	1.6	0.0	0.0	22.5	11.4	21.3
11/12	11.5	33.7	0.0	0.2	0.0	1.0	0.0	4.3	35.9	10.6	1.6	1.1
12/13	37.0	16.4	4.8	0.0	0.4	2.4	1.0	7.8	0.0	4.4	22.3	3.4
13/14	7.9	19.1	5.8	5.5	1.8	7.4	15.8	13.7	3.8	8.7	6.5	4.1
14/15	14.3	7.6	2.7	16.2	−	1.0	0.0	0.3	2.2	20.4	6.3	28.9
15/16	20.4	7.3	15.7	9.5	10.5	1.3	0.0	1.8	4.7	17.0	6.3	5.5
Average	8.4	6.9	3.4	6.0	5.1	24.8	9.9	7.8	7.7	7.8	3.9	8.4

Table C.2A: Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [032–033] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [032-033] are available in Table 10. The values are plotted in Figure 11.

Year	FLA [032–033] (%)	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	42.2	12.7	4.4	20.8	9.5	–	–	9.2	1.2
90/91	7.3	14.7	23.5	5.1	40.2	4.5	–	4.3	0.4
91/92	0.6	17.1	15.3	11.9	46.0	1.8	–	6.5	0.7
92/93	43.2	12.5	12.7	18.9	10.8	1.7	0.1	0.0	0.0
93/94	60.9	6.7	13.5	3.5	13.6	0.4	–	1.2	0.2
94/95	56.6	0.1	7.0	6.6	28.3	0.5	–	0.7	0.3
95/96	29.5	–	33.1	22.8	13.6	–	–	0.1	0.9
96/97	62.4	–	26.7	1.8	5.9	3.0	–	0.0	0.1
97/98	67.9	–	12.6	0.0	13.9	0.6	–	2.1	2.9
98/99	58.7	–	20.4	0.7	6.8	13.0	–	0.1	0.4
99/00	40.5	0.2	50.5	0.0	7.1	0.6	–	0.5	0.6
00/01	26.0	–	67.8	1.3	4.6	–	–	–	0.3
01/02	40.1	23.4	14.5	12.9	7.1	0.4	–	1.5	0.0
02/03	33.3	11.0	18.4	13.6	9.6	8.8	–	4.7	0.6
03/04	17.3	19.7	23.5	25.5	9.7	3.7	–	0.3	0.2
04/05	31.7	0.7	17.6	31.5	7.2	8.7	–	1.9	0.7
05/06	26.7	–	11.6	24.0	32.3	1.7	–	3.5	0.3
06/07	31.9	1.8	13.4	23.9	17.0	7.2	–	4.2	0.5
07/08	39.3	0.8	11.9	16.5	23.6	6.1	–	1.5	0.4
08/09	28.4	0.5	11.2	23.8	30.6	3.7	–	1.6	0.3
09/10	36.7	8.0	5.4	5.9	31.0	10.6	–	1.9	0.4
10/11	21.1	11.7	7.3	13.7	36.9	5.6	–	1.2	2.6
11/12	23.7	17.6	8.7	9.2	27.7	9.7	0.0	2.3	1.1
12/13	16.8	38.8	8.1	2.5	23.9	8.1	–	1.3	0.5
13/14	13.2	44.0	7.3	7.4	20.9	5.4	–	1.8	0.1
14/15	9.9	32.2	2.4	23.9	17.9	11.9	–	0.8	0.8
15/16	7.8	21.3	10.6	18.9	21.6	18.0	–	1.4	0.5
Average	26.8	14.6	15.2	15.5	18.7	6.6	0.0	2.0	0.6

Table C.2B: Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [034] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [034] are available in Table 10. The values are plotted in Figure 11.

Year	FLA [034] (%)	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	68.9	6.3	2.9	11.8	3.7	0.2	–	5.0	1.1
90/91	53.7	8.3	13.5	12.5	6.4	1.3	–	3.5	1.0
91/92	59.3	6.5	3.4	27.3	2.4	0.2	–	0.8	0.2
92/93	61.0	0.3	2.4	33.0	2.9	0.1	–	0.2	0.3
93/94	81.5	0.8	2.0	13.1	2.1	0.3	–	0.0	0.2
94/95	78.3	1.3	1.5	14.9	3.6	0.1	–	0.1	0.1
95/96	74.5	3.4	4.6	12.0	2.4	2.6	–	0.3	0.2
96/97	74.0	–	13.8	9.7	1.8	0.2	–	0.4	0.1
97/98	82.9	0.3	6.5	7.1	1.8	0.0	–	0.1	1.3
98/99	65.6	0.0	22.8	6.4	1.8	1.5	–	1.0	0.9
99/00	56.7	0.2	32.4	1.6	5.0	1.8	–	2.1	0.2
00/01	62.3	0.8	30.4	4.1	1.5	0.0	–	0.7	0.2
01/02	44.2	5.3	35.4	12.9	1.4	0.5	–	0.1	0.1
02/03	57.9	8.4	16.1	10.3	2.8	1.7	–	2.1	0.8
03/04	61.2	5.9	11.3	17.3	1.5	0.9	–	2.0	0.1
04/05	50.8	1.6	9.9	28.0	2.5	1.2	–	5.7	0.1
05/06	62.4	0.7	10.4	18.3	3.8	0.2	–	4.1	0.1
06/07	66.5	0.2	2.6	23.3	2.2	1.9	0.0	3.1	0.2
07/08	67.8	2.3	3.5	22.1	1.9	0.4	–	1.4	0.5
08/09	70.1	1.8	4.8	16.8	3.8	1.3	–	1.4	0.1
09/10	75.1	6.1	2.9	9.4	3.5	1.0	–	1.7	0.2
10/11	41.9	14.0	2.6	29.3	6.9	1.0	0.0	3.9	0.5
11/12	40.3	42.8	3.0	4.3	2.8	2.7	0.0	3.6	0.5
12/13	35.4	43.8	4.4	4.1	4.5	5.3	–	2.2	0.3
13/14	33.3	42.8	4.0	10.5	3.8	2.8	–	2.6	0.1
14/15	38.8	37.8	2.7	8.7	3.0	5.8	–	2.4	0.9
15/16	44.8	27.4	1.4	12.4	4.0	5.7	–	2.5	1.7
Average	56.3	12.4	9.3	14.8	3.0	1.7	0.0	2.1	0.4

Table C.2C: **Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [035] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [035] are available in Table 10. The values are plotted in Figure 11.**

Year	FLA [035] (%)	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	77.6	12.0	0.6	9.4	0.3	–	–	–	0.0
90/91	67.1	6.9	6.5	17.9	0.3	0.0	–	0.0	1.2
91/92	78.6	2.2	0.3	18.4	0.4	0.0	–	–	0.1
92/93	79.2	1.3	2.2	17.2	0.0	–	0.0	0.0	0.0
93/94	87.1	1.4	4.4	7.1	0.0	–	–	–	0.0
94/95	74.9	–	18.3	6.4	0.3	–	–	–	0.2
95/96	77.4	7.0	7.5	8.0	0.1	–	–	–	0.0
96/97	88.4	4.8	4.0	0.6	2.0	–	–	–	0.1
97/98	84.4	1.3	4.3	9.1	0.8	–	–	–	0.0
98/99	91.0	0.3	4.8	2.2	0.4	–	0.6	–	0.7
99/00	79.1	12.6	4.5	–	2.6	–	0.3	0.0	0.8
00/01	78.0	3.5	8.4	3.2	6.0	0.8	–	0.1	0.0
01/02	44.1	9.7	34.1	8.3	2.1	1.4	–	0.1	0.1
02/03	70.1	9.3	13.5	3.0	2.2	0.0	–	–	1.9
03/04	68.6	10.2	4.0	11.7	4.3	0.0	0.1	0.0	1.0
04/05	52.7	3.0	16.5	23.5	1.4	2.5	–	0.2	0.1
05/06	63.5	0.9	6.0	24.2	2.1	0.1	0.1	1.6	1.5
06/07	68.9	1.1	4.9	21.7	1.8	–	0.0	0.0	1.6
07/08	66.6	–	6.2	22.5	4.0	0.0	0.0	0.0	0.7
08/09	71.3	4.2	4.6	16.8	2.6	0.2	0.1	0.1	0.2
09/10	51.7	19.4	3.3	22.2	1.4	–	1.0	0.0	0.9
10/11	60.8	21.3	2.3	11.1	2.5	0.0	0.1	0.2	1.8
11/12	57.4	34.6	1.1	3.7	1.2	–	0.0	0.1	1.9
12/13	46.3	48.4	1.2	1.3	2.2	0.2	–	0.1	0.2
13/14	53.8	37.0	2.1	3.6	2.5	0.1	–	0.2	0.6
14/15	60.5	23.1	1.6	8.0	4.5	0.0	–	0.4	2.0
15/16	73.3	19.6	0.9	2.3	2.1	0.5	–	0.4	0.9
Average	66.9	13.0	5.8	11.2	1.9	0.3	0.1	0.1	0.7

Table C.2D: **Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [036] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [036] are available in Table 10. The values are plotted in Figure 11.**

Year	FLA [036] (%)	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	35.9	0.5	33.0	–	3.5	–	12.4	–	14.7
90/91	44.1	3.7	24.7	–	7.8	1.7	0.8	7.4	9.7
91/92	47.5	4.8	28.6	7.5	10.2	0.0	0.6	–	0.7
92/93	30.3	–	25.4	40.8	0.0	–	–	–	3.5
93/94	26.0	–	47.6	9.3	16.6	–	–	–	0.5
94/95	19.9	18.5	33.2	2.5	8.2	12.7	2.4	–	2.7
95/96	36.2	13.3	37.9	3.6	0.3	3.0	–	–	5.7
96/97	19.3	14.3	50.8	0.6	1.9	–	8.4	–	4.6
97/98	28.0	12.5	54.5	0.0	1.9	–	–	–	3.1
98/99	20.0	17.4	31.2	5.6	15.6	–	0.8	0.2	9.2
99/00	20.8	7.8	49.4	0.3	20.5	–	–	1.3	0.0
00/01	11.0	6.8	53.6	0.0	27.0	–	–	–	1.6
01/02	8.4	23.9	50.9	1.5	6.2	–	–	–	9.1
02/03	15.2	28.2	27.9	–	25.2	–	–	–	3.5
03/04	6.4	12.1	31.1	8.6	35.7	2.4	–	–	3.7
04/05	15.3	14.1	40.7	2.4	16.3	1.6	6.3	–	3.3
05/06	4.0	4.3	25.3	1.7	30.6	15.6	11.0	–	7.6
06/07	11.4	3.2	56.9	3.9	8.8	4.9	3.5	–	7.5
07/08	2.8	9.1	54.6	5.0	15.7	5.5	5.9	–	1.3
08/09	7.1	5.1	51.0	3.6	29.4	1.7	–	–	2.1
09/10	9.7	10.7	15.2	1.8	51.4	1.1	7.1	–	3.0
10/11	2.5	14.7	37.3	–	28.1	3.8	4.8	0.0	8.7
11/12	3.6	42.9	14.2	0.0	38.0	0.0	0.2	–	1.0
12/13	1.5	35.7	10.5	–	36.2	0.0	13.2	0.0	2.9
13/14	2.5	26.6	23.9	–	38.9	3.2	2.7	–	2.1
14/15	2.8	17.5	10.4	–	48.6	5.1	–	–	15.6
15/16	3.3	44.5	3.8	0.6	43.0	2.4	–	–	2.4
Average	13.9	14.9	34.9	3.5	22.0	2.7	3.0	0.2	4.8

Table C.2E: Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [016-018, 037-038] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [016-018, 037-038] are available in Table 10. The values are plotted in Figure 11.

Year	FLA	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
[016-018, 037-038] (%)									
89/90	67.1	7.6	9.3	1.8	1.2	0.2	3.0	0.02	9.9
90/91	50.6	12.9	19.2	2.4	2.1	0.8	2.9	0.01	9.2
91/92	49.1	17.3	23.2	4.7	0.8	1.1	0.8	0.00	2.9
92/93	60.9	5.0	19.3	8.8	0.3	0.5	1.5	0.37	3.2
93/94	59.0	9.0	19.0	7.7	2.8	0.3	0.5	0.07	1.6
94/95	50.5	4.9	28.5	10.3	1.6	1.6	0.4	0.01	2.2
95/96	53.9	2.4	25.5	10.6	3.5	0.3	0.8	0.00	3.1
96/97	60.2	3.2	25.5	8.0	0.5	1.0	0.5	0.00	1.1
97/98	81.7	0.9	7.5	4.2	1.0	0.6	0.9	0.12	3.1
98/99	55.8	0.8	17.9	8.5	1.6	4.7	2.4	0.00	8.2
99/00	71.0	2.2	18.4	0.6	3.5	0.4	2.4	0.01	1.5
00/01	48.0	14.4	24.8	2.5	4.3	1.3	2.3	0.00	2.2
01/02	57.5	6.1	26.3	2.6	1.3	0.4	0.7	0.00	5.0
02/03	56.7	11.5	19.5	1.5	1.4	2.5	2.9	0.00	4.0
03/04	63.9	7.8	19.0	2.2	1.7	0.7	2.5	0.00	2.2
04/05	63.9	2.6	24.1	2.2	1.7	1.9	1.7	0.04	1.9
05/06	64.6	5.3	13.7	4.1	5.5	1.5	3.8	0.01	1.7
06/07	62.0	6.9	13.2	6.3	0.8	6.5	2.2	0.00	2.0
07/08	49.5	6.0	22.5	9.3	0.9	5.4	3.9	0.01	2.4
08/09	64.8	5.9	15.5	4.4	2.4	4.0	1.4	0.00	1.6
09/10	59.1	14.0	11.7	4.8	1.7	1.8	3.5	0.00	3.4
10/11	53.9	19.5	5.6	4.6	5.5	3.3	3.4	0.00	4.2
11/12	53.6	20.2	7.9	2.1	7.5	2.1	1.7	0.04	4.9
12/13	46.4	33.7	3.5	1.4	6.9	2.8	1.8	0.01	3.4
13/14	48.5	25.7	8.1	1.4	6.2	2.9	3.6	0.01	3.6
14/15	45.1	32.5	2.9	1.0	2.8	6.1	3.4	0.00	6.1
15/16	56.6	25.9	1.2	0.7	5.9	2.4	2.2	0.00	5.0
Average	57.0	12.4	15.4	4.3	2.9	2.2	2.1	0.03	3.7

Table C.2F: **Distribution of GUR 7 landings (%) by fishing year and by target species for bottom trawl in statistical area group [039-040] based on trips which landed gurnard. Annual total bottom trawl landings (t) for [039-040] are available in Table 10. The values are plotted in Figure 11.**

Year	FLA [039-040] (%)	GUR	BAR	RCO	TAR	WAR	SNA	STA	OTH
89/90	78.1	–	0.5	–	–	–	13.6	–	7.8
90/91	5.0	26.7	7.6	–	–	–	17.4	0.1	43.2
91/92	0.0	28.6	2.1	0.0	–	–	51.4	–	17.9
92/93	1.8	–	3.2	0.0	–	–	25.8	–	69.2
93/94	31.9	8.5	11.3	–	0.0	1.4	33.5	–	13.2
94/95	42.9	–	42.6	–	1.7	–	12.5	–	0.2
95/96	58.4	12.1	25.4	3.1	0.3	–	0.0	–	0.7
96/97	24.8	10.4	64.6	–	–	0.2	0.0	–	0.0
97/98	56.2	19.8	19.3	–	–	–	0.0	–	4.7
98/99	18.0	15.6	5.1	–	–	–	17.9	0.9	42.5
99/00	7.1	49.1	11.0	–	–	0.0	–	–	32.8
00/01	33.0	29.1	0.0	–	0.0	–	–	–	37.9
01/02	4.0	69.9	7.3	3.8	0.0	–	1.1	–	13.9
02/03	6.9	17.6	33.4	–	–	14.8	–	–	27.3
03/04	4.3	86.4	8.1	–	0.0	0.0	–	–	1.1
04/05	56.9	17.8	24.4	–	0.8	0.0	–	–	0.1
05/06	20.7	48.3	0.3	–	25.6	0.8	–	–	4.3
06/07	20.5	66.7	2.7	–	0.0	0.9	–	–	9.2
07/08	4.8	2.8	20.9	3.8	31.8	5.1	1.9	–	28.9
08/09	2.7	16.7	2.4	–	70.3	3.0	–	–	4.8
09/10	13.0	27.7	–	–	4.8	–	2.6	–	51.9
10/11	–	23.0	0.0	0.0	28.2	8.4	17.0	–	23.4
11/12	6.0	26.8	6.8	0.5	49.5	–	0.3	–	10.0
12/13	–	4.9	2.6	0.4	35.0	0.4	16.4	–	40.3
13/14	–	7.7	1.2	0.1	58.9	–	0.0	–	32.1
14/15	1.6	20.8	–	3.0	18.7	1.2	4.4	–	50.3
15/16	4.8	26.6	0.7	–	42.0	0.0	0.0	–	26.0
Average	16.1	30.1	12.9	0.8	9.8	1.0	8.2	0.0	21.1

Appendix D. METHOD USED TO EXCLUDE "OUT-OF-RANGE" LANDINGS

D.1 Introduction

The method described in this section was used to identify "implausibly large" landings due to data errors (possibly at the data entry step), with landings from single trips occasionally exceeding 100–300 t for some species. These errors can result in substantial deviations from the accepted QMR/MHR catches and affect the credibility of the characterisation and CPUE analyses.

D.2 Methods

The method evaluated trips with very large landings based on internal evidence within the trip that potentially corroborate the landings. The method proceeded in two steps:

Step 1   Trips with large landings above a specified threshold were selected using the empirical distribution of trip landing totals from all trips in the data set (for instance, all trips in the largest 1% quantile in terms of total trip landings);

Step 2   Internal evidence substantiating the landings within each trip was derived from summing the estimated catch for the species in question, as well as summing the "calculated green weight" (=*number_bins*avg_weight_bin*conversion_factor*) (Eq. D.1). The ratio of each these totals was taken with the declared green weight for the trip, with the minimum of the two ratios taken as the "best" validation (Eq. D.2). High values for this ratio (for instance, a value of 9 for this ratio implies that the declared green weight is 9 times larger than the "best" secondary total) are taken as evidence that the declared greenweight landing for the trip was not corroborated using the other available data, making the trip a candidate for dropping.

A two-way grid search was implemented, applying this procedure across a range of empirical quantiles (Step 1) and test ratio values (Step 2).

D.2.1 Equations

For every trip, there exist three estimates of total greenweight catch for species *s*:

$$G_{t,s}^{d} = \sum_{i=1}^{n_t} gwt_{t,s,i}$$

Eq. D.1 $$G_{t,s}^{c} = \sum_{i=1}^{n_t} CF_s * W_{t,i} * B_{t,i}$$

$$G_{t,s}^{e} = \sum_{j=1}^{m_t} est_{t,s,j}$$

where $G_{t,s}^{d}$ = sum of declared greenweight (*gwt*) for trip *t* over all n_t landing records;

$G_{t,s}^{c}$ = sum of calculated greenweight for trip *t* over all n_t landing records, using conversion factor CF_s, weight of bin $W_{t,i}$ and number of bins $B_{t,i}$;

$G_{t,s}^{e}$ = sum of estimated catch (*est*) for trip *t* over all m_t effort records.

Assuming that $G_{t,s}^{d}$ is the best available estimate of the total landings of species *s* for trip *t*, calculate the following ratios:

$$r1_{t,s} = G_{t,s}^{d} / G_{t,s}^{c}$$

Eq. D.2 $$r2_{t,s} = G_{t,s}^{d} / G_{t,s}^{e}$$

$$rat_{t,s} = \min(r1_{t,s}, r2_{t,s})$$

where $G_{t,s}^d$, $G_{t,s}^c$ and $G_{t,s}^e$ are defined in Eq. D.1, and ignoring $r1_{t,s}$ or $r2_{t,s}$ if missing when calculating $rat_{t,s}$.

The ratio $rat_{t,s}$ can be considered the "best available information" to corroborate the landings declared in the total $G_{t,s}^d$, with ratios exceeding a threshold value (e.g. $rat_{t,s} > 9.0$) considered to be uncorroborated. This criterion can be applied to a set of trips selected using a quantile of the empirical distribution of total trip greenweights. The set of trips to drop was selected on the basis of the pair of criteria (quantile and ratio threshold) which gave the lowest SSq^z (Eq. D.3) relative to the annual QMR/MHR totals:

Eq. D.3

$$gg_y^z = \sum_1^{p_y^z} L_y^z$$

$$Ssq^z = \sum_{y=89/90}^{y=14/15} \left(gg_y^z - MHR_y \right)^2$$

where p_y^z is the number landing records in year y for iteration z (i.e.: a combination of a ratio threshold criterion with an empirical quantile cut-off criterion);

L_y^z is a landing record included in year y for iteration z.

MHR_y is the corresponding MHR/QMR landing total for SPO in year y.

D.3 Results

A total of 16 trips were dropped, representing just over 150 t of greenweight landings (Table D.1). The results of these edits are plotted in Figure D.1 and tabulated in Table D.2. These removals are minor, representing just under 1% of the total landings and an even smaller percentage of the trips, but resulting in visible improvements to the "fit" of the landings with the QMR/MHR data in 1992–93, 1996–97 and 1998–99.

Table D.1: **Statistics associated with the selected minimum in each QMA.** $MHR_y =$ **QMR/MHR landings in year** y; $gg_y^0 =$ **unedited landings in year** y; $gg_y =$ **edited landings at selected minimum in year** y; $rat_{t,s}$ **as defined in Eq. D.2.**

Fishstock	Quantile	$rat_{t,s}$	Number trips dropped	Total trips in data set	Sum landings dropped (t)	$\sum_{y=89/90}^{y=15/16} MHR_y$	$\sum_{y=89/90}^{y=15/16} gg_y^0$	$\sum_{y=89/90}^{y=15/16} gg_y$	$\sum_{y=89/90}^{y=15/16} gg_y - \sum_{y=89/90}^{y=15/16} MHR_y$
GUR 7	99.5	5	16	62 693	150.1	16 138	16 271	16 121	-17

Table D.2: Annual statistics associated with the selected minima in GUR 7. $MHR_y = $ QMR/MHR landings in year y; $gg_y^0 = $ unedited landings in year y; $gg_y = $ edited landings at selected minimum in year y. The final two columns are the annual result of applying Eq. D.3 to the unedited landings and to the selected QMA "minimum" defined in Table D.1.

Fishing year	MHR_y	gg_y^0	gg_y	$Ssq^{unedited}$	Ssq^{edited}
89/90	510.6	455.6	450.5	3 029.3	3 607.3
90/91	443.0	429.4	429.4	186.7	186.7
91/92	704.1	684.7	684.7	374.2	374.2
92/93	760.8	810.5	780.3	2 466.8	382.3
93/94	469.5	472.2	472.2	7.5	7.5
94/95	455.9	459.9	450.7	16.2	27.2
95/96	380.4	366.1	366.1	203.8	203.8
96/97	386.6	437.7	405.1	2 611.5	341.9
97/98	305.0	318.1	318.1	169.1	169.1
98/99	323.7	356.9	330.0	1 103.7	40.0
99/00	331.2	341.8	341.8	113.2	113.2
00/01	571.2	571.3	571.3	0.0	0.0
01/02	685.2	690.8	690.8	31.1	31.1
02/03	793.0	798.9	794.3	34.5	1.7
03/04	717.0	739.2	739.2	495.3	495.3
04/05	688.3	684.7	684.7	12.9	12.9
05/06	603.7	606.0	606.0	5.2	5.2
06/07	713.9	727.0	712.6	171.5	1.7
07/08	563.2	567.9	567.9	22.6	22.6
08/09	594.7	609.1	591.9	205.7	8.2
09/10	604.0	602.4	602.4	2.5	2.5
10/11	544.9	536.1	536.1	77.4	77.4
11/12	683.6	687.4	677.4	14.7	38.1
12/13	763.4	764.6	764.6	1.5	1.5
13/14	837.2	836.5	836.5	0.5	0.5
14/15	852.2	861.5	861.5	86.3	86.3
15/16	851.5	854.7	854.7	9.8	9.8
Total	16 137.7	16 270.9	16 120.8	11 453.3	6 247.8
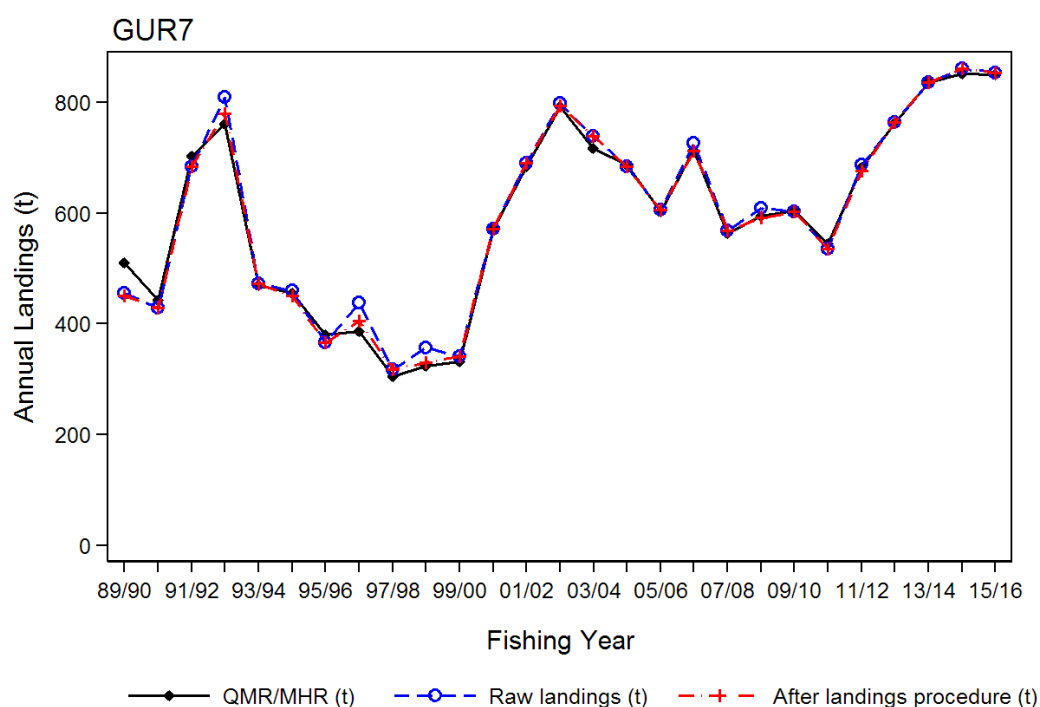
Figure D.1: Comparison of QMR/MHR annual total landings for GUR 7 with two data sets: A: unedited or "raw" landings; and B: total landings after dropping the trips identified at the selected QMA "minimum" quantile/ratio pairing defined in Table D.1.

Appendix E.   DATA SELECTION CRITERIA FOR GUR 7 CPUE ANALYSES

E.1   Introduction

The following selection criteria were used by Kendrick et al. (2011) and repeated by Langley (2014) for defining the four fisheries they used for monitoring GUR 7:

Model	Target species	Statistical Areas	Core fleet
WCSI(FLA)	FLA	033–036	5 years with 5+ trips
WCSI(MIX)	RCO, TAR, BAR, STA, WAR	033–036	5 years with 4+ trips
TBGB(FLA)	FLA, RCO	038, 017	5 years with 5+ trips
TBCS(MIX)	TAR, BAR, WAR	038, 039, 017, 018	5 years with 5+ trips

There are several aspects to these selection criteria which seem problematic:

- Statistical Area 037 is missing from the two Tasman Bay series

- Statistical Area 018 has been included in the TBCS(MIX) analysis

- GUR is not listed as a target species, even though it is an important target species in either (MIX) fishery definition (although this importance was just beginning to be expressed when Kendrick et al. (2011) did their analysis) (see Figure 10)

- RCO is combined with FLA in the TBGB(FLA) CPUE series, even though that fishery operates at deeper depths than FLA

E.2   Discussion

E.2.1   West Coast South Island (WCSI)

Figure 7 shows the spatial distribution of GUR landings on the WCSI: these landings extend from the top of Statistical Area 032 into western Cook Strait north of Farewell Spit. The choice of the four areas 033 to 036 seems appropriate and has continued with this analysis.

The distribution of bottom trawl landings which targeted GUR by fishing year from the four statistical areas shows how important the GUR target fishery has become in this data set, beginning from about 2010–11 (Table E.1). Therefore this target species should be added to the definition list for this CPUE series.

The cumulative depth profile of gurnard estimated catches from Statistical Areas 033 to 036, averaged over 2007–08 to 2015–16, shows that GUR by-catch while fishing for FLA is at more shallow depths than for any of the other target species (Figure E.2). This same plot shows that the depth profile for gurnard, when targeting GUR, resembles the RCO depth profile, leading to the conclusion that GUR target species should be placed in the (MIX) analysis rather than the (FLA) analysis.

E.2.2   Tasman Bay/Golden Bay (TBGB)

Figure E.1 shows the spatial distribution of GUR landings in Cook Strait: the boundary between Areas 037 and 038 pass through a continuous region of gurnard landings. Consequently, Area 037 should be included in this CPUE series.

The distribution of bottom trawl landings which targeted GUR by fishing year for the three TBGB statistical areas shows that, while GUR is not as dominant in these areas as on the WCSI, it is still the second most important target species in this data set (Table E.2). Therefore this target species should be added to the definition list for this CPUE series.

The cumulative depth profile of gurnard estimated catches for Area 038, averaged over 2007–08 to 2015–16, shows that gurnard by-catch, while fishing for FLA, has the most shallow profile of all the target species (Figure E.3). As on the WCSI, the depth profile for gurnard, when targeting GUR, resembles the RCO depth profile, leading to the conclusion that both GUR and RCO should be placed in the (MIX) analysis rather than the (FLA) analysis.

E.2.3 Cook Strait (CookSt)

Figure E.1 shows the spatial distribution of GUR landings in Cook Strait: the Area 039 and 040 fisheries for GUR tend to hug the South Taranaki Bight coastline and consequently may be primarily GUR 8 rather than GUR 7. However, for completeness, it seems useful to provide a sensitivity analysis which explores the complete Cook Strait fishery rather the just the southern and western components of this fishery.

The distribution of bottom trawl landings which targeted GUR by fishing year for the five Cook Strait statistical areas shows that the overall catch of GUR increased by over 600 t relative to the TBGB fishery (compare totals in Table E.3 with those in Table E.2). This increase is spread across a range of target species, with the greatest increase from GUR targeting. The important aspect of the totals in Table E.3 is the drop in the relative importance of RCO, which apparently is fished relatively less frequently when Areas 039 and 040 are added to the analysis. Consequently, RCO has not been included in the (MIX) fishery definition and is replaced by TRE.

As with the TBGB fishery, the cumulative depth profile of gurnard estimated catches for the combined 017, 037–040 statistical areas, averaged over 2007–08 to 2015–16, closely resembles the same plot for Area 038 (Figure E.4). All species except FLA will be placed in the (MIX) fishery definition, leaving FLA as a separate fishery definition.

Table E.1: **Distribution by year and by declared target species for GUR bottom trawl landings (t) from Areas 033–036.**

Fishing year	FLA	GUR	RCO	TAR	BAR	WAR	STA	ELE	SNA	OTH	Total
07/08	187.1	6.1	64.7	27.5	28.0	6.5	3.6	0.8	1.1	1.5	326.9
08/09	168.7	7.0	51.0	32.1	25.9	4.3	2.8	0.0	0.1	1.0	293.0
09/10	153.5	33.4	35.4	35.3	15.0	9.0	3.0	0.3	2.2	1.6	288.8
10/11	96.0	39.7	51.2	42.3	16.3	6.5	5.4	1.7	0.9	3.7	263.6
11/12	144.4	131.4	19.9	41.8	17.8	16.0	9.2	0.6	0.1	3.3	384.4
12/13	134.9	180.3	12.4	41.0	24.2	19.1	5.9	0.3	1.7	1.3	421.2
13/14	169.5	208.6	39.8	41.5	27.9	14.0	8.6	0.6	0.4	0.9	511.8
14/15	150.0	158.2	65.4	41.2	14.9	34.1	7.4	3.3	–	3.0	477.5
15/16	205.7	129.9	59.8	49.9	20.9	41.5	8.2	3.4	–	2.6	522.0
Total	1 409.9	894.7	399.6	352.6	190.9	151.0	54.0	10.9	6.5	18.9	3 489.1

Table E.2: **Distribution by year and by declared target species for GUR bottom trawl landings (t) from Areas 017, 037–038.**

Fishing year	FLA	GUR	BAR	TAR	WAR	RCO	SNA	LEA	JDO	TRE	OTH	Total
07/08	91.9	18.1	44.4	2.0	10.0	17.9	7.5	3.3	1.2	0.4	4.5	201.3
08/09	162.3	22.7	41.1	5.9	10.1	11.4	3.8	3.7	0.2	1.0	3.1	265.2
09/10	155.5	47.5	31.0	6.0	4.9	13.1	9.9	12.8	0.4	3.3	6.1	290.5
10/11	116.3	61.5	11.9	13.2	8.8	10.4	8.8	4.7	0.4	3.4	4.6	244.1
11/12	119.8	52.9	18.6	16.4	6.7	5.0	4.6	13.7	0.9	4.1	1.3	244.0
12/13	120.7	94.6	10.1	19.3	8.1	3.4	5.1	6.2	1.6	4.7	1.9	275.6
13/14	113.7	71.7	18.8	14.8	8.5	3.5	8.9	4.3	2.7	4.3	2.6	253.8
14/15	120.2	97.2	7.6	8.0	18.3	2.7	8.9	2.3	13.4	6.7	0.9	286.2
15/16	160.8	80.5	3.7	16.8	8.0	2.1	6.3	1.2	12.1	3.6	2.0	297.0
Total	1 161.3	546.9	187.1	102.4	83.4	69.6	63.7	52.1	32.7	31.4	27.0	2 357.8

Table E.3: Distribution by year and by declared target species for GUR bottom trawl landings (t) from Areas 017, 037–040.

Fishing year	FLA	GUR	BAR	TAR	TRE	SNA	WAR	JDO	LEA	RCO	OTH	Total
07/08	101.7	34.5	46.9	6.9	9.9	10.1	10.2	3.4	5.9	18.8	8.4	256.8
08/09	177.2	71.3	42.0	9.8	6.9	5.6	10.1	1.5	6.8	11.4	3.6	346.4
09/10	160.3	90.2	31.1	12.9	22.8	12.1	4.9	4.6	19.8	13.1	6.8	378.5
10/11	121.5	118.6	12.3	15.9	14.1	13.0	8.9	4.4	5.8	10.4	5.6	330.6
11/12	126.5	103.1	21.3	19.6	12.1	6.9	6.7	4.4	18.8	5.0	1.6	326.0
12/13	121.5	128.7	10.4	21.4	19.2	7.1	8.1	5.8	7.5	3.5	2.4	335.4
13/14	117.4	105.4	19.3	18.7	14.5	9.5	8.5	8.1	5.5	3.5	2.8	313.2
14/15	127.1	132.6	7.6	9.4	15.2	12.6	18.3	23.9	3.0	2.8	2.6	355.1
15/16	161.5	106.6	5.4	20.5	17.6	8.7	8.1	18.4	1.3	2.1	2.8	352.9
Total	1 214.7	891.1	196.3	135.1	132.3	85.6	83.9	74.5	74.4	70.7	36.4	2 995.0
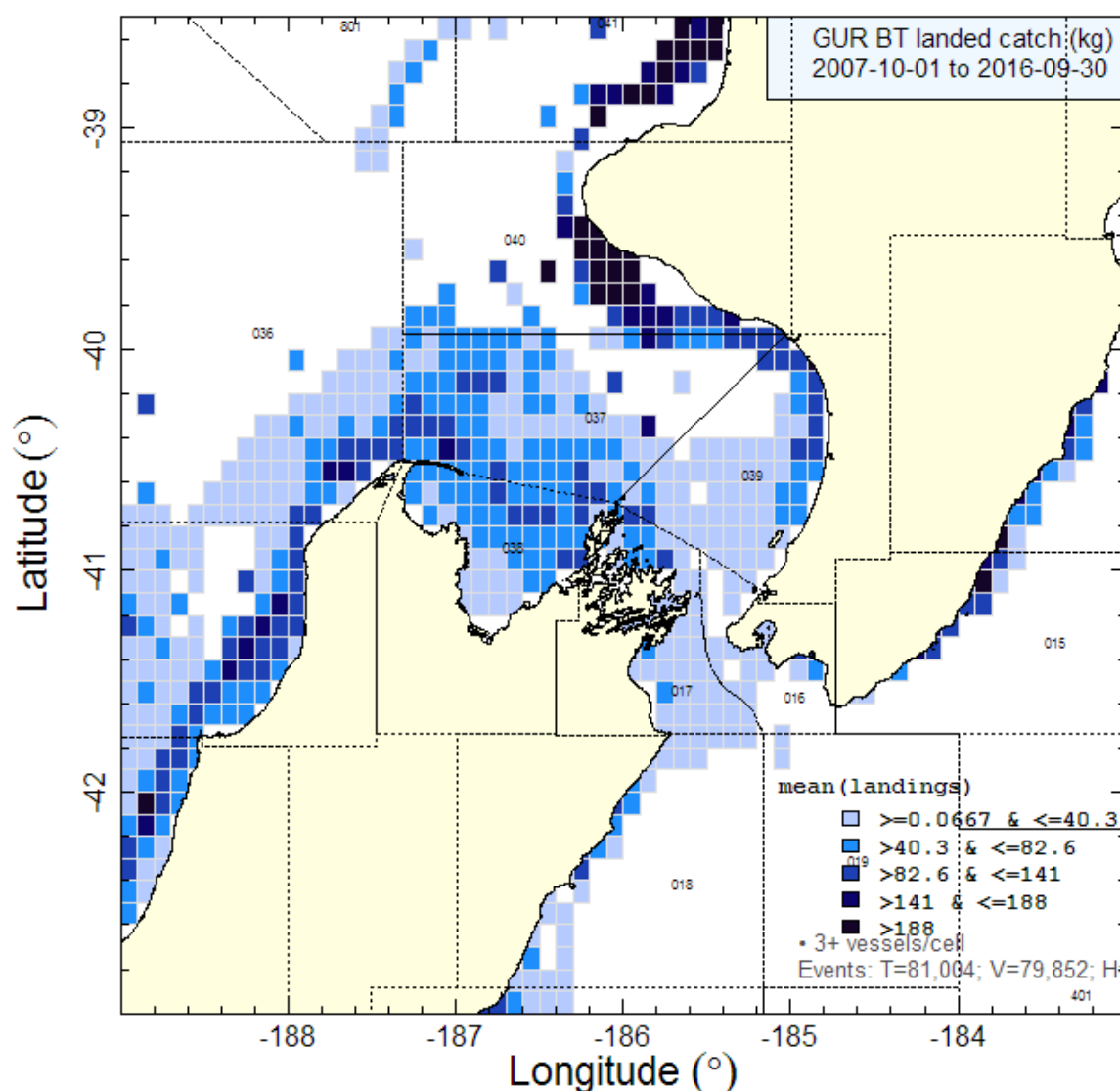
Figure E.1: Spatial distribution of gurnard bottom trawl landings (t) in Cook Strait, arranged in 0.1° × 0.1° grids and summed from 2007–08 to 2015–16. Legend colours divide the distribution of total landings into 25%, 50%, 75%, 90% and 95% quantiles. Only grids which have at least three reporting vessels are plotted. Note that this requirement has dropped 1152 of 81 004 events. Boundaries are shown for the general statistical areas plotted in Appendix B. These catch distributions are generated from the bottom trawl CPUE data set which contains all gurnard captured in the plotted statistical areas, regardless of the QMA landed.

WCSI by target species: weighted by estimated GUR catch
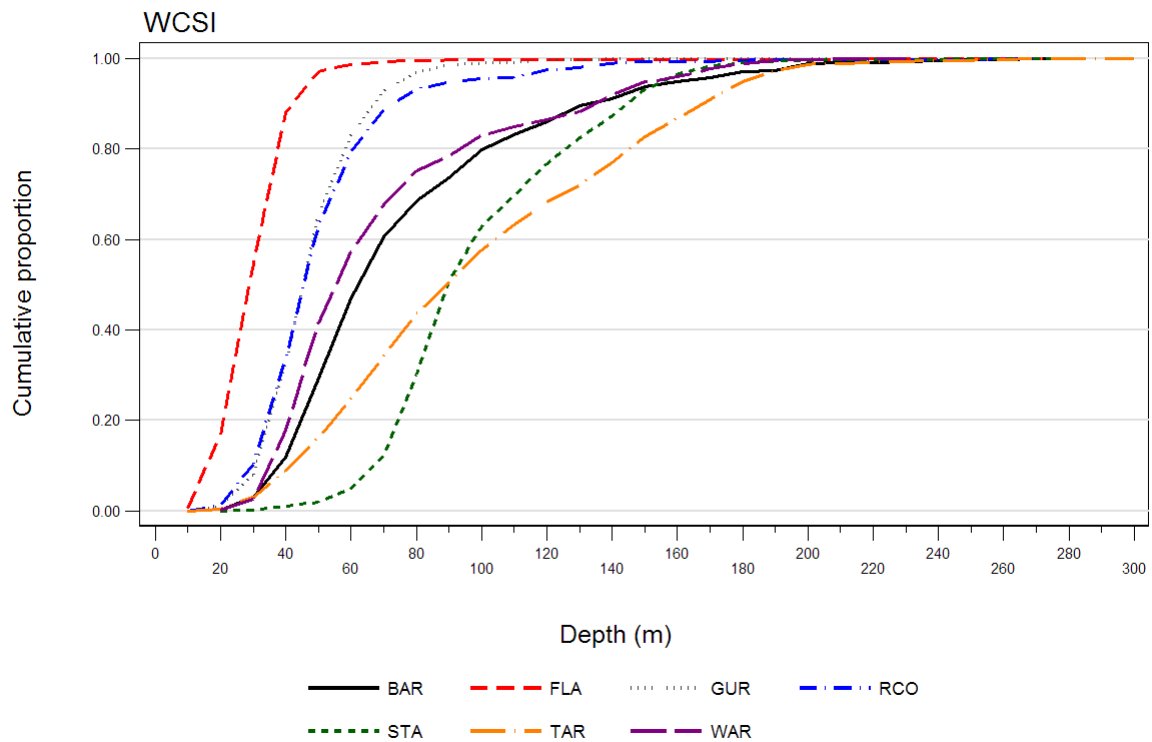
Figure E.2: **Cumulative depth plots by target species category for the four combined WCSI statistical areas (Areas 033–036), averaged over the period 2007–08 to 2015–16.**

Tasman/Golden Bays by target species: weighted by estimated GUR catch
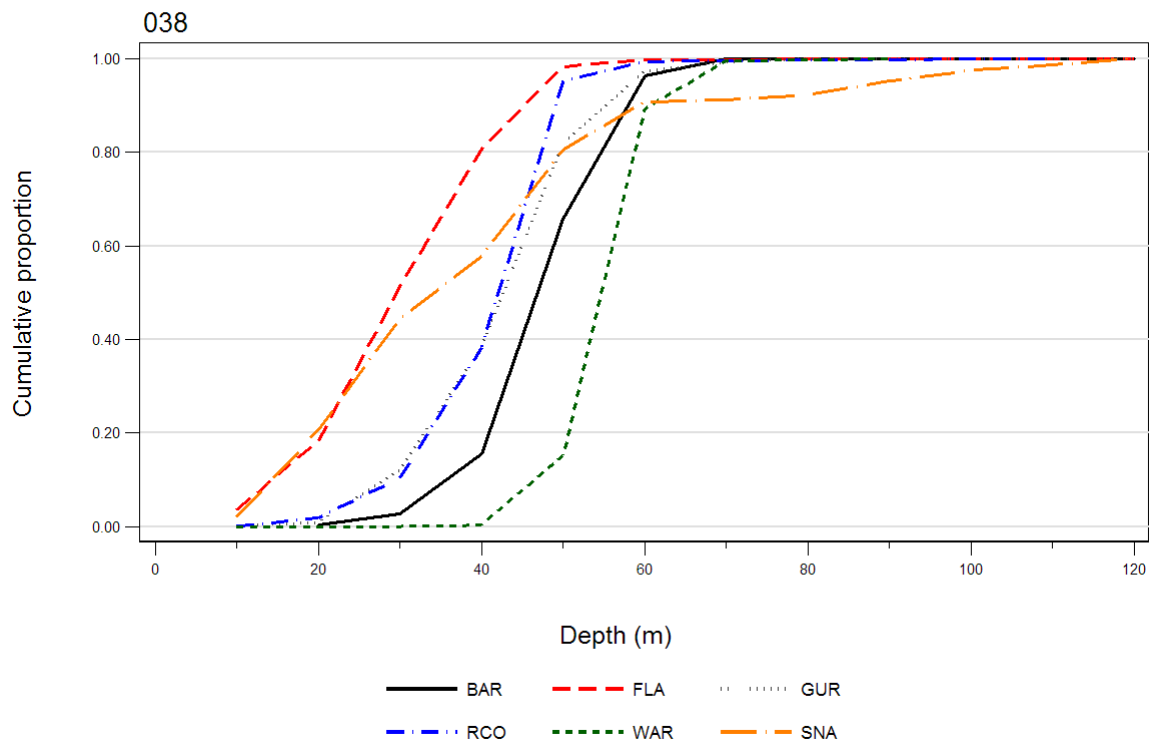
Figure E.3: **Cumulative depth plots by target species category for Statistical Area 038, averaged over the period 2007–08 to 2015–16.**
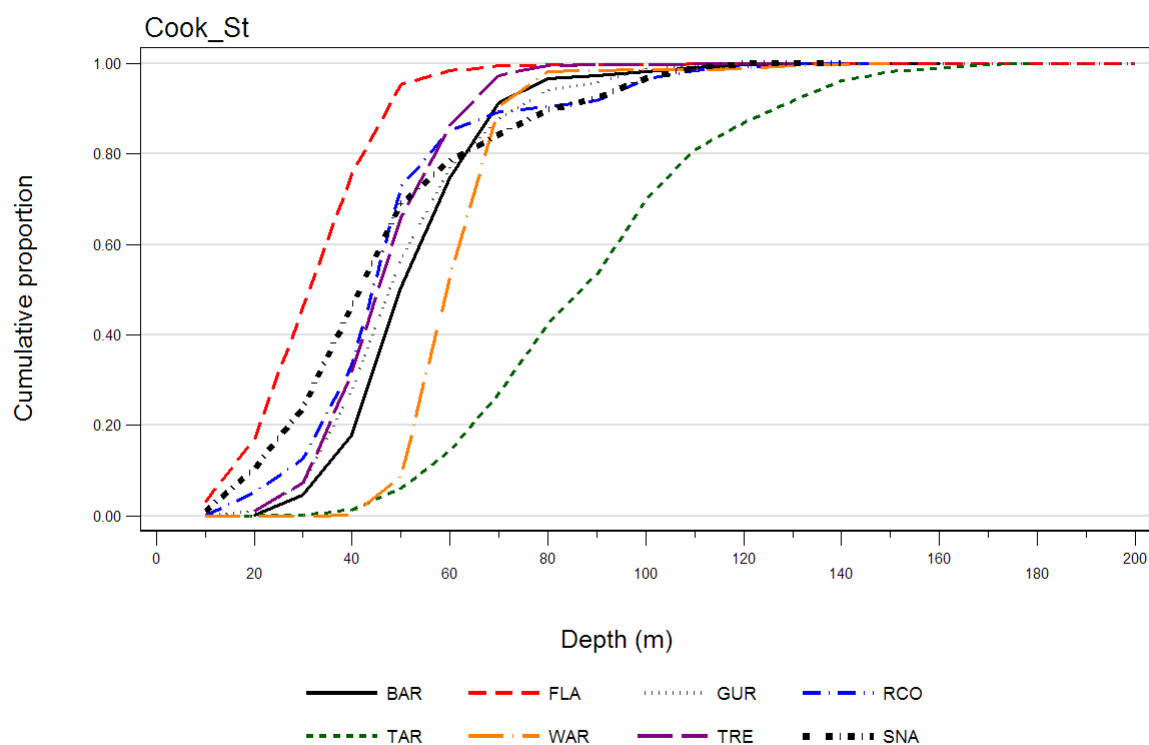
Figure E.4: Cumulative depth plots by target species category for the five combined Cook Strait statistical areas (Areas 017, 037–040), averaged over the period 2007–08 to 2015–16.

Appendix F. GUR 7 CPUE ANALYSIS

F.1 General overview

This Appendix describes an update of a GUR 7 CPUE analysis that was first presented in Kendrick et al. (2011) and then updated by Langley (2014). This Appendix and Appendix G to Appendix L support the analyses presented in Section 3 of the main report. This Appendix contains the definitions for the modelled fisheries, equations used, and procedures followed. Appendix G to Appendix L provide detailed tables and figures with statistics and diagnostics, and final tables giving the estimated indices with the standard error.

F.2 Methods

F.2.1 Data Preparation

The identification of candidate trips for these analyses and the methods used to prepare them are described in Section 2.3.1 in the main report. Landings were allocated to effort at the "daily effort stratum" resolution procedure described on page 7. As described in Section 2.3.1, the CPUE data set was prepared using the "Statistical Area" expansion procedure, whereby the trip expansion was based on the statistical area fished without reference to the Fishstock that was landed. This meant that trips which fished in shared statistical areas and which landed to several GUR QMAs were maintained in the data set rather than dropped. However, this procedure requires that fishery definitions will be based on statistical area fished, rather than on QMA, and implies that landings from QMAs other than GUR 7 will be included in the analysis. This approach has been used to ensure that a larger proportion of the catch is retained in the data set.

Those groups of events that satisfied the criteria of target species, method of capture and statistical areas that defined each fishery were selected from available fishing trips. Any effort strata that were matched to a landing of gurnard were termed "successful", and may include relevant but unsuccessful effort given that a "daily-effort stratum" represents amalgamated catch and effort. Consequently, the analysis of catch rates in successful strata also incorporates some zero catch information.

The potential explanatory variables available from each trip in these data sets include fishing year, the number of tows, the duration of fishing, statistical area, target species, month of landing, and a unique vessel identifier. The dependent variable will be either log(catch), where catch will be the scaled daily landings, or presence/absence of GUR. Data might not represent an entire fishing trip; just those portions of it that qualified. Trips were not dropped because they targeted more than one species or fished in more than one statistical area.

Datasets were further restricted to core fleets of vessels, defined by their activity in the fishery, thus selecting only the most active vessels without dropping too much of the available catch and effort data.

F.2.2 Analytical methods for standardisation

Arithmetic CPUE $\left(\hat{A}_y \right)$ in year y was calculated as the mean of catch divided by effort for each observation in the year:

Eq. F.1
$$\hat{A}_y = \frac{\sum_{i=1}^{N_y} C_{i,y} / E_{i,y}}{N_y}$$

where $C_{i,y}$ is the [*catch*] and $E_{i,y} = L_{i,y}$ ([*tows*]–for bottom trawl) in record i in year y, and N_y is the number of records in year y.

Unstandardised CPUE $\left(\hat{U}_y \right)$ in year y is the geometric mean of the ratio of catch to effort for each record i in year y:

Eq. F.2
$$\hat{U}_y = \exp\left[\frac{\sum_{i=1}^{N_y} \ln\left(C_{i,y} \big/ E_{i,y} \right)}{N_y} \right]$$

where C_i, $E_{i,y}$ and N_y are as defined for Eq. F.1. Unstandardised CPUE assumes a log-normal distribution, but does not take into account changes in the fishery. This index is the same as the "year index" calculated by the standardisation procedure, when not using additional explanatory variables and using the same definition for $E_{i,y}$. Presenting the arithmetic and unstandardised CPUE indices in this report provides measures of how much the standardisation procedure has modified the series from these two sets of indices.

A standardised abundance index (Eq. F.3) was calculated from a generalised linear model (GLM) (Quinn & Deriso 1999) using a range of explanatory variables including [*year*], [*month*], [*vessel*] and other available factors:

Eq. F.3
$$\ln(I_i) = B + Y_{y_i} + \alpha_{a_i} + \beta_{b_i} + ... + f\left(\chi_i \right) + f\left(\delta_i \right) .... + \varepsilon_i$$

where $I_i = C_i$ for the ith record, Y_{y_i} is the year coefficient for the year corresponding to the ith record, α_{a_i} and β_{b_i} are the coefficients for factorial variables a and b corresponding to the ith record, and $f\left(\chi_i \right)$ and $f\left(\delta_i \right)$ are polynomial functions (to the 3rd order) of the continuous variables χ_i and δ_i corresponding to the ith record, B is the intercept and ε_i is an error term. The actual number of factorial and continuous explanatory variables in each model depends on the model selection criteria. Fishing year was always forced as the first variable, and month (of landing), statistical area, target species, and a unique vessel identifier were also offered as categorical variables. Number tows $\left(\ln(T)_i \right)$ and fishing duration $\left(\ln(D_i) \right)$ were offered to the bottom trawl models as continuous third order polynomial variables.

It was decided to force the lognormal distribution for analysing the positive catch part of each of the six CPUE analyses. This was done for consistency with past analyses, which selected the lognormal as the "best" distribution when analysed by Kendrick et al. (2011) and when extended by Langley (2014).

For the positive catch records, log(catch) was regressed against the full set of explanatory variables in a stepwise procedure, selecting variables one at a time until the improvement in the model R^2 was less than 0.01. The order of the variables in the selection process was based on the variable with the lowest AIC, so that the degrees of freedom were minimised.

Canonical coefficients and standard errors were calculated for each categorical variable (Francis 1999). Standardised analyses typically set one of the coefficients to 1.0 without an error term and estimate the remaining coefficients and the associated error relative to the fixed coefficient. This is required because of parameter confounding. The Francis (1999) procedure rescales all coefficients so that the geometric mean of the coefficients is equal to 1.0 and calculates a standard error for each coefficient, including the fixed coefficient.

The procedure described by Eq. F.3 is necessarily confined to the positive catch observations in the data set because the logarithm of zero is undefined. Observations with zero catch were modelled by

fitting a linear regression model based on a binomial distribution and using the presence/absence of gurnard as the dependent variable (where 1 is substituted for $\ln(I_i)$ in Eq. F.3 if it is a successful catch record and 0 if it is not successful), using the same data set. Explanatory factors were estimated in the model in the same manner as described for Eq. F.3. Such a model provides an alternative series of standardised coefficients of relative annual changes that is analogous to the equivalent series estimated from the positive catch regression.

A combined model, which integrates the lognormal and binomial annual abundance coefficients, was estimated using the delta distribution, which allows zero and positive observations (Vignaux 1994):

Eq. F.4
$$^{C}Y_y = \frac{^{L}Y_y}{\left(1 - P_0\left[1 - \dfrac{1}{^{B}Y_y}\right]\right)}$$

where $^{C}Y_y$ = combined index for year y

$^{L}Y_y$ = lognormal index for year i

$^{B}Y_y$ = binomial index for year i

P_0 = proportion zero for base year 0

Confidence bounds, while straightforward to calculate for the binomial and lognormal models, were not calculated for the combined model because a bootstrap procedure (recommended by Francis 2001) has not yet been implemented in the available software.

F.2.3   Fishery definitions

The following selection criteria were used for defining the six bottom trawl fisheries described in this report:

Model	Target species	Statistical Areas	Core Fleet Definition	Document Reference
WCSI(FLA)	FLA	033–036	5 years with 5+ trips	Appendix G
WCSI(MIX)	GUR, RCO, BAR, TAR, WAR, STA	033–036	5 years with 5+ trips	Appendix H
TBGB(FLA)	FLA	017, 037–038	5 years with 10+ trips	Appendix I
TBGB(MIX)	GUR, BAR, TAR, WAR, RCO, SNA	017, 037–038	5 years with 5+ trips	Appendix J
CookSt(FLA)	FLA	017, 037–040	5 years with 10+ trips	Appendix K
CookSt(MIX)	GUR, BAR, TAR, TRE, WAR, SNA	017, 037–040	5 years with 5+ trips	Appendix L

All series use the lognormal distribution for the positive catch model. A binomial model based on the presence/absence of gurnard in each data set was also calculated. The two models were then combined using the delta-lognormal method (Eq. F.4) to form a final composite model. Diagnostic plots are provided for each positive catch model and binomial diagnostic plots are provided for the two WCSI models.

Appendix G.   DIAGNOSTICS AND SUPPORTING ANALYSES FOR WCSI(FLA)

G.1   Introduction
This CPUE analysis was accepted in 2014 for monitoring GUR 7 by the Southern Inshore Fishery Assessment Working Group (MPI 2016). Following a 2017 review, the Plenary agreed to use the WCSI trawl survey for monitoring GUR 7 and will use this series [along with WCSI(MIX)] to corroborate the survey observations (MPI 2017).

G.2   Fishery definition
WCSI(FLA): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 033, 034, 035 and 036 and declared target species FLA.

G.3   Core vessel selection
The criteria used to define the core fleet were those vessels that had fished for at least 5 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 56 vessels which took 79% of the catch (Figure G.1).

G.3.1   Data summary

Table G.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 5 trips per year in 5 years) in the WCSI(FLA) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	22	337	677	691	1.02	1 989	6 884	82.96	98.8	0.9	0.28
1991	19	373	828	832	1.00	2 518	8 489	77.76	98.4	1.9	0.90
1992	28	381	988	1 004	1.02	3 266	10 649	147.12	98.7	6.9	6.61
1993	35	711	1 676	1 686	1.01	5 675	19 205	198.24	95.4	9.3	7.21
1994	36	472	1 139	1 147	1.01	3 504	11 518	100.65	96.2	15.4	10.64
1995	34	540	1 363	1 388	1.02	4 344	14 121	86.59	94.1	9.5	6.23
1996	33	640	1 532	1 557	1.02	4 783	15 801	89.73	95.3	8.2	6.68
1997	35	637	1 709	1 728	1.01	5 429	17 955	91.84	92.0	13.5	13.56
1998	37	609	1 371	1 382	1.01	4 128	13 462	82.35	91.6	9.9	9.52
1999	37	677	1 738	1 748	1.01	5 452	17 958	102.47	95.0	14.8	11.42
2000	33	367	858	859	1.00	2 473	8 605	63.62	95.4	10.6	4.39
2001	30	427	1 233	1 242	1.01	3 722	13 456	184.81	98.6	10.0	6.27
2002	29	265	744	746	1.00	2 220	8 478	126.58	98.1	2.3	1.17
2003	25	349	954	956	1.00	2 742	11 075	209.73	97.4	4.4	5.09
2004	25	420	1 193	1 203	1.01	3 507	13 299	195.60	97.4	9.1	9.02
2005	27	409	1 198	1 203	1.00	3 610	14 130	172.21	98.5	6.0	4.29
2006	27	433	1 303	1 312	1.01	3 735	14 726	137.76	99.1	4.4	2.32
2007	28	474	1 356	1 371	1.01	3 959	16 198	148.99	98.5	1.5	0.33
2008	26	280	990	2 800	2.83	2 833	13 104	127.98	99.3	2.9	0.33
2009	25	318	1 046	2 778	2.66	2 832	12 903	129.63	97.2	3.6	0.61
2010	21	306	984	2 815	2.86	2 830	12 224	108.72	99.4	2.6	0.37
2011	20	231	662	1 798	2.72	1 798	8 236	81.98	99.6	1.7	0.39
2012	20	192	589	1 718	2.92	1 718	8 053	132.00	97.9	1.6	0.22
2013	15	187	628	1 822	2.90	1 822	8 738	160.21	98.9	0.5	0.01
2014	17	196	632	1 786	2.83	1 786	8 429	179.41	99.0	0.5	0.04
2015	20	250	822	2 270	2.76	2 270	10 723	147.41	99.2	0.0	0.00
2016	18	186	544	1 518	2.79	1 518	7 377	147.14	98.9	0.0	0.00

G.3.2   Core vessel selection
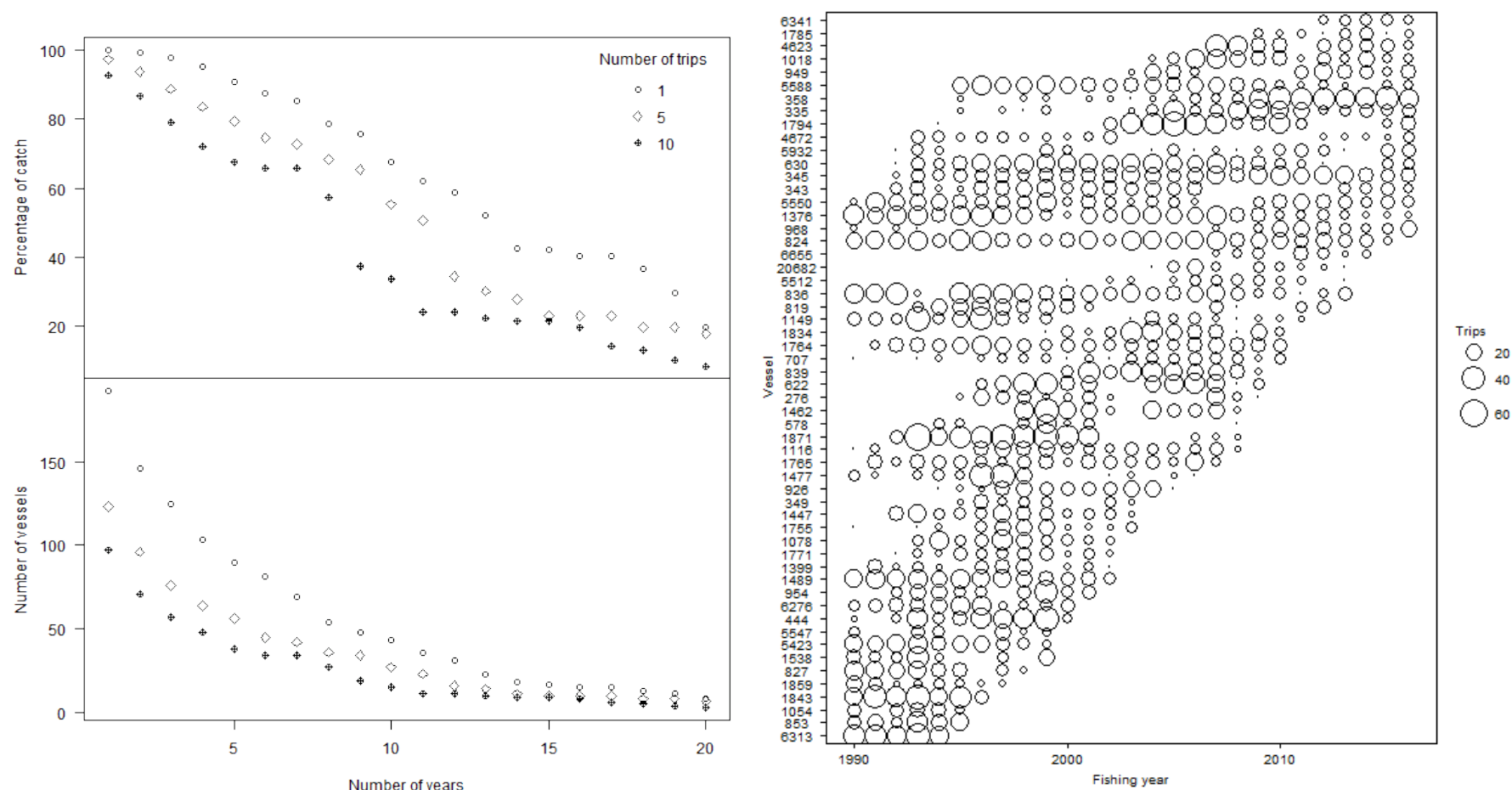
Figure G.1:   [left panel] total landed GUR and number of vessels plotted against the number of years used to define core vessels participating in the WCSI(FLA) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 5 trips in 5 or more fishing years) by fishing year.

G.3.3   Exploratory data plots for core vessel data set
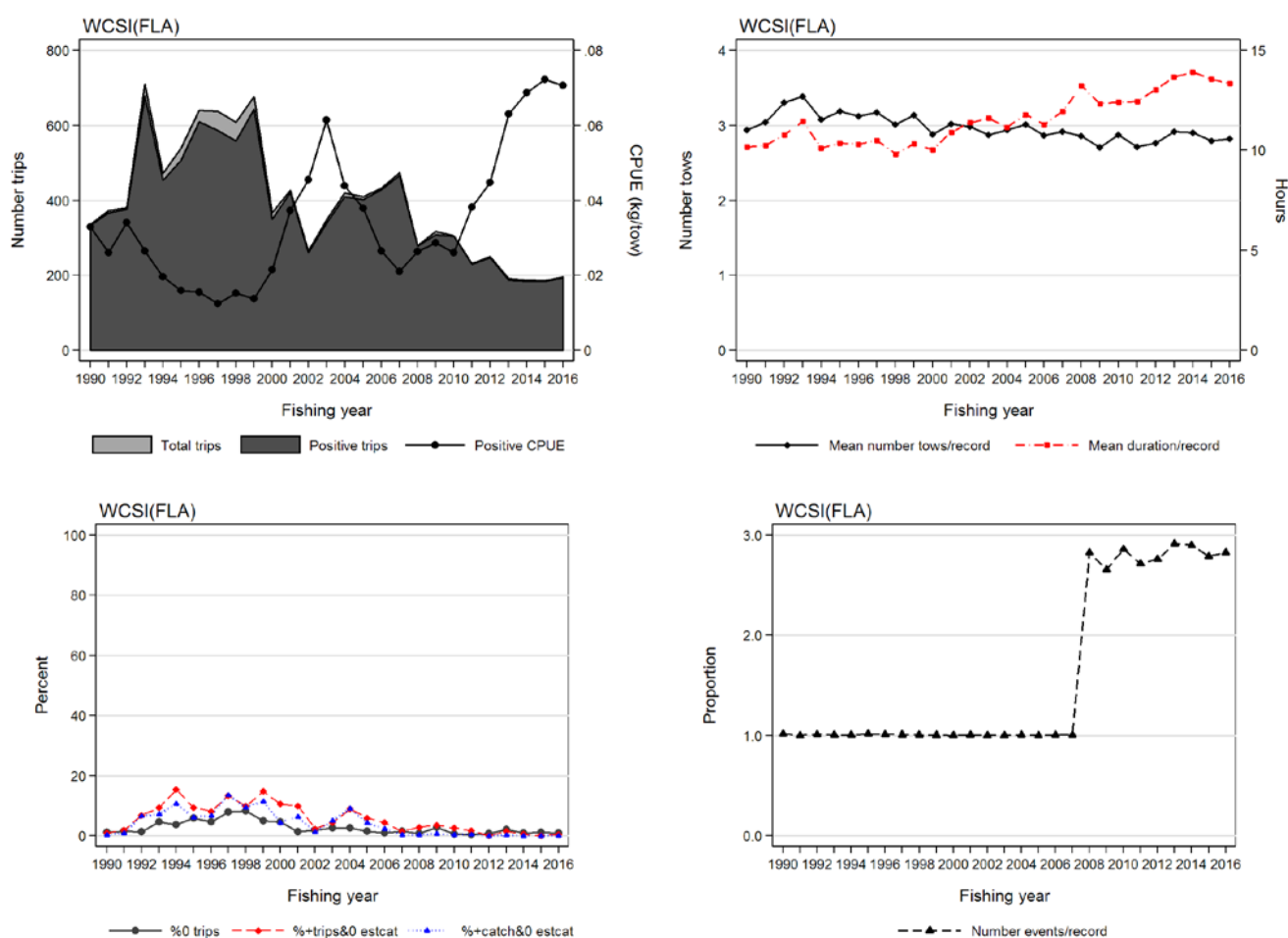
Figure G.2:   **Core vessel summary plots by fishing year for model WCSI(FLA): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch:** $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i}\right)$ **; [upper right panel]: mean number of tows and mean duration per daily-effort stratum record; [lower left panel]: proportion of trips with a) no catch of gurnard, b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.**

G.4 Positive catch model selection table

Two explanatory variables entered the model after fishing year (Table G.2), with duration fishing, month and area non-significant. A plot of the model is provided in Figure G.3 and the CPUE indices are listed in Table G.4.

Table G.2: **Order of acceptance of variables into the lognormal model of successful catches in the WCSI(FLA) fishery model for core vessels based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-149 754	299 564	16.86	*
vessel	83	-146 486	293 138	35.35	*
poly(log(tows), 3)	86	-144 075	288 321	**46.30**	*
poly(log(duration), 3)	89	-143 874	287 925	47.12	
month	100	-143 691	287 581	47.86	
area	103	-143 617	287 439	48.16	
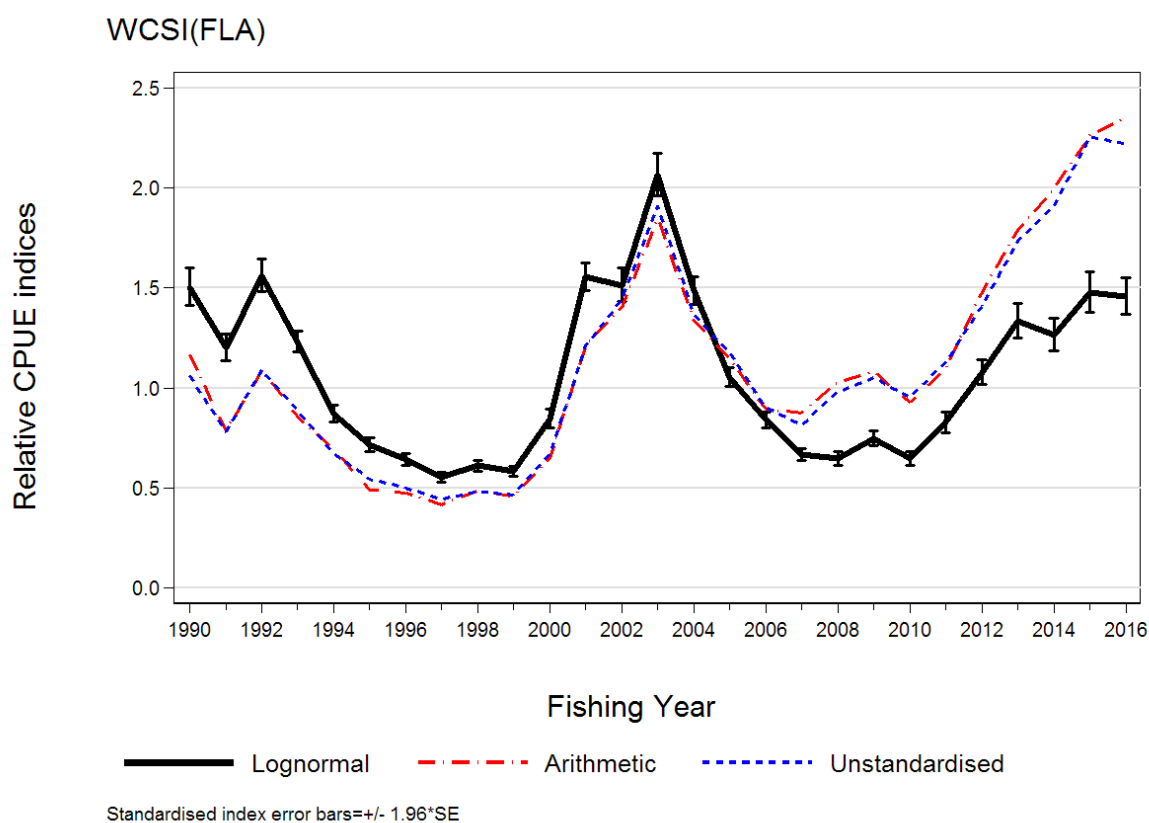
Figure G.3: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(FLA) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).**
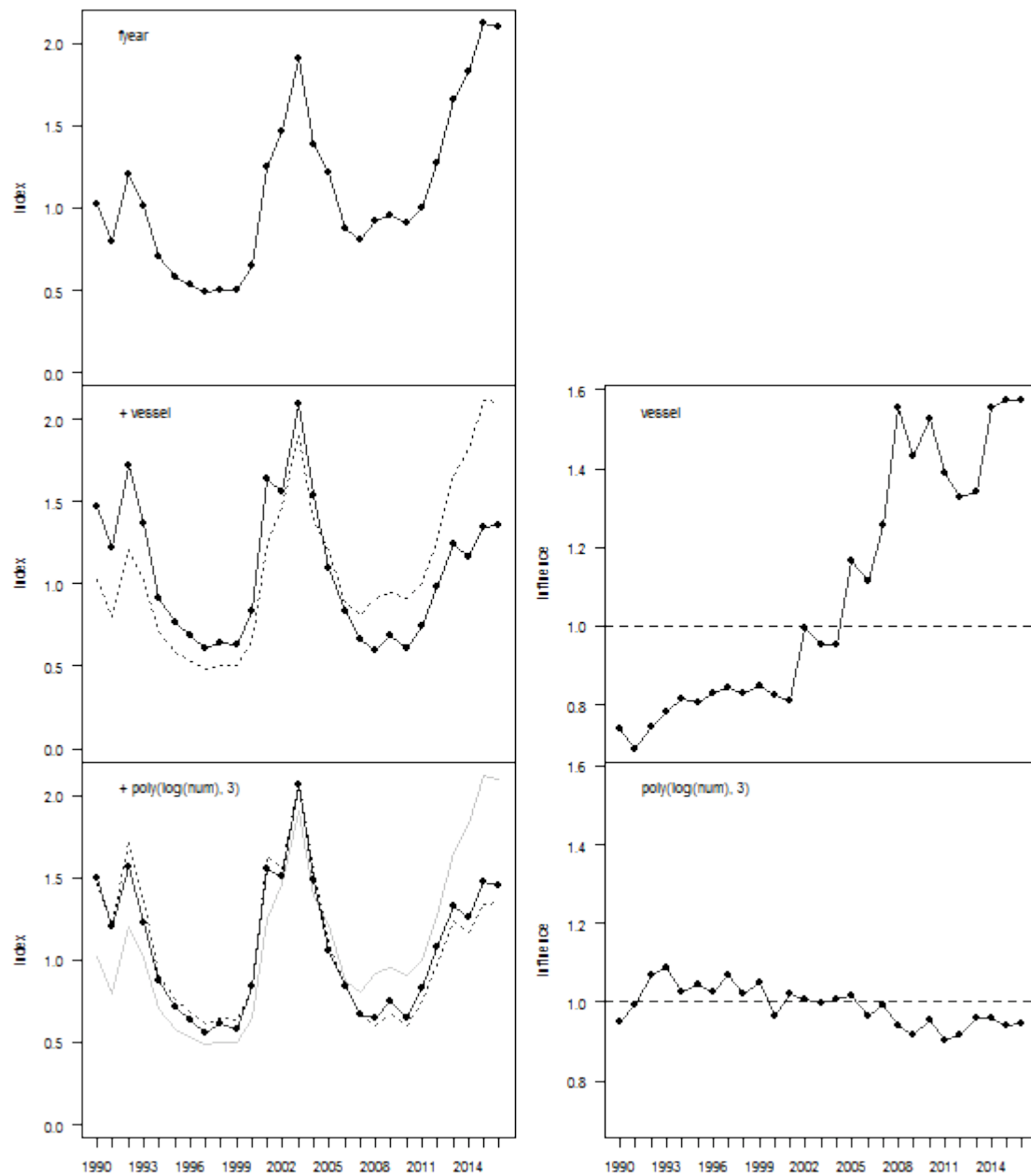
Figure G.4: [left column]: annual indices from the lognormal model of WCSI(FLA) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

G.4.1 Residual and diagnostic plots
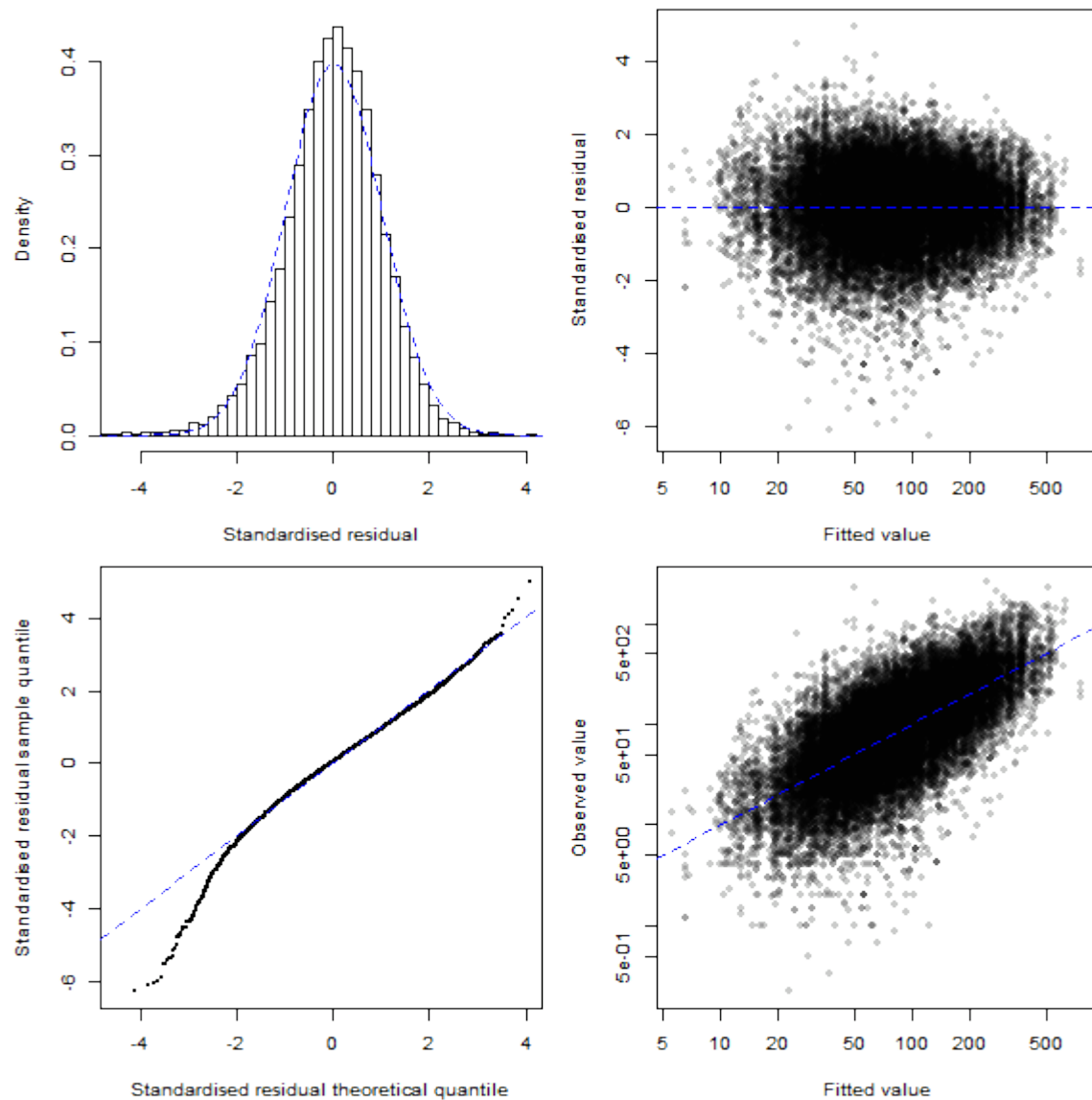
Figure G.5: **Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the WCSI(FLA) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.**

G.4.2   Model coefficients
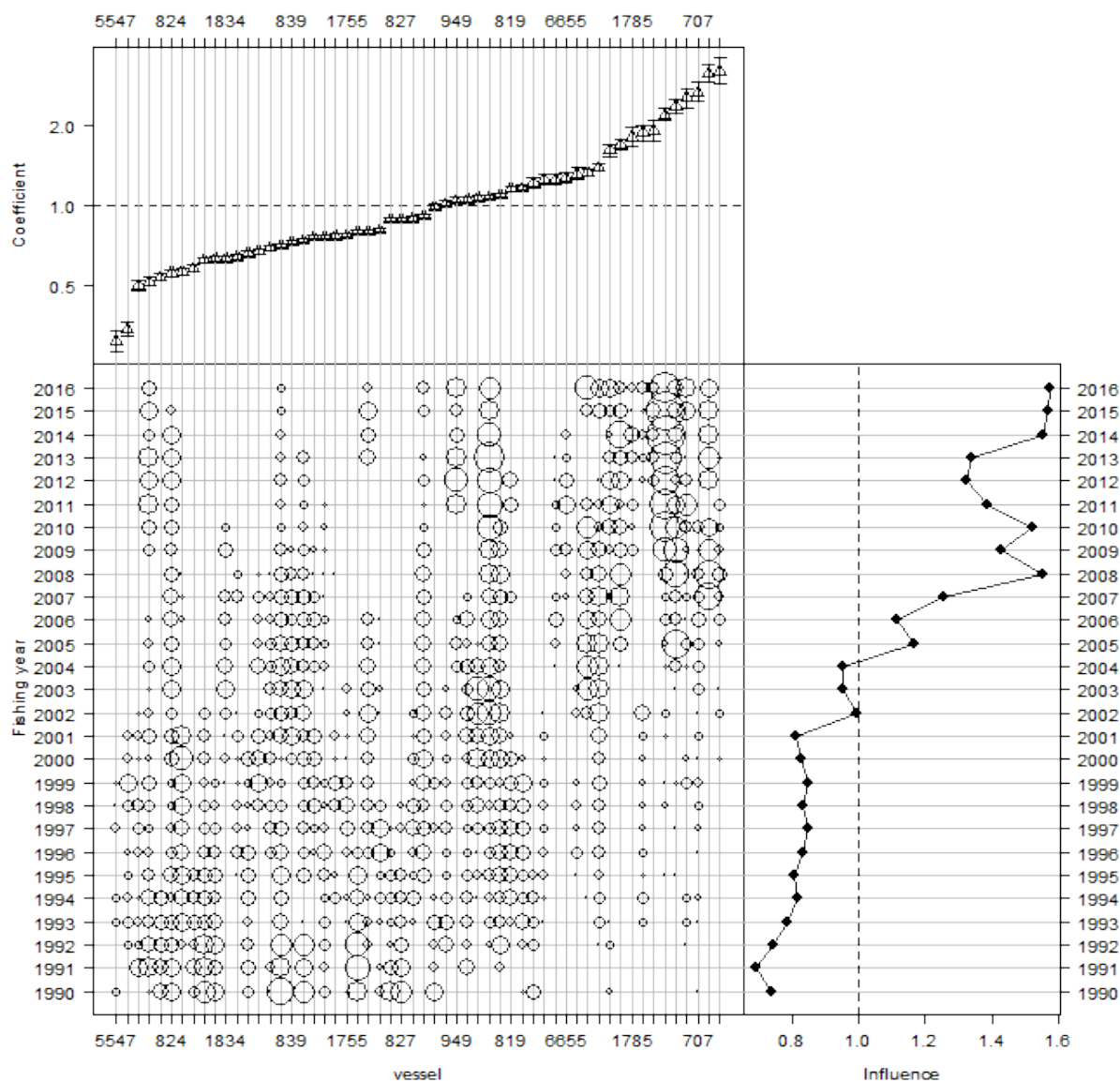
Figure G.6:   **Effect of vessel in the lognormal model for the gurnard WCSI(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
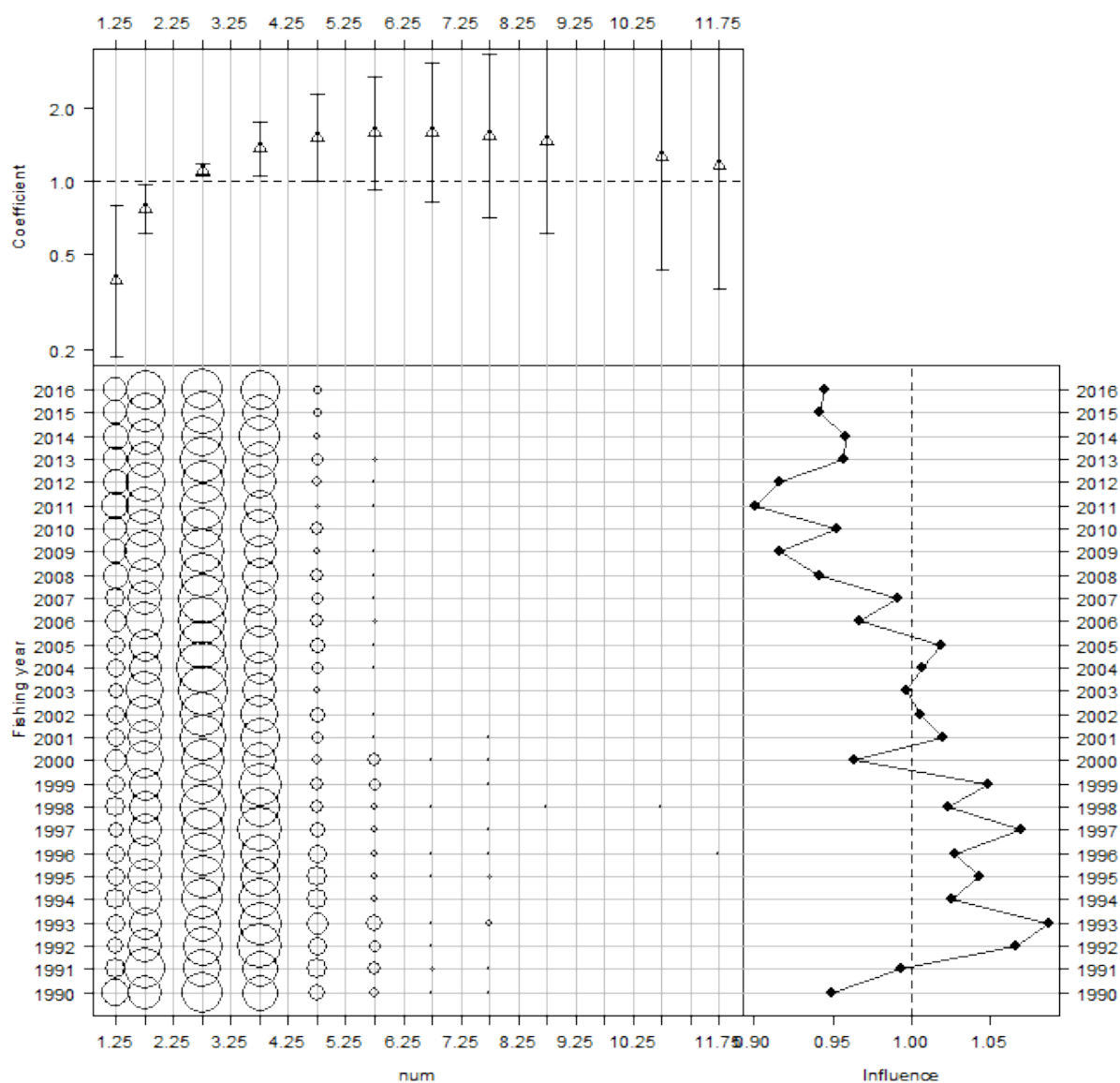
Figure G.7: **Effect of tows in the lognormal model for the gurnard WCSI(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**

G.4.3 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table G.3), with area and duration fished non-significant. A plot of the binomial model and the combined delta-lognormal model is provided in Figure G.8 and the CPUE indices are listed in Table G.4.

Table G.3: Order of acceptance of variables into the binomial (logistic) model of presence/absence of gurnard in the WCSI(FLA) fishery model for core vessels based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-8 215	16 484	5.55	*
vessel	82	-7 822	15 809	11.40	*
poly(log(tows), 3)	85	-7 740	15 651	12.60	*
month	96	-7 654	15 500	**13.87**	*
area	99	-7 621	15 440	14.35	
poly(log(duration), 3)	102	-7 610	15 424	14.50	
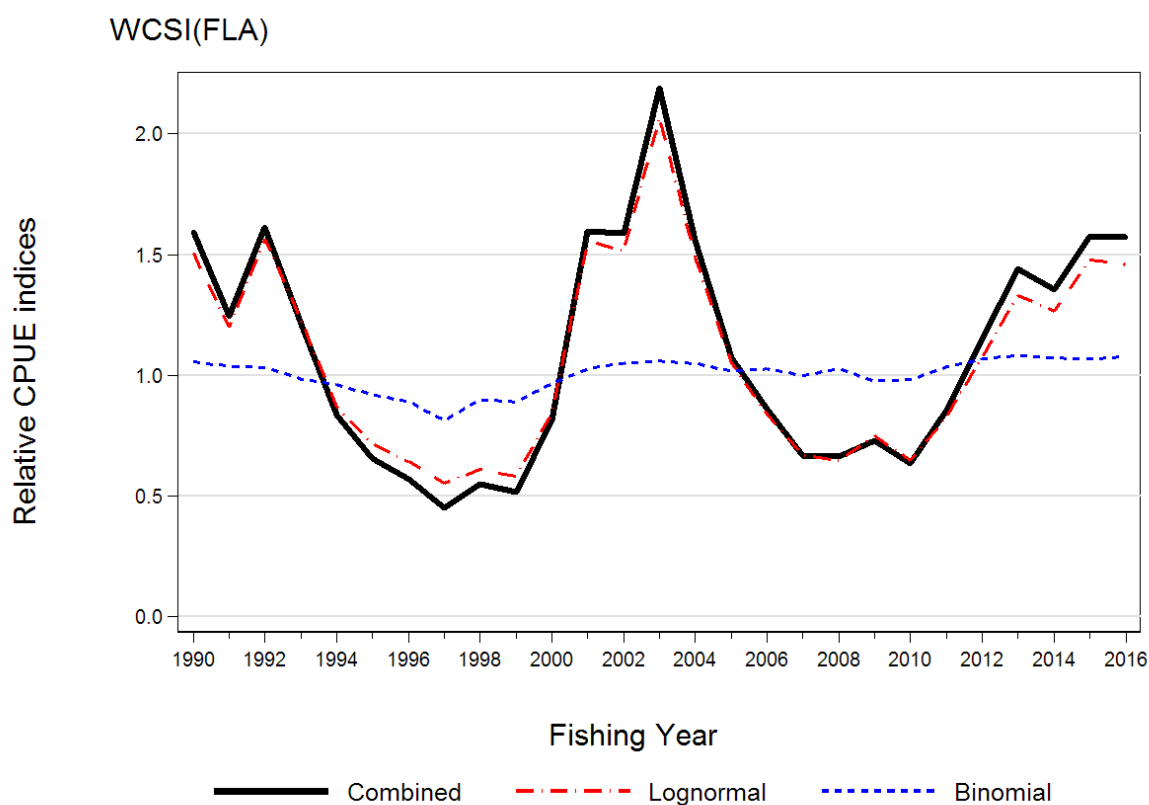
Figure G.8: Relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(FLA) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure (Eq. F.4).
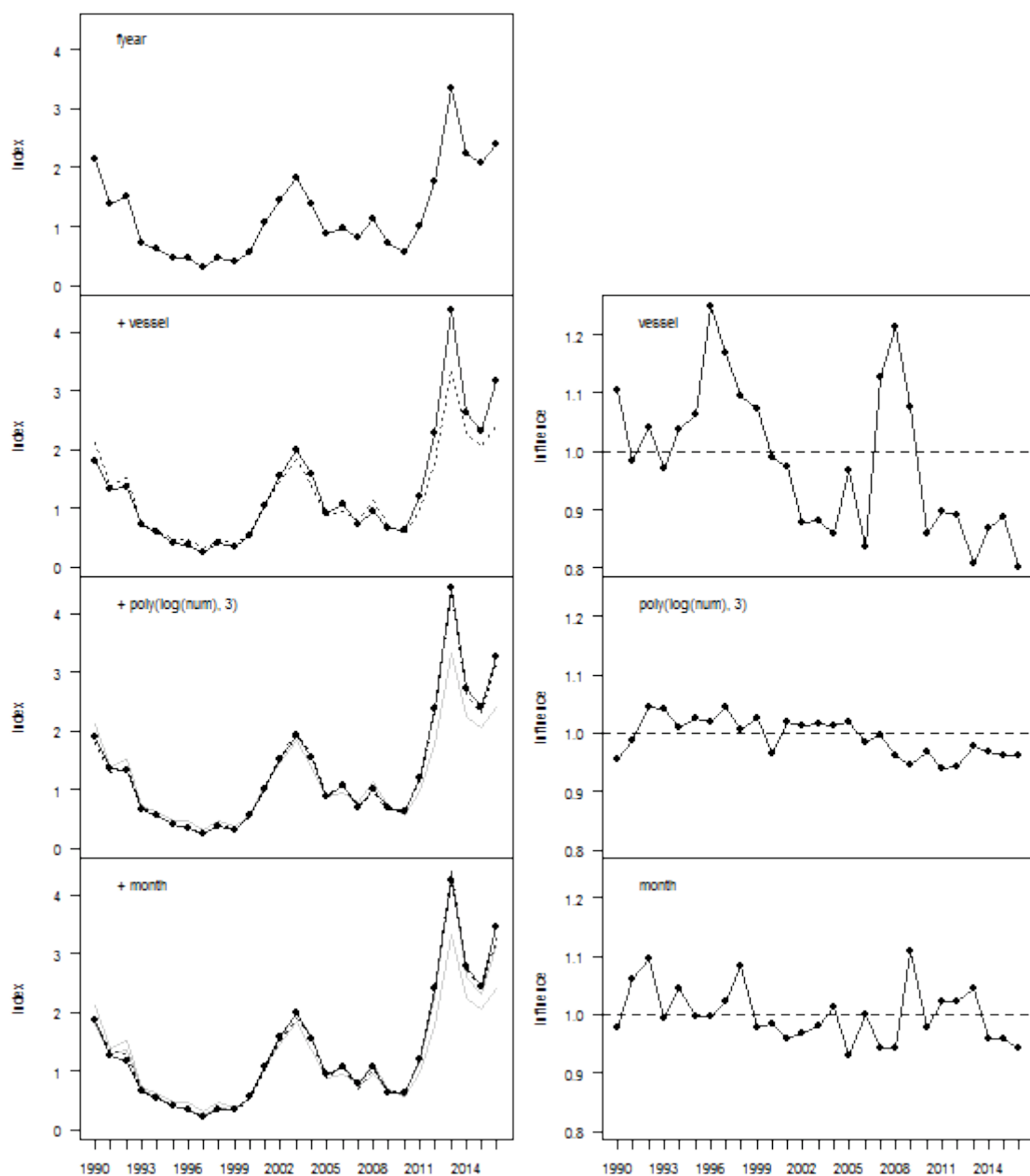
Figure G.9: [left column]: annual indices from the binomial model of WCSI(FLA) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

G.4.4   Model coefficients
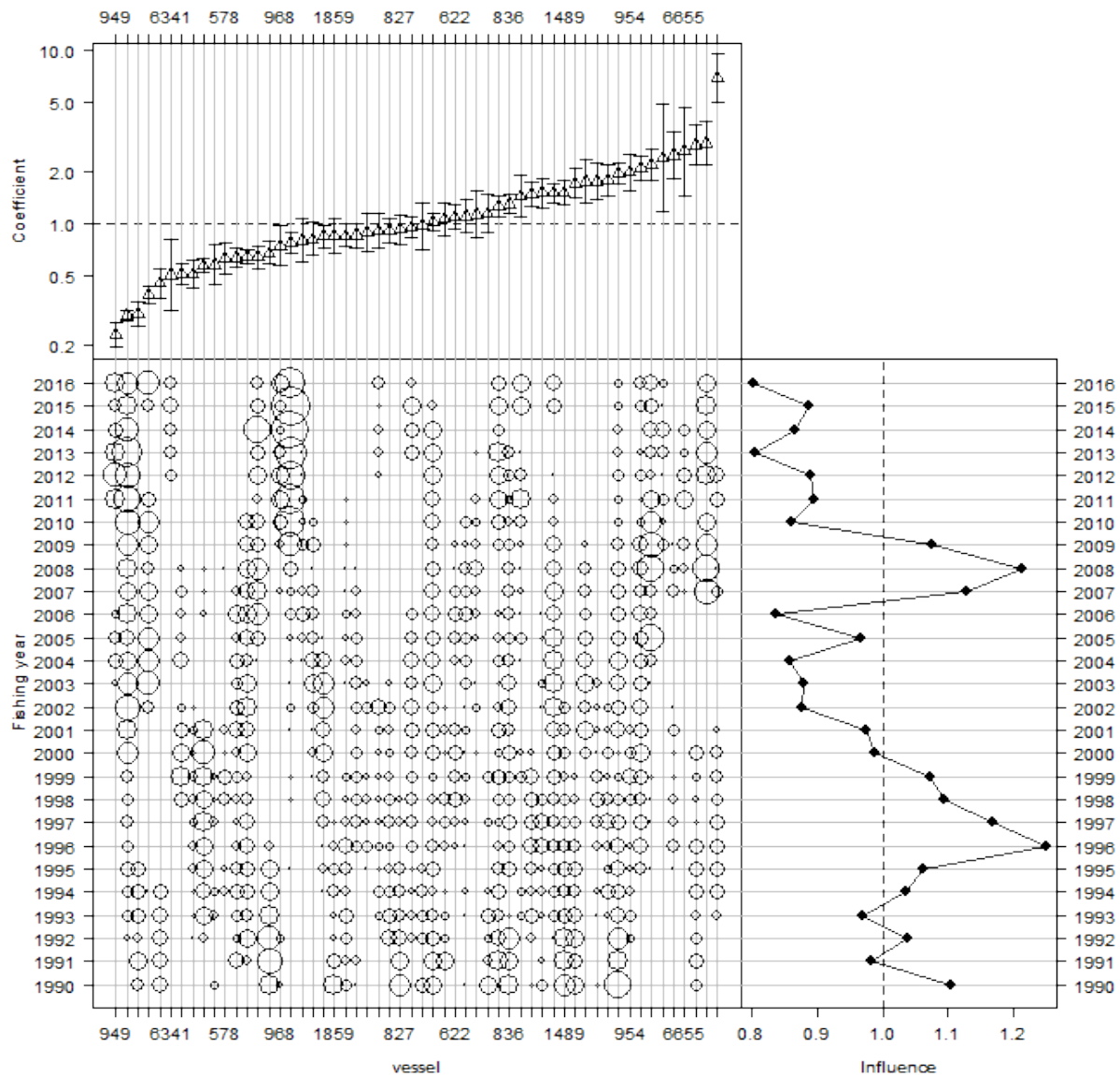
Figure G.10:   **Effect of vessel in the binomial model for the gurnard WCSI(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
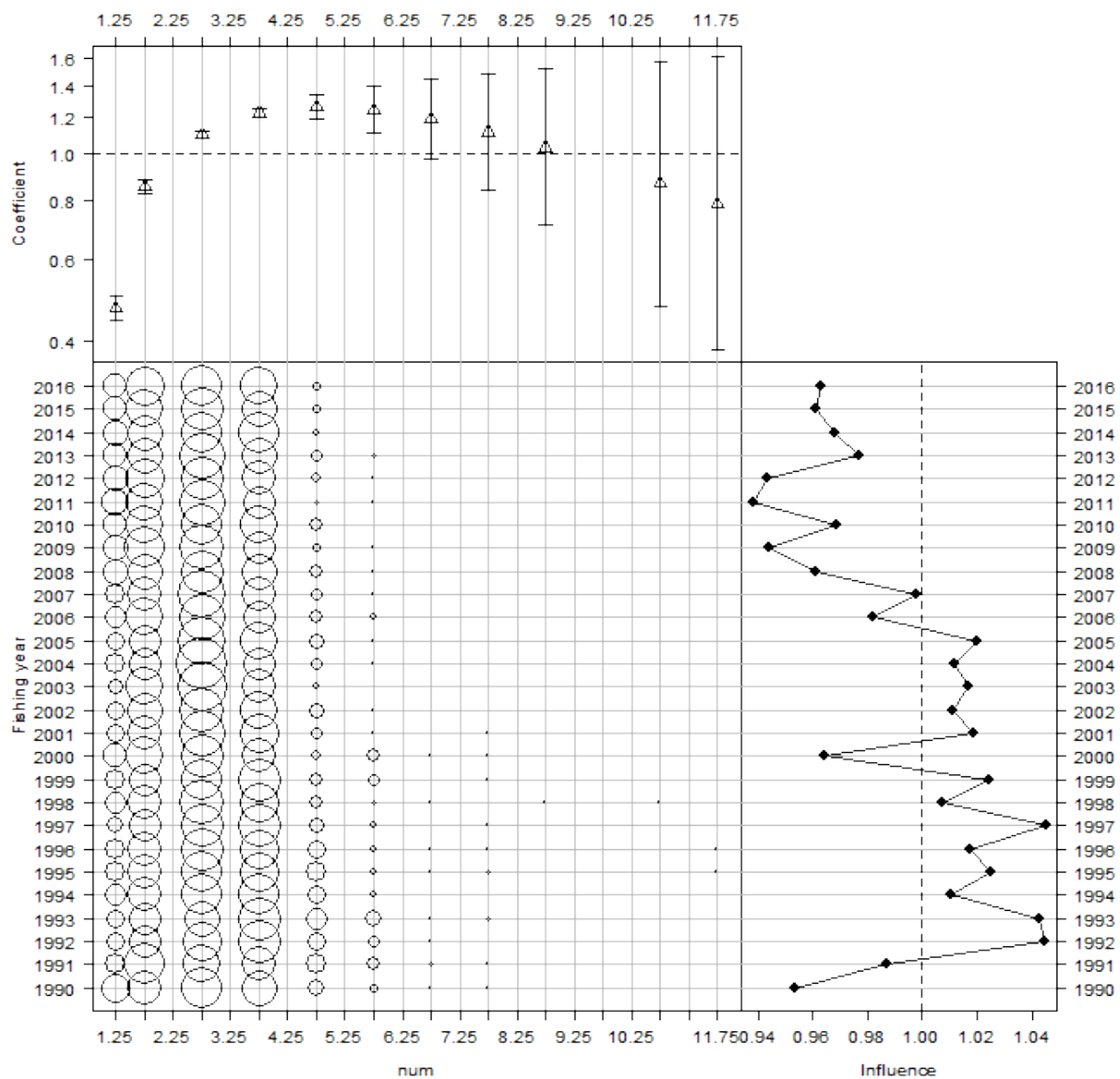
Figure G.11: Effect of tows in the binomial model for the gurnard WCSI(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
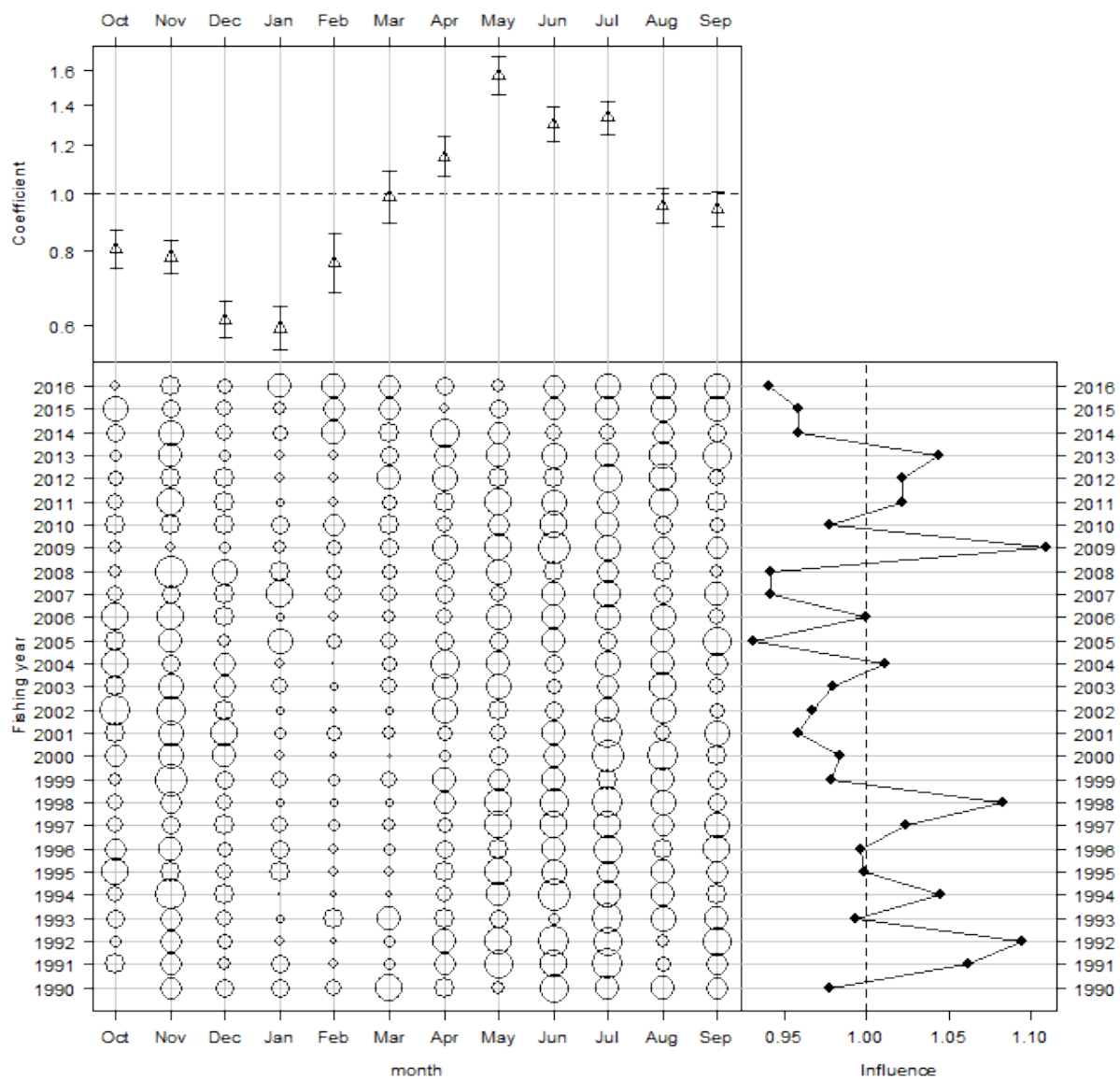
Figure G.12: Effect of month in the binomial model for the gurnard WCSI(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

G.4.5 CPUE indices

Table G.4: **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard WCSI(FLA) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Core vessels Combined
1990	1.093	1.168	1.060	1.505	0.0317	1.057	1.591
1991	0.761	0.783	0.781	1.201	0.0289	1.037	1.245
1992	1.143	1.089	1.093	1.563	0.0263	1.032	1.614
1993	0.882	0.857	0.886	1.229	0.0215	0.985	1.211
1994	0.731	0.693	0.672	0.870	0.0251	0.962	0.836
1995	0.501	0.491	0.546	0.715	0.0233	0.919	0.657
1996	0.444	0.476	0.501	0.641	0.0223	0.891	0.572
1997	0.390	0.417	0.443	0.554	0.0219	0.814	0.451
1998	0.445	0.488	0.484	0.611	0.0232	0.899	0.549
1999	0.460	0.458	0.465	0.582	0.0214	0.889	0.517
2000	0.625	0.647	0.668	0.845	0.0280	0.966	0.816
2001	1.145	1.214	1.210	1.556	0.0232	1.027	1.597
2002	1.446	1.404	1.443	1.514	0.0289	1.050	1.590
2003	1.896	1.846	1.910	2.065	0.0258	1.060	2.189
2004	1.320	1.339	1.369	1.486	0.0233	1.049	1.559
2005	1.158	1.149	1.176	1.053	0.0236	1.018	1.073
2006	1.001	0.892	0.902	0.839	0.0227	1.026	0.862
2007	0.995	0.877	0.814	0.668	0.0225	1.000	0.668
2008	1.100	1.027	0.979	0.646	0.0263	1.027	0.664
2009	1.122	1.082	1.052	0.748	0.0258	0.976	0.731
2010	1.012	0.928	0.953	0.648	0.0268	0.981	0.636
2011	1.143	1.095	1.128	0.828	0.0320	1.034	0.857
2012	1.331	1.479	1.410	1.078	0.0287	1.067	1.150
2013	1.716	1.791	1.733	1.332	0.0329	1.082	1.442
2014	1.968	1.994	1.909	1.265	0.0327	1.072	1.356
2015	2.149	2.264	2.256	1.477	0.0344	1.068	1.576
2016	2.228	2.352	2.222	1.459	0.0319	1.078	1.572

Appendix H.   DIAGNOSTICS AND SUPPORTING ANALYSES FOR WCSI(MIX)

H.1   Introduction
This CPUE analysis was accepted in 2014 for monitoring GUR 7 by the Southern Inshore Fishery Assessment Working Group (MPI 2016). Following a 2017 review, the Plenary agreed to use the WCSI trawl survey for monitoring GUR 7 and will use this series [along with WCSI(FLA)] to corroborate the survey observations (MPI 2017). This CPUE analysis differs from the analysis presented in MPI 2016 by adding GUR as a target species.

H.2   Fishery definition
WCSI(MIX): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 033, 034, 035 and 036 and declaring target species GUR, RCO, BAR, TAR, WAR, STA.

H.3   Core vessel selection
The criteria used to define the core fleet were those vessels that had fished for at least 5 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 37 vessels which took 84% of the catch (Figure H.1).

H.3.1   Data summary

Table H.1:   **Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 5 trips per year in 5 years) in the WCSI(MIX) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.**

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	11	92	380	461	1.21	1 183	3 894	27.05	87.0	31.3	8.42
1991	17	159	640	688	1.08	1 874	5 761	73.65	89.9	11.9	5.71
1992	21	260	916	922	1.01	2 636	9 258	117.63	75.4	18.9	4.46
1993	23	315	1 085	1 099	1.01	3 225	11 301	119.61	78.4	25.5	7.10
1994	21	204	619	667	1.08	1 688	5 394	31.94	63.2	28.7	10.92
1995	21	186	602	719	1.19	1 728	5 087	37.70	75.3	35.0	18.43
1996	26	259	801	830	1.04	2 275	7 057	44.20	67.6	34.3	14.75
1997	24	264	952	985	1.03	2 704	9 360	32.31	70.1	33.5	14.56
1998	20	178	496	506	1.02	1 354	4 453	20.92	67.4	39.2	9.07
1999	26	321	919	969	1.05	2 675	9 079	52.40	81.9	32.3	14.27
2000	23	277	876	939	1.07	2 518	9 247	61.49	85.6	27.9	5.93
2001	22	294	1 020	1 090	1.07	3 036	11 186	130.72	91.5	24.2	2.90
2002	23	257	841	924	1.10	2 456	8 255	182.20	81.7	11.0	0.62
2003	21	246	863	931	1.08	2 525	9 103	196.75	80.5	7.1	0.70
2004	21	215	817	896	1.10	2 306	8 886	159.26	82.3	14.7	2.13
2005	19	222	865	1 039	1.20	2 534	9 630	177.59	87.8	10.8	0.94
2006	20	224	915	1 044	1.14	2 682	10 154	135.89	81.3	8.2	1.09
2007	21	308	1 233	1 349	1.09	3 663	13 820	153.43	83.4	19.8	2.27
2008	21	268	978	2 696	2.76	2 698	11 794	117.83	84.3	20.4	5.08
2009	21	272	1 089	2 991	2.75	2 991	12 997	108.78	85.7	24.5	6.94
2010	21	318	1 089	3 005	2.76	3 005	11 995	104.01	84.9	19.6	5.46
2011	20	295	1 068	2 932	2.75	2 932	12 021	122.10	86.1	18.5	2.82
2012	21	296	1 053	2 852	2.71	2 852	12 181	184.60	84.8	13.2	2.01
2013	21	298	1 047	2 877	2.75	2 877	12 266	199.34	88.3	10.7	2.57
2014	21	322	1 156	3 244	2.81	3 244	13 738	281.56	87.9	7.4	1.17
2015	20	278	1 025	2 802	2.73	2 802	12 074	253.53	87.4	9.9	0.82
2016	20	257	966	2 822	2.92	2 822	11 955	221.61	88.7	11.4	1.68

H.3.2   Core vessel selection
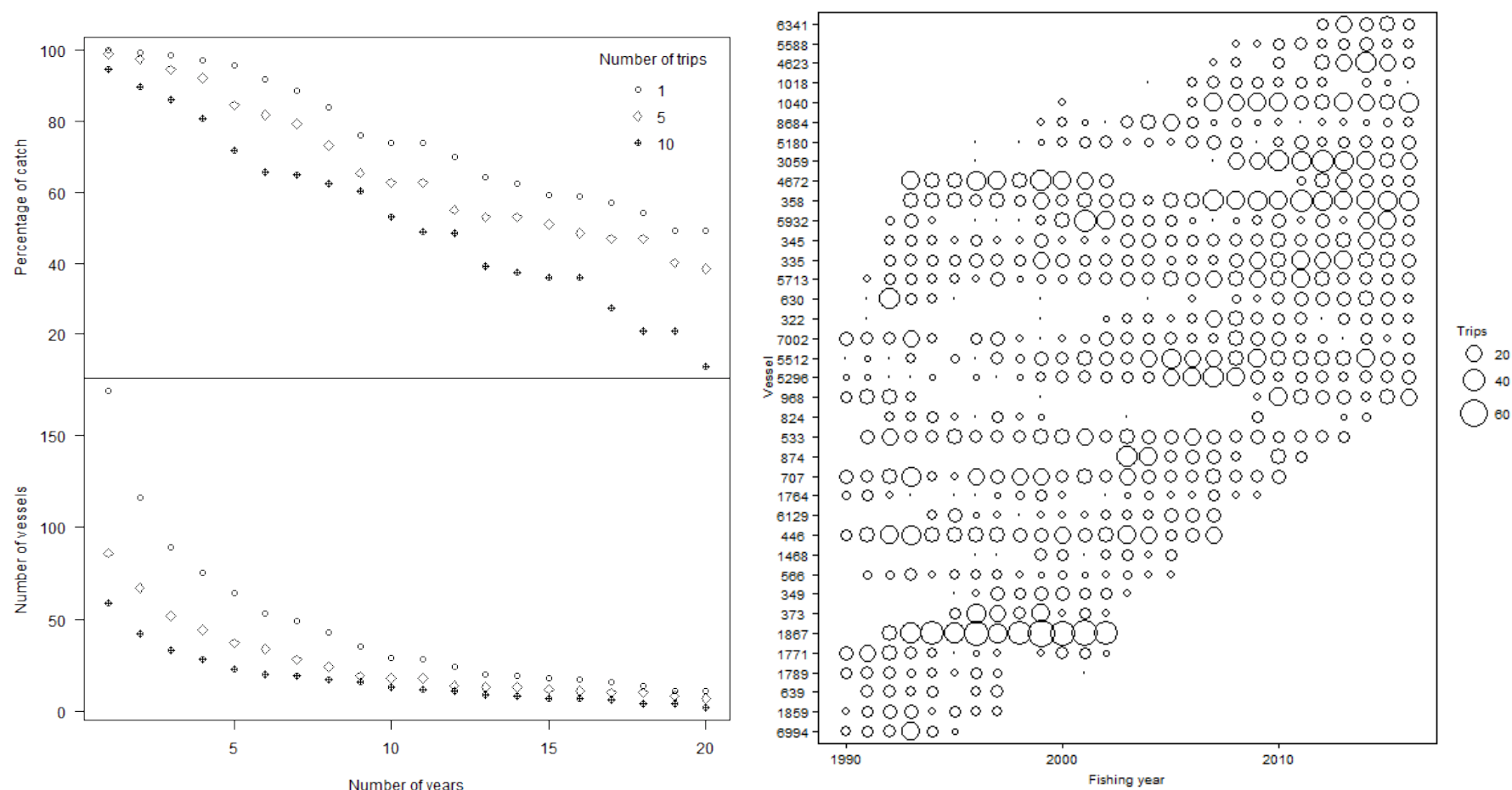
Figure H.1: [left panel] total landed gurnard and number of vessels plotted against the number of years used to define core vessels participating in the WCSI(MIX) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 5 trips in 5 or more fishing years) by fishing year.

H.3.3 Exploratory data plots for core vessel data set
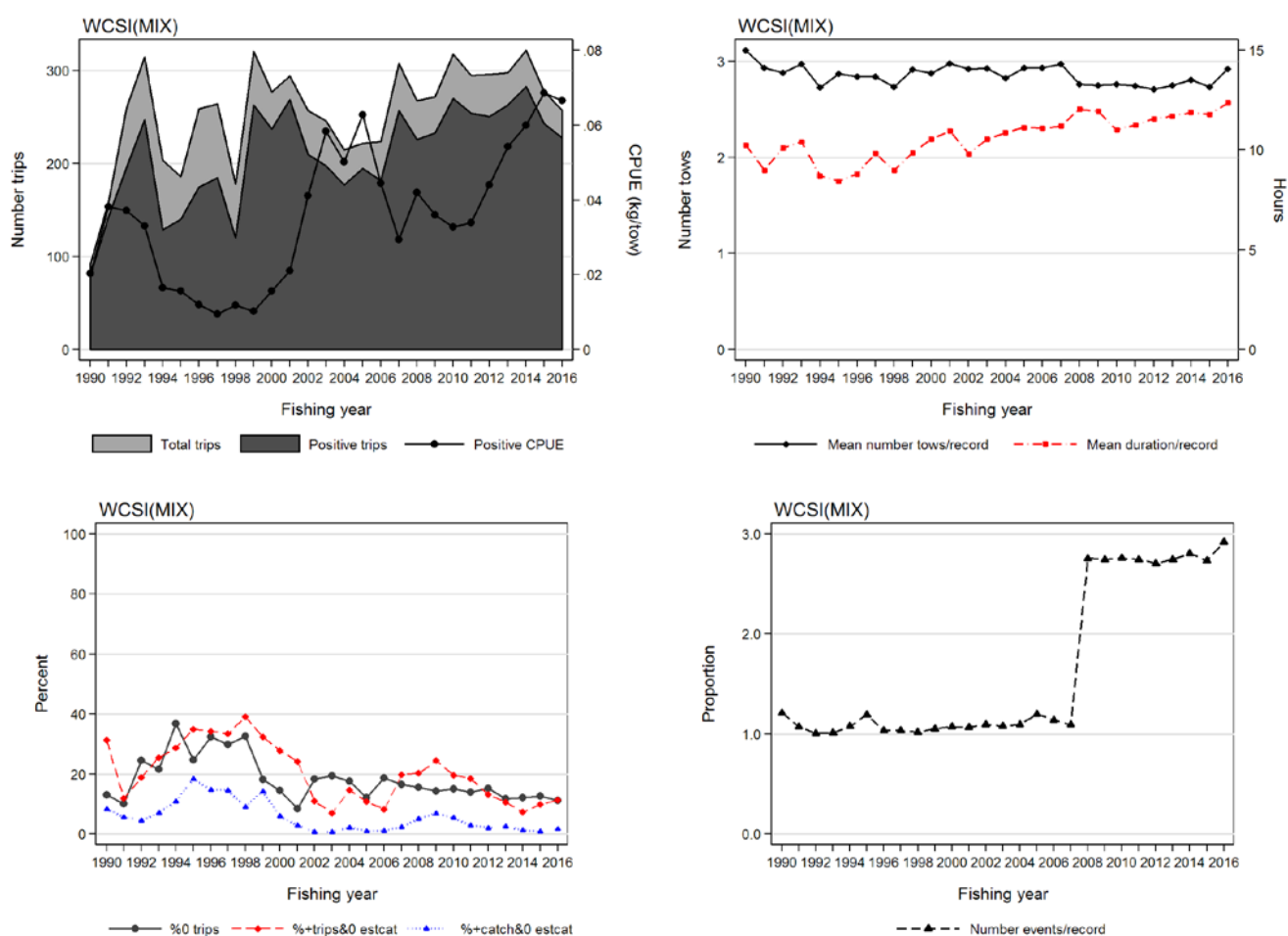
Figure H.2: Core vessel summary plots by fishing year for model WCSI(MIX): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips i with positive catch: $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of sets and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of gurnard; b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.

H.4 Positive catch model selection table

Four explanatory variables entered the model after fishing year (Table H.2), with area and duration fishing non-significant. A plot of the model is provided in Figure H.3 and the CPUE indices are listed in Table H.4.

Table H.2: **Order of acceptance of variables into the lognormal model of successful catches in the WCSI(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-94 180	188 416	13.46	*
target	33	-93 178	186 421	24.26	*
month	44	-92 441	184 969	31.33	*
poly(log(tows), 3)	47	-91 938	183 969	35.77	*
vessel	83	-91 621	183 407	**38.42**	*
area	86	-91 515	183 202	39.28	
poly(log(duration), 3)	89	-91 512	183 202	39.31	
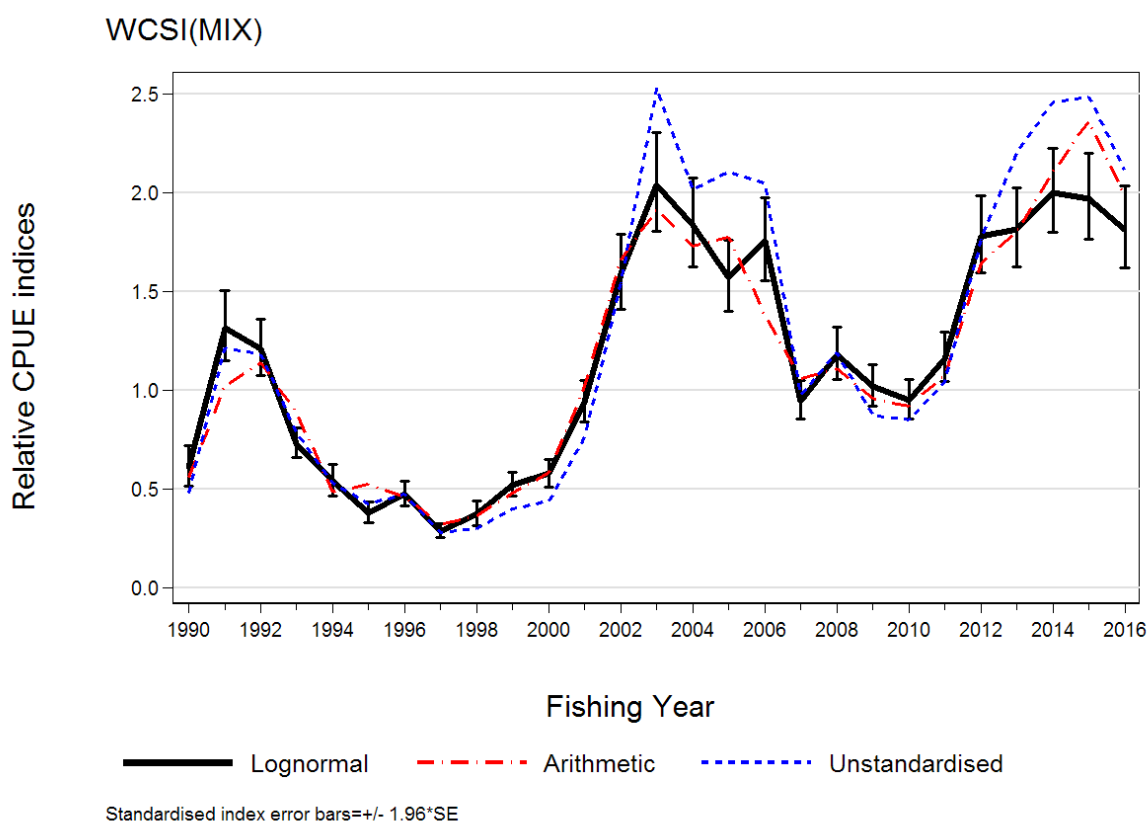
Figure H.3: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(MIX) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).**
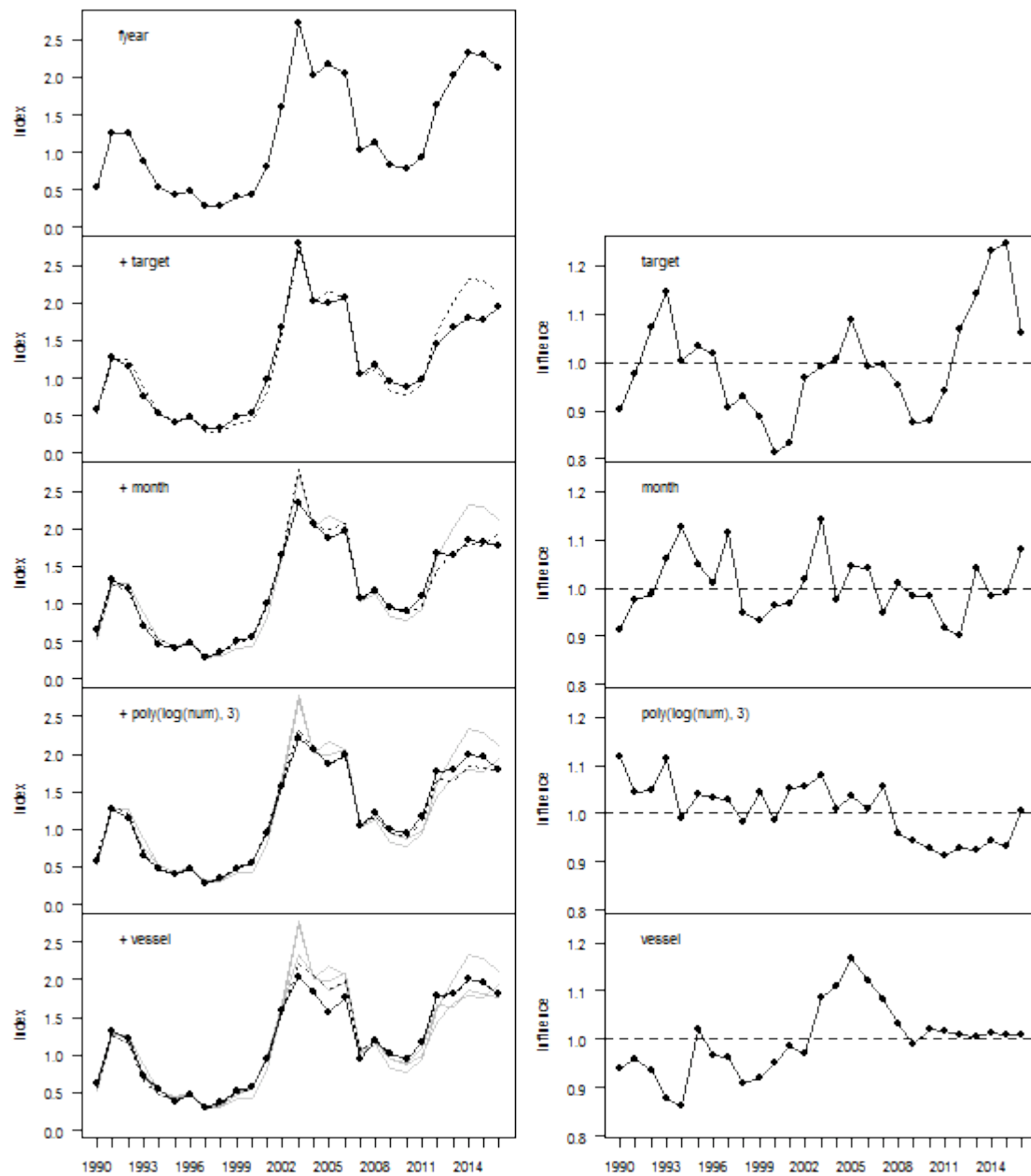
Figure H.4: [left column]: annual indices from the lognormal model of WCSI(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

H.4.1   Residual and diagnostic plots
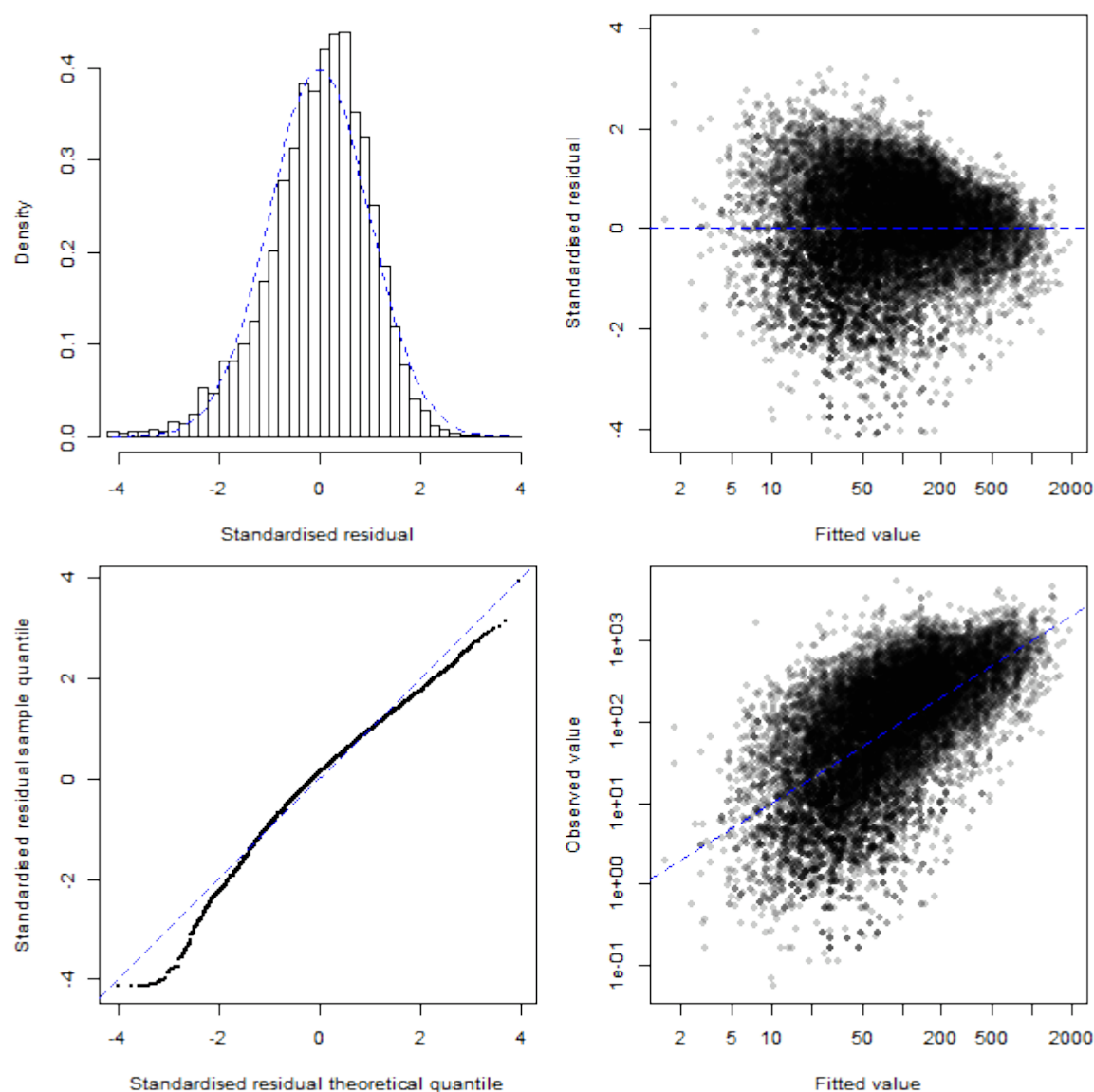
Figure H.5:   **Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the WCSI(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.**

H.4.2   Model coefficients
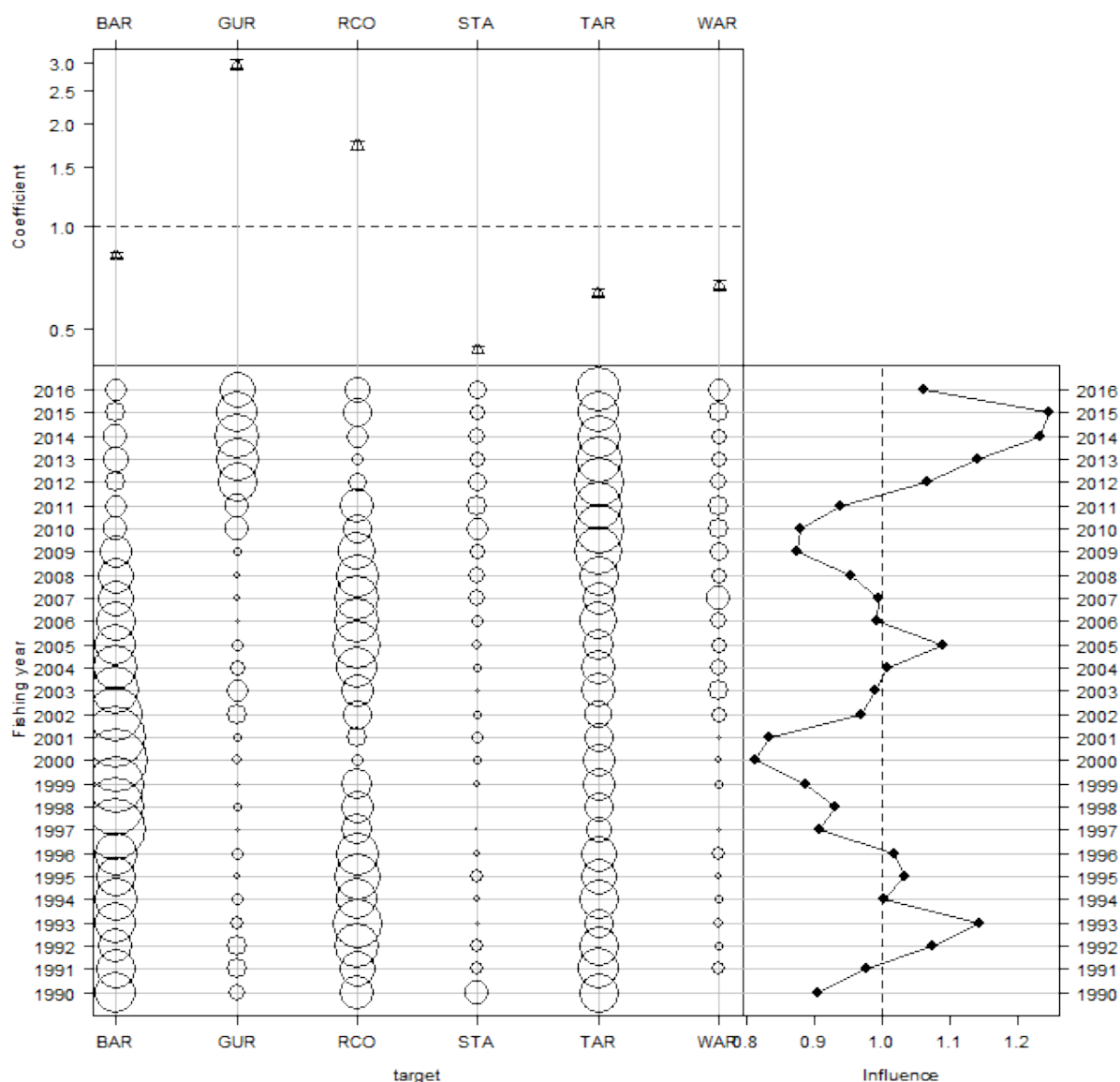
Figure H.6:   **Effect of target species in the lognormal model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
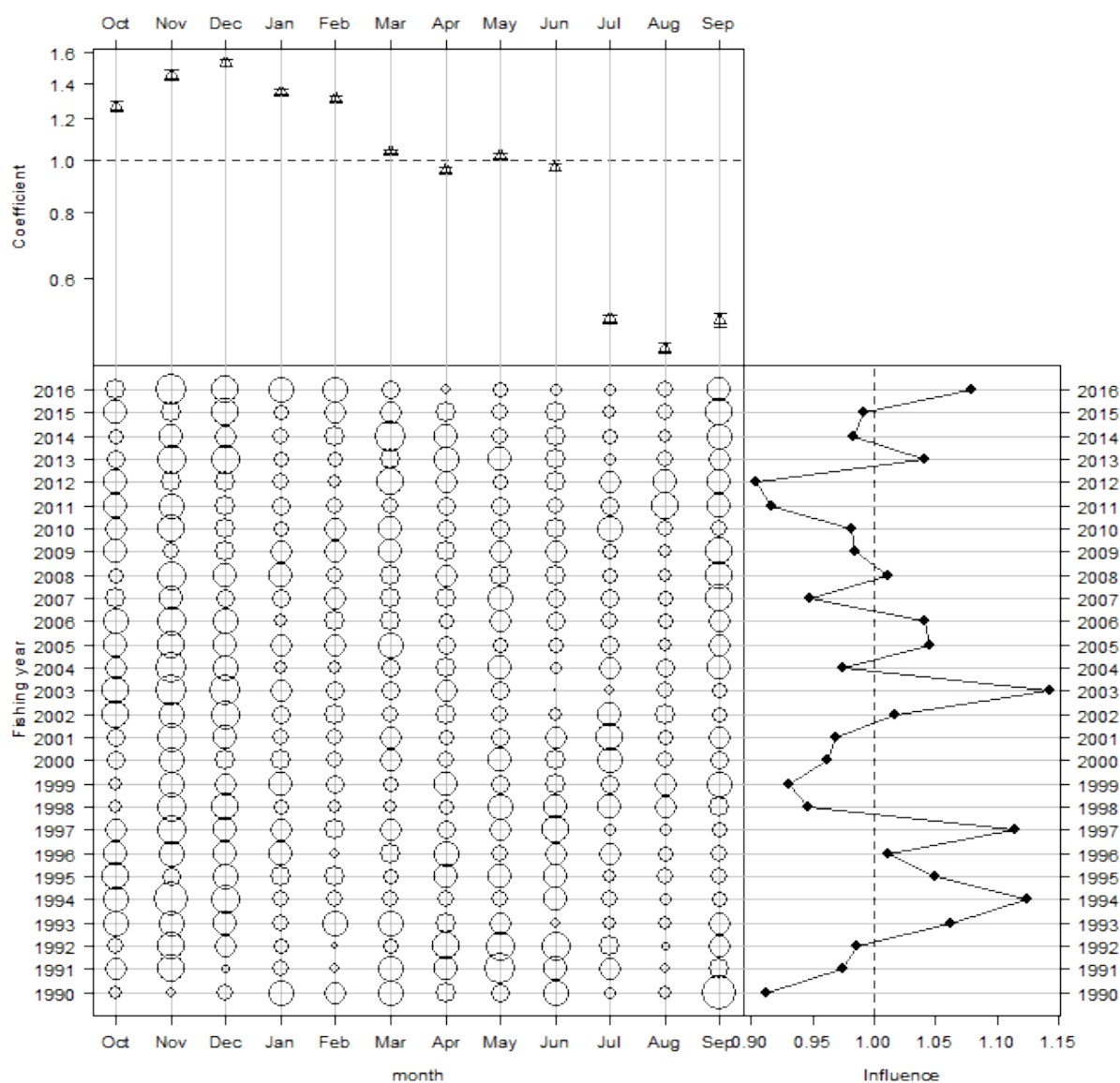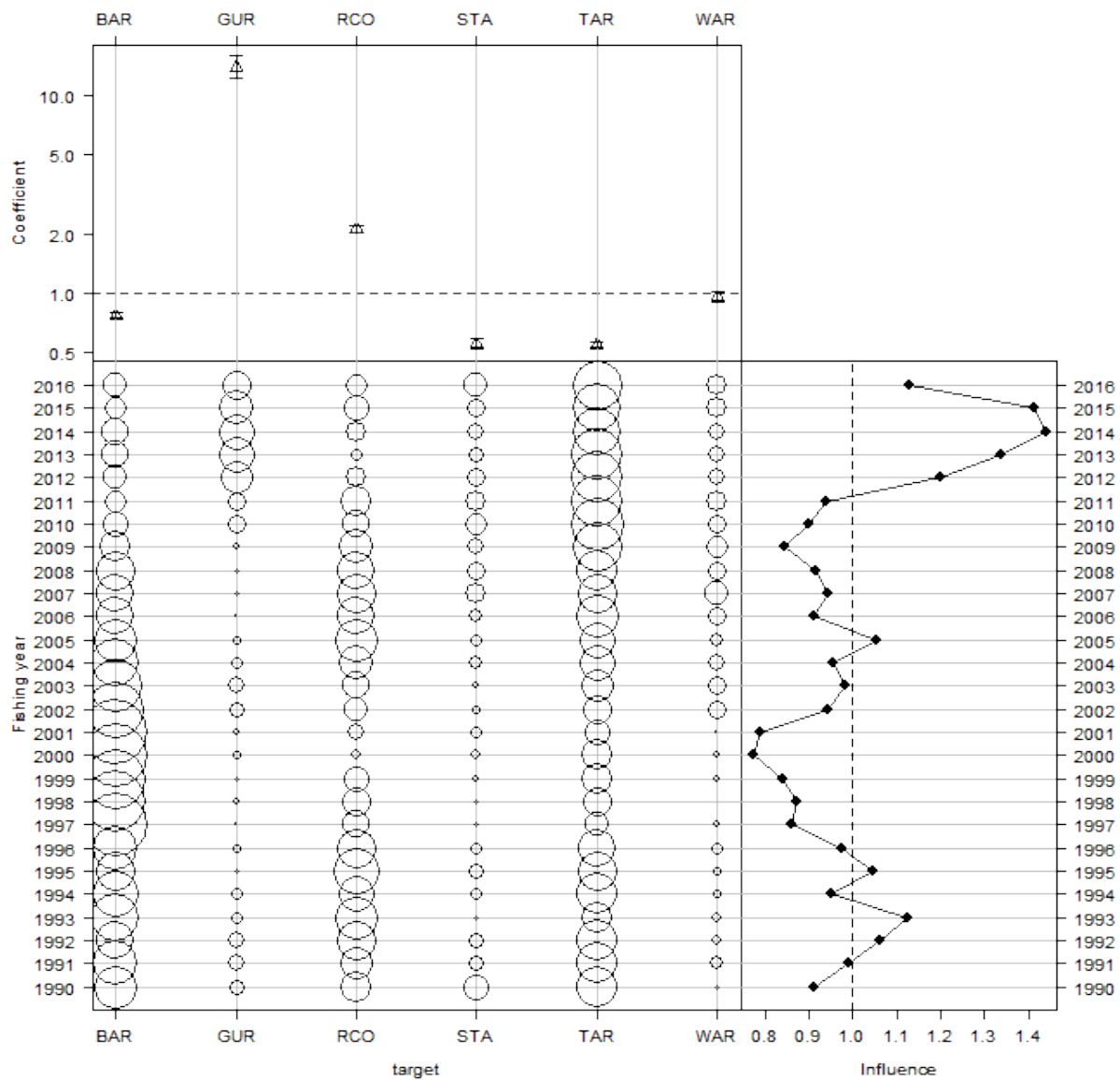
Figure H.7: **Effect of month in the lognormal model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
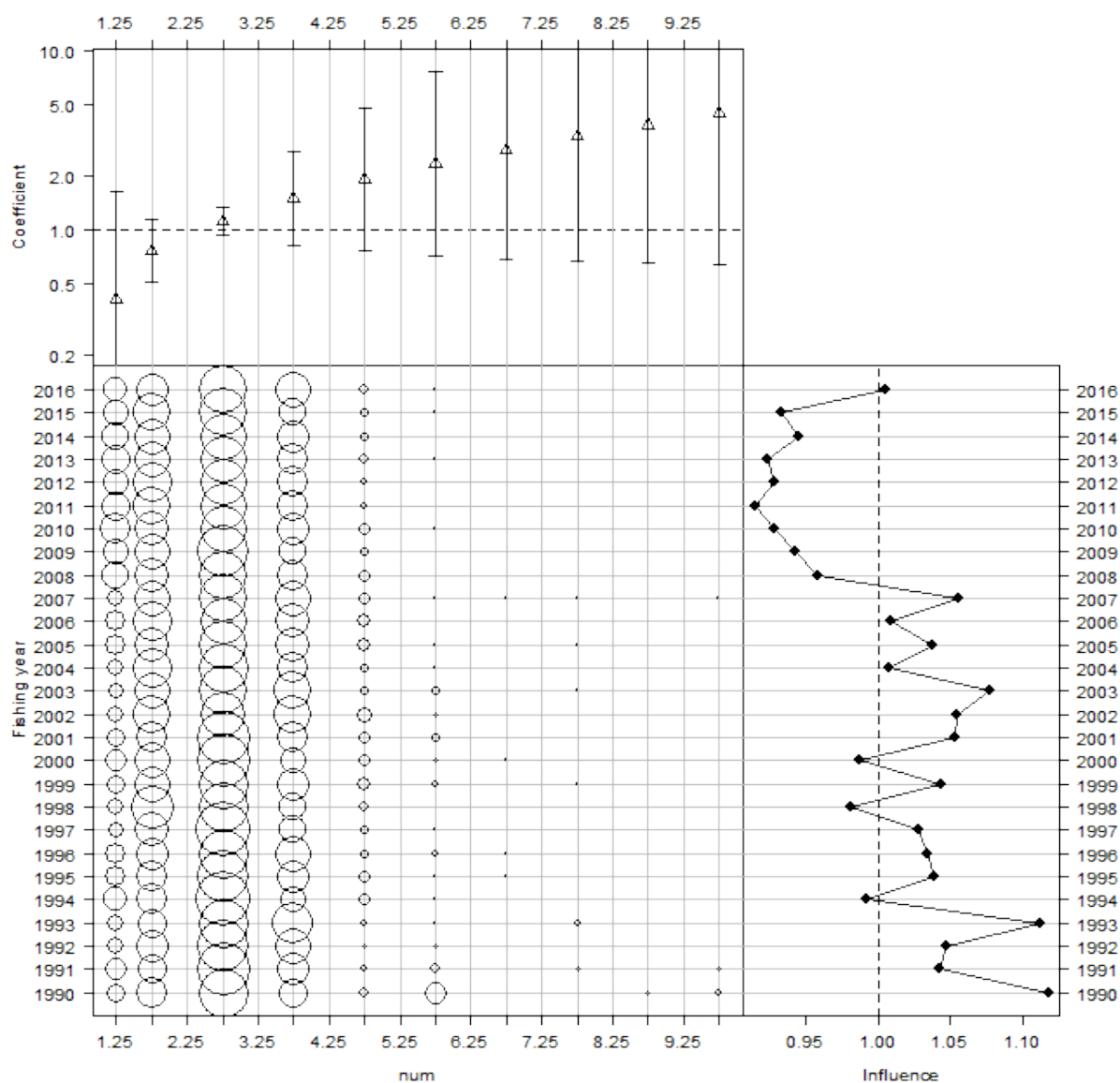
Figure H.8: Effect of tows in the lognormal model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
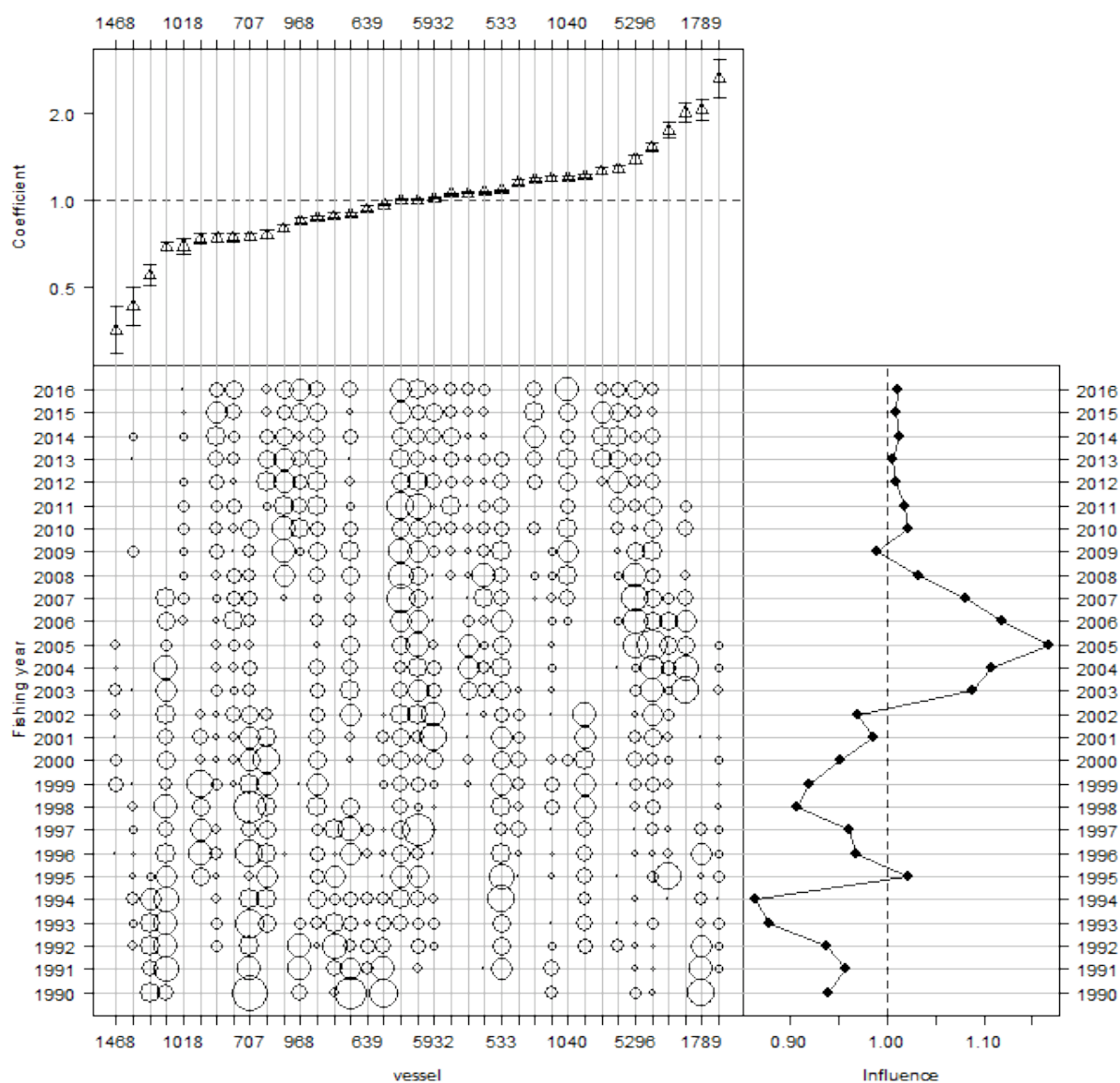
Figure H.9: Effect of vessel in the lognormal model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
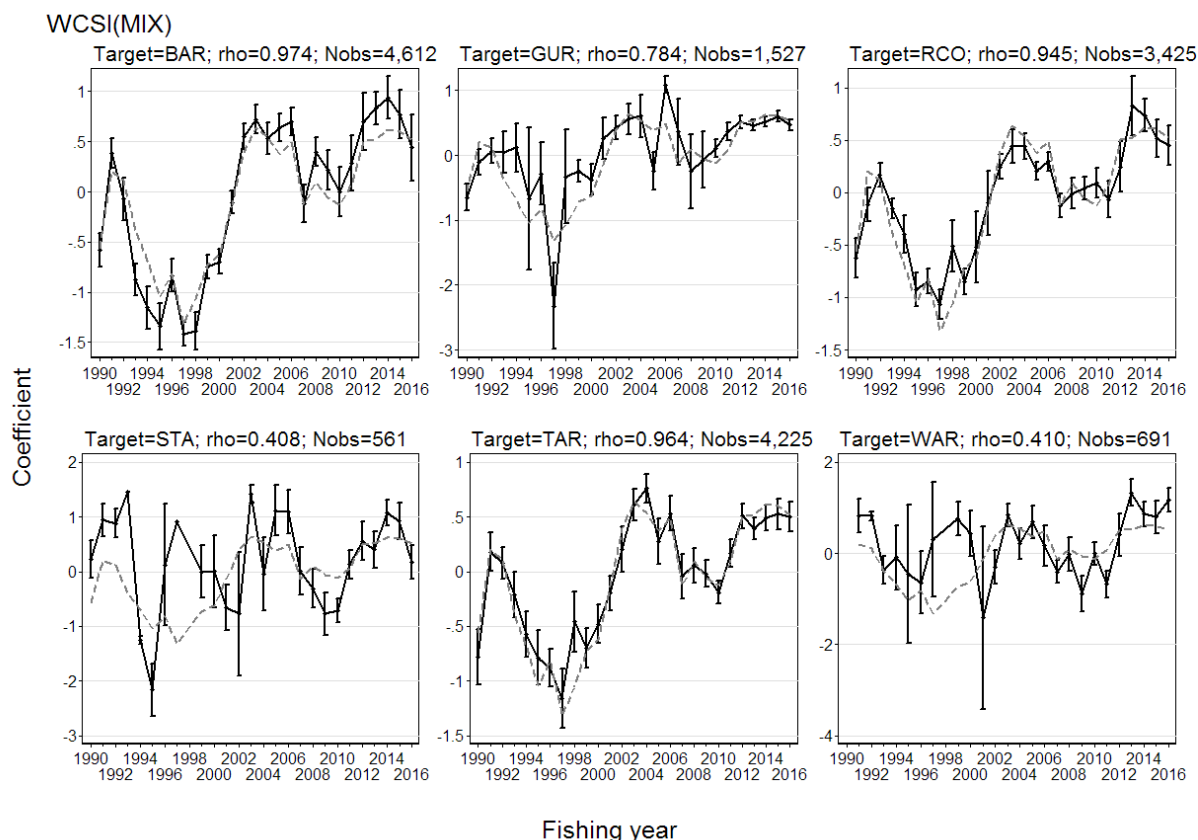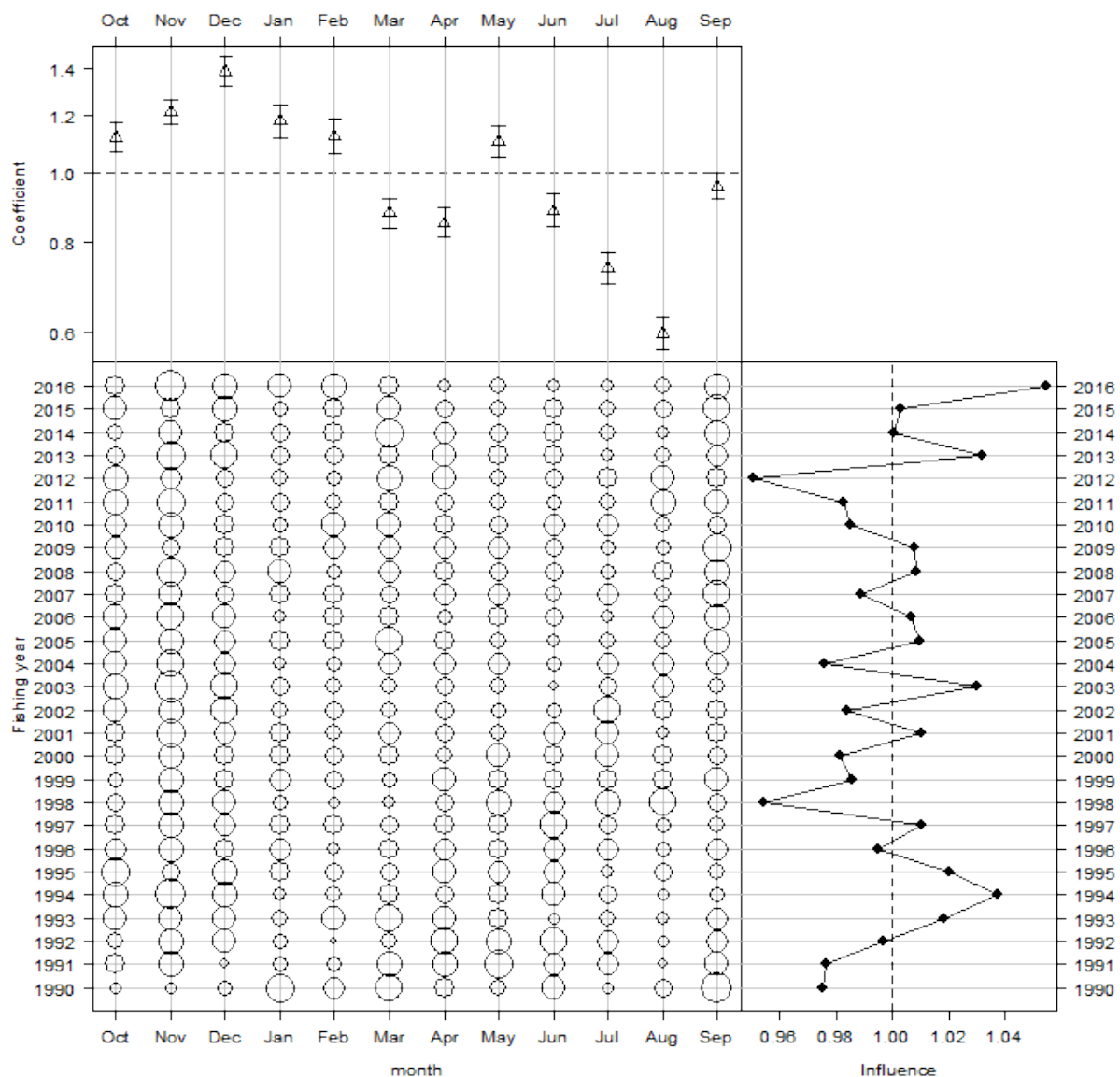
Figure H.10: Residual implied coefficients for target species × fishing year interaction (interaction term not offered to the model) in the gurnard WCSI(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.

H.4.3 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table H.3), with duration fished, number tows and area non-significant. A plot of the binomial model and the combined delta-lognormal model is provided in Figure H.11 and the CPUE indices are listed in Table H.4.

Table H.3: Order of acceptance of variables into the binomial (logistic) model of presence/absence of gurnard in the WCSI(MIX) fishery model for core vessels based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-15 983	32 020	1.17	*
target	32	-14 981	30 026	11.87	*
vessel	68	-14 534	29 203	16.37	*
month	79	-14 423	29 004	**17.46**	*
poly(log(duration), 3)	82	-14 414	28 991	17.55	
poly(log(tows), 3)	85	-14 399	28 968	17.69	
area	88	-14 394	28 963	17.75	
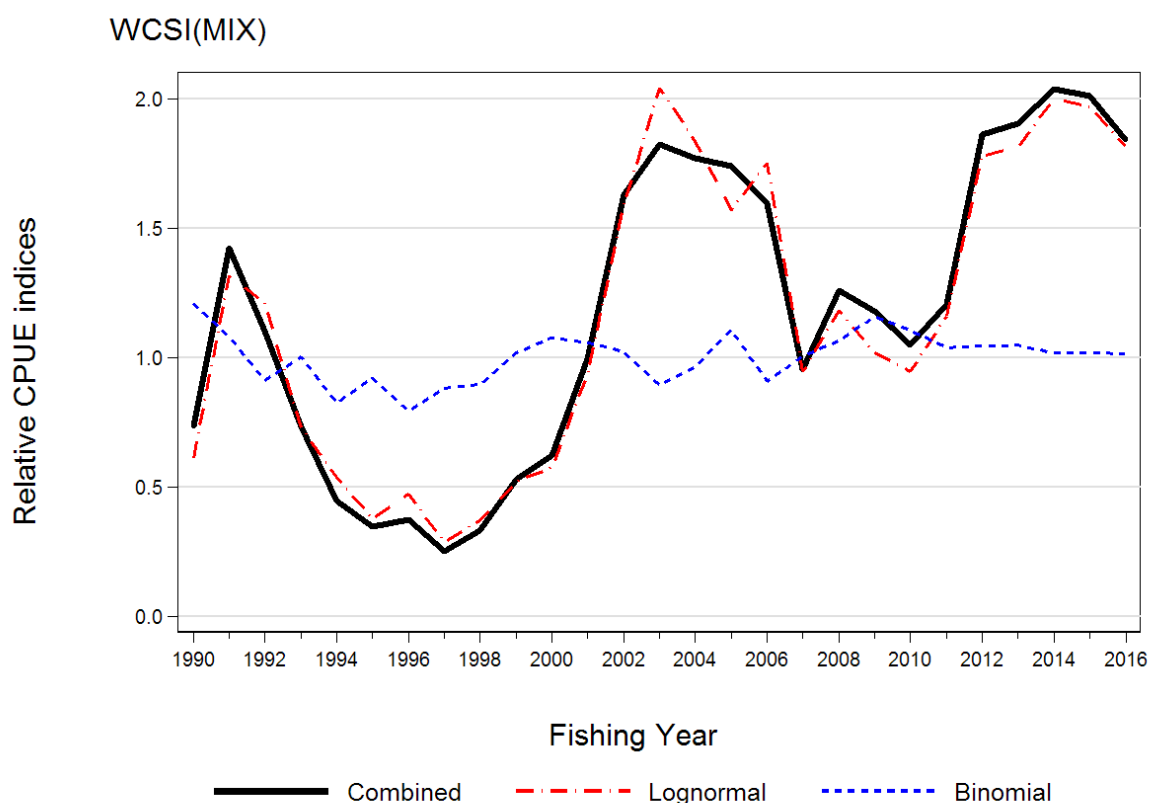
Figure H.11: Relative CPUE indices for gurnard using the lognormal non-zero model based on the WCSI(MIX) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure suggested by Vignaux (1994).
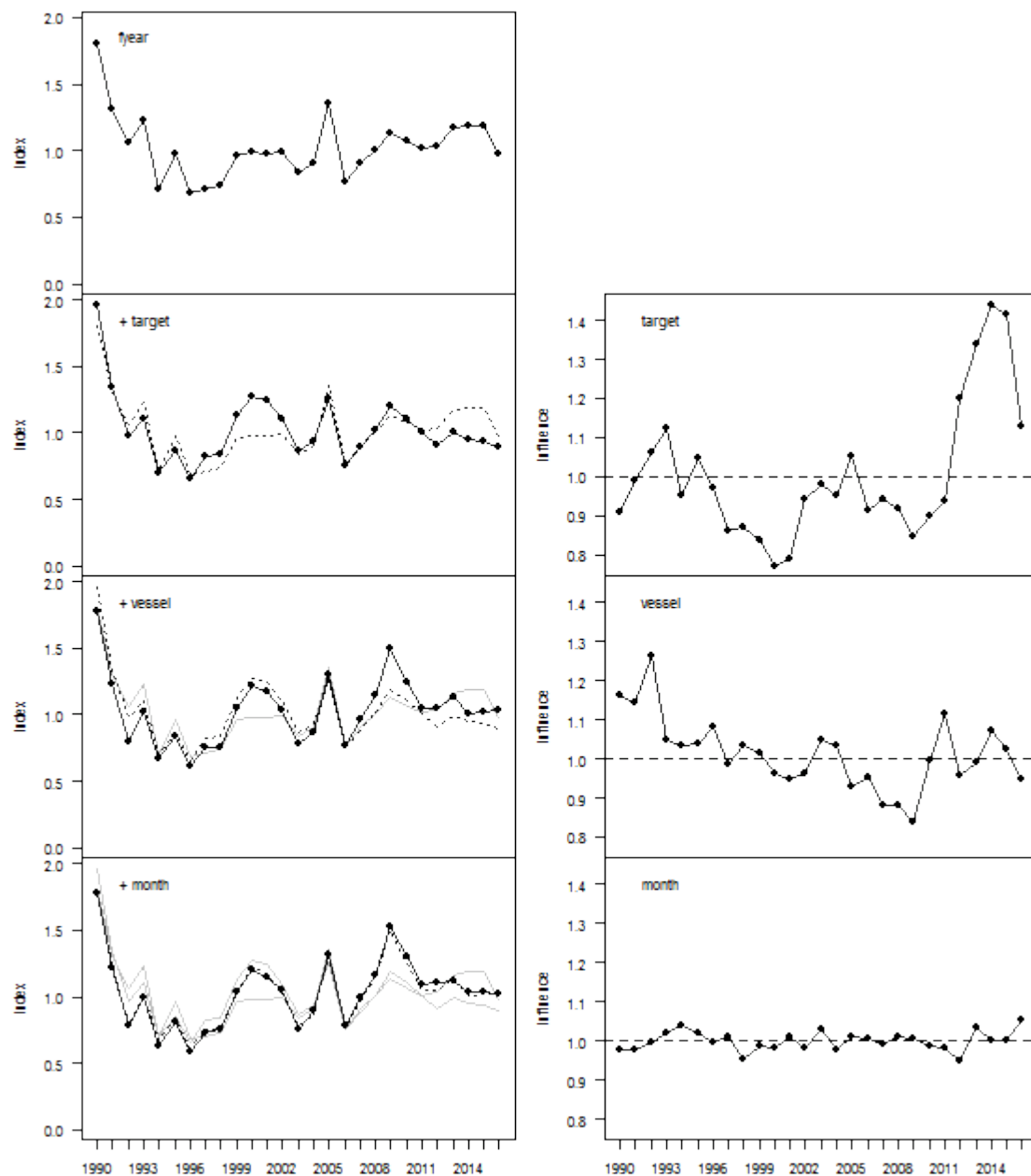
Figure H.12: [left column]: annual indices from the binomial model of WCSI(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

H.4.4 Model coefficients

Figure H.13: Effect of target species in the binomial model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
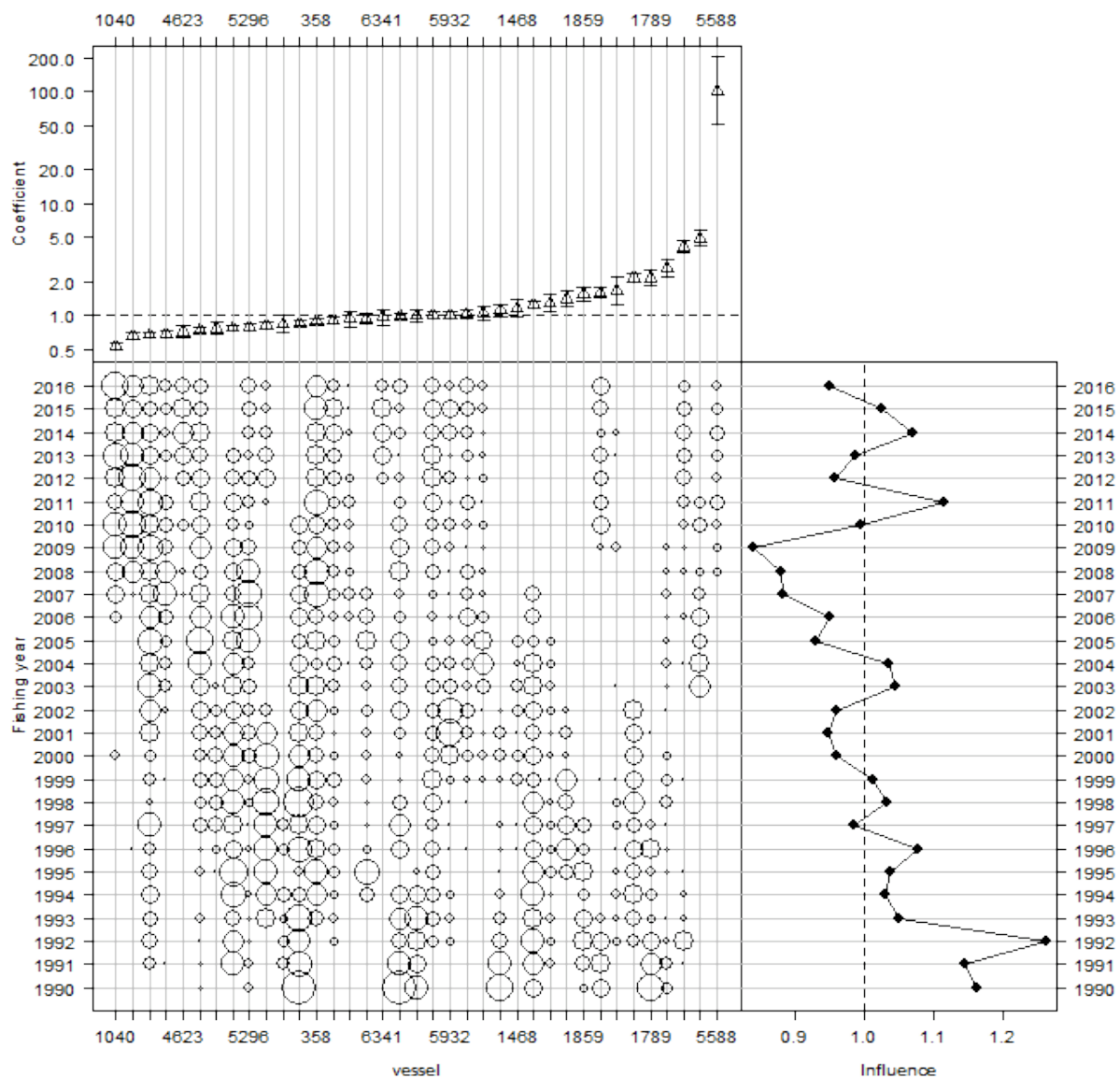
Figure H.14: Effect of vessel in the binomial model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

Figure H.15: **Effect of month in the binomial model for the gurnard WCSI(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
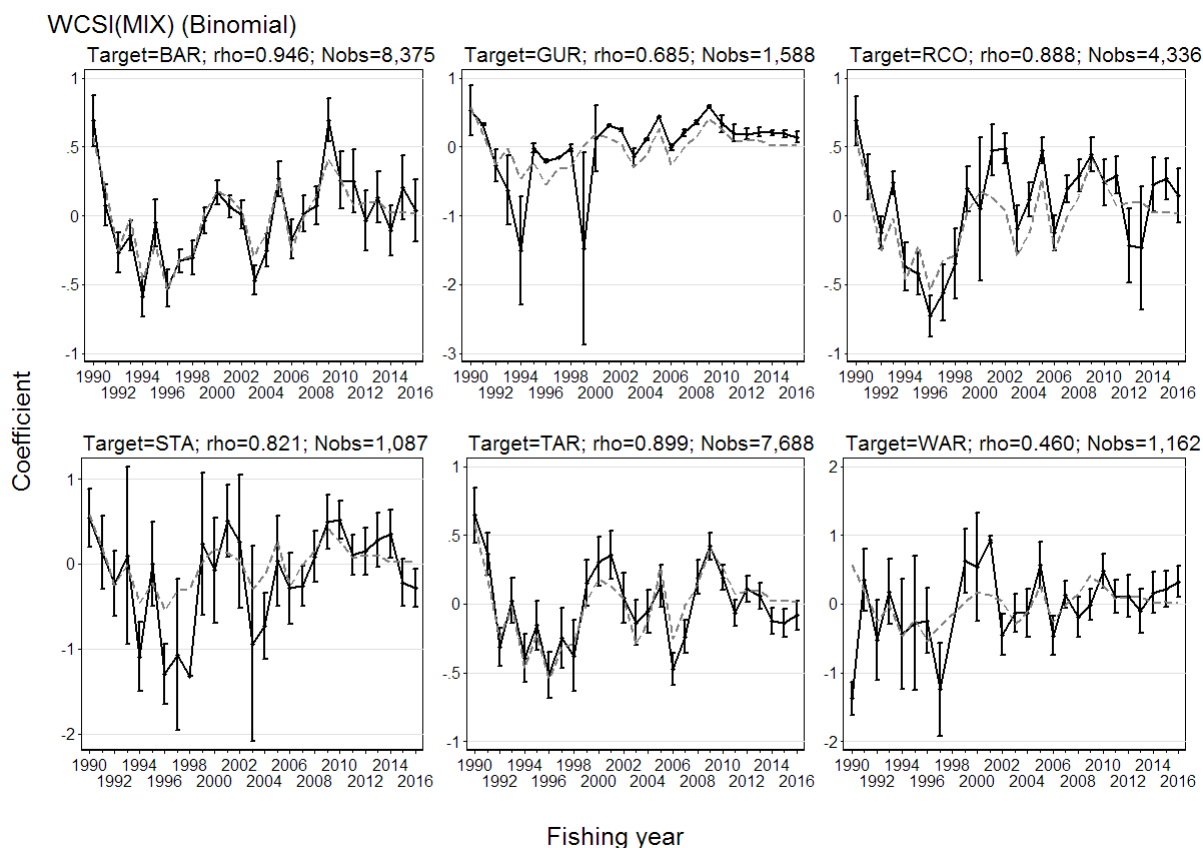
Figure H.16: Residual implied coefficients for target species × fishing year interaction (interaction term not offered to the model) in the gurnard WCSI(MIX) binomial model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.

H.4.5 CPUE indices

Table H.4: **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard WCSI(MIX) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Core vessels Combined
1990	0.698	0.562	0.479	0.610	0.0845	1.211	0.739
1991	0.953	1.018	1.213	1.317	0.0679	1.083	1.426
1992	1.157	1.139	1.182	1.209	0.0600	0.912	1.103
1993	0.946	0.885	0.784	0.731	0.0535	1.004	0.734
1994	0.477	0.484	0.532	0.541	0.0751	0.826	0.447
1995	0.502	0.523	0.423	0.378	0.0717	0.923	0.349
1996	0.455	0.459	0.476	0.473	0.0671	0.794	0.376
1997	0.340	0.322	0.280	0.287	0.0629	0.885	0.254
1998	0.386	0.366	0.300	0.373	0.0828	0.897	0.334
1999	0.461	0.479	0.401	0.522	0.0606	1.020	0.532
2000	0.525	0.584	0.439	0.578	0.0610	1.078	0.623
2001	0.953	1.020	0.763	0.940	0.0570	1.060	0.996
2002	1.804	1.661	1.540	1.591	0.0608	1.025	1.631
2003	1.885	1.915	2.531	2.043	0.0623	0.895	1.827
2004	1.768	1.732	2.016	1.838	0.0628	0.964	1.771
2005	1.722	1.774	2.107	1.571	0.0577	1.109	1.742
2006	1.384	1.383	2.049	1.754	0.0615	0.910	1.596
2007	1.042	1.060	0.975	0.947	0.0523	1.008	0.955
2008	1.023	1.109	1.192	1.183	0.0569	1.066	1.261
2009	0.951	0.961	0.875	1.019	0.0530	1.160	1.182
2010	0.930	0.919	0.851	0.949	0.0540	1.107	1.051
2011	1.066	1.077	1.038	1.162	0.0553	1.039	1.208
2012	1.602	1.640	1.762	1.781	0.0561	1.047	1.865
2013	1.870	1.805	2.205	1.816	0.0561	1.049	1.905
2014	2.075	2.103	2.460	2.001	0.0542	1.019	2.038
2015	2.277	2.365	2.487	1.970	0.0564	1.021	2.012
2016	2.053	1.985	2.118	1.816	0.0587	1.017	1.846

Appendix I. DIAGNOSTICS AND SUPPORTING ANALYSES FOR TBGB(FLA)

I.1 Introduction
This CPUE analysis differs from the analysis presented in the 2016 Plenary document (MPI 2016) by adding Statistical Area 037 and dropping RCO as a target species. This analysis was not accepted in 2017 by the SINSWG for monitoring GUR 7.

I.2 Fishery definition
TBGB(FLA): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 017, 037 and 038 and declaring target species FLA.

I.3 Core vessel selection
The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 54 vessels which took 77% of the catch (Figure I.1).

I.3.1 Data summary

Table I.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 10 trips per year in 5 years) in the TBGB(FLA) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.

| Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	23	618	1 151	1 197	1.04	4 070	8 852	90.04	93.0	4.5	1.49
1991	24	390	780	789	1.01	2 696	5 986	35.57	92.1	7.0	1.71
1992	25	521	1 080	1 096	1.01	3 645	8 475	69.68	93.5	6.4	1.35
1993	32	871	1 650	1 690	1.02	6 067	13 933	112.88	90.0	8.7	3.82
1994	35	803	1 648	1 679	1.02	5 601	12 226	98.76	89.3	7.4	1.36
1995	35	802	1 578	1 623	1.03	5 393	11 227	59.81	78.4	17.0	3.65
1996	32	755	1 574	1 667	1.06	5 240	11 071	49.89	75.9	16.4	5.66
1997	31	872	1 978	2 079	1.05	6 853	16 441	71.43	77.5	10.1	2.98
1998	31	744	1 938	2 059	1.06	6 494	16 136	65.19	82.0	15.3	4.06
1999	28	562	1 306	1 384	1.06	4 501	10 122	38.04	68.0	13.4	3.50
2000	22	480	1 140	1 234	1.08	4 183	9 570	97.91	72.5	3.7	0.29
2001	20	318	807	825	1.02	2 601	7 338	71.79	95.6	4.9	1.21
2002	21	448	1 102	1 105	1.00	3 380	10 225	83.32	90.4	3.0	1.61
2003	25	481	1 127	1 134	1.01	3 329	10 174	87.11	83.8	5.2	1.47
2004	30	546	1 475	1 478	1.00	4 432	13 848	104.11	95.2	2.5	0.88
2005	28	581	1 706	1 720	1.01	4 939	15 109	96.85	92.6	1.3	0.27
2006	25	556	1 552	1 566	1.01	4 346	13 855	103.94	95.0	1.0	0.10
2007	31	739	1 986	1 997	1.01	5 614	17 478	149.58	93.8	2.2	0.11
2008	27	518	1 412	3 664	2.59	3 794	11 349	87.74	98.8	3.3	0.42
2009	27	484	1 349	3 497	2.59	3 576	10 501	104.60	92.8	4.0	1.08
2010	27	583	1 640	4 574	2.79	4 574	12 834	129.68	97.8	2.6	0.41
2011	25	407	1 097	2 940	2.68	2 940	8 457	101.74	98.5	4.2	0.56
2012	25	429	1 156	3 155	2.73	3 155	8 805	109.56	98.8	2.4	0.24
2013	21	440	1 151	3 127	2.72	3 127	8 780	113.12	99.1	1.8	0.26
2014	21	329	862	2 309	2.68	2 309	6 736	106.62	99.4	0.9	0.04
2015	16	320	890	2 415	2.71	2 415	7 461	110.63	99.1	0.6	0.04
2016	15	392	1 138	2 806	2.47	2 806	9 311	142.93	98.7	0.5	0.09

I.3.2   Core vessel selection
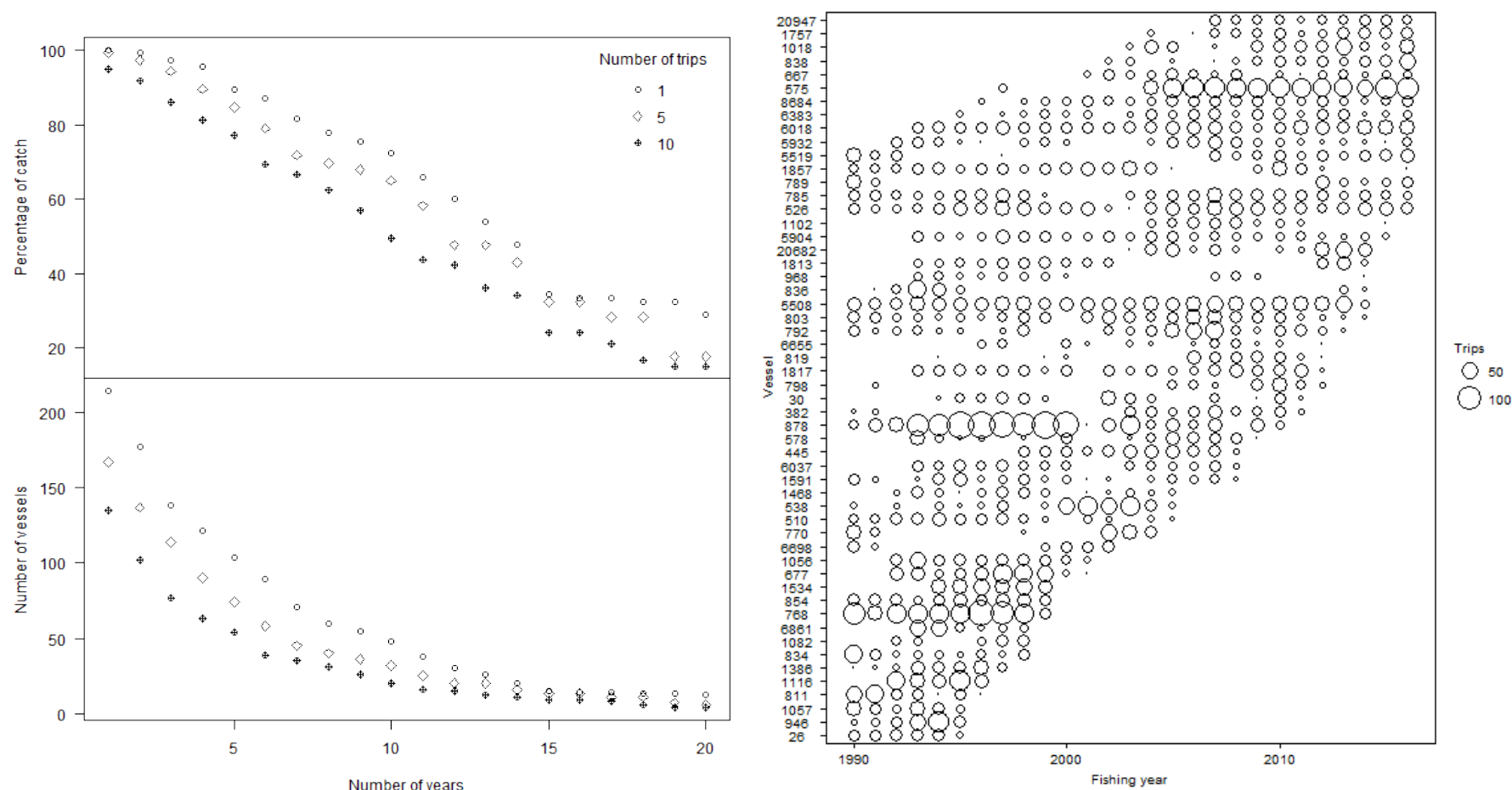
Figure I.1: [left panel] total landed gurnard and number of vessels plotted against the number of years used to define core vessels participating in the TBGB(FLA) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 5 or more fishing years) by fishing year.

I.3.3   Exploratory data plots for core vessel data set
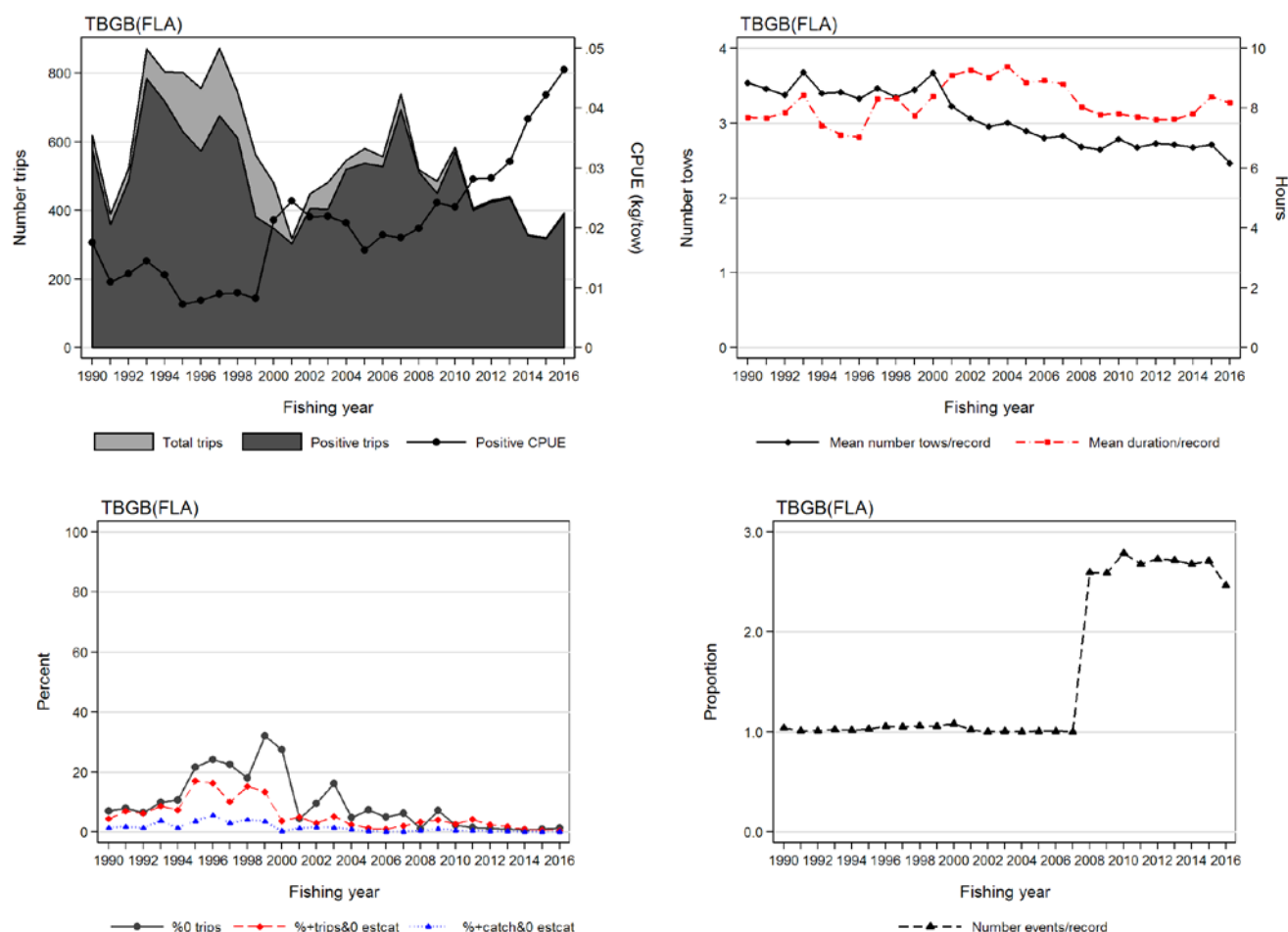
Figure I.2:   **Core vessel summary plots by fishing year for model TBGB(FLA): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch:** $A_y = \text{median}\left(C_{y,i}\big/E_{y,i}\right)$ **; [upper right panel]: mean number of sets and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of gurnard; b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.**

I.4 Positive catch model selection table

Two explanatory variables entered the model after fishing year (Table I.2), with month, duration fishing and area non-significant. A plot of the model is provided in Figure I.3 and the CPUE indices are listed in Table I.4.

Table I.2: **Order of acceptance of variables into the lognormal model of successful catches in the TBGB(FLA) fishery model for core vessels based on the vessel selection criteria of at least 10 trips in 5 or more fishing years, with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-165 104	330 264	11.86	*
vessel	81	-160 690	321 543	33.88	*
poly(log(tows), 3)	84	-158 433	317 035	**42.92**	*
month	95	-158 208	316 605	43.75	
poly(log(duration), 3)	98	-158 040	316 276	44.36	
area	100	-157 989	316 179	44.55	

TBGB(FLA)

Standardised index error bars=+/- 1.96*SE
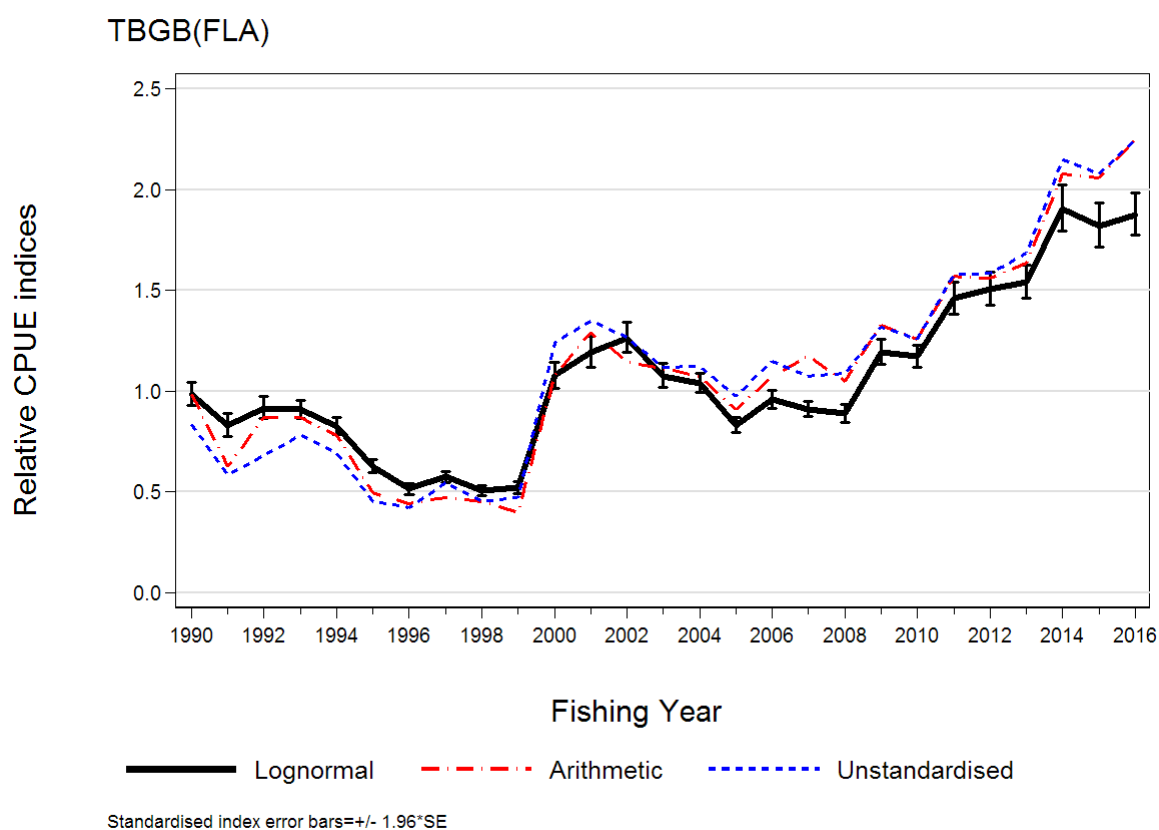
Figure I.3: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(FLA) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).**
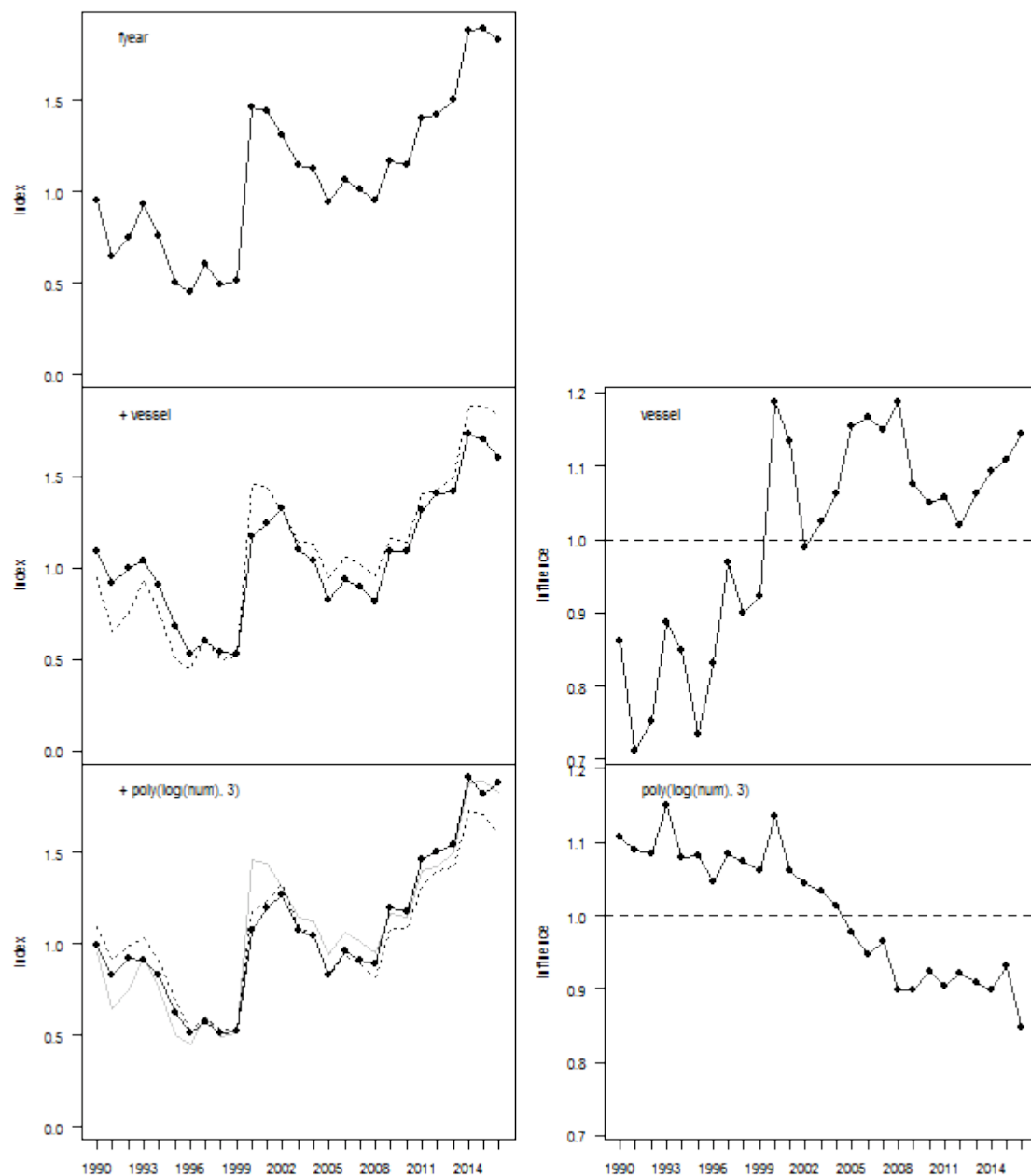
Figure I.4: [left column]: annual indices from the lognormal model of TBGB(FLA) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

I.4.1   Residual and diagnostic plots
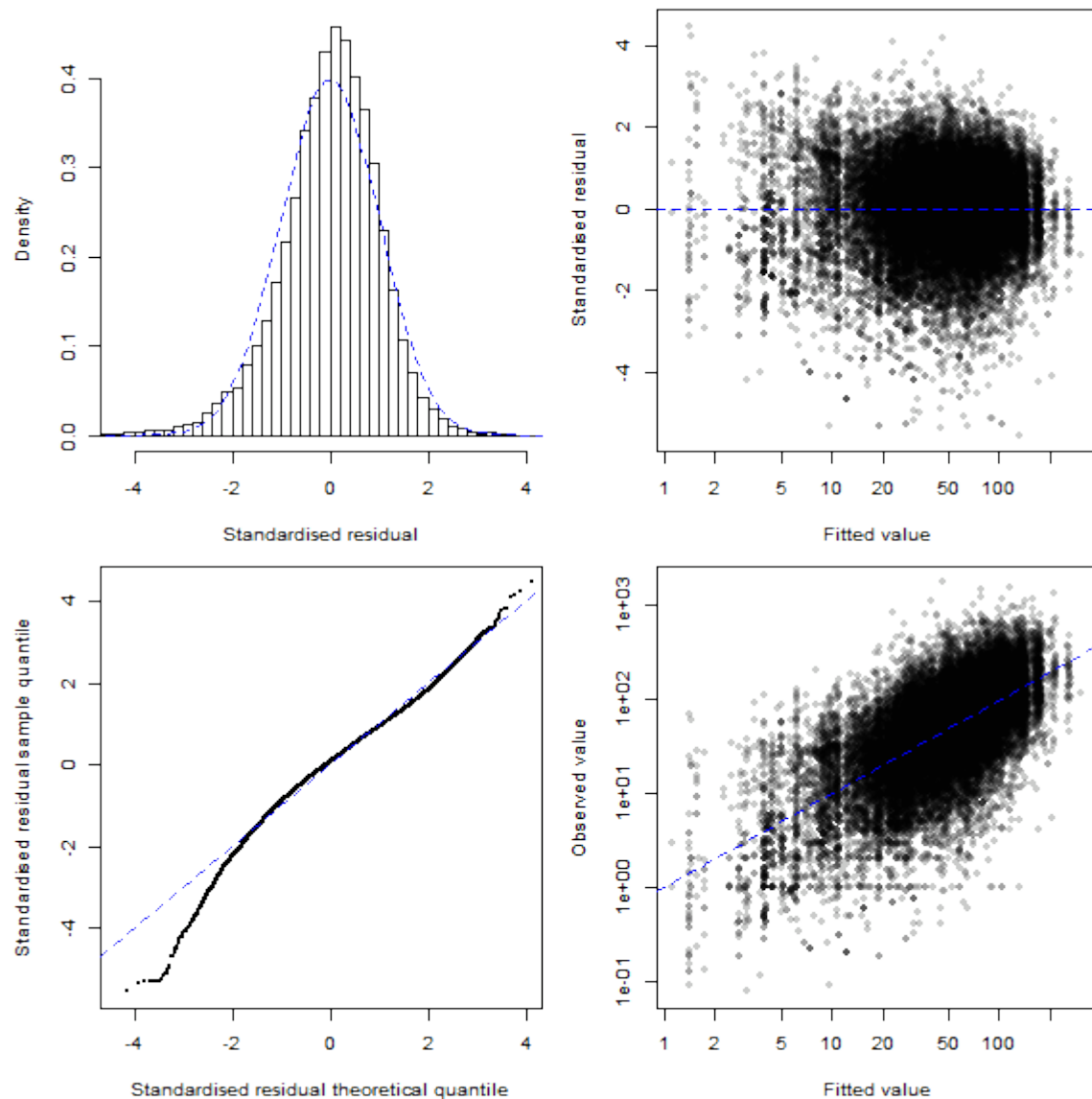
Figure I.5:   **Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the TBGB(FLA) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.**

I.4.2   Model coefficients
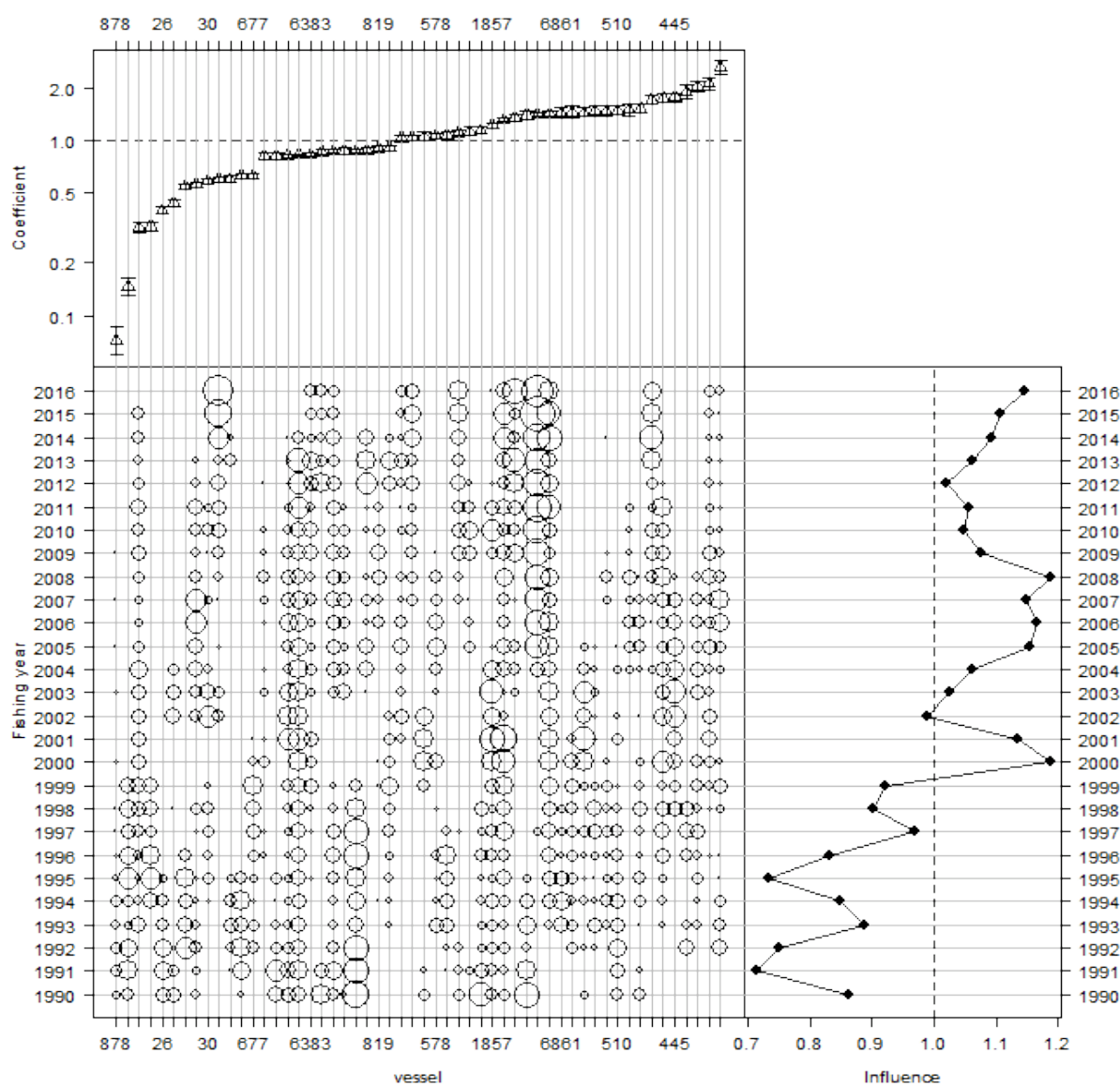
Figure I.6:   **Effect of vessel in the lognormal model for the gurnard TBGB(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
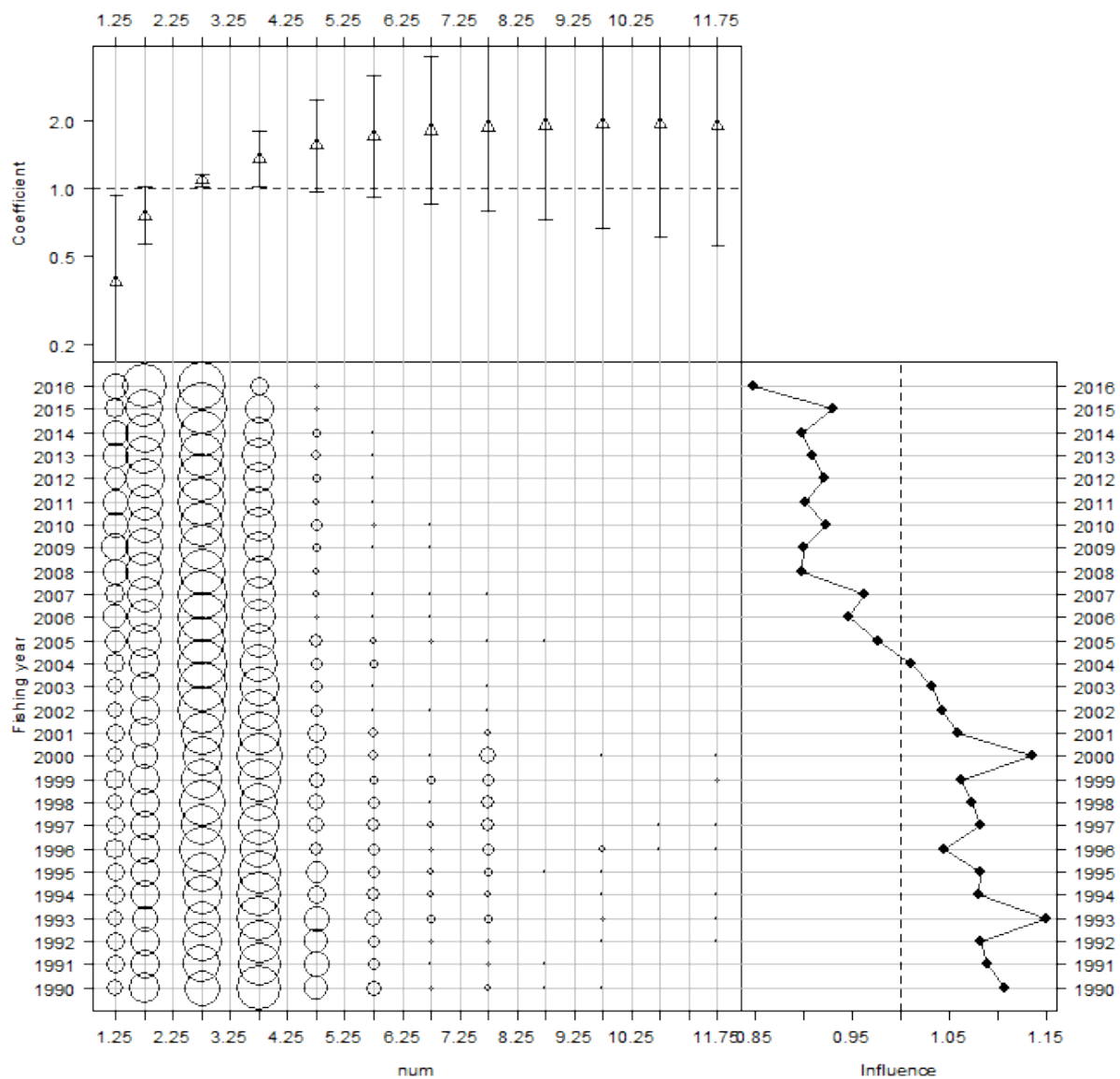
Figure I.7: Effect of tows in the lognormal model for the gurnard TBGB(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
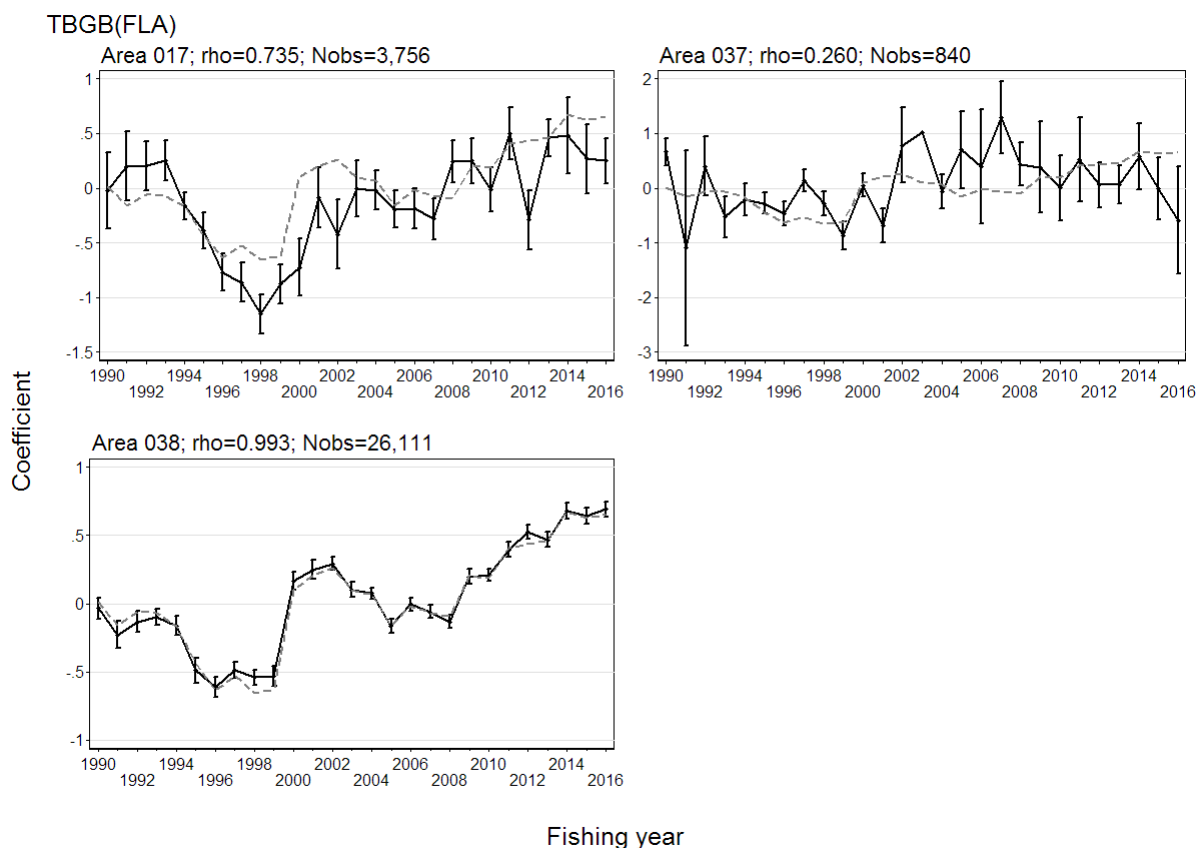
TBGB(FLA)

Figure I.8: **Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model and note that area was not accepted into the lognormal model – see Table I.2) in the gurnard TBGB(FLA) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.**

I.4.3 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table I.3), with area and duration fished non-significant. A plot of the binomial model and the combined delta-lognormal model is provided in Figure I.9 and the CPUE indices are listed in Table I.4.

Table I.3: Order of acceptance of variables into the binomial (logistic) model of successful catches in the TBGB(FLA) fishery model for core vessels based on the vessel selection criteria of at least 10 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-14 417	28 888	9.68	*
vessel	80	-12 040	24 240	29.92	*
area	82	-11 877	23 919	**31.21**	*
poly(log(tows), 3)	85	-11 754	23 677	32.18	
poly(log(duration), 3)	88	-11 740	23 657	32.29	
month	99	-11 724	23 645	32.42	
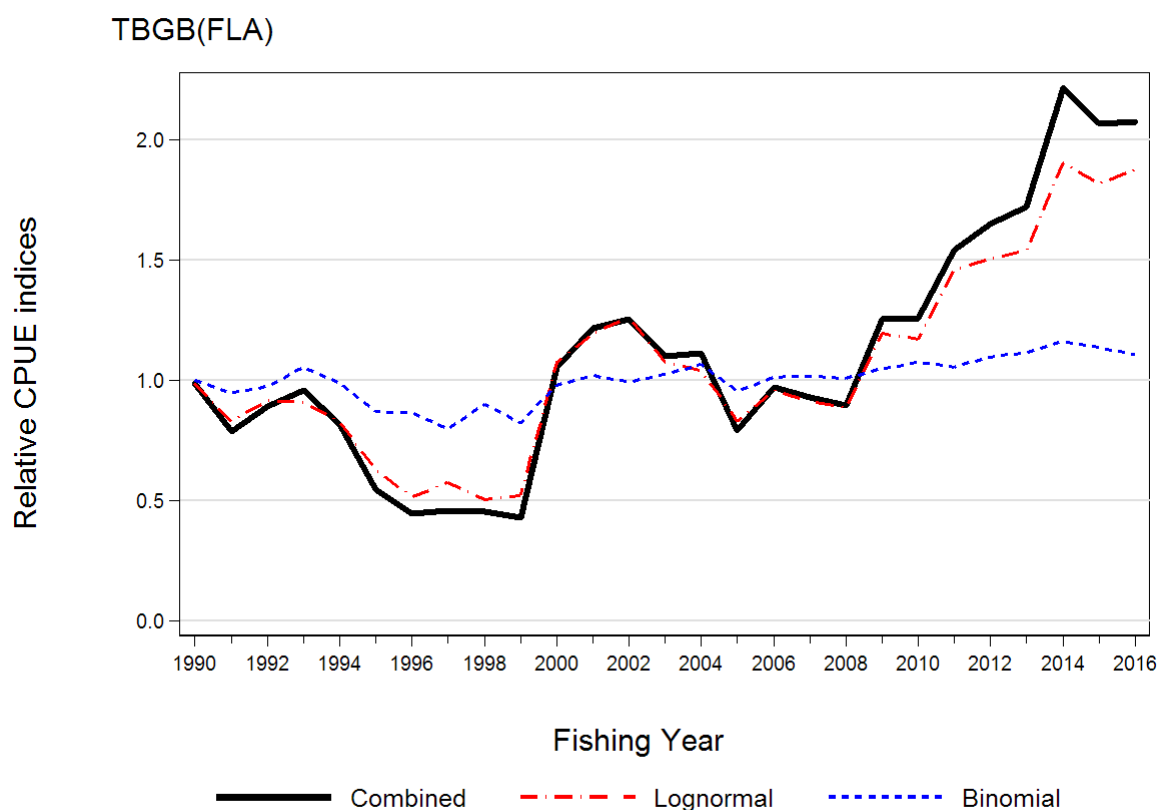
Figure I.9: Relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(FLA) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure suggested by Vignaux (1994).

I.4.4 CPUE indices

Table I.4: **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard TBGB(FLA) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Core vessels Combined
1990	0.924	0.986	0.836	0.987	0.0298	1.001	0.988
1991	0.704	0.627	0.585	0.831	0.0361	0.949	0.788
1992	0.959	0.870	0.681	0.916	0.0308	0.975	0.894
1993	0.824	0.868	0.782	0.910	0.0249	1.054	0.960
1994	0.786	0.780	0.695	0.825	0.0258	0.991	0.817
1995	0.590	0.496	0.454	0.628	0.0275	0.870	0.546
1996	0.464	0.441	0.424	0.515	0.0271	0.864	0.446
1997	0.452	0.473	0.546	0.575	0.0244	0.799	0.459
1998	0.533	0.454	0.453	0.506	0.0239	0.901	0.456
1999	0.420	0.399	0.472	0.521	0.0301	0.823	0.429
2000	0.971	1.073	1.240	1.077	0.0297	0.981	1.056
2001	1.048	1.292	1.350	1.192	0.0329	1.020	1.217
2002	1.087	1.147	1.266	1.265	0.0293	0.993	1.257
2003	0.973	1.111	1.120	1.075	0.0285	1.025	1.103
2004	0.958	1.074	1.124	1.040	0.0241	1.068	1.111
2005	0.901	0.910	0.975	0.831	0.0237	0.955	0.794
2006	1.061	1.072	1.148	0.958	0.0243	1.013	0.971
2007	1.340	1.176	1.076	0.912	0.0216	1.019	0.929
2008	1.062	1.051	1.088	0.887	0.0253	1.008	0.895
2009	1.611	1.326	1.319	1.195	0.0259	1.050	1.254
2010	1.279	1.258	1.259	1.171	0.0234	1.076	1.260
2011	1.491	1.571	1.578	1.461	0.0279	1.057	1.543
2012	1.497	1.559	1.586	1.506	0.0275	1.098	1.653
2013	1.537	1.634	1.684	1.542	0.0275	1.117	1.723
2014	1.987	2.077	2.151	1.906	0.0307	1.163	2.217
2015	1.990	2.058	2.079	1.820	0.0309	1.136	2.069
2016	2.283	2.249	2.249	1.876	0.0286	1.108	2.078

Appendix J.   DIAGNOSTICS AND SUPPORTING ANALYSES FOR TBGB(MIX)

J.1   Introduction

This CPUE analysis differs from the analysis presented in the 2016 Plenary document (MPI 2016) by adding Statistical Area 037, dropping Statistical Areas 018 and 039, and extending the list of target species from TAR, BAR and WAR to also include GUR, RCO and SNA. This analysis was not accepted in 2017 for monitoring GUR 7 (MPI 2017).

J.2   Fishery definition

TBGB(MIX): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 017, 037 and 038 and declaring target species GUR, BAR, TAR, WAR, RCO, SNA.

J.3   Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 5 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 35 vessels which took 77% of the catch (Figure J.1).

J.3.1   Data summary

Table J.1:   Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 5 trips per year in 5 years) in the TBGB(MIX) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.

| Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	14	122	275	276	1.00	872	2 502	25.03	85.3	16.4	2.82
1991	15	204	469	480	1.02	1 393	4 120	38.77	84.3	18.0	2.11
1992	18	211	537	583	1.09	1 569	4 753	74.44	87.2	19.0	2.79
1993	19	264	740	810	1.09	2 356	7 111	51.66	78.8	17.3	2.74
1994	18	205	536	564	1.05	1 755	4 795	54.17	85.9	22.2	7.02
1995	22	237	596	736	1.23	1 819	5 509	85.13	83.5	19.7	7.12
1996	24	233	662	764	1.15	1 930	5 984	48.26	77.3	26.1	5.92
1997	21	271	694	810	1.17	2 155	6 289	35.49	72.3	30.1	12.87
1998	22	213	435	500	1.15	1 202	3 618	18.26	60.1	35.2	7.79
1999	24	283	670	755	1.13	1 939	5 992	33.16	68.9	29.2	7.69
2000	20	289	689	789	1.15	2 039	6 251	40.93	73.0	30.3	5.24
2001	24	296	770	849	1.10	2 420	8 176	77.53	77.0	23.3	1.49
2002	22	290	720	816	1.13	2 079	7 177	66.94	72.4	16.7	1.36
2003	19	275	741	809	1.09	2 171	7 613	83.08	69.1	16.8	2.41
2004	25	326	808	886	1.10	2 162	7 533	72.11	66.3	13.0	2.42
2005	21	281	674	739	1.10	1 764	5 999	63.27	71.9	5.9	0.53
2006	20	222	572	642	1.12	1 561	5 059	62.59	80.6	13.4	0.58
2007	18	253	632	767	1.21	1 765	5 551	98.81	79.1	15.0	1.23
2008	19	221	593	1 569	2.65	1 577	5 351	80.87	81.9	9.4	1.30
2009	14	196	454	1 162	2.56	1 162	3 966	63.21	80.1	10.8	0.72
2010	19	243	577	1 532	2.66	1 532	4 877	88.44	81.5	6.1	0.48
2011	19	257	637	1 778	2.79	1 778	5 500	89.75	83.3	16.4	1.88
2012	20	288	738	2 043	2.77	2 043	6 773	89.35	85.4	19.9	1.68
2013	21	327	780	2 146	2.75	2 146	6 915	88.34	83.8	22.3	2.05
2014	21	286	642	1 724	2.69	1 724	5 572	85.92	81.8	15.4	1.37
2015	18	258	646	1 788	2.77	1 788	5 162	115.82	84.5	21.6	0.79
2016	19	274	629	1 804	2.87	1 804	5 403	81.90	75.6	29.0	1.58

J.3.2   Core vessel selection
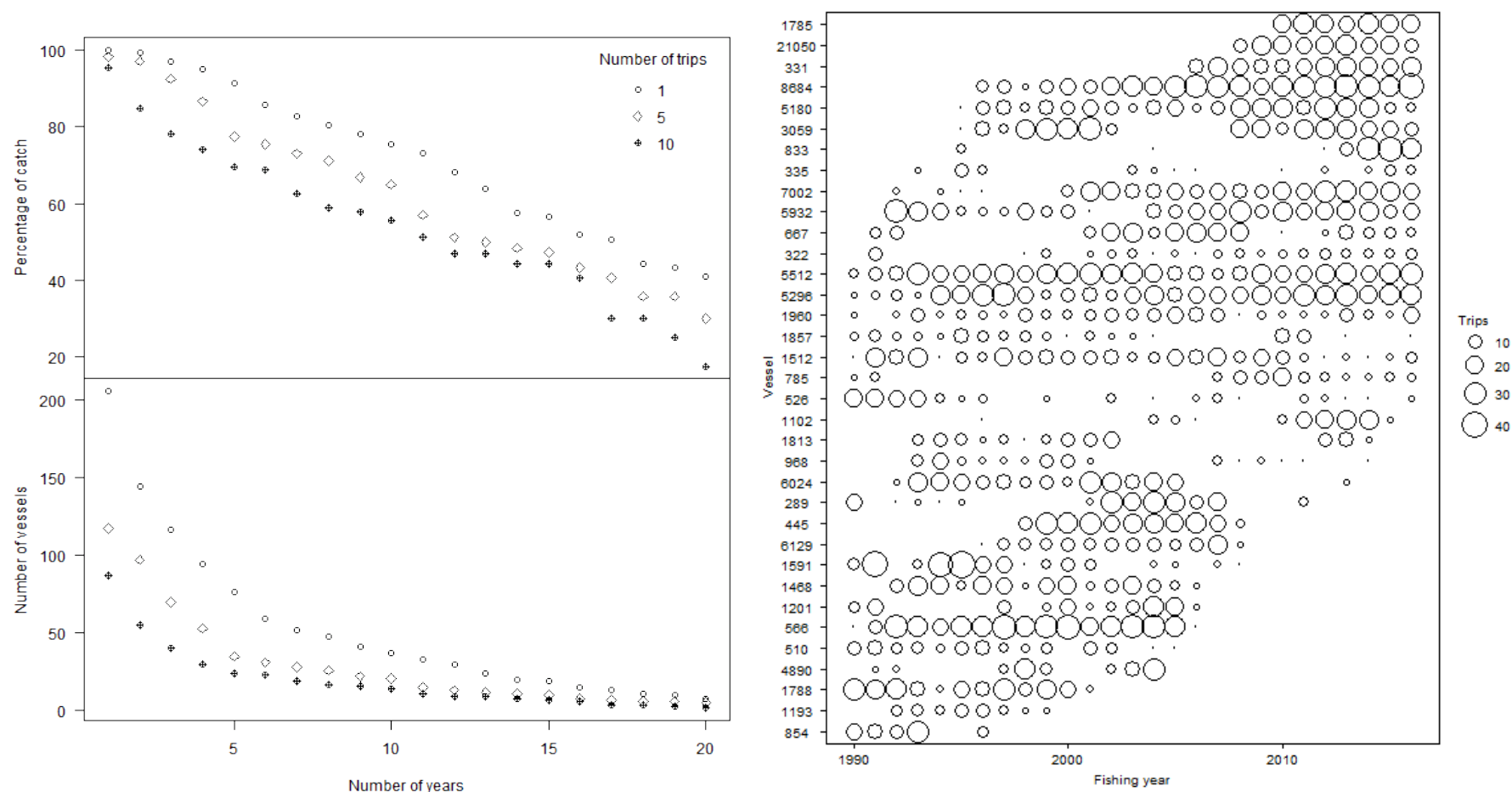
Figure J.1:   [left panel] total landed gurnard and number of vessels plotted against the number of years used to define core vessels participating in the TBGB(MIX) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 5 trips in 5 or more fishing years) by fishing year.

J.3.3   Exploratory data plots for core vessel data set
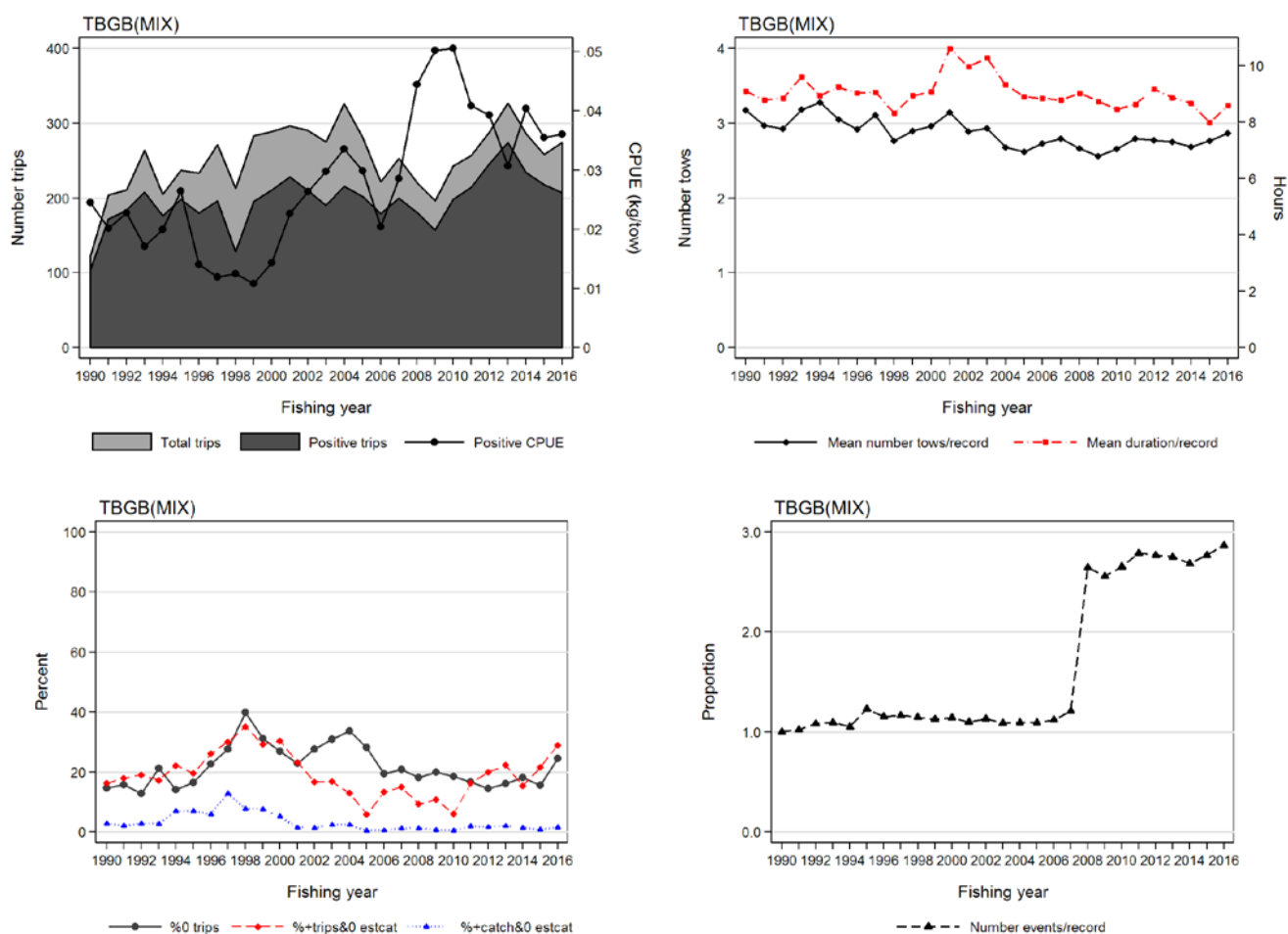
Figure J.2:   **Core vessel summary plots by fishing year for model TBGB(MIX): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch:** $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i} \right)$**; [upper right panel]: mean number of sets and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of gurnard; b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.**

J.4 Positive catch model selection table

Four explanatory variables entered the model after fishing year (Table J.2), with month and number tows non-significant. A plot of the model is provided in Figure J.3 and the CPUE indices are listed in Table J.4.

Table J.2: Order of acceptance of variables into the lognormal model of successful catches in the TBGB(MIX) fishery model for core vessels based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-68 976	138 009	3.76	*
area	30	-67 661	135 383	23.53	*
target	35	-66 691	133 452	35.47	*
poly(log(duration), 3)	38	-66 226	132 529	40.51	*
vessel	72	-65 818	131 780	**44.60**	*
month	83	-65 755	131 676	45.21	
poly(log(tows), 3)	86	-65 741	131 654	45.35	
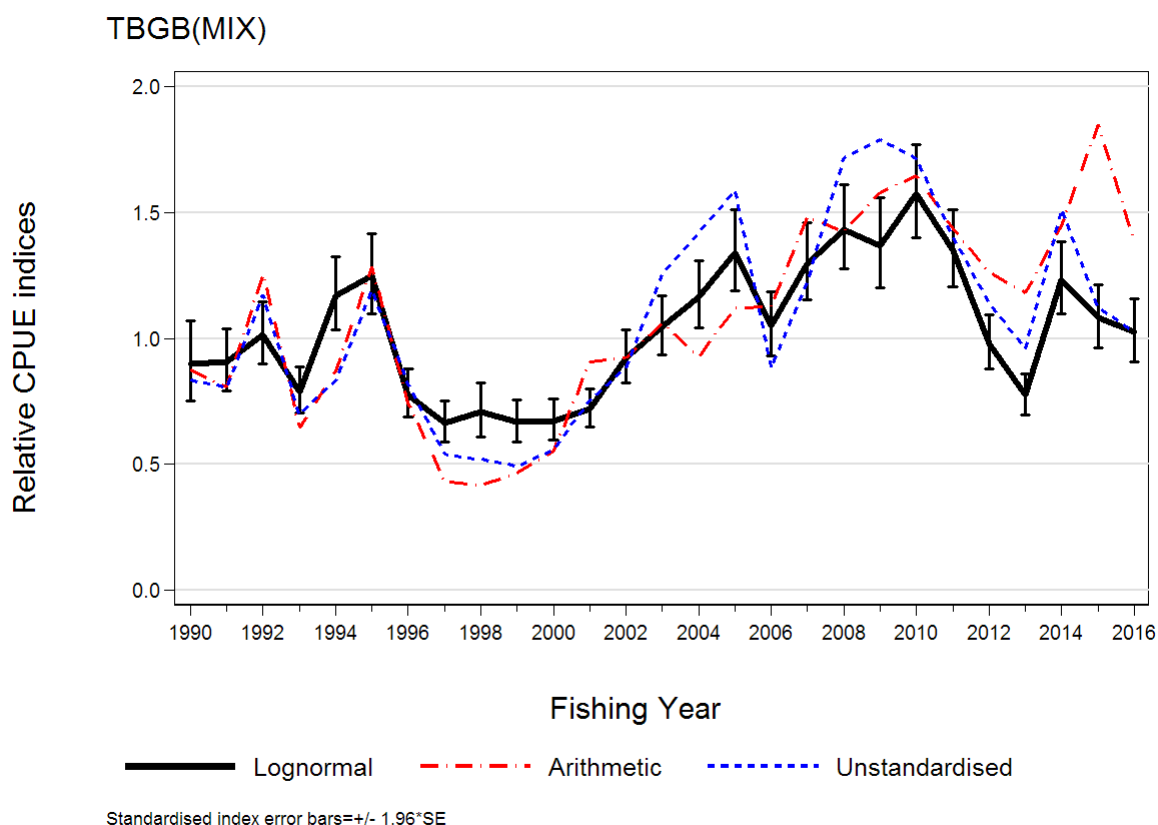
Figure J.3: Relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(MIX) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).
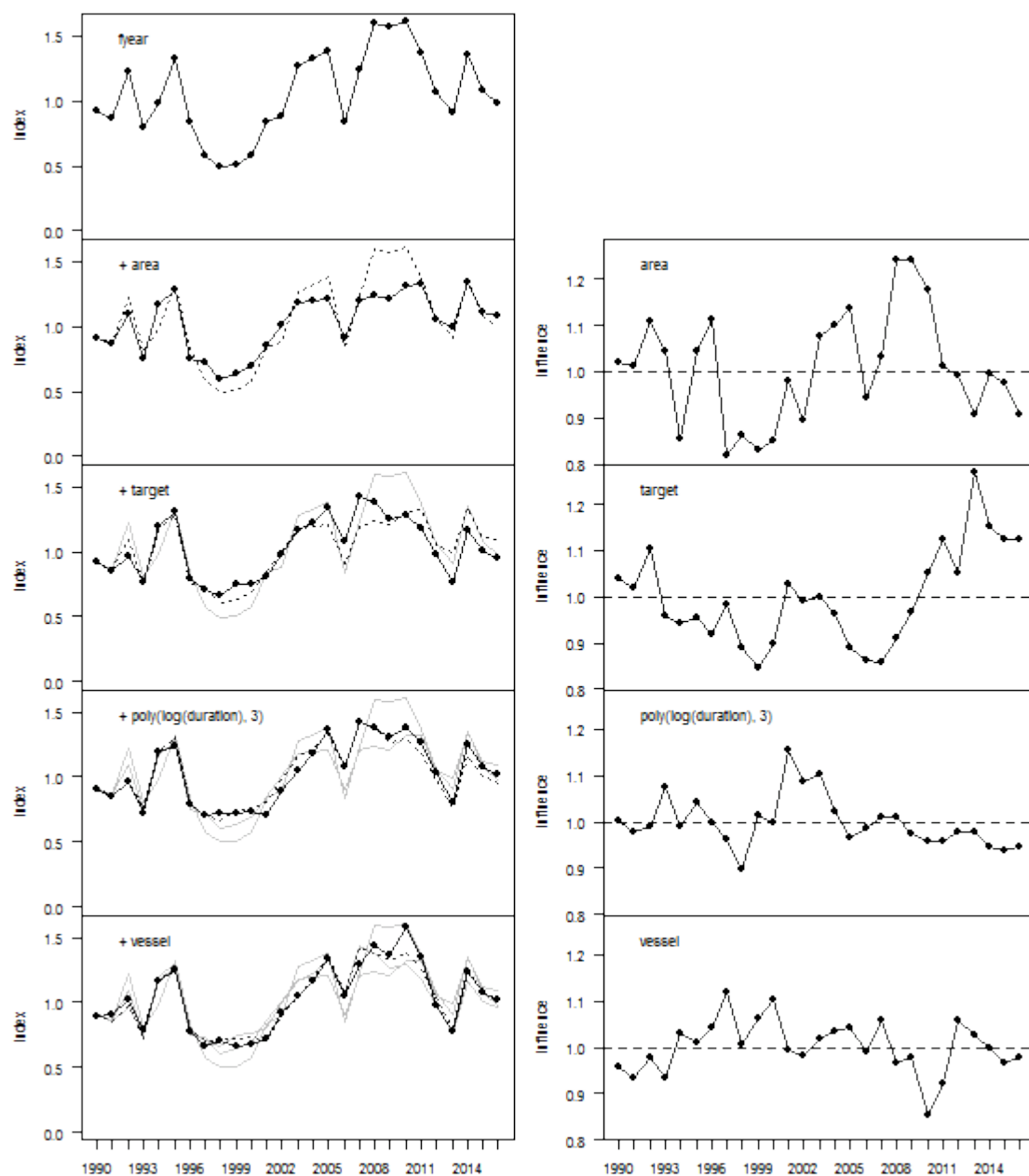
Figure J.4: [left column]: annual indices from the lognormal model of TBGB(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

J.4.1   Residual and diagnostic plots
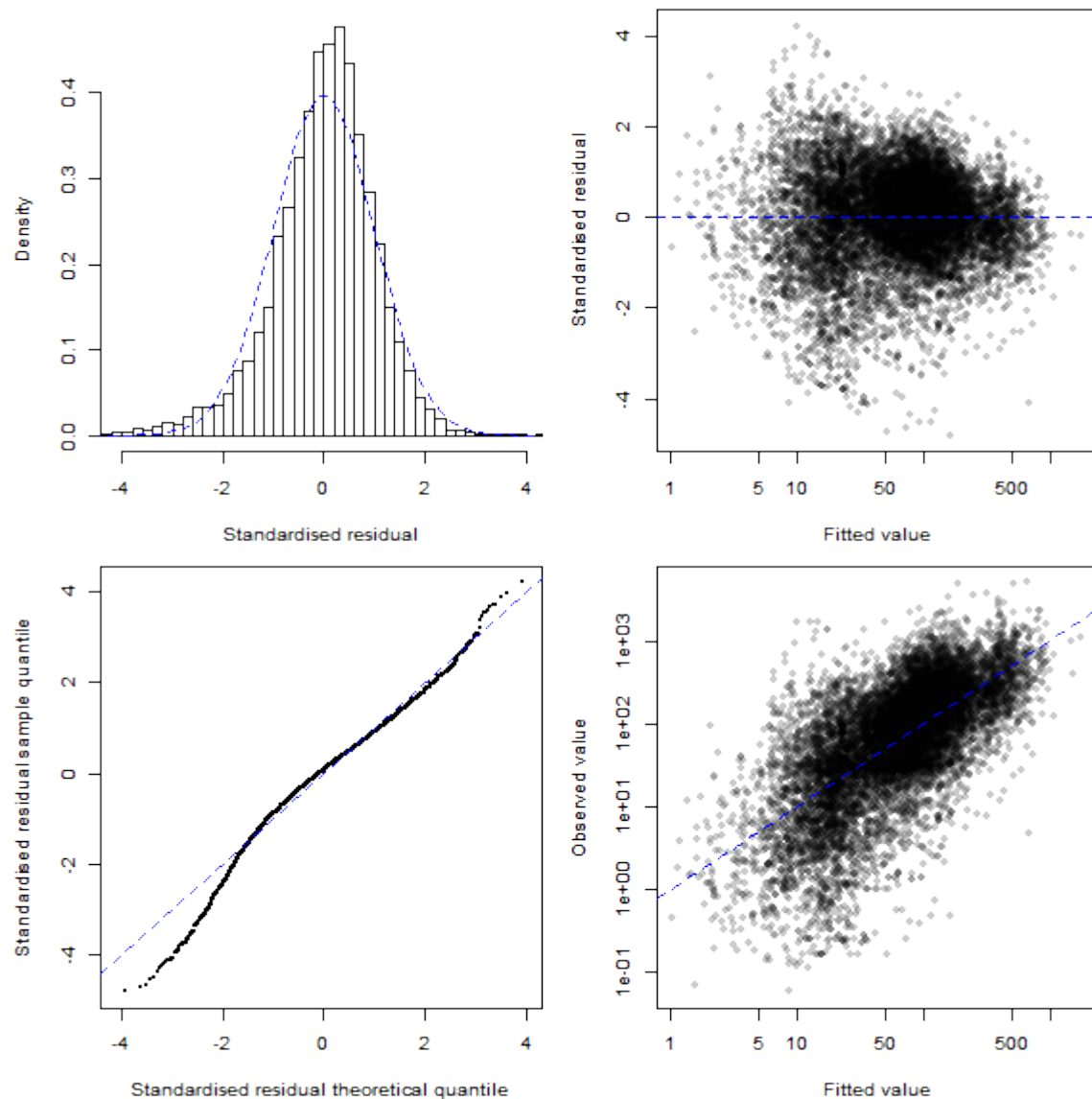
Figure J.5:   Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the TBGB(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

J.4.2 Model coefficients
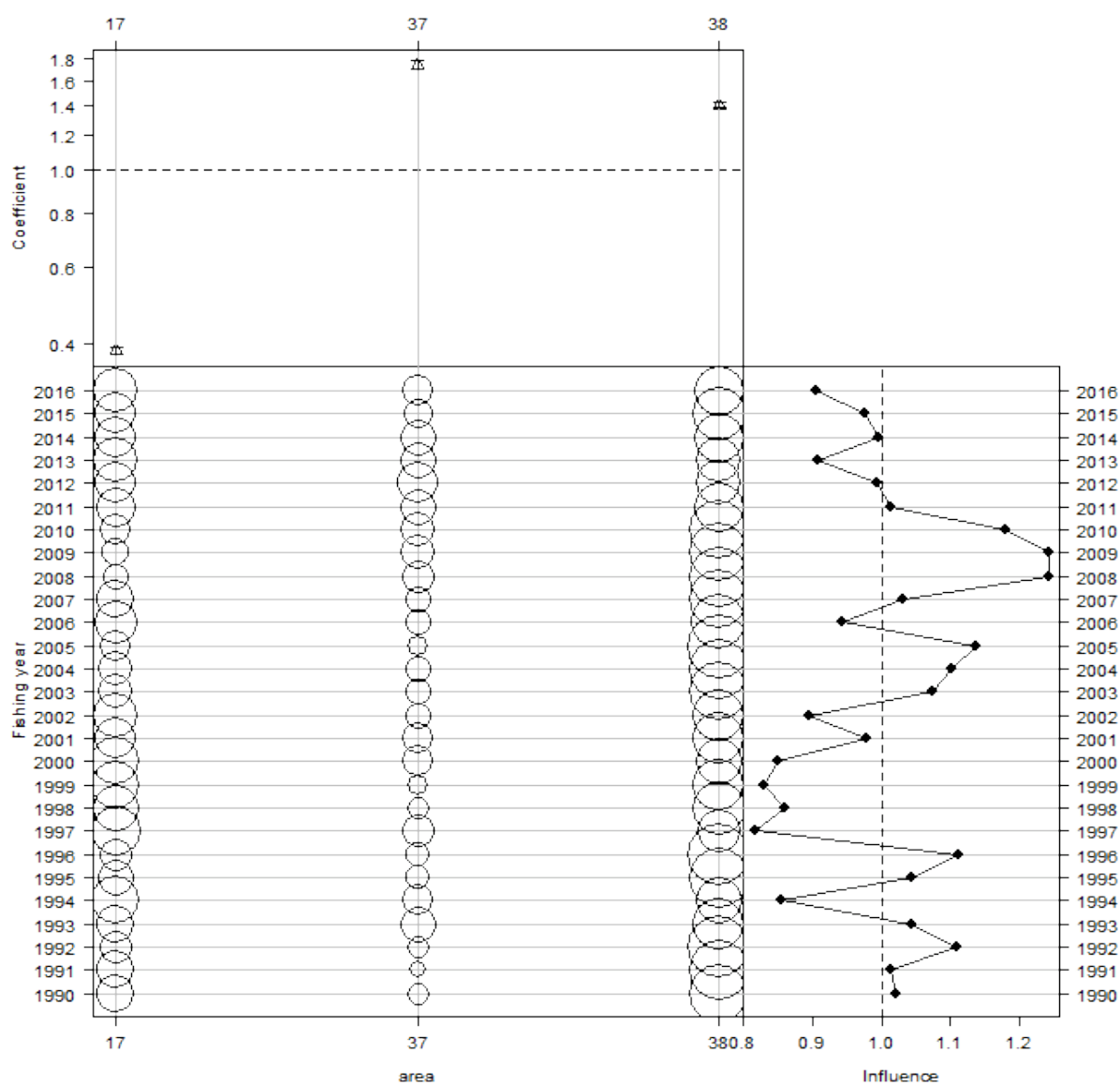
Figure J.6: Effect of statistical area in the lognormal model for the gurnard TBGB(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
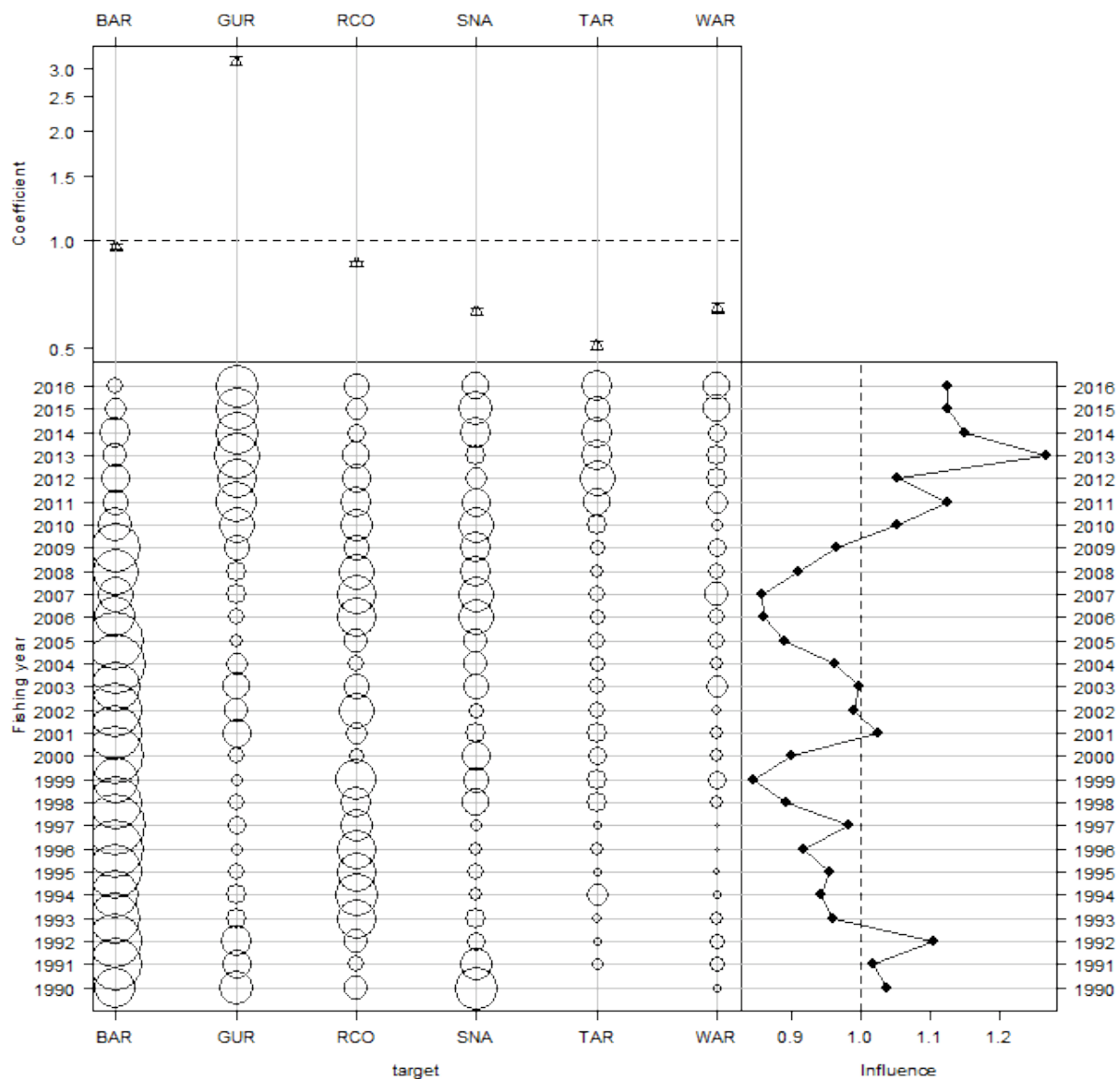
Figure J.7: **Effect of target species in the lognormal model for the gurnard TBGB(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
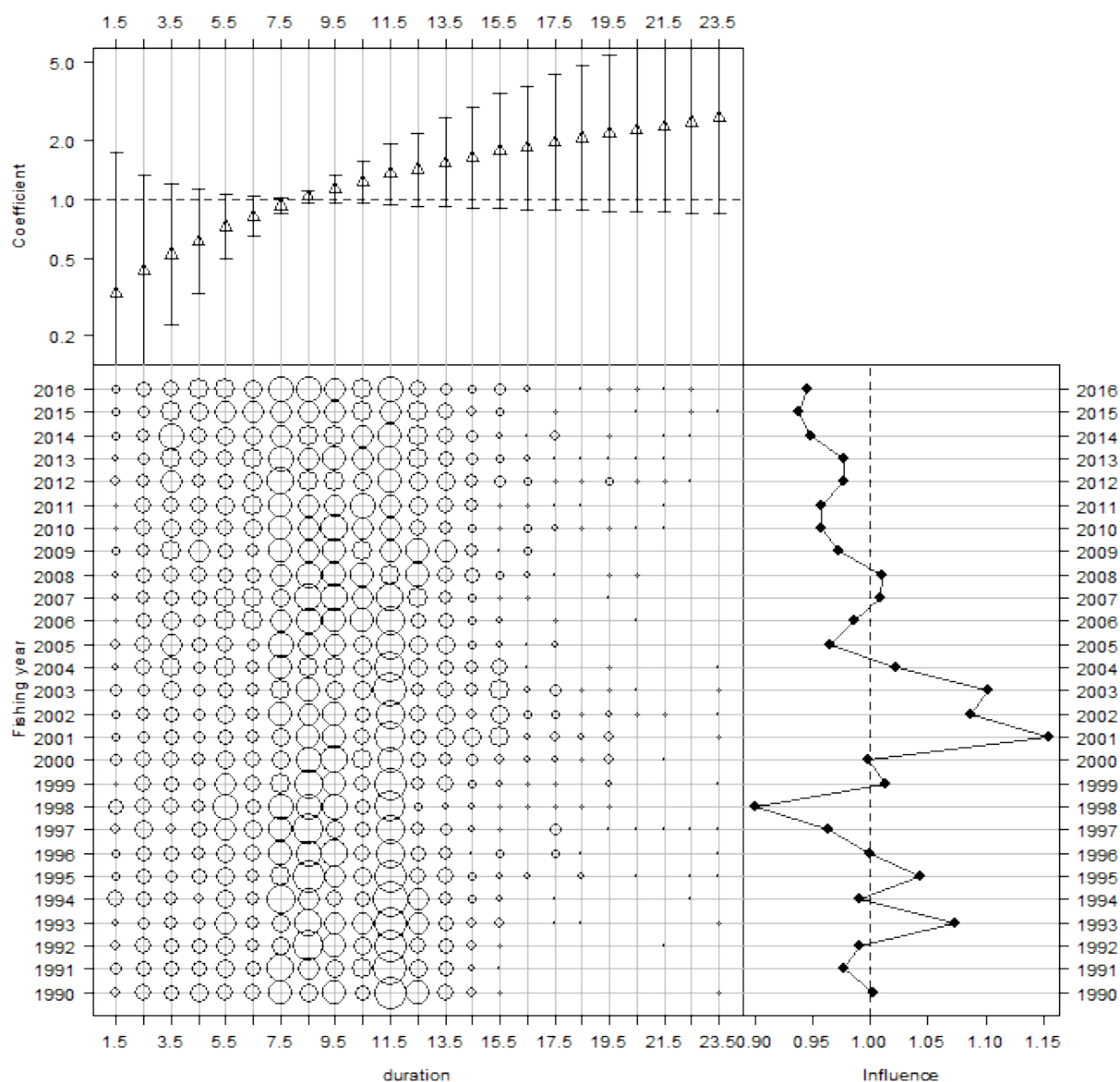
Figure J.8: **Effect of duration in the lognormal model for the gurnard TBGB(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
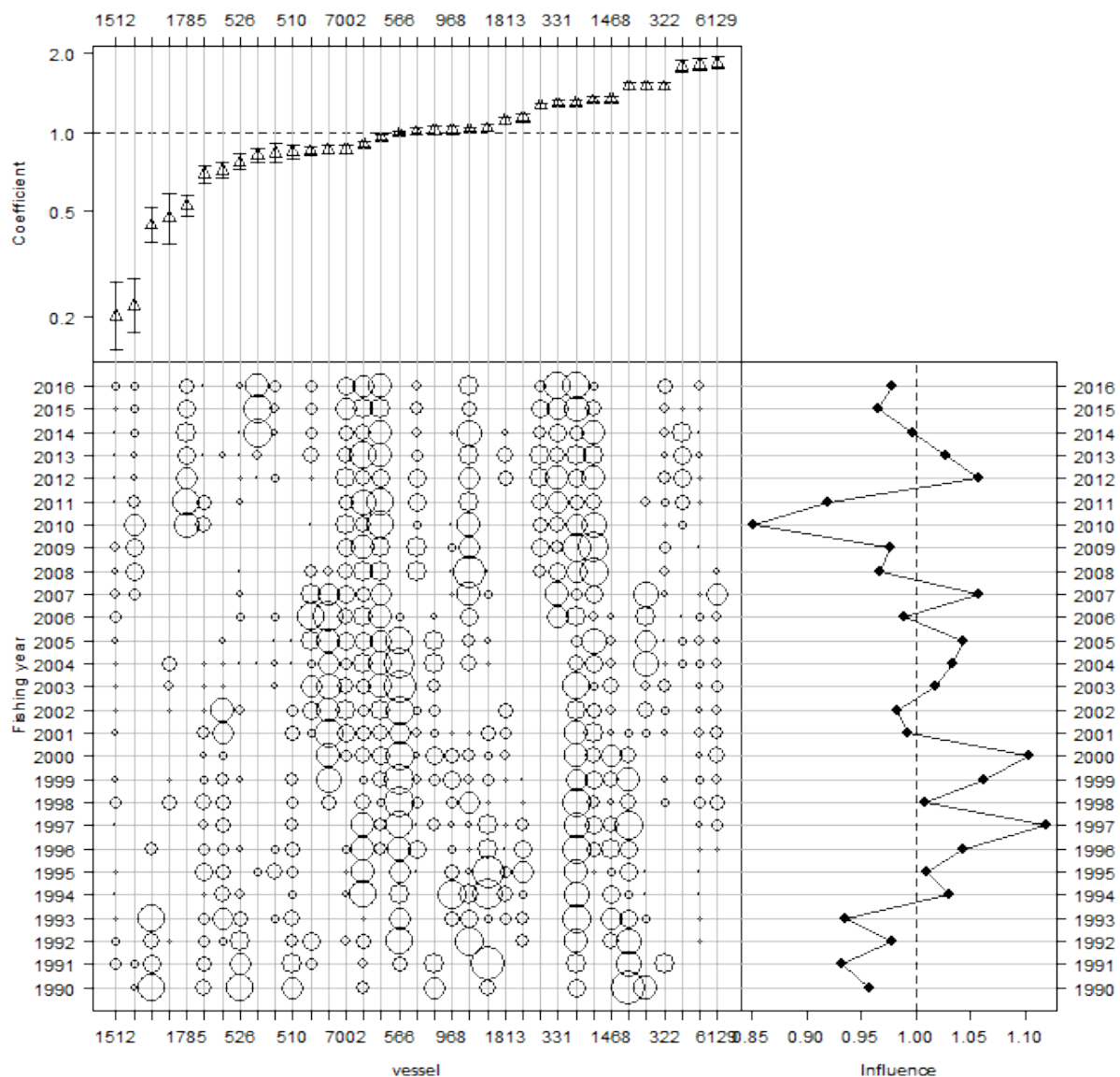
Figure J.9: Effect of vessel in the lognormal model for the gurnard TBGB(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
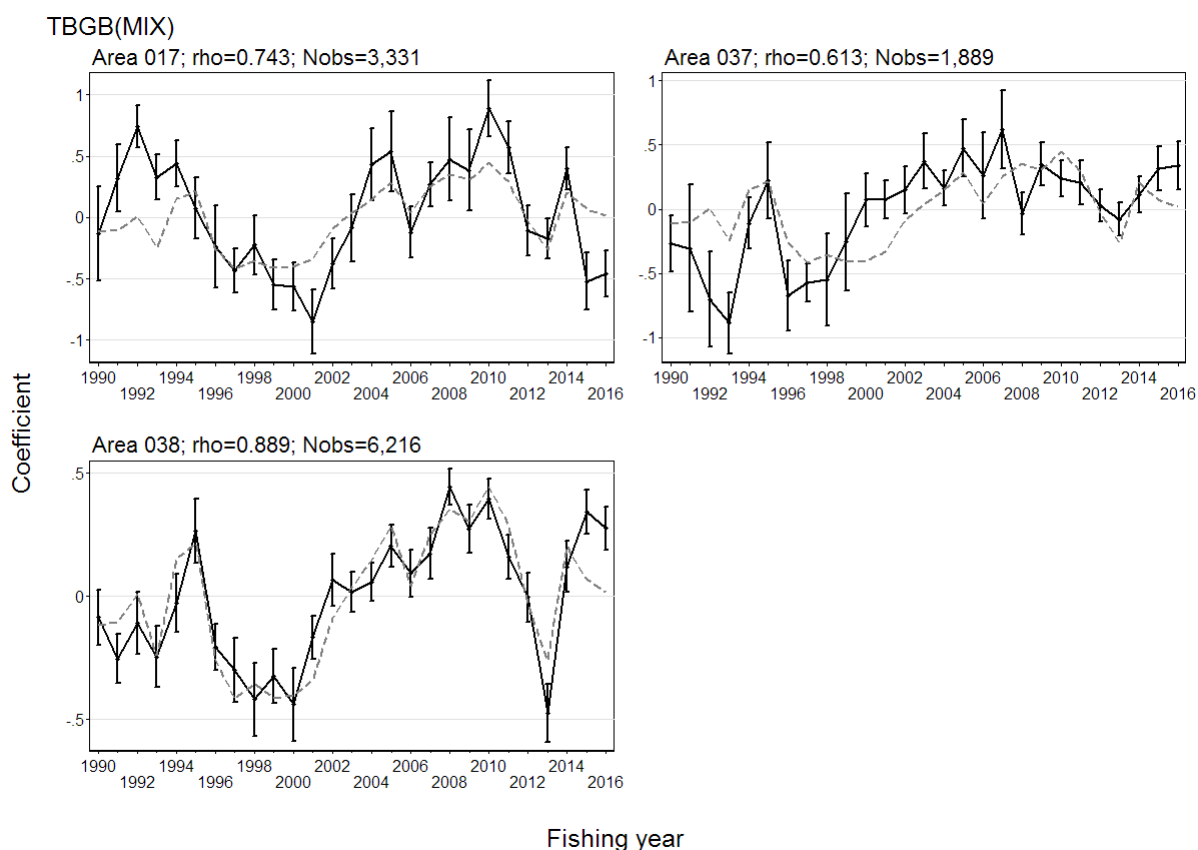
Figure J.10: **Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the gurnard TBGB(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.**

TBGB(MIX)
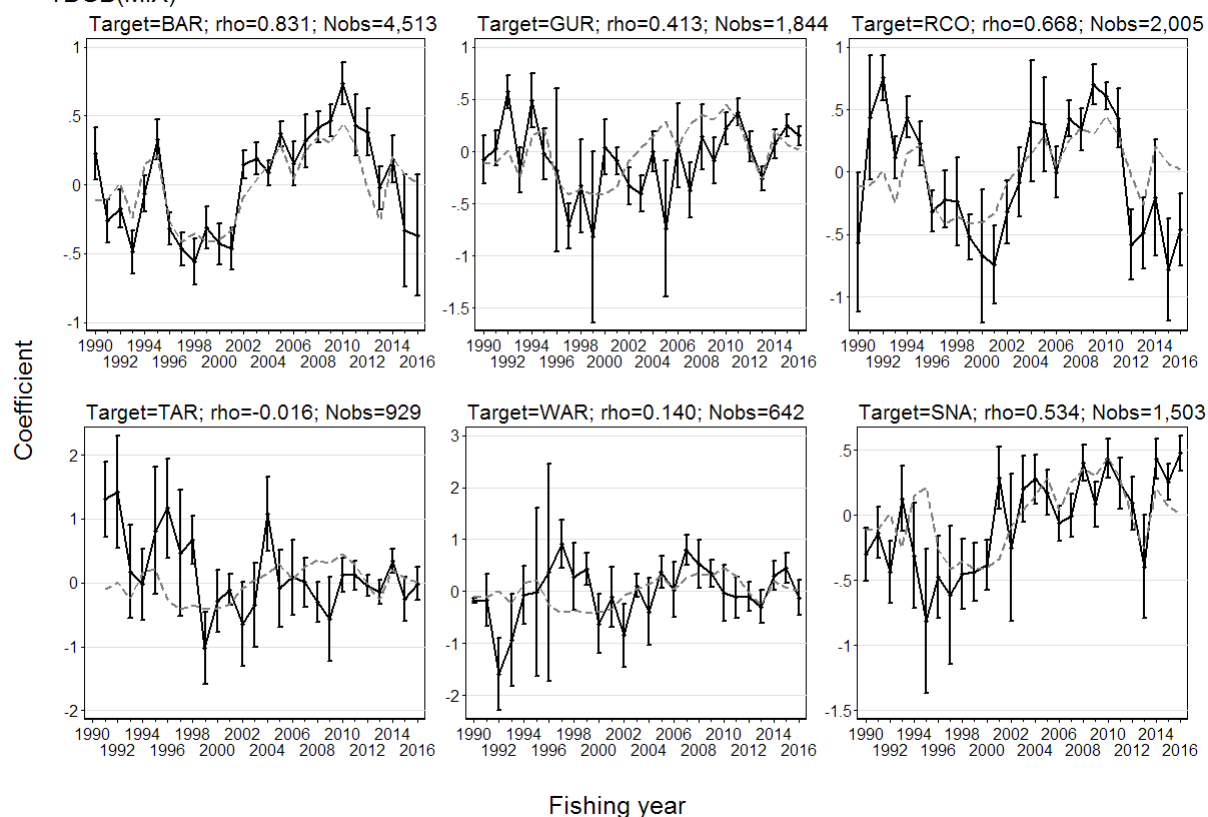
Figure J.11: **Residual implied coefficients for target species × fishing year interaction (interaction term not offered to the model) in the gurnard TBGB(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (_rho_) between the category year index and the overall model index, and the number of records supporting the category.**

J.4.3 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table J.3), with duration fished non-significant. The model discarded [tows] and [month] as explanatory variables. A plot of the binomial model and the combined delta-lognormal model is provided in Figure J.12 and the CPUE indices are listed in Table J.4.

Table J.3: **Order of acceptance of variables into the binomial (logistic) model of presence/absence of gurnard in the TBGB(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-10 410	20 875	3.45	*
target	32	-9 519	19 103	17.09	*
area	34	-9 092	18 252	23.14	*
vessel	68	-8 904	17 945	**25.71**	*
poly(log(duration), 3)	71	-8 869	17 880	26.18	
poly(log(tows), 3)	–	–	–	–	
month	–	–	–	–	
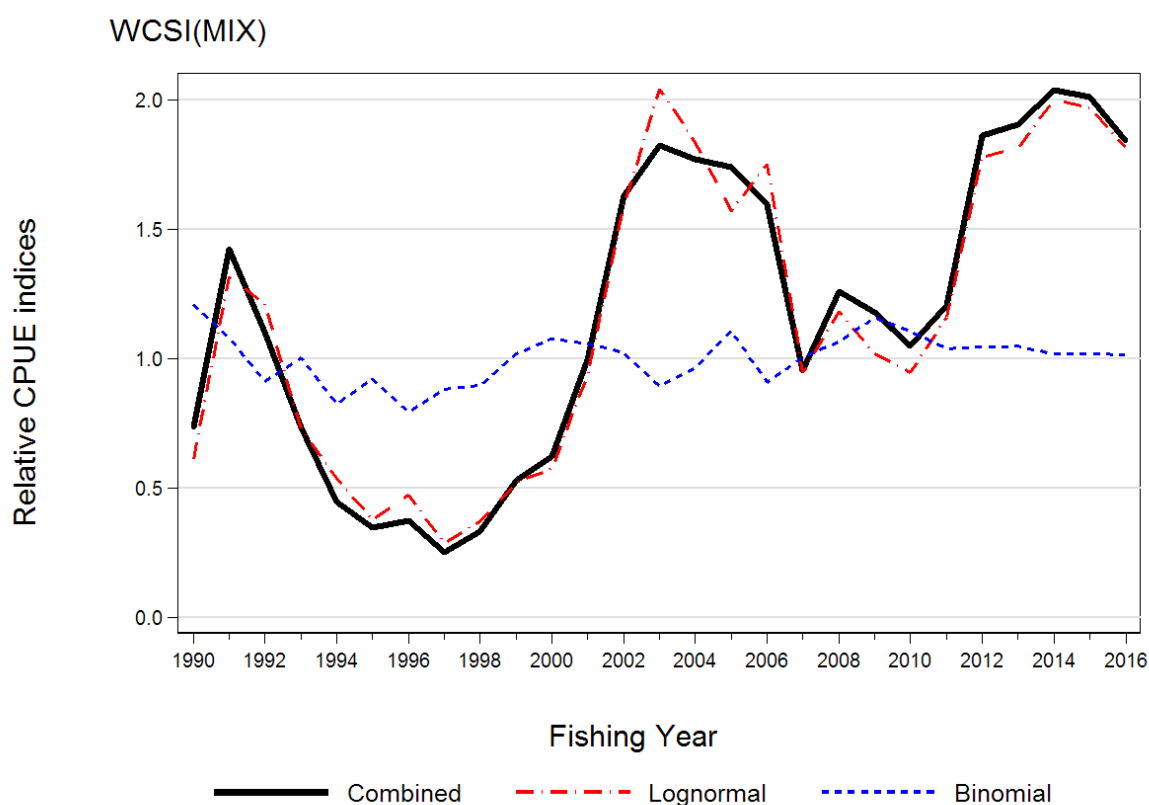
Figure J.12: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the TBGB(MIX) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure (Eq. F.4).**

J.4.4   CPUE indices

Table J.4:   **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard TBGB(MIX) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Core vessels Combined
1990	0.694	0.874	0.835	0.898	0.0896	0.953	0.855
1991	0.734	0.807	0.806	0.907	0.0693	1.004	0.911
1992	1.141	1.255	1.172	1.016	0.0621	0.954	0.969
1993	0.755	0.645	0.697	0.789	0.0597	0.859	0.678
1994	0.819	0.869	0.833	1.171	0.0625	1.105	1.294
1995	1.056	1.284	1.191	1.248	0.0648	0.879	1.097
1996	0.612	0.744	0.821	0.777	0.0630	0.784	0.610
1997	0.606	0.434	0.540	0.664	0.0626	0.862	0.573
1998	0.382	0.416	0.520	0.707	0.0782	0.878	0.620
1999	0.477	0.464	0.492	0.667	0.0629	0.903	0.602
2000	0.548	0.552	0.558	0.674	0.0615	0.903	0.608
2001	0.910	0.908	0.753	0.720	0.0543	1.035	0.745
2002	0.934	0.924	0.884	0.923	0.0579	0.993	0.916
2003	1.010	1.061	1.257	1.046	0.0575	0.943	0.986
2004	0.845	0.928	1.418	1.167	0.0577	0.881	1.028
2005	1.126	1.121	1.589	1.341	0.0613	0.900	1.208
2006	1.254	1.128	0.883	1.051	0.0616	1.108	1.165
2007	1.554	1.484	1.229	1.297	0.0598	1.134	1.471
2008	1.503	1.423	1.719	1.434	0.0595	1.091	1.565
2009	1.606	1.580	1.792	1.367	0.0668	1.130	1.544
2010	1.585	1.648	1.715	1.574	0.0596	1.129	1.777
2011	1.513	1.438	1.405	1.349	0.0583	1.094	1.476
2012	1.265	1.264	1.141	0.980	0.0560	1.101	1.079
2013	1.289	1.182	0.960	0.775	0.0535	1.161	0.900
2014	1.485	1.447	1.513	1.234	0.0594	1.090	1.344
2015	1.846	1.850	1.122	1.080	0.0589	1.171	1.265
2016	1.729	1.386	1.027	1.025	0.0615	1.130	1.158

Appendix K. DIAGNOSTICS AND SUPPORTING ANALYSES FOR COOKST(FLA)

K.1 Introduction

This CPUE analysis is a new analysis intended to include information from the northwestern part of Cook Strait and is presented as a sensitivity analysis to the TBGB(FLA) series, with the only difference being the addition of two statistical areas with catch from the Lower Taranaki Bight. This analysis was not accepted for monitoring GUR 7 in 2017.

K.2 Fishery definition

COOKST(FLA): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 017, 037, 038, 039, 040 and declaring target species FLA.

K.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 54 vessels which took 74% of the catch (Figure K.1).

K.3.1 Data summary

Table K.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 10 trips per year in 5 years) in the COOKST(FLA) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.

| Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	23	619	1 155	1 201	1.04	4 087	8 897	90.77	93.1	4.51	1.47
1991	25	393	789	798	1.01	2 720	6 054	36.07	92.1	6.91	1.69
1992	25	521	1 080	1 096	1.01	3 645	8 475	69.68	93.5	6.37	1.35
1993	32	871	1 651	1 691	1.02	6 070	13 944	112.95	90.0	8.67	3.81
1994	35	805	1 659	1 690	1.02	5 640	12 268	100.00	89.2	7.38	1.35
1995	35	805	1 592	1 637	1.03	5 446	11 360	61.94	78.5	16.93	3.52
1996	32	776	1 635	1 729	1.06	5 415	11 608	52.88	76.4	16.53	5.84
1997	31	879	1 999	2 100	1.05	6 920	16 658	72.14	77.6	10.12	3.24
1998	31	746	1 952	2 073	1.06	6 530	16 240	65.96	82.0	15.20	4.02
1999	28	562	1 310	1 388	1.06	4 512	10 168	38.36	68.2	13.32	3.47
2000	22	482	1 147	1 241	1.08	4 207	9 649	98.05	72.2	3.74	0.29
2001	20	319	814	832	1.02	2 631	7 427	72.58	95.6	4.92	1.20
2002	21	450	1 117	1 121	1.00	3 434	10 418	84.83	90.7	2.94	1.59
2003	25	481	1 130	1 137	1.01	3 338	10 207	87.59	84.0	5.20	1.46
2004	30	555	1 524	1 527	1.00	4 580	14 421	120.30	96.2	2.43	0.76
2005	28	590	1 763	1 777	1.01	5 113	15 698	118.54	92.9	1.28	0.22
2006	25	565	1 582	1 596	1.01	4 441	14 203	113.31	95.0	0.93	0.10
2007	31	751	2 021	2 032	1.01	5 742	17 903	157.43	94.3	2.12	0.10
2008	27	529	1 450	3 757	2.59	3 893	11 753	93.22	99.2	3.24	0.39
2009	27	488	1 368	3 549	2.59	3 636	10 697	106.86	92.8	3.97	1.05
2010	27	584	1 648	4 592	2.79	4 592	12 899	131.42	97.8	2.63	0.41
2011	25	408	1 099	2 945	2.68	2 945	8 470	101.79	98.5	4.23	0.56
2012	25	434	1 173	3 211	2.74	3 211	8 978	113.17	99.1	2.33	0.23
2013	21	440	1 158	3 147	2.72	3 147	8 840	113.70	99.1	1.83	0.26
2014	21	333	876	2 366	2.70	2 366	6 928	110.54	99.4	0.91	0.04
2015	16	324	898	2 443	2.72	2 443	7 566	113.12	99.1	0.62	0.04
2016	15	393	1 139	2 808	2.47	2 808	9 319	142.96	98.7	0.52	0.09

K.3.2 Core vessel selection
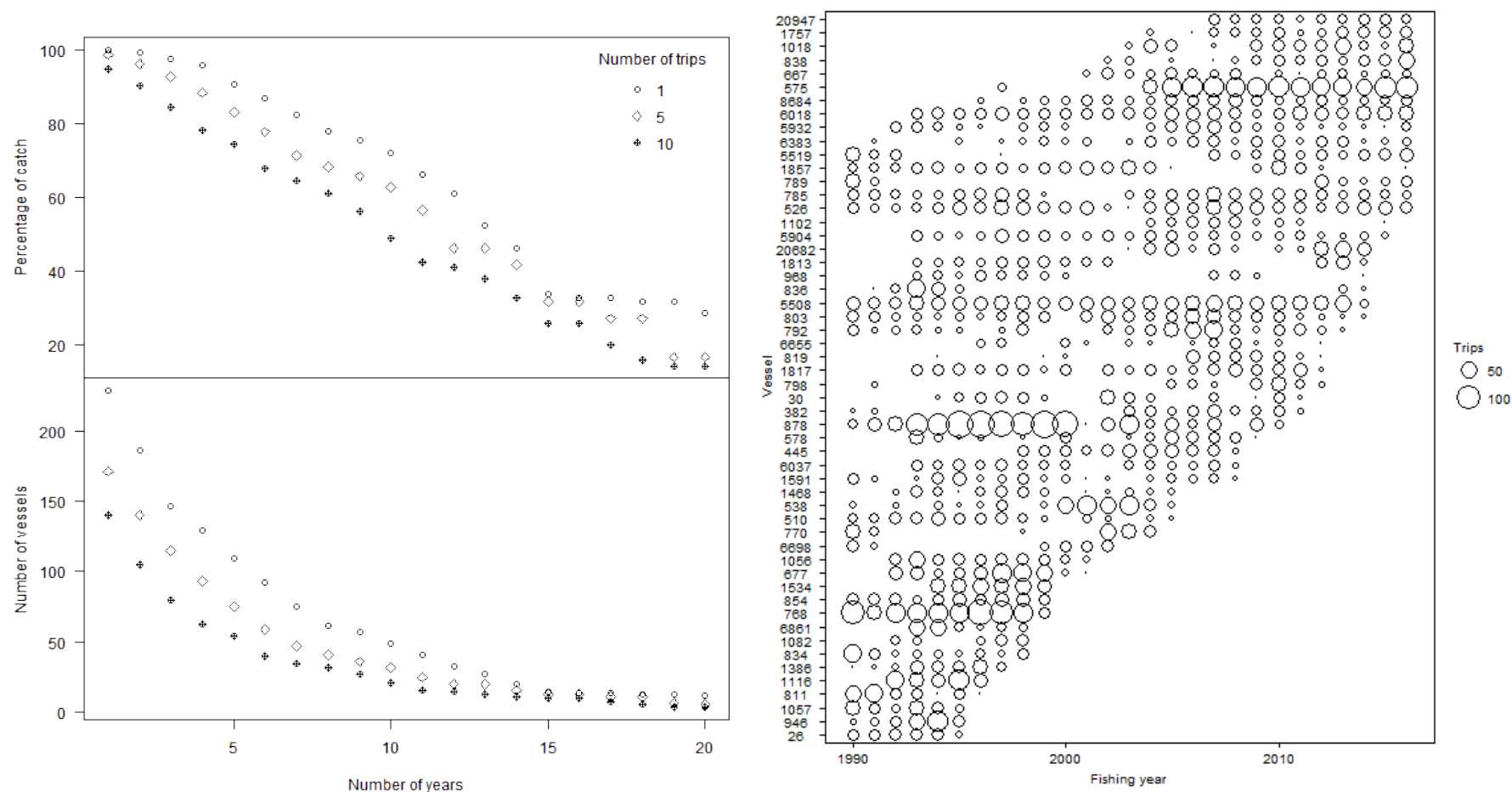
Figure K.1: [left panel] total landed gurnard and number of vessels plotted against the number of years used to define core vessels participating in the COOKST(FLA) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 5 or more fishing years) by fishing year.

K.3.3   Exploratory data plots for core vessel data set
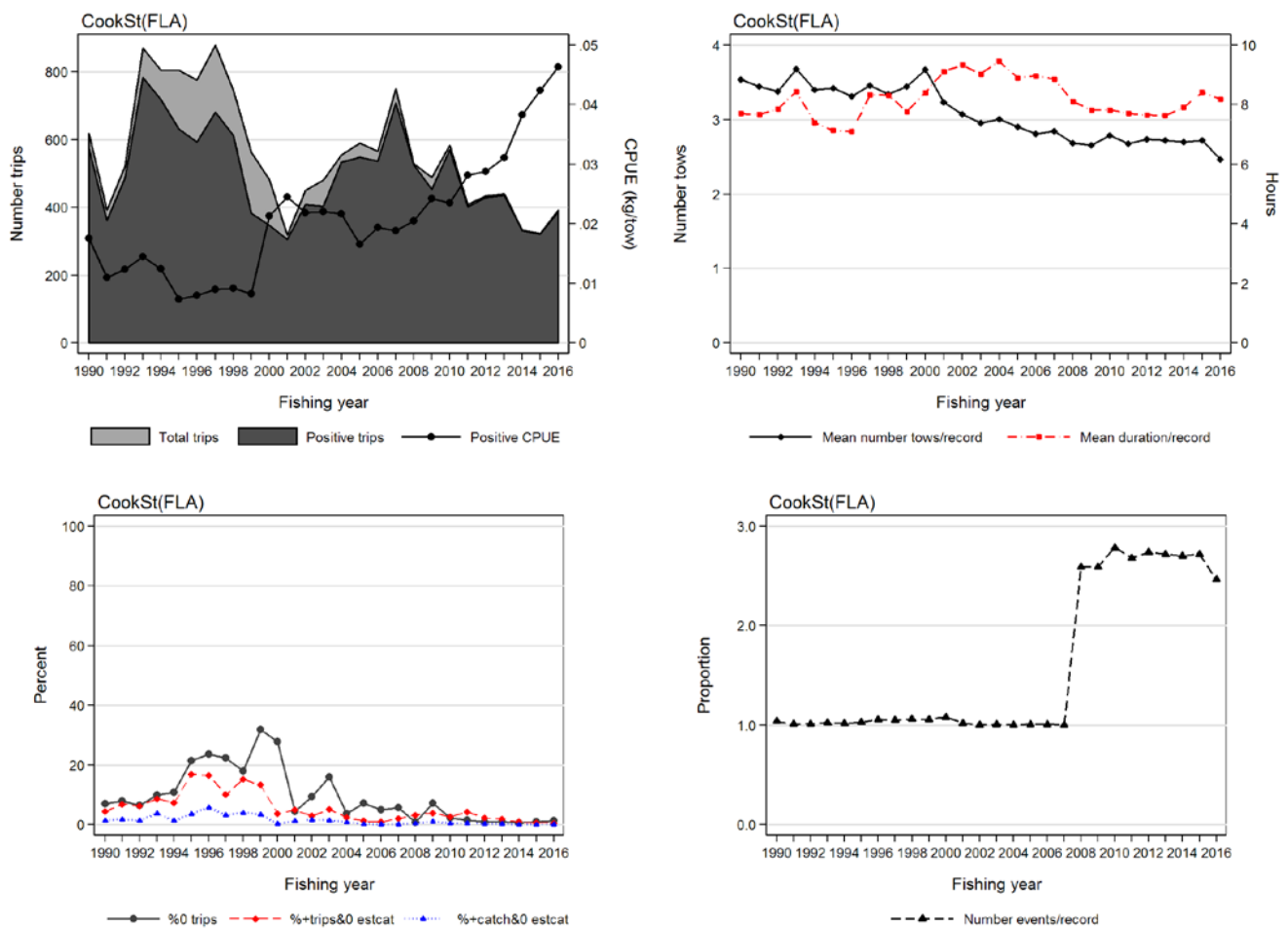
Figure K.2:   **Core vessel summary plots by fishing year for model COOKST(FLA): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips i with positive catch: $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i}\right)$;**

[upper right panel]: mean number of sets and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of gurnard; b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.

K.4 Positive catch model selection table

Two explanatory variables entered the model after fishing year (Table K.2), with month, duration fishing and area non-significant. A plot of the model is provided in Figure K.3 and the CPUE indices are listed in Table K.4.

Table K.2: Order of acceptance of variables into the lognormal model of successful catches in the CookSt(FLA) fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-167 812	335 680	11.73	*
vessel	81	-163 300	326 762	33.95	*
poly(log(tows), 3)	84	-161 027	322 222	**42.93**	*
month	95	-160 821	321 831	43.68	
poly(log(duration), 3)	98	-160 647	321 491	44.31	
area	102	-160 551	321 305	44.65	

CookSt(FLA)

Standardised index error bars=+/- 1.96*SE
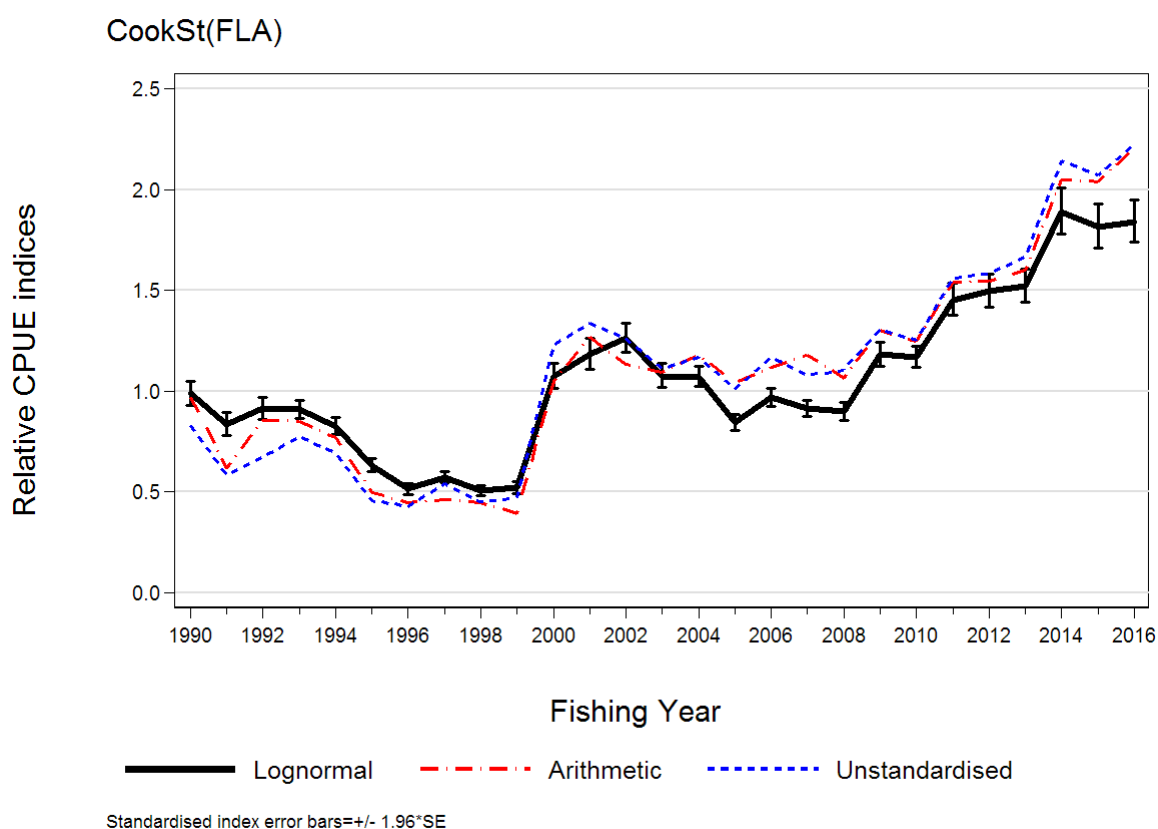
Figure K.3: Relative CPUE indices for gurnard using the lognormal non-zero model based on the CookSt(FLA) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).
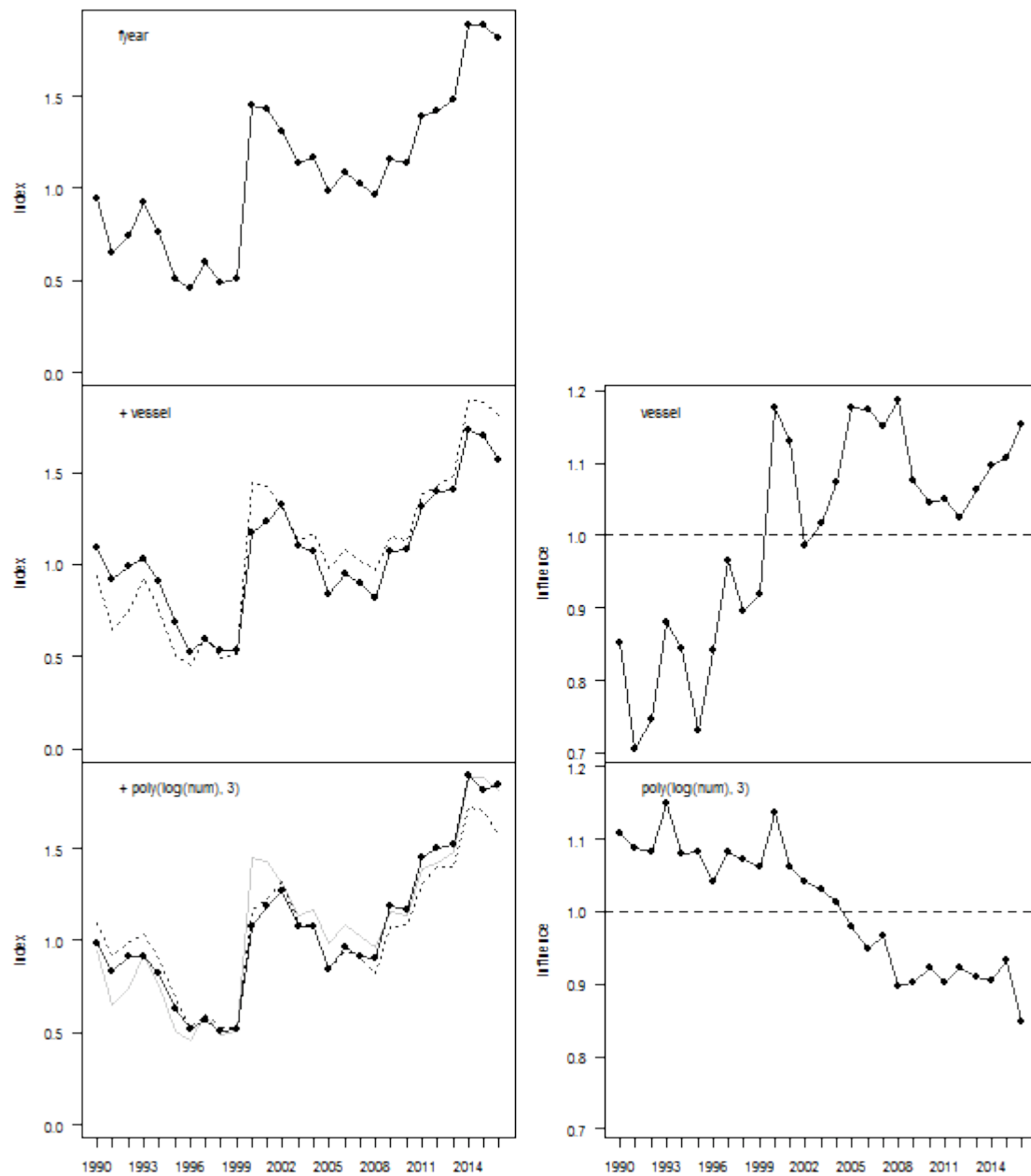
Figure K.4: [left column]: annual indices from the lognormal model of CookSt(FLA) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.
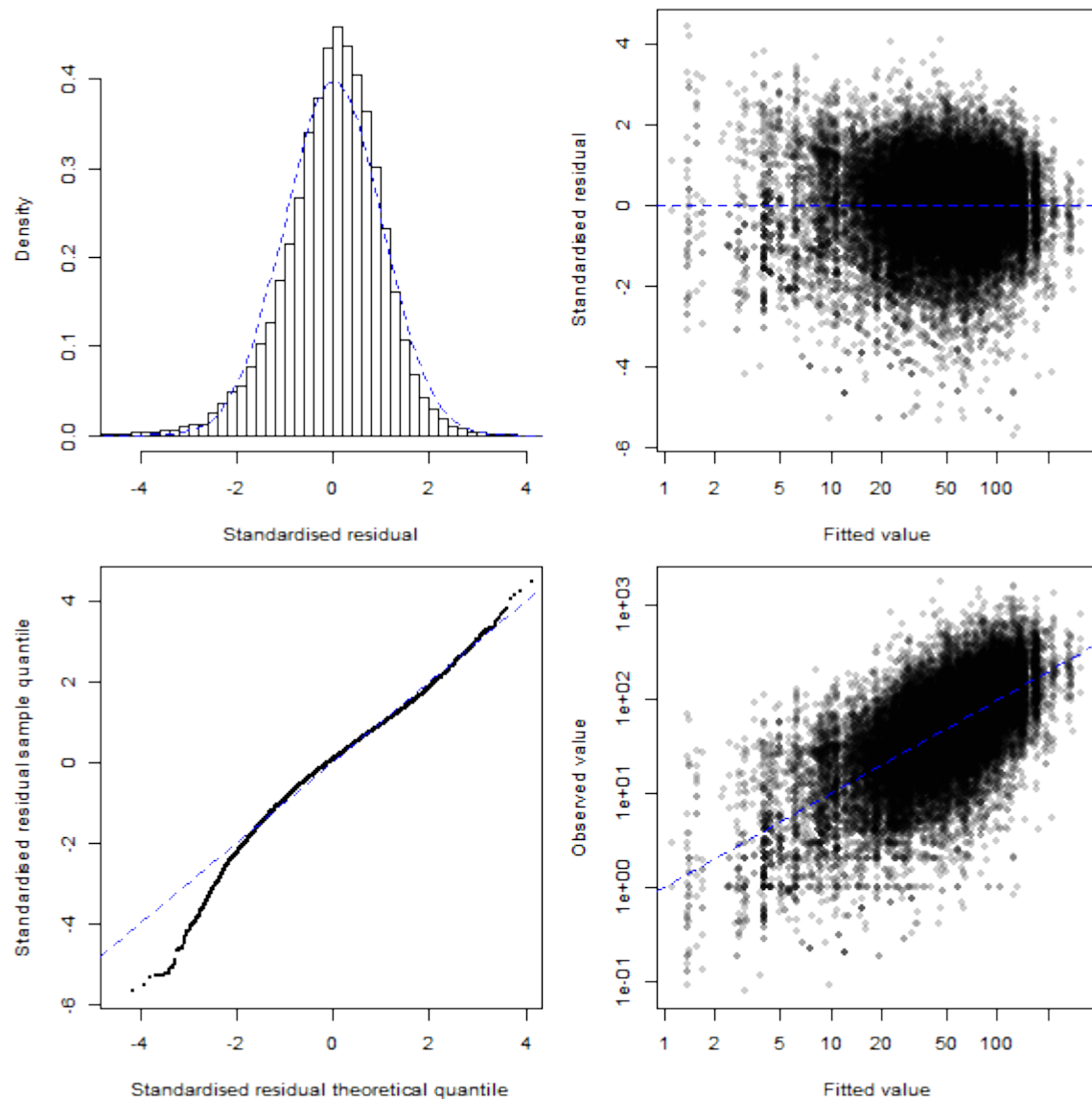
K.4.1 Residual and diagnostic plots

Figure K.5: **Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the COOKST(FLA) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.**

K.4.2 Model coefficients
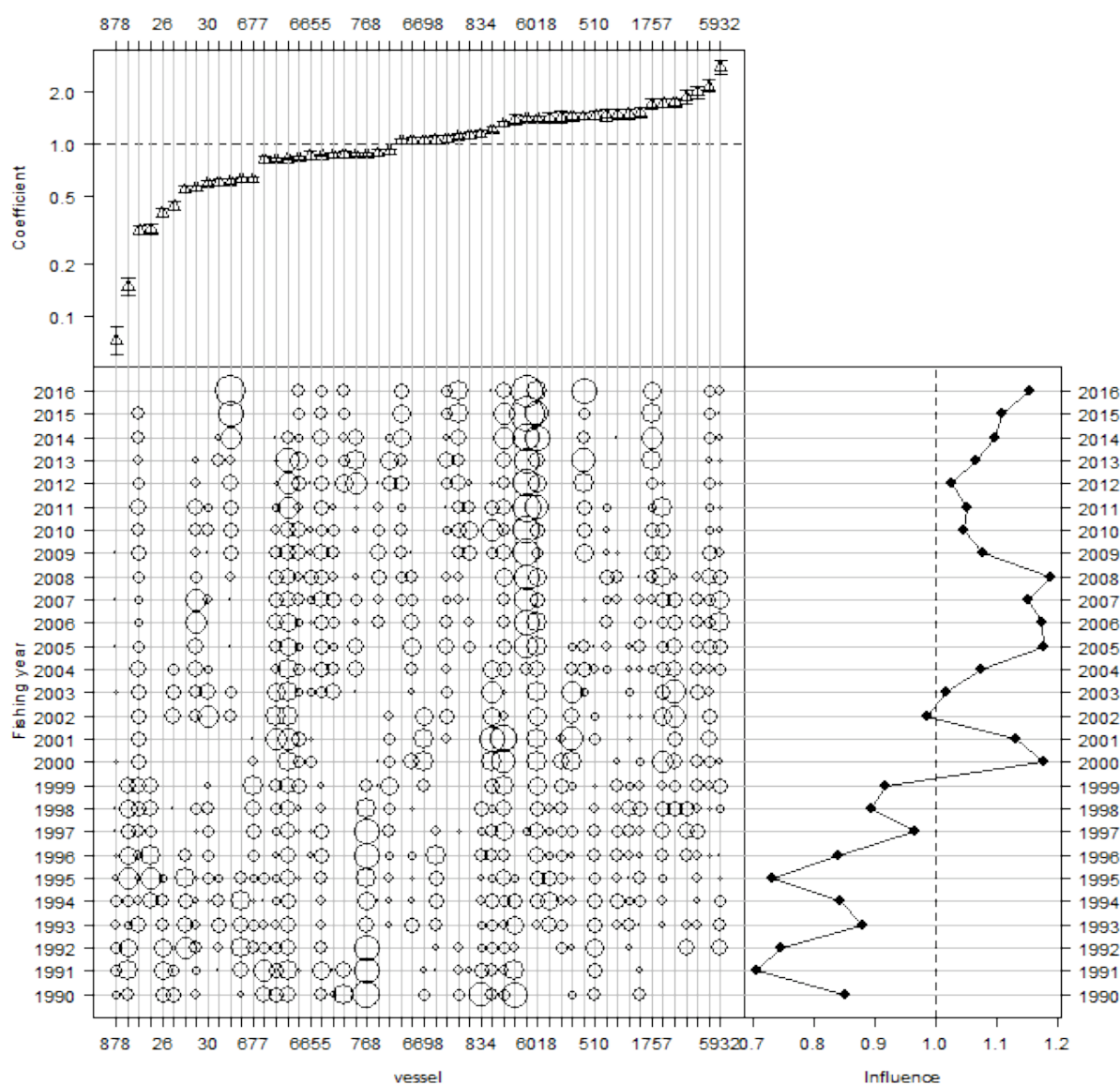
Figure K.6: **Effect of vessel in the lognormal model for the gurnard COOKST(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
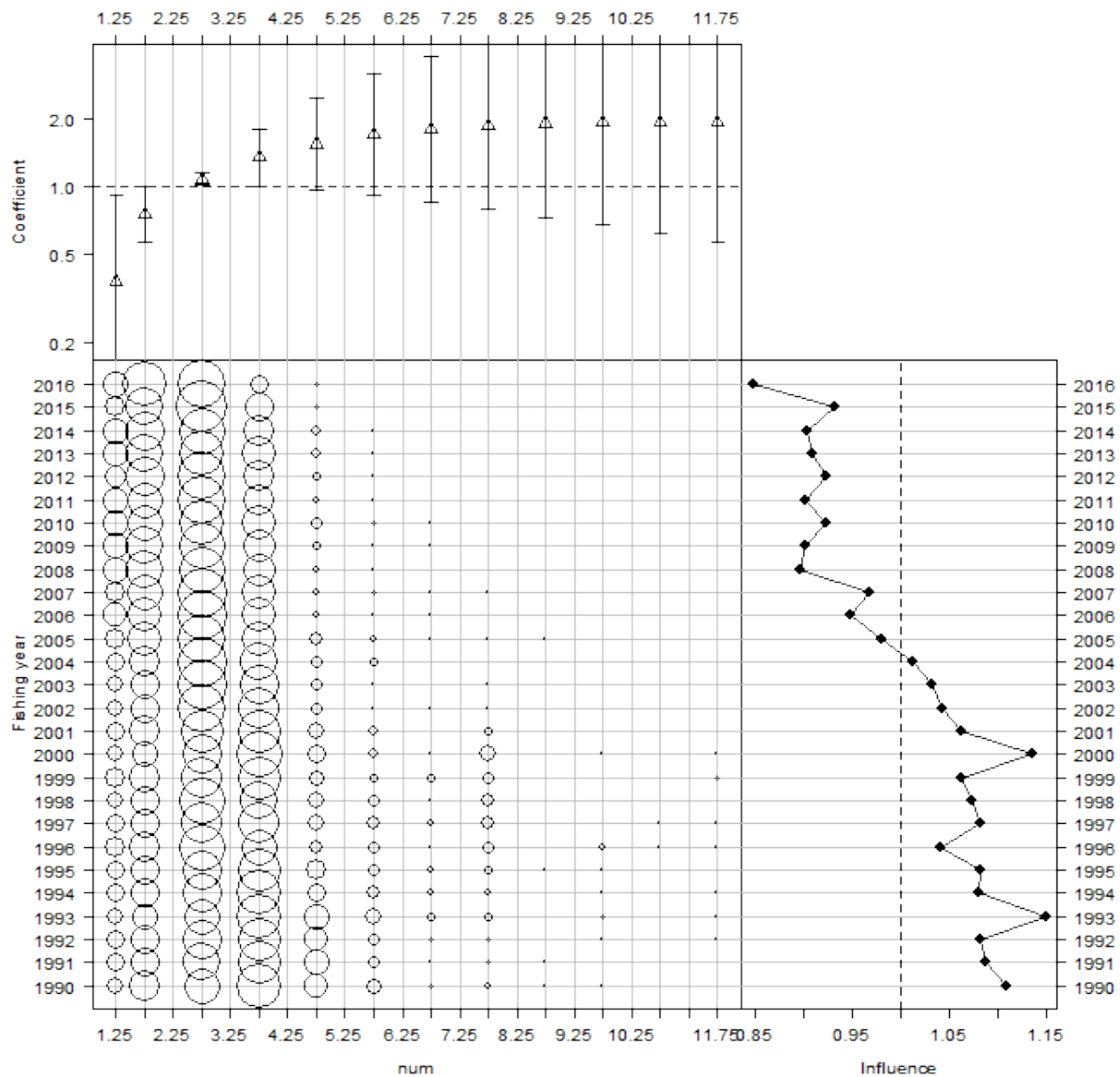
Figure K.7: Effect of tows in the lognormal model for the gurnard COOKST(FLA) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
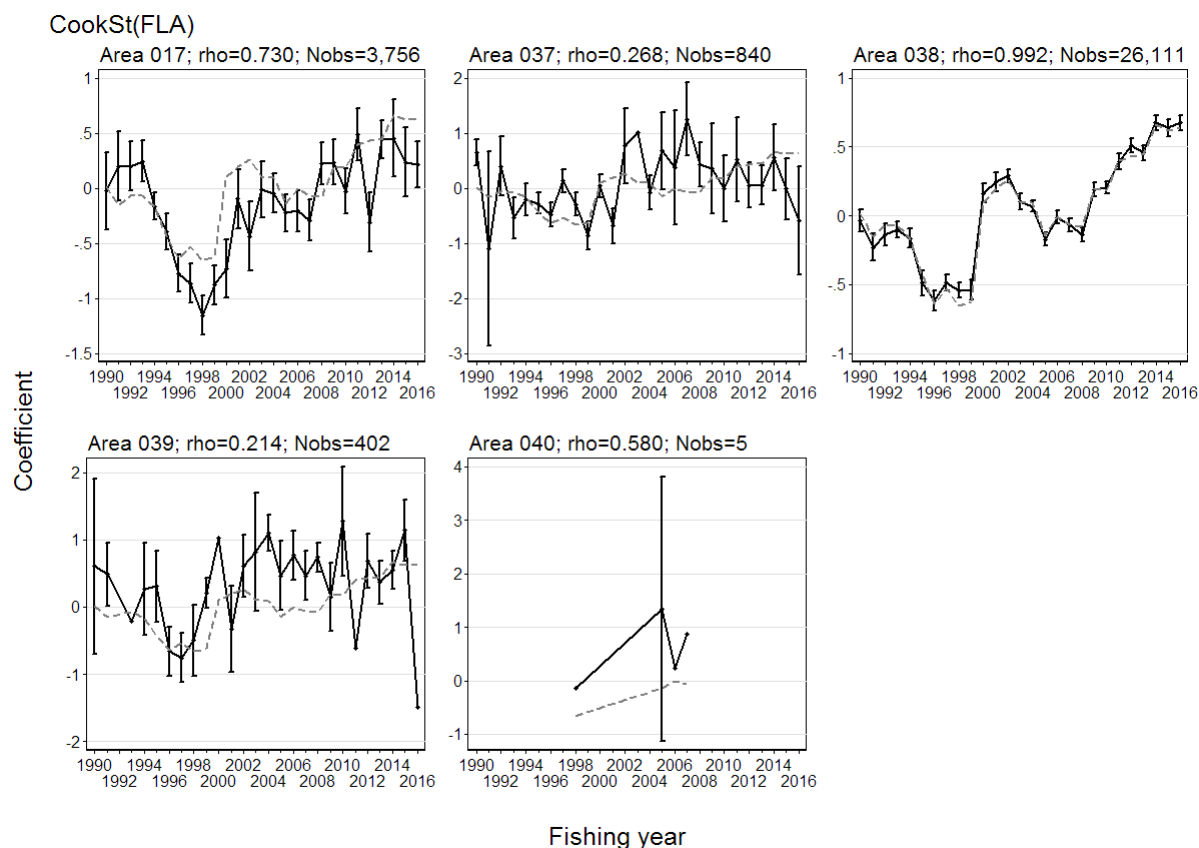
CookSt(FLA)

Figure K.8: **Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model and note that area was not accepted into the lognormal model – see Table K.2) in the gurnard COOKST(FLA) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.**

K.4.3 Logistic (binomial) model selection table

Two explanatory variables entered the model after fishing year (Table K.3), with number tows, duration fished and month non-significant. A plot of the binomial model and the combined delta-lognormal model is provided in Figure K.9 and the CPUE indices are listed in Table K.4.

Table K.3: Order of acceptance of variables into the binomial (logistic) model of presence/absence of gurnard catches in the COOKST(FLA) fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

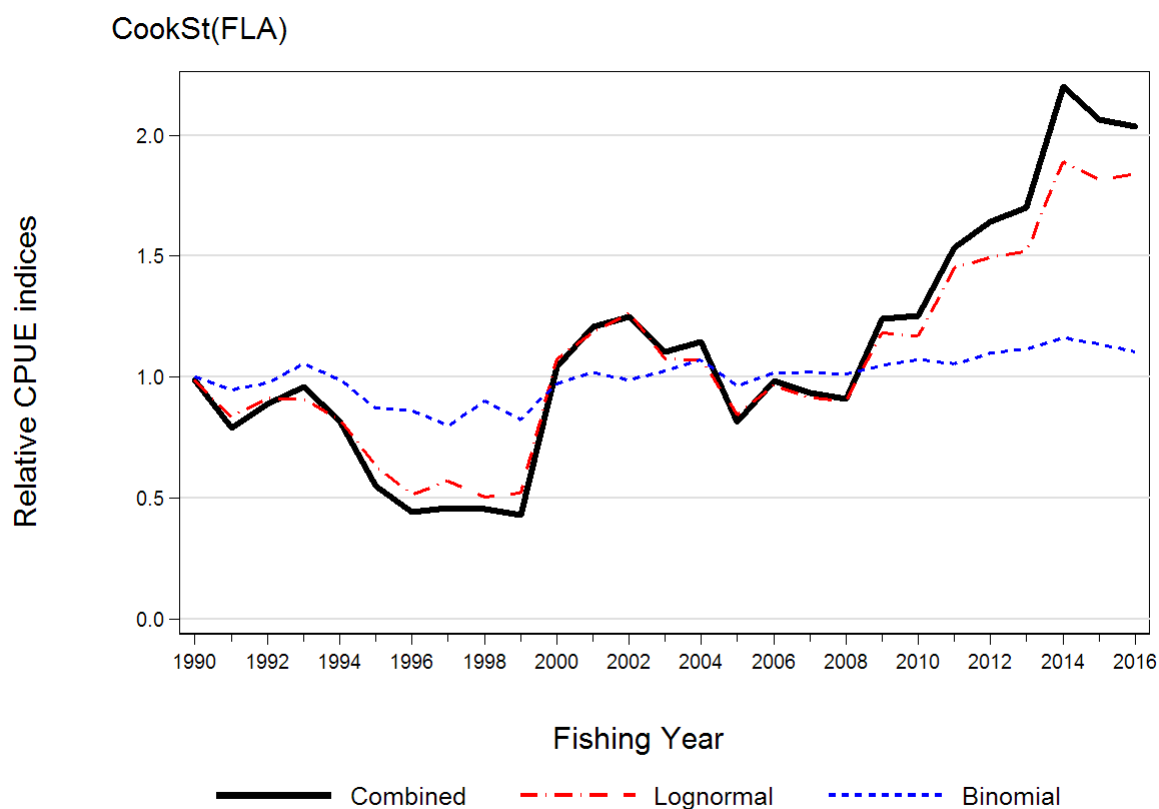| Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-14 560	29 174	9.69	*
vessel	80	-12 186	24 532	29.71	*
area	84	-12 022	24 212	**30.99**	*
poly(log(tows), 3)	87	-11 896	23 966	31.98	
poly(log(duration), 3)	90	-11 883	23 946	32.08	
month	101	-11 866	23 933	32.21	

Figure K.9: Relative CPUE indices for gurnard using the lognormal non-zero model based on the COOKST(FLA) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure (Eq. F.4).

K.4.4 CPUE indices

Table K.4: **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard CookSt(FLA) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Core vessels Combined
1990	0.897	0.971	0.829	0.988	0.0299	1.002	0.989
1991	0.686	0.618	0.584	0.836	0.0361	0.948	0.792
1992	0.934	0.854	0.674	0.913	0.0310	0.976	0.891
1993	0.815	0.852	0.774	0.908	0.0250	1.055	0.958
1994	0.848	0.770	0.692	0.826	0.0258	0.991	0.819
1995	0.598	0.498	0.457	0.632	0.0275	0.872	0.551
1996	0.475	0.445	0.429	0.514	0.0266	0.863	0.444
1997	0.435	0.464	0.542	0.573	0.0244	0.799	0.457
1998	0.521	0.448	0.450	0.505	0.0239	0.902	0.456
1999	0.409	0.394	0.470	0.520	0.0302	0.824	0.428
2000	0.943	1.049	1.229	1.075	0.0298	0.971	1.044
2001	1.009	1.268	1.338	1.185	0.0329	1.019	1.207
2002	1.127	1.133	1.261	1.265	0.0292	0.989	1.251
2003	0.977	1.094	1.112	1.075	0.0286	1.025	1.102
2004	1.094	1.179	1.169	1.071	0.0238	1.071	1.147
2005	1.007	1.044	1.011	0.845	0.0233	0.963	0.813
2006	1.109	1.117	1.168	0.967	0.0241	1.017	0.984
2007	1.336	1.181	1.080	0.914	0.0215	1.020	0.933
2008	1.074	1.066	1.104	0.900	0.0251	1.011	0.910
2009	1.600	1.305	1.308	1.184	0.0259	1.048	1.241
2010	1.256	1.246	1.253	1.169	0.0234	1.074	1.255
2011	1.449	1.540	1.562	1.454	0.0280	1.055	1.533
2012	1.474	1.548	1.584	1.497	0.0274	1.098	1.644
2013	1.471	1.603	1.666	1.523	0.0275	1.117	1.701
2014	1.911	2.052	2.144	1.892	0.0306	1.163	2.199
2015	1.979	2.038	2.074	1.816	0.0308	1.136	2.063
2016	2.179	2.207	2.224	1.842	0.0286	1.106	2.037

Appendix L. DIAGNOSTICS AND SUPPORTING ANALYSES FOR COOKST(MIX)

L.1 Introduction
This CPUE analysis is a new analysis intended to include information from the northwestern part of Cook Strait, and is presented as a sensitivity analysis to the TBGB(MIX) series. This analysis was not accepted for monitoring GUR 7 in 2017.

L.2 Fishery definition
COOKST(MIX): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 017, 037, 038, 039, 040 and declaring target species GUR, BAR, TAR, TRE, WAR, SNA.

L.3 Core vessel selection
The criteria used to define the core fleet were those vessels that had fished for at least 5 trips in each of at least 5 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 38 vessels which took 82% of the catch (Figure L.1).

L.3.1 Data summary

Table L.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, tows, hours fished, landed GUR (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 5 trips per year in 5 years) in the COOKST (MIX) fishery. Final two columns apply to trips which declared no estimated catch of gurnard but reported GUR landings, giving the proportion of these trips relative to trips which reported GUR and the proportion of the reported catch from these trips relative to the total annual GUR reported catch.

| Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	15	148	324	331	1.02	1 058	2 699	34.23	91.2	10.4	4.04
1991	18	275	629	639	1.02	1 864	5 255	62.12	86.9	15.5	2.12
1992	20	268	597	696	1.17	1 667	5 200	83.09	83.2	20.2	5.93
1993	19	253	618	723	1.17	1 849	5 637	62.64	80.6	13.7	3.53
1994	19	198	484	543	1.12	1 536	4 185	57.42	86.9	23.3	8.21
1995	23	233	586	742	1.27	1 732	5 270	119.66	87.1	19.7	5.53
1996	22	209	611	748	1.22	1 819	5 774	63.65	75.1	24.2	4.51
1997	22	326	742	900	1.21	2 269	6 865	62.76	62.0	31.2	7.43
1998	23	242	552	784	1.42	1 572	4 999	89.11	70.3	29.4	1.68
1999	24	325	701	838	1.20	2 064	6 401	61.54	63.1	22.0	4.08
2000	20	322	826	988	1.20	2 602	8 247	84.41	81.4	22.9	2.70
2001	24	305	837	1 056	1.26	2 650	9 243	147.49	83.0	18.2	0.73
2002	23	289	769	1 049	1.36	2 273	8 040	164.51	84.4	11.9	0.60
2003	21	291	875	1 036	1.18	2 612	9 222	176.30	85.6	11.7	1.62
2004	27	353	998	1 257	1.26	2 710	9 720	214.55	79.9	8.9	0.76
2005	21	301	814	1 012	1.24	2 176	7 857	181.20	80.4	7.0	0.48
2006	23	258	645	953	1.48	1 766	6 329	181.23	78.7	12.3	0.52
2007	22	285	639	896	1.40	1 816	5 897	174.92	76.1	14.8	0.55
2008	22	241	615	1 645	2.67	1 650	5 672	107.69	83.4	9.5	1.40
2009	16	240	565	1 487	2.63	1 487	5 265	97.93	77.5	11.3	0.75
2010	21	299	705	1 896	2.69	1 896	6 264	136.16	78.9	8.5	0.41
2011	22	289	737	2 154	2.92	2 154	6 910	153.06	81.7	14.0	0.54
2012	23	321	877	2 480	2.83	2 480	8 664	153.27	83.5	13.4	0.77
2013	23	340	829	2 330	2.81	2 330	7 860	137.11	83.8	20.4	0.88
2014	22	326	802	2 148	2.68	2 148	7 252	127.53	81.9	14.6	0.90
2015	21	299	722	1 919	2.66	1 919	6 032	157.11	81.9	18.0	0.52
2016	23	324	758	2 089	2.76	2 089	6 773	131.95	77.2	25.6	0.96

L.3.2   Core vessel selection
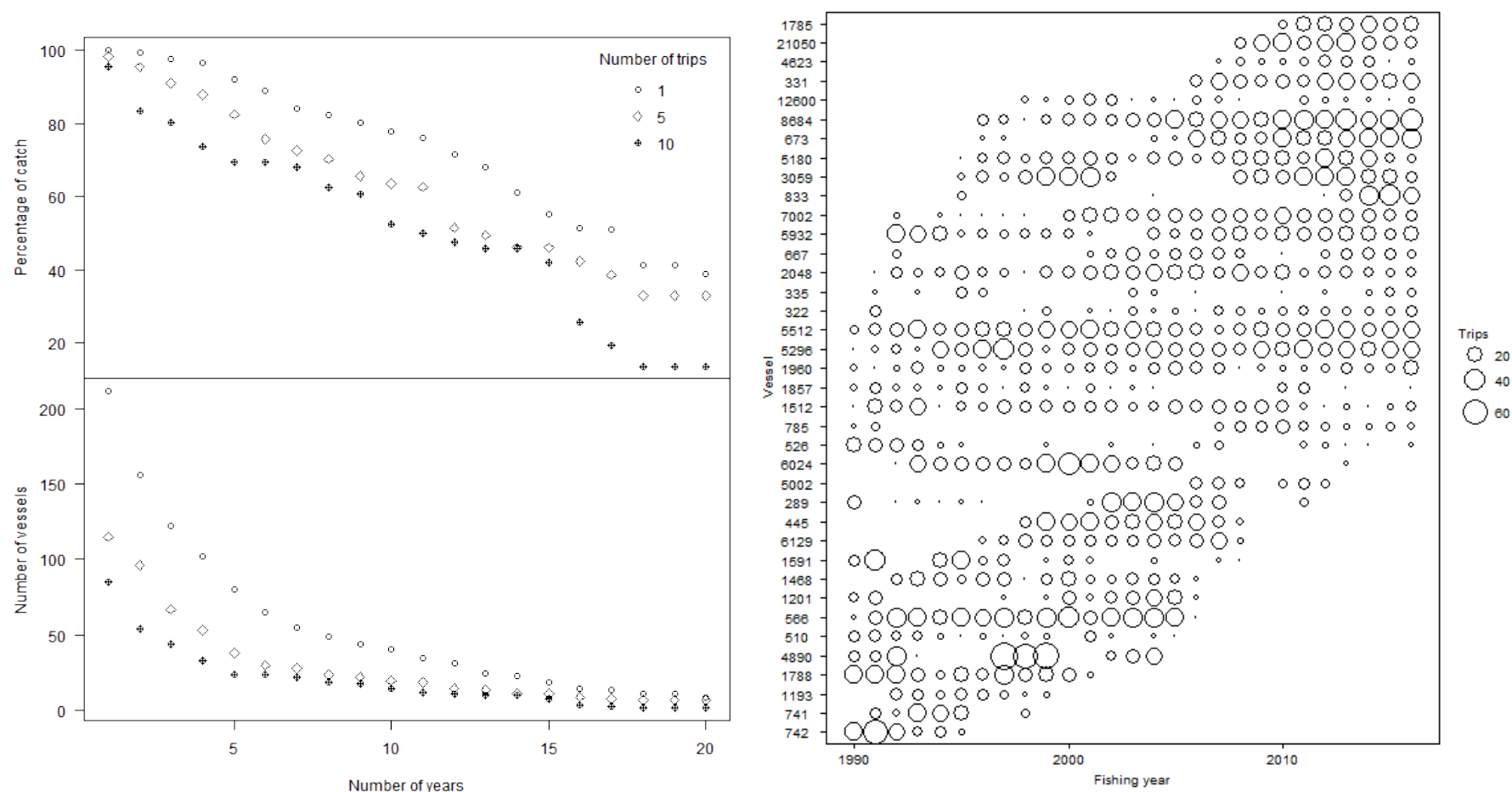
Figure L.1: [left panel] total landed gurnard and number of vessels plotted against the number of years used to define core vessels participating in the COOKST(MIX) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 5 trips in 5 or more fishing years) by fishing year.

L.3.3   Exploratory data plots for core vessel data set
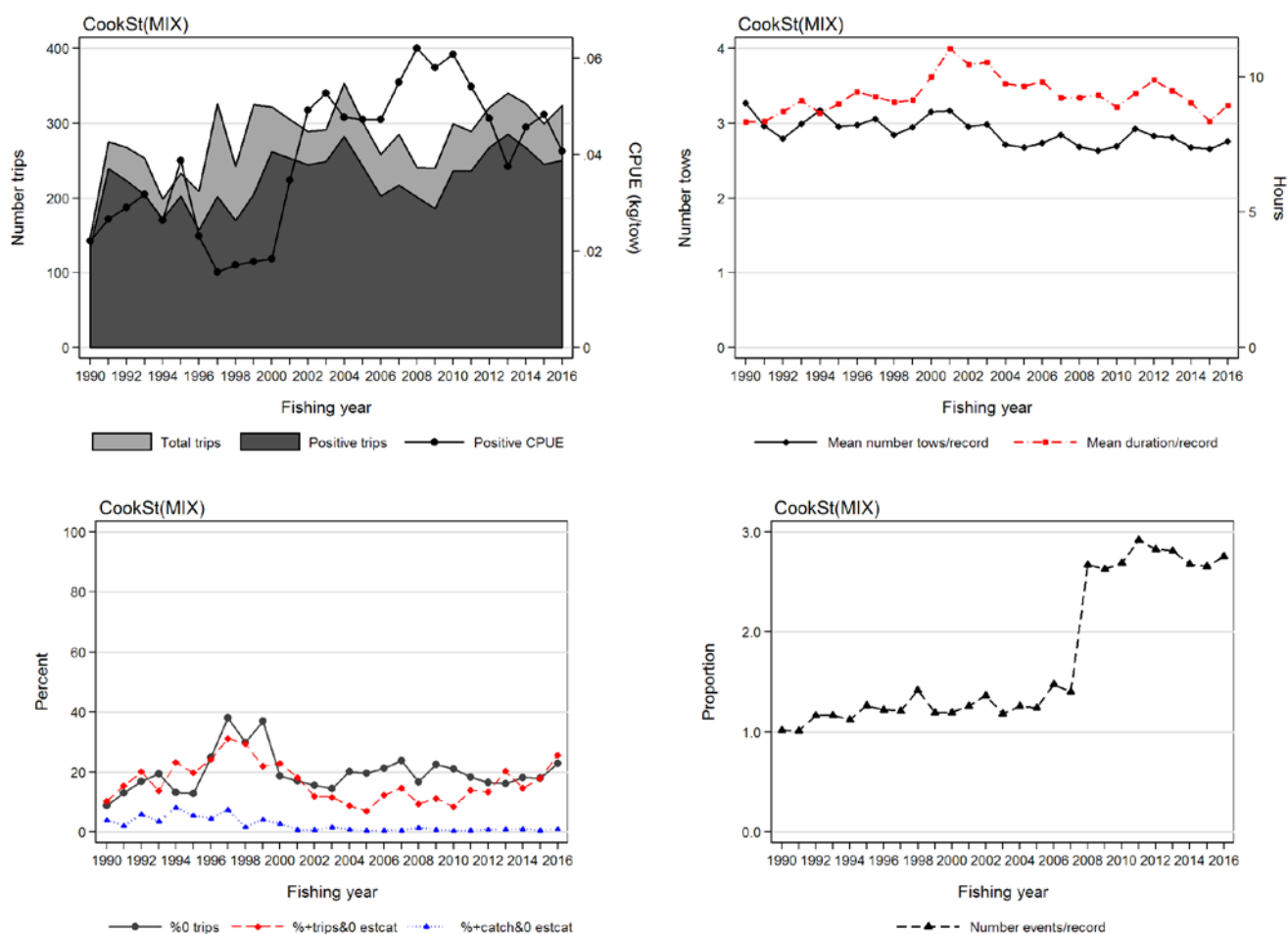
Figure L.2: **Core vessel summary plots by fishing year for model CookSt(MIX): [upper left panel]: total trips (light grey) and trips with gurnard catch (dark grey) overlaid with median annual arithmetic CPUE (kg/set) for all trips i with positive catch: $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i}\right)$;**

[upper right panel]: mean number of sets and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of gurnard; b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.

L.4 Positive catch model selection table

Four explanatory variables entered the model after fishing year (Table L.2), with month and number tows non-significant. A plot of the model is provided in Figure L.3 and the CPUE indices are listed in Table L.4.

Table L.2: **Order of acceptance of variables into the lognormal model of successful catches in the COOKST(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-85 290	170 635	3.05	*
area	32	-83 774	167 613	22.97	*
target	37	-82 553	165 179	36.00	*
vessel	74	-81 733	163 614	43.49	*
poly(log(duration), 3)	77	-81 081	162 317	**48.81**	*
month	88	-81 044	162 263	49.10	
poly(log(tows), 3)	91	-81 038	162 258	49.14	
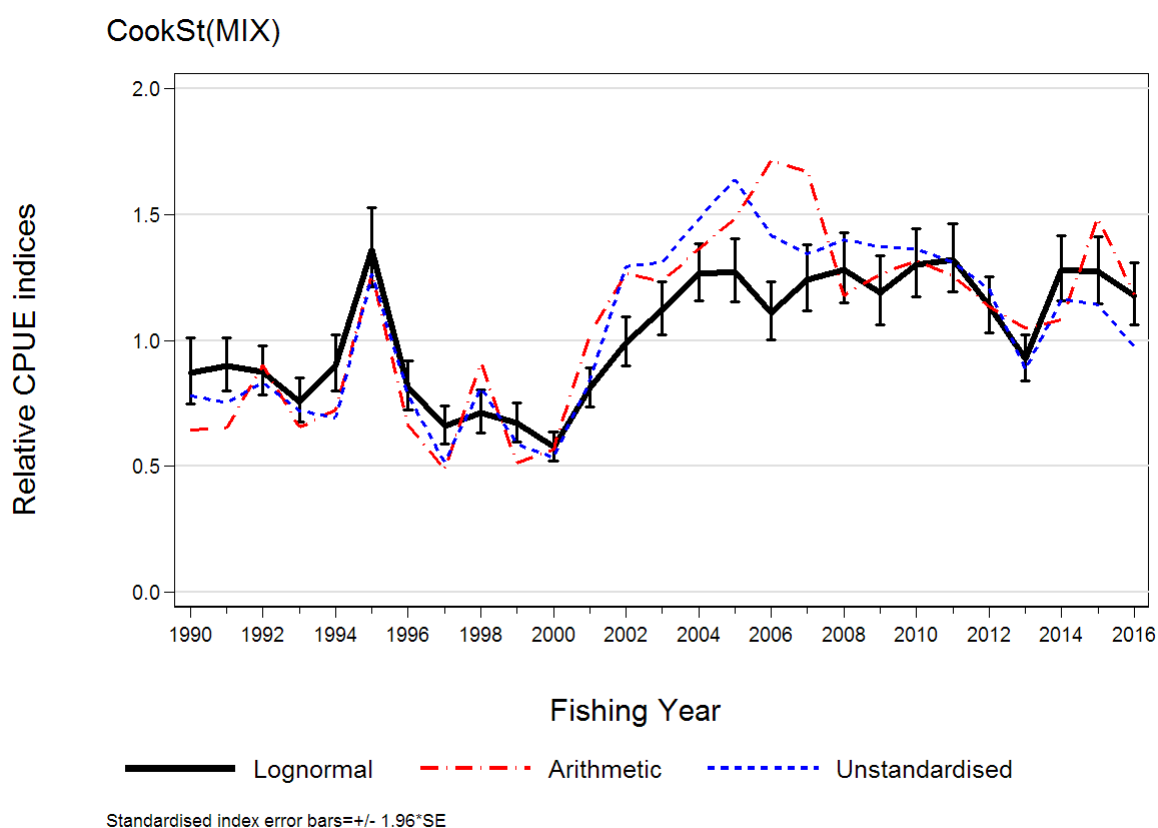
Figure L.3: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the COOKST(MIX) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. F.1) and b) Unstandardised (Eq. F.2).**
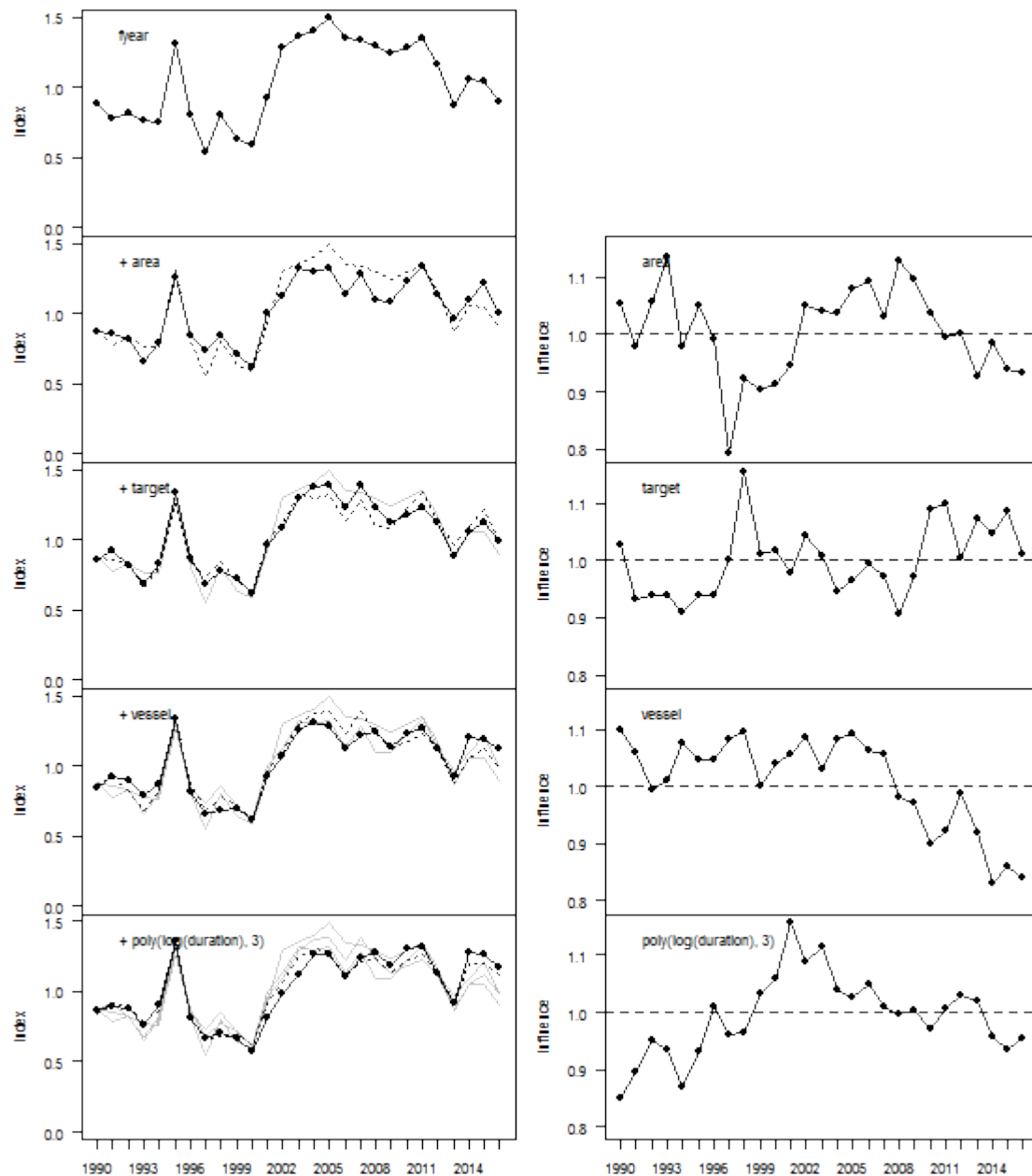
Figure L.4: [left column]: annual indices from the lognormal model of CookSt(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

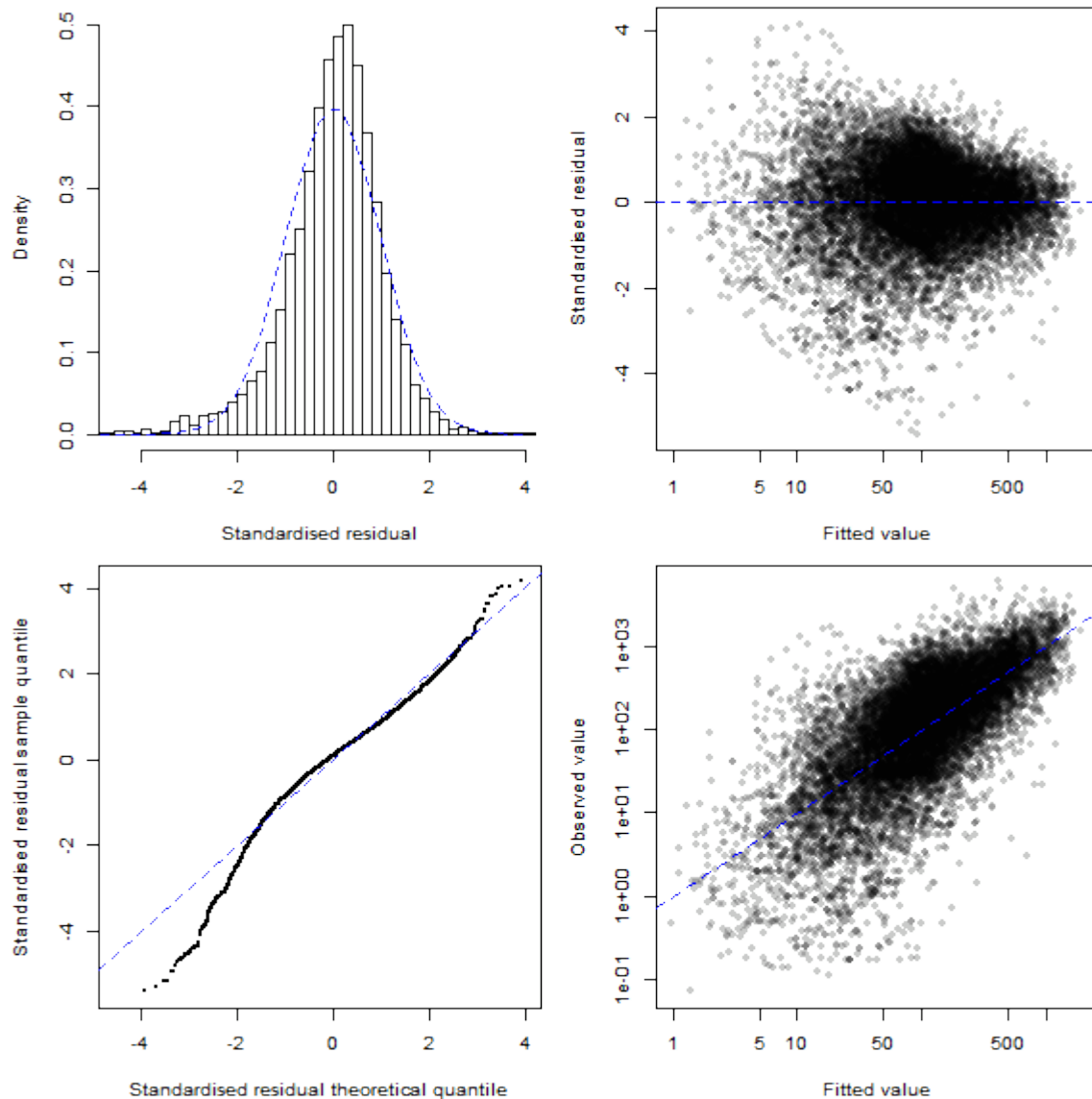## L.4.1   Residual and diagnostic plots

Figure L.5:   **Plots of the fit of the lognormal standardised CPUE model of successful catches of gurnard in the COOKST(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.**

L.4.2 Model coefficients
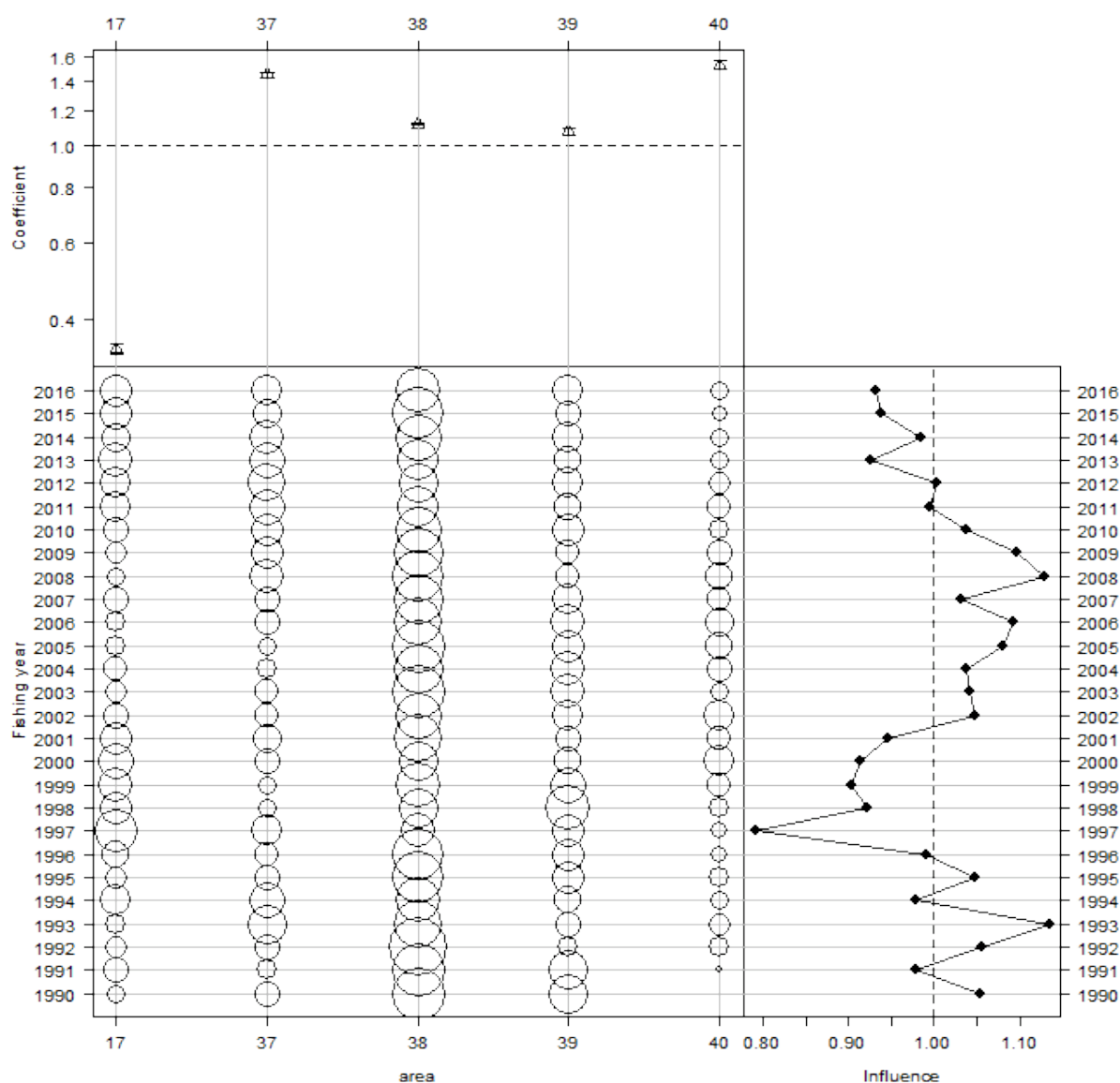
Figure L.6: **Effect of statistical area in the lognormal model for the gurnard COOKST(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
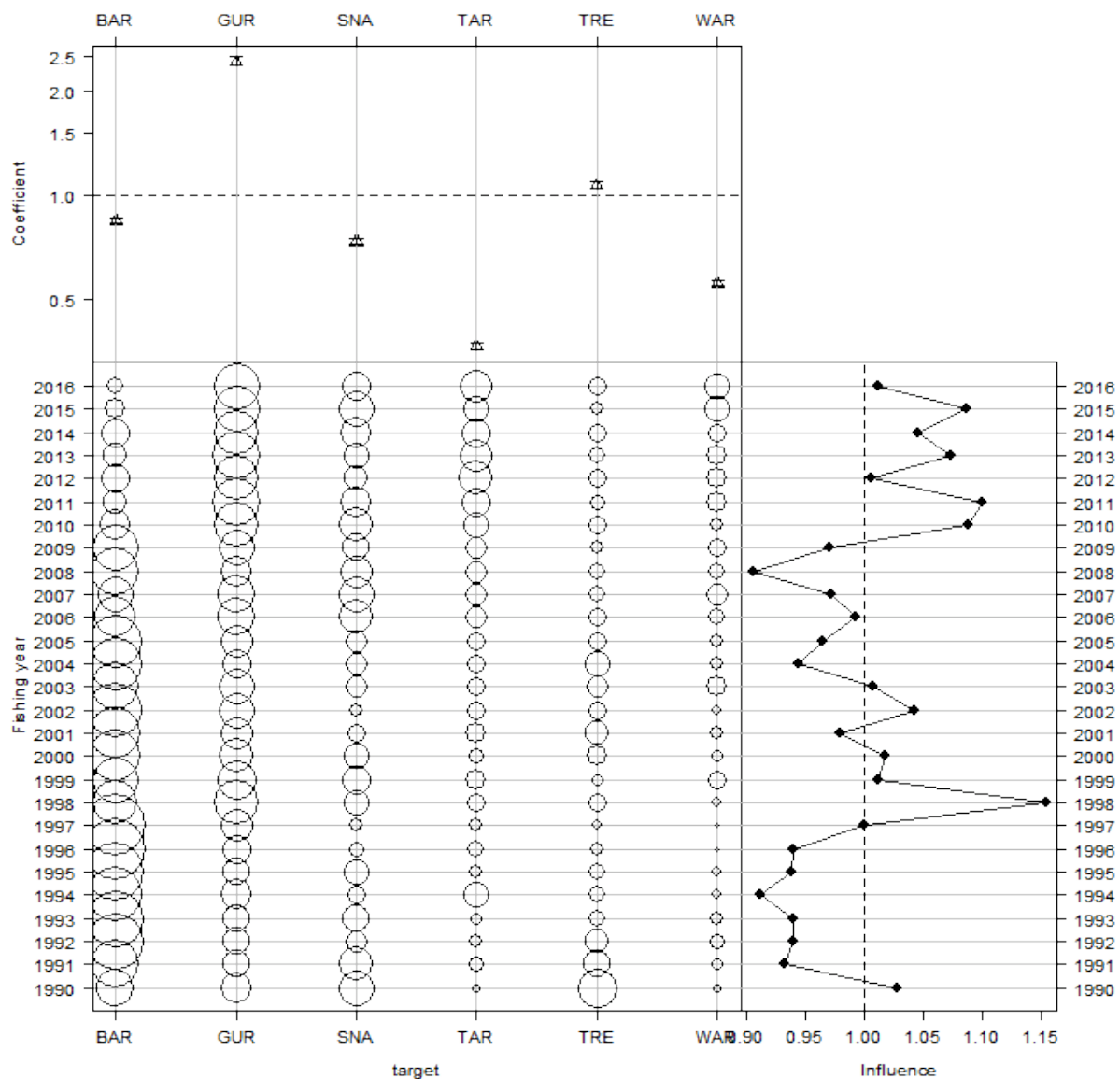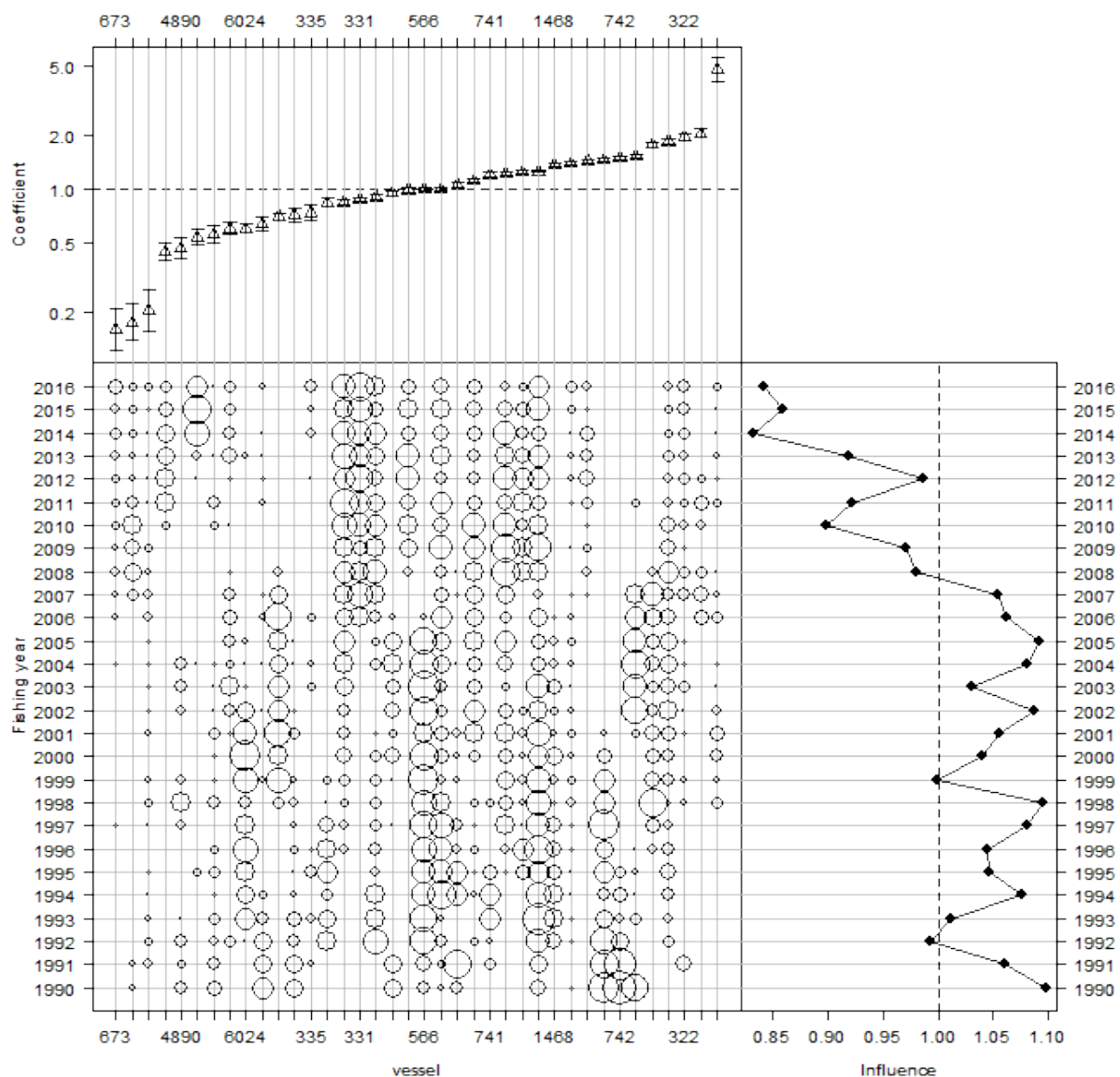
Figure L.7: Effect of target species in the lognormal model for the gurnard COOKST(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

Figure L.8: Effect of vessel in the lognormal model for the gurnard COOKST(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).
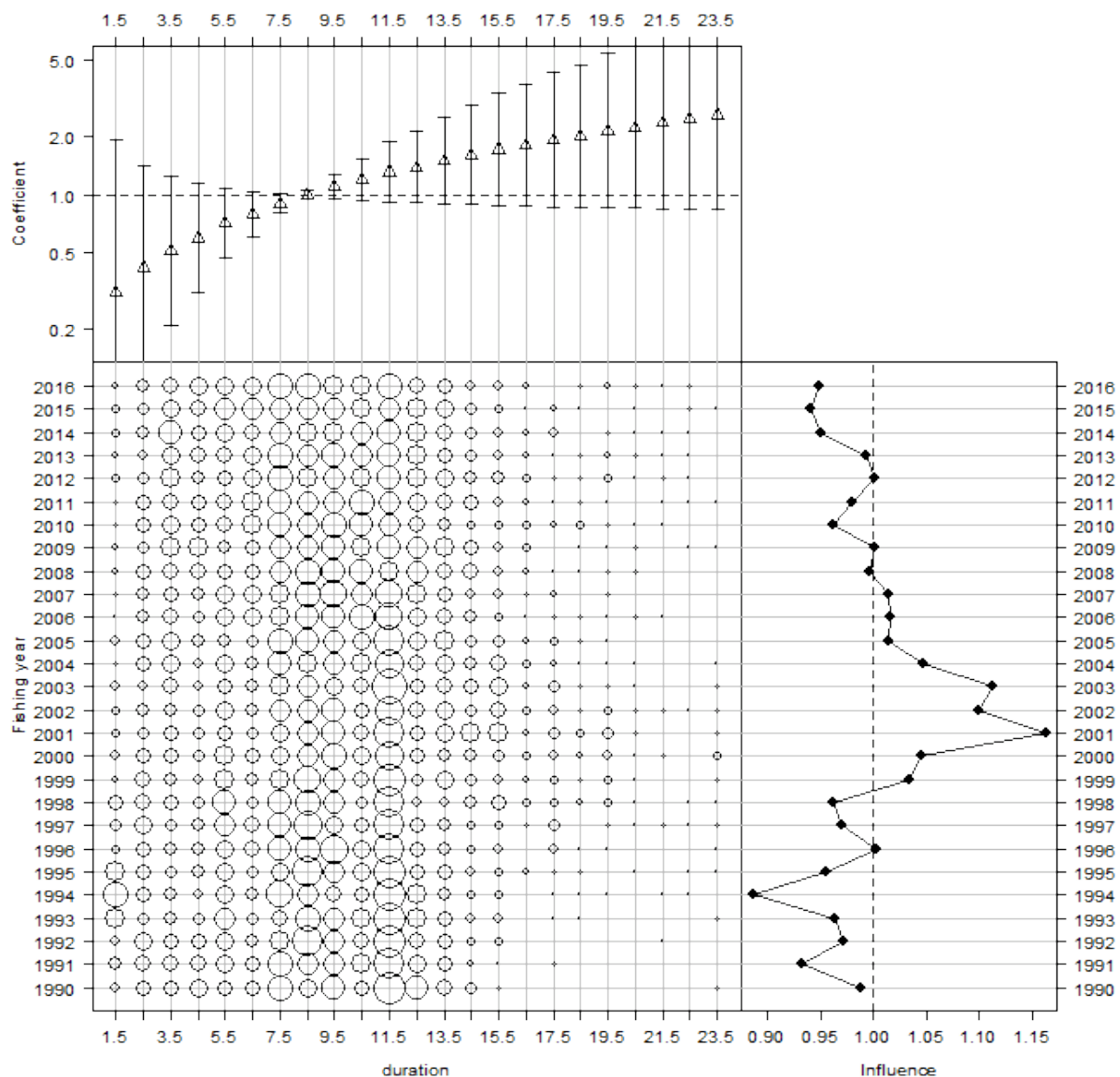
Figure L.9: **Effect of duration in the lognormal model for the gurnard COOKST(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).**
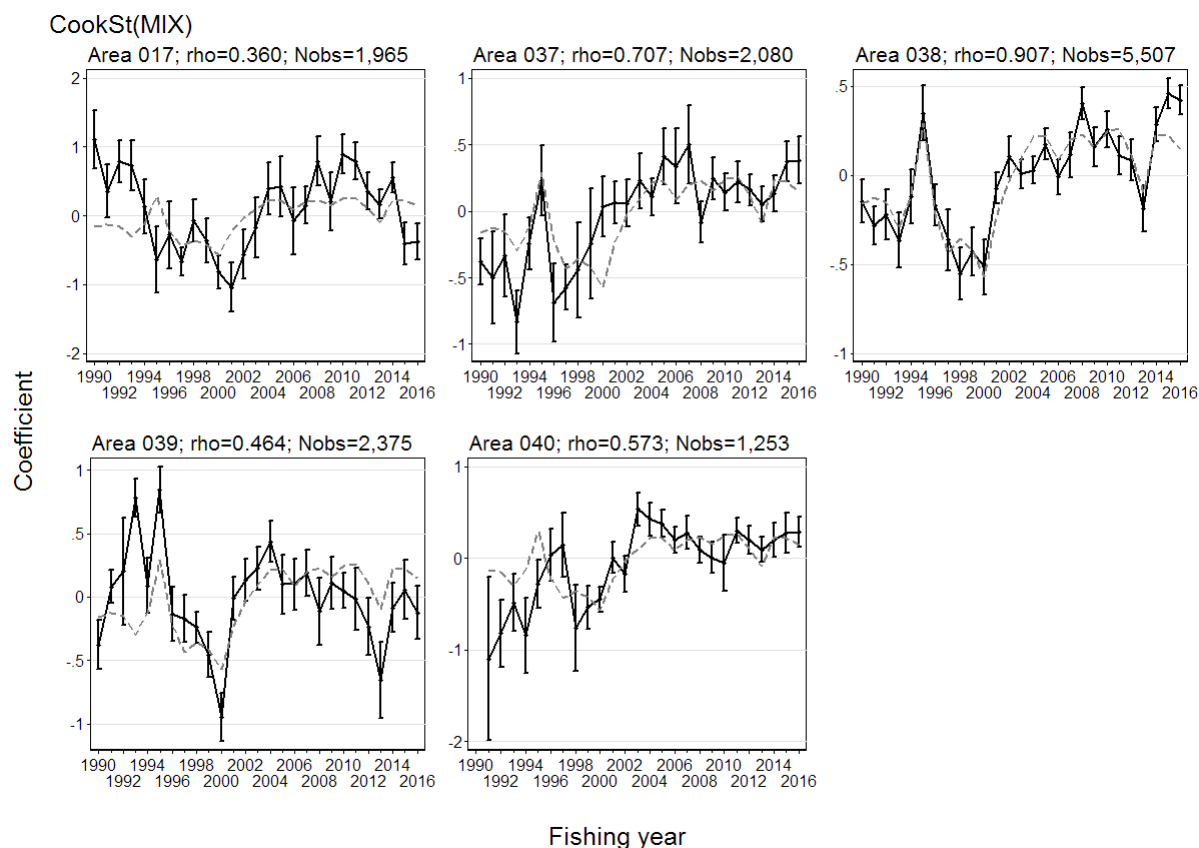
Figure L.10: **Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the gurnard CookSt(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.**
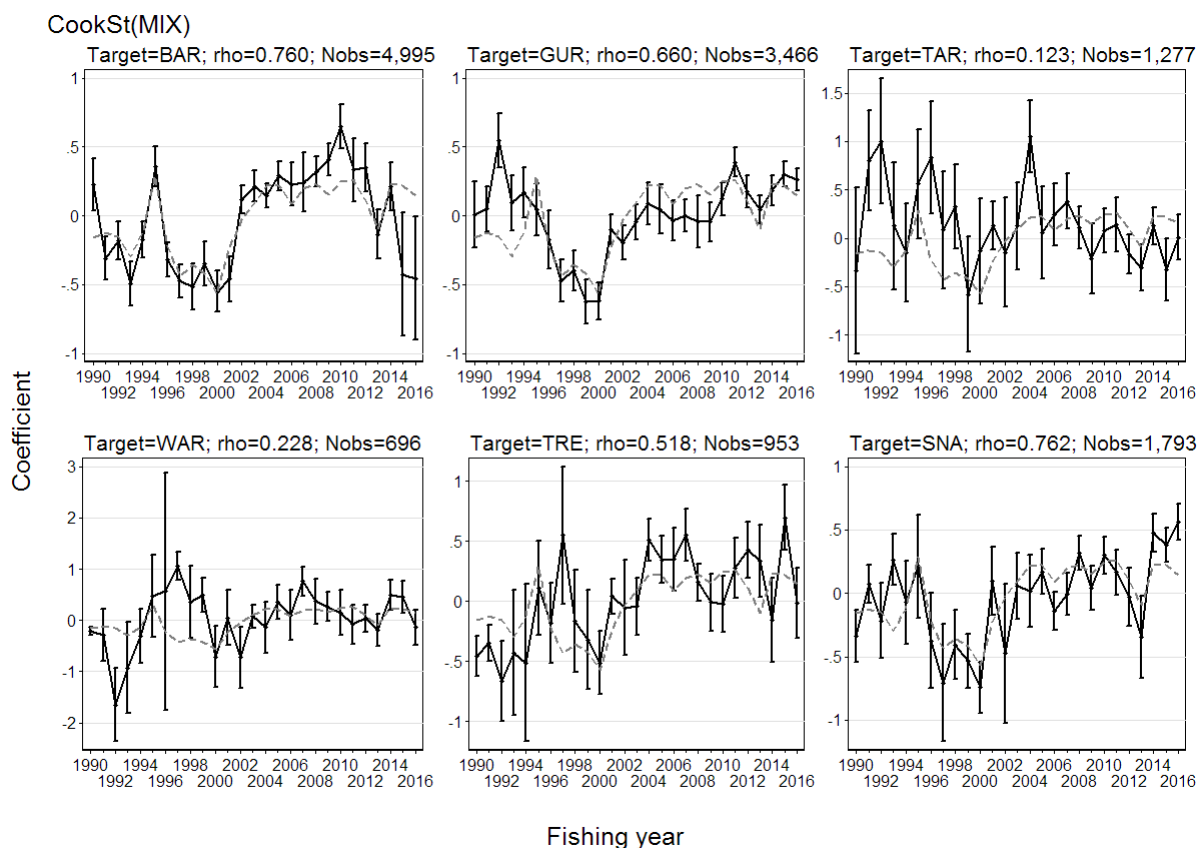
CookSt(MIX)

Figure L.11: **Residual implied coefficients for target species × fishing year interaction (interaction term not offered to the model) in the gurnard COOKST(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.**

L.4.3 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table L.3), with duration fished and month non-significant. The model discarded [tows] as an explanatory variable. A plot of the binomial model and the combined delta-lognormal model is provided in Figure L.12 and the CPUE indices are listed in Table L.4.

Table L.3: **Order of acceptance of variables into the binomial (logistic) model of presence/absence of gurnard catches in the COOKST(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 5 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.**

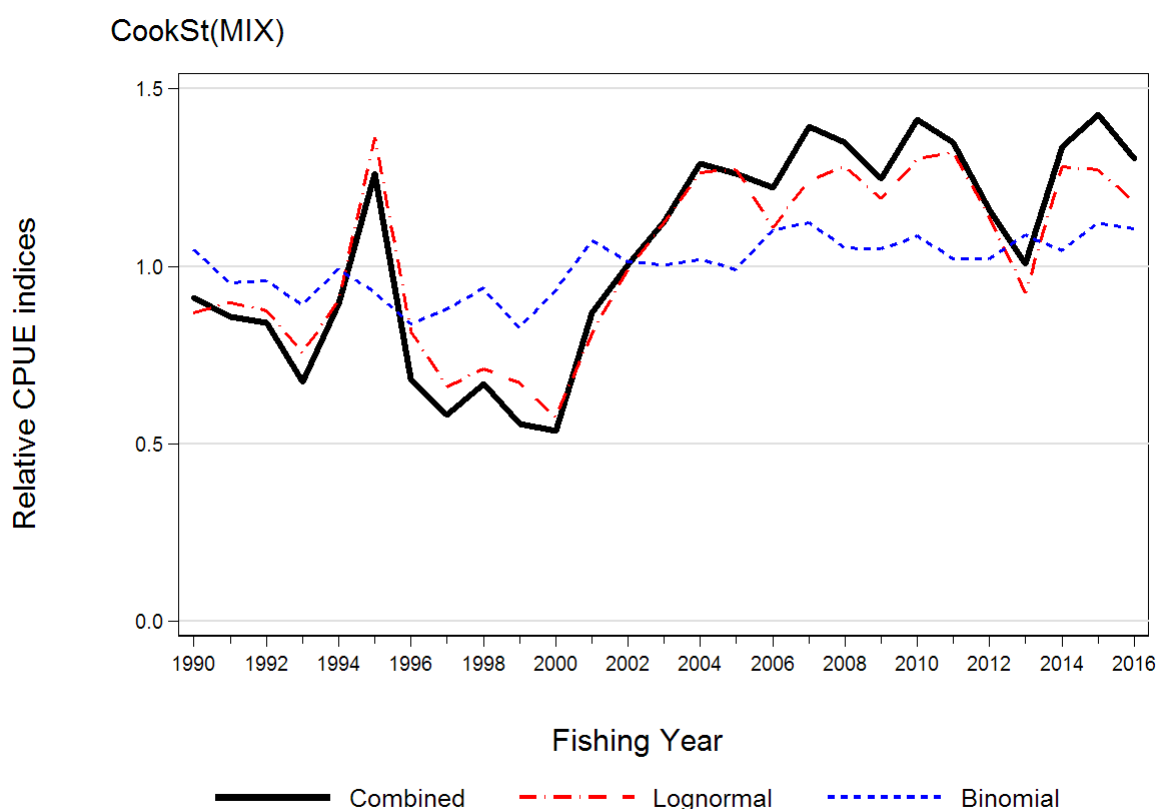| Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-11 372	22 797	1.76	*
target	32	-9 736	19 536	24.11	*
area	36	-9 409	18 891	28.12	*
vessel	73	-9 197	18 541	**30.66**	*
poly(log(duration), 3)	76	-9 154	18 461	31.16	
month	87	-9 138	18 450	31.36	
poly(log(tows), 3)	–	–	–	–	

Figure L.12: **Relative CPUE indices for gurnard using the lognormal non-zero model based on the COOKST(MIX) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of gurnard, and the combined model using the delta-lognormal procedure (Eq. F.4).**

L.4.4   CPUE indices

Table L.4:   **Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the gurnard COOKST(MIX) analysis. All series (except SE) standardised to geometric mean=1.0.**

Fishing year	All vessels Arithmetic	Arithmetic	Geometric	Standardised	SE	Core vessels Binomial	Combined
1990	0.610	0.643	0.779	0.870	0.0770	1.046	0.910
1991	0.595	0.651	0.753	0.899	0.0606	0.953	0.857
1992	0.814	0.903	0.832	0.876	0.0575	0.960	0.840
1993	0.658	0.654	0.722	0.757	0.0589	0.891	0.674
1994	0.674	0.724	0.693	0.903	0.0629	0.992	0.895
1995	1.010	1.267	1.264	1.362	0.0593	0.926	1.261
1996	0.534	0.663	0.781	0.816	0.0606	0.837	0.683
1997	0.577	0.486	0.517	0.660	0.0578	0.880	0.580
1998	0.832	0.910	0.813	0.712	0.0615	0.938	0.668
1999	0.520	0.513	0.589	0.670	0.0590	0.827	0.554
2000	0.833	0.565	0.534	0.576	0.0512	0.932	0.537
2001	0.985	1.024	0.839	0.810	0.0482	1.072	0.868
2002	1.267	1.267	1.295	0.992	0.0509	1.014	1.005
2003	1.221	1.235	1.311	1.122	0.0482	1.004	1.127
2004	1.290	1.364	1.482	1.265	0.0458	1.020	1.290
2005	1.599	1.483	1.638	1.272	0.0497	0.991	1.262
2006	1.735	1.715	1.418	1.110	0.0530	1.102	1.223
2007	1.682	1.672	1.343	1.242	0.0544	1.123	1.395
2008	1.182	1.179	1.400	1.282	0.0552	1.052	1.349
2009	1.334	1.262	1.373	1.190	0.0588	1.048	1.248
2010	1.321	1.318	1.362	1.303	0.0525	1.085	1.413
2011	1.296	1.259	1.312	1.322	0.0524	1.021	1.349
2012	1.131	1.134	1.206	1.136	0.0506	1.021	1.160
2013	1.078	1.050	0.884	0.926	0.0502	1.088	1.007
2014	1.109	1.081	1.166	1.280	0.0517	1.044	1.336
2015	1.501	1.486	1.143	1.272	0.0528	1.123	1.428
2016	1.351	1.182	0.978	1.179	0.0534	1.105	1.303