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FISHERY CHARACTERISATION AND CPUE ANALYSIS OF LIN 1

New Zealand Fisheries Assessment Report 2016/62

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EXECUTIVE SUMMARY

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The fisheries taking ling (*Genypterus blacodes*) in Quota Management Area (QMA) LIN 1 are described from 1989–90 to 2011–12 based on compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI). This QMA includes the east coast of the North Island from North Cape to Cape Runaway and the west coast of the North Island down to about New Plymouth. The bottom trawl (BT) and bottom longline (BLL) fisheries account for more than 98% of the total accumulated landings of LIN 1 over the 23 year period of record, with the BLL fishery targeting ling accounting for 40% of the overall total. The remaining 60% of the landings are spread out amongst a wide range of fisheries, with the most important being the bycatch of ling in BT fisheries targeting scampi (15%), gemfish (10%), hoki (8%) and tarakihi (4%). About 9% of the total landings are taken by BT target fishing for ling. Detailed characteristics of the LIN 1 landing data, as well as the spatial, temporal, target species and depth distributions relative to the catch of ling in LIN 1 are presented. Annual performance of the LIN 1 catches and some regulatory information are also presented.

The TACC for LIN 1 was raised from 265 t/year to 400 t/year at the beginning of the 2002–03 fishing year, when the QMA entered the Adaptive Management Programme (AMP). That programme was discontinued in 2009, but the higher TACC for LIN 1 remained. Reviews of LIN 1, under the provisions of the AMP, were conducted in 2005, 2007 and 2009. Three analyses of commercial Catch Per Unit Effort (CPUE) were considered as candidates for use as biomass indices to track population trends in LIN 1. One of these fisheries (BT(SCI)) had been previously rejected by the AMP Fishery Assessment Working Group but was updated for another review. Another trawl fishery series (BT(MIX)) was developed in response to a 2009 recommendation from the AMPWG. Upon review by the NINSWG, both bottom trawl series were considered unsuitable for monitoring LIN 1 abundance, leaving the BLL(LIN) CPUE series as the only remaining candidate for monitoring this QMA. This series was provisionally accepted by the NINSWG with a Science Information Quality ranking of “2” (“Medium or Mixed Quality”), largely due to the lack of data in the analysis. This acceptance was combined with the requirement that each accepted CPUE index value in the series had to be determined by at least three vessels. This latter requirement removed an apparently spurious 1998–99 index value based on only two vessels fishing in a localised manner.

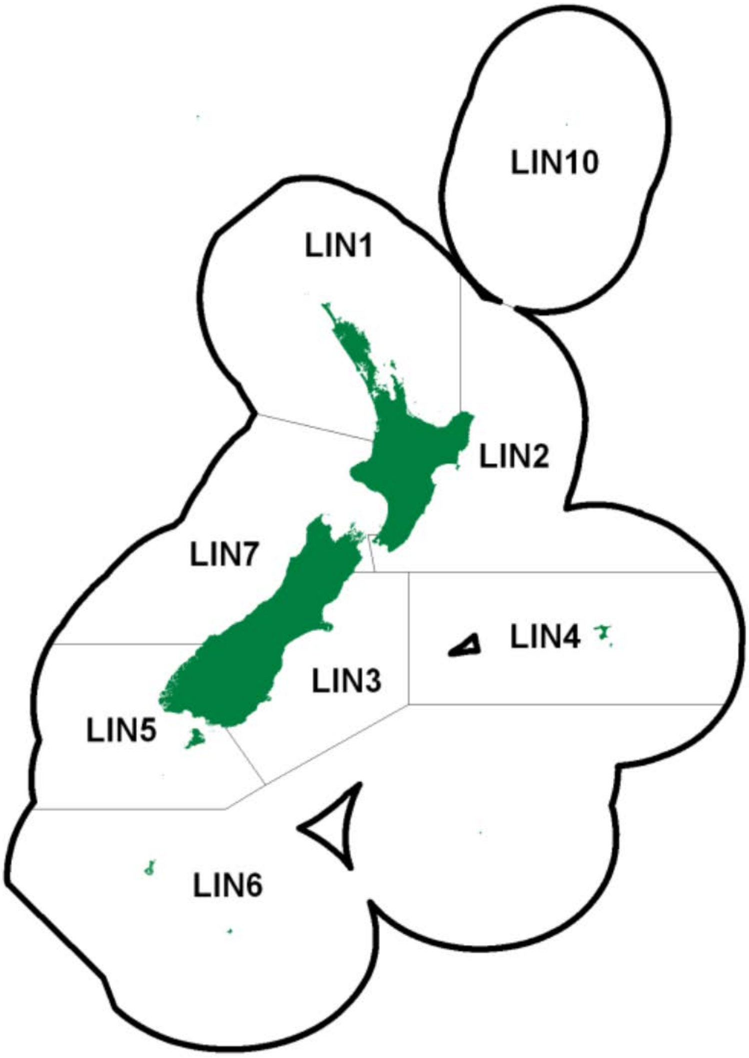

Figure 1: Map of LIN QMAs.

1 INTRODUCTION

This document describes work conducted under Objectives 1 and 2 of the Ministry for Primary Industries (MPI) contract LIN2012/01.

Overall Objective:

1. To characterise the Ling (*Genypterus blacodes*) fishery and undertake a CPUE analysis in LIN 1

Specific Objectives:

1. To characterise the LIN 1 fisheries.
2. To analyse existing commercial catch and effort data to the end of the 2011–12 fishing year with the aim of developing a standardised CPUE index of abundance based on the target longline fishery.

The TACC for LIN 1 (Figure 1) was increased from 265 t to 400 t within the Adaptive Management Plan (AMP) on 1 October 2002. Reviews of the LIN 1 AMP were carried out in 2005 (SeaFIC 2005), in 2007 (Starr et al. 2007) and in 2009 (Starr et al. 2009). The AMP programme was discontinued by the Minister of Fisheries in 2009–10, but the higher TACC remained in place (Table 1; Figure 2). This paper documents an update of the LIN 1 CPUE analyses that was commissioned in 2013 by the Ministry for Primary Industries (MPI). That update was reviewed and accepted by the Northern Inshore Working Group (NINSWG) in March 2013 (Kendrick & Starr 2013). The results of the 2013 review are summarised in Chapter 42 of the MPI Plenary stock assessment report (Ministry for Primary Industries 2016).

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

2 INFORMATION ABOUT THE STOCK/FISHERY

2.1 TRENDS IN COMMERCIAL CATCH

The fishery for ling in QMA 1 exceeded the previous TACC of 265 t in five of the six years prior to the introduction of this Fishstock into the AMP (Table 1; Figure 2). Landings declined in the first two years (2002–03 and 2003–04) of the operation at the higher TACC, but have since risen, exceeding 300 t in every year since 2005–06 and rising above the TACC in 2010–11 with a catch of 438 t, the highest since the Fishstock was introduced into the QMS in 1986.

Table 1: Reported landings (t), TACC (t) and adjusted landings of ling in LIN 1 from 1989–90 to 2011–12 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2011–12). $\tilde{SL}_y$ is the sum of landings in a year adjusted for changes in conversion factor (see caption for Table 2) and SL_y is the sum of the same landings without adjustment.

Year	QMR_y	TACC_y	$R_y = \tilde{SL}_y / SL_y$	$\tilde{\text{QMR}}_y = \text{QMR}_y * R_y$
1986–87	105	200	0.982[1]	103
1987–88	248	237	0.982[1]	243
1988–89	218	238	0.982[1]	214
1989–90	121	265	0.977	118
1990–91	207	265	0.986	204
1991–92	241	265	0.982	237
1992–93	253	265	0.982	249
1993–94	237	265	1.000	237
1994–95	261	265	1.000	261
1995–96	240	265	1.000	240
1996–97	313	265	1.000	313
1997–98	300	265	0.998	300
1998–99	208	265	0.995	207
1999–00	313	265	0.996	311
2000–01	296	265	0.992	294
2001–02	303	265	0.997	302
2002–03	246	400	1.000	246
2003–04	249	400	1.000	249
2004–05	283	400	1.000	283
2005–06	364	400	1.000	364
2006–07	301	400	1.000	301
2007–08	381	400	1.000	381
2008–09	320	400	1.000	320
2009–10	386	400	1.000	386
2010–11	438	400	1.000	438
2011–12	384	400	1.000	384

[1] average: 1989–90 to 1991–92

2.2 REGULATIONS AFFECTING THE FISHERY

There have been changes to the factors used to convert processed weight to greenweight at the time of landing in this data series and these have been adjusted to a constant conversion factor when preparing the data for the analyses presented in this report (see Table 6 in Section 2.4). The changes are minor, resulting in small shifts in the declared landings of about 1 to 4% for LIN 1 in the early 1990s compared to the sum of the greenweights as declared at the time of landing (Table 1; Figure 2).

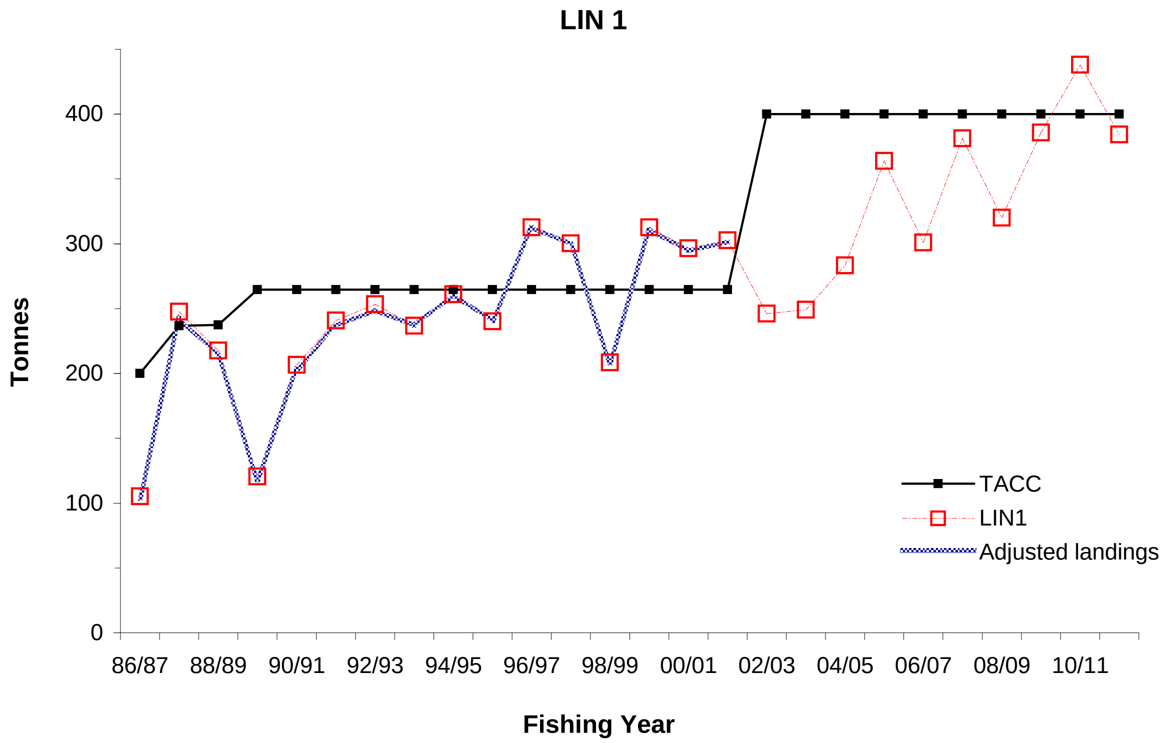

Figure 2: Annual landings and TACCs for the LIN 1 fishery by fishing year from 1986–87 to 2011–12 (Table 1). Landings adjusted from 1986–87 to 2001–02 as presented in Table 1.

2.3 ANALYSIS OF LIN 1 CATCH AND EFFORT DATA

2.3.1 METHODS USED FOR ANALYSIS OF MPI CATCH AND EFFORT DATA

Three data extracts were obtained from the Ministry for Primary Industries (MPI) Warehou database (Ministry of Fisheries 2010). One extract consisted of the complete data (all fishing event information along with all ling landing information) from every trip which recorded landing ling in LIN 1, starting from 1 October 1989 and extending to 30 September 2012). Two further extracts were obtained: one consisting of all trips using the method BT (bottom trawl) which targeted or caught scampi (SCI), gemfish (SKI), tarakihi (TAR), ling (LIN), or hoki (HOK) and fished at least once in a valid LIN 1 statistical area. The third extract requested all trips which used the bottom longline (BLL) method which targeted or caught ling (LIN), hapuku/bass (HPB), hapuku (HAP), bass (BAS), bluenose (BNS), or ribaldo (RIB) and fished at least once in a valid LIN 1 statistical area. Once these trips were identified, all fishing event data and ling landing data from the entire trip, regardless of method of capture, were obtained. These data extracts (MPI replog 8826) were received 10 March 2013. The first data extract was used to characterise and understand the fisheries taking LIN 1. These characterisations are reported in Sections 2.4 and 2.5. The remaining two extracts were used to calculate CPUE standardisations (Section 3, Appendix D, Appendix F and Appendix G).

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 are documented in Appendix C; the remaining procedures used to prepare these 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. These data were amalgamated into a common level of stratification known as a "trip stratum" (Appendix A). 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 ling by trip were allocated to the "trip strata" in proportion to the estimated ling catches in each "trip stratum". In situations when trips recorded landings of ling 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 ling landings were allocated proportionally to effort (tows for trawl data and number of sets for longline data) in each "trip stratum".

Table 2: Comparison of the total adjusted LIN 1 QMR/MHR catch (t), reported by fishing year, with the sum of the corrected landed catch totals (bottom part of the MPI CELR form or the CLR 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 8826: 1989–90 to 2011–12. Landings and QMR/MHR totals have been adjusted to consistent conversion factors across years (see Table 6 in Section 2.4).

Fishing Year	QMR/MHR (t)	Total landed catch (t)[1]	% landed/ QMR/MHR	Total Analysis catch (t)	% Analysis /Landed	Total Estimated Catch (t)	% Estimated /Analysis
89/90	118	110	93	95	86	53	56
90/91	204	194	95	190	98	120	63
91/92	237	239	101	229	96	156	68
92/93	249	244	98	242	99	153	63
93/94	237	244	103	242	99	164	68
94/95	261	254	97	243	95	177	73
95/96	240	241	100	239	99	190	80
96/97	313	282	90	274	97	222	81
97/98	300	286	96	284	99	216	76
98/99	208	216	104	194	90	146	75
99/00	311	328	106	326	99	278	85
00/01	294	284	97	282	99	249	88
01/02	302	301	100	298	99	239	80
02/03	246	244	99	244	100	200	82
03/04	249	219	88	216	99	173	80
04/05	283	267	94	267	100	206	77
05/06	364	358	98	356	99	289	81
06/07	301	296	98	296	100	225	76
07/08	381	380	100	378	99	354	94
08/09	320	311	97	310	100	289	93
09/10	386	377	98	376	100	343	91
10/11	438	442	101	423	96	377	89
11/12	384	389	101	377	97	335	89
Total	6 626	6 508	98	6 379	98	5 153	81

[1] Totals summed after applying procedure described in Appendix C.

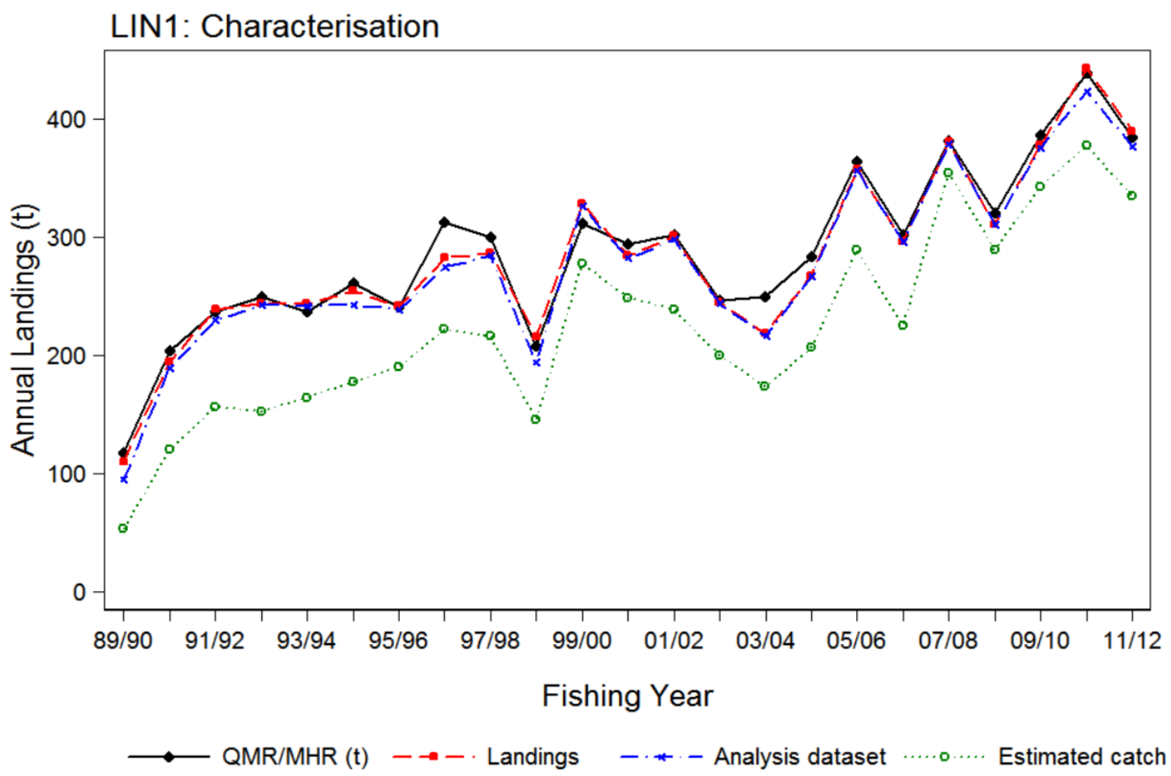

Figure 3: Plot of catch datasets presented in Table 2. The estimated catch total is the sum of the estimated catch in the analysis dataset. The QMR/MHR catches have been adjusted as shown in Table 1, landings have been purged of spurious trips (Appendix C), and the Analysis and estimated catches are as presented in Table 2.

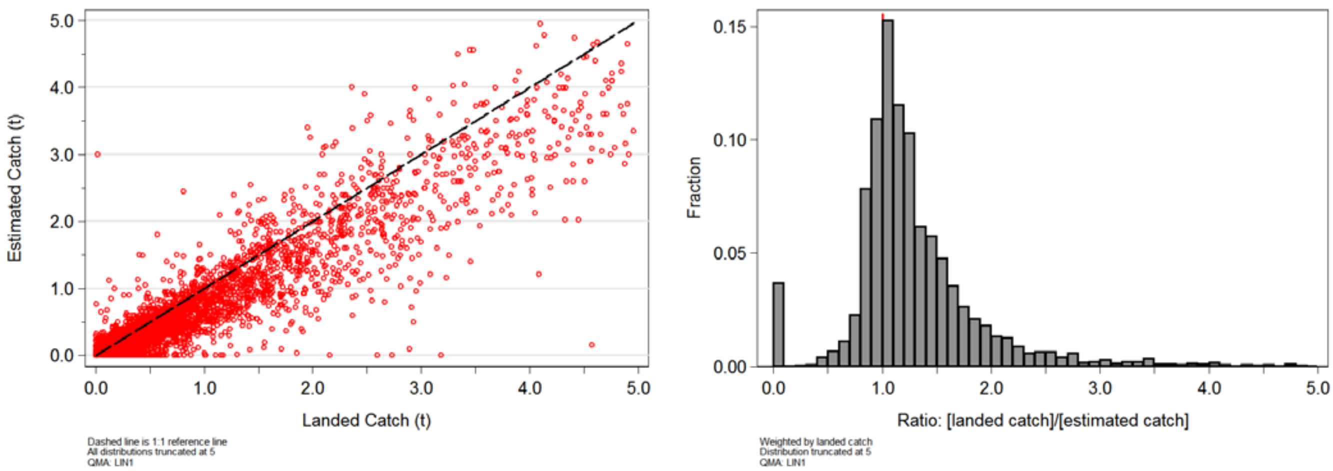

Figure 4: [left panel]: Scatter plot of the sum of landed and estimated ling catch for each trip in the LIN 1 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

The catch totals (Table 2; Figure 3) resulting from the dataset used for this analysis may not be the same as those reported to the QMS system because the QMS is a reporting system separate from the MPI catch/effort reporting system. The data are further modified during the preparation procedure described above because trips are dropped with a corresponding loss of data, including dropped trips which have large landings of the target Fishstock without sufficient effort to corroborate the large landing. The most important source of data loss in this procedure results from dropping trips which fished in straddling statistical areas and which report more than one valid Fishstock for that statistical area (Table 2).

Catch totals in the fishery characterisation tables have been scaled to the adjusted QMR/MHR totals reported in column 5, 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 annual ratio:

$$\tilde{L}'_{i,y} = \tilde{L}_{i,y} \frac{\tilde{\mathbf{Q}}\mathbf{MR}_y}{\tilde{A}L_y} \qquad \text{Eq. 1}$$

where $\tilde{\mathbf{Q}}\mathbf{MR}_y$, $\tilde{L}_{i,y}$ and $\tilde{A}L_y$ are landings adjusted for changes in the conversion factors as defined in Table 1 and Table 2.

Table 3: Summary statistics pertaining to the reporting of estimated catch from the LIN 1 analysis dataset. All calculations made on the landings data set resulting from the procedure described in Appendix A.

	Trips with landed catch but which report no estimated catch			Dataset statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	53	11	13	0.62	1.30	1.60	3.34
90/91	45	6	13	0.63	1.34	1.83	3.98
91/92	47	5	12	0.60	1.20	1.49	3.00
92/93	44	7	17	0.53	1.39	1.71	4.15
93/94	46	5	13	0.48	1.33	1.76	3.53
94/95	47	5	12	0.50	1.36	2.14	3.60
95/96	39	6	14	0.50	1.19	1.53	2.90
96/97	37	5	15	0.56	1.27	1.75	3.60
97/98	39	4	12	0.58	1.23	1.99	4.00
98/99	42	6	12	0.57	1.23	1.63	3.94
99/00	50	5	17	0.56	1.11	1.66	3.80
00/01	40	4	11	0.54	1.20	1.57	3.67
01/02	39	3	8	0.57	1.20	1.57	3.44
02/03	46	5	11	0.58	1.20	1.51	3.33
03/04	39	4	10	0.56	1.20	1.58	3.67
04/05	43	3	8	0.58	1.33	1.79	4.14
05/06	41	2	7	0.53	1.28	1.73	3.97
06/07	40	2	6	0.50	1.30	1.73	4.07
07/08	36	2	6	0.53	1.18	1.90	4.15
08/09	36	2	7	0.51	1.26	1.73	3.89
09/10	31	1	5	0.58	1.26	1.77	3.86
10/11	34	1	6	0.61	1.30	1.77	4.06
11/12	34	1	5	0.60	1.23	1.90	4.50
Total	41	4	241	0.56	1.25	1.72	3.80

Annual totals from this data set compared with the annual QMR/MHR totals in Table 1 are presented in Table 2 and Figure 3. Total landings from the bottom part of the CELR form or CLR form are very close to the QMR/MHR totals after applying the procedure to drop spurious non-LIN 1 landing described in Appendix C. The sum of the estimated catches from the analysis dataset ranges between 56 and 94% of the sum of the “Analysis” catches (Table 2; Figure 3). A comparison scatter plot of the estimated and landed catch by trip shows that most trips underestimate the landing total for the trip and that the majority of the trips are below the 1:1 line (Figure 4; [left panel]). The distribution of the ratios of the landed to estimated catch shows that there is a strong mode of the ratios grouped near one, but with a long tail to the right (Figure 4; [right panel]). There is also a secondary mode at zero, resulting from the 4 % of the trips by weight that land LIN 1 report no estimated catch.

The 5% to 95% percentiles (excluding trips where there is no estimated catch) for the ratio of landed to estimated catch range from 0.56 to 3.80 for the LIN 1 portion of the dataset, with the median ratio of the landings at 125% of the estimated catch and the mean ratio 72% higher than the estimated catch

(Table 3). Four percent of trips by landed weight and 41% by number estimate no ling catch at all, representing total landings of about 240 t over the 23 years of data (Table 3). There has been a drop in the proportion of trips with no reported ling estimated catch after the introduction of the new event-based forms in October 2006 and October 2007 (Table 3).

2.4 DESCRIPTION OF LIN 1 LANDING INFORMATION

Landing data for ling were provided for all trips which landed LIN 1 at least once, with one record for every reported LIN landing (this will include LIN QMAs from all other LIN Fishstocks) from the trip. The LIN 1 data request stipulated that every landing record associated with each trip be provided because previous extracts have shown large amounts of statistical area misreporting for ling, with operators reporting the FMA rather than the actual statistical area fished (see Appendix C). This is a problem for ling because a large amount of the ling catch is taken by autolongliners operating on the Chatham Rise and the Sub-Antarctic. In the past, these vessels reported on the CELR forms which have no requirement to report the position of the fishing event. If the operators report 4, 5 or 6 (for LIN 4, LIN 5 or LIN 6) in the statistical area field, the CPUE data extracts will identify these trips as being valid for LIN 1, even though they were not fishing in LIN 1. Appendix C describes the procedure followed to identify spurious landings in the LIN 1 data set. A total of 2 100 t of landings were dropped from the data set on the basis of this analysis.

Table 4: Destination codes in the unedited landing data received for the LIN 1 analysis. The "how used" column indicates which destination codes were included in the characterisation and CPUE analyses.

Destination code	Number events	Green weight (t)	Description	How used
L	23 847	6 976.3	Landed in NZ (to LFR)	Keep
C	19	3.4	Disposed to Crown	Keep
E	36	0.5	Eaten	Keep
F	34	0.3	Section 111 Recreational Catch	Keep
U	13	0.2	Bait used on board	Keep
A	6	0.1	Accidental loss	Keep
S	1	0.1	Seized by Crown	Keep
W	1	0.0	Sold at wharf	Keep
R	106	1 418.4	Retained on board	Drop
T	3	3.1	Transferred to another vessel	Drop
Q	79	1.5	Holding receptacle on land	Drop
NULL	13	0.8	Nothing	Drop
B	12	0.0	Bait stored for later use	Drop
D	2	0.0	Discarded (non-ITQ)	Drop

Each landing record contained a reported greenweight (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 4), 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 4). However, other codes (e.g., A, O and C; Table 4) also potentially describe valid landings which were included in this analysis. A number of other codes (notably R, Q and T; Table 4) were not included because these landings were likely to have been reported at a later date under the 'L' destination category. Table 4 indicates that a large amount of LIN 1 landings (about 1400 t) use destination code 'R' (retained on board). However, excluding these landings from further analysis appears to be the correct decision because including the 'R' landings would further inflate the landings above those reported to the QMR (Table 2).

Table 5: **Total greenweight reported and number of events by state code in the unedited landing file used to process the LIN 1 characterisation data, arranged in descending order of landed weight.**

State code	Number Events	Total reported greenweight (t)	Description
GRE	17 457	3 412.9	Green (or whole)
HGU	5 626	2 467.0	Headed and gutted
DRE	717	879.9	Dressed
HGT	55	101.0	Headed, gutted, and tailed
USK	4	98.0	Fillets: skin-off untrimmed
ROE	3	8.9	Roe
Other	95	13.3	Other (misc)

[1] TSK (fillets: skin-off trimmed); FIL (Fillets: skin-on); Null; HDS (heads}; MEA (fish meal); HGF (headed, gutted, and finned)

Table 6: **Median conversion factor for the five most important state codes reported in Table 5 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process the LIN 1 landing data. Landing totals are for LIN 1 only and exclude trip=973634 (which used primarily landed state code USK).**

	Landed State Code					Landed State Code				
	GRE	HGU	DRE	HGT	OTH	GRE	HGU	DRE	HGT	OTH
	Median conversion factor					Landed weight (t)				
89/90	1	1.5	–	1.7	1.1	26.0	29.6	–	58.1	2.0
90/91	1	1.5	1.8	1.7	–	36.0	86.1	75.1	0.1	–
91/92	1	1.5	1.8	–	1.25	48.5	129.0	66.0	–	0.0
92/93	1	1.5	1.8	–	1.25	69.0	133.4	46.2	–	0.0
93/94	1	1.45	1.8	–	1.15	51.4	146.5	46.0	–	0.0
94/95	1	1.45	1.8	–	0.575	62.2	161.2	27.8	–	3.6
95/96	1	1.45	1.8	1.55	1.15	85.8	138.1	20.7	0.3	0.4
96/97	1	1.45	1.8	–	1.15	175.0	101.7	12.3	–	0.3
97/98	1	1.45	1.85	–	1.15	169.1	98.4	21.0	–	0.3
98/99	1	1.45	1.85	–	1.15	152.2	40.7	24.3	–	0.0
99/00	1	1.45	1.85	–	–	193.7	77.1	59.4	–	–
00/01	1	1.45	1.85	–	1.15	138.3	74.7	73.3	–	0.0
01/02	1	1.45	1.85	1.55	1.15	172.1	69.6	52.0	3.9	4.3
02/03	1	1.45	1.8	–	1.15	133.2	84.6	26.0	–	0.6
03/04	1	1.45	1.8	–	1.15	95.0	85.3	47.8	–	0.0
04/05	1	1.45	1.8	1.55	1.15	100.8	123.8	42.8	0.0	0.0
05/06	1	1.45	1.8	–	1.15	174.5	161.7	21.4	–	0.0
06/07	1	1.45	1.8	1.6	1.15	152.8	118.4	20.5	7.1	0.0
07/08	1	1.45	1.8	1.625	1.15	228.5	137.9	15.4	1.4	0.1
08/09	1	1.45	1.8	–	1.15	256.4	35.4	20.1	–	0.1
09/10	1	1.45	1.8	–	1.15	299.7	59.4	19.7	–	0.0
10/11	1	1.45	1.8	–	1.15	304.3	115.5	25.7	–	0.4
11/12	1	1.45	1.8	–	–	272.2	99.2	24.9	–	–
Total						3 396.7	2 307.3	788.3	70.9	12.2

A range of state codes (GRE, HGU, DRE, HGT) are used to report LIN 1 landings (Table 5). State codes GRE, HGU, DRE, and HGT have been reported for ling using variable conversion factors over the data period, with small changes shown over the period of available data (Table 6). Greenweight landings $\left(G^{'}_{i,s,y}\right)$ were adjusted in the CPUE analysis and for some parts of the characterisation analysis for state codes HGU, DRE, HGT to consistent conversion factors using the following equation:

$$G^{'}_{i,s,y} = G_{i,s,y} \, {cf_{i,s,endyr}}\Big/{cf_{i,s,y}} \qquad \text{Eq. 2}$$

where

$G_{i,s,y}$ is the reported greenweight for record *i* using landed state code *s* in year *y*;

$cf_{i,s,y}$ is the conversion factor for record *i* using landed state code *s* in year *y*;

$cf_{i,s,endyr}$ is the conversion factor for record *i* using landed state code *s* in *endyr* (last year in data)

Table 7: Distribution of total landings (t) by ling Fishstock and by fishing year for the set of trips that recorded LIN 1 landings. Landing records with improbable greenweights have been dropped, including trip 973634.

Fishing year	LIN 1	LIN 2	LIN 3	LIN 4	LIN 5	LIN 6	LIN 7	Total
89/90	113	31	2	13	4		34	196
90/91	194	22	13	258	6	4	3	500
91/92	239	53	25	31	22	23	13	407
92/93	244	44	61	90	160	9	47	653
93/94	244	65	38	194	20	147	25	733
94/95	255	82	81	502	1	351	35	1 306
95/96	245	88	141	245	1	33	30	783
96/97	289	165	183	495	107	149	62	1 450
97/98	288	117	48	133	20	2	13	621
98/99	217	189	11	8			16	441
99/00	329	77	59	4	21	123	31	643
00/01	284	21	36	38	25	52	38	495
01/02	301	59	1	0	1	0	6	368
02/03	244	61	26	7	0		19	357
03/04	228	40	7	0	1		30	307
04/05	267	19	17	5	1		9	317
05/06	358	38	2	13	0		13	424
06/07	299	45	0	0			41	386
07/08	383	52					2	437
08/09	312	39	0				2	353
09/10	379	38	0	0			8	425
10/11	446	52	0	0			32	531
11/12	396	49	3	4	24	1	24	500
Total	6 555	1 445	754	2 040	413	893	532	12 631

Landings in the final data set are primarily from LIN 1 but there are significant landings from LIN 2 and LIN 4 (Table 7). This is because the data request included all ling landings from every trip that fished in LIN 1 and it appears that many of the trips are wide ranging, even after implementing the procedure described in Appendix C. About 70% of the LIN 1 landings were reported on CELR forms until the form change in 2007–08, with the remainder on CLR forms (Catch Landing Returns; Table 8). The CLR forms are used by larger vessels using the TCEPR and LCER forms to report their effort and, after 2007–08, by smaller trawl and longline (between 6 and 28 m) vessels using the new event-based forms. Only a negligible amount of landings of LIN 1 are reported on the NCELR form (Table 8). After 2007–08, there is a clear increase in the use of the fishing event based forms (TCER and LTCER), with the percentage of the LIN 1 catch reported on CELR forms dropping to less than 10% of the annual total in recent years (Table 8).

Table 8: Distribution by form type for landed catch by weight for each fishing year in LIN 1. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data using statistical areas consistent with LIN 1. CELR: Catch, Effort, Landing Return; CLR: Catch Landing Return; NCELR: Netting Catch Effort Landing Return, TCEPR: Trawl Catch Effort Processing Return; TCER: Trawl Catch Effort Return; LTCER: Lining Trip Catch Effort Return. Forms other than CELR and NCELR have their related landings reported on CLR forms.

Fishing	Landings[1]		Days Fishing (%)[2]				Days Fishing					
Year	CELR	CLR	CELR	TCEPR	TCER	LTCER	CELR	TCEPR	TCER	LTCER	Other	Total
89/90	34	66	79	21	–	–	1 751	460	–	–	–	2 211
90/91	49	51	76	24	–	–	2 222	703	–	–	–	2 925
91/92	69	31	85	15	–	–	2 744	489	–	–	1	3 234
92/93	79	21	85	15	–	–	3 052	534	–	–	2	3 588
93/94	79	21	81	19	–	–	2 868	653	–	–	1	3 522
94/95	79	21	72	28	–	–	2 418	958	–	–	2	3 378
95/96	61	39	41	59	–	–	1 381	1 956	–	–	2	3 339
96/97	42	58	41	58	–	–	1 752	2 467	–	–	6	4 225
97/98	41	59	38	62	–	–	1 751	2 835	–	–	–	4 586
98/99	41	59	38	61	–	–	1 539	2 464	–	–	5	4 008
99/00	39	61	44	56	–	–	2 044	2 560	–	–	2	4 606
00/01	38	62	39	61	–	–	1 722	2 642	–	–	1	4 365
01/02	31	69	43	57	–	–	1 638	2 149	–	–	1	3 788
02/03	44	56	44	56	–	–	1 702	2 147	–	–	–	3 849
03/04	43	57	40	60	–	–	1 552	2 364	–	–	–	3 916
04/05	68	32	40	59	–	–	1 634	2 416	–	–	15	4 065
05/06	62	38	45	55	–	–	1 799	2 199	–	–	8	4 006
06/07	70	30	48	51	–	–	1 768	1 871	–	–	27	3 666
07/08	7	93	9	37	24	28	352	1 436	918	1 085	40	3 831
08/09	2	98	8	38	25	27	290	1 438	966	1 024	75	3 793
09/10	1	99	8	36	26	30	301	1 419	1 018	1 180	31	3 949
10/11	1	99	9	35	19	36	351	1 426	798	1 498	32	4 105
11/12	0	100	5	42	20	32	165	1 492	697	1 153	43	3 550
Total	39	61	43	45	5	7	36 796	39 078	4 397	5 940	294[3]	86 505

[1] Percentages of landed greenweight (about 100 kg of total landings using the NCELR form have been omitted)
[2] Percentages of number of days fishing
[3] includes 110 days for NCELR (Netting Catch Effort Lining Return), 69 days for LCER (Lining Catch Effort Return), and 115 days for TUN (Tuna Longlining Catch Effort Return)

2.5 DESCRIPTION OF THE LIN 1 FISHERY

Distributions by statistical area, major fishing method and target species in this section are provided by summarised statistical areas, methods and target species in Table 9.

Table 9: Definitions of statistical area (see Appendix B for the locations of the indicated statistical areas), major method codes and target species codes used in the distribution tables and plots in this report. Number events=number of effort records in analysis dataset; number records=number of records in analysis dataset after rolling up to trip/statistical area/method/target species.

Code used in report	Statistical area region definition	Number events	Number records
001	001	2 388	1 056
002	002	12 723	5 491
003	003	11 410	4 124
004	004	4 546	1 668
HG	005, 006, 007	7 145	2 413
008	008	24 017	5 545
009	009	38 091	12 515
010	010	27 098	9 391
041–045	041, 042, 043, 044, 045	17 676	5 361
046	046	7 973	3 037
047–048	047, 048	16 238	5 225
101–107	101, 102, 103, 104, 105, 106, 107	1 838	519

Region code	Statistical area definition for Regions	Number events	Number records
EN	001, 002, 003, 004, 105, 106	32 044	12 604
HG	005, 006, 007	7 145	2 413
BoP	008, 009, 010, 107	89 549	27 569
WCNI	041, 042, 043, 044, 045, 046, 047, 048, 101, 102, 103, 104	42 405	13 759

Method designation	Methods included	Number events	Number records
BLL	Bottom longline	25 514	11 077
BT	Bottom trawl	135 038	40 130
OTH	All other methods: reporting >1 t of LIN 1 total landings in ranked descending order: trot line, setnet, bottom pair trawl, Dahn line, Danish seine, midwater trawl	10 591	5 138

Target species code[1]	Target species definition	Number events	Number records
SCI	Scampi	15 866	928
SKI	Gemfish	8 060	2 657
LIN	Ling	1 032	614
HOK	Hoki	3 385	1 610
TAR	Tarakihi	32 581	11 989
SNA	Snapper	30 653	8 770
TRE	Trevally	20 599	5 861
RBY	Rubyfish	410	269
BAR	Barracouta	3 454	1 438
GUR	Red gurnard	6 472	2 199
OTH	All other species: > 3 t of total LIN 1 landings in ranked descending order: look-down dory, john dory, silver dory, alfonsino, orange roughy, arrow squid, silver warehou	12 526	3 795

Target species code[2]	Target species definition	Number events	Number records
LIN	Ling	4 223	1 420
BNS	Bluenose	12 179	5 004
RIB	Ribaldo	894	287
HPB	Hapuku/bass	5 066	2 390
SPO	Rig	157	45
SNA	Snapper	2 286	1 468
OTH	All other species: > 1 t of total LIN 1 landings in ranked descending order: gemfish, school shark	709	463

[1] bottom trawl method only
[2] bottom longline method only

LIN 1 shares only Statistical Area 041 with LIN 7. The remaining statistical area boundaries coincide with the QMA boundaries (Appendix B). The LIN 1 fishery is taken primarily by the bottom longline and bottom trawl methods, with only minor amounts of landings using other methods (Table 10; Figure 5). The bottom longline fishery has taken 49% percent of the landings and a further 49% has been taken by the bottom trawl fishery over the 23 years of available catch history. The remaining methods have taken less than 2% of the total landings.

About one-half of the LIN 1 bottom longline landings are taken in the Bay of Plenty (Figure 6; Table 11) while two-thirds of the bottom trawl landings come from this region (Figure 7; Table 11). East Northland is the other important area for bottom longline landings while the WCNI accounts for a large proportion of the bottom trawl landings in some years (Figure 7; Table 11).

Table 10: Total landings (t) and distribution of landings (%) of ling from trips which landed LIN 1 by statistical area group and important fishing methods (Table 9), summed from 1989–90 to 2011–12. Landings (t) have been scaled to the adjusted QMR totals $\left(\tilde{\text{Q}}\text{MR}_y\right)$ using Eq. 1.

Statistical Area	Fishing Method				Fishing Method		
	BLL	BT	Other	Total	BLL	BT	Other
	Total landings (t)				Distribution (%)		
001	181	14	18	213	2.7	0.2	0.3
002	796	127	9	931	12.0	1.9	0.1
003	55	53	7	115	0.8	0.8	0.1
004	48	37	1	86	0.7	0.6	0.0
HG	0	6	0	6	0.0	0.1	0.0
008	75	902	2	979	1.1	13.6	0.0
009	704	962	13	1 680	10.6	14.5	0.2
010	819	337	39	1 195	12.4	5.1	0.6
041–045	401	204	5	610	6.1	3.1	0.1
046	97	333	6	436	1.5	5.0	0.1
047–048	89	263	7	359	1.3	4.0	0.1
101–107	8	7	0	15	0.1	0.1	0.0
Region							
EN	1 087	236	34	1 356	16.4	3.6	0.5
HG	0	6	0	6	0.0	0.1	0.0
BoP	1 599	2 202	54	3 856	24.1	33.2	0.8
WCNI	588	801	19	1 407	8.9	12.1	0.3
Total	**3 274**	**3 244**	**108**	**6 626**	**49.4**	**49.0**	**1.6**

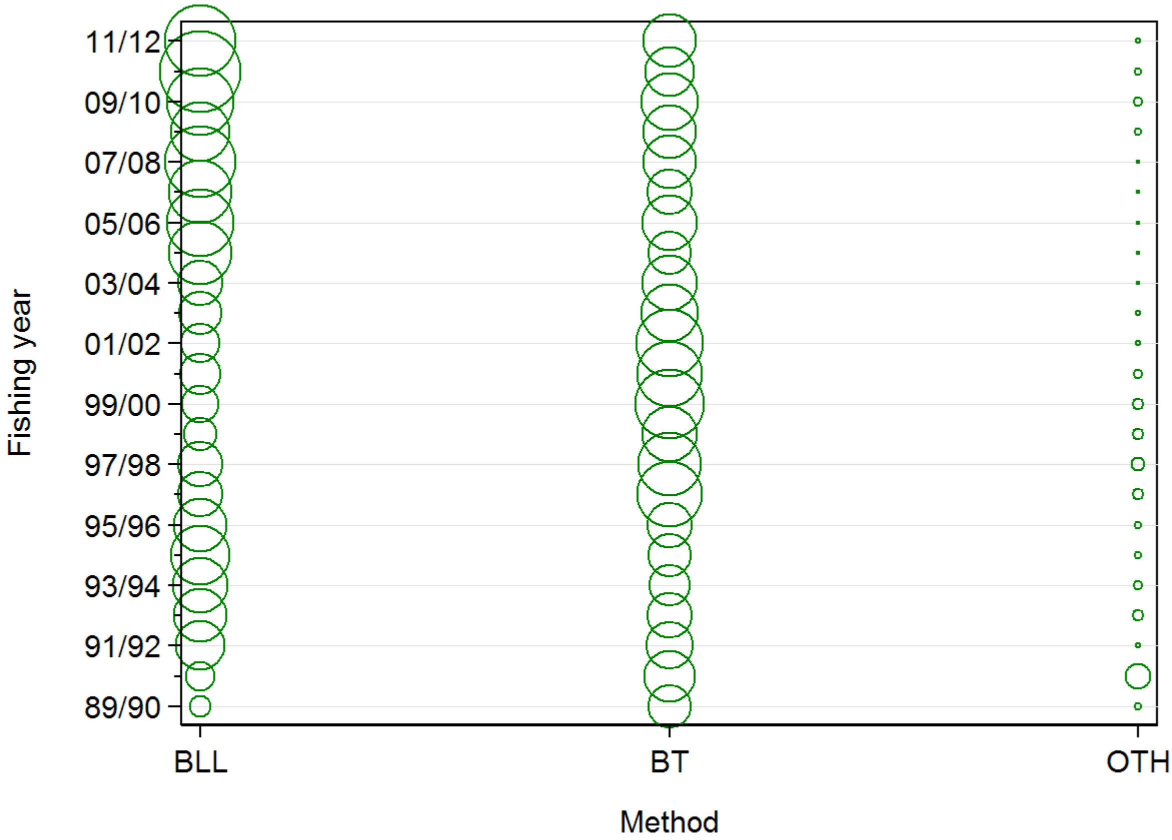

Figure 5: Distribution of catches for the major fishing methods by fishing year from trips which landed LIN 1. Circles are proportional to the catch totals by method and fishing year, with the largest circle representing: 315 t in 10/11 for BLL.

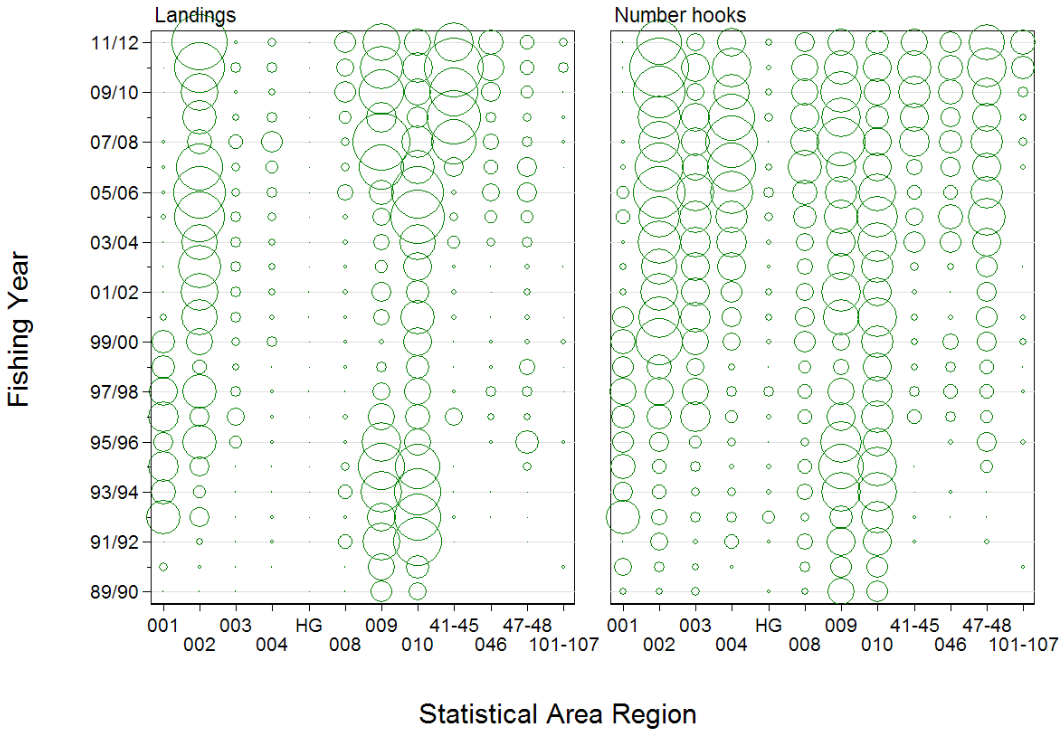

Figure 6: Distribution of landings and number of hooks/sets for the bottom longline method by Statistical Area Region (see Table 9 for definition) and fishing year from trips landing to LIN 1. Circles are proportional within each panel: [landings] largest circle= 105 t in 10/11 for Region 041–045; [number hooks] largest circle= 9.31 × 10^5 hooks in 10/11 for Area 002.

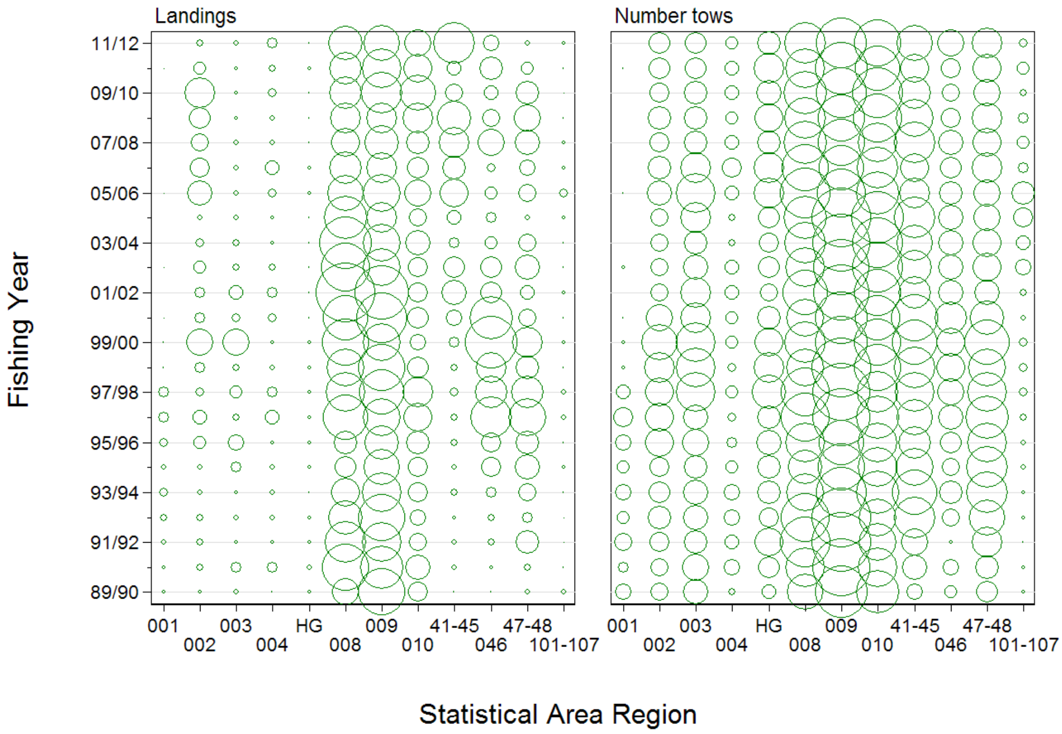

Figure 7: Distribution of landings and number of tows for the bottom trawl method by Statistical Area Region (see Table 9 for definition) and fishing year from trips landing to LIN 1. Circles are proportional within each panel: [landings] largest circle= 91 t in 01/02 for Area 008; [number tows] largest circle=2104 tows in 92/93 for Area 009.

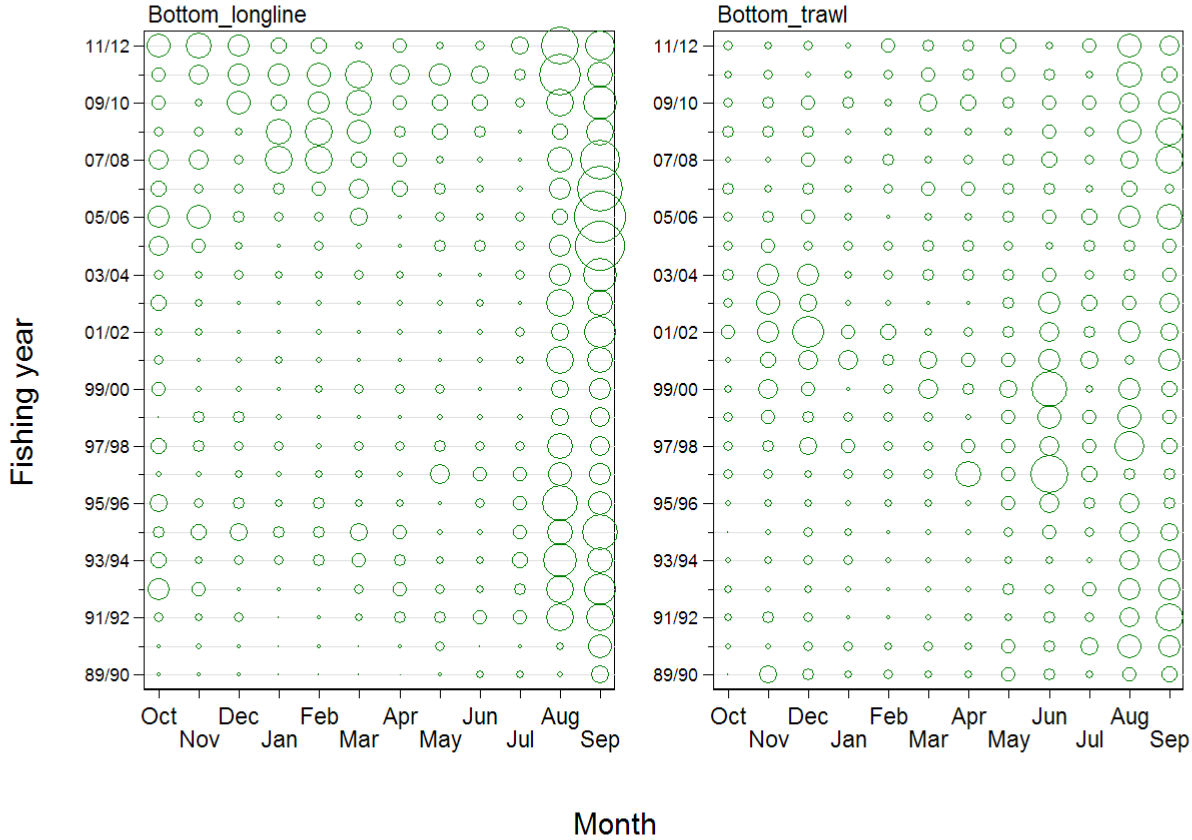

Figure 8: Total landings by month and fishing year for bottom longline and bottom trawl based on trips which landed LIN 1. Circles sizes are proportional across panels with the largest circle= 119 t for bottom longline in September 05/06.

Bottom longline landings of LIN 1 have a wide sporadic distribution, with the Bay of Plenty landings coming primarily from Statistical Areas 009 and 010 (Figure 6). Bottom longline landings increased since about 2000 in East Northland Statistical Area 002, fell off considerably in 2007–08 but then increased to levels similar to those observed in the mid-2000s (Figure 6). The distribution of bottom longline effort by year shows much effort in Areas 003 and 004 and on the west coast North Island, areas which take relatively less LIN 1 (Figure 6). It is likely that this is effort directed at other species, such as snapper. The distribution of bottom trawl effort is broader than the distribution of the catch, with effort taking some LIN 1 in East Northland and on the west coast in most years (Figure 7). It is difficult to know if there are any trends in the effort or landings, due to the small amount of landings and the diverse fisheries which take this species. However, the landings of LIN 1 in the Bay of Plenty trawl fishery appear to have dropped in recent years and the recent increase in LIN 1 landings appears to come from increased bottom longline landings in East Northland and the Bay of Plenty (Figure 6 and Figure 7).

The bottom longline landings of LIN 1 are taken mainly in the final two months of the fishing year while the bottom trawl landings of LIN 1 have been more evenly distributed across the year (Figure 8; Table 12). There is some convergence between the two fisheries, with the BLL landings becoming more seasonally widespread from 2007–08 onwards while there is a suggestion that the importance of August and September bottom trawl landings is increasing (Figure 8; Table 12). Both fisheries have relatively sporadic seasonal patterns, probably reflecting the small amount of landings in most years and the by-catch nature of many of the fisheries. Bottom longline landings of ling are concentrated in the last two months of the fishing year in both East Northland and the Bay of Plenty while the west coast North Island longline fishery is more spread out in the fishing year (Figure 9). The seasonal pattern of the bottom trawl fishery by region shows that the Bay of Plenty fishery extends relatively evenly through the fishing year while the other regions are more sporadic in their seasonal timing (Figure 10). This broader seasonal pattern in the west coast fishery probably reflects the large commitment required to fish in this area.

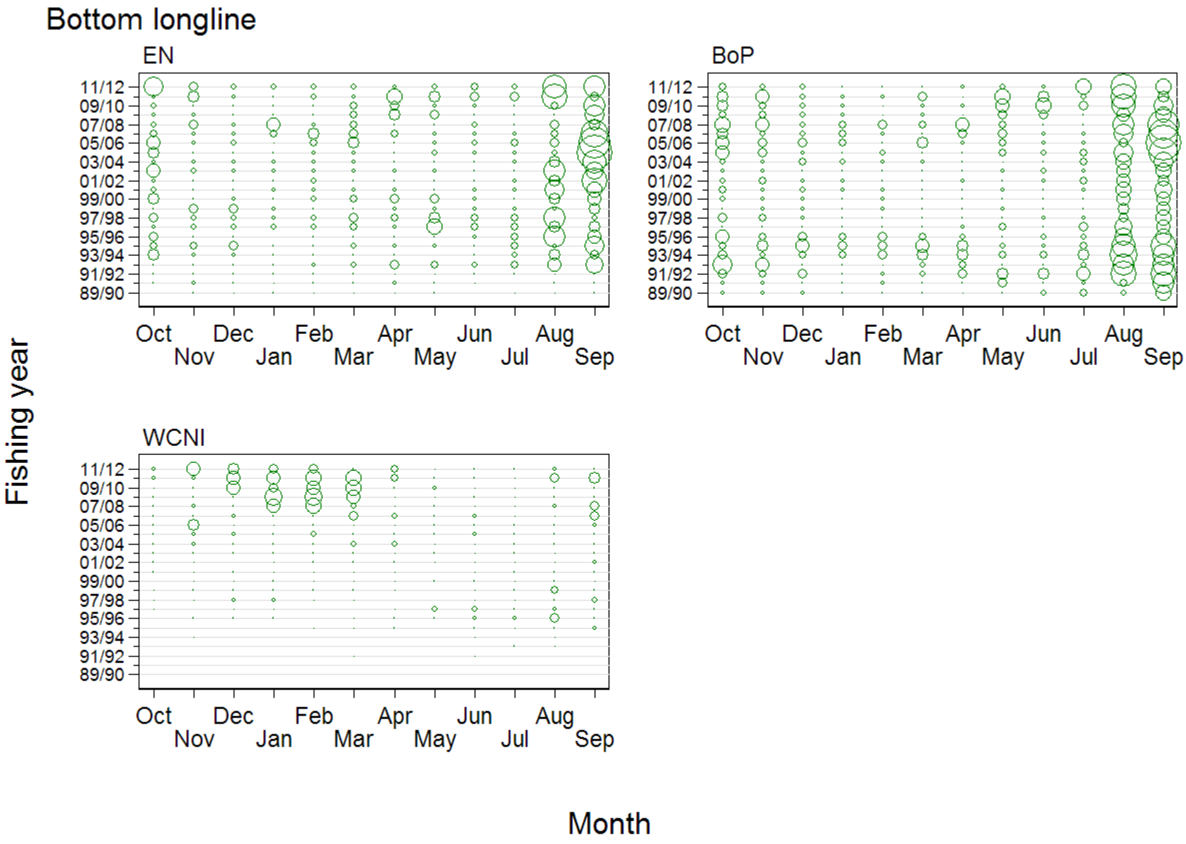

Figure 9: Distribution of landings for the bottom longline method by grouped statistical area (see Table 9 for definition) for month and fishing year from trips which landed LIN 1. Circle sizes are proportional across panels: maximum value: 67 t for EN 04/05 in September. HG plot not shown because of negligible BLL landings.

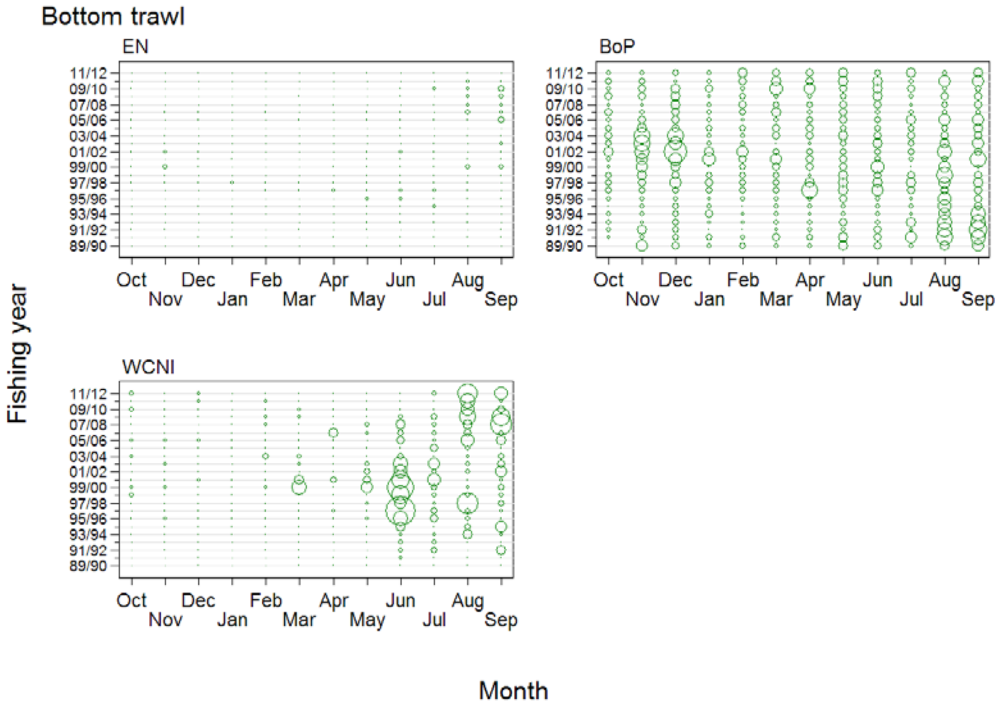

Figure 10: Distribution of landings for the bottom trawl method by grouped statistical area (see Table 9 for definition) for month and fishing year from trips which landed LIN 1. Circle sizes are proportional across panels: maximum value: 75 t for WCVI 96/97 in June. HG plot not shown because of negligible BT landings.

Table 11: **Percent distribution of landings by region (Table 9) from 1989–90 to 2011–12 for the bottom trawl and bottom longline methods for trips which landed LIN 1. Annual landings by method are available in Table 12 and the rows sum to 100%. '–': no data.**

Fishing Year	Bottom trawl (%) EN	HG	BoP	WCNI	Bottom longline (%) EN	HG	BoP	WCNI
	Region				Region			
89/90	2	0	97	1	2	0	98	–
90/91	5	0	93	2	7	–	93	–
91/92	3	0	83	14	2	0	98	0
92/93	4	0	91	5	35	0	65	0
93/94	5	0	81	14	16	0	84	0
94/95	6	0	64	30	23	0	75	2
95/96	13	0	59	28	37	0	50	13
96/97	7	0	52	40	48	0	40	12
97/98	7	0	63	30	61	0	32	8
98/99	4	0	71	25	44	0	39	17
99/00	17	0	42	41	62	0	36	2
00/01	3	0	66	31	49	0	48	2
01/02	5	0	79	16	61	0	36	3
02/03	4	0	71	25	66	0	32	2
03/04	3	0	87	11	43	0	46	10
04/05	2	0	88	10	43	0	51	6
05/06	14	0	62	24	39	0	50	10
06/07	16	0	61	23	36	0	48	16
07/08	7	0	49	44	17	0	53	30
08/09	9	0	50	41	23	0	25	52
09/10	16	0	67	17	20	0	42	38
10/11	5	0	75	20	28	0	30	42
11/12	3	0	60	37	39	0	31	29
total	7	0	68	25	33	0	49	18

Table 12: **Percent distribution of landings by month and total annual landings (t) of LIN 1 from 1989–90 to 2011–12 for the bottom trawl and bottom longline methods for trips which landed LIN 1. Landings (t) have been scaled to the adjusted QMR totals $\left(\tilde{\mathrm{Q}}\mathrm{MR}_y\right)$ using Eq. 1.**

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (t)
	Month												
Bottom Longline (%)													
89/90	2.2	4.6	3.4	1.4	1.3	1.1	0.1	1.7	10.1	12.5	7.1	54.5	24.5
90/91	1.5	4.0	1.2	0.5	2.3	0.9	2.1	11.5	0.5	2.3	7.8	65.4	40.5
91/92	4.4	2.5	3.9	0.3	0.9	1.9	5.3	5.8	7.1	7.6	31.0	29.4	122.2
92/93	15.6	6.9	0.3	0.6	0.8	3.4	6.0	3.3	1.6	4.4	25.3	31.8	138.6
93/94	8.7	2.1	3.0	2.9	4.3	6.0	5.0	2.0	2.2	7.4	34.4	22.0	146.2
94/95	4.0	7.0	9.2	3.6	3.5	8.2	5.5	1.3	0.9	4.7	18.1	34.0	170.0
95/96	11.3	3.5	4.4	2.4	4.6	2.7	1.7	0.6	3.8	5.7	41.2	18.1	137.8
96/97	1.3	2.2	2.8	2.0	2.8	3.3	1.3	19.5	7.8	9.0	27.6	20.3	99.0
97/98	10.8	5.6	4.2	3.7	1.9	5.2	3.8	7.3	4.3	4.2	32.6	16.7	101.4
98/99	0.4	12.0	11.6	3.5	1.8	1.4	1.6	2.2	2.9	3.5	25.3	33.8	53.0
99/00	14.4	1.9	2.3	1.4	3.4	5.5	7.2	7.1	1.4	0.9	23.3	31.2	69.2
00/01	5.6	1.3	2.1	2.7	2.0	1.0	1.1	1.2	1.7	2.8	41.9	36.6	86.1
01/02	4.1	3.7	1.2	1.2	2.3	0.9	1.8	0.6	1.8	6.1	19.8	56.5	79.3
02/03	12.0	2.5	1.0	1.1	1.3	1.0	1.4	1.8	2.7	0.8	39.6	34.7	90.0
03/04	3.9	2.9	3.7	3.3	2.2	5.1	3.2	0.5	0.6	4.7	20.0	49.9	104.4
04/05	9.1	4.2	1.6	0.5	2.7	0.7	0.6	3.1	3.0	2.4	12.6	59.7	189.9
05/06	9.9	11.5	2.9	1.7	1.8	6.2	0.4	2.4	1.5	1.9	5.3	54.4	217.9
06/07	5.8	1.9	2.2	3.8	4.5	9.0	6.4	3.8	1.3	1.0	11.8	48.6	199.5
07/08	7.0	7.4	1.6	15.3	13.8	5.0	4.0	1.3	0.8	0.4	13.6	29.8	244.5
08/09	2.6	2.9	1.8	18.2	20.4	14.3	4.3	6.2	3.3	0.5	5.9	19.5	174.0
09/10	4.5	1.4	10.7	5.5	9.3	14.1	3.5	5.1	5.8	2.1	15.5	22.4	225.1
10/11	3.0	6.0	7.7	7.3	8.5	11.7	6.0	6.5	4.8	2.2	26.3	10.0	315.1
11/12	10.9	12.5	8.2	4.8	4.9	1.1	4.1	1.4	1.8	6.3	28.0	16.1	245.6
Mean	6.9	5.3	4.4	4.9	5.6	6.0	3.7	3.9	2.9	3.5	21.5	31.4	3274.0[1]

Fishing Year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (t)
	Bottom Trawl(%)												
89/90	0.1	19.4	9.3	3.3	6.6	4.0	3.5	11.7	8.9	4.1	12.0	17.0	89.6
90/91	1.2	1.9	4.8	4.3	2.8	5.1	3.5	9.3	6.2	14.0	25.8	20.9	132.3
91/92	2.8	9.0	5.0	0.6	0.7	1.5	3.0	3.2	7.7	5.2	21.8	39.4	112.3
92/93	2.9	1.5	4.4	1.6	1.4	2.5	2.8	8.7	6.3	13.2	27.2	27.5	102.4
93/94	3.0	3.9	6.5	8.3	2.2	2.8	2.3	4.2	4.6	3.0	28.4	30.8	86.0
94/95	0.3	3.1	7.2	4.2	0.9	3.2	2.6	5.6	14.0	6.9	28.8	23.1	88.3
95/96	2.9	3.6	3.9	2.1	3.6	3.6	2.7	13.1	26.2	7.9	22.3	8.2	98.8
96/97	2.5	3.2	2.3	2.8	3.2	2.5	18.5	5.5	43.7	7.1	4.6	4.1	207.2
97/98	3.7	4.4	9.4	6.1	3.3	3.6	6.1	6.4	13.5	7.1	27.8	8.6	189.6
98/99	4.5	7.7	5.1	3.4	3.4	4.2	1.0	8.2	23.6	7.8	23.1	8.0	149.0
99/00	1.8	10.9	5.8	0.4	2.4	10.8	4.2	8.6	34.9	1.8	12.0	6.5	234.6
00/01	1.4	7.5	11.4	10.8	3.7	10.5	5.5	5.9	15.5	9.2	3.6	15.0	202.8
01/02	4.9	12.5	26.9	5.3	7.0	1.9	2.3	4.4	9.9	3.7	12.4	8.8	220.4
02/03	3.8	21.2	12.3	1.6	1.8	0.8	0.9	5.1	18.2	11.0	8.5	14.7	154.7
03/04	5.1	20.4	19.5	2.5	4.4	6.8	6.4	6.6	8.7	4.7	6.5	8.1	144.1
04/05	5.8	14.0	7.0	6.9	6.4	7.8	10.1	6.8	4.9	10.4	8.4	11.5	92.8
05/06	4.1	6.5	7.1	2.4	1.0	2.9	3.2	6.6	7.7	9.6	21.9	27.0	145.2
06/07	9.4	3.9	8.9	3.3	6.8	11.8	11.2	9.3	8.0	4.8	15.3	7.2	101.0
07/08	1.6	1.3	9.1	2.5	6.5	3.5	4.7	7.3	11.4	3.6	13.9	34.6	135.8
08/09	5.4	5.5	6.7	1.3	3.1	2.9	2.9	3.1	8.7	4.3	25.1	30.9	143.3
09/10	3.9	5.2	7.2	4.8	2.1	12.6	10.7	5.9	8.4	6.8	14.0	18.3	156.5
10/11	3.9	4.9	2.2	2.7	6.0	8.8	6.1	8.7	8.4	3.4	32.5	12.5	120.2
11/12	4.0	2.6	4.7	1.6	8.8	5.4	6.4	10.6	3.3	9.0	25.2	18.3	137.2
Mean	3.4	7.8	8.7	3.6	3.8	5.4	5.5	7.0	14.8	6.8	17.2	16.1	3 244.0

[1] Total for all fishing years for method

About one-half of the LIN 1 landings are taken by target fishing for ling, mainly in the longline fishery (Table 13). The most important bottom trawl fishery taking ling is the scampi fishery, but it still only accounts for about one-third of the bottom trawl catch of LIN 1 (Table 13; Figure 11). Other important bottom trawl fisheries which have taken LIN 1 include the gemfish, hoki and tarakihi fisheries (Figure 11). The other longline fisheries which take significant amounts of LIN 1 include the target bluenose, hapuku/bass and ribaldo fisheries. There has been some variation in the importance of some of these fisheries over the 23 years of data, with an apparent decline in recent years of the by-catch of LIN 1 in the target scampi and gemfish bottom trawl fisheries, reflecting quota cuts in both of these fisheries (Table 14; Figure 11). On the other hand, there has been an increase in recent years in the bottom longline landings of target ling fishing, probably contributing to the recent rise in overall LIN 1 landings (Figure 11).

Table 13: Landings (t) and distribution of landings (%) of ling from trips which landed LIN 1 by target species and important fishing methods (Table 9), summed from 1989–90 to 2011–12. Landings (t) have been scaled to the adjusted QMR totals $\left(\tilde{\text{Q}}\text{MR}_y\right)$ using Eq. 1. '–': no landings.

Target Species	Fishing Method				Fishing Method			
	BLL	BT	Other	Total	BLL	BT	Other	Total
	Total landings (t)				**Distribution (%)**			
LIN	2 596	626	32	3 255	39.2	9.4	0.5	49.1
SCI	–	987	–	987	–	14.9	–	14.9
SKI	4	649	11	665	0.1	9.8	0.2	10.0
HOK	0	527	3	531	0.0	7.9	0.1	8.0
BNS	333	1	9	343	5.0	0.0	0.1	5.2
TAR	1	268	14	283	0.0	4.0	0.2	4.3
RIB	176	0	0	176	2.6	0.0	0.0	2.7
HPB	124	0	27	151	1.9	0.0	0.4	2.3
SNA	13	53	3	70	0.2	0.8	0.1	1.1
OTH	27	132	8	167	0.4	2.0	0.1	2.5
Total	3 274	3 244	108	6 626	49.4	49.0	1.6	100.0

Table 14A: Percent distribution of landings by target species (Table 9) from 1989–90 to 2011–12 for bottom longline which landed LIN 1. The final column shows the percent landing for BLL in each fishing year. Annual landings by method are available in Table 12. '–': no data.

Fishing	Declared Target Species							
year	LIN	BNS	RIB	HPB	SPO	SNA	OTH	Total
	Bottom longline							
89/90	11.6	83.6	1.2	1.3	–	1.5	0.9	0.7
90/91	66.6	29.6	0.6	2.7	–	0.4	0.0	1.2
91/92	79.7	5.3	13.3	1.5	–	0.1	0.1	3.7
92/93	83.4	5.9	5.9	4.4	–	0.2	0.1	4.2
93/94	68.8	9.8	5.5	7.2	8.7	0.1	0.1	4.5
94/95	69.6	9.8	15.3	2.9	0.9	0.3	1.2	5.2
95/96	70.9	6.3	13.3	2.1	5.7	0.1	1.5	4.2
96/97	70.7	16.9	9.8	2.0	–	0.6	0.0	3.0
97/98	76.9	15.5	–	6.6	–	0.6	0.5	3.1
98/99	52.6	20.6	14.4	11.1	–	0.8	0.6	1.6
99/00	56.4	20.4	11.9	7.6	–	3.1	0.6	2.1
00/01	73.6	16.6	0.4	5.6	–	2.9	1.0	2.6
01/02	70.8	18.0	1.1	7.3	–	1.9	0.9	2.4
02/03	84.4	8.4	0.3	5.6	–	1.0	0.3	2.7
03/04	66.9	13.7	4.2	14.2	–	0.6	0.3	3.2
04/05	79.3	12.1	3.7	4.6	–	0.2	0.2	5.8
05/06	78.4	8.7	8.9	3.7	–	0.1	0.1	6.7
06/07	79.1	9.8	7.6	3.2	–	0.2	0.1	6.1
07/08	86.6	8.2	3.5	1.5	0.0	0.1	0.0	7.5
08/09	85.6	5.4	7.4	1.3	–	0.2	0.2	5.3
09/10	90.3	7.0	1.1	1.4	0.0	0.1	0.2	6.9
10/11	91.0	5.8	0.4	2.6	–	0.1	0.1	9.6
11/12	92.3	5.3	0.1	2.3	–	0.1	0.0	7.5
Mean	79.3	10.2	5.4	3.8	0.7	0.4	0.3	100.0

Table 14B. Percent distribution of landings by target species (Table 9) from 1989–90 to 2011–12 for bottom trawl which landed LIN 1. The final column shows the percent landing for BT in each fishing year. Annual landings by method are available in Table 12.

	Declared Target Species											
	SCI	SKI	LIN	HOK	TAR	SNA	TRE	RBY	BAR	GUR	OTH	Total
	Bottom trawl											
89/90	77.2	11.6	0.2	0.2	4.8	3.9	0.6	0.0	0.7	0.0	0.8	2.8
90/91	78.7	11.1	0.0	0.3	7.0	1.6	0.6	0.0	0.2	0.1	0.6	4.1
91/92	66.5	14.4	7.1	0.6	7.4	2.7	0.3	0.1	0.4	0.3	0.4	3.5
92/93	46.7	22.0	4.6	6.8	10.5	2.7	0.8	0.2	4.2	1.0	0.6	3.2
93/94	53.5	8.8	6.9	1.2	21.4	2.4	1.0	0.0	3.4	0.7	0.5	2.7
94/95	38.5	25.6	5.4	3.2	21.0	2.9	0.8	0.0	1.2	0.2	1.2	2.7
95/96	17.4	52.5	0.8	6.1	15.2	5.8	0.4	0.0	1.1	0.2	0.6	3.0
96/97	6.4	49.3	0.3	29.6	9.8	1.8	1.0	0.0	0.5	0.3	0.8	6.4
97/98	11.6	45.8	0.9	27.0	8.8	1.8	0.9	0.5	0.7	0.4	1.7	5.8
98/99	13.9	36.1	11.8	24.1	8.5	1.9	1.3	0.4	1.0	0.3	0.7	4.6
99/00	29.5	29.3	7.8	24.6	4.3	0.9	1.0	0.0	0.4	0.3	1.9	7.2
00/01	36.4	33.5	4.8	11.9	7.8	1.1	1.1	1.4	0.4	0.6	0.9	6.2
01/02	41.7	14.1	13.3	15.8	4.4	0.7	0.6	0.5	0.4	0.3	8.2	6.8
02/03	31.8	27.7	23.5	6.0	6.7	0.9	0.7	0.1	0.1	1.0	1.5	4.8
03/04	36.9	10.2	14.1	26.5	8.9	1.5	0.8	0.0	0.2	0.4	0.5	4.4
04/05	49.2	5.0	11.8	18.2	9.7	2.0	1.4	0.3	0.2	0.9	1.3	2.9
05/06	15.3	2.5	59.5	11.4	6.4	1.3	0.7	0.1	0.1	0.5	2.2	4.5
06/07	27.3	2.8	37.5	19.2	7.4	2.3	1.1	0.5	0.0	0.2	1.7	3.1
07/08	11.5	7.5	58.5	11.8	5.0	0.9	0.8	0.9	0.0	0.4	2.6	4.2
08/09	14.2	2.1	61.5	10.8	7.0	0.9	0.9	1.5	0.0	0.3	0.8	4.4
09/10	12.3	2.4	48.3	26.1	6.2	0.5	0.6	2.1	0.0	0.3	1.2	4.8
10/11	20.9	2.4	33.8	25.6	9.8	0.7	1.7	2.4	0.2	0.2	2.4	3.7
11/12	18.5	3.1	35.8	29.1	8.0	1.1	1.6	1.9	0.0	0.2	0.7	4.2
Mean	30.4	20.0	19.3	16.2	8.3	1.6	0.9	0.6	0.6	0.4	1.7	100.0

Target bottom longline fishing for ling predominates in both the Bay of Plenty and East Northland, with both fisheries showing an increase in recent fishing years (Figure 12). The west coast North Island longline landings of ling appear to be split between a target ling fishery and by-catch from the target bluenose/hapuku longline fishery.

Target fishing patterns in the bottom trawl fishery by region show a decline in LIN 1 landings in the Bay of Plenty scampi trawl fishery in recent years as well as the disappearance of ling by-catch in the gemfish Bay of Plenty trawl fishery (coinciding with the reduction in SKI 1 TACC; Figure 13). The by-catch of ling by the west coast North Island gemfish trawl fishery ceased around 2002–03, again coinciding with the reduction in SKI 1 TACC, but this fishery has been replaced with a trawl fishery targeting ling. There is a relatively consistent by-catch of ling in both the Bay of Plenty and East Northland target tarakihi trawl fisheries as well as in the target hoki fishery in the Bay of Plenty.

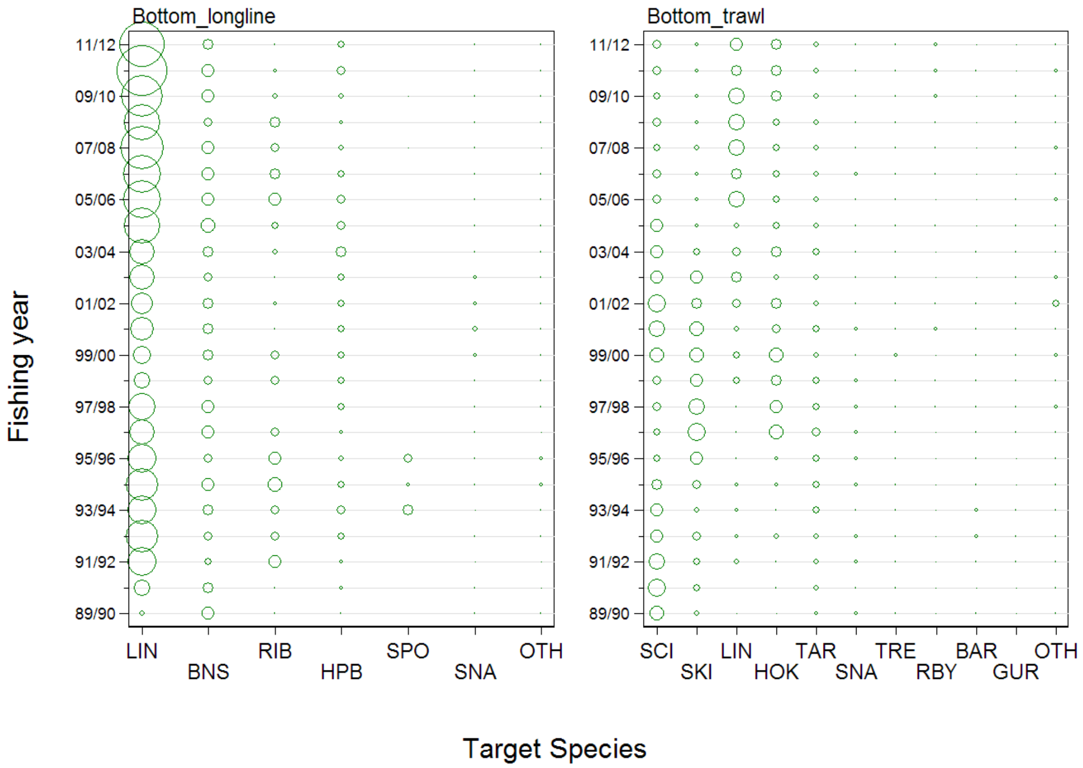

Figure 11: Total landings by target species (Table 9) and fishing year for the bottom longline and bottom trawl methods based on trips which landed LIN 1. Circle sizes are proportional across panels with the largest circle= 287 t for targeting LIN by bottom longline in 10/11.

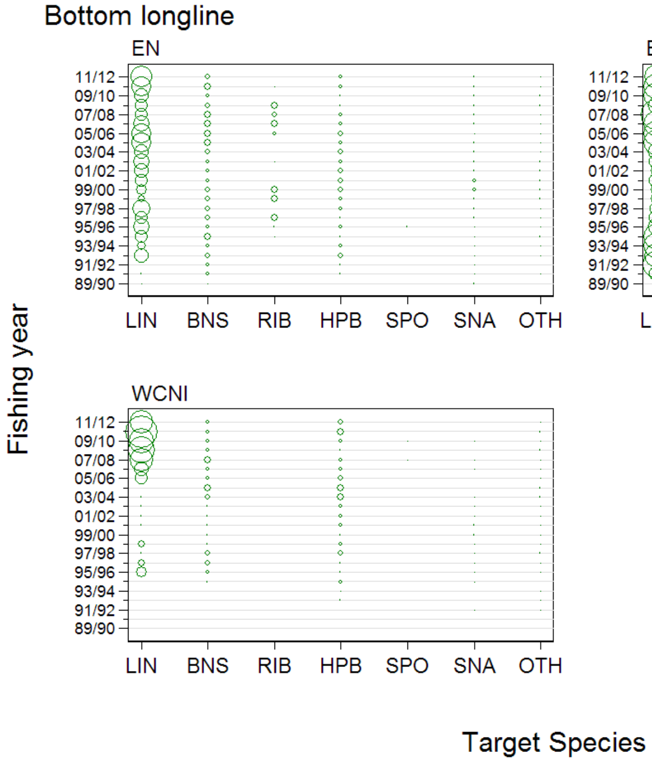

Figure 12: Distribution of landings for the bottom longline method by grouped statistical area (see Table 9 for definition) for target species and fishing year from trips which landed LIN 1. Circle sizes are proportional across panels: maximum value: 126 t for LIN in WCVI 10/11. HG plot not shown because of negligible BLL landings.

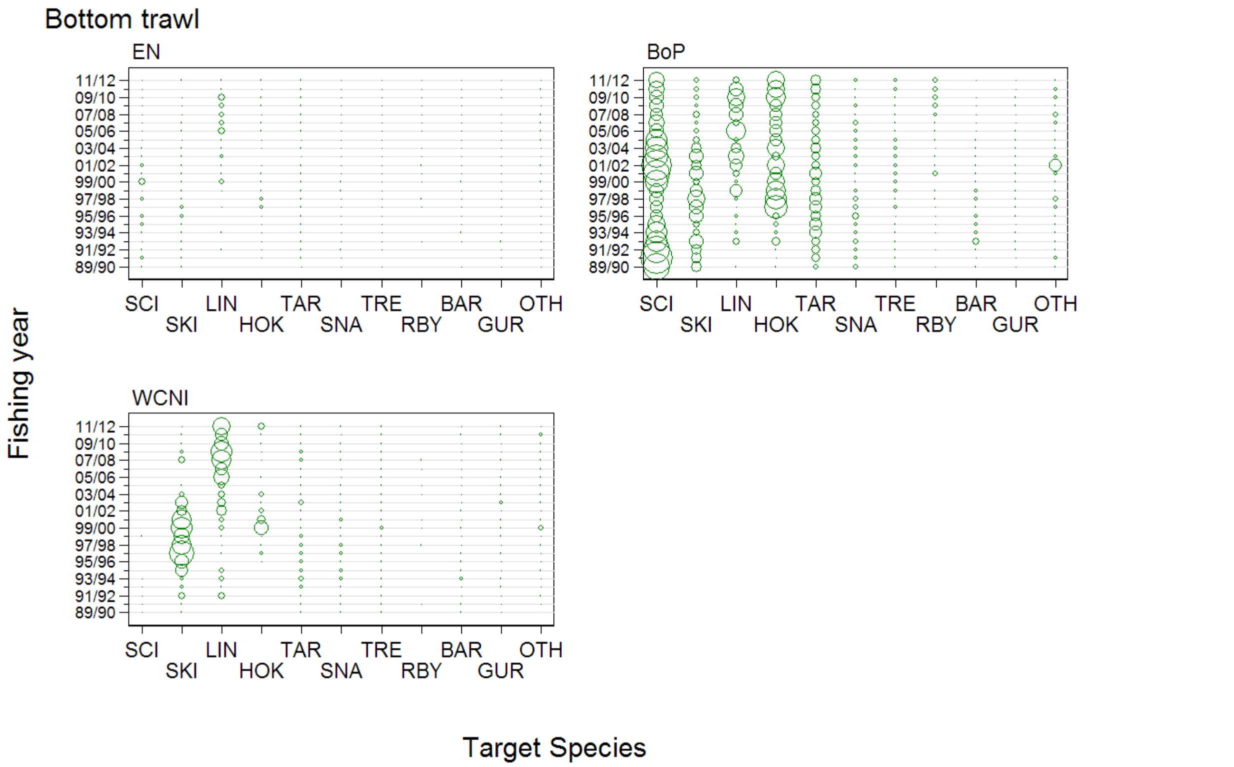

Figure 13: Distribution of landings for the bottom trawl method by grouped statistical area (see Table 9 for definitions) for target species and fishing year from trips which landed LIN 1. Circles sizes are proportional across panels: maximum value: 100 t for SCI in BoP 90/91. HG plot not shown because of negligible BT landings.

Table 15: Summary statistics from distributions of bottom depth from TCEPR, TCER, LCER, and LTCER forms using the bottom trawl and bottom longline methods for effort that targeted or caught ling by target species category. These statistics are derived from a set of effort data selected for LIN 1 for the period 2007–08 to 2011–12.

		Depth (m)			
Target species category	**Number observations**	**Lower 5% of distribution**	**Mean of distribution**	**Median (50%) of distribution**	**Upper 95% of distribution**
Bottom trawl					
SCI	1 333	348	391	392	430
TAR	1 176	78	164	156	260
HOK	566	300	402	400	477
LIN	473	225	399	417	480
SKI	193	165	304	330	407
RBY	129	160	333	350	438
JDO	49	57	90	89	130
SNA	43	43	107	90	265
GUR	38	48	90	90	125
SDO	22	320	414	423	450
TRE	19	37	70	70	120
SCH	15	161	220	198	430
Other	46	210	492	450	867
Total	4 102	90	312	365	450
Bottom longline					
LIN	2 087	320	537	550	665
BNS	1 352	335	480	484	628
HPB	423	170	299	290	490
SNA	153	24	76	75	127
RIB	105	630	644	650	660
Other	32	48	173	160	300
Total	4 152	170	477	500	660

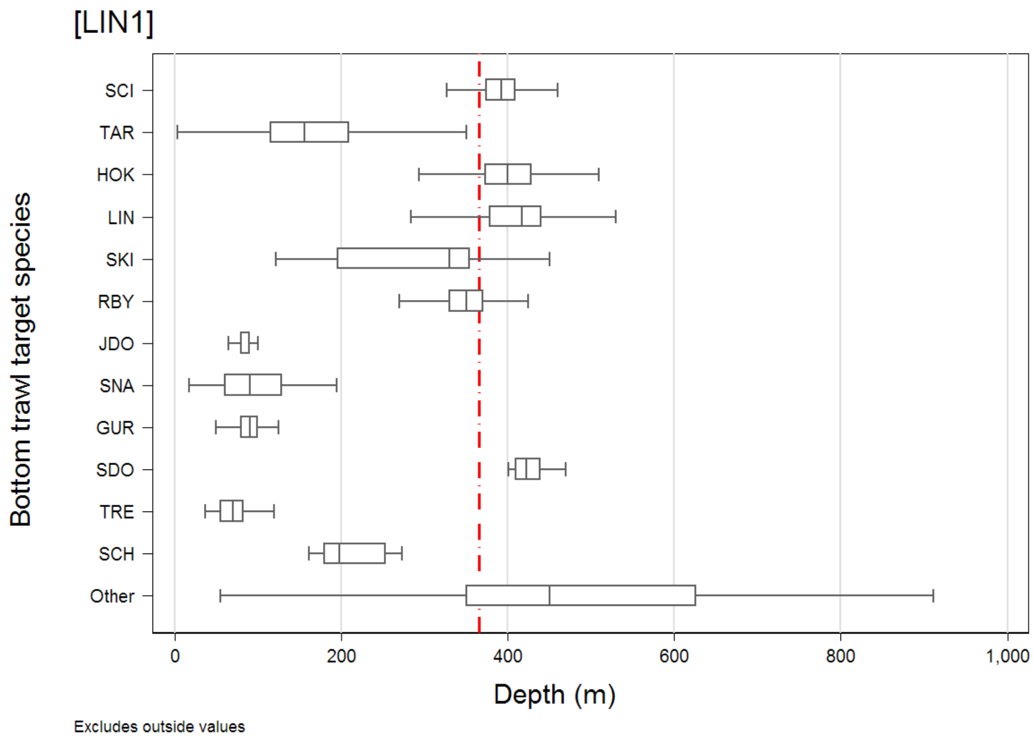

Figure 14: Box plot distributions of bottom depth from TCEPR and TCER forms using the bottom trawl method for effort that targeted or caught ling by target species category. These statistics are derived from a set of effort data for LIN 1 for the period 2007–08 to 2011–12. Vertical line indicates the median depth from all tows which caught or targeted ling.

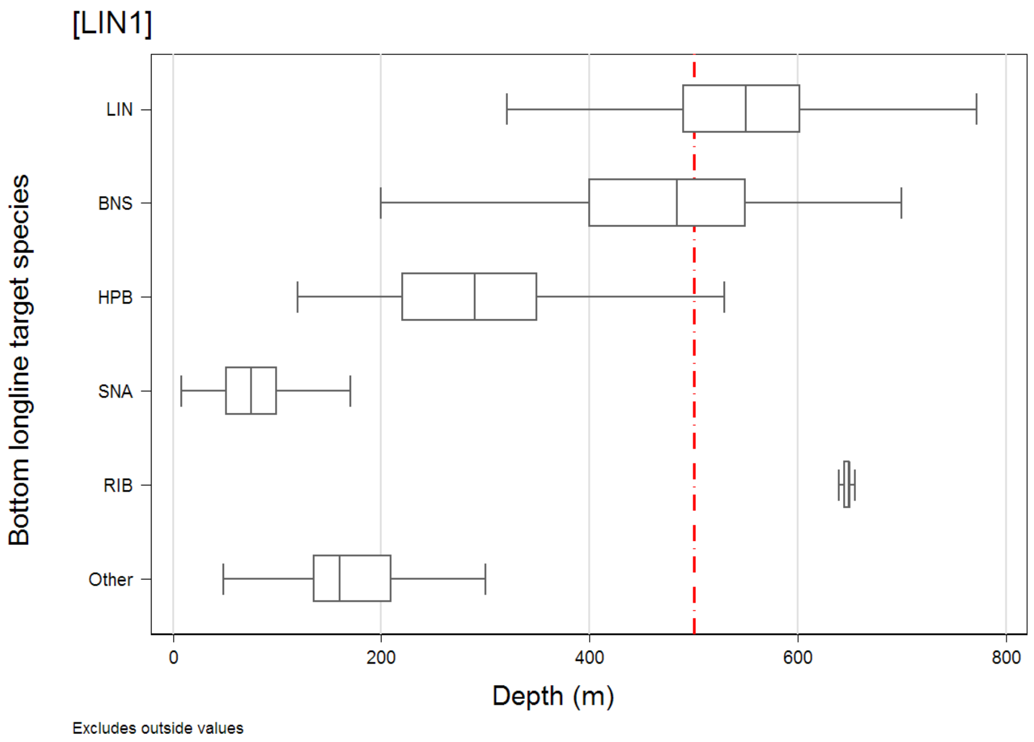

Figure 15: Box plot distributions of bottom depth from LCER and LTCER forms using the bottom longline method for effort that targeted or caught ling by target species category. These statistics are derived from a set of effort data for LIN 1 covering the period 2007–08 to 2011–12. Vertical line indicates the median depth from all tows which caught or targeted ling.

Depth information by fishing event is available from TCEPR and the new TCER forms which report bottom trawl catches pertaining to ling (either recording an estimated catch or as target species; Table 15) and from longline vessels completing the new LCER and LTCER forms. These reports show that trawl-caught ling are mainly taken between 90 and 450 m of depth, with the median value at 365 m). Bottom longline fisheries went deeper: the 5–95 percentiles are 170 to 660 m, with mean 477 m and median 500 m.

The distribution of tows which caught or targeted ling varies mainly according to the target fishery, with deeper fisheries such as scampi, gemfish, hoki, and ling target bottom trawl taking ling in deeper waters compared to the more shallow trawl fisheries such as tarakihi, barracouta, trevally and snapper (Figure 14). The ling target bottom longline fishery has a relatively deep depth distribution, deeper than the target trawl hoki, gemfish and scampi fisheries: 5–95% range is 320–665 m for target LIN bottom longline and 225–480 m for target LIN bottom trawl (Figure 15; Table 15).

3 LIN 1 STANDARDISED CPUE ANALYSIS

The geographic complexity of the ling fishery in LIN 1 is high, with diverse fisheries operating on the west coast of the North Island, as well as off the upper east coast in East Northland and in the Bay of Plenty. The main difficulty with the fisheries in this QMA is that there are so many and the amount of data available is small, given the size of the TACC (Table 1). When this amount of catch is divided among eight to ten fisheries, the amount available for any one fishery is usually too little to perform a standardised CPUE analysis. Each of the previous reviews of the LIN 1 fisheries has attempted to extract as much information as possible from these data, with little success because most of the potential fisheries had too little associated landings or effort (SeaFIC 2005, Starr et al. 2007, 2009).

The 2007 and 2009 reviews of the LIN 1 AMP concluded that only the bycatch of ling in the target scampi bottom trawl fishery operating in the Bay of Plenty and the target ling bottom longline fishery operating in the Bay of Plenty and East Northland had sufficient information to warrant attempting a standardised CPUE analysis (Starr et al. 2007, 2009). These analyses were repeated in 2013, although both of the earlier reviews concluded that the SCI bottom trawl series was not fully satisfactory or credible and that the target LIN BLL series had many shortcomings.

The Bay of Plenty BT(SCI) fishery and the East Northland/Bay of Plenty BLL(LIN) fishery were selected in 2009 to proceed with a standardised analysis, largely because they represented the greatest amount of LIN 1 catch and effort in definable fisheries (Table 16). Following a recommendation from the 2009 review, an alternative bottom trawl index series from the East Northland/Bay of Plenty bottom trawl fisheries targeted at LIN, HOK and TAR was developed for the 2013 [designated BT(MIX)]. The BT(SCI) fishery was dominated by the MPI TCEPR forms in the early years, allowing this analysis to be made on a tow event basis. An event-based analysis was also followed for the BT(MIX) fishery. The BLL(LIN) was selected because it is a ling target fishery covering a large area on the east side of the North Island, in spite of problems with lack of data. These analyses are presented in Appendix D [BLL(LIN)], Appendix F [BT(SCI)], and Appendix G [BT(MIX)].

Table 16: Summary of information available for the major LIN 1 fisheries from the characterisation dataset, with all catch and efforts totals summed from 1989–90 to 2011–12. Codes for target species, region and method codes are described in Table 9. Effort totals are in number of tows for BT and number of sets for BLL. Fisheries selected for standardised CPUE analysis are indicated in grey.

	Bottom longline				Bottom trawl			
Fishery	**EN**	**BoP**	**WCNI**	**Total**	**EN**	**BoP**	**WCNI**	**Total**
Landings (t)								
BoP BT(SCI)	–	–	–	–	–	900.8	–	900.8
EN_BoP BT(LIN/HOK/TAR)	–	–	–	–	135.0	857.5	–	992.5
EN_BoP BLL(LIN)	827.9	1 194.4	–	2 022.3	–	–	–	–
EN_BoP BT(SKI)	–	–	–	–	34.3	229.0	–	263.4
EN_BoP BLL(BNS)	105.8	176.7	–	282.6	–	–	–	–
WCNI BT(SKI)	–	–	–	–	–	–	355.9	355.9
WCNI BLL(LIN	–	–	491.2	491.2	–	–	–	–
WCNI BLL(BNS)	–	–	34.3	34.3	–	–	–	–
Effort (BLL=sets; BT=tows)								
BoP BT(SCI)	–	–	–	–	–	15 129	–	15 129
EN_BoP BT(LIN/HOK/TAR)	–	–	–	–	7 905	30 357	–	38 262
EN_BoP BLL(LIN)	1 839	2 745	–	4 584	–	–	–	–
EN_BoP BT(SKI)	–	–	–	–	2 632	6 284	–	8 916
EN_BoP BLL(BNS)	6 825	8 319	–	15 144	–	–	–	–
WCNI BT(SKI)	–	–	–	–	–	–	1 977	1 977
WCNI BLL(LIN	–	–	1 085	1 085	–	–	–	–
WCNI BLL(BNS)	–	–	2 048	2 048	–	–	–	–

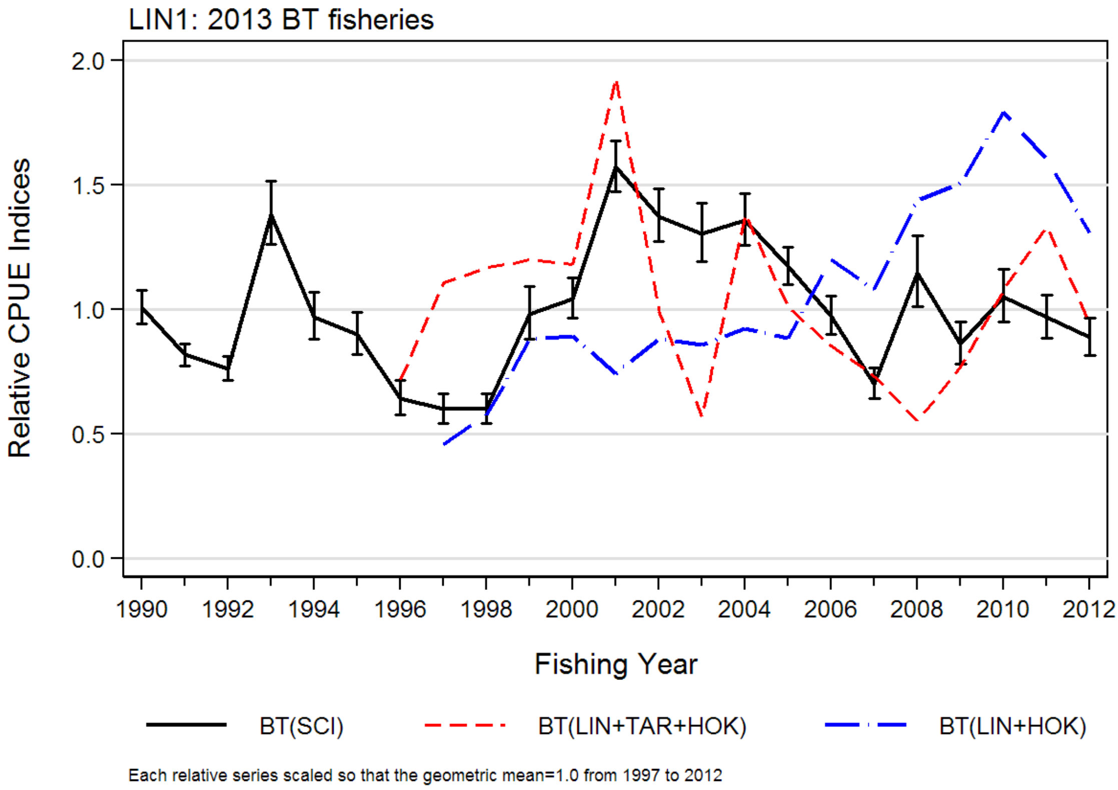

Figure 16: Comparison of three 2013 LIN 1 bottom trawl standardised CPUE models: A) model fitted to SCI target species data using the log.logistic distribution for positive catches; B) model fitted to target species data for LIN, HOK or TAR using the lognormal distribution for positive catches; C) model fitted to target species data for LIN or HOK using the lognormal distribution for positive catches. Model 'A' is reported in Appendix F, model 'B' is reported in Appendix G and model 'C' is not reported.

When these analyses were presented in March 2013, the NINSWG rejected the two standardised CPUE analyses based on bottom trawl data (see discussion in Chapter 42 of MPI 2016). The reasons for this conclusion included the relatively small amount of data available to each of these fisheries, the small number of vessels operating in the BT(SCI) fishery, the abrupt jumps in each series which led to the conclusion that the year indices were responding to unmodelled factors other than abundance. The change in trend direction in the BT(MIX) series when the TAR target tows were omitted reinforced the conclusion that this was not an abundance-based series (Figure 16).

The NINSWG also reviewed the BLL(LIN) series, noting the lack of data in many of the years, but agreeing that the BLL(LIN) target index had more potential as an abundance index for LIN 1. However, there is a large anomalous peak in the series in 1998–99 (Figure 17) that troubled the WG and there was concern about the small amount of data in the analysis. Closer examination of the data showed that the anomalous 1998–99 peak was associated with only two vessels fishing at the end of the fishing year (Table 17). Although it cannot be reported in detail, these vessels were experienced and likely to have been fishing in localised areas. On the basis of this information, the NINSWG concluded that this pattern was likely to be non-representative of the fishery, with the standardisation model unable to estimate a credible index in that year. The NINSWG tentatively accepted the BLL(LIN) index series (Figure 17) as an index of LIN 1 abundance, coupled with the requirement that each accepted CPUE index value had to be determined by at least three vessels, thus removing the 1998–99 index value. The NINSWG gave the BLL(LIN) series a Science Information Quality ranking of "2" ("Medium or Mixed Quality"), largely due to the lack of data in the analysis (Table 17).

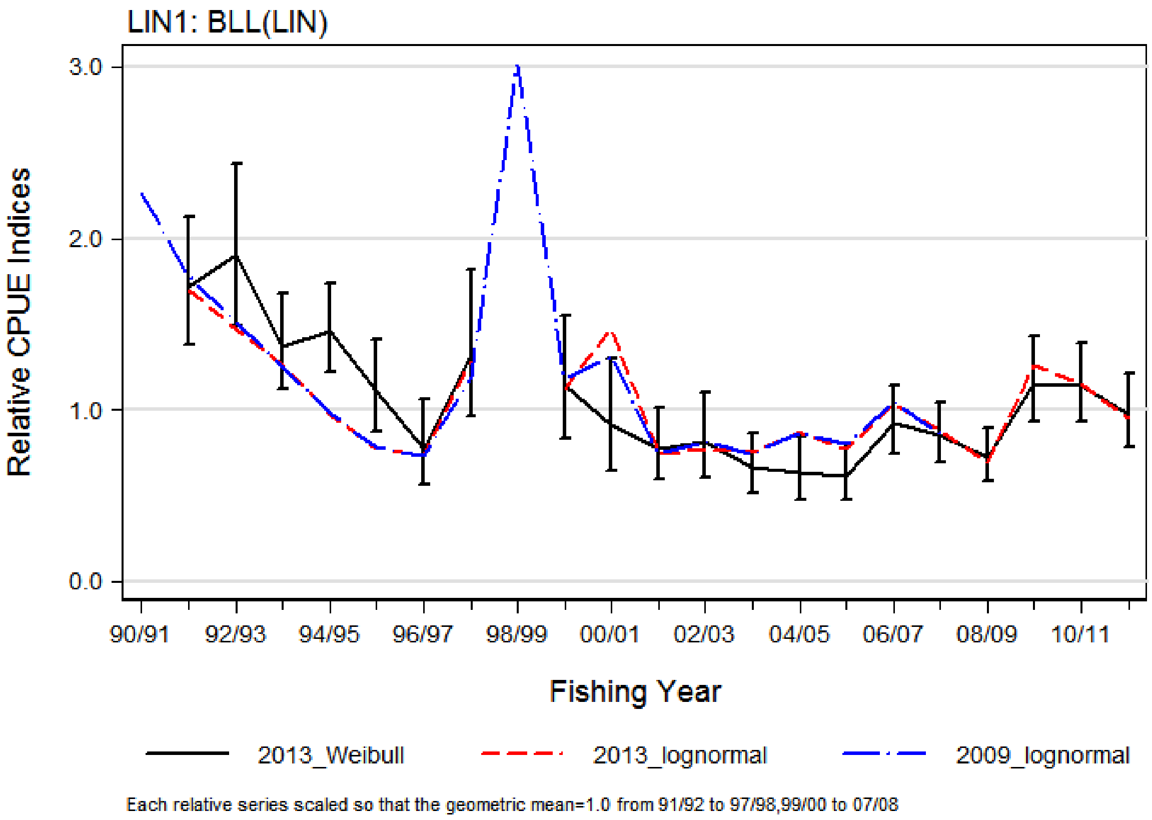

Figure 17: Comparison of three 2013 LIN 1 bottom longline standardised CPUE models: A) BLL(LIN) (see Appendix D), based on the Weibull distribution; b) a version of BLL(LIN) based on the lognormal index for comparison to the 2009 index; c) 2009 lognormal index, including the anomalous 1998–99 index value omitted from the two 2013 series.

Table 17: Number of vessels reporting by month in the BLL(LIN) data set, showing the information for the omitted 1998–99 fishing year.

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
91/92	2	4	1	–	1	1	1	4	3	3	9	8
92/93	4	3	–	–	–	1	1	–	–	3	8	8
93/94	4	2	1	1	1	1	1	1	3	5	10	7
94/95	3	4	3	1	1	3	2	1	–	4	10	11
95/96	7	6	2	–	–	–	1	–	1	1	5	6
96/97	1	–	1	–	–	–	–	–	–	2	3	2
97/98	5	4	–	–	–	–	–	–	2	1	1	1
98/99	–	–	–	–	–	–	–	–	–	–	1	2
99/00	2	–	–	–	–	–	–	–	–	–	4	4
00/01	2	1	1	–	–	–	–	–	–	1	4	4
01/02	1	–	–	–	–	–	–	–	1	2	6	4
02/03	3	1	–	–	–	–	–	–	2	1	5	6
03/04	1	–	–	1	–	2	–	–	1	2	5	8
04/05	4	3	–	–	–	–	–	2	1	–	1	6
05/06	3	3	1	–	–	1	–	1	–	1	3	9
06/07	1	1	2	1	1	–	1	1	1	3	8	8
07/08	5	5	2	2	1	2	3	2	–	–	8	9
08/09	3	4	3	1	1	2	1	1	2	–	5	5
09/10	3	2	3	–	–	2	3	2	3	2	5	6
10/11	5	7	2	2	2	2	3	3	3	4	5	6
11/12	7	2	2	2	1	1	1	3	2	1	7	5

The BLL(LIN) series shows an overall decline from the beginning of the series to the mid-2000s, once the 1998–99 peak has been removed (Figure 18). Following the nadir around 2005–06, the series climbs to a level that is near the long-term average index and about 50–70% below the index values at the beginning of the series. This standardised series also shows considerable modification from the unstandardised series, with the model adjusting for trends in the composition of the fishing fleet, the months fished and the configuration of effort (see step and influence plot: Figure D.2). This model is also based on small amounts of data, with only 971 records available to estimate 114 parameters, including 19 annual indices (after dropping the 1998–99 index). No binomial model was attempted as the number of records with zero catch was very small.

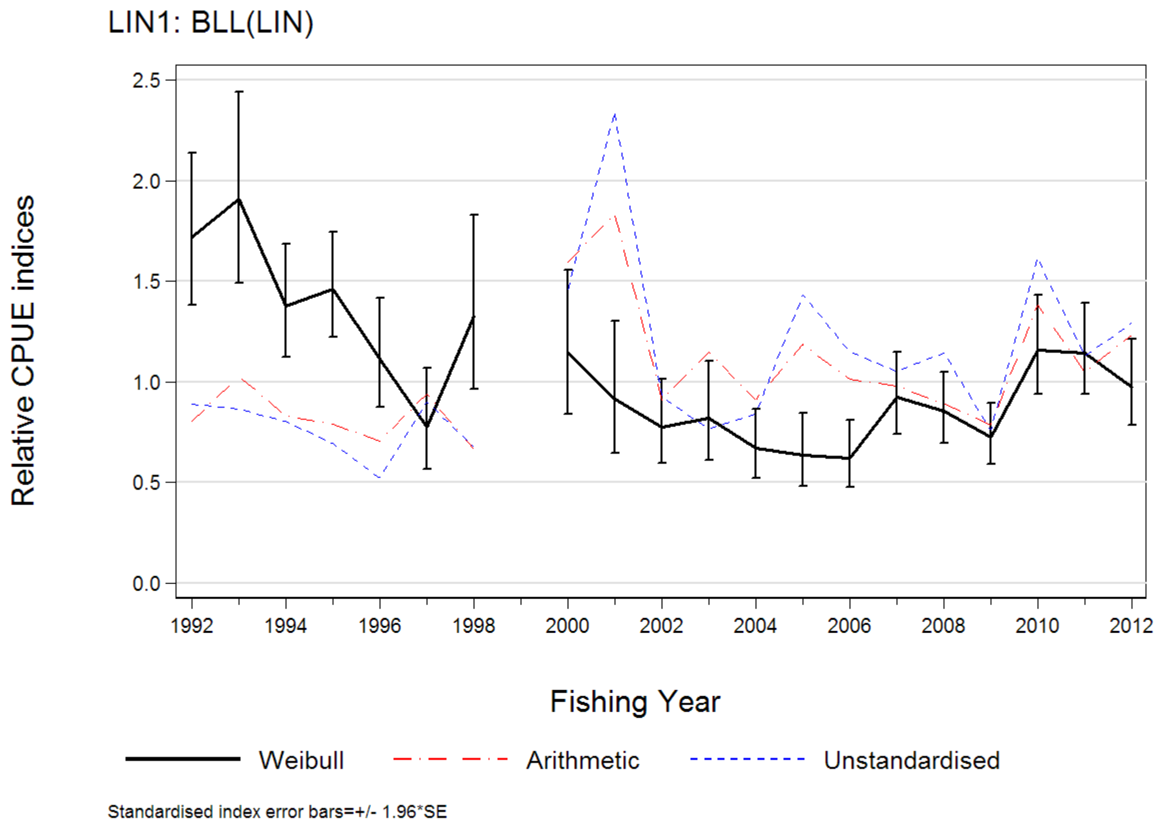

Figure 18: Relative CPUE indices for LIN 1 using the lognormal non-zero model based on target ling bottom longline [BLL(LIN)]. Also shown are two unstandardised series from the same data: a) Arithmetic $A_y = \sum_{i=1}^{N_y} C_{i,y} \Big/ \sum_{i=1}^{N_y} E_{i,y}$ and b) Unstandardised $U_y = \exp\left(\frac{\sum_{i=1}^{N_y} \ln\left(C_{i,y}/E_{i,y}\right)}{N_y}\right)$ which is the geometric mean of the observations. $C_{i,y}$ =landings in year *y*. $E_{i,y}$ =number hooks in year *y*.

4 ACKNOWLEDGEMENTS

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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
AMPWG	Adaptive Management Programme Fishery Assessment Working Group
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
CDI plot	Coefficient-distribution-influence plot (see Figure E.5 for an example) (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
destination code	code indicating how each landing was directed after leaving vessel (see Table 4)
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 ling 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 and LTCER form types)
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 ling
FMA	MPI Fishery Management Areas: 10 legally defined areas used by MPI to define large scale stock management units; QMAs consist of one or more of these regions
landing event	weight of ling off-loaded from a vessel at the end of a trip or otherwise disposed of as part of a transaction. 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 Working Group: MPI Working Group overseeing the work presented in this report
QMA	Quota Management Area: legally defined unit area used for ling 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"
RTWG	MPI Recreational Technical Working Group
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

Term/Abbreviation	Definition
	represent the relative change in species abundance
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

Table A.2: Code definitions used in the body of the main report and in Appendix D, Appendix F and Appendix G.

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	ELE	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
		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

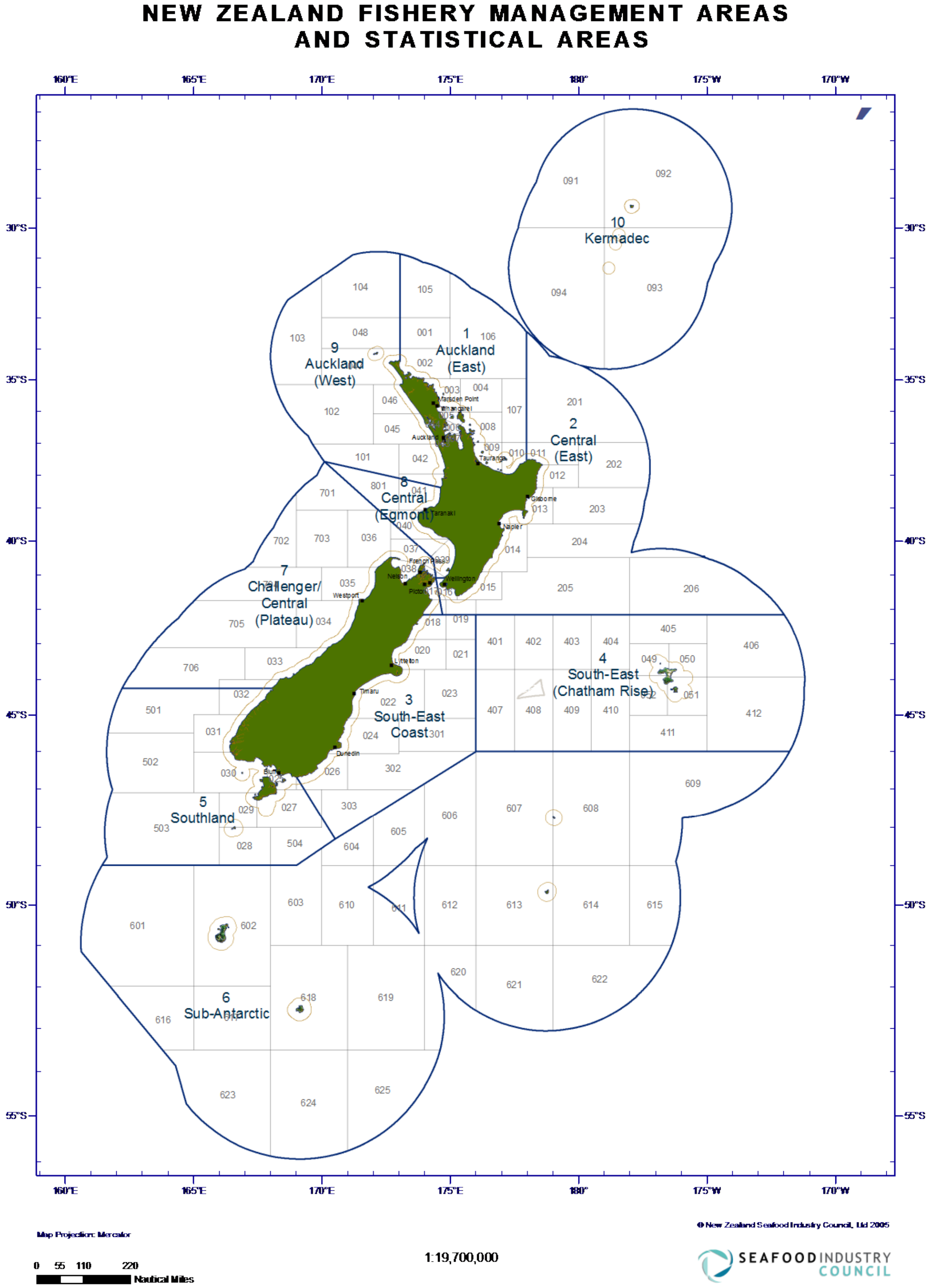

Figure B.1: Map of Ministry for Primary Industries statistical areas and Fishery Management Area (FMA) boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries.

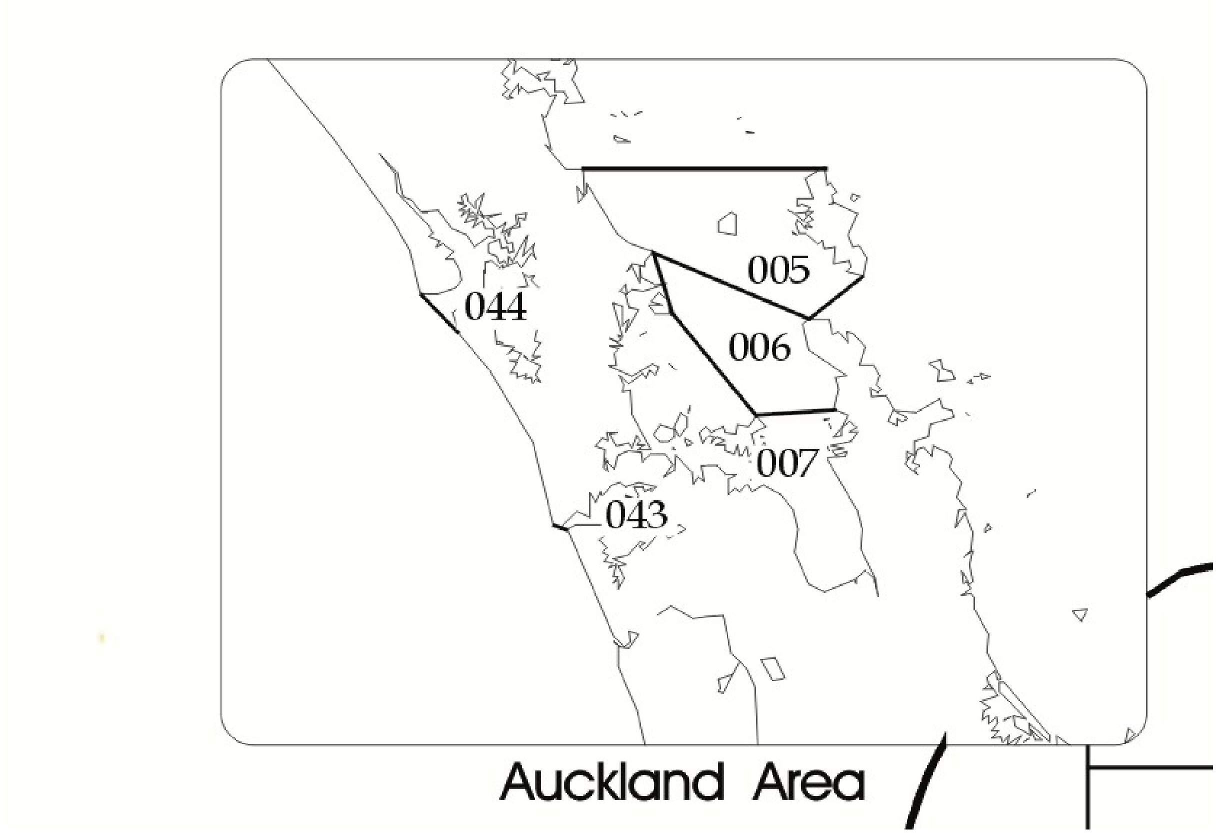

Figure B.2: Inset map of showing location of the Hauraki Gulf Statistical Areas (005, 006 and 007). Statistical Areas 043 and 044 are the Kaipara and Manukau Harbours respectively.

Appendix C. FINDING SPURIOUS LIN 1 LANDINGS

C.1 General overview

A three step procedure was used to screen implausible trips from the LIN 1 data set. This was required because Starr et al. (2009) had previously identified the problem that many fishers designated "5", "6" or "7" when asked to identify the "area" of capture. What they probably meant was LIN 5, LIN 6 and LIN 7 but, in many instances, these entries were interpreted at the point of data entry as statistical areas 005, 006 or 007, all within the inner Hauraki Gulf and part of LIN 1 (Appendix B: all MPI finfish Statistical Areas; Figure B.2: inset map showing location of Areas 005, 006 and 007). The Hauraki Gulf is not ling habitat and declared catches in this region can be safely interpreted as coming from somewhere else.

The forms used to report catch to MPI are in two parts, with the "top" part used to report location and date of capture, the area of capture, the effort expended and some information about the most important species catch. The "bottom" part of the form (or else in a separate form, known as the Catch Landing Return [CLR]) is used to report landings, linked by the trip number with the effort data (in both instances). It is only at this latter step that the QMA is reported, with the top part of the form only reporting the "area" of capture. Consequently, it is not possible to simply use the QMA of record to exclude the spurious or implausible trips. The presence of spurious trips in the landing data set can be seen in Figure C.1, with the sum of the declared landings (shown by the blue line) exceeding the sum of LIN 1 landings from the QMR/MHR system, particularly in the years 1993–94, 1994–95, 1997–98 to 1999–2000, 2001–02, 2010–11 and 2011–12.

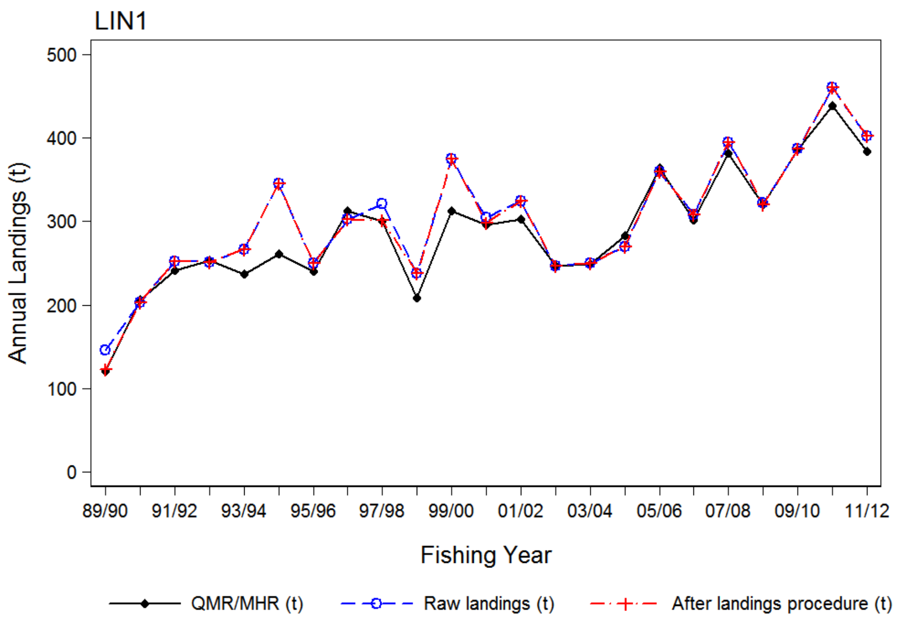

Figure C.1: Comparison of the total annual QMR/MHR landings with the total annual raw landings in the LIN 1 data set (blue line) and the annual landings which remained after excluding the six trips identified in Table C.1.

C.2 Methods

The following three steps were used to exclude spurious trips in LIN 1:

1. identify "out-of-range" landings, where large amounts of landings are recorded without adequate corroborative information in the trip, using the procedure described in Starr & Kendrick (2016);

2. identify trips which fished in Statistical Areas south of LIN 1 or LIN 2, on the assumption that LIN 1 is a local fishery and that landings off the South Island were extremely unlikely to occur on the same trip;

3. from the remaining trips, identify trips which reported estimated catches from Statistical Areas 005, 006 or 007, as these areas are not suitable habitat for ling.

C.3 Results

C.3.1 Identifying "out-of-range" landings

The method described in detail by Starr & Kendrick (2016) was followed, resulting in identifying six trips which failed the screening (Table C.1), indicating that large and potentially unreasonable trips were not a problem with this data set. These trips only accounted for 50 t of total catch (Table C.2) and had negligible effect on the problem identified in Figure C.1.

Table C.1: Six trips identified in the LIN 1 data set as having unreasonably large landings relative to the internal evidence in the trip (see appendix D in Starr & Kendrick 2016 for a description of the method). Landings are the sum for the entire trip while calculated landings are based on the number of containers multiplied by the average weight of the containers for the trip. Ratio 1 is calculated relative to the calculated landings and Ratio 2 is calculated relative to the estimated catch. These are the only trips which exceeded 1.44 t (the 95th quantile of landing sum) and also had a Ratio of at least 3 in either Ratio 1 or Ratio 2.

Fishing year	Trip number	Sum landings (t)	Sum calculated landings (t)	Sum estimated catch (t)	N events	N landing events	Ratio 1	Ratio 2
89/90	2287261	14.87	1.67	1.6	65	1	8.9	9.3
89/90	2163108	7.91	0.11	0	5	1	75.4	–
97/98	2979605	6.23	0.63	0.4	13	1	9.9	15.6
97/98	1989979	13.9	0.12	0.07	4	1	119.8	185.4
00/01	3658739	6.0	0.02	0	3	1	344.8	–
08/09	5391639	1.52	0.04	0.01	3	1	34.9	101.3

C.3.2 Identifying trips which fished off either coast of the South Island

Three hundred and forty trips were identified in the data set as reporting fishing in LIN 1 but also reported fishing in Statistical Areas off of the east or west coasts of the South Island or off the South Taranaki Bight. These trips represented nearly 9000 records (Table C.3) and were distributed throughout the data set, representing a total of nearly 2000 t (Table C.2). However, there were still some discrepancies in the annual totals, particularly in the 1999–2000 fishing year, after these trips were dropped (Figure C.2). Note that there are only 335 trips identified in Table C.2. This is because five trips in the effort section of the LIN 1 data set did not have corresponding landing data, a frequent occurrence in these data sets, probably attributable to discarding trips with "P", "Q" or "R" destination codes (see Table 4 in Section 2.4).

C.3.3 Identifying additional trips which misreported LIN 1

Although all the remaining trips in the data set only fished in Statistical Areas that were consistent with LIN 1 or LIN 2 (Table C.4), there still were some anomalies in the annual totals (Figure C.2). It was noted that 108 of the remaining trips reported estimated catches from Statistical Areas 005, 006 and 007, which seemed very unlikely, given the location of these areas in the inner Hauraki Gulf which is unsuitable ling habitat. When these trips were dropped, representing about 70 t spread over the 23 years of data (Table C.2), the major anomaly in the 1999–2000 disappeared (Figure C.3) and the remaining trips were deemed acceptable for use in the characterisation and CPUE analyses.

Table C.2: Tonnage and number of trips represented by trips dropped from the LIN 1 data set by fishing year and sequence step described in Section C.2.

Fishing	Exclude out of range trips		Exclude trips fishing off South Island		Exclude trips reporting estimated catches in Areas 005, 006 or 007		Total	
year	N trips	Sum landings (t)	N trips	Sum landings (t)	N trips	Sum landings (t)	N trips	Sum landings (t)
89/90	2	22.8	12	30.1	5	0.4	19	53.3
90/91	–	–	10	15.2	10	3.7	20	18.9
91/92	–	–	8	26.7	6	0.4	14	27.1
92/93	–	–	13	33.5	5	0.1	18	33.6
93/94	–	–	18	346.2	4	0.3	22	346.5
94/95	–	–	15	284.5	3	0.1	18	284.7
95/96	–	–	18	16.2	2	0.0	20	16.2
96/97	–	–	24	71.2	4	10.1	28	81.4
97/98	2	20.1	27	372.3	8	0.3	37	392.8
98/99	–	–	20	69.2	6	1.7	26	70.9
99/00	–	–	22	24.4	12	39.0	34	63.3
00/01	1	6.0	21	93.0	4	0.0	26	99.0
01/02	–	–	16	75.9	5	0.0	21	75.9
02/03	–	–	4	2.4	3	0.1	7	2.4
03/04	–	–	15	24.5	4	15.0	19	39.5
04/05	–	–	16	417.5	1	0.0	17	417.5
05/06	–	–	7	2.1	1	0.1	8	2.2
06/07	–	–	10	20.1	4	0.1	14	20.1
07/08	–	–	8	14.5	5	0.3	13	14.8
08/09	1	1.5	16	10.3	7	0.0	24	11.8
09/10	–	–	9	8.6	4	0.1	13	8.7
10/11	–	–	15	15.4	2	0.1	17	15.5
11/12	–	–	11	8.7	3	0.0	14	8.7
Total	6	50.4	335	1 982.6	108	72.1	449	2 105.1

Table C.3: Number of records by year and LIN QMA, with QMA being determined from the Statistical Area for the 335 trips (Table C.2) identified as having fished in Statistical Areas below LIN 1 or LIN 2.

Fishing	Statistical Areas consistent with LIN QMA							
year	LIN 1	LIN 2	LIN 3	LIN 4	LIN 5	LIN 7	LIN 8	Total
89/90	91	57	50	55	123	130	–	506
90/91	56	91	31	23	22	44	–	267
91/92	48	71	2	86	–	24	–	231
92/93	99	107	8	150	10	119	–	493
93/94	140	116	74	276	152	19	1	778
94/95	67	6	21	26	84	17	–	221
95/96	28	22	66	43	1	25	–	185
96/97	128	41	116	104	113	125	3	630
97/98	169	27	52	67	5	159	–	479
98/99	126	55	32	45	11	105	4	378
99/00	134	50	55	109	23	122	8	501
00/01	122	81	67	60	–	35	3	368
01/02	65	24	108	110	27	195	–	529
02/03	58	5	3	–	30	3	–	99
03/04	278	1	70	172	133	36	–	690
04/05	86	2	15	37	144	52	–	336
05/06	61	–	8	88	–	3	–	160
06/07	100	4	29	11	69	67	7	287
07/08	38	1	19	24	48	195	18	343
08/09	142	35	67	51	34	88	58	475
09/10	161	–	1	39	–	141	19	361
10/11	162	–	25	30	–	92	33	342
11/12	119	7	9	103	7	61	21	327
Total	2 478	803	928	1 709	1 036	1 857	175	8 986

Table C.4: Number of records by year and LIN QMA, with QMA being determined from the Statistical Area for the 108 trips (Table C.2) identified as having fished in LIN 1 or LIN 2 but had also declared estimated catches in Statistical Areas 005, 006 or 007.

Fishing year	Statistical Areas consistent with LIN QMA: LIN 1	LIN 2	Total
89/90	21	–	21
90/91	87	1	88
91/92	14	–	14
92/93	11	–	11
93/94	12	–	12
94/95	5	–	5
95/96	5	–	5
96/97	79	23	102
97/98	63	4	67
98/99	57	–	57
99/00	75	–	75
00/01	45	–	45
01/02	14	–	14
02/03	6	1	7
03/04	25	–	25
04/05	5	–	5
05/06	2	–	2
06/07	43	–	43
07/08	18	–	18
08/09	68	–	68
09/10	56	–	56
10/11	19	–	19
11/12	16	–	16
Total	746	29	775

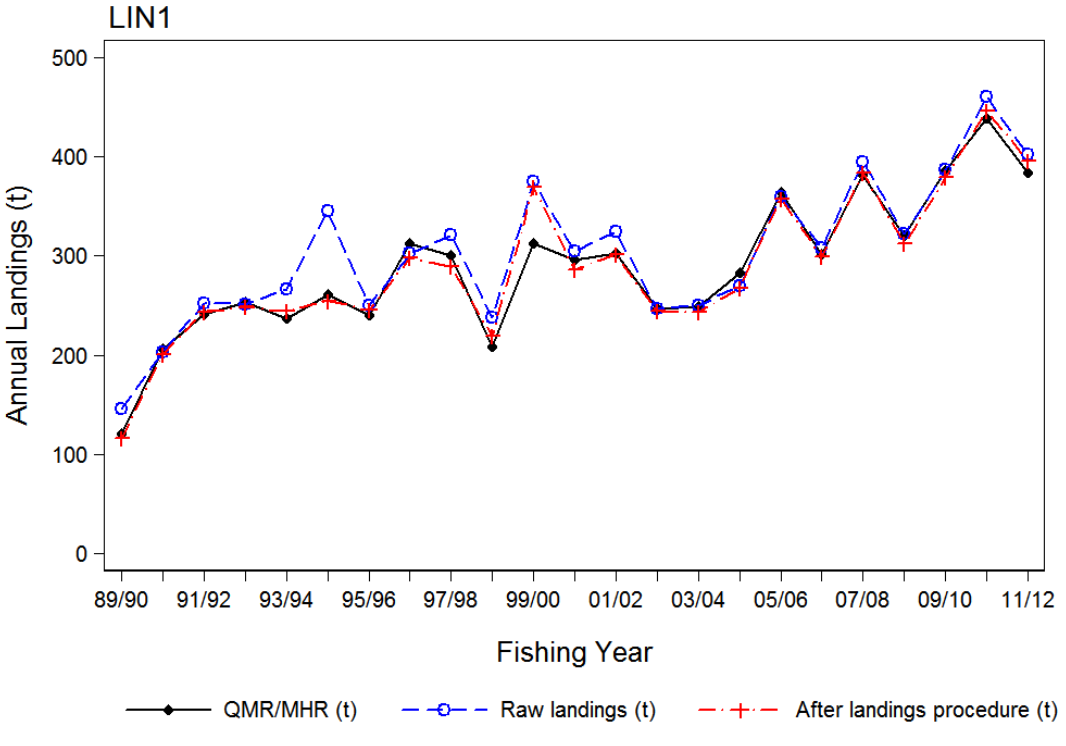

Figure C.2: Comparison of the total annual QMR/MHR landings with the total annual raw landings in the LIN 1 data set (blue line) and the annual landings which remained after excluding the six trips identified in Table C.1 and the 335 trips excluded in Table C.2.

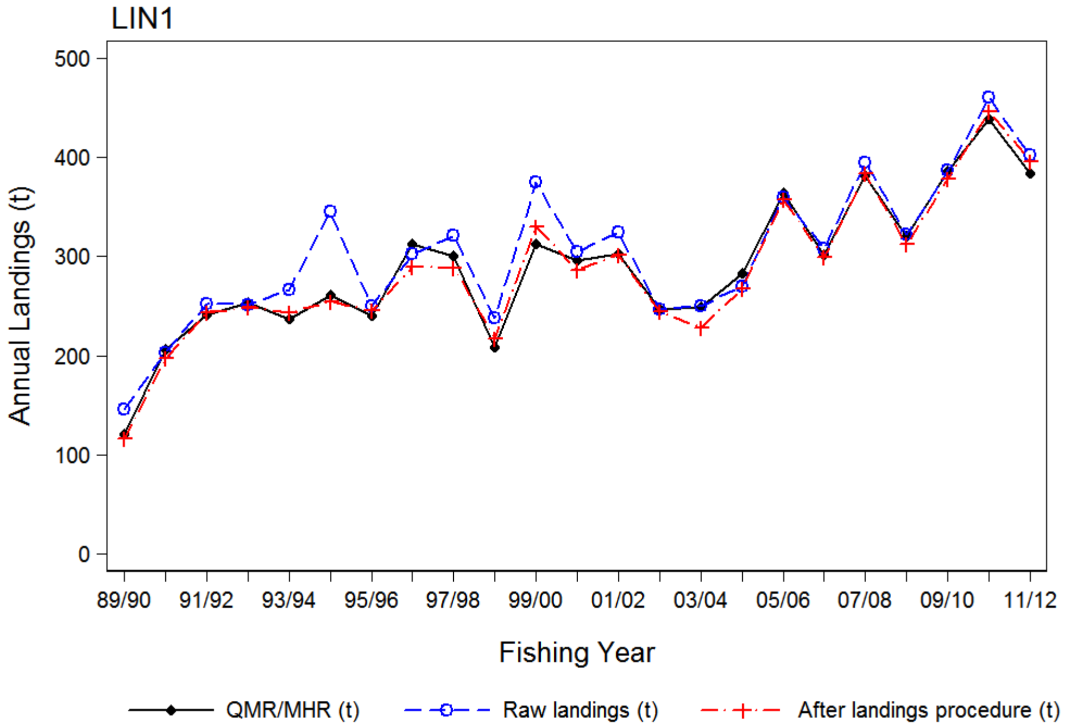

Figure C.3: Comparison of the total annual QMR/MHR landings with the total annual raw landings in the LIN 1 data set (blue line) and the annual landings which remained after excluding the six trips identified in Table C.1, the 335 trips excluded in Table C.2 and the 108 trips excluded in Table C.4.

Appendix D. LIN 1 CPUE ANALYSIS

D.1 General overview

Previous work investigated CPUE series from the LIN 1 bottom trawl and the bottom longline fisheries. When the CPUE series were reviewed in 2009, the AMPWG concluded that the bottom trawl fisheries had operated inconsistently and consequently could not be used as reliable indices of abundance. It then went on to conclude that the target ling bottom longline series operating in East Northland and the Bay of Plenty was the best candidate for monitoring abundance of ling (Starr et al. 2009). This study updated the LIN 1 target longline CPUE series as well as the scampi bottom trawl CPUE series, while also developing a standardised series based on a wider trawl CPUE targeted at species other than scampi.

Three candidate standardised CPUE indices of abundance were presented to the NINSWG in March 2013. These were based on 1) target LIN BLL [=BLL(LIN)], 2) LIN by-catch in the scampi trawl fishery [=BT(SCI)] and 3) bottom trawl catch and effort when targeting LIN, HOK or TAR [=BT(MIX)]. The two BT series were rejected as indices of abundance based on a combination of: implausible trends, poor diagnostics and little data and are not described in detail here. However, results and diagnostics for the BT(SCI) standardised analysis are reported in Appendix F and for the BT(MIX) standardised analysis in Appendix G.

The bottom longline fishery was previously analysed on the basis of estimated catch because of concerns that the proportion of the landings being retained for landing (sale) at another date; breaking the link between effort and the landing information, which render the landing data potentially unusable. However, models that were offered alternative data treatments demonstrated no discernible difference in the year effects between analyses based on estimated and on allocated landed catch, and this analysis used landed catch (Starr et al. 2009).

The BLL(LIN) dataset is sparse, with an unlikely peak in 1998–99 which appeared to be due to the model attempting to estimate a year effect from just two months of data and two participating vessels (see Table 17). The BLL(LIN) index series was accepted by the NINSWG with the proviso that all years with less than three vessels fishing were excluded. This removed the strong peak in 1998–99.

D.2 Data Preparation

Candidate trips were identified by searching for all trips which, at least for one event in the trip, fished in a valid statistical area for LIN 1 and used the bottom longline method and targeted ling. This produced a list of trips for which all effort and landing records associated with these trips were extracted, regardless of the method or target species.

Extreme values in the effort data were identified as outliers by examining the distribution for each effort field by vessel and for the whole fleet. All records for a trip with missing or out-of-range effort data were removed. Missing values for vessel ID, statistical area, method, or target species within any trip were substituted with the predominant (most frequent) value for that field over all records for the trip. Trips which were missing in all records for one of these fields were dropped, as were trips which used multiple methods and had a missing method field.

Effort and estimated catch data were summarised by fishing trip, for every unique combination of fishing method, statistical area, and target species, referred to as a “trip stratum”. This reduced both CELR and TCEPR format records to lower resolution “amalgamated” data, resulting in fewer records per trip but retaining the original method, area, and target species recorded by the skipper. The daily resolution in the CELR data is lost as is the tow-by-to resolution in the TCEPR data.

The landed catches of LIN 1 for each trip were allocated to “trip strata” (defined as statistical area, target species and method) in proportion to the ling estimated catch in each “trip stratum”. In the case where there were no estimated catches in any of the trip strata, the allocation of the landing data was made proportionate to the number of sets, depending on the fishing method being analysed. The main assumption made in this allocation procedure is that the reporting of ling is consistent across statistical areas and target species within a trip. In contrast, if estimated catches were used directly, the assumption must be made that reporting rates are constant across the entire fleet and all statistical areas for all years, as well as making the assumption that the ratio of estimated catch to landed greenweight catch is also consistent across the entire fleet for all years

The data variables available from each trip include estimated and landed catch of ling, the number of sets, number of hooks for the longline effort, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data might not represent an entire fishing trip; just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip based on the estimated catches which apportion the landings to each trip stratum. Trips were not dropped because they targeted more than one species or fished in more than one statistical area. Trips landing more than one Fishstock of any species from one of the straddling statistical areas were entirely dropped. Trips were also dropped where there was a mismatch between the statistical area fished and the declared Fishstock on landing.

D.2.1 Data selection and methods

Those groups of events that satisfied the criteria of target species, method and statistical areas defining the defined fisheries were selected from available fishing trips. Any effort strata that were matched to a landing of LIN 1 were termed “successful”, and included any relevant but unsuccessful effort, so that the analysis of catch rates in successful strata also incorporates much of the relevant zero catch information. Strata which did not include any landed LIN 1 were assigned a value of zero so that the effort data associated with them could be included in the analysis that considered total effort (as differentiated from successful effort only).

Strata which did not include any landed LIN 1 were assigned a value of zero. Target fisheries contain very few zero catch records, and those are largely a product of the merge process that assigns landed catch on the basis of estimated catch. Zero catches in this dataset were excluded, and a linear model was fit to those trip-strata with positive catches.

Regression models using five different distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) that predicted catch based on a fixed set of explanatory variables (year, month, area, vessel and log[number of sets]) were evaluated by examining the residual diagnostics, selecting the error distribution with the lowest negative log likelihood for the final stepwise regression.

A linear regression model that assumed the selected error distribution was then fitted to log(catch) based only on records with successful catches of LIN 1. The regression was performed in a stepwise manner against the available explanatory variables; selecting each explanatory variable until the improvement in model R^2 (deviance) was less than 0.01. The year effects are expressed in canonical form, allowing the calculation of confidence bounds for each year (Francis 1999). Fishing year was always forced as the first explanatory variable, and the explanatory variables offered to the model included month (of landing), statistical area and a unique vessel identifier. Continuous variables offered to the model included log(sets) and log(hooks). The range of explanatory variables offered to the models are given in Table D.1.

D.2.2 Fishery definitions for CPUE analysis

BLL (LIN) – Ling bottom longline; The Fishery is defined from bottom longline fishing events which fished in Statistical Areas 002 to 004 or 008 to 010, and targeted ling. This is a target fishery and the few zero catches have been excluded. Data for 1998–99 were excluded under the NINSWG agreement to exclude years where fewer than three core vessels were operating. Both the fishery and the model are referred to in this report as BLL(LIN).

D.3 Unstandardised CPUE

D.3.1 BLL (LIN) Ling bottom longline

The pattern of number of trips has fluctuated widely in this fishery, peaking in the mid 1990s, then declining to lowest levels of activity in the late 1990s and recovering to nearly the early 1990 peak since then. Catch per trip of ling in this fishery has varied in a reciprocal pattern to effort, peaking during the years of lowest effort but with a flat trend overall (Figure D.1 [left panel]). The amalgamation of data shows a trend of an increasing number of original records per trip stratum in the last half of the series which is reflected in the number of sets per trip stratum (Figure D.1 [right panel]). Note that there are very few zero catch trips (Figure D.1 [left panel]), leading to the decision that no binomial standardisation was required. It also leads to the conclusion that the "roll-up" process will not introduce a bias into the analysis. The effect of the shift to reporting of individual sets in 2007–08 is apparent.

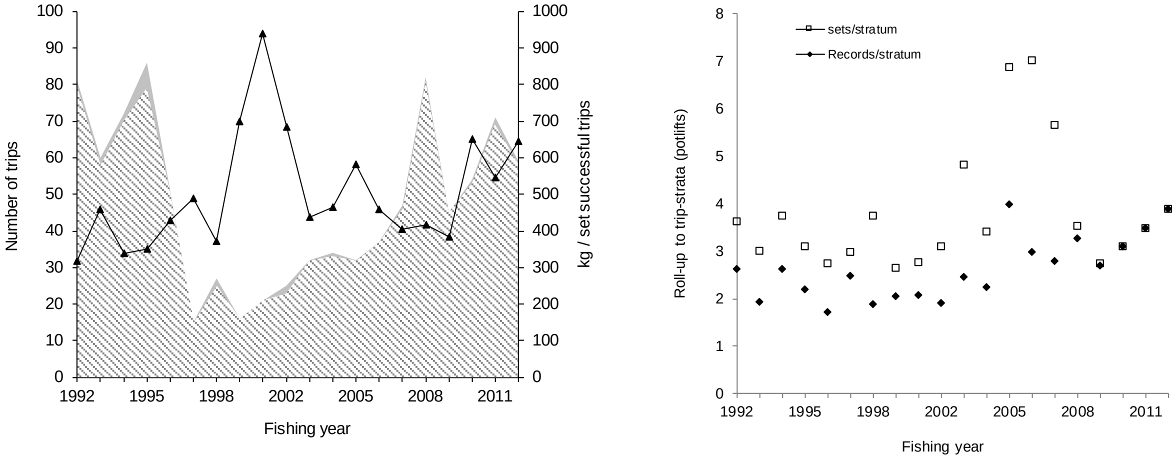

Figure D.1: [left panel]: number of trips targeting ling by bottom longline, (dark area), the number of those trips that landed LIN 1 (light area) and the simple catch rate (kg/set) of LIN 1 in successful trips, by fishing year; [right panel]: the effect of data rollup indicated by the ratio of original records per trip-stratum, and number of sets per trip-stratum by fishing year [right].

D.4 Standardised CPUE analysis

D.4.1 Core fleet definitions

The data sets used for the standardised CPUE analysis were further restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables; the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery. The effect of these two variables on the amount of landed ling retained in the dataset and on the number of core vessels is shown for the BLL(LIN) fishery in Figure E.1 [left panel]. The core fleet was selected using criteria that were not very stringent (at least 3 trips in any one year), given the small number of vessels in this model. The number of trip-strata in each fishing year for the selected vessels is shown in Figure E.1 [right panel]. Summaries of the core vessel data set can be found Table E.1.

D.4.2 Model selection

Alternative error distributions were fitted to a saturated model containing the positive estimated catches. By comparing the resultant log likelihoods and residual patterns, the most appropriate error distribution for this data set was selected, with the Weibull error distribution providing the best model fit to BLL(LIN) data (Figure E.2).

The final model selected for standardising positive catches is described in Table D.1. This table includes the explanatory variables that improved the AIC and do not necessarily include a complete list of the variables that were offered because some variables (e.g. [area]) had no effect on the AIC. Variables that were accepted into the model needed to improve the R^2 by at least 1%; these variables are indicated with asterisks in the table, along with the amount of variance they explained. Fishing year was forced as the first variable and explained about 8% of the variance in catch. The log of number of sets is the most important variable in terms of explanatory power, entering second and explaining an additional 40 % of the variance. Vessel entered the model third and explained a further 17% of variance. The final model explained 74% of the variance in log(catch).

Table D.1: Order of acceptance of variables into the Weibull model of successful catches of in the BLL(LIN) fishery model for core vessels based on the vessel selection criteria of at least 3 trips in 1 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. The variable [area] did not enter the model because it had no effect on the AIC.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	21	-7 952	15 947	8.05	*
poly(log(num), 3)	24	-7 677	15 403	48.48	*
vessel	101	-7 488	15 179	65.42	*
month	112	-7 395	15 014	71.58	*
poly(log(hooks), 3)	115	-7 348	14 926	**74.27**	*
area	–	–	–	–	

The annual indices are plotted at each step of this selection procedure in Figure D.2, demonstrating the progressive effect on the annual indices of each explanatory variable as it enters the model, and comparing the influence of each variable on observed catch (which the model adjusts for) in adjacent panels. These plots highlight the observation made in Bentley et al. (2012) that the variables that explain the most deviance are not necessarily the ones responsible for most of the difference between standardised and observed series of CPUE. The log of number of sets is the most important variable with respect to explaining variance, but there is no overall trend to shifts in this measure of effort and its influence on observed catches is flat. The inclusion of vessel, in contrast, introduces considerable structure into the standardised series, changing a flat trajectory to one that declines steadily over the first half of the time series and then increases in the second half. Month and log(hooks) each have considerable explanatory power on the observed catches but their inclusion in the model does not markedly alter the standardised series further.

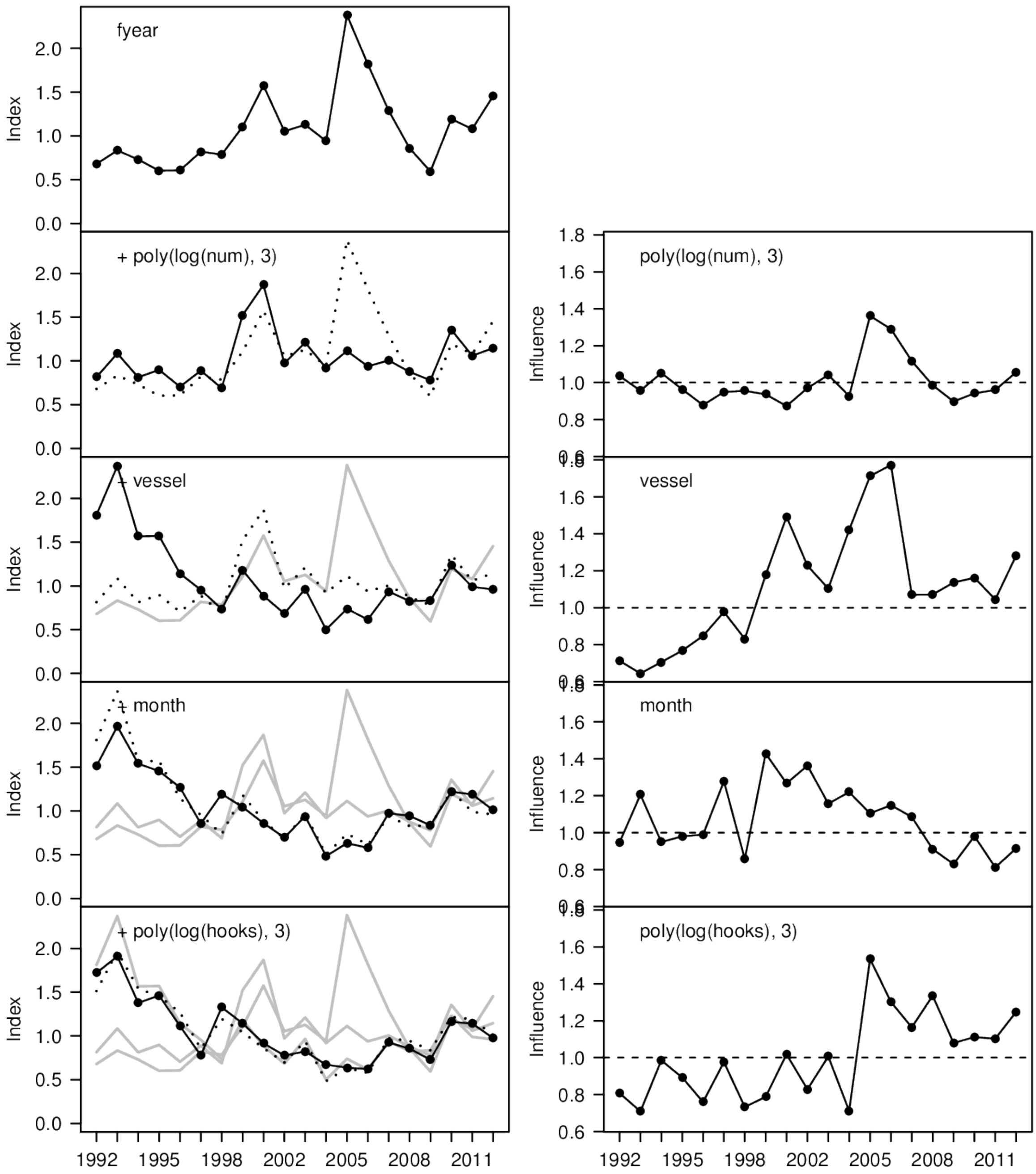

Figure D.2: [left column]: annual indices from the Weibull model of BLL(LIN) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

Diagnostic residual plots are presented in Figure E.3 which show a reasonably good fit of the data to the underlying Weibull distributional assumption. The influence (CDI) plot for log(sets) shows an adjustment for high number of sets per record in the mid 2000s, but little influence on the overall trend (Figure E.4).

The coefficients for vessel show consistent differences in performance among vessels with respect to ling catch, and a general improvement in the performance of the fleet to peak in the mid 2000s, after which the loss from the fishery of several top vessels coinciding with the entry of several poorer performing vessels is predicted to have accounted for about a 50% decline in potential catches (Figure E.5).

The coefficients for month demonstrate a strong seasonal pattern with highest catches predicted for the spring months of August to September, and a trend away from those peak months towards more year round fishing that is predicted to have lowered potential catches (Figure E.6)

A shift in the number of hooks per record is likely to have been an effect of the amalgamation procedure and its effect on the CPUE series is adjusted by the model (Figure E.7), but without changing the trend in the annual indices.

Residual implied coefficients, which show predicted indices for each year by statistical area and which serve as an alternative to fitting a full model with year×area interaction terms (see Starr & Kendrick 2016 for a discussion on this issue) are plotted in Figure E.8. This plot should be interpreted with caution, given that area did not have any effect in the main model (Table D.1). This plot shows good correspondence of the individual area×year effects for those areas with most of the data (these are Statistical Areas 002, 009 and 010) Data are sparse in the other statistical areas and contribute little to the overall trend.

D.4.3 Trends in model year effects

D.4.3.1 BLL(LIN) Ling bottom longline fishery

The year effects from the BLL(LIN) model show a steadily declining trend from the highest point in 1991–92 to the lowest point in 2005–06 followed by some recovery in the subsequent six years (Table E.2, Figure D.3). The trends are well-determined because they hold over consecutive years with little interannual variation. There is reasonably good agreement with the previous series presented in 2009 for the years that include more than two vessels (Figure D.3).

The effect of standardisation is to lift points in the first half of the series and lower those in the second half, changing a trajectory that is flat and spiky to one that describes a smoother and more realistic pattern of decline and subsequent upturn (Figure D.3).

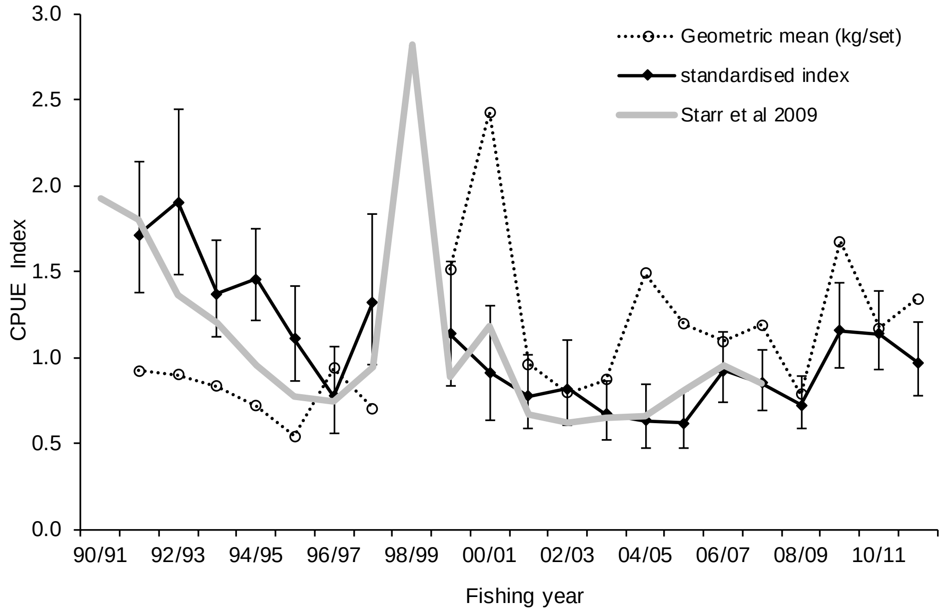

Figure D.3: The effect of standardisation on the raw CPUE of ling in successful trips by core vessels in the BLL(LIN) fishery. Broken line is the annual geometric mean of kg /set, bold line is the Weibull standardised canonical indices with ± 2 × SE error bars. Grey line is the previous lognormal series (Starr et al. 2009) for this fishery. All series are relative to the geometric mean over the years in common.

D.4.4 Comparison with Other models

The effect of selecting the error distribution that gave the most consistent residual pattern relative to the distributional assumption was not substantial: there is little difference in the estimated year indices when the "best" (Weibull) series is compared to an alternative series based on a lognormal distribution (Figure D.4).

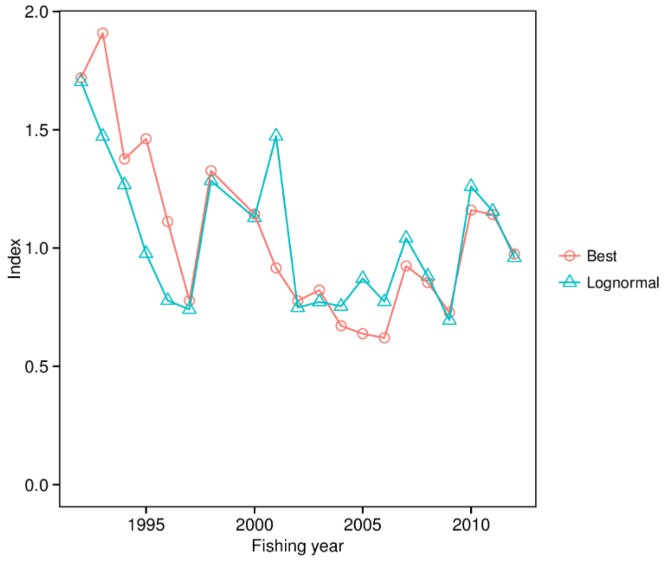

Figure D.4: Comparison between the Weibull indices and indices obtained from a similar model that assumed lognormal error distributions.

Appendix E. DETAILED DIAGNOSTICS FOR BLL(LIN) CPUE STANDARDISATION

E.1 Core vessel selection

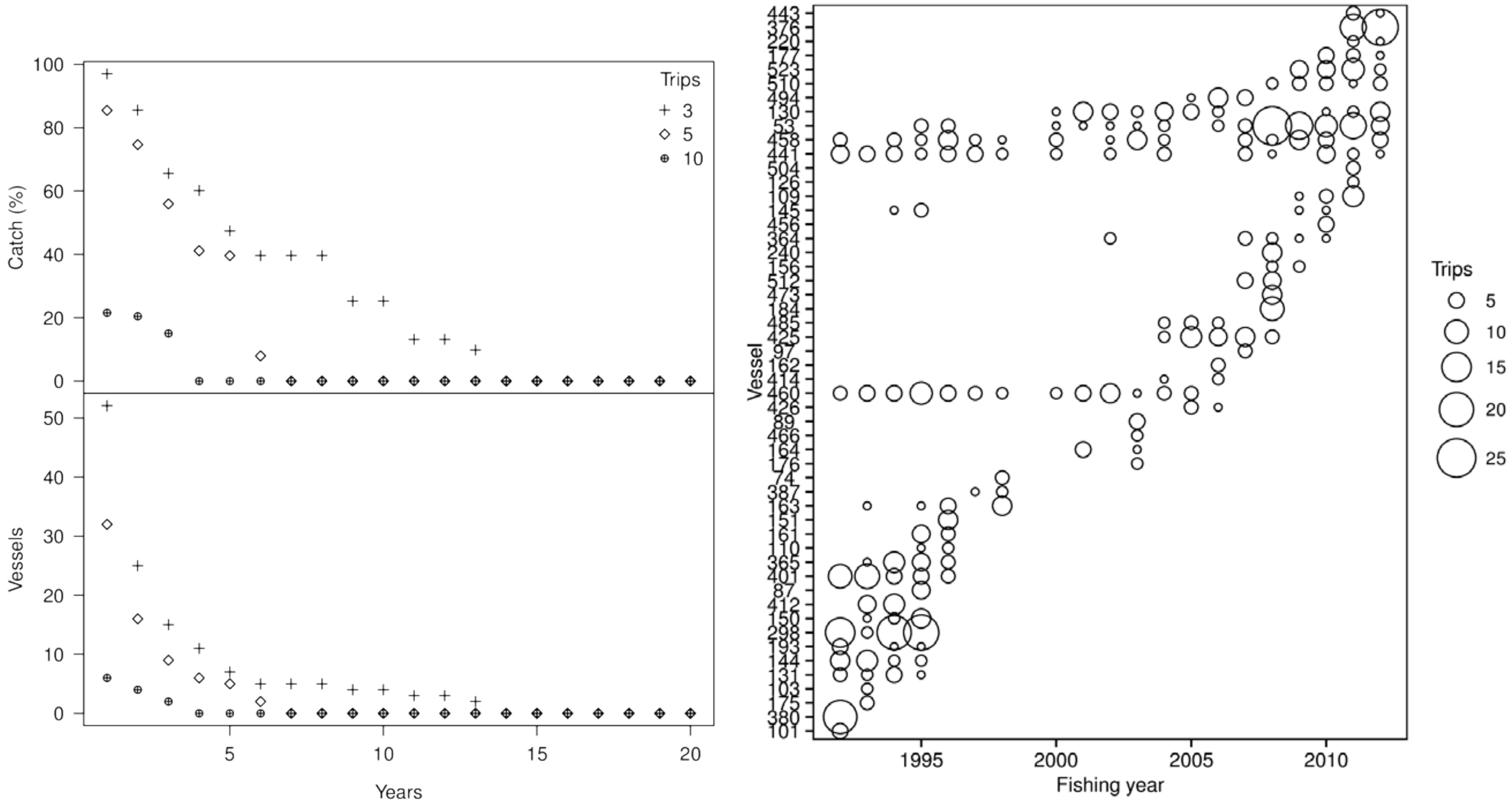

Figure E.1: [left panel] total landed LIN 1 and number of vessels plotted against the number of years used to define core vessels participating in the BLL(LIN) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of trip-strata for selected core vessels (based on at least 3 trips in 1 or more fishing years) by fishing year.

E.2 Data summary

Table E.1: Number of number of core vessels, trips, trip strata, number of events that have been "rolled up" into trip strata, calculated number of events per trip-stratum, number of sets, landed LIN 1 (t), proportion of trips with catch and proportion of trip-strata with catch, by fishing year for core vessels (based on a minimum of 3 trips per year in at least 1 years) in the BLL(LIN) fishery.

Fishing year	Vessels	Trips	Trip strata	Events	Events per stratum	Number sets	Number hooks ('000s)	Catch (t)	Trips with catch (%)	Strata with catch (%)
1992	11	80	83	220	2.65	303	233.305	94.37	97.5	97.6
1993	13	55	56	113	2.02	174	140.170	80.55	96.4	96.4
1994	14	72	72	189	2.63	271	299.050	89.49	97.2	97.2
1995	17	86	89	197	2.21	276	299.996	88.58	91.9	92.1
1996	12	50	50	87	1.74	139	138.400	60.25	100	100
1997	5	15	16	40	2.50	48	56.650	23.45	100	100
1998	6	22	23	42	1.83	81	58.450	35.11	100	100
2000	6	15	16	34	2.13	44	47.500	31.39	100	100
2001	4	19	21	46	2.19	62	94.600	60.07	100	100
2002	8	24	26	50	1.92	82	77.323	50.68	91.7	92.3
2003	10	29	31	73	2.36	145	151.250	66.24	100.0	96.8
2004	9	29	34	78	2.29	119	98.917	58.20	96.6	97.1
2005	8	29	30	129	4.30	222	278.927	126.47	100	100
2006	11	34	37	116	3.14	271	276.085	119.32	100	100
2007	12	41	45	126	2.80	254	277.036	101.37	97.6	97.8
2008	13	75	92	308	3.35	323	558.668	136.62	98.7	98.9
2009	12	43	53	141	2.66	144	263.947	56.50	100	100
2010	12	51	57	181	3.18	181	296.650	118.48	100	100
2011	13	68	80	286	3.58	286	493.028	152.58	97.1	97.5
2012	11	56	60	240	4.00	240	368.606	154.92	98.2	98.3

E.3 Residual and diagnostic plots

The best distribution was the Weibull.

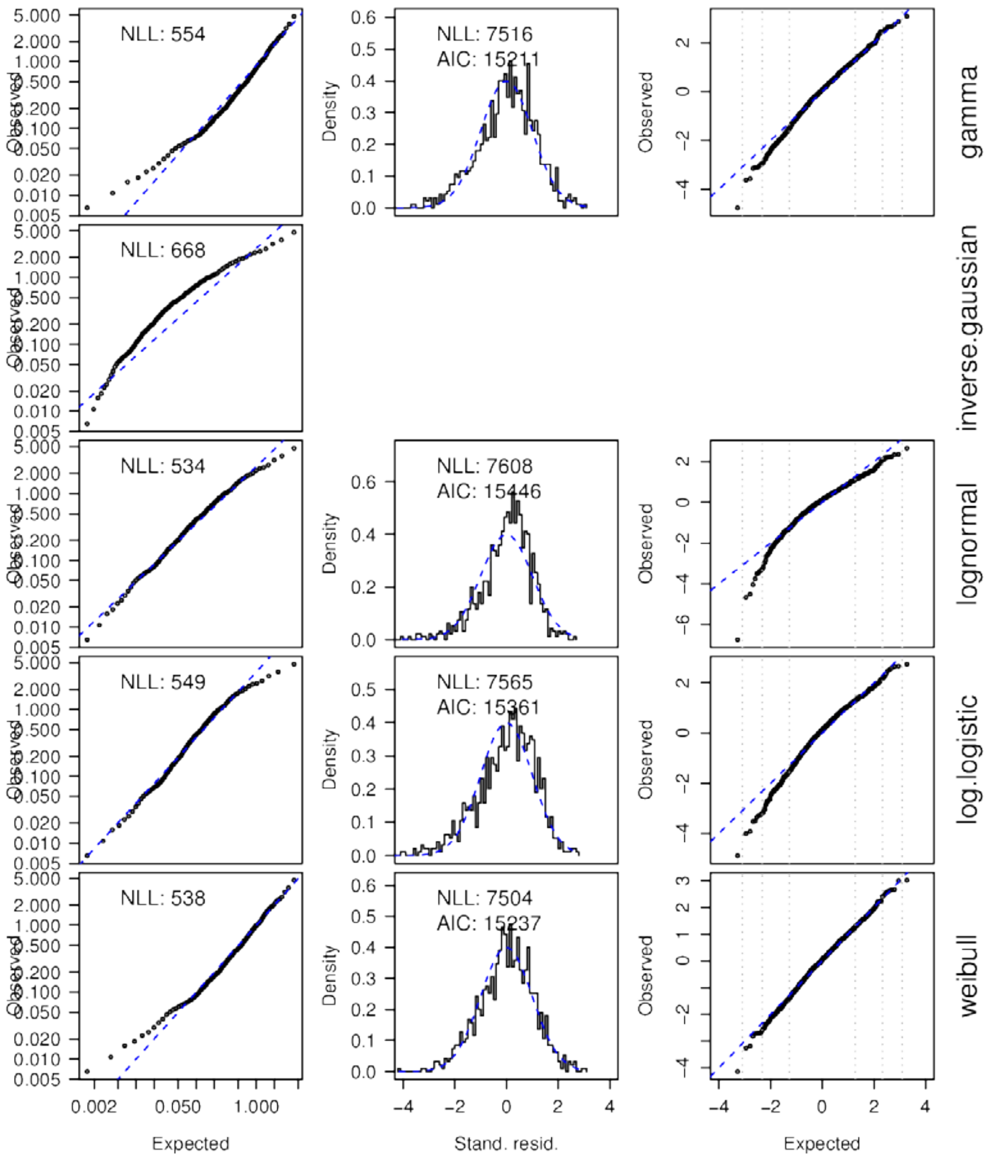

Figure E.2: Diagnostics for alternative distributional assumptions for catch in the BLL(LIN) fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month +area+ vessel + log(sets) and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

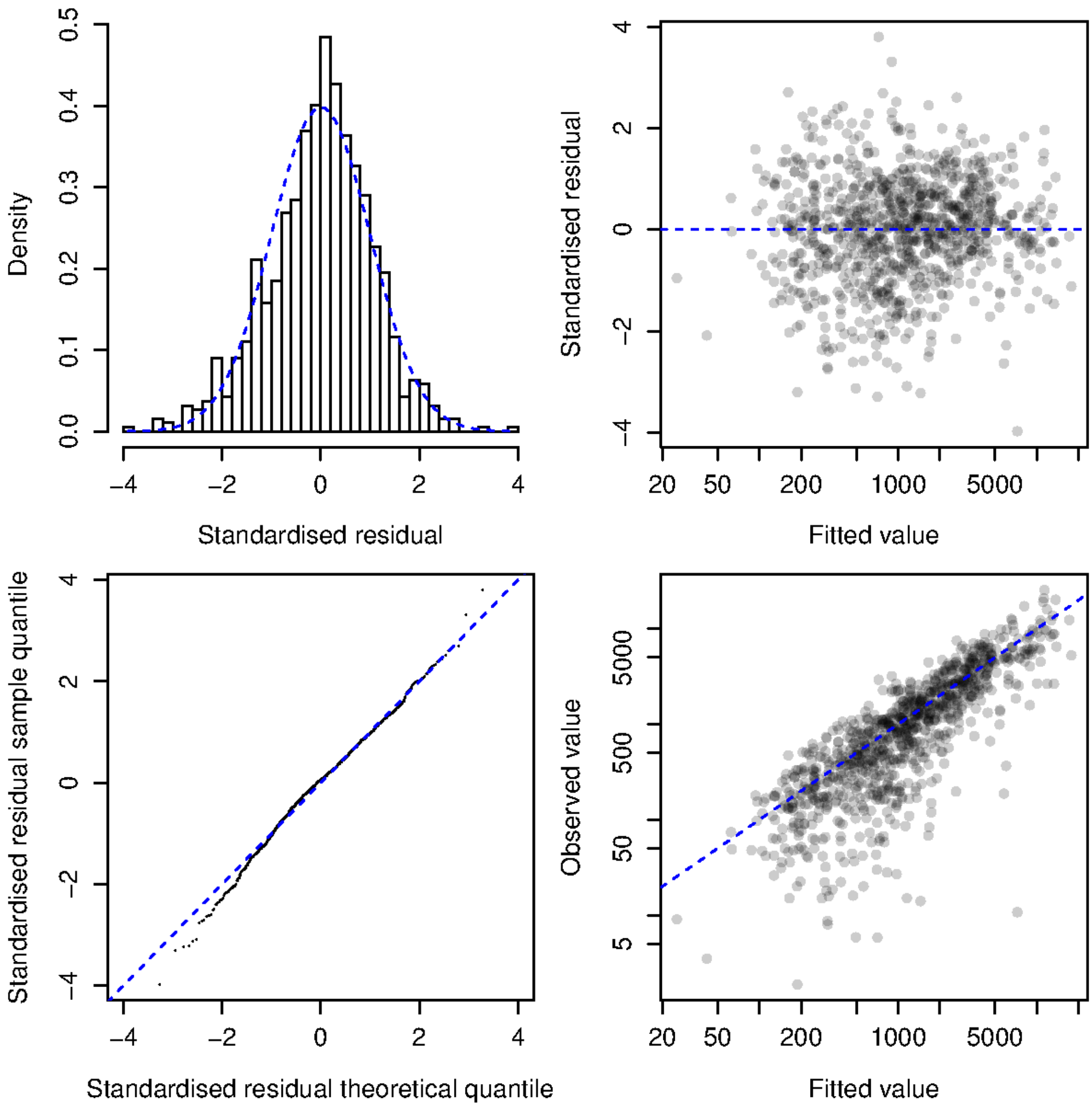

Figure E.3: Plots of the fit of the Weibull standardised CPUE model to successful catches of LIN 1 in the BLL(LIN) model. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised 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.

E.4 Model coefficients

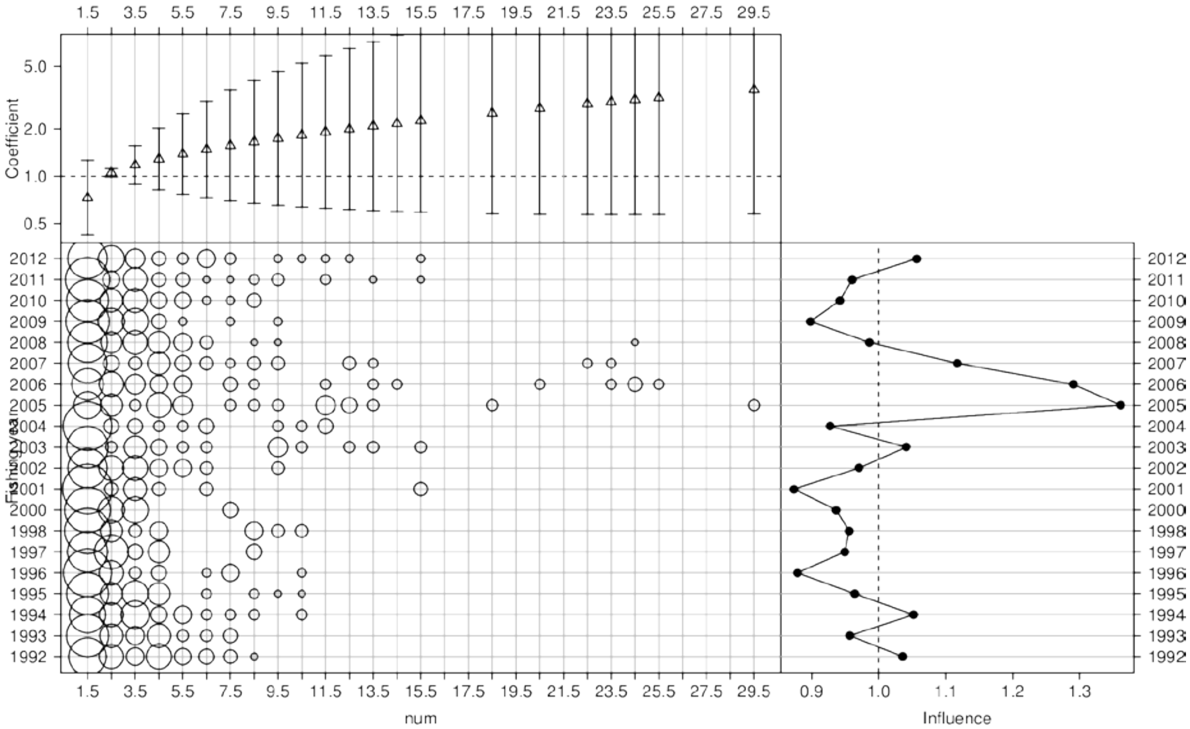

Figure E.4: Effect of log number of sets in the Weibull model for the LIN 1 BLL(LIN) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

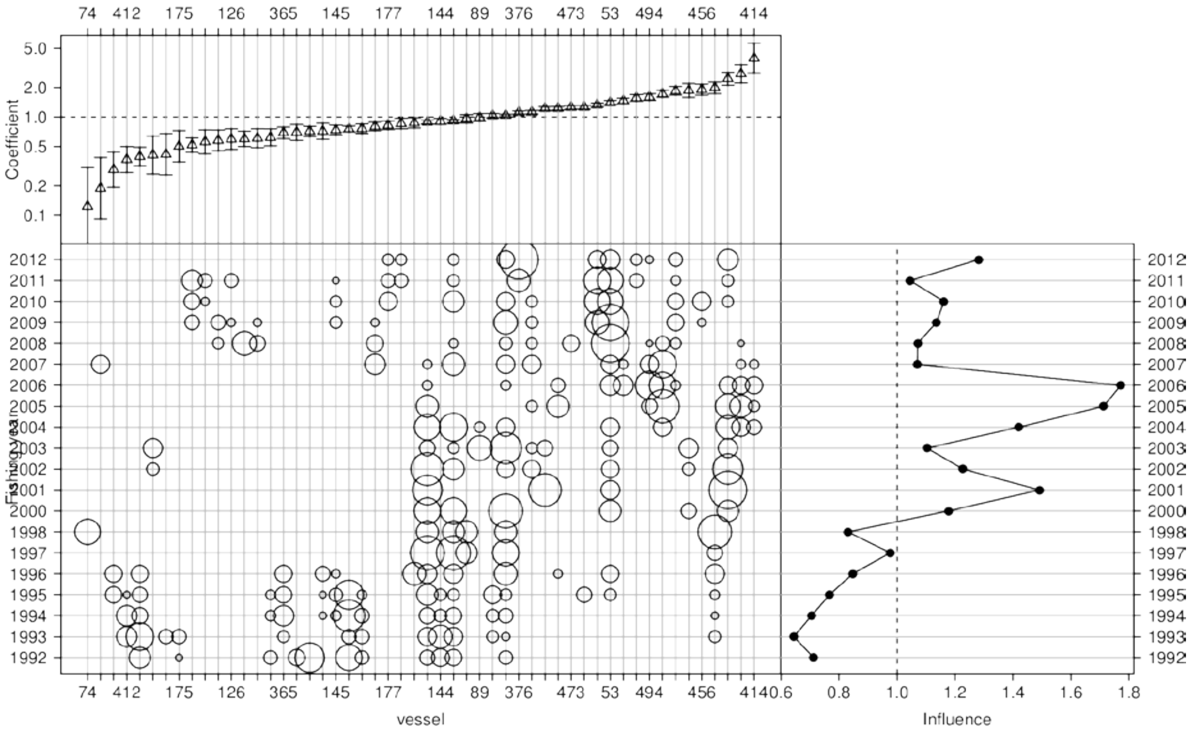

Figure E.5: Effect of vessel in the Weibull model for the LIN 1 BLL(LIN) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

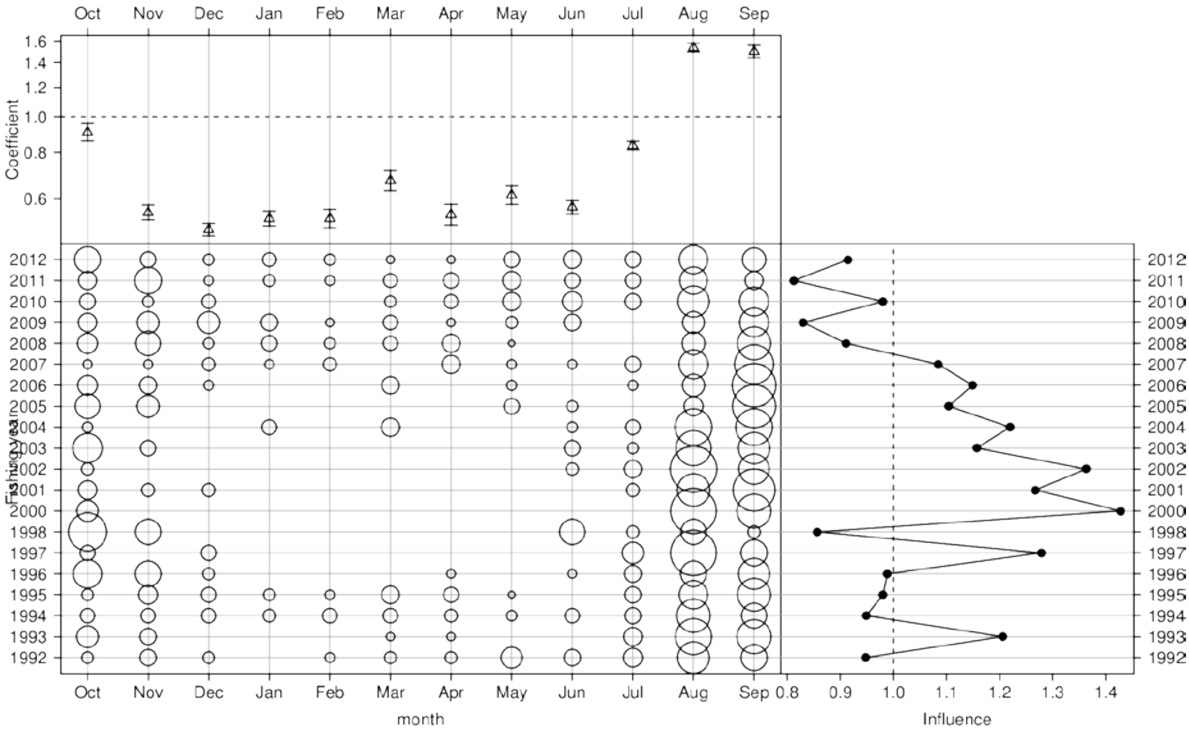

Figure E.6: Effect of month in the Weibull model for the LIN 1 BLL(LIN) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

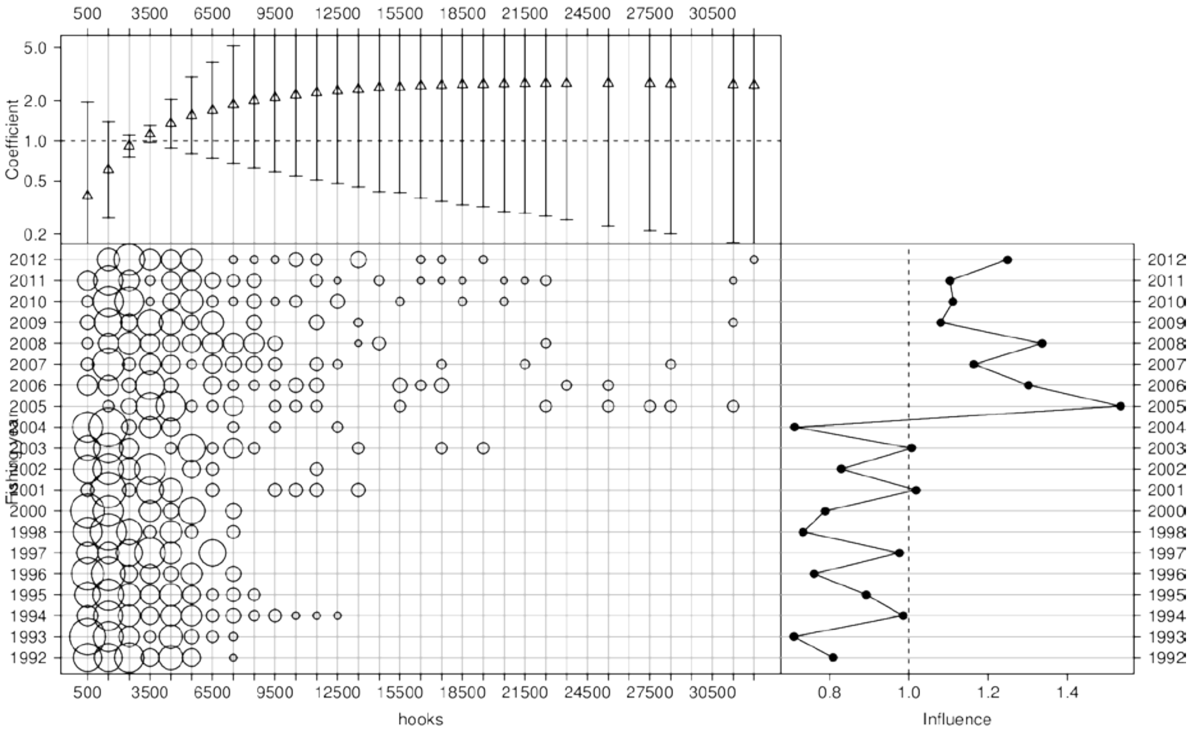

Figure E.7: Effect of log number of hooks in the Weibull model for the LIN 1 BLL(LIN) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

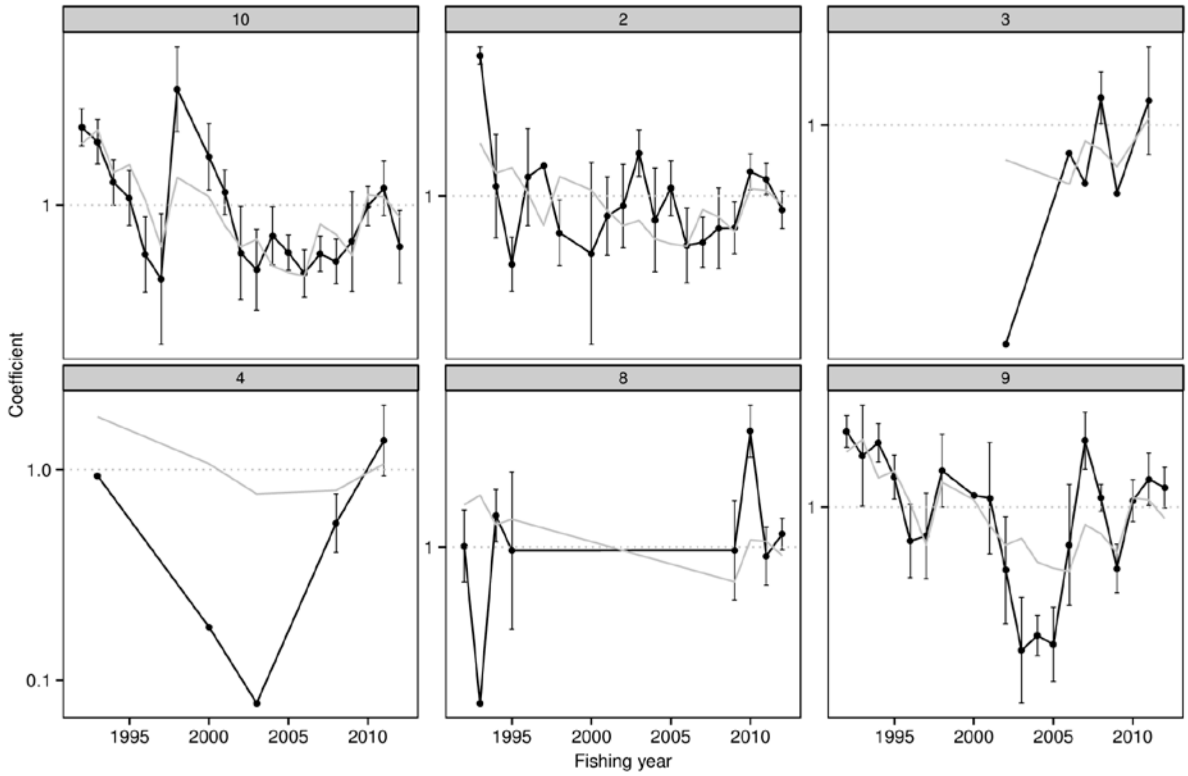

Figure E.8: Residual implied coefficients for area × fishing year interaction (not offered) in the BLL(LIN) Weibull model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. 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.

E.5 CPUE indices

Table E.2: Arithmetic indices for the total and core data sets, geometric and Weibull standardised indices and associated standard error for the core data set by fishing year for the BLL(LIN) analysis.

	All vessels				Core vessels
	Arithmetic	Arithmetic	Geometric	Standardised	SE
1992	0.815	0.807	0.889	1.720	0.1107
1993	0.991	1.028	0.866	1.909	0.1255
1994	0.849	0.832	0.804	1.377	0.1031
1995	0.805	0.789	0.694	1.462	0.0908
1996	0.716	0.708	0.523	1.112	0.1229
1997	0.959	0.940	0.902	0.778	0.1615
1998	0.624	0.667	0.677	1.327	0.1636
2000	1.532	1.595	1.457	1.144	0.1573
2001	1.717	1.834	2.342	0.916	0.1795
2002	0.982	0.911	0.927	0.777	0.1364
2003	1.120	1.148	0.767	0.822	0.1511
2004	0.858	0.912	0.842	0.671	0.1279
2005	1.310	1.187	1.434	0.637	0.1447
2006	1.124	1.012	1.151	0.620	0.1354
2007	0.981	0.981	1.053	0.924	0.1115
2008	0.887	0.893	1.146	0.854	0.1046
2009	0.789	0.787	0.759	0.727	0.1057
2010	1.344	1.383	1.616	1.161	0.1069
2011	1.041	1.050	1.129	1.142	0.1006
2012	1.207	1.234	1.293	0.975	0.1106

Appendix F. DIAGNOSTICS FOR BT(SCI) CPUE STANDARDISATION

F.1 Introduction

This model was not accepted by the NINSWG but the results and diagnostics for this model are reported here without comment for reference.

F.2 Fishery definition

BT (SCI) – Ling bottom trawl; The Fishery is defined from bottom trawl fishing events which fished in Statistical Areas 008, 009 or 010, and targeted scampi. The analysis was restricted to vessels which reported on TCEPR or TCER forms.

F.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 3 trips in each of at least 2 years. These criteria resulted in a core fleet size of 9 vessels which took 95% of the catch.

F.4 Data summary

Table F.1: Number of number of core vessels, trips, trip strata, number of events that have been "rolled up" into trip strata, calculated number of events per trip-stratum, number of tows, sum of duration fished, landed LIN 1 (t), proportion of trips with catch and proportion of trip-strata with catch, by fishing year for core vessels (based on a minimum of 3 trips per year in at least 2 years) in the BT(SCI) fishery.

Fishing year	Vessels	Trips	Trip strata	Events	Events per stratum	Number tows	Duration (h)	Catch (t)	Trips with catch (%)	Strata with catch (%)
1990	4	30	792	792	1	792	2 975	52.91	90.0	70.1
1991	7	41	1228	1228	1	1228	5 741	92.33	95.1	84.4
1992	6	34	906	906	1	906	5 191	66.38	82.4	73.8
1993	4	24	588	588	1	588	3 203	44.45	79.2	44.6
1994	4	20	497	497	1	497	2 653	46.14	75.0	53.5
1995	4	17	344	344	1	344	1 852	28.53	94.1	68.0
1996	3	11	264	264	1	264	1 415	13.65	100	64.8
1997	3	15	364	364	1	364	1 939	11.70	80.0	57.7
1998	2	9	259	259	1	259	1 719	12.12	88.9	83.8
1999	6	17	301	301	1	301	1 782	18.34	70.6	62.5
2000	6	17	556	556	1	556	3 642	53.19	88.2	89.4
2001	5	20	726	726	1	726	5 151	69.66	90.0	80.9
2002	6	30	712	712	1	712	4 895	74.72	90.0	74.3
2003	5	13	502	502	1	502	3 518	41.47	100	70.9
2004	6	19	746	746	1	746	5 109	45.81	68.4	64.5
2005	3	14	742	742	1	742	5 207	42.24	85.7	64.7
2006	2	13	780	780	1	780	5 383	21.76	84.6	39.5
2007	2	11	730	730	1	730	5 134	19.78	100	45.6
2008	2	10	558	558	1	558	3 911	11.78	90.0	31.0
2009	2	12	770	770	1	770	5 394	19.00	100	32.2
2010	3	12	745	745	1	745	5 226	16.56	83.3	26.7
2011	2	14	784	784	1	784	5 621	24.09	85.7	34.8
2012	2	14	747	747	1	747	5 403	23.91	85.7	38.3

F.5 Model selection table

Table F.2: Order of acceptance of variables into the log.logistic model of successful catches of in the BT(SCI) fishery model for core vessels based on the vessel selection criteria of at least 3 trips in 2 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	24	-46 357	92 762	8.03	*
bottom depth	25	-45 887	91 824	17.66	*
vessel	41	-45 427	90 937	26.09	*
month	52	-45 175	90 453	30.35	*
area	54	-45 096	90 301	**31.62**	*
poly(log(duration), 3)	57	-45 033	90 181	32.62	

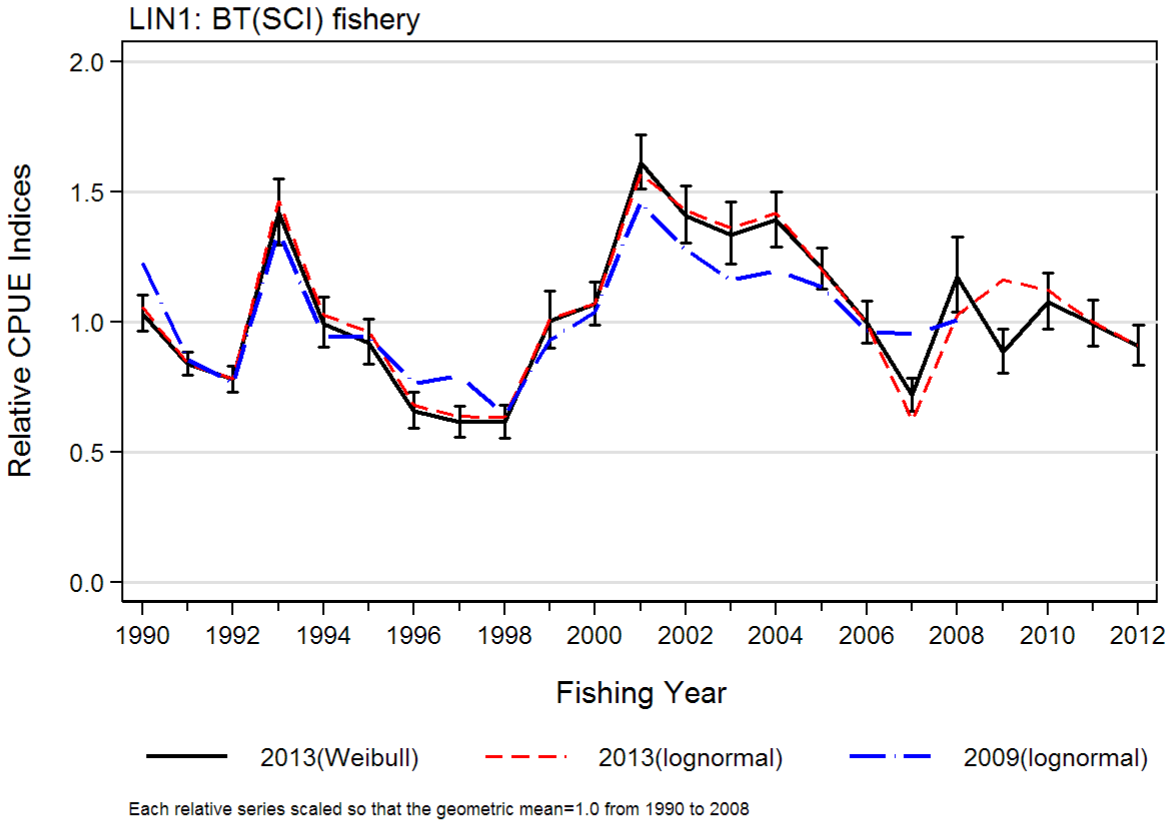

Figure F.1: Comparison of three versions of the LIN 1 BT(SCI) standardised CPUE model: A) 2013 model fitted to data up to the 2011–12 fishing year using the Weibull distribution for positive catches; B) 2013 model fitted to data up to the 2011–12 fishing year using the lognormal distribution for positive catches; C) 2009 model fitted to data up to the 2007–08 fishing year using the lognormal distribution for positive catches.

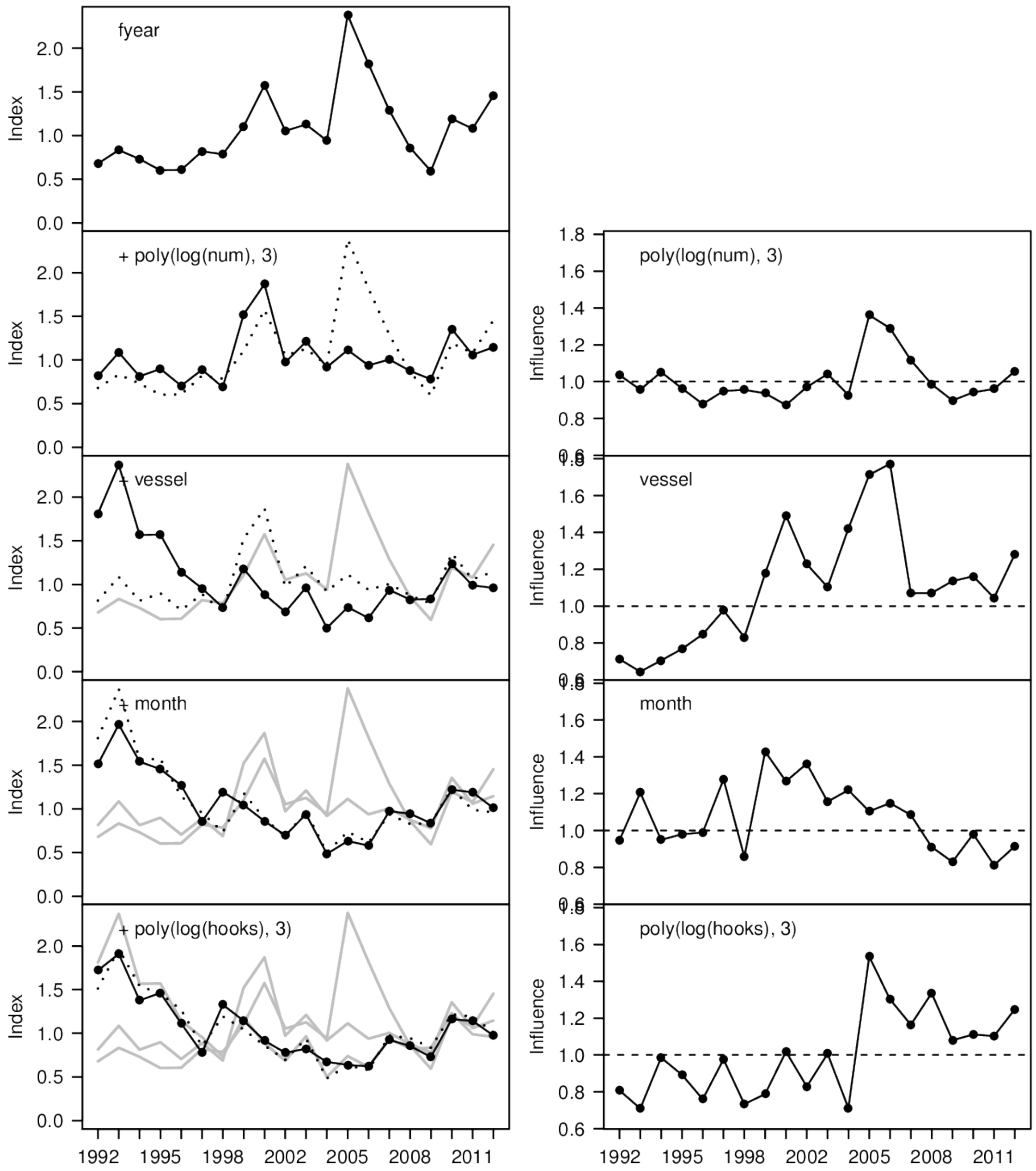

Figure F.2: [left column]: annual indices from the log.logistic model of BT(SCI) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

F.6 Core vessel selection

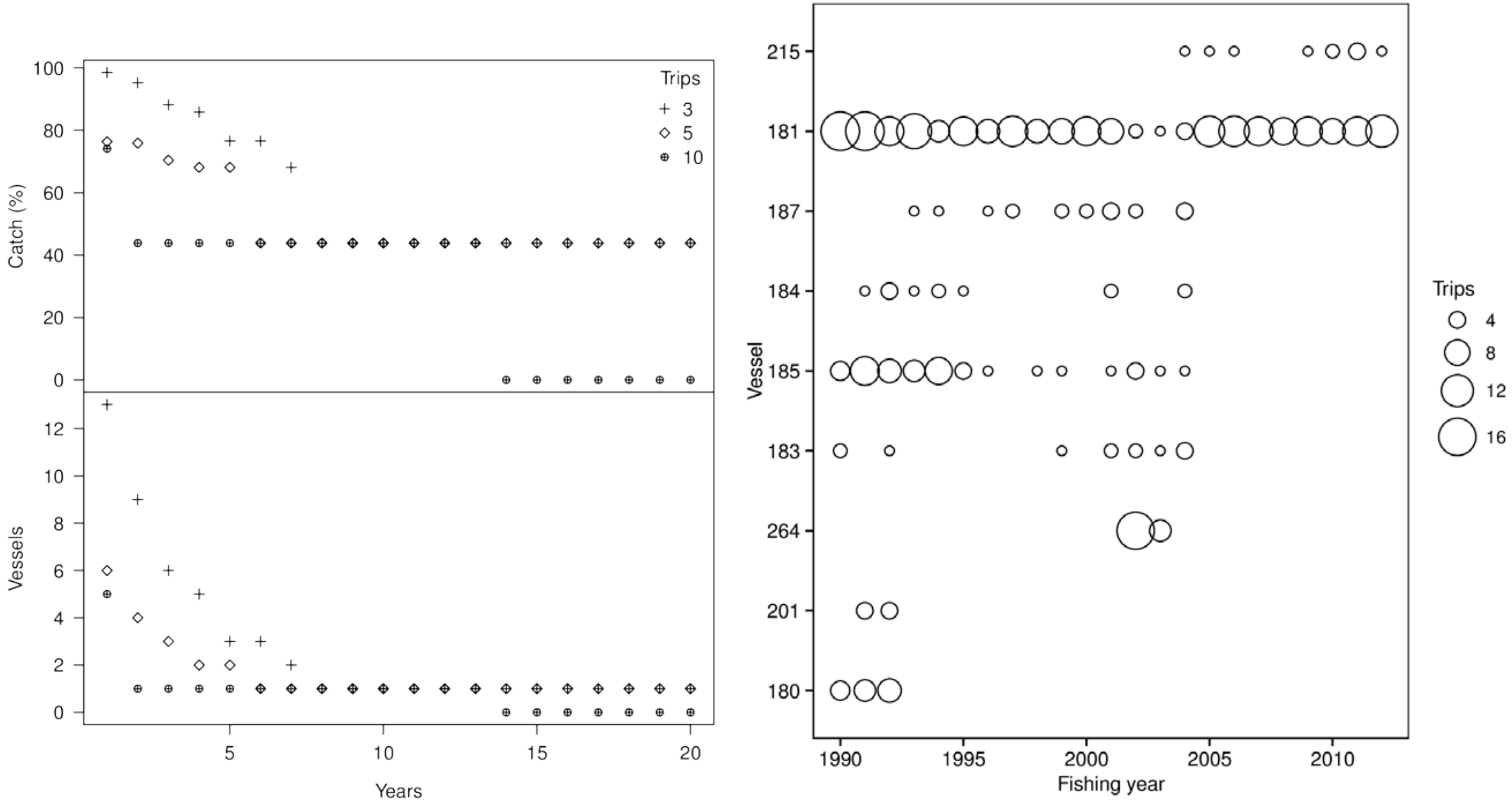

Figure F.3: [left panel] total landed LIN 1 and number of vessels plotted against the number of years used to define core vessels participating in the BT(SCI) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of trip-strata for selected core vessels (based on at least 3 trips in 2 or more fishing years) by fishing year

F.7 Residual and diagnostic plots

The best distribution was log.logistic.

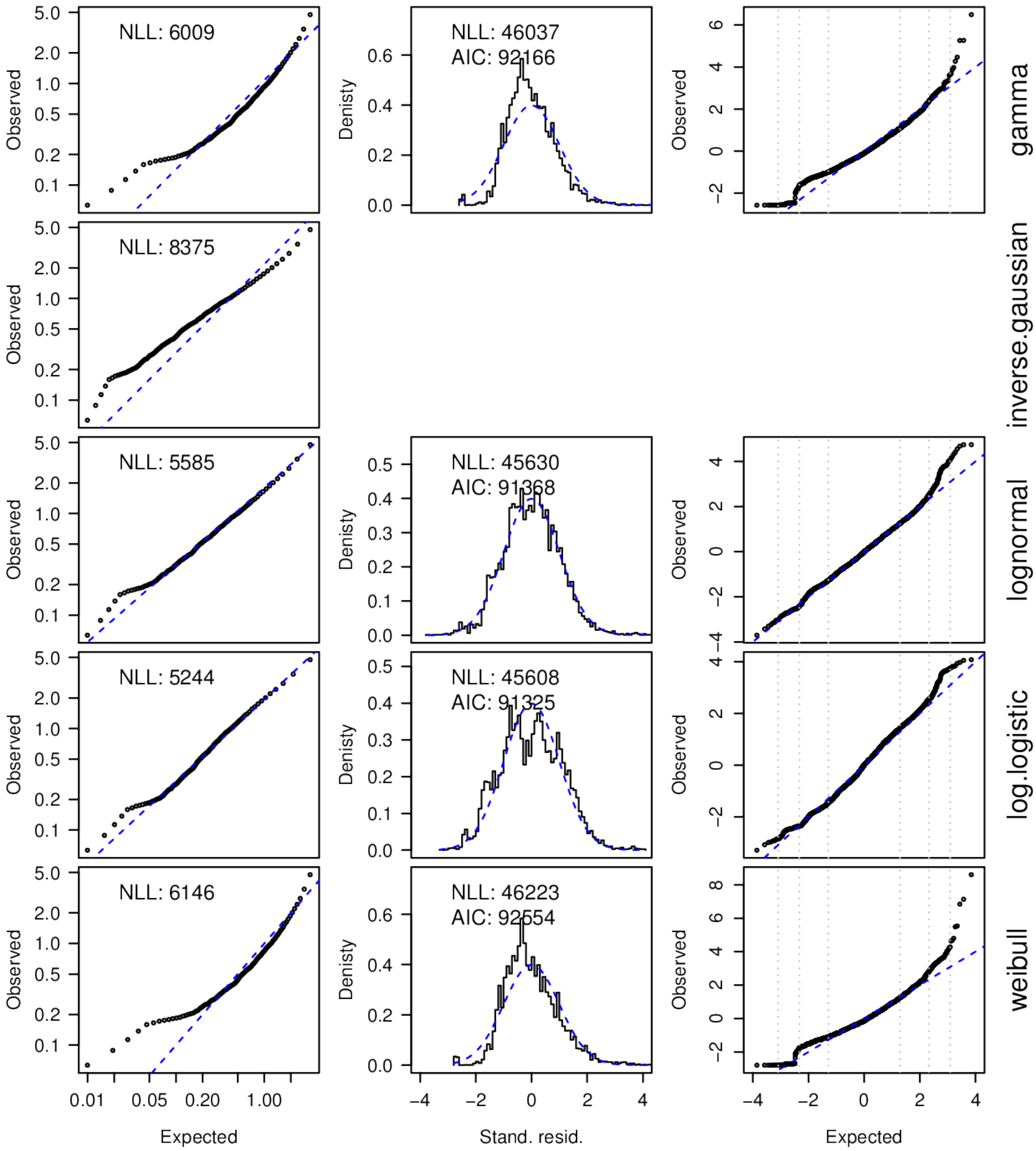

Figure F.4: Diagnostics for alternative distributional assumptions for catch in the BT(SCI) fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month +area+ vessel + log(sets) and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

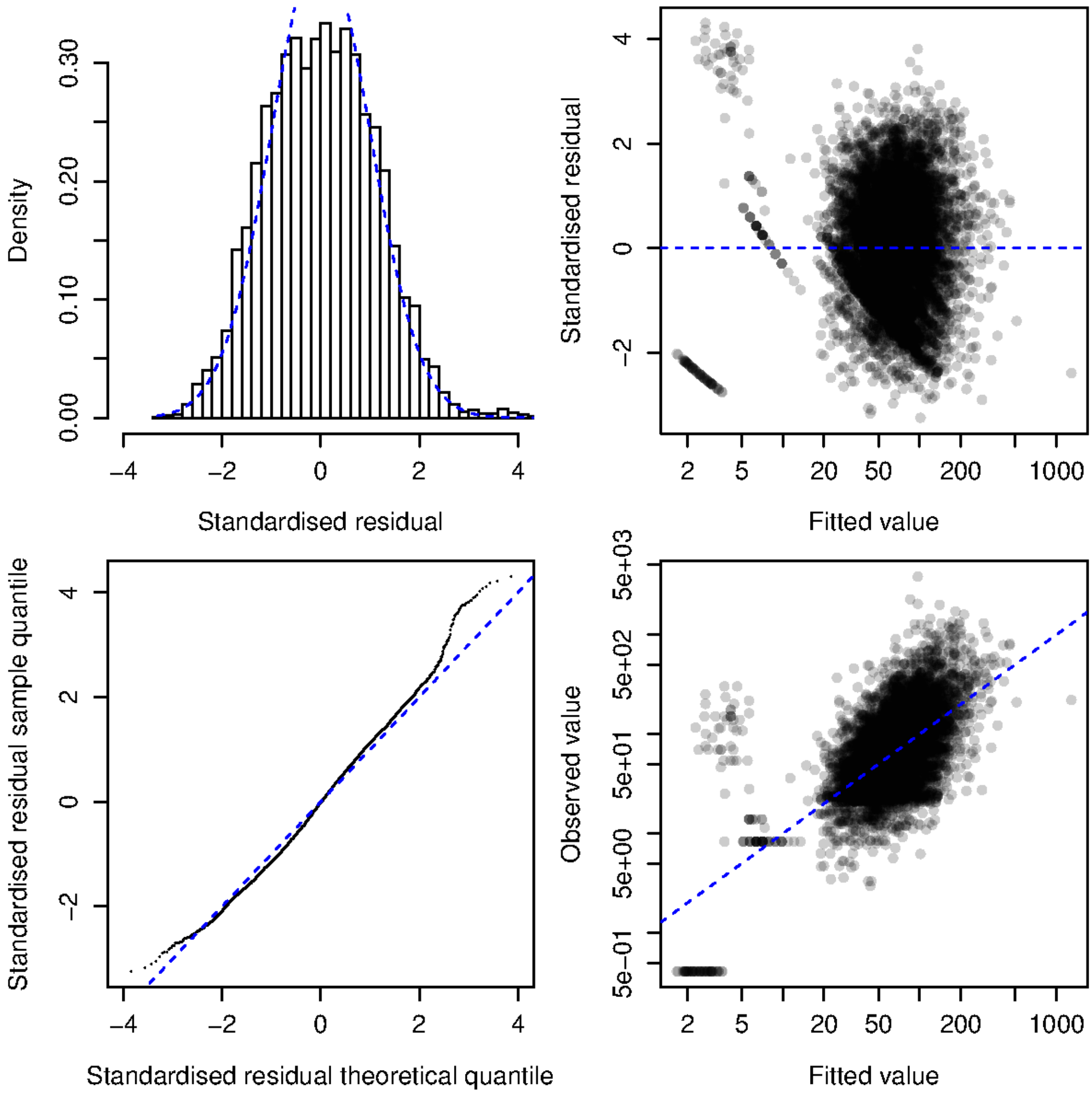

Figure F.5: Plots of the fit of the log.logistic standardised CPUE model to successful catches of LIN 1 in the BT(SCI) fishery. [Upper left] histogram of the standardised residuals compared to a log.logistic distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised 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.

F.8 Model coefficients

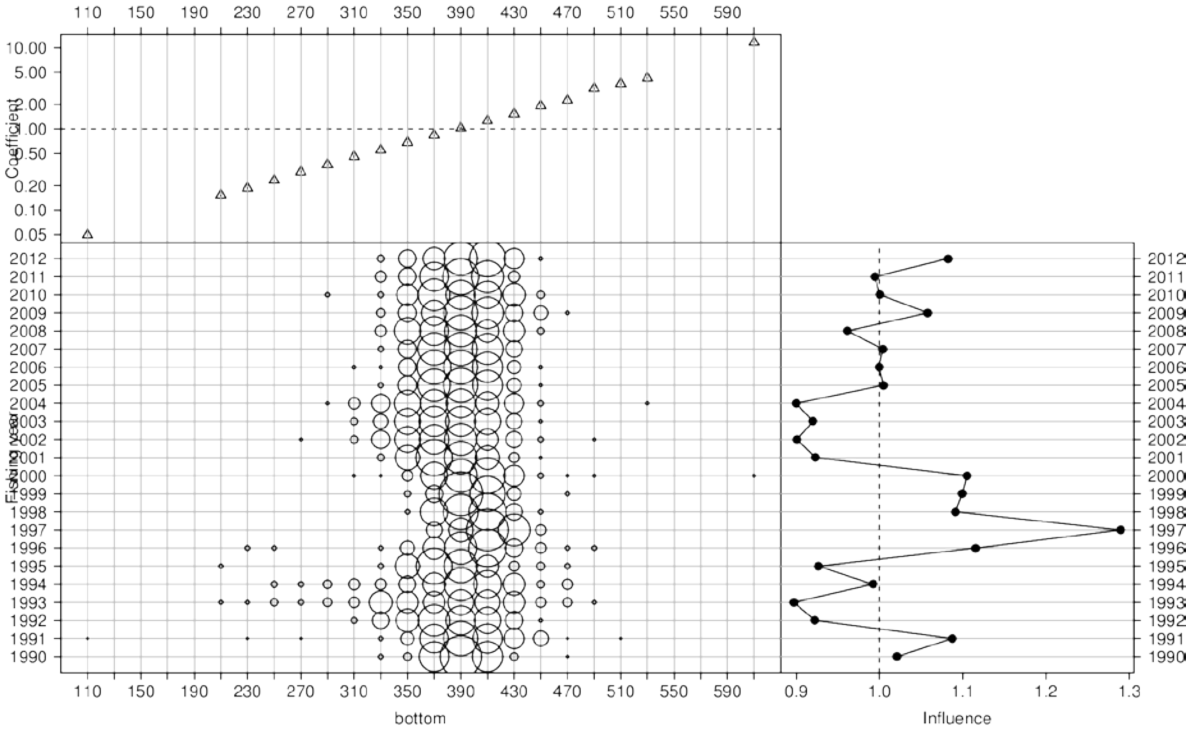

Figure F.6: Effect of bottom depth in the log.logistic model for the LIN 1 BT(SCI) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

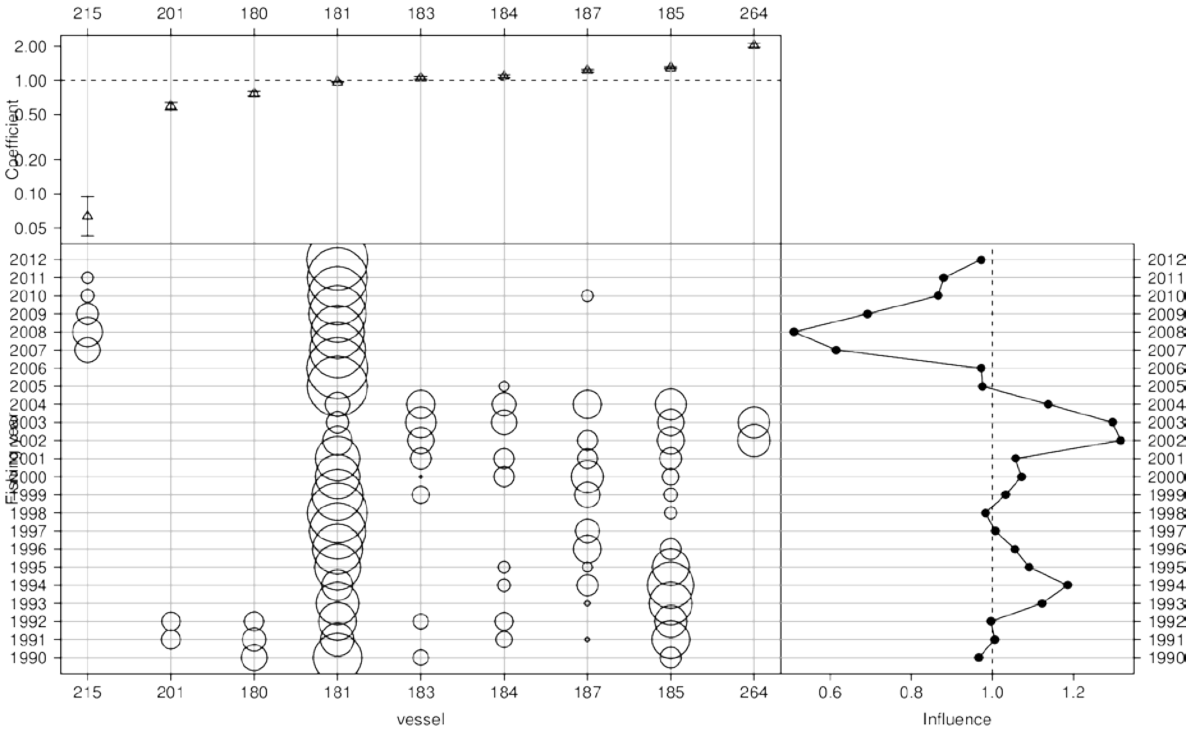

Figure F.7: Effect of vessel in the log.logistic model for the LIN 1 BT(SCI) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

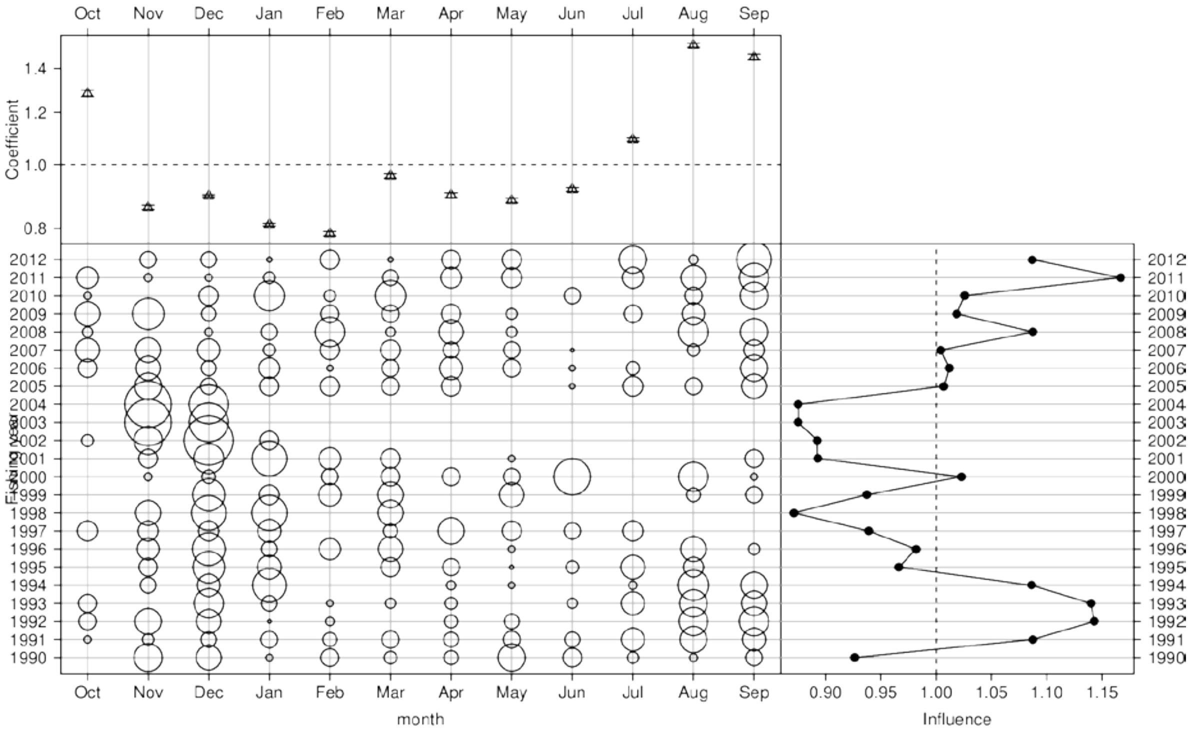

Figure F.8: Effect of month in the log.logistic model for the LIN 1 BT(SCI) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

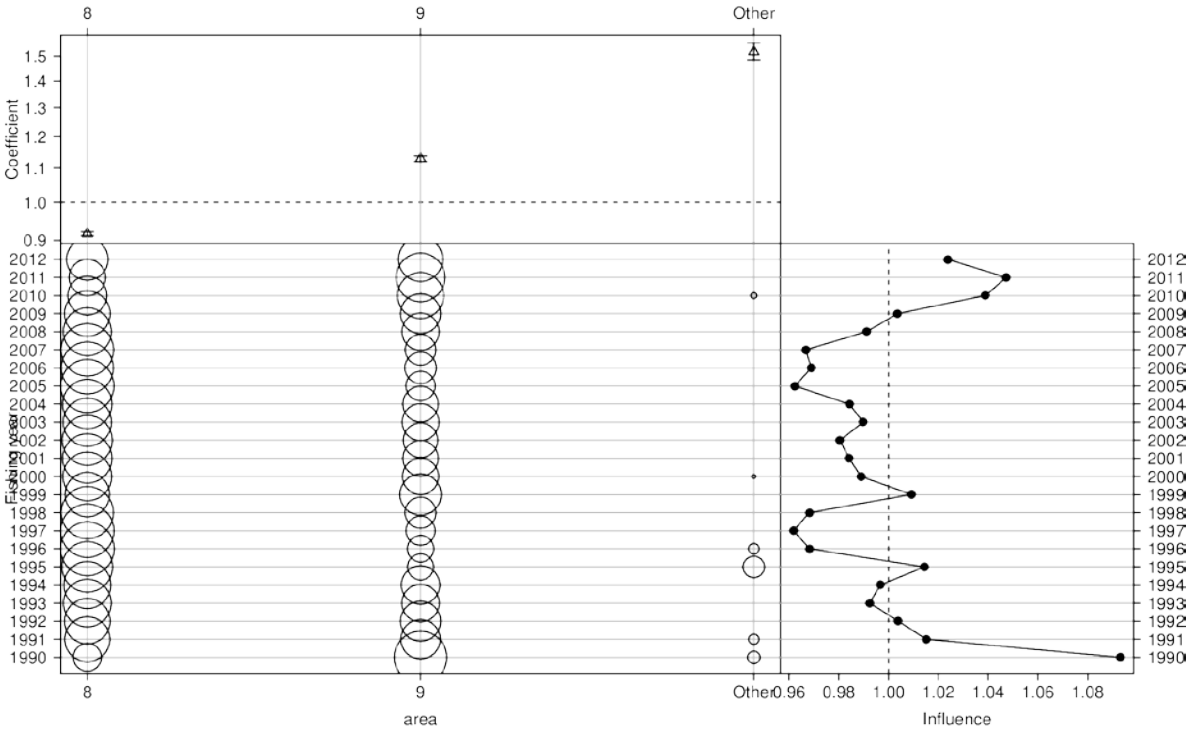

Figure F.9: Effect of area in the log.logistic model for the LIN 1 BT(SCI) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

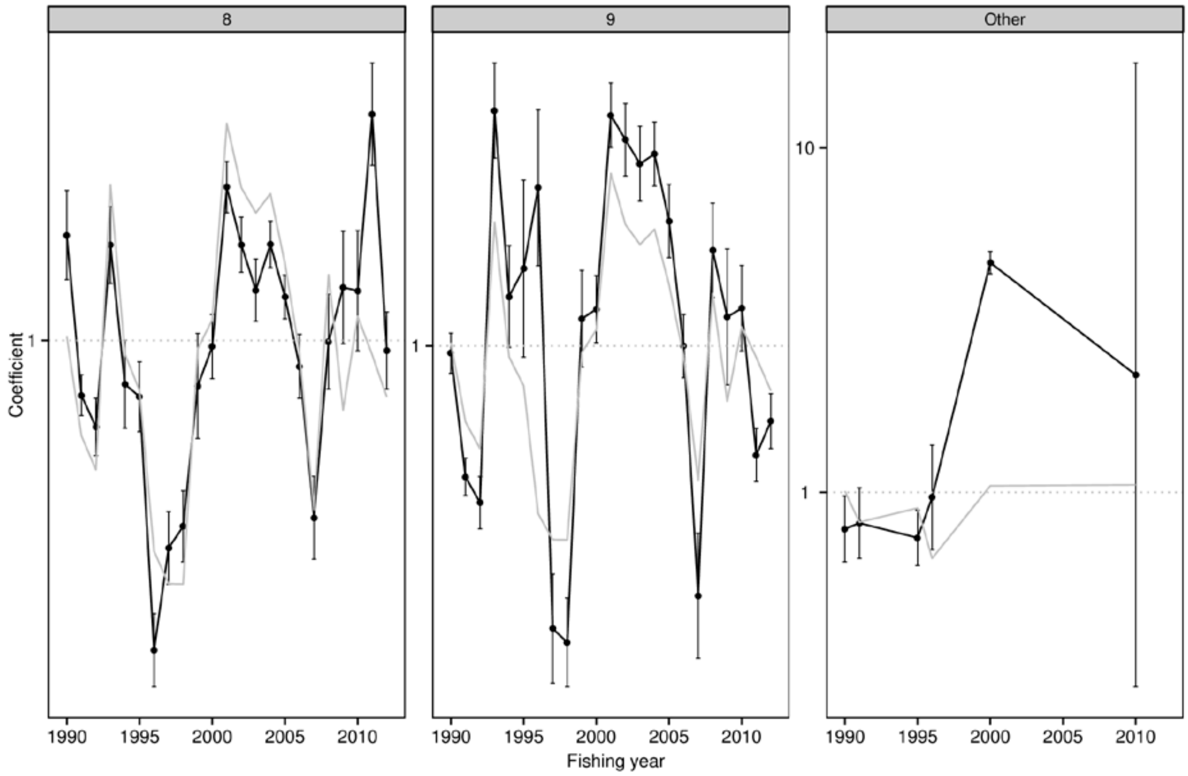

Figure F.10: Residual implied coefficients for area × fishing year interaction (not offered) in the BT(SCI) log.logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and 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.

F.9 CPUE indices

Table F.3: Arithmetic indices for the total and core data sets, geometric and log.logistic standardised indices and associated standard error for the core data set by fishing year for the BT(SCI) analysis.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.253	1.295	1.063	1.039	0.0336
1991	1.440	1.458	1.013	0.844	0.0273
1992	1.470	1.421	0.827	0.786	0.0321
1993	1.376	1.466	1.697	1.427	0.0460
1994	1.790	1.800	1.319	1.001	0.0492
1995	1.585	1.608	0.948	0.927	0.0479
1996	0.967	1.003	0.758	0.663	0.0545
1997	0.635	0.623	0.729	0.619	0.0498
1998	1.131	0.907	0.668	0.618	0.0515
1999	1.161	1.181	1.095	1.012	0.0553
2000	1.840	1.855	1.284	1.076	0.0395
2001	1.820	1.860	1.353	1.622	0.0331
2002	1.808	2.035	1.471	1.418	0.0398
2003	1.528	1.602	1.366	1.345	0.0459
2004	1.224	1.191	1.242	1.400	0.0388
2005	1.026	1.104	1.143	1.210	0.0331
2006	0.549	0.541	0.951	1.004	0.0406
2007	0.663	0.525	0.399	0.723	0.0445
2008	0.405	0.409	0.603	1.182	0.0631
2009	0.454	0.478	0.901	0.891	0.0495
2010	0.423	0.431	1.080	1.083	0.0515
2011	0.621	0.596	1.097	0.999	0.0451
2012	0.587	0.621	1.084	0.915	0.0424

Appendix G. DIAGNOSTICS FOR BT(MIX) CPUE STANDARDISATION

G.1 Introduction

This model was not accepted by the NINSWG but the results and diagnostics for this model are reported here without comment for reference.

G.2 Fishery definition

BT (MIX) – Ling bottom trawl; The Fishery is defined from bottom trawl fishing events which fished in Statistical Areas 002, 003, 004, 008, 009 or 010, and targeted LIN, HOK or TAR. The analysis was restricted to vessels which reported on TCEPR or TCER forms.

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. These criteria resulted in a core fleet size of 29 vessels which took 88% of the catch.

G.4 Data summary

Table G.1: Number of number of core vessels, trips, trip strata, number of events that have been "rolled up" into trip strata, calculated number of events per trip-stratum, number of tows, sum of duration fished, landed LIN 1 (t), proportion of trips with catch and proportion of trip-strata with catch, by fishing year for core vessels (based on a minimum of 5 trips per year in at least 5 years) in the BT(MIX) fishery.

Fishing year	Vessels	Trips	Trip strata	Events	Events per stratum	Number tows	Duration (h)	Catch (t)	Trips with catch (%)	Strata with catch (%)
1996	21	142	554	554	1	554	2 141	5.00	61.3	51.6
1997	21	230	1 064	1 064	1	1 064	4 024	18.92	70.0	47.9
1998	23	251	1 207	1 207	1	1 207	4 706	30.53	76.5	55.0
1999	21	263	1 177	1 177	1	1 177	4 553	50.87	72.6	48.4
2000	20	250	1 255	1 255	1	1 255	4 774	35.36	76.0	57.6
2001	24	282	1 124	1 124	1	1 124	4 166	29.03	80.9	55.5
2002	23	309	1 194	1 194	1	1 194	4 927	42.85	79.6	53.4
2003	20	315	1 449	1 449	1	1 449	6 112	34.53	75.2	56.1
2004	21	353	1 376	1 376	1	1 376	6 194	47.29	78.8	46.3
2005	17	333	1 635	1 635	1	1 635	7 242	26.39	76.3	45.1
2006	17	350	1 767	1 767	1	1 767	7 859	68.13	76.0	48.3
2007	13	264	1 329	1 329	1	1 329	5 687	31.90	81.1	49.5
2008	17	300	1 649	1 649	1	1 649	6 821	47.94	76.0	46.0
2009	16	312	1 839	1 839	1	1 839	7 544	55.87	80.5	48.1
2010	13	337	1 907	1 907	1	1 907	7 924	90.61	79.8	44.4
2011	15	313	1 703	1 703	1	1 703	7 210	57.74	78.6	41.3
2012	14	307	1 680	1 680	1	1 680	6 585	46.96	79.5	44.6

G.5 Model selection table

Table G.2: Order of acceptance of variables into the lognormal model of successful catches of in the BT(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	17	-26 102	52 240	4.05	*
target species	19	-23 049	46 139	43.97	*
vessel	47	-21 629	43 353	56.45	*
area	52	-21 193	42 491	59.71	*
bottom depth	53	-20 819	41 746	**62.31**	*
poly(log(duration), 3)	56	-20 700	41 513	63.10	
month	67	-20 620	41 376	63.62	

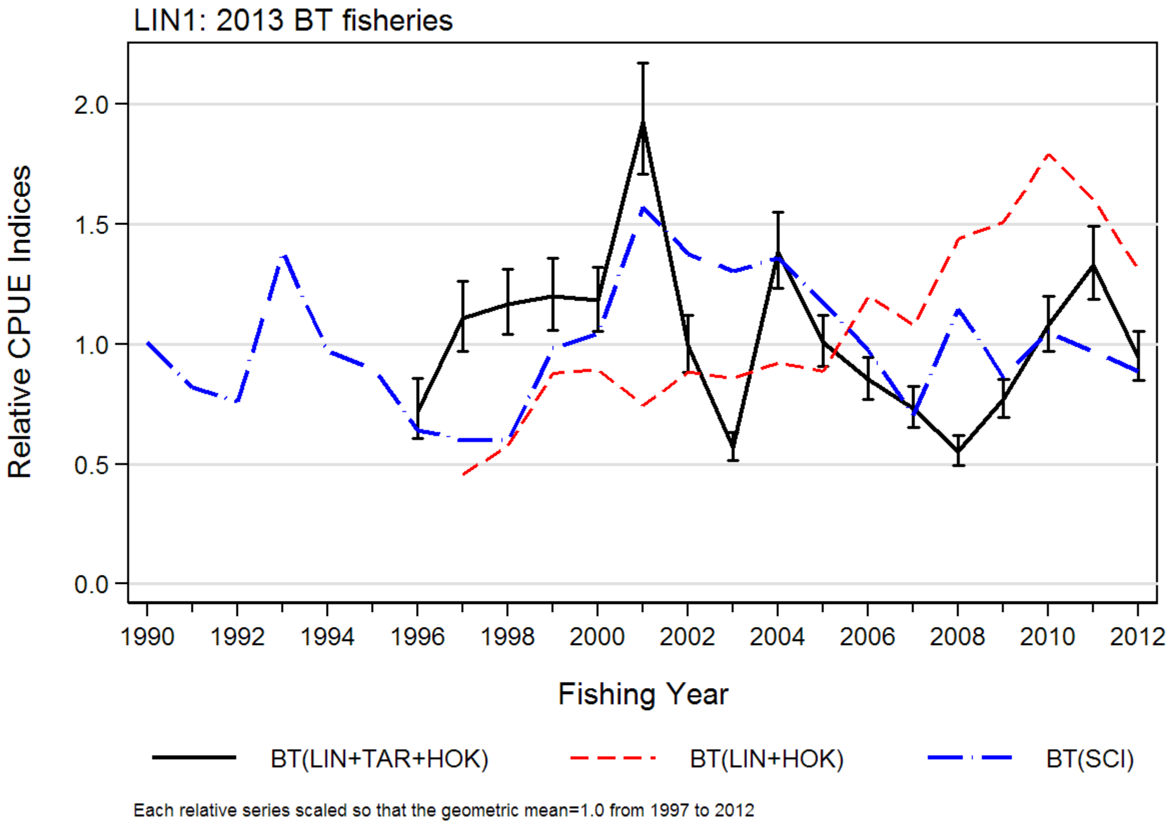

Figure G.1: Comparison of three 2013 LIN 1 bottom trawl standardised CPUE models: A) model fitted to target species data for LIN, HOK or TAR using the lognormal distribution for positive catches; B) model fitted to target species data for LIN or HOK using the lognormal distribution for positive catches; C) model fitted to target species data for SCI using the log.logistic distribution for positive catches. Model 'A' is reported in Appendix G, model 'B; is not reported and model 'C' is reported in Appendix F.

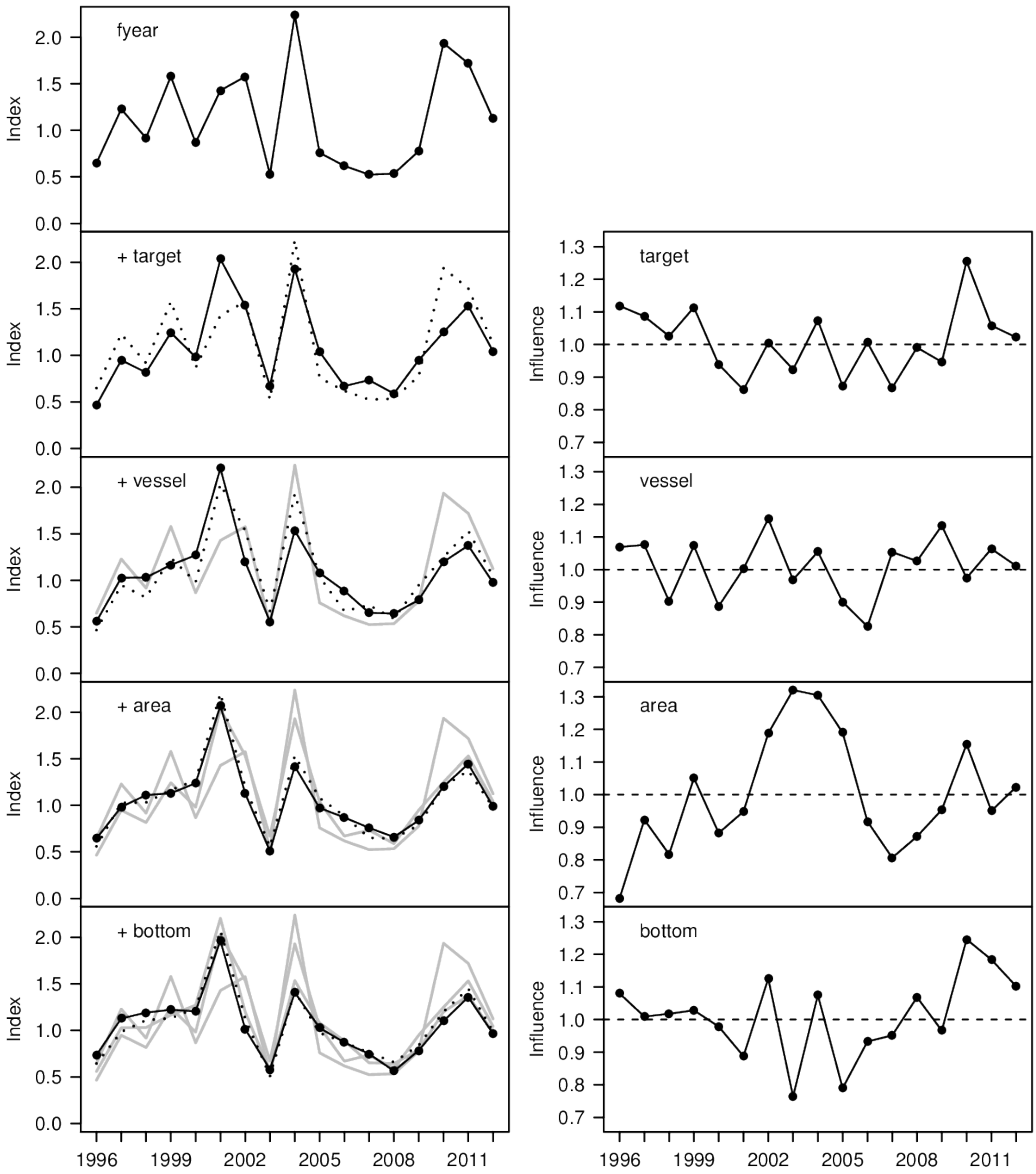

Figure G.2: [left column]: annual indices from the lognormal model of BT(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

G.6 Core vessel selection

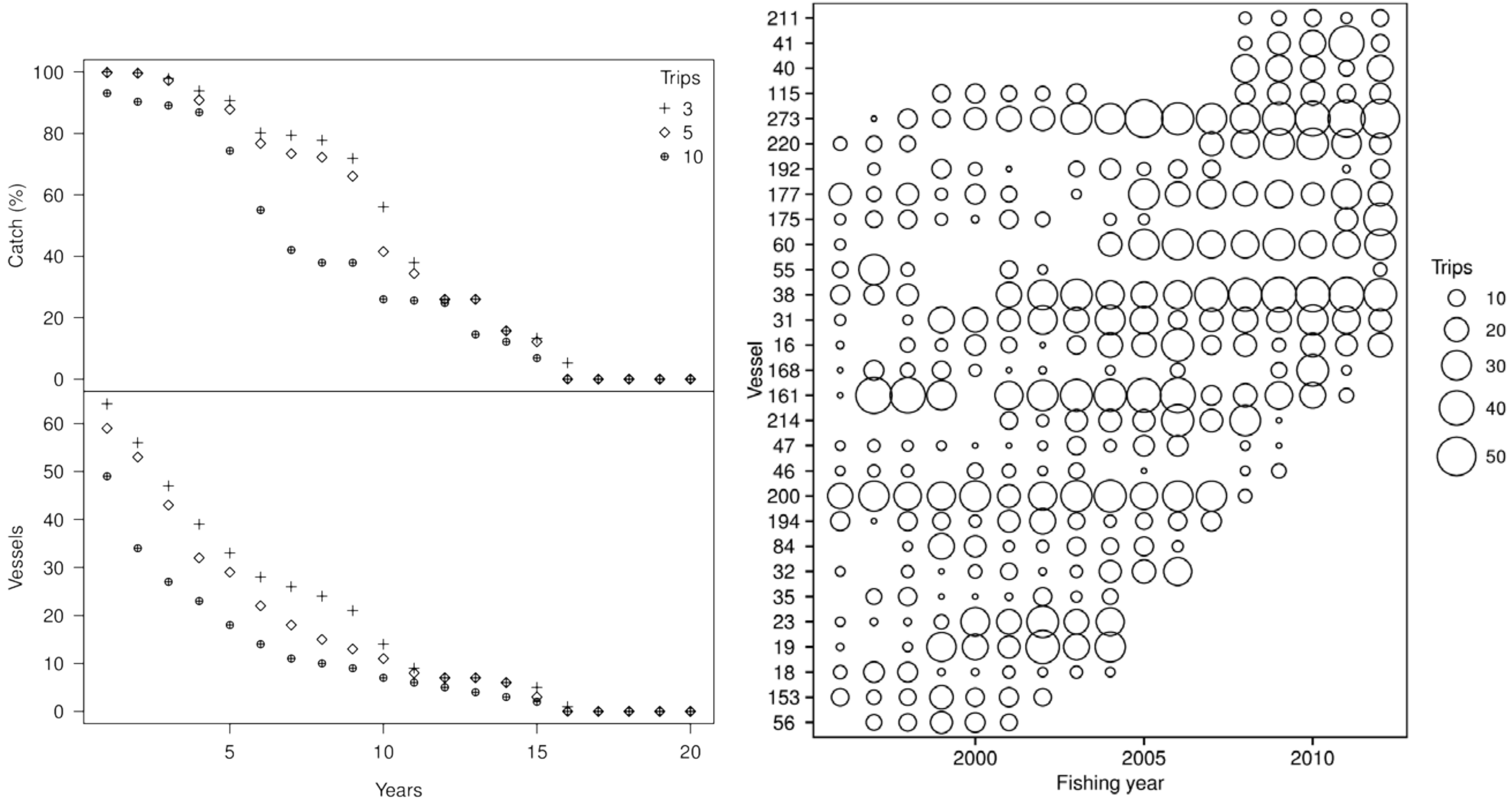

Figure G.3: [left panel] total landed LIN 1 and number of vessels plotted against the number of years used to define core vessels participating in the BT(MIX) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of trip-strata for selected core vessels (based on at least 5 trips in 5 or more fishing years) by fishing year.

G.7 Residual and diagnostic plots

The best distribution was lognormal.

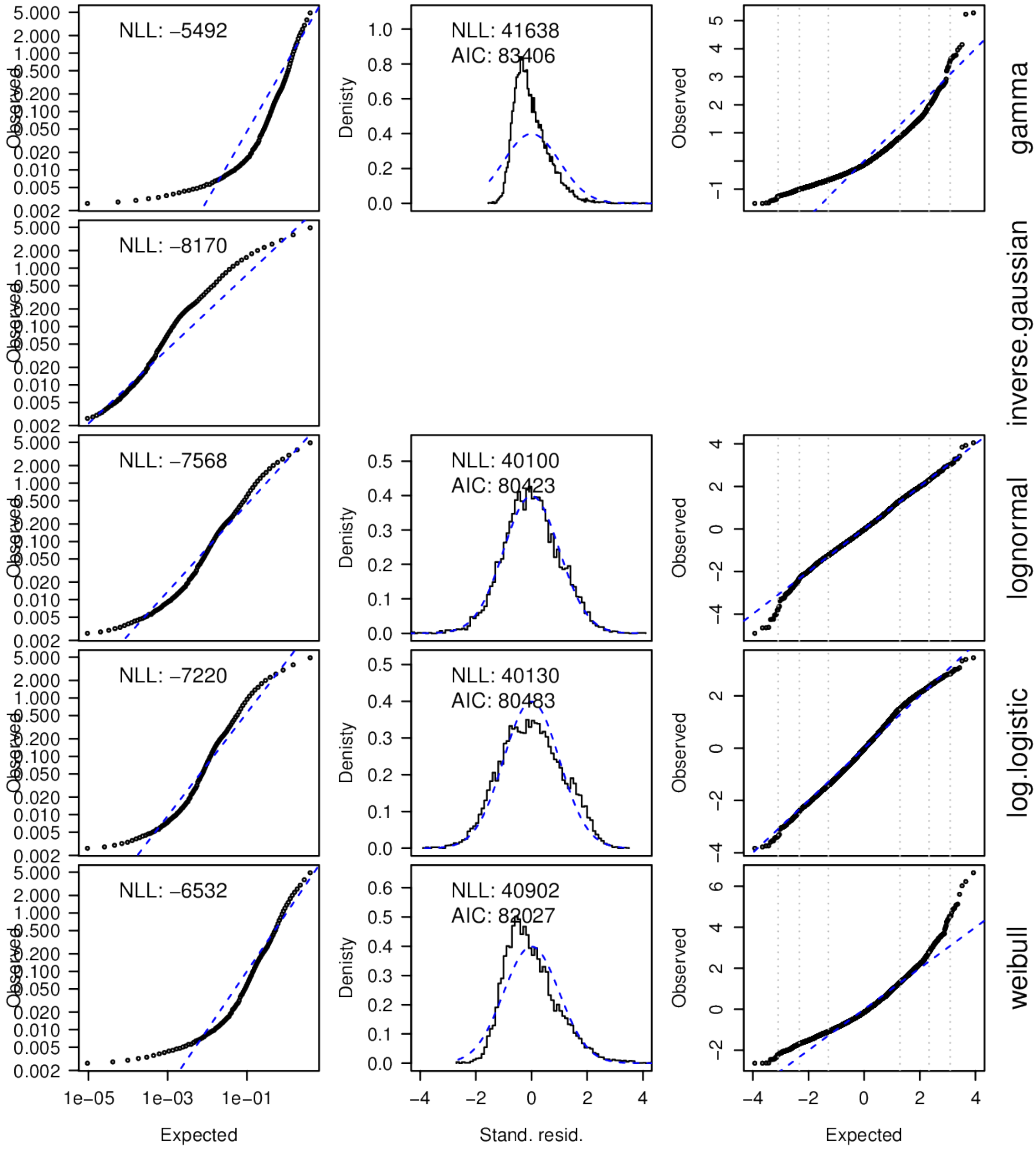

Figure G.4: Diagnostics for alternative distributional assumptions for catch in the BT(MIX) fishery. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); Middle: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month +area+ vessel + log(sets) and the distribution (missing panel indicates the model failed to converge); Right: quantile-quantile plot of model standardised residuals against standard normal (vertical lines represent 0.1%, 1% and 10% percentiles). NLL = negative log-likelihood; AIC = Akaike information criterion.

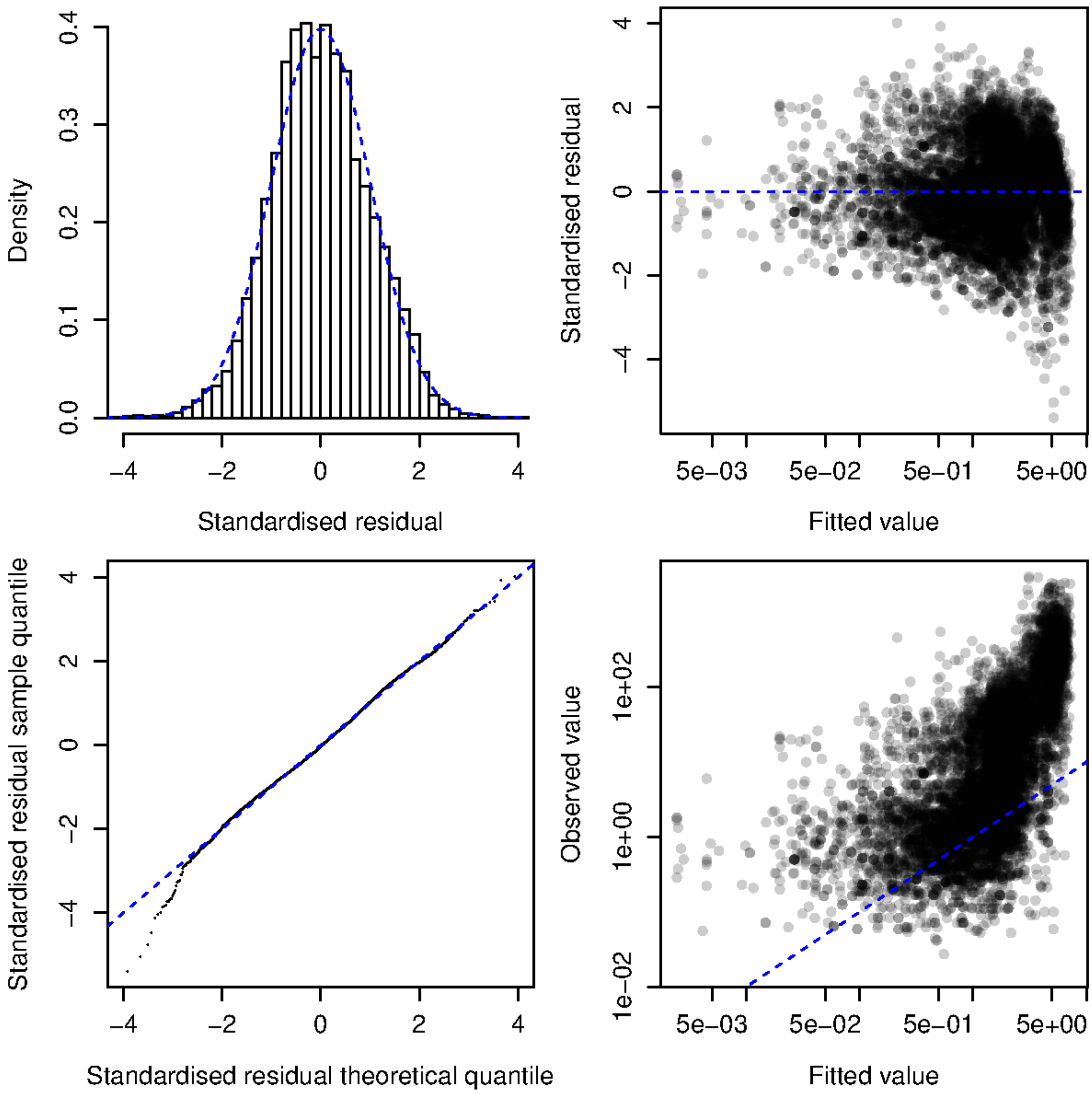

Figure G.5: Plots of the fit of the lognormal standardised CPUE model to successful catches of LIN 1 in the BT(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised 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.

G.8 Model coefficients

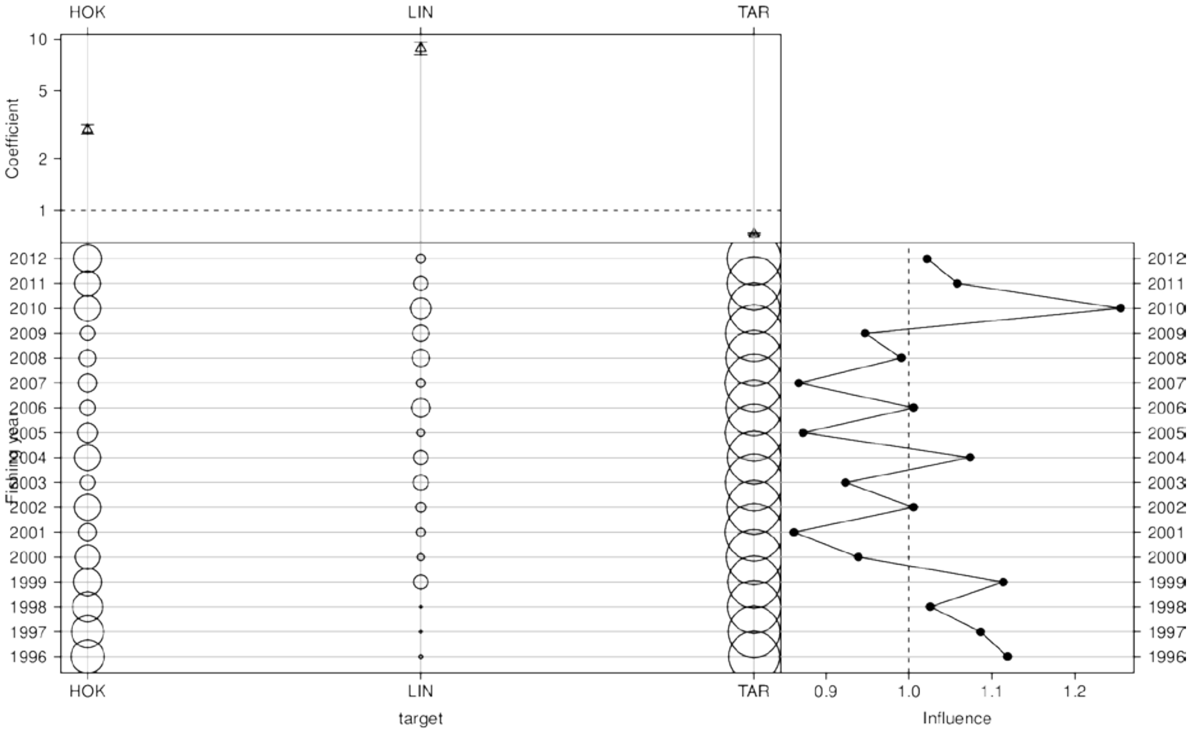

Figure G.6: Effect of target species in the lognormal model for the LIN 1 BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

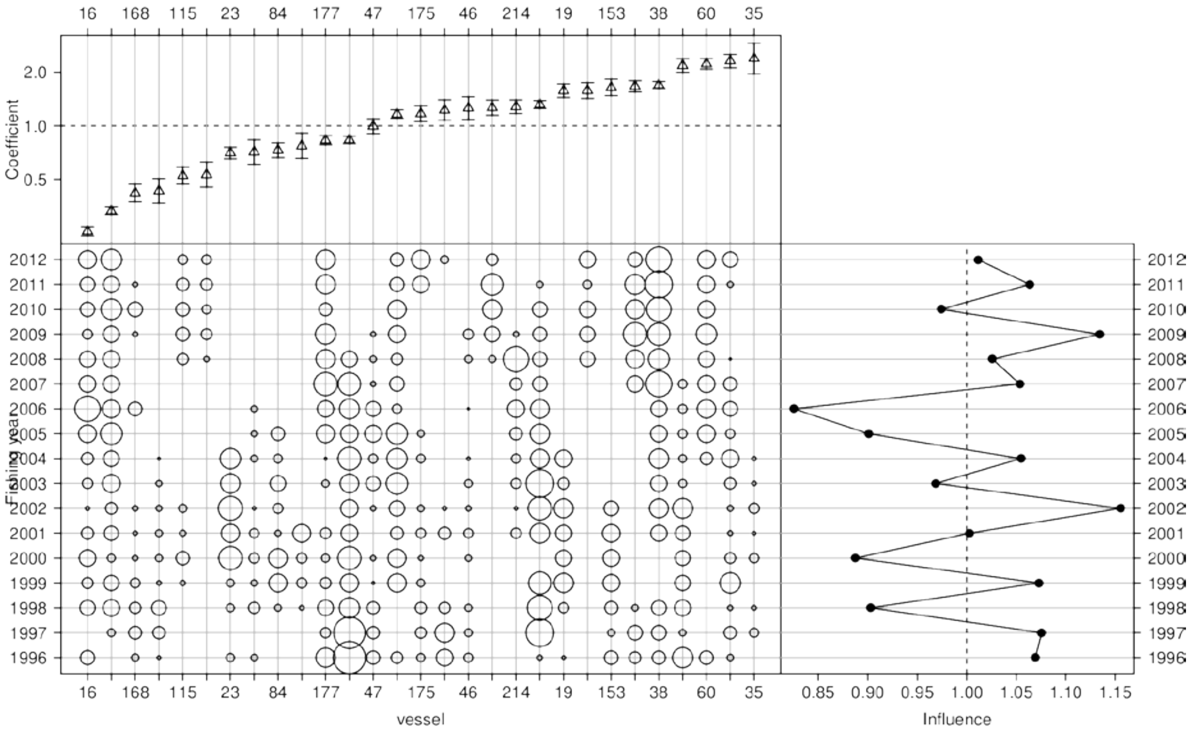

Figure G.7: Effect of vessel in the lognormal model for the LIN 1 BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

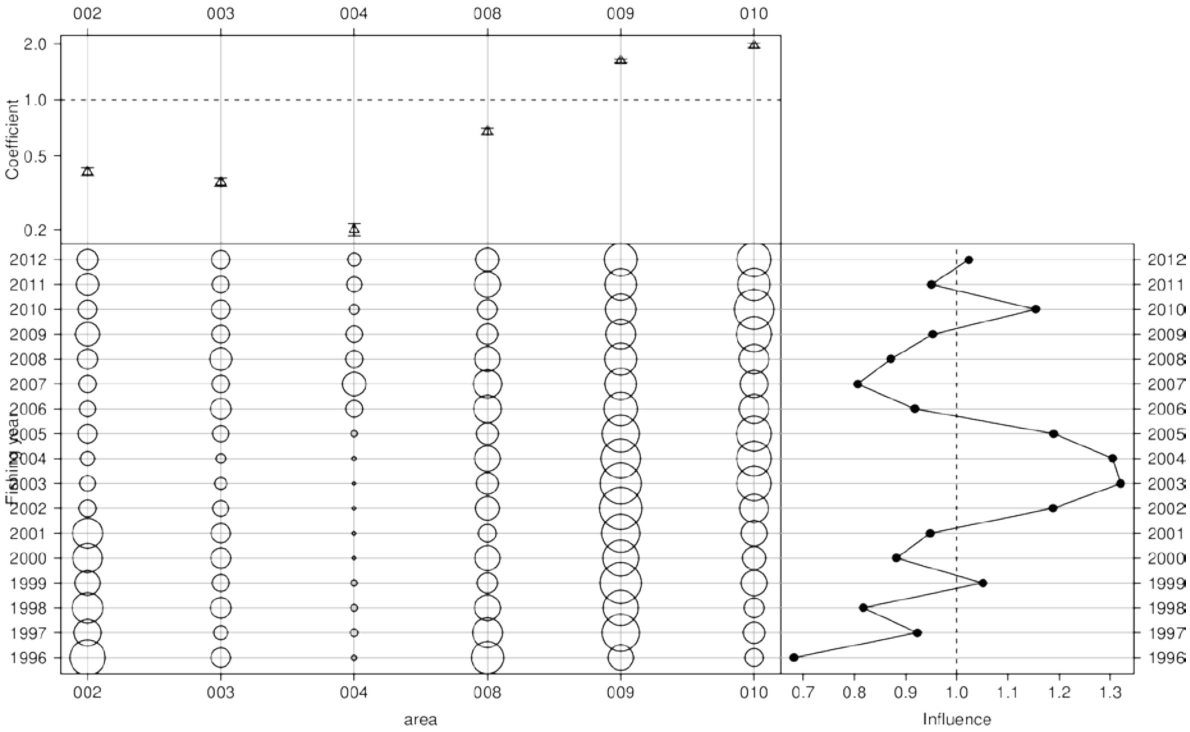

Figure G.8: Effect of area in the lognormal model for the LIN 1 BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

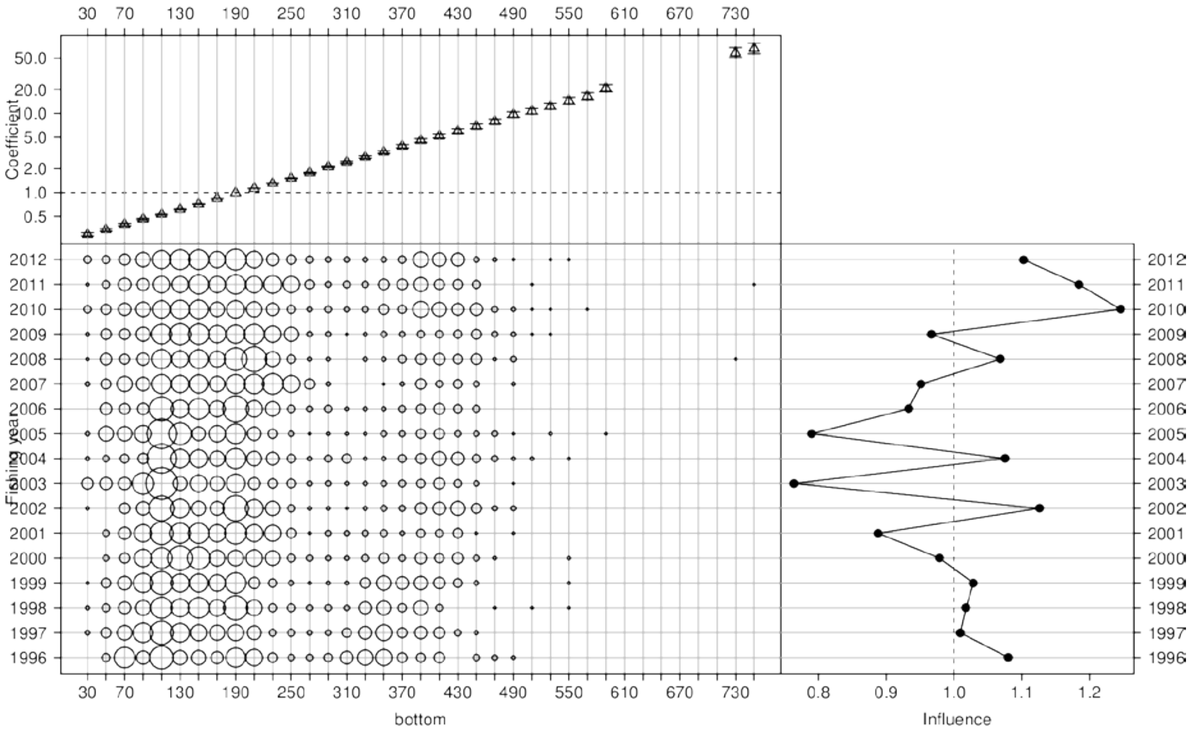

Figure G.9: Effect of bottom depth in the lognormal model for the LIN 1 BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

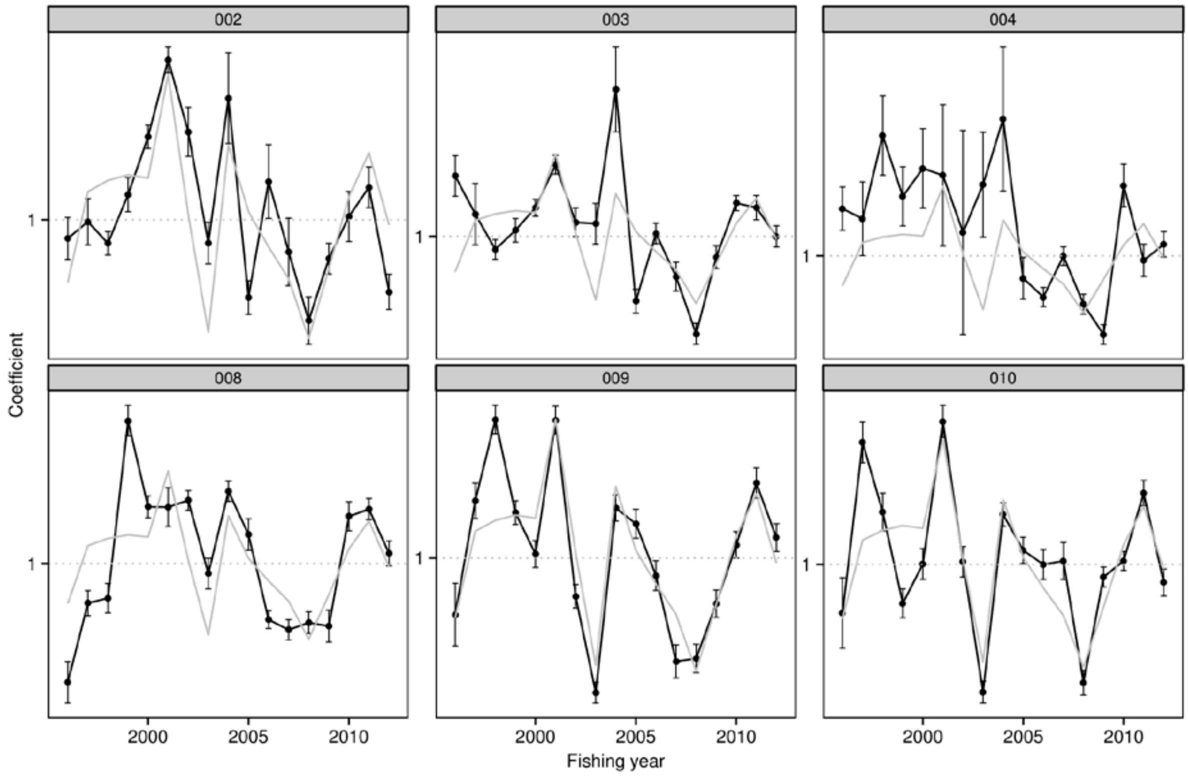

Figure G.10: Residual implied coefficients for area × fishing year interaction (not offered) in the BT(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. 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.

G.9 CPUE indices

Table G.3: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error for the core data set by fishing year for the BT(MIX) analysis.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1996	0.366	0.334	0.640	0.735	0.0873
1997	1.212	0.657	1.229	1.128	0.0675
1998	1.163	0.935	0.923	1.190	0.0591
1999	1.279	1.598	1.639	1.222	0.0634
2000	0.933	1.041	0.862	1.204	0.0577
2001	0.848	0.955	1.413	1.964	0.0613
2002	1.242	1.327	1.558	1.014	0.0604
2003	0.858	0.881	0.524	0.580	0.0533
2004	1.233	1.270	2.210	1.408	0.0586
2005	0.576	0.597	0.765	1.027	0.0545
2006	1.368	1.425	0.589	0.869	0.0525
2007	0.900	0.887	0.525	0.747	0.0583
2008	1.017	1.075	0.539	0.564	0.0563
2009	1.075	1.123	0.783	0.784	0.0532
2010	1.655	1.756	1.947	1.100	0.0540
2011	1.171	1.253	1.733	1.357	0.0585
2012	0.968	1.033	1.133	0.964	0.0558