Fisheries New Zealand

Tini a Tangaroa

FLA 1 Fishery Characterisation and CPUE

New Zealand Fisheries Assessment Report 2019/09

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ISSN 1179-5352 (online)
ISBN 978-1-98-859410-1 (online)

March 2019

New Zealand Government

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Starr, P.J.; Kendrick, T.H. (2019). FLA 1 Fishery Characterisation and CPUE.

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The fisheries for flatfish located off the east and west coasts of the upper part of the North Island (FLA 1) are described for the period 1989–90 to 2016–17 using compulsory reported commercial catch and effort data held by Fisheries New Zealand. These fisheries are almost entirely setnet, with 95% of the FLA 1 catch taken by this method over the 28 years of catch and effort history (97% in the most recent five years). The fisheries take place in estuarine harbours on both coasts, with the major fisheries located in Manukau and Kaipara Harbours on the west coast and in the Thames estuary at the bottom of the Hauraki Gulf on the east coast. Flatfish are the only target species in these setnet fisheries, with non-flatfish species making up only about 2% of the flatfish estimated catches. There is no depth information associated with these fisheries because the setnet forms used to report the catch and effort data do not require this information. From the early 2000s, there has been a tendency in this QMA to store catches on land as frozen product before being sold on to Licensed Fish Receivers: this practise now represents the majority of landed FLA 1. There is little uptake of the event-based NCELR setnet reporting forms introduced in October 2006 because vessels under 6 m are exempt from the requirement to use this form. Consequently there are no fine scale positional data for these fisheries.

Seven consequential setnet fisheries have been identified for FLA 1. Four are major fisheries, accounting for about 80% of the total FLA 1 catch since 1989–90. Two of these fisheries are located in the large west coast Manukau (Area 043) and Kaipara (Area 044) Harbours and catch predominantly yellowbelly flounder. The other two fisheries are located in the lower Hauraki Gulf (Areas 005–007) and are targeted at two species: yellowbelly flounder and sand flounder. Three minor fisheries are identified which include a number of harbours and estuaries: Lower Waikato (Areas 041 and 042), Northwest (Areas 045–047) and East Northland (Areas 002 and 003). A fourth minor fishery, the Bay of Plenty (covering Areas 004, 008–010), was considered too inconsistent and too small to provide the basis for a standardised CPUE that would reflect relative abundance.

CPUE for the two west coast harbour fisheries declined in both harbours by more than 60% since the early 1990s, with the decline mainly attributed to reductions in water quality. The yellowbelly flounder Hauraki Gulf series shows no overall longterm trend, but there was a long period of decline from the mid-2000s to 2015–16. The NINSWG rejected the associated Hauraki Gulf sand flounder series because of variability in the reporting frequency of this species over the time period which may lead to bias in the series. A series tracking the total Hauraki Gulf FLA catch was substituted, which resembles the associated YBF series because of the strong overlap of data between the two series.

The NINSWG has little confidence in the minor FLA 1 series as indices of relative abundance because of small amount of available data and the amalgamation of data across a number of FLA fishing locations, resulting in considerable potential for masking or confounding trends.

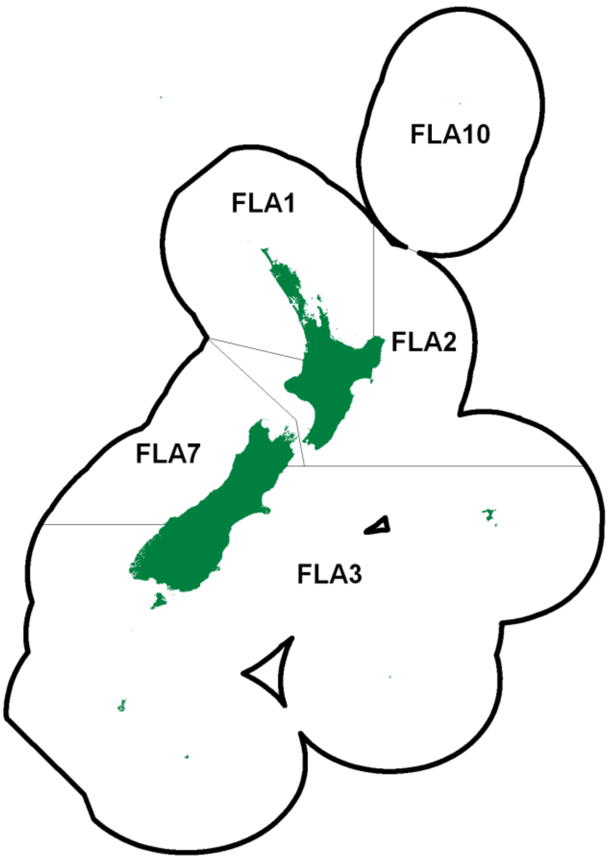

Figure 1: Map of FLA QMAs.

1. INTRODUCTION

This document describes work conducted under Objectives 1 and 2 of the Ministry for Primary Industries (MPI) contract FLA2017-01.

Overall Objective:

1. To monitor the relative abundance of flatfish in FLA 1.

Specific Objectives:

1. To characterise the FLA 1 fishery.
2. To update the standardised CPUE index for flatfish (FLA 1), with the inclusion of data up to the end of the 2016–17 fishing year.

1.1 Background

The present report is the fifth in a series of characterisation and CPUE analyses of the FLA 1 fishery. The following table provides the final fishing year covered by each previous analysis and the year that it was presented to the Northern Inshore Fisheries Assessment Working Group:

Analysis year	Reference	Final fishing year in analysis
2005	Beentjes & Coburn (2005)	2003–04
2009	Kendrick & Bentley (2011)	2007–08
2012	Kendrick & Bentley (2012a)	2010–11
2015	Kendrick & Bentley (2015)	2013–14

FLA 1 is a complicated Quota Management Area (QMA–Figure 1), which incorporates two coasts but is mainly concentrated in several harbours: the Firth of Thames at the bottom of the Hauraki Gulf and the Manukau and Kaipara Harbours on the west coast of the North Island. Minor fisheries exist in the other west coast harbours (such as Hokianga, Kawhia, Raglan and the Waikato estuary) but the nature of the catch reporting system is such that it is not possible to separate out catch specifically to these areas. Manukau and Kaipara are identifiable as separate entities because they have been defined as independent statistical areas. Although setnet fishers generally were required to report event level data, including positional information, from 1 October 2006, setnetters operating vessels less than 6 m were exempted from this requirement. This exemption applies to the majority of the FLA 1 setnet fishery as harbour setnet vessels are generally smaller than 6 m. Consequently, fine scale positional information is not available for these fisheries. Kendrick & Bentley (2011) investigated using the "port of landing" as an alternative indicator of catch location, but concluded that the information obtained from that field was similar to statistical area.

Setnet is the primary method capturing FLA on both coasts, with minor amounts of bottom trawl and some Danish seine in the mid-1990s. Previous characterisation work divided FLA 1 into seven "regions": Kaipara (044), Manukau (043), Hauraki Gulf (005, 006, 007), Northwest (045–047), Lower Waikato (041, 042), East Northland (002,003) and Bay of Plenty (004, 008–010). Catches in Statistical Areas 048 and 001 are too far north to have much flatfish habitat. Moreover, fishers sometimes report "1" in the statistical area field when they meant "1" as in FLA 1, which is another reason to mistrust data attributed to Area 001.

FLA 1 is an amalgamation of flatfish species, with no strong enforcement by Fisheries New Zealand of the requirement to report estimated catches by the component species rather than using the generic FLA code. Previous reports show that, unlike FLA 3, the proportion of reporting by species in FLA 1 is relatively low, with almost no species reports in Manukau Harbour, but some increase in species reported in Hauraki Gulf and Kaipara Harbour in the three years up to 2013–14. Summarisation by estimated catch species is included in this report for each of the seven regions.

This FAR characterises the FLA 1 fisheries, and updates the standardised CPUE analyses developed by Kendrick & Bentley (2011, 2012a, 2015) to the 2016–17 fishing year. A table of definitions, along with frequently used abbreviations, can be found in Appendix A. A map showing the locations of the General Statistical Areas, along with the boundaries of the FMAs used for managing Fishstocks in New Zealand, can be found in Appendix B.

2. INFORMATION ABOUT THE STOCK/FISHERY

2.1 Catches

The TACC for flatfish in FLA 1 was set at 1100 t when this Fishstock was introduced into the QMS in 1986 and then increased to 1187 t by 1990–91, probably due to quota appeals, which is where it remains (Figure 2; Table 1). While catch levels have never exceeded the FLA 1 TACC, they reached about 95% of the TACC in 1992–93 and 1993–94 (Figure 2; Table 1). FLA 1 landings peaked a second time in 2004–05 at just above 1000 t and have since declined to low levels, reaching a nadir in 2015–16 at 277 t. Landings rose to 421 t in 2016–17. FLA 1 has never been placed on Schedule(2) of the 1996 Fisheries Act, which includes stocks managed with in-season adjustments to the TACC.

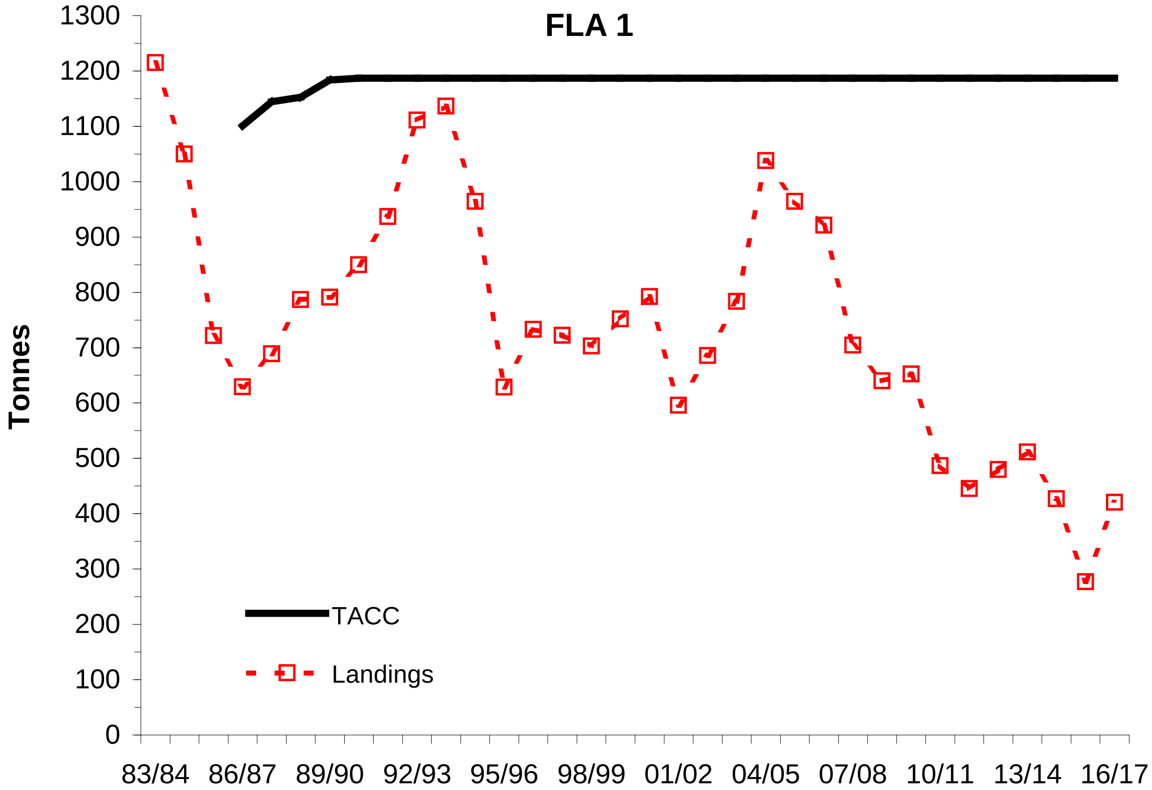

Figure 2: **Plots of FLA 1 landings and TACCs from 1983–84 to 2016–17 (see Table 1for list of landings and TACCs by FLA QMA).**

Table 1. **Reported landings (t) and TACC (t) of flatfish in FLA 1 from 1983–84 to 2016–17 (Data sources: 1983–84 to 1985–86 (Fisheries New Zealand 2018, Chapter 20, Table 2); QMR [1986–87 to 2000–01]; MHR [2001–02 to 2016–17].**

Fishing Year	QMR_y	$TACC_y$	Fishing Year	QMR_y	$TACC_y$
1983–84	1 215	–	2000–01	792	1 187
1984–85	1 050	–	2001–02	596	1 187
1985–86	722	–	2002–03	686	1 187
1985–86	629	1 101	2003–04	784	1 187
1987–88	689	1 145	2004–05	1 038	1 187
1988–89	787	1 153	2005–06	964	1 187
1989–90	791	1 184	2006–07	922	1 187
1990–91	850	1 187	2007–08	705	1 187
1991–92	937	1 187	2008–09	640	1 187
1992–93	1 111	1 187	2009–10	652	1 187
1993–94	1 136	1 187	2010–11	487	1 187
1994–95	964	1 187	2011–12	445	1 187
1995–96	629	1 187	2012–13	480	1 187
1996–97	733	1 187	2013–14	511	1 187
1997–98	722	1 187	2014–15	427	1 187
1998–99	703	1 187	2015–16	277	1 187
1999–00	752	1 187	2016–17	421	1 187

2.2 Regulations affecting the fishery

The following regulations apply to fishing for flatfish in FLA 1 (John Taunton-Clark, Fisheries New Zealand, Auckland office, pers.comm.):

- Minimum mesh size: 114 mm for ‘flatfish’.
- MLS for YBF: 25 cm
- MLS for SFL: 23 cm.

- Gear must be marked with vessel registration number
- Nets must not span more than ¼ of the width of a channel, bay, arm of the sea etc.
- Nets must not stall (exposed at low tide)
- Maximum soak time: 18 h
- No poles or stakes with set nets
- Maximum net length limit: 1000 m in estuaries
- Nets more than 60 m from adjacent nets
- Set nets prohibited in defined reef and island waters

Setnet and trawl fisheries on the outside of the west coast North Island harbours and estuaries were restricted in 2013 to protect dolphins through a series of regulations that were jointly issued by the Minister for Primary Industries and the Minister of Conservation (Appendix C). These regulations do not generally apply to the harbour and estuarine setnet fisheries for flatfish, except in the Manukau and Kaipara Harbour entrances (Figure C.1).

2.3 Analysis of FLA 1 catch and effort data

2.3.1 Methods used for 2018 analysis of Fisheries New Zealand catch and effort data

2.3.1.1 Obtaining data extracts

Two data extracts were obtained from the Fisheries New Zealand combined Warehou and EDW databases (Ministry of Fisheries 2010, John Moriarty, Fisheries New Zealand Data Management, pers. comm.). One extract consisted of the complete data set (all fishing event information along with all flatfish landing information) from every trip that recorded a flatfish[1] landing in FLA 1, starting from 1 October 1989 and extending to 30 September 2017. A second extract was obtained which consisted of all New Zealand trips using the method SN (setnet) in the statistical areas valid for FLA 1 (001–010, 041–048, 101–107). Once these trips were identified, all fishing event data and flatfish landing data[2] from the entire trip, regardless of method of capture, were obtained. These data extracts (Fisheries New Zealand replog 11700) were received 20 March 2018. The first data extract was used to characterise and understand all FLA 1 fisheries taking flatfish. The second extract was used to calculate CPUE standardisations for SN (Section 3).

2.3.1.2 Preparation of data extracts

The original level of time stratification for a trip is either by “fishing event” or by fishing day, 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’ (see table of definitions: Appendix A) for the characterisation part of this report. Depending on how frequently an operator changed areas, method of capture or target species, a trip could consist of one or 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. Ordinarily, landings of flatfish recorded on the bottom section of the trip form would be allocated to the ‘trip strata’ in proportion to the estimated flatfish catches in each ‘trip stratum’. However, this was not possible with the FLA 1 data set because of the frequent use of intermediate Destination code ‘Q’ (holding receptacle on land – see Section 2.3.2.1 below). The matching procedure described by Starr (2007) assumes that the landings associated with a trip represent the product of the effort expended in the trip. If this is not the case, then it would be incorrect to use the matching procedure to allocate the trip landings to the estimated catches from the top part of the form. There is no requirement that landings

[1] additionally identified the following Fishstocks as being part of FLA 1: BFL 1, BLF 1, BRI 1, ESO 1, FLO 1, GFL 1, LSO 1, SFI 1, SFL 1, SOL 1, TUR 1, WIT 1, YBF 1, BOT 1, GBL 1, MAN 1, SLS 1, SDF 1

[2] requested landings using the following three letter codes: 'FLA', 'BFL', 'BLF', 'BRI', 'ESO', 'FLO', 'GFL', 'LSO', 'SFL', 'SOL', 'TUR', 'WIT', 'YBF', 'BOT','GBL', 'MAN', 'SLS', 'SDF'

reported at the end of a trip were taken by the associated trip effort, so it is possible that some or all of the declared landings at the end of a trip were taken during another trip. As well, the practice of landing to intermediate destination codes (which are discarded to avoid double counting) will result in trips with no associated landings and in trips where there are only landings with no associated effort.

Table 2 presents the annual totals at different stages of the data preparation procedure for FLA 1. Summed annual landings in the Warehou database differ from the QMR/MHR annual landings in nearly all years, with large positive deviations in 1993–94, 1996–97 and 1997–98 in the unedited landings data (Figure D.1). As well, over 1100 t of FLA 1 landings were coded with non-standard 3-letter codes referencing specific flatfish species rather the required generic "FLA" code (Table D.1). However, Figure D.1 shows that these additional landings were not the cause of the large overages in landings during the 1990s and the addition of these non-standard landings increased the summed landings sufficiently to match the reported MHR landings from 2011–12 to 2016–17. Consequently these landings have been left in the data set. A search through the landing records based on internal evidence for each trip (see Appendix C) identified 25 trips which were the cause of much of the observed overages in Figure D.1 (see Table D.2 and Table D.3). However, it was not possible to more closely match the QMR/MHR landing totals without dropping a very large number of trips, so the search for data errors in the reported landings was stopped with the 25 trips reported in Table D.2.

Table 2 also shows that there were 1850 t of FLA 1 landings which have no matching effort (compare totals in column 3 with column 5). As well, only 14 800 t of estimated catch have matching landings, leaving 2200 t of estimated catches with no associated landings. These discrepancies illustrate the effect of breaking the link between the effort and landing information resulting from the use of intermediate destination codes (Section 2.3.2.1 below and first paragraph in 2.3.1.2). The method of Starr (2007) typically uses the apportioned landings by trip to characterise the fishery. However this approach was not feasible for this QMA, given the discrepancies between landings and estimated catches demonstrated in Table 2. Therefore the characterisation section of this report is based on the estimated catches summarised in column 9 of Table 2, on the assumption that the trips with estimated catches represent the entire fishery. A different procedure, based on scaling estimated catches using a "vessel correction factor", was used to scale the estimated catches to the landings for the CPUE analysis (see Appendix E). Statistical areas[3] are used to define FLA 1 for both the characterisation section of this report as well as the CPUE section rather than using the actual landings.

Table 2: Comparison of the FLA 1 QMR/MHR catch (t) with the sum of the landed catch totals (bottom part of the CELR/CLR forms), the total catch after matching effort with landing data ('Analysis' data set) and the sum of the estimated catches from the Analysis data set. "Raw" estimated catch column=sum of estimated catches including trips without matching landing data. Data source: Fisheries New Zealand replog 11700: 1989–90 to 2016–17.

Fishing Year	QMR/MHR (t)	Total [1] landed catch (t)	% landed/ QMR/MHR	Landings matched with effort (t)	% Matched [2]/ Landed	Matched [3] Estimated Catch (t)	% Estimated /Matched[2]	All [4] Estimated Catch (t)
89/90	791	627	79	626	100	547	87	547
90/91	850	880	104	868	99	762	87	763
91/92	937	967	103	958	99	840	87	841
92/93	1 111	1 117	101	1 107	99	973	87	973
93/94	1 136	1 178	104	1 172	99	1 026	87	1 027
94/95	964	1 036	107	1 025	99	880	85	881
95/96	629	732	116	572	78	494	67	499
96/97	733	769	105	646	84	528	69	530
97/98	722	776	107	655	84	510	66	511
98/99	703	756	108	696	92	536	71	537
99/00	752	844	112	831	98	641	76	643
00/01	792	847	107	842	99	710	84	713
01/02	596	625	105	610	98	511	82	521
02/03	686	718	105	695	97	548	76	592
03/04	784	804	103	756	94	566	70	672

[3] The statistical area definition for FLA 1: 001–010, 041–048, 101–107

Fishing Year	QMR/MHR (t)	Total [1] landed catch (t)	% landed/ QMR/MHR	Landings matched with effort (t)	% Matched [2]/ Landed	Matched [3] Estimated Catch (t)	% Estimated /Matched[2]	All [4] Estimated Catch (t)
04/05	1 038	1 087	105	974	90	663	61	882
05/06	964	993	103	905	91	630	63	812
06/07	922	956	104	831	87	563	59	768
07/08	705	732	104	624	85	429	59	589
08/09	640	645	101	545	84	384	60	546
09/10	652	656	101	538	82	382	58	562
10/11	487	506	104	426	84	278	55	417
11/12	445	448	101	374	84	252	56	382
12/13	480	481	100	384	80	249	52	405
13/14	511	520	102	432	83	284	55	441
14/15	427	424	99	352	83	241	57	357
15/16	277	284	102	213	75	137	48	231
16/17	421	430	102	329	77	239	56	364
Total	20 156	20 836	103	18 986	91	14 804	71	17 007

[1] includes landings with no associated effort after the removal of 25 out-of-range trips (see Appendix C)
[2] these are trips with associated effort: column 5 divided by column 3
[3] estimated catch from trips with matched effort and landings
[4] includes trips without matched landings

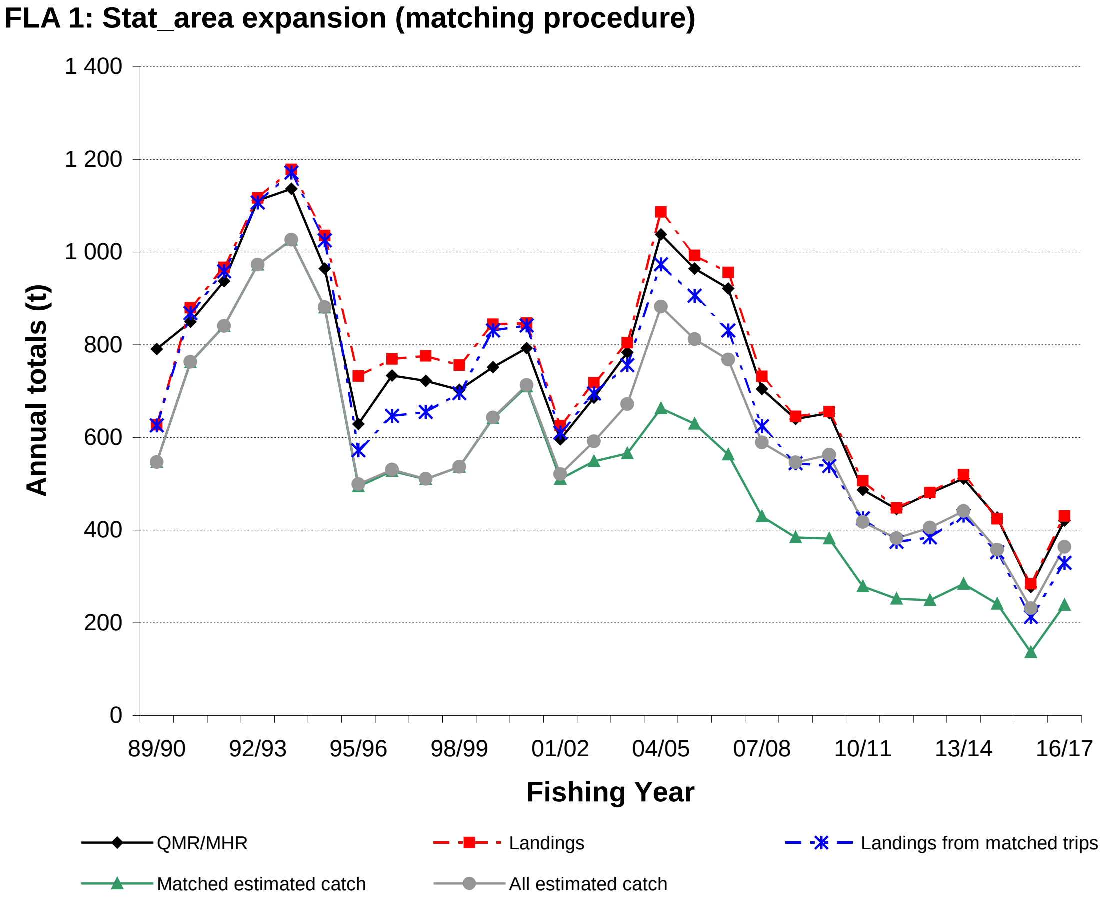

Figure 3: Plot of the FLA 1 catch datasets for totals presented in Table 2. The ‘landings’ series has had the 25 trips identified in Appendix C removed. “Matching” refers to trips where the effort and landings portions of the reporting have been successfully matched.

Estimated catch totals in the fishery characterisation tables have been scaled to the QMR/MHR totals reported in Table 1 by calculating the ratio of these catches with the total FLA 1 estimated catches in the analysis data set (tabulated in column 9 of Table 2: using all estimated catches, including trips with unmatched landings). The estimated catches are scaled using this formula:

Eq. 1 $$Q^{'}_{i,y} = E_{i,y}\frac{\mathbf{QMR}_y}{E^A_y}$$

where $\mathbf{QMR}_y$ are the annual QMR/MHR landings, E^A_y are the corresponding total annual estimated catches in the analysis data set, $E_{i,y}$ is the estimated catch for record *i* in year *y* and $Q^{'}_{i,y}$ is the resulting scaled QMR estimate for record *i*.

2.3.1.3 'Daily effort stratum' data preparation procedure

Data used for CPUE analysis were prepared using the 'daily effort stratum' (defined in Appendix A) procedure proposed by Langley (2014). As noted above, catch/effort data must be summarised to a common level of stratification in order to construct a consistent time series of CPUE indices that spans the change in reporting forms instituted in the late 2000s. Although the 'trip-stratum' procedure proposed by Starr (2007) addresses the nominal instructions provided to fishers using the daily-effort CELR forms, Langley (2014) was able to show that the realised stratification in the earlier form types was daily, with the fisher tending to report the 'predominant' statistical area of capture and target species rather than explicitly following the instructions. He showed this by noting that the frequency of changes in statistical area of fishing or target species within a day of fishing was much higher for comparable event-based forms than in the earlier daily forms. Consequently, we have adopted Langley's (2014) recommendation to use the 'daily stratum' method for preparing data for CPUE analysis. The following steps were used to 'rollup' the event-based data (set-by-set data) to a 'daily stratum'[4]:

1. discard trips that used more than one method in the trip (except for rock lobster potting, cod potting and fyke nets whereby these methods were simply dropped because they are unlikely to catch flatfish) or used more than one form type;
2. sum effort for each day of fishing in the trip;
3. sum estimated catch for each day of fishing in the trip and only use the estimated catch from the top five species, sorted by weight in descending order; in the case of a tie for the fifth most prevalent species, a secondary sort is made on the species 3-digit code which results in taking the species that comes first in alphabetical order[5];
4. calculate the modal statistical area and target species for each day of fishing, each weighted by the number of fishing events: these are the values assigned to the effort and catch for that day of fishing;
5. create a list of "most relevant" target species in the total FLA 1 data set by summing the landings in the appropriate characterisation data set across all years to identify the main target fisheries which capture flatfish (Table 3). This list was used to screen daily effort by discarding entire trips which reported target species that were not in this list. This was done because it was felt that the effort from the discarded species was not relevant nor necessary to include in the flatfish CPUE analysis. The decision to discard the entire trip rather than just discarding the effort with the non-relevant target species was made because analysis (not reported) showed that there was potential for bias when linking flatfish landings by trip with the remaining partial trip – it is safer to drop the entire trip;
6. this data preparation step also adjusted the estimated catches to represent landings using the procedure described in Appendix E.

Note that the above procedure was also applied to the daily effort (CELR) forms to ensure that each of these trips was also reduced to 'daily strata' if fishers reported more than one statistical area or target species in a day of fishing. In practice, this preparation step has very little impact in FLA 1, given that most fishing events consist of a single day of fishing, in one statistical area and targeted at FLA.

[4] Although there were very few FLA 1 event-level records in this data set, this procedure was followed for consistency with other inshore CPUE analyses and to ensure that all trips were stratified to the same level.
[5] This secondary sort needs to occur to ensure that repeat analyses of the same data will give the same results; otherwise the sort order will change randomly unless it is constrained by a rule.

Table 3: Table of declared SN target species which take FLA 1, summed over the period 1989–90 to 2016–17, based on the characterisation data set. The top 15 species were used in the SN CPUE analysis, with trips taking any of the remaining species dropped entirely. The total catch for species rank 16–71 is 1.7 t.

Rank	Species code	Common name	Sum of FLA catch (t)	Cumulative %
1	FLA	Flats	16 985	97.6
2	SPO	Rig	169.8	98.6
3	SNA	Snapper	111.1	99.2
4	GUR	Gurnard	51.4	99.5
5	TRE	Trevally	30.1	99.7
6	KAH	Kahawai	20.9	99.8
7	GMU	Grey Mullet	20.4	99.9
8	PAD	Paddle Crab	4.69	99.9
9	JDO	John Dory	3.63	99.96
10	SCH	School Shark	2.02	99.97
11	SPD	Spiny Dogfish	1.07	99.98
12	PAR	Parore	0.88	99.98
13	SDO	Silver Dory	0.62	99.99
14	TAR	Tarakihi	0.36	99.99
15	JMA	Jack Mackerel	0.24	99.99
16	FLY	Flying Fish	0.196	99.991
17	CRA	Rock Lobster	0.188	99.992
18	BAR	Barracouta	0.174	99.993
19	RMO	Red Moki	0.150	99.994
20	KIN	Kingfish	0.135	99.995
21	RLA	Resania lanceolata	0.124	99.996
22	POR	Porae	0.116	99.996
23	YEM	Yellow-eyed Mullet	0.0989	99.997
24	LIN	Ling	0.0903	99.997
25	PMA	Pink Maomao	0.0844	99.998
26	WAR	Common Warehou	0.0707	99.998
27	SSK	Smooth Skate	0.0454	99.999
28	FAL	transposition of FLA	0.0391	99.999
29	EGR	Eagle Ray	0.0340	99.999
30	SPE	Sea Perch	0.0295	99.999
31	RCO	Red Cod	0.0226	99.999
32	RIB	Ribaldo	0.0206	99.999
33	BWH	Bronze Whaler Shark	0.0193	99.9995
34	ELE	Elephant Fish	0.0190	99.9996
35	MOK	Moki	0.0141	99.9997
36	YBO	Yellow Boarfish	0.0130	99.9998
37	EMA	Blue Mackerel	0.0120	99.9998
38	SWA	Silver Warehou	0.0109	99.9999
39	SPI	Spider Crab	0.0076	99.9999
40	SPZ	Spotted Stargazer	0.0062	99.99998
41	FRO	Frostfish	0.0018	99.99998
42	SBO	Southern Boarfish	0.0012	99.99999
43	GAR	Garfish	0	100
44	FLU	Perch	0	100
45	PIL	Pilchard	0	100
46	HOK	Hoki	0	100
47	BYX	Alfonsino & Long-finned Beryx	0	100
48	MAR	Marlin	0	100
49	PAH	Opah	0	100
50	RSN	Red Snapper	0	100
51	KOI	Koi Carp	0	100
52	BNS	Bluenose	0	100
53	EBI	unknown	0	100
54	MUU	Mullet	0	100

Rank	Species code	Common name	Sum of FLA catch (t)	Cumulative %
55	RBY	Ruby Fish	0	100
56	SPR	Sprats	0	100
57	BCO	Blue Cod	0	100
58	LFB	Longfinned Boarfish	0	100
59	BOA	Sowfish	0	100
60	HPB	Hapuku & Bass	0	100
61	SKI	Gemfish	0	100
62	HHS	Hammerhead Shark	0	100
63	BMA	Blue Maomao	0	100
64	SKA	Skate	0	100
65	SFE	Short-finned Eel	0	100
66	SQU	Arrow Squid	0	100
67	BUT	Butterfish	0	100
68	STR	Stingray	0	100
69	SAR	Squilla armata	0	100
70	WWA	White Warehou	0	100
71	KTA	King Tarakihi	0	100

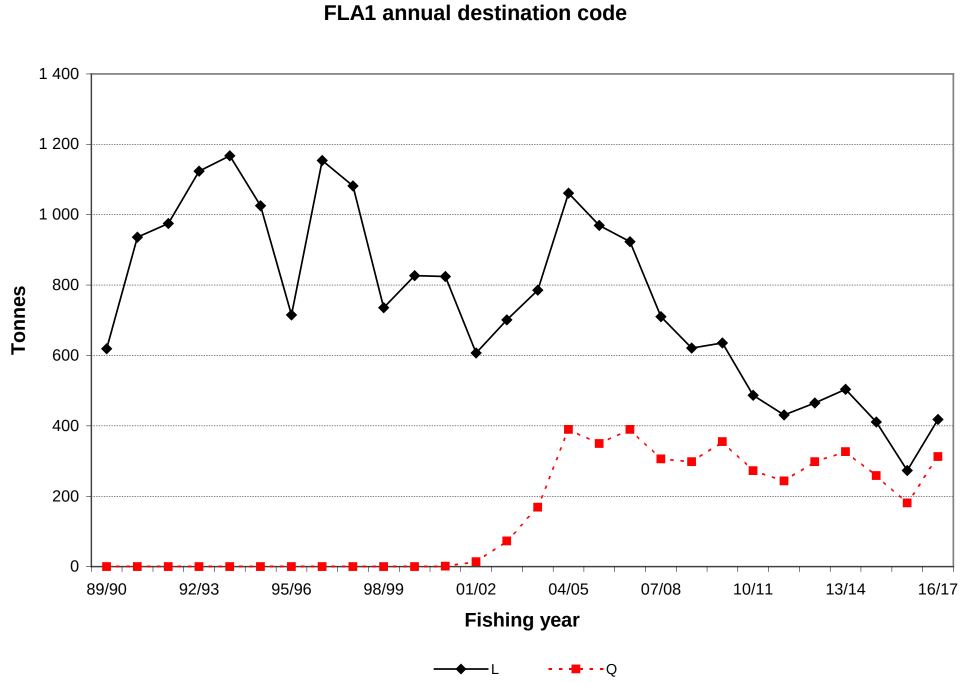

Figure 4: **Time series of L and Q destination codes in the FLA 1 landing data.**

Table 4: **Destination codes in the unedited landing data received for the FLA 1 CPUE analysis. The 'how used' column indicates which destination codes were included in the characterisation analysis. These data summaries have been combined over the period 1989–90 to 2016–17.**

Destination code	Number events	Greenweight (t)	Description	How used
L	301 979	21 189.5	Landed in NZ (to LFR)	keep
W	27 394	932.6	Sold at wharf	keep
F	1 081	9.0	Section 111 Recreational Catch	keep
E	400	1.9	Eaten	keep
O	27	1.0	Conveyed outside NZ	keep
C	18	1.0	Disposed to Crown	keep
U	89	0.9	Bait used on board	keep
A	56	0.8	Accidental loss	keep
S	30	0.8	Seized by Crown	keep
H	16	0.1	Loss from holding pot	keep
X	1	0.0	QMS returned to sea (except 6A)	keep
J	1	0.0	Returned to sea [Section 72(5)(2)]	keep

Destination code	Number events	Greenweight (t)	Description	How used
Q	81 041	4 238.8	Holding receptacle on land	drop
R	925	43.4	Retained on board	drop
T	392	27.3	Transferred to another vessel	drop
D	394	6.8	Discarded (non-ITQ)	drop
P	31	1.5	Holding receptacle in water	drop
B	58	0.9	Bait stored for later use	drop

Table 5: Total green weight reported and number of events by state code in the unedited landing file used to process the FLA 1 characterisation and CPUE data, arranged in descending landed weight. These data summaries are summed over the period 1989–90 to 2016–17.

State code	Number events	Total reported green weight (t)	Description
GUT	279 651	19 297.0	Gutted
GRE	132 471	7 029.9	Green (or whole)
[NULL]	75	355.1	Missing
HGU	585	72.5	Headed and gutted
GGO	897	39.7	Gilled and gutted tail-on
DRE	339	17.7	Dressed
Other	30	0.6	Other (misc.)

Table 6: Annual median conversion factors and total reported weight for the five most important state codes (in terms of overall total landed green weight). These data summaries are for the period 1989–90 to 2016–17. Only trips using destinations coded as “keep” in Table 4 are included. ‘–’: no observations.

Fishing	Median conversion factors						Annual reported landings					
year	GUT	GRE	HGU	GGO	DRE	Other	GUT	GRE	HGU	GGO	DRE	Other
89/90	1.1	1	1.4	1.1	–	1.4	412.2	212.5	0.2	2.5	–	0.0
90/91	1.1	1	1.4	1.1	1.8	–	605.6	272.9	0.5	0.7	0.0	–
91/92	1.1	1	1.4	–	1.8	4.95	601.6	364.3	0.6	–	0.2	0.1
92/93	1.1	1	1.4	–	1.8	–	717.8	396.3	1.8	–	0.6	–
93/94	1.1	1	1.4	–	1.8	–	787.7	386.3	3.5	–	0.5	–
94/95	1.1	1	1.4	–	1.8	1.8	721.4	306.5	7.5	0.1	0.3	0.0
95/96	1.1	1	1.4	–	1.8	–	474.4	191.5	57.2	8.5	0.3	0.5
96/97	1.1	1	1.4	–	1.8	–	540.2	224.1	0.7	2.1	0.9	0.9
97/98	1.1	1	1.4	–	1.8	0.9	531.4	234.6	0.1	8.2	0.5	0.8
98/99	1.1	1	1.4	–	1.8	–	507.4	237.1	0.1	10.3	0.8	0.5
99/00	1.1	1	1.4	–	1.8	–	590.2	248.3	0.1	5.0	0.3	0.1
00/01	1.1	1	1.4	–	1.8	1.8	601.4	242.3	0.0	2.4	0.4	0.1
01/02	1.1	1	1.4	–	1.8	–	443.6	181.0	0.0	–	0.4	0.1
02/03	1.1	1	1.4	–	1.8	1.8	530.7	187.1	0.1	–	0.2	0.0
03/04	1.1	1	1.5	–	1.8	1.8	602.6	196.4	0.0	–	4.9	0.2
04/05	1.1	1	1.4	–	1.8	–	875.1	210.7	0.0	–	0.4	0.4
05/06	1.1	1	1.4	–	1.8	–	780.4	212.3	0.0	–	0.1	–
06/07	1.1	1	1.4	–	1.8	2.25	757.9	196.8	0.0	–	1.2	0.0
07/08	1.1	1	–	–	1.8	–	581.3	150.0	–	–	0.7	–
08/09	1.1	1	1.4	–	1.8	–	557.0	84.9	0.0	–	3.2	–
09/10	1.1	1	1.4	–	1.8	2.25	569.2	86.4	0.0	–	0.2	0.0
10/11	1.1	1	–	–	1.8	2.25	430.2	76.1	–	–	0.0	0.0
11/12	1.1	1	–	–	1.8	–	377.4	69.9	–	–	0.3	–
12/13	1.1	1	1.4	–	1.8	–	407.8	72.9	0.0	–	0.1	–
13/14	1.1	1	–	–	1.8	–	446.7	73.1	–	–	0.0	–
14/15	1.1	1	1.4	–	1.8	–	351.8	72.0	0.1	–	0.0	–
15/16	1.1	1	–	–	–	–	239.2	44.5	–	–	–	–
16/17	1.1	1	–	–	1.8	–	380.4	49.6	–	–	0.1	–
Total	–	–	–	–	–	–	15 422	5 280.5	72.5	39.7	16.7	3.8

2.3.2 Description landing information for FLA 1

2.3.2.1 Destination codes in the FLA landing data

Landing data for flatfish were provided for every trip that landed FLA 1 at least once, with one record for every reported FLA landing from the trip. Each of these records contained a reported green weight (in kilograms), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a ‘destination code’ (Table 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’, ‘C’ or ‘W’; Table 4) also potentially described valid landings and were included in this analysis but these are all minor compared to code ‘L’. A number of other codes (notably ‘Q’; Table 4) were not included because these landings would be reported at a later date under the ‘L’ destination category. Two other codes (‘D’ and ‘NULL’) represented errors that could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Some of the destination codes (‘P’, ‘Q’, ‘R’ and ‘T’) represent intermediate holding states that have the potential to invalidate the method of Starr (2007), which assumes that the reported landings for a trip have been taken using the effort reported for the trip. These intermediate landing destination codes are dropped (due to the potential for double counting) because it is possible that ‘L’ landings reported for a trip may have been taken by another trip where the landings were declared by an intermediate code, leaving some trips with only effort data and other trips where landings have been added. There are even trips with no associated effort. Table 4 shows that there has been a large number of ‘Q’ destination codes in FLA 1, indicating that there is no assurance that trip landings on the form correspond to the reported trip effort on the form. The use of the “Q” desination code began in the 2002–03 fishing year and represented a substantial fraction of the total FLA 1 landings from the late 2000s to the present (Figure 4).

2.3.2.2 State codes in the FLA landing data

Just over 70% of the valid landing data for FLA 1 were reported using state code GUT, a landing code which has shown no change over time and which represents a very small amount of change from green weight (Table 5). Almost all of the remaining landings (26%) were landed GRE, with no change in landed weight. There is no evidence in the data of changes over time in the conversion factors used for FLA (Table 6).

Total landings in the FLA 1 data set for FLA QMAs other than FLA 1 while landing FLA 1 are negligible (Table 7).

2.3.2.1 Form types used in the FLA 1 landing and effort data

There are a range of form types used by Fisheries New Zealand to report catch and effort (see Appendix A and Ministry of Fisheries 2010). The daily CELR form is an all-purpose form which reports effort, estimated catch and landings and has been in use by the entire inshore fleet since mid-1989. While the event-based TCER form replaced the CELR form in October 2007 for trawl vessels between 6 and 28 m, this form is not used very much in the various FLA 1 fisheries (Table 8, Table 9). Landings for trips which use this form are reported on the CLR form (Table 8). More pertinent to the FLA 1 fishery was the introduction of the event-based NCELR form in October 2006. Landings are reported on this form (as for the CELR form) but it can be seen from Table 8 and Table 9 that there has been very little use made of this form in FLA 1, with less than 5% of landings reported using this form from 2006–07 to 2016–17. The reason for the low use of this form in FLA 1 is that vessels under 6 m are allowed by Fisheries New Zealand to continue using the CELR form and this category of vessel makes up the majority of the FLA 1 setnet fleet.

Table 7: Distribution of total landings (t) by flatfish Fishstock and by fishing year for all trips that recorded FLA landings, regardless of QMA in the replog 11700 data set. This summary includes landings with no associated effort but was made after the removal of 25 out-of-range trips (see Appendix C).

Fishing year	FLA1	FLA2	FLA3	FLA7	Total
89/90	627.3	1.4	0.0	0.3	629.0
90/91	879.7	1.8	0.7	0.1	882.3
91/92	966.8	3.3	0.2	0.1	970.4
92/93	1 116.6	2.7	0.7	0.2	1 120.2
93/94	1 178.1	2.6	0.0	.	1 180.7
94/95	1 035.8	1.7	0.4	0.2	1 038.1
95/96	732.2	2.8	18.4	0.8	754.2
96/97	768.9	3.3	15.0	2.9	790.1
97/98	775.7	4.6	1.5	1.5	783.3
98/99	756.2	4.9	2.1	0.5	763.7
99/00	844.0	1.8	4.8	1.0	851.6
00/01	846.5	2.1	2.9	0.9	852.4
01/02	625.2	1.6	2.5	0.9	630.2
02/03	718.1	1.0	0.6	0.7	720.4
03/04	804.2	3.7	0.0	0.2	808.1
04/05	1 086.6	2.6	1.1	1.1	1 091.4
05/06	992.7	2.6	1.0	0.7	997.0
06/07	955.9	3.3	2.3	0.5	962.0
07/08	732.0	5.9	0.2	1.6	739.7
08/09	645.1	2.1	0.5	7.3	655.0
09/10	655.8	2.6	0.9	0.3	659.6
10/11	506.3	1.8	0.2	5.6	513.9
11/12	447.6	2.4	0.4	0.5	450.9
12/13	480.8	2.8	2.1	0.9	486.6
13/14	519.8	1.0	0.6	0.1	521.5
14/15	423.9	0.9	2.4	0.7	427.9
15/16	283.7	1.1	6.1	0.2	291.1
16/17	430.1	0.9	0.7	4.1	435.8
Total	20 835.7	69.2	68.2	34.0	21 007.1

Table 8: Distribution by form type for landed catch by weight for each fishing year in the FLA 1 landings data set. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data in the FLA 1 data set. See Appendix A for definitions of abbreviations used in this table. '–': cell not available or applicable.

	Landings (%)[1]			Days fishing (%)[2]					Days fishing					
year	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	LTCER	CELR	TCEPR	TCER	NCELR	LTCER	Total
89/90	100	0.01	0	100	0	–	–	–	9 322	4	–	–	–	9 326
90/91	100	0	0	100	0	–	–	–	13 551	7	–	–	–	13 558
91/92	100	0.3	0	100	0	–	–	–	14 938	18	–	–	–	14 956
92/93	100	0.2	0	98	2	–	–	–	16 737	300	–	–	–	17 037
93/94	100	0.4	0	98	2	–	–	–	15 765	332	–	–	–	16 097
94/95	100	0.3	0	96	4	–	–	–	14 361	523	–	–	–	14 884
95/96	97	3.1	0	88	12	–	–	–	10 737	1 469	–	–	–	12 206
96/97	99	1.4	0	89	11	–	–	–	11 011	1 387	–	–	–	12 398
97/98	99	0.9	0	90	10	–	–	–	11 501	1 318	–	–	–	12 819
98/99	99	1.4	0	89	11	–	–	–	12 318	1 554	–	–	–	13 872
99/00	99	0.7	0	92	8	–	–	–	14 844	1 271	–	–	–	16 115
00/01	99	1.1	0	90	10	–	–	–	15 300	1 758	–	–	–	17 058
01/02	99	1.5	0	87	13	–	–	–	13 167	1 938	–	–	–	15 105
02/03	98	1.6	0	86	14	–	–	–	13 947	2 264	–	–	–	16 211
03/04	98	2.5	0	85	15	–	–	–	14 735	2 636	–	–	–	17 371
04/05	97	3.3	0	85	15	–	–	–	15 598	2 729	–	–	–	18 327
05/06	97	3.2	0	88	12	–	–	–	14 647	2 036	–	–	–	16 683
06/07	90	3.3	7.2	82	13	–	5	–	13 188	2 054	–	838	–	16 080
07/08	87	4.7	8.0	71.5	11	11	6	0.1	9 657	1 448	1 546	848	12	13 511
08/09	88	4.3	7.2	71.9	11	11	6	0.3	9 248	1 402	1 351	826	36	12 863
09/10	91	3.7	5.2	73.0	10	11	6	0.2	10 035	1 380	1 535	774	28	13 752
10/11	90	6.0	4.2	73.9	10	10	5	1.2	9 757	1 370	1 310	611	152	13 200
11/12	89	6.7	4.0	71.2	12	10	6	0.6	8 731	1 459	1 215	790	74	12 269
12/13	88	5.9	6.0	74.2	10	10	6	0.1	9 590	1 308	1 259	752	7	12 916
13/14	91	5.7	3.4	74.8	10	9	6	0.3	9 267	1 277	1 115	690	40	12 389
14/15	92	6.0	1.6	71.4	12	12	5	0.0	7 506	1 212	1 225	562	3	10 508

	Landings (%)[1]			Days fishing (%)[2]					Days fishing					
year	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	LTCER	CELR	TCEPR	TCER	NCELR	LTCER	Total
15/16	92	6.8	1.4	74.2	11	12	3	0.1	6 398	919	1 008	294	8	8 627
16/17	94	4.4	1.9	71.4	12	11	3	2.3	6 233	1 028	968	295	205	8 729
Mean [3]	99	1.3	–	91	9	–	–	–	13 675	1 267	–	–	–	14 943
Mean [4]	90	5.2	4.5	72.8	11	11	5	0.5	9 055	1 351	1 253	662	57	12 259

[1] Percentages of landed green weight
[2] Percentages of number of days fishing
[3] average: 1989–90 to 2005–06 only
[4] average: 2006–07 to 2016–17 only

Table 9: Distribution (in %) of formtype in FLA 1 landing data, weighted by landings, in the analysis data set (column 5 in Table 2). See Appendix A for definitions of abbreviations used in this table. '–': cell not available or applicable.

Fishing year	CELR	TCEPR	TCER	NCELR
89/90	100.0	0.0	–	–
90/91	100.0	0.0	–	–
91/92	100.0	0.0	–	–
92/93	99.8	0.2	–	–
93/94	99.7	0.3	–	–
94/95	99.7	0.3	–	–
95/96	96.4	3.6	–	–
96/97	98.4	1.6	–	–
97/98	98.9	1.1	–	–
98/99	98.6	1.4	–	–
99/00	99.3	0.7	–	–
00/01	99.0	1.0	–	–
01/02	98.5	1.5	–	–
02/03	98.4	1.6	–	–
03/04	97.5	2.5	–	–
04/05	96.4	3.6	–	–
05/06	96.6	3.4	–	–
06/07	91.7	3.7	–	4.6
07/08	90.2	2.1	2.7	5.0
08/09	91.4	1.3	2.8	4.5
09/10	92.7	1.2	2.9	3.2
10/11	92.4	1.2	3.8	2.7
11/12	89.3	1.7	5.2	3.8
12/13	88.8	2.1	5.0	4.2
13/14	91.1	1.7	4.4	2.9
14/15	91.7	2.1	4.3	1.8
15/16	92.6	3.5	2.9	1.0
16/17	94.7	2.0	1.6	1.8
Mean[1]	98.7	1.3	–	–
Mean[2]	91.5	2.0	3.6	3.2

[1] 1989–90 to 2005–06 only
[2] 2006–07 to 2016–17 only

Table 10: Estimated catches (t) scaled to QMR totals (Eq. 1) for the top ten statistical areas in terms of summed 1989–90 to 2016–17 landings for the combined FLA 1 fisheries.

Fishing	Statistical Area												
year	007	044	043	003	009	010	006	041	046	002	042	Other	Total
89/90	270	272	98	30	28	8	7	10	11	12	8	37	791
90/91	391	194	94	28	30	18	11	10	12	6	3	52	850
91/92	427	205	99	32	20	20	48	11	19	6	8	42	937
92/93	463	207	136	41	25	33	78	13	10	8	14	80	1 111
93/94	464	168	145	32	20	44	173	9	12	8	12	49	1 136
94/95	344	217	127	28	18	36	88	12	14	9	14	57	964
95/96	143	186	92	23	29	37	8	14	10	10	10	65	629
96/97	179	226	108	29	28	49	7	25	9	18	4	51	733
97/98	173	216	143	25	22	37	1	24	10	13	9	48	722
98/99	185	204	124	26	19	30	0	22	25	16	10	41	703
99/00	185	290	137	31	13	12	1	17	16	15	12	22	752
00/01	213	311	136	34	7	3	1	18	27	18	8	17	792
01/02	122	237	99	42	9	2	2	16	26	12	16	12	596
02/03	260	217	71	36	14	8	2	18	17	11	22	9	686
03/04	273	246	88	42	16	10	4	15	34	16	29	11	784
04/05	498	206	100	50	44	24	4	15	34	14	33	15	1 038
05/06	476	152	90	41	83	26	7	19	23	14	20	14	964
06/07	451	153	103	38	47	39	10	19	16	14	14	20	922
07/08	279	182	87	31	28	17	2	24	15	17	6	17	705
08/09	262	196	38	33	28	4	1	24	20	17	9	9	640
09/10	331	174	31	25	17	6	0	16	16	13	15	7	652
10/11	204	132	42	32	14	6	0	17	12	12	11	4	487
11/12	194	102	29	32	22	4	1	23	12	13	8	5	445
12/13	190	143	37	29	15	3	0	19	12	18	6	7	480
13/14	213	130	55	29	13	2	0	19	19	19	6	8	511
14/15	203	112	38	25	8	0	0	14	6	12	3	5	427
15/16	100	86	24	21	3	1	0	6	10	13	9	3	277
16/17	253	65	22	18	16	4	0	8	7	12	14	2	421
Total	7 744	5 233	2 395	884	637	486	458	458	455	366	333	709	20 156
Distribution (%)	38	26	12	4.4	3.2	2.4	2.3	2.3	2.3	1.8	1.7	3.5	–

2.3.3 Description of the FLA 1 fisheries

2.3.3.1 Introduction

As discussed in Section 2.3.1.2, the link between the effort and landing components of the reporting forms has been broken in FLA 1 because of the extensive use of intermediate destination codes. This invalidates the approach advocated by Starr (2007) which scales the estimated catches by the trip landings and requires the use of estimated catches without modification, except to scale them up to represent QMR/MHR catches (Eq. 1). This approach assumes that the estimated catches are representative of the fishery and that operators, on average, have the same bias across areas and years when they estimate their catch. While this latter assumption is not ideal, there is no alternative.

Table 10 shows the distribution of flatfish estimated catches by fishing year for the top 11 statistical areas in terms of total accumulated FLA estimated catches. The top statistical area in terms of total estimated catches is Area 007 (Thames estuary), which exceeds all other statistical areas and accounts for 38% of the total combined FLA estimated catches over the 28 years of data. The next two statistical areas of importance are the west coast statistical areas 044 (Kaipara Harbour) and 043 (Manukau Harbour) (Table 10). Together these three fisheries account for 76% of the total FLA 1 catch, demonstrating why these areas are considered the major fisheries in this QMA, with the remaining statistical areas making up the balance (24%) of the FLA 1 catch.

The characterisation analysis divides FLA 1 into three main regions based on the statistical area of capture (Table 11): A) Manukau Harbour (043) (12% of catches, Table 12); B) Kaipara Harbour (044) (26% of catches, Table 12); and C) Thames estuary at the bottom of Hauraki Gulf (005–007) (41% of catches, Table 12); and four minor areas: D) lower Waikato (041, 042) (4% of catches, Table 12); E) Northwest (045–047) (4% of catches, Table 12); F) East Northland (002, 003) (6% of catches, Table 12); and G) Bay of Plenty (004, 008–010) (6% of catches, Table 12). These seven ‘fishery strata’ were established by Beentjes & Coburn (2005) and modified slightly by Kendrick & Bentley (2011). Area 001 is dropped in all FMA 1 analyses because fishers often enter ‘1’ for statistical area when filling out their forms when they intend to record the QMA. Areas 001 and 048 are also dropped because the flatfish habitat associated with these areas is minimal and only minor amounts of flatfish reported are reported from these areas.

Table 11: Divisions of the FLA 1 spatial data into fishery strata, defined from statistical area aggregations, showing the selection of statistical areas included in each ‘Fishery stratum’.

Coded name	Long name	Statistical areas included
Major areas		
MH	Manukau Harbour	043
KH	Kaipara Harbour	044
HG	Hauraki Gulf	005, 006, 007
Minor areas		
LW	Lower Waikato	041, 042
NW	Northwest	045, 046, 047, 048
EN	East Northland	002, 003
BoP	Bay of Plenty	004, 008, 009, 010

2.3.3.2 Distribution of estimated catch and effort by method of capture and fishery strata

Flatfish are taken almost entirely by setnet (SN) in all seven of the fishery strata defined in Table 11 (Figure 5; Table 12), with SN accounting for 95% of the FLA 1 estimated catch over the summarised 28 year history (97% in the most recent five years). Other capture methods are relatively insignificant, accounting for 1% to 6% of catches since 2002–03 (15 years: Table 13) in some strata. The only exception to this was a brief flurry of Danish seine catches in the early 1990s in the Hauraki Gulf where the annual contribution by this capture method was near to or above 10% from 1992–93 to 1994–95

(Table 13; Figure 5B), probably coinciding with the development of a Danish seine fleet targeting snapper. Some bottom trawl activity has occurred in the minor fisheries operating off the west coast of the North Island (Lower Waikato and Northwest, Figure 5A) and in the Bay of Plenty (Figure 5B), but these catches are minor relative to the SN catches in most fishery strata, except in the Lower Waikato and the Bay of Plenty (Figure 5; Table 12).

Annual catches of flatfish caught using setnet (as reported through estimated catches), as well as the associated effort, peaked in the early 2000s in the four west coast North Island fishery strata and have since steadily declined (Figure 6A). Patterns of catch and effort are more complicated on the east coast of the North Island, with the Hauraki Gulf showing two strong peaks of catch and effort in the early 1990s and in the second half of the 2000s (Figure 6B). However, while both the East Northland and Bay of Plenty fishery strata show catch and effort peaks in the second half of the 2000s, they are missing the strong early peak seen in the Hauraki Gulf.

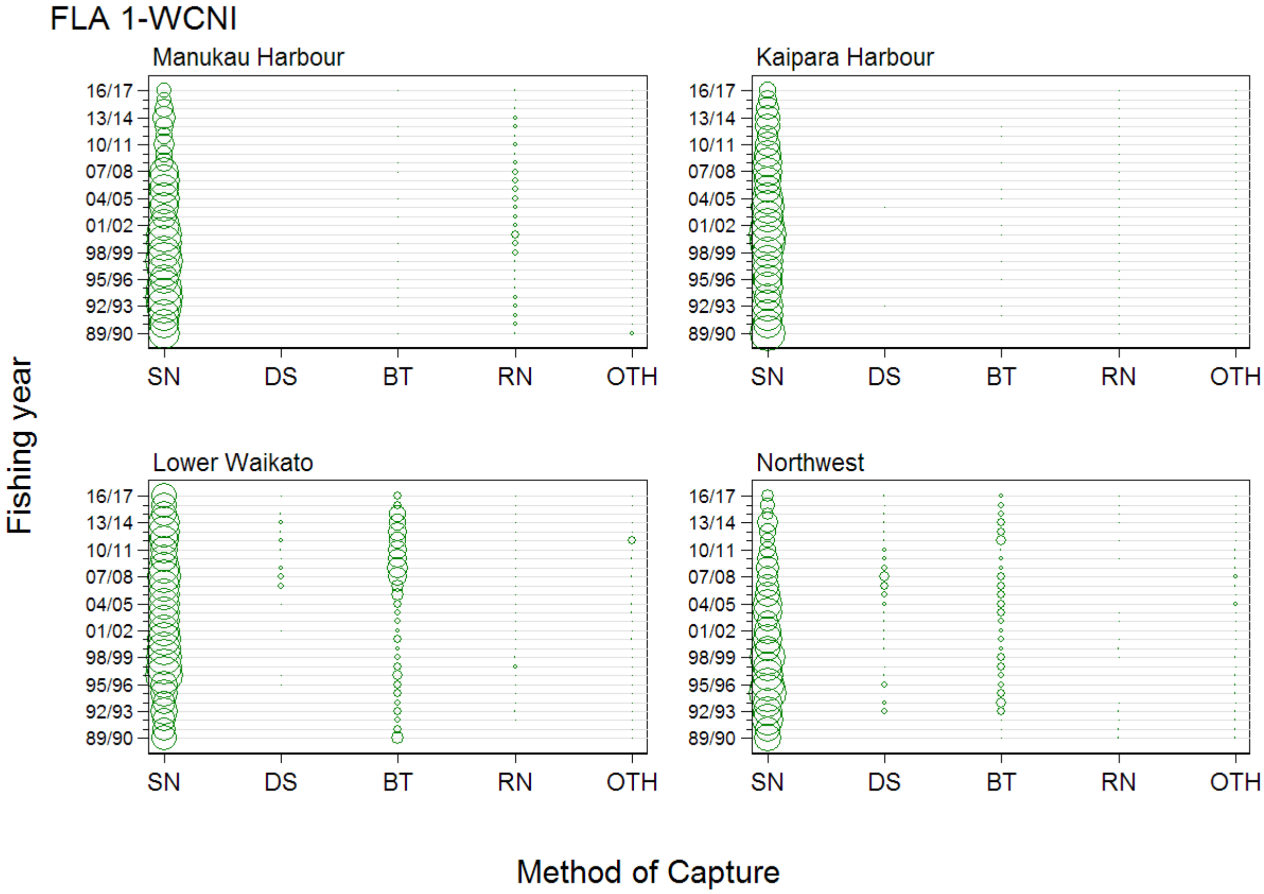

Figure 5A: Distribution of scaled (Eq. 1) estimated flatfish catches (t) for the major fishing methods by fishing year for the WCNI FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17. Circles are proportional to catch totals by method and fishing year within each sub-graph: [Manukau Harbour]: largest circle= 143 t in 97/98 for SN; [Kaipara Harbour]: largest circle= 311 t in 00/01 for SN; [Lower Waikato]: largest circle= 40 t in 96/97 for SN; [Northwest]: largest circle= 60 t in 94/95 for SN. Data for these plots are presented in Table G.1.

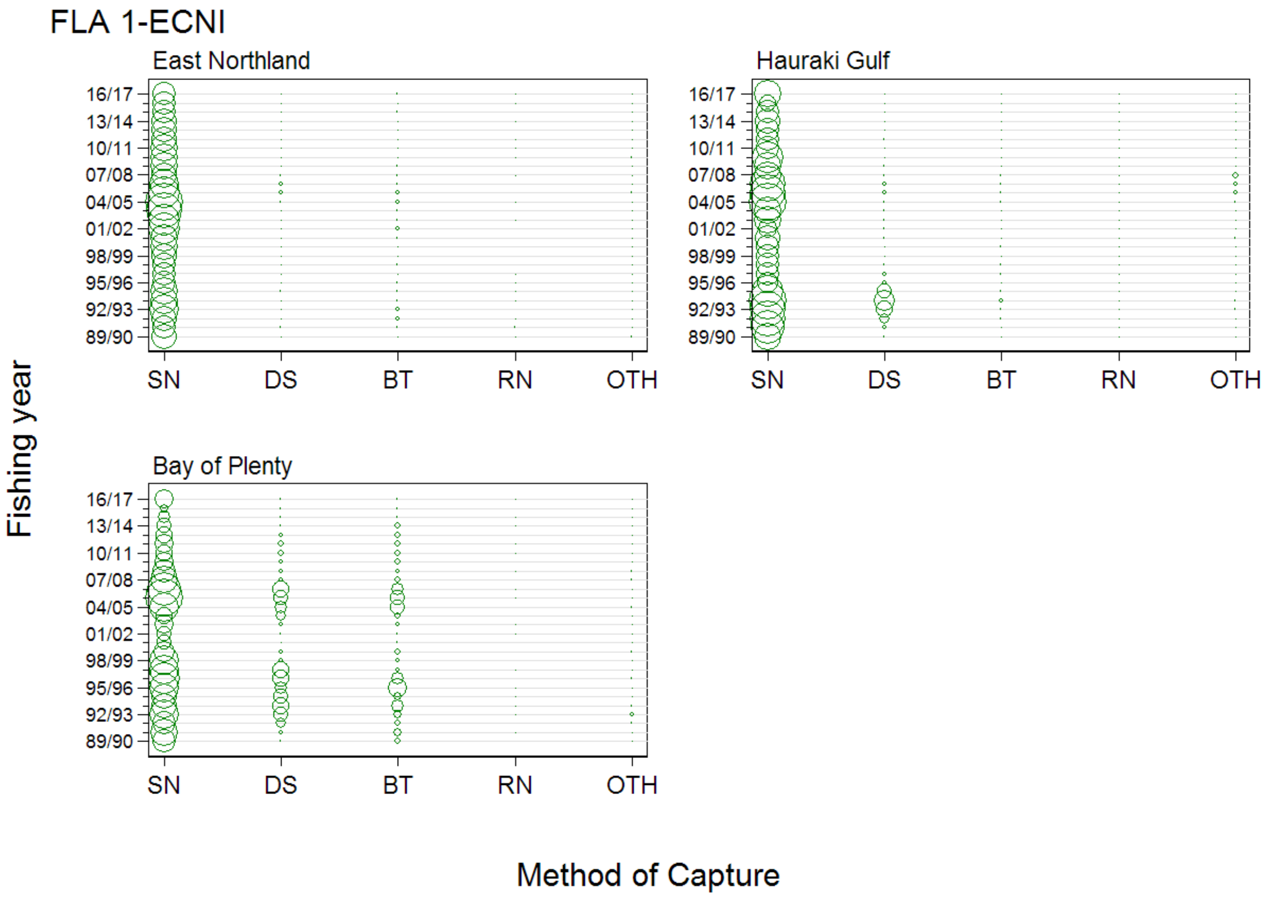

Figure 5B: Distribution of scaled (Eq. 1) estimated flatfish catches (t) by fishing year for the ECNI FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17. Circles are proportional to catch totals by method and fishing year within each sub-graph: [East Northland]: largest circle= 82 t in 04/05 for SN; [Hauraki Gulf]: largest circle= 497 t in 04/05 for SN; [Bay of Plenty]: largest circle= 86 t in 05/06 for SN. Data for these plots are presented in Table G.1.

Table 12: Total scaled (Eq. 1) estimated catches (t) and distribution of catches (%) for flatfish for important fishing methods over the FLA 1 fishery strata (Table 11) from trips that landed flatfish, summed from 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in this table. '–': no data.

	Capture method						Capture method distribution (%)					
Stratum	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total
Stat Area 001	118.8	2.2	0.3	0.01	0.04	121.3	97.9	1.8	0.2	0.01	0.03	0.6
Manukau Harbour	2 341.5	–	0.04	50.8	2.6	2 394.9	97.8	–	0.002	2.1	0.1	11.9
Kaipara Harbour	5 230.4	0.1	–	1.6	0.7	5 232.7	100.0	0.001	–	0.03	0.01	26.0
Lower Waikato	703.2	3.6	117.1	0.4	2.2	826.5	85.1	0.4	14.2	0.1	0.3	4.1
Northwest	787.3	18.2	52.6	0.9	2.9	861.9	91.3	2.1	6.1	0.1	0.3	4.3
East Northland	1 204.1	3.4	8.1	0.2	0.7	1 216.5	99.0	0.3	0.7	0.02	0.1	6.0
Hauraki Gulf	7 787.9	430.6	18.2	1.0	29.9	8 267.5	94.2	5.2	0.2	0.01	0.4	41.0
Bay of Plenty	955.3	154.4	121.8	0.1	3.3	1 234.9	77.4	12.5	9.9	0.01	0.3	6.1
Total	19 128.4	612.6	318.1	54.9	42.3	20 156.3	94.9	3.0	1.6	0.3	0.2	100.0

Table 13: Total scaled (Eq. 1) estimated catches (t) and distribution of catches (%) by fishing year for flatfish for important fishing methods over all combined FLA 1 statistical areas (Table 11) from trips that landed flatfish. See Appendix A for definitions of abbreviations used in this table.

Fishing	Capture method						Capture method distribution (%)				
year	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other
89/90	777.6	3.8	6.7	0.3	2.6	791.1	98.3	0.5	0.8	0.04	0.3
90/91	831.2	9.7	6.2	2.3	0.3	849.7	97.8	1.1	0.7	0.3	0.04
91/92	879.7	49.0	5.8	2.3	0.4	937.2	93.9	5.2	0.6	0.2	0.04
92/93	984.6	107.0	14.2	2.9	2.3	1 111.0	88.6	9.6	1.3	0.3	0.2
93/94	935.0	178.6	18.4	2.7	1.6	1 136.4	82.3	15.7	1.6	0.2	0.1
94/95	853.6	99.8	10.5	0.1	0.4	964.5	88.5	10.3	1.1	0.0	0.04
95/96	584.9	19.2	23.9	0.6	0.2	628.8	93.0	3.0	3.8	0.1	0.03
96/97	694.2	21.3	16.8	0.5	0.4	733.3	94.7	2.9	2.3	0.1	0.1
97/98	695.1	19.6	6.7	0.6	0.1	722.2	96.3	2.7	0.9	0.1	0.02
98/99	692.6	1.8	5.2	3.0	0.3	702.9	98.5	0.3	0.7	0.4	0.04
99/00	742.7	1.1	4.2	3.2	0.7	751.9	98.8	0.1	0.6	0.4	0.1
00/01	781.0	0.6	4.2	5.9	0.8	792.5	98.6	0.1	0.5	0.7	0.1
01/02	589.0	2.0	3.1	1.9	0.1	596.0	98.8	0.3	0.5	0.3	0.01
02/03	676.4	3.4	4.6	1.5	0.1	686.0	98.6	0.5	0.7	0.2	0.01
03/04	762.6	10.8	7.6	2.8	0.1	783.8	97.3	1.4	1.0	0.4	0.01
04/05	996.0	11.9	21.8	4.4	3.8	1 037.8	96.0	1.1	2.1	0.4	0.4
05/06	910.0	21.6	24.0	2.9	5.8	964.4	94.4	2.2	2.5	0.3	0.6
06/07	863.3	27.5	19.4	3.1	8.3	921.6	93.7	3.0	2.1	0.3	0.9
07/08	666.3	8.5	15.6	3.1	11.1	704.7	94.6	1.2	2.2	0.4	1.6
08/09	619.7	3.1	14.4	2.4	0.4	640.0	96.8	0.5	2.2	0.4	0.1
09/10	636.9	2.2	11.8	1.1	0.4	652.4	97.6	0.3	1.8	0.2	0.1
10/11	471.1	2.7	11.7	1.4	0.2	487.0	96.7	0.5	2.4	0.3	0.03
11/12	423.1	3.3	15.9	1.0	1.8	445.1	95.0	0.7	3.6	0.2	0.4
12/13	462.3	1.4	14.8	1.2	0.0	479.8	96.4	0.3	3.1	0.2	0.003
13/14	494.2	1.3	13.1	2.6	0.0	511.2	96.7	0.3	2.6	0.5	0.01
14/15	415.5	0.3	10.7	0.6	0.0	427.2	97.3	0.1	2.5	0.1	0.005
15/16	272.7	0.6	3.6	0.1	0.0	277.1	98.4	0.2	1.3	0.03	0.002
16/17	417.0	0.3	3.1	0.3	0.0	420.7	99.1	0.1	0.7	0.1	0.01
Total	19 128.4	612.6	318.1	54.9	42.3	20 156.3	94.9	3.0	1.6	0.3	0.2
Last five years	2 061.8	4.0	45.4	4.7	0.1	2 116.0	97.4	0.2	2.1	0.2	0.005

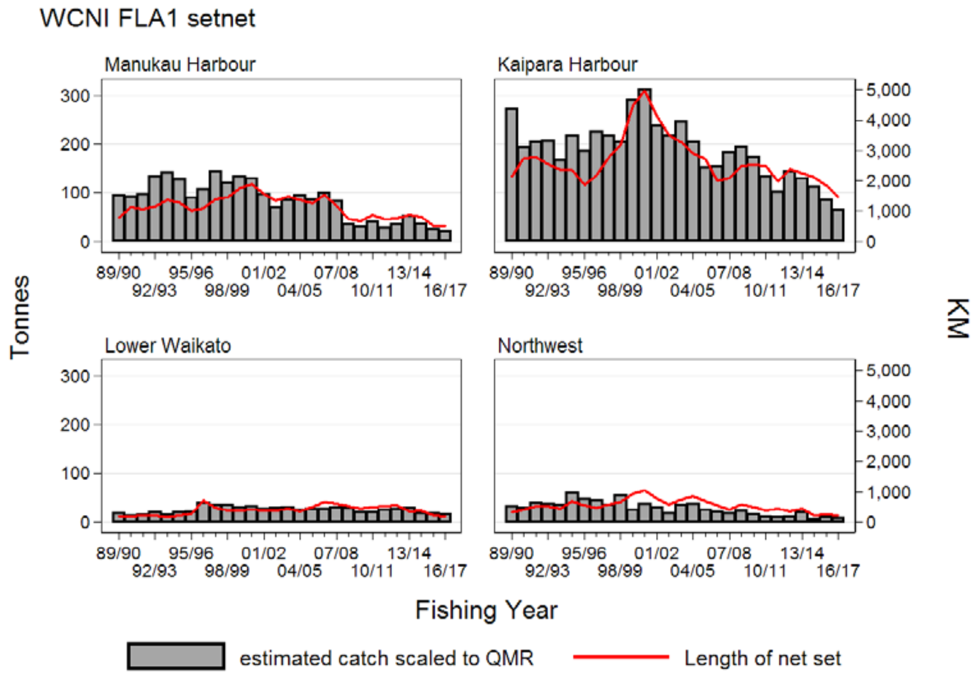

Figure 6A: Bar plots of total annual estimated catches scaled to QMR (t) (Eq. 1) and total length of net set (km) for the four west coast North Island FLA 1 fishery strata. Data for these plots are presented in Table G.1 and Table G.2.

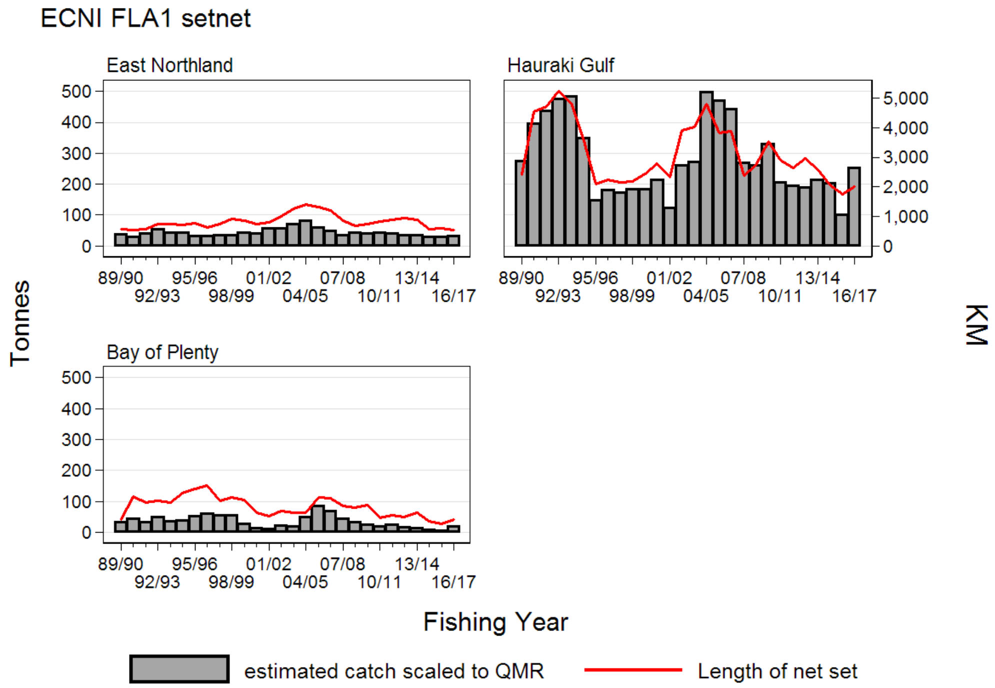

Figure 6B: Bar plots of total annual estimated catches scaled to QMR (t) (Eq. 1) and total length of net set (km) for the three east coast North Island FLA 1 fishery strata. Data for these plots are presented in Table G.1 and Table G.2.

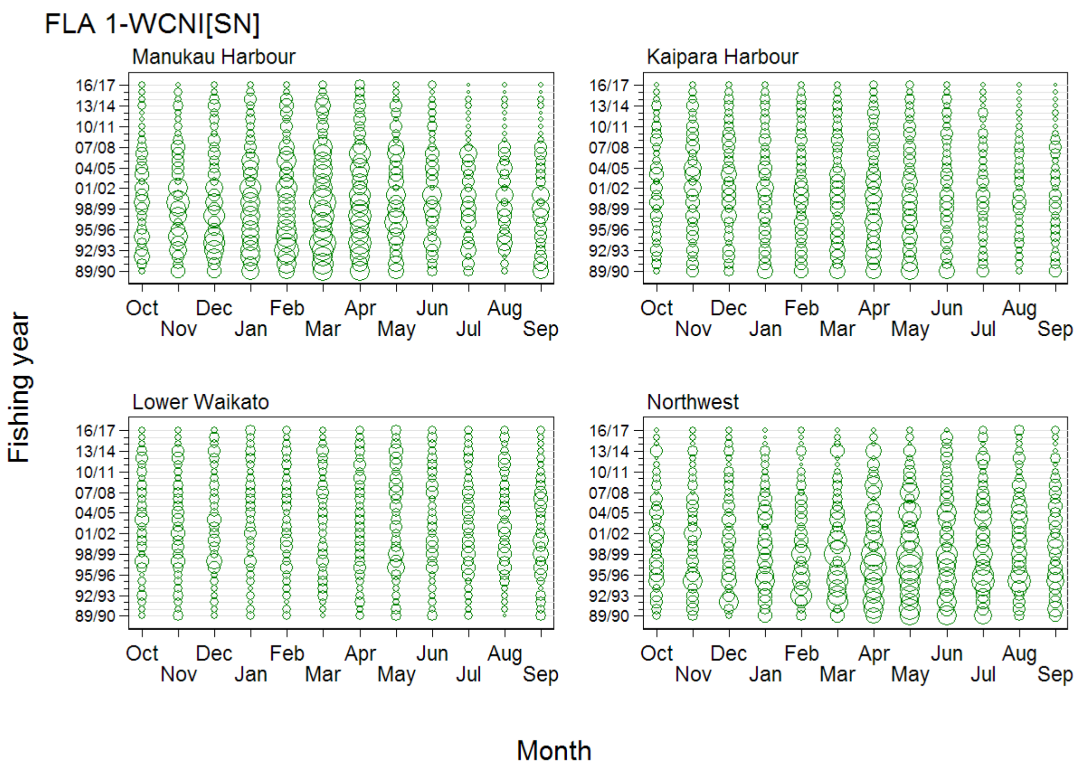

Figure 7A: Distribution of setnet scaled (Eq. 1) estimated flatfish catches (t) by month and fishing year for the WCNI FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17. Circles are proportional to catch totals by method and fishing year within each sub-graph: [Manukau Harbour]: largest circle= 28 t in 99/00 for Mar; [Kaipara Harbour]: largest circle= 42 t in 01/02 for Nov; [Lower Waikato]: largest circle= 6.3 t in 96/97 for May; [Northwest]: largest circle= 9.4 t in 96/97 for May. Values for the plotted data are provided in Table G.3.

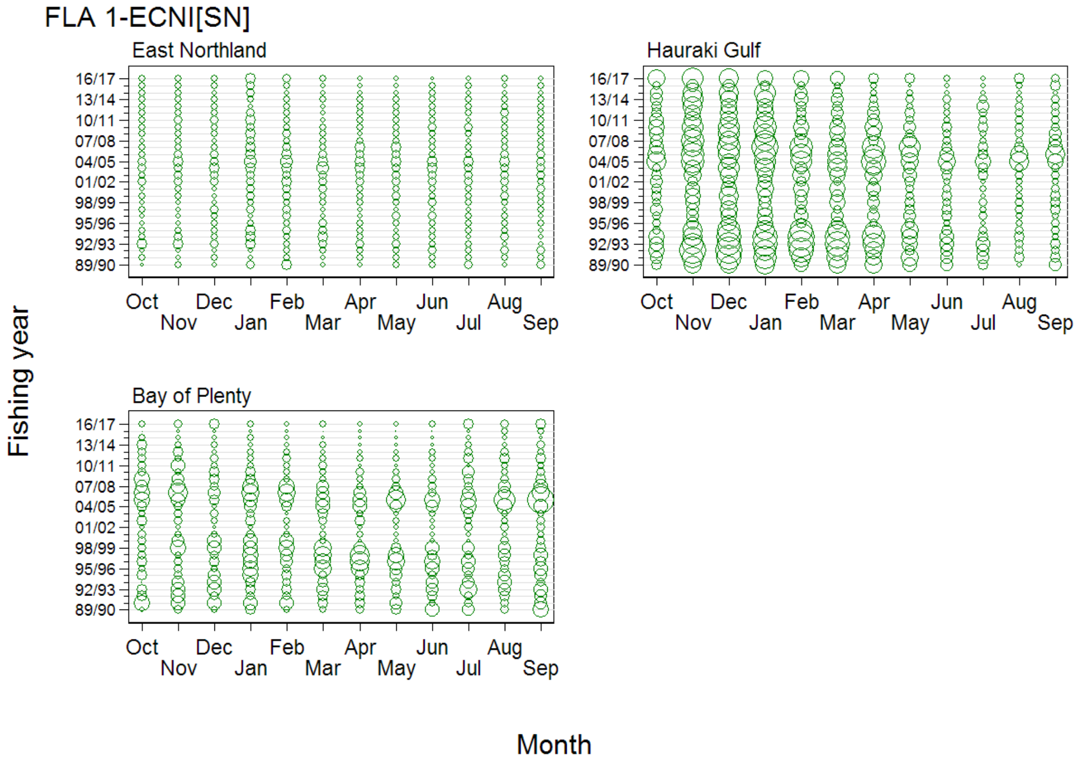

Figure 7B: Distribution of setnet scaled (Eq. 1) estimated flatfish catches (t) by month and fishing year for the ECNI FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17. Circles are proportional to catch totals by method and fishing year within each sub-graph: [East Northland]: largest circle= 8.8 t in 03/04 for Mar; [Hauraki Gulf]: largest circle= 78 t in 93/94 for Feb; [Bay of Plenty]: largest circle= 19 t in 05/06 for Sep. Values for the plotted data are provided in Table G.3.

2.3.3.3 Seasonal distribution of estimated catches in the setnet fishery

There appears to be relatively little seasonality in the estimated flatfish setnet catches in any of the seven fishery strata defined in Table 11 (Figure 7). The only fishery stratum with a suggestion of seasonality is the Hauraki Gulf, where there appears to be some attenuation of catch after April (Figure 7B). However, the other two main harbour fisheries (Manukau and Kaipara, Figure 7A) do not show a similar drop in autumn and winter catches. None of the four minor fishery strata show much seasonality (Figure 7A, Figure 7B).

2.3.3.4 Distribution of estimated catches by declared target species in the setnet fishery

There is almost no contrast in the targeting information in the FLA 1 setnet data set, with 90% of all declared target species assigned to the generic FLA code (Table 14). Of the three major setnet fishing strata, only Kaipara Harbour fishers used alternative target species codes, with 16% of the estimated catches directed at YBF rather than FLA (Table 14). There is a trend in the use of the YBF target species code in Kaipara Harbour, with over 30% in 2015–16 and over 50% in 2016–17 of estimated catches declaring YBF as the target species (Figure 8). The use of FLA target species other than the generic FLA code is nearly non-existent in the other FLA 1 fishery strata (Table 14). As well, the FLA 1 setnet fishery in these seven fishery strata is exclusively (98%) a FLA target fishery, with 1% (or less) of the estimated catches directed at SPO or SNA, the next two most prevalent declared target species (Table 15).

Table 14: Distribution of estimated setnet flatfish catches (%) by declared flatfish target species for each of the FLA 1 fishery strata (Table 11) from trips that landed flatfish, summed from 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in this table. NUL: missing target species information. '–': no data.

Species code	Missing stat_area	Stat_area 001	Manukau Harbour	Kaipara Harbour	Lower Waikato	Northwest	East Northland	Hauraki Gulf	Bay of Plenty	Total	scaled to QMR/MHR[1]
FLA	77.2	87.9	97.6	83.3	84.1	93.2	95.1	92.1	84.3	89.9	16 790
YBF	17.9	6.0	1.1	16.2	12.8	1.2	3.0	3.8	2.5	7.0	1 309
SFL	0.2	2.5	0.04	0.01	0.4	0.0005	0.3	0.8	3.5	0.5	102
GFL	0.1	1.0	–	0.001	1.3	0.01	–	0.2	0.02	0.2	29
ESO	–	–	–	–	–	–	–	–	1.9	0.1	17
LSO	–	–	–	–	–	–	–	–	0.0	0.002	0.4
SOL	0.4	–	–	–	–	–	–	–	–	0.001	0.2
BFL	0.3	–	–	–	–	–	–	–	–	0.001	0.1
FLO	–	–	–	0.001	–	0.002	–	0.0001	–	0.000	0.1
BRI	–	–	–	–	–	–	–	–	0.002	0.0001	0.01
TUR	–	–	–	–	0.0002	–	–	–	–	0.00001	0.001
NUL	3.9	2.7	1.2	0.5	1.4	5.6	1.6	3.1	7.8	2.3	436
Total	0.2	0.6	12.1	27.1	3.6	4.1	6.3	41.0	4.9	100	18 684

[1] distribution scaled to the SN FLA total in Table 15

Table 15: Total scaled (Eq. 1) estimated setnet catches (t) and distribution of catches (%) for all target species over the FLA 1 fishery strata (Table 11) from trips that landed flatfish, summed from 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in this table. '–': no data.

	Target species (t)								Distribution of target species (%)						
Stratum	FLA	SPO	SNA	GUR	TRE	GMU	Other	Total	FLA	SPO	SNA	GUR	TRE	GMU	Other
Stat Area 001	115.6	1.0	0.3	0.78	0.84	0.1	0.2	118.8	97.3	0.8	0.3	0.7	0.7	0.1	0.1
Manukau Harbour	2 312.5	19.9	0.18	0.2	5.6	2.1	1.1	2 341.5	98.8	0.9	0.01	0.01	0.2	0.1	0.05
Kaipara Harbour	5 205.7	14.3	0.119	0.2	2.0	7.3	0.7	5 230.4	99.5	0.3	0.002	0.004	0.04	0.1	0.01
Lower Waikato	693.3	6.8	0.0	1.2	0.4	0.9	0.6	703.2	98.6	1.0	0.003	0.2	0.1	0.1	0.1
Northwest	743.4	18.8	0.3	18.9	2.2	2.6	1.2	787.3	94.4	2.4	0.03	2.4	0.3	0.3	0.2
East Northland	1 184.4	6.8	1.9	0.5	0.9	6.3	3.2	1 204.1	98.4	0.6	0.2	0.04	0.1	0.5	0.3
Hauraki Gulf	7 547.5	101.4	101.7	1.0	10.3	4.1	21.9	7 787.9	96.9	1.3	1.3	0.01	0.1	0.1	0.3
Bay of Plenty	881.4	15.6	6.1	32.4	11.1	0.5	8.2	955.3	92.3	1.6	0.6	3.4	1.2	0.05	0.9
Total	18 683.8	184.6	110.6	55.2	33.3	23.8	37.1	19 128.4	97.7	1.0	0.6	0.3	0.2	0.1	0.2

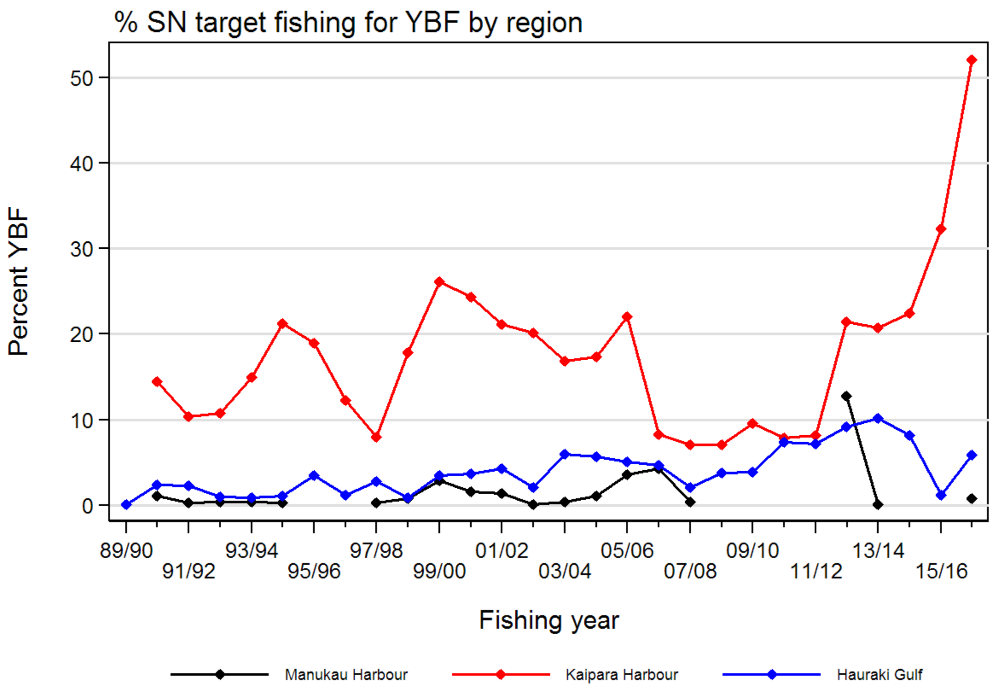

Figure 8: Percentage of estimated setnet flatfish catch declared using YBF as the target species for each of the primary FLA 1 fishery strata (Table 11) by fishing year, 1989–90 to 2016–17.

2.3.3.5 Distribution of flatfish component species in the setnet fishery

The use of non-generic flatfish species codes when reporting estimated catch is of importance if CPUE analyses are to reflect actual species catch rather than being lumped into a single composite FLA code. Starr et al. (2018) were able to extract species-specific information from the FLA 3 fishery off the east coast of the South Island by identifying “splitter” trips where all estimated flatfish catches used non-generic species code. The existence of such trips was seen to increase over time because the use of species-specific flatfish codes was being encouraged by local Fisheries New Zealand field staff in FMA 3.

The use of non-generic flatfish species codes when reporting estimated catch in FLA 1 seems to be minimal and there is little indication that there are trends in this form of reporting. Table 16 shows that, overall, 57% of estimated catches use the generic FLA code. The next two codes in terms of importance are YBF (32%) and SFL (8%). The remaining six species codes in the data set comprise less than 4% of the reported estimated catches (Table 16).

Catches from the two western harbours are primarily YBF, but the use of the YBF code was rare in Manukau Harbour up to 2012–13, when the percentage of estimated catches using this code increased to just over 20%, where it has remained to 2016–17 (Figure 9A). The Kaipara Harbour fishery makes more use of the YBF code (overall 38% of the estimated catch: Table 16), with the percentage reported approaching or exceeding 40% since the early 1990s and going above 60% in 2015–16 and 2016–17 (Figure 9A).

The Hauraki Gulf fishery stratum is a mixed species flatfish fishery, with both YBF and SFL being captured (Table 16). Unfortunately, the use of SFL code dropped to low levels (less than 5%) in the 2000s, with a corresponding increase in the use of the generic FLA code (Figure 9A). This renders CPUE analyses which make use of the SFL code problematic in this fishery because there is no assurance that the fishers who continue to use the code are representative of the overall SFL catch when reporting levels get so low. Figure 9A shows that there is likely to be a trade-off between the use of the generic FLA code and the prevalence of the two primary species-specific codes. Such a trade-off can introduce bias into the use of these data for tracking species abundance.

The use of species-specific codes in the minor fishery strata is also problematic. The two west coast fishery strata are primarily YBF, but there is an increase in the SFL code in the Lower Waikato from 2012–13 to 2014–15 (Figure 9B). It is not clear whether this is the result of a short-term increase in SFL abundance or a reporting anomaly that has since disappeared. The Northwest fishery stratum shows an attenuation in the reporting of YBF since the early 2000s and a near complete disappearance of species-specific code reporting after 2013–14 (Figure 9B). East Northland shows a reasonably steady reporting of YBF of around 40% of total estimated catch, but there is a strong increase in SFL in 2016–17 (Figure 9B). It is not possible to tell whether this is due to increased species-specific reporting or to a true increase in SFL abundance. The species composition in the Bay of Plenty setnet fishery is more complex than any of the other six strata, with much variation and no trend in the reporting by specific species (Figure 9B). It would be difficult to extract species trends from these data.

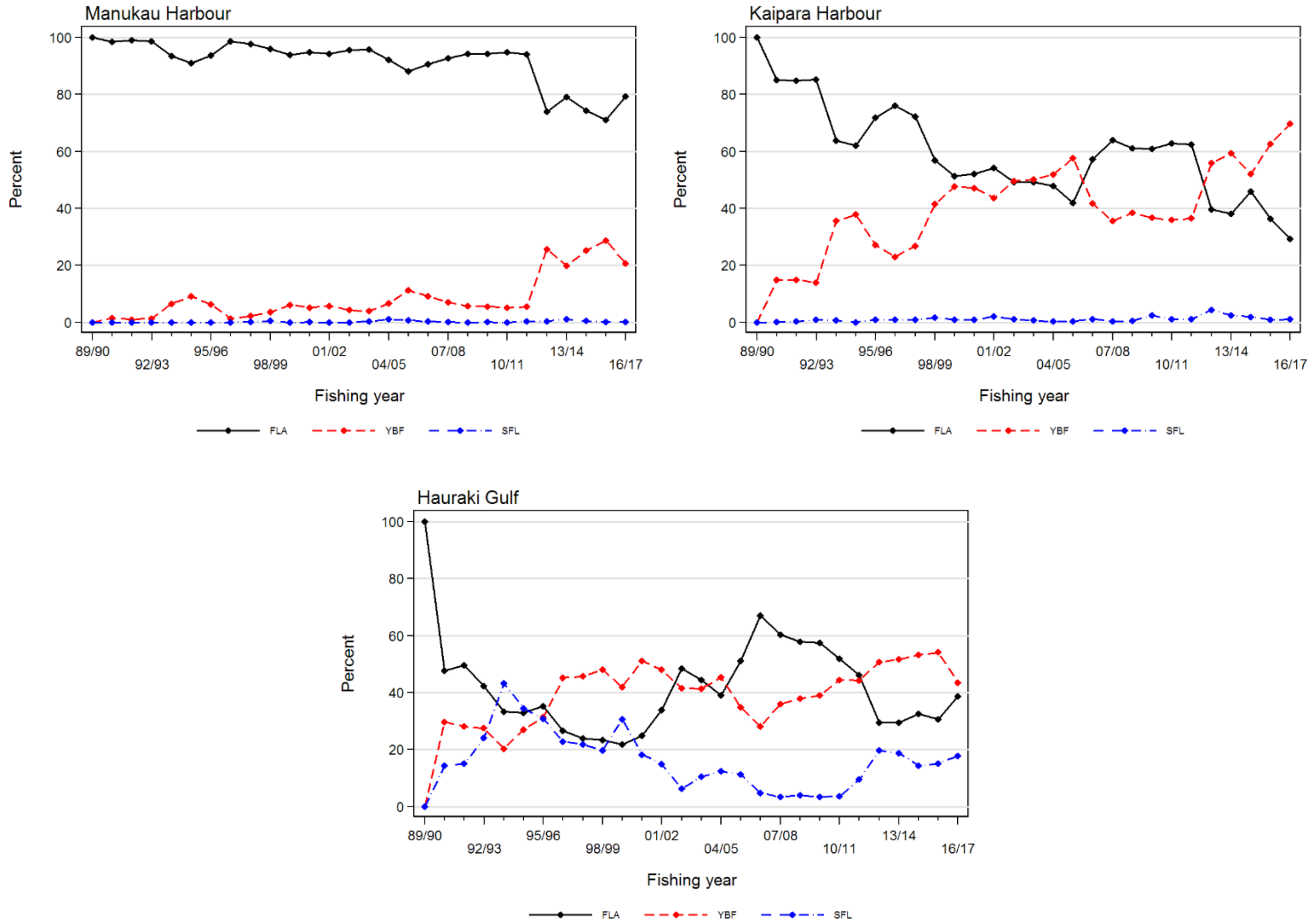

Figure 9A: Percentage of estimated setnet flatfish catch reported by flatfish species code for each of the major FLA 1 fishery strata (Table 11) by fishing year, 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in the figure legend.

Table 16: Distribution of estimated setnet flatfish catches (%) by species code used for the estimated catch for each of the FLA 1 fishery strata (Table 11) from trips that landed flatfish, summed from 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in this table. NUL: missing target species information. '–': no data.

Species code	Missing stat_area	Stat_area 001	Manukau Harbour	Kaipara Harbour	Lower Waikato	Northwest	East Northland	Hauraki Gulf	Bay of Plenty	Total	scaled to QMR/MHR[1]
FLA	48.1	55.3	93.6	61.1	81.4	71.7	54.7	44.9	19.9	57.1	10 927
YBF	33.6	15.2	6.2	37.9	16.4	24.8	39.5	37.6	16.5	31.5	6 026
SFL	10.6	9.7	0.2	1.0	0.5	1.3	5.7	14.0	25.3	7.8	1 491
ESO	1.1	0.3	0.0001	0.00003	0.2	2.1	0.05	0.1	25.0	1.3	258
GFL	4.8	19.1	–	0.002	1.3	0.01	0.001	3.0	1.3	1.5	285
LSO	0.1	0.3	–	–	0.04	0.01	0.02	0.01	9.5	0.5	90
BRI	0.1	0.04	–	–	0.1	0.01	0.001	0.001	2.3	0.1	23
BFL	1.5	–	–	–	–	–	0.03	0.3	0.02	0.1	27
TUR	0.2	0.01	0.0002	–	0.0	0.1	0.01	0.002	0.1	0.01	2
Total	0.2	0.6	12.1	27.1	3.6	4.1	6.3	41.0	4.9	100	19 128

[1] distribution in the penultimate column scaled to SN total in Table 12

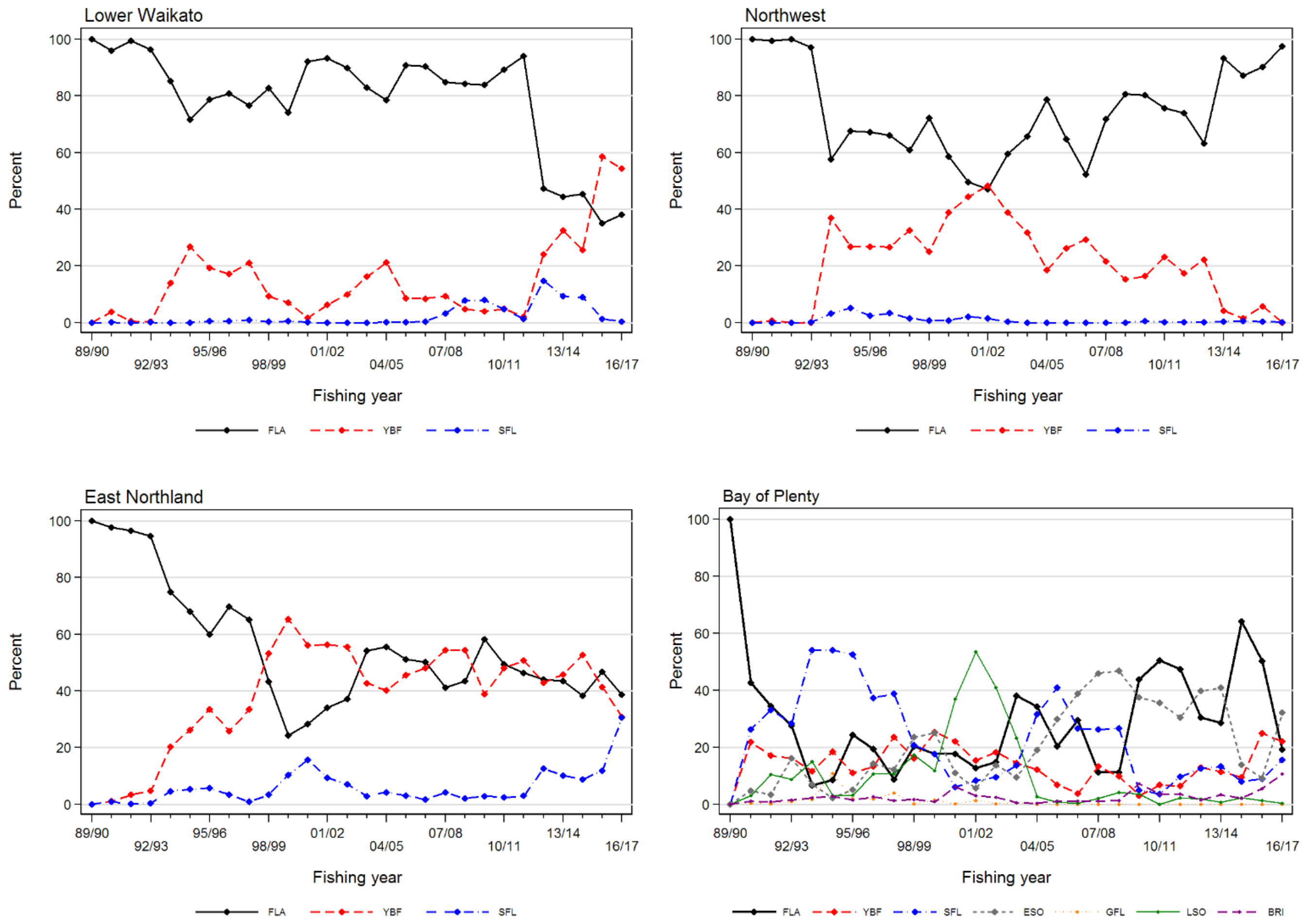

Figure 9B: Percentage of estimated setnet flatfish catch reported by flatfish species code for each of the minor FLA 1 fishery strata (Table 11) by fishing year, 1989–90 to 2016–17. See Appendix A for definitions of abbreviations used in the figure legend.

3. STANDARDISED CPUE ANALYSIS

3.1 Description and specification of analyses

Standardised CPUE analyses were performed on four major fishery strata (Table 17) and three minor fishery strata (Table 18). These seven strata/regions were originally specified by Beentjes & Coburn (2005) and their definitions have been continued in subsequent reports, with the exception of adding in Areas 005 and 006 with 007 and calling the resulting grouping “Hauraki Gulf” (proposed by Kendrick & Bentley 2011). Kendrick & Bentley (2011) dropped the Bay of Plenty standardised CPUE analysis due to data scarcity and complex species composition, a practice which has been continued in this report.

The positive catch distributions listed in Table 17 and Table 18 were selected to ensure continuity with earlier versions of the same analyses (see Kendrick & Bentley 2011, 2012a, 2015). The only exception was the `HG(TOT)-est` model, a new model proposed for this report by the NINSWG, where a range of alternative positive catch distributions were tested with the data set and the gamma distribution was selected because it gave the best fit (Figure L.3).

Kendrick & Bentley (2015) report a SFL series for the Hauraki Gulf. When this report was initially reviewed in April 2018, the NINSWG rejected the SFL series because of the poor reporting rate for SFL in this fishery during the 2000s (see [lower central] panel in Figure 9 and Appendix P). The NINSWG was concerned that, because of the low reporting level across a number of years during the 2000s (see upper and lower left panels in Figure P.2), there was potential for bias in the CPUE estimates because the remaining reporting fleet might not be representative of the total fleet catch. Consequently the SFL series was replaced with a Hauraki Gulf series which combined all FLA catches into a single vector (`HG(TOT)-est`; Table 17).

This report implemented a catch correction algorithm (Appendix F) developed by Kendrick & Bentley (2012b) to correct for rig (SPO 1) being landed using intermediate destination codes and subsequently sold to a LFR at a later date. Appendix Q compares a series analysed using data where the catch vector has been prepared with the F2 algorithm with a series prepared using the same data except that the catch vector was based on unmodified estimated catch. The correspondence between series prepared using the alternative catch vectors was sufficiently good that the NINSWG recommended that only the estimated catch series were required.

Table 17: List of specifications for modelled FLA 1 setnet (SN) major fishery strata (Table 11). FLA(TOT): amalgamation of all FLA estimated catch species codes.

Model label	Location	Statistical area definition	FLA species definition	Core fleet definition	Number vessels and % retained catch	Positive catch distribution	Document reference
`MH(TOT)-est`	Manukau Harbour	043	FLA(TOT)	10 trips/6 years	42 vessels/84%	log-logistic	Appendix I
`KH(TOT)-est`	Kaipara Harbour	044	FLA(TOT)	10 trips/4 years	68 vessels/90%	log-logistic	Appendix J
`HG(YBF)-est`	Hauraki Gulf	005–007	YBF	10 trips/4 years	40 vessels/86%	gamma	Appendix K
`HG(TOT)-est`[1]	Hauraki Gulf	005–007	FLA(TOT)	10 trips/4 years	103 vessels/87%	gamma	Appendix L

[1] new model: created at request of NINSWG

Table 18: List of specifications for modelled FLA 1 setnet (SN) minor fishery strata (Table 11). FLA(TOT): amalgamation of all FLA estimated catch species codes.

Model label	Location	Statistical area definition	FLA species definition	Core fleet definition	Number vessels and % retained catch	Positive catch distribution	Document reference
`LW(TOT)-est`	Lower Waikato	041 & 042	FLA(TOT)	10 trips/4 years	16 vessels/87%	log-logistic	Appendix M
`NW(TOT)-est`	Northwest	045–047	FLA(TOT)	10 trips/3 years	19 vessels/85%	log-logistic	Appendix N
`EN(TOT)-est`	East Northland	002 & 003	FLA(TOT)	10 trips/4 years	25 vessels/80%	log-logistic	Appendix O

3.2 Comparison with previous FLA 1 CPUE standardisation analyses

Three of the four models reported in Table 17 are repeats of models generated by Kendrick & Bentley (2015) and all three of the models in Table 18 were also reported by Kendrick & Bentley (2015). Superimposed plots of the respective positive catch series show good correspondence between the series generated for this report with the equivalent Kendrick & Bentley (2015) series for the major (Figure 10) and minor fishery strata (Figure 11)

Kendrick & Bentley (2015) reported a presence-absence analysis based on the binomial distribution. Such an analysis is frequently done in the Inshore Working Groups to capture changes in species reporting standards and discards (see Langley 2014 for a discussion). Given that these setnet fisheries are primarily targeted at FLA, the incidence of zero catch records is low when all FLA catches are amalgamated and only a positive catch series is required. However, there is a much higher incidence of zero records in the Hauraki Gulf setnet fishery when only reporting YBF (see Figure K.2) or SFL (see Figure P.2). The presence-absence series was initially repeated for this report, but the NINSWG rejected this analysis for Hauraki Gulf YBF because there was concern that changes in the proportion of zeros in this fishery were often due to species reporting issues rather than to changes in abundance.

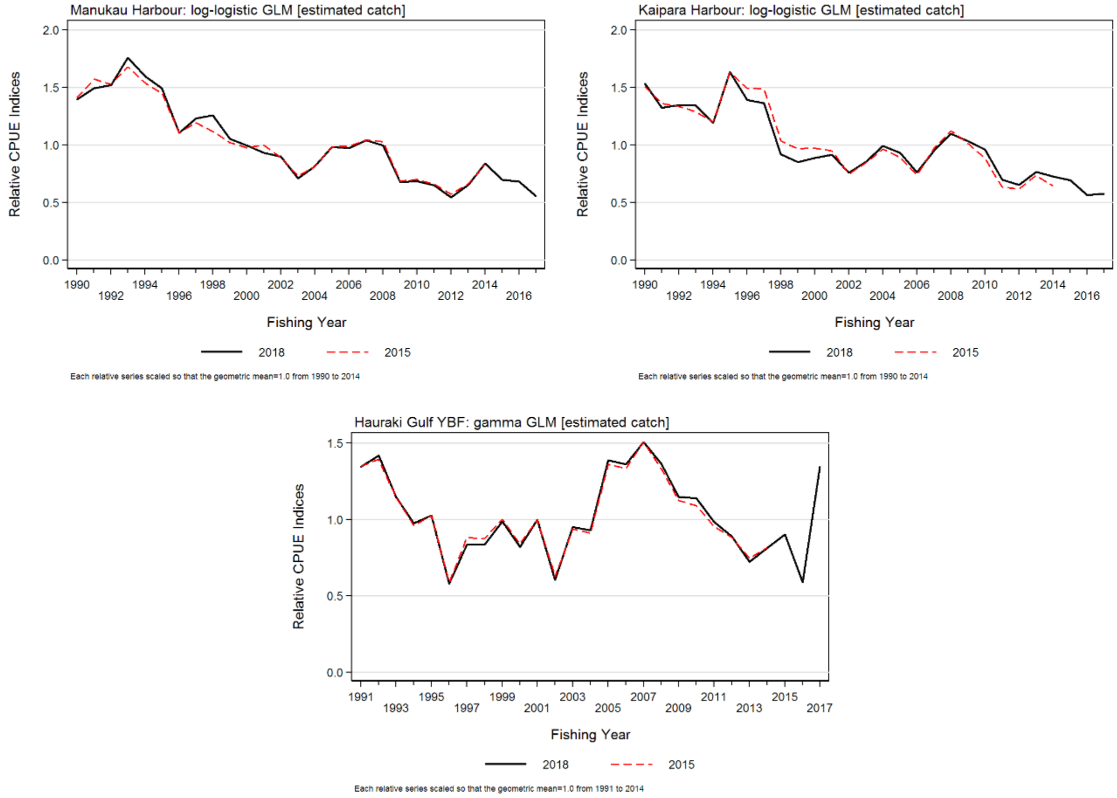

Figure 10: Comparison of three major 2018 standardised positive catch models with equivalent 2015 models; [upper left panel]: Manukau Harbour; [upper right panel]: Kaipara Harbour; [lower central panel]: Hauraki Gulf YBF. See Table 17 for model specifications.

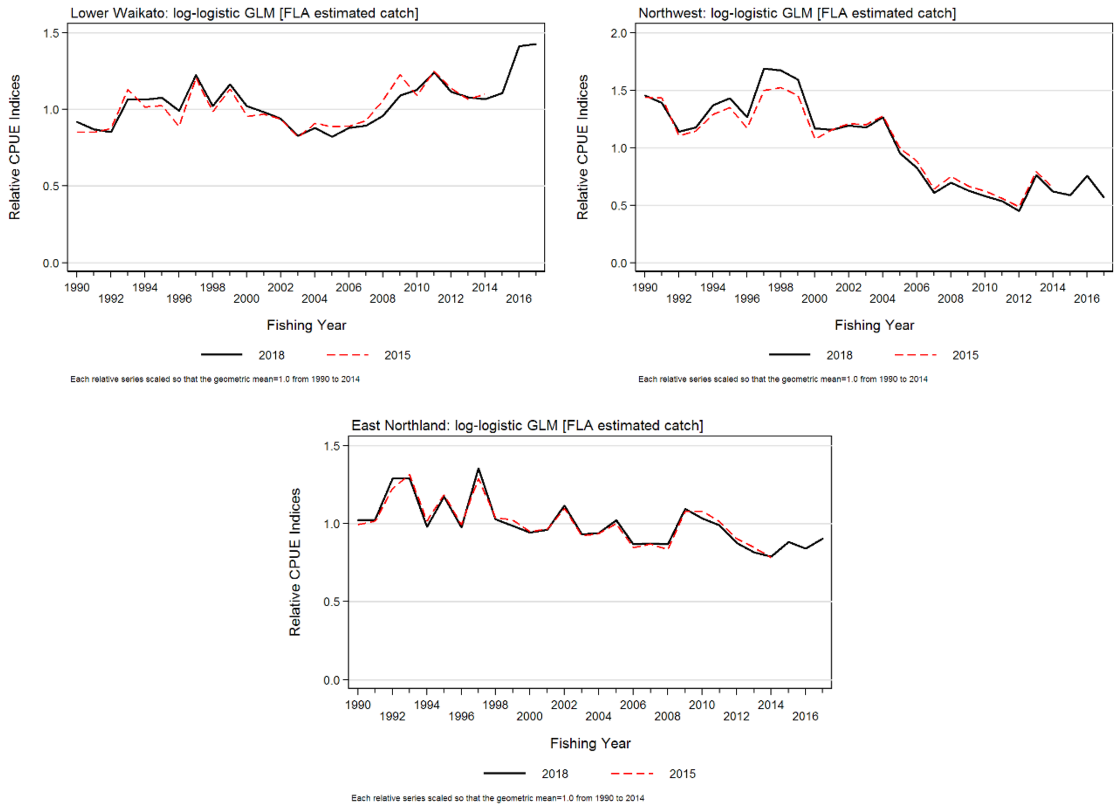

Figure 11: Comparison of three minor 2018 standardised positive catch models with equivalent 2015 models; [upper left panel]: Lower Waikato; [upper right panel]: Northwest; [lower central panel]: East Northland. See Table 18 for model specifications.

3.3 Description of standardised SN CPUE from FLA 1 major fishery strata

3.3.1 Manukau Harbour

Detailed diagnostics for the Manukau Harbour standardised positive catch model are presented in Appendix I and the relative CPUE series and contributing catches are plotted in Figure 12 [upper left panel]. There is only a minor effect from the standardisation procedure (Figure I.3) with acceptable diagnostics for this model. The series peaked in 1992–93 and has since declined 68% from the peak. Research has shown that there is a correlation between siltation and declining water quality in this harbour with the CPUE trend (McKenzie et al. 2013), leading to the conclusion that factors other than fishing are causing the decline in CPUE. Catches have also dropped along with the drop in CPUE (Fisheries New Zealand 2018).

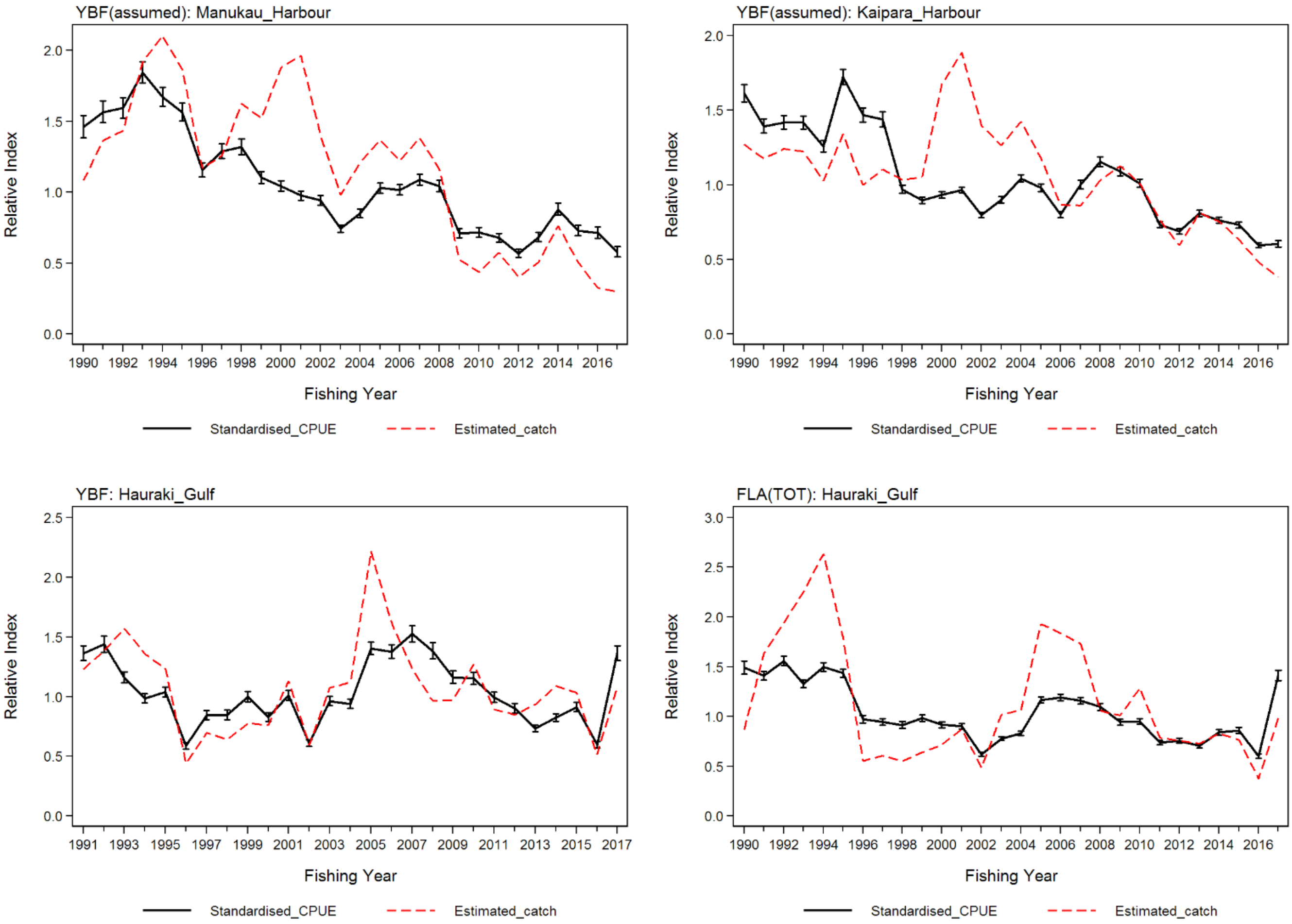

Figure 12: Setnet positive catch CPUE series (showing upper and lower 95% bounds) and relative catch (geometric mean=1.0 for both series) for the four FLA 1 major fishery strata (see Table 11): [upper left panel] Manukau Harbour; [upper right panel] Kaipara Harbour; [lower left panel]: Hauraki Gulf YBF; [lower right panel] Hauraki Gulf FLA(TOT).

3.3.2 Kaipara Harbour

Detailed diagnostics for the Kaipara Harbour standardised positive catch model are presented in Appendix J and the relative CPUE series and contributing catches are plotted in Figure 12 [upper right panel]. As for the Manukau Harbour series, there is only a minor effect from the standardisation procedure (Figure J.3) with acceptable diagnostics for this model. The series peaked in 1994–95 and has since declined 66% from the peak. The research in Manukau Harbour which correlates the CPUE decline with reduced water quality in the harbour (McKenzie et al. 2013), leads to the same conclusion for this harbour as for the Manukau: factors other than fishing are causing the decline in CPUE, given that catches have also dropped along with the drop in CPUE (Fisheries New Zealand 2018).

3.3.3 Hauraki Gulf YBF

Detailed diagnostics for the Hauraki Gulf YBF standardised positive catch model are presented in Appendix K and the relative CPUE series and contributing catches are plotted in Figure 12 [lower left panel]. The standardisation effect is not large but it is greater than for the two west coast harbour series (Figure K.3) with acceptable diagnostics for this model. The series shows very little overall trend, but that conclusion is dependent on the very strong upturn observed in 2016–17. The series peaked in 2006–07 and then declined steadily to 2015–16. The strong upturn in 2016–17 has brought the series above its long-term mean.

3.3.4 Hauraki Gulf FLA(TOT)

Detailed diagnostics for the Hauraki Gulf FLA(TOT) standardised positive catch model are presented in Appendix L and the relative CPUE series and contributing catches are plotted in Figure 12 [lower right panel]. The standardisation effect is greater than for the comparable `HG(YBF)-est` series (Figure L.4) with acceptable diagnostics for this model. The series peaked in the early 1990s and then declined to 2001–02 when it climbed to a secondary peak around 2006–07. Then, as for the `HG(YBF)-est` series, there was a decline to 2015–16 followed by a strong upturn in 2016–17 that has brought the series above its long-term mean. There will be a considerable overlap in the data contributing to these two Hauraki Gulf series.

3.4 Description of standardised SN CPUE from FLA 1 minor fishery strata

These analyses are reported here for completeness. They have not been accepted by the NINSWG for monitoring these fisheries due to the lack of area-specific catch information, leading to the amalgamation of harbours and other flatfish fishing locations which may conceal local trends. As well, the amount of data held in these three fisheries is limited, with the combined three fisheries only accounting for 14% of the total FLA estimated catch over the 28 year period of record (see Table 12).

3.4.1 Lower Waikato

Detailed diagnostics for the Lower Waikato standardised positive catch model are presented in Appendix M and the relative CPUE series and contributing catches are plotted in Figure 13 [upper left panel]. The standardisation effect flattens the series, with the procedure lifting all the early CPUE 1990s indices, effecting little change in the middle section of the series and then pushing down the final 10–12 years of the series (Figure M.3). The series appears to be increasing, but most of the increase has occurred in the most recent 10 to 12 years. Note that the strong CPUE increases in 2015–16 and 2016–17 are not associated with a corresponding increase in catch (Figure 13 [upper left panel]).

3.4.2 Northwest

Detailed diagnostics for the Northwest standardised positive catch model are presented in Appendix N and the relative CPUE series and contributing catches are plotted in Figure 13 [upper right panel]. There is a fairly strong standardisation effect, with the procedure lifting all the early CPUE indices up to the mid-2000s and pushing down the latter part of the series, accentuating the decline (Figure N.3). The series peaked in the late 1990s and has steadily declined since then. There have only been two to four vessels in this analysis since the mid-2000s, indicating that this series is likely to be unreliable, particularly in recent years. Catches have dropped correspondingly with the decline in CPUE (Figure 13 [upper right panel]).

3.4.3 East Northland

Detailed diagnostics for the East Northland standardised positive catch model are presented in Appendix O and the relative CPUE series and contributing catches are plotted in Figure 13 [lower centre panel]. The standardisation effect in this series is similar to that seen in the Lower Waikato series, with the procedure lifting all the early 1990s CPUE indices, and then pushing down the indices in the remainder of the series (Figure O.3). This series starts out with no trend and then turns into a slowly declining series, dropping about 33% from its peak in 1996–97. Catches have matched the CPUE trend except for a broad peak in catches during most of the early 2000s while CPUE remained static (Figure 13 [upper right panel]).

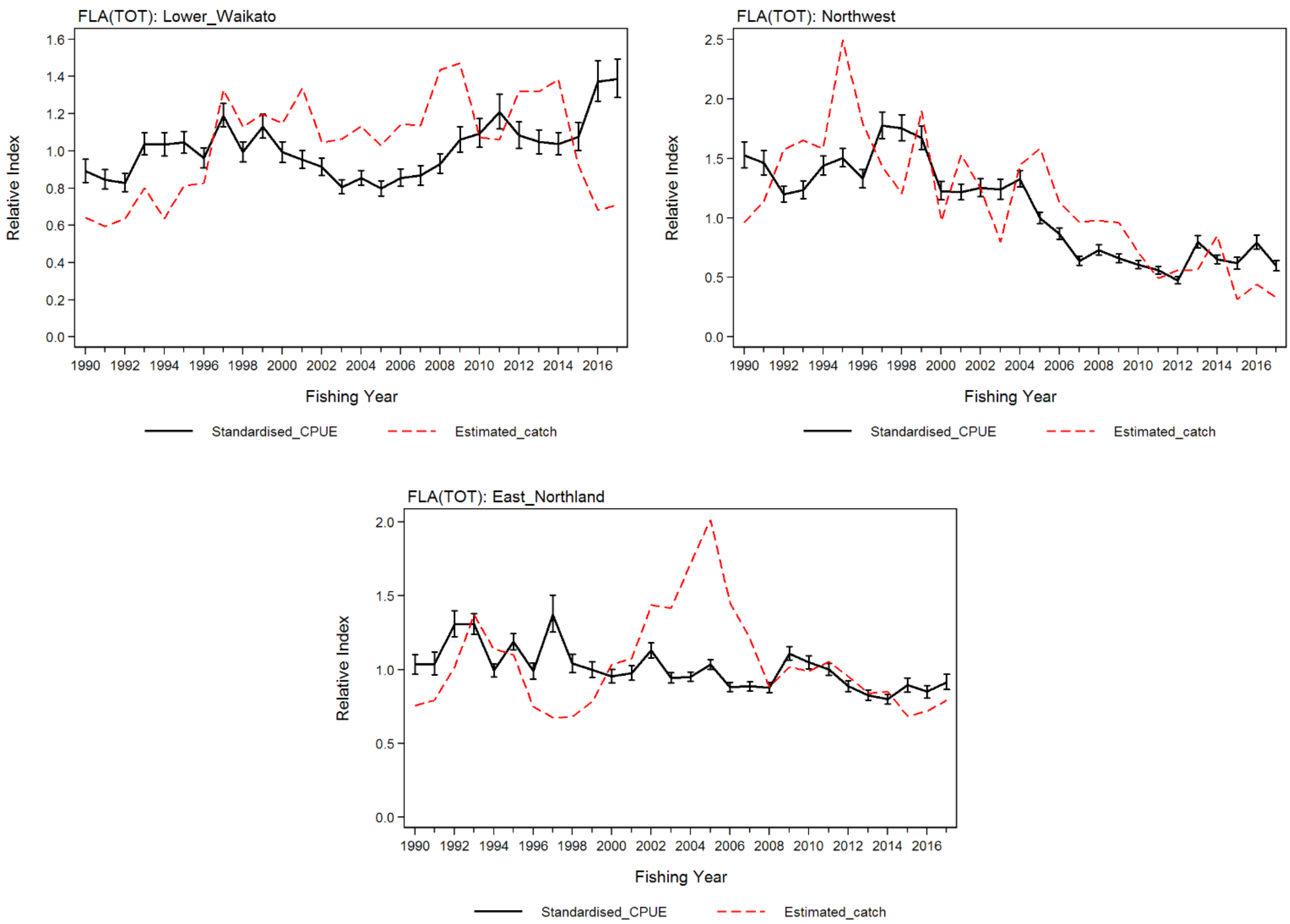

Figure 13: Setnet positive catch CPUE series (showing upper and lower 95% bounds) and relative catch (geometric mean=1.0 for both series) for the three FLA 1 minor fishery strata (see Table 11): [upper left panel] Lower Waikato FLA(TOT); [upper right panel] Northwest FLA(TOT); [lower centre panel]: East Northland FLA(TOT).

3.5 FLA 1 series comparisons

The two series from the west coast North Island harbours strongly resemble each other ([upper left panel]: Figure 14), indicating that the environmental effects which are likely to be influencing these series are operating similarly in both harbours. The two Hauraki Gulf series are also very similar to each other, with a reduced peak in centre of the series for `HG(TOT)-est` series and an increased level at the beginning of the series ([upper right panel]: Figure 14). The similarity in the series is unsurprising, given that the `HG(YBF)-est` series is a subset of the `HG(TOT)-est` series. However, the reduction in the centre of the `HG(TOT)-est` may reflect a drop in the SFL abundance that was hinted at in the discarded `HG(SFL)-est` series during the same time period (Figure P.3). Finally, there is little that can be said about the three minor fishery strata series ([lower centre panel]: Figure 14); the relatively small amount of data and the amalgamation of multiple fishing areas make these series unreliable indicators of relative abundance.

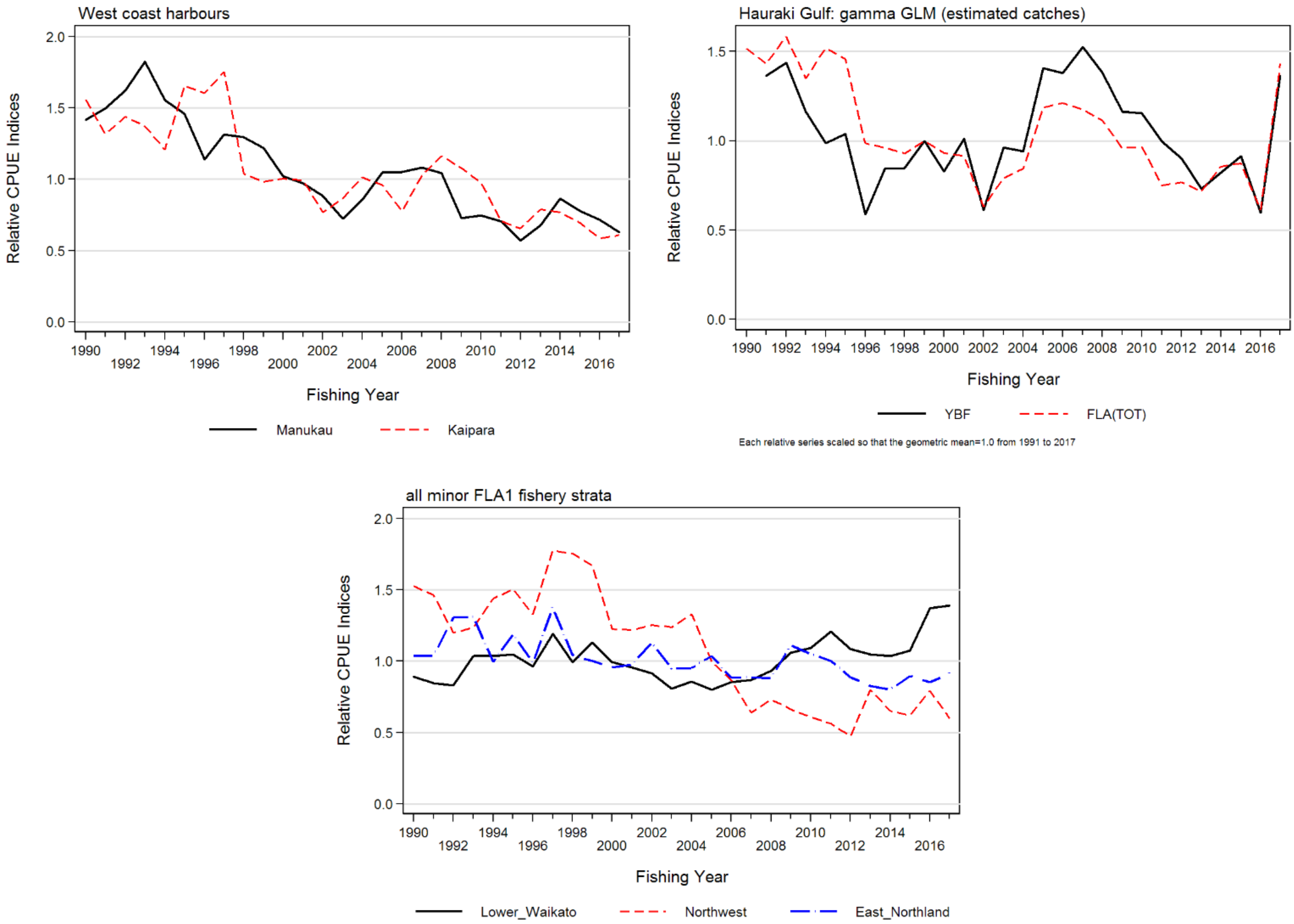

Figure 14: Comparison of related 2018 standardised CPUE models; [upper left panel]: Manukau and Kaipara Harbours; [upper right panel]: Hauraki Gulf: YBF and FLA(TOT); [lower central panel]: three minor FLA 1 fishery strata (Table 18).

4. ACKNOWLEDGEMENTS

This work was funded by MPI Research Project FLA2017-01. We thank the Fisheries New Zealand Information & Data Management team for providing the catch/effort data in a timely manner. Members of the Southern Inshore Working Group provided important input and advice through several iterations of the analyses contained in this report.

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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
analysis data set	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 (Bentley et al. 2012)
CELR	Catch/Effort Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels less than 28 m. Fishing events are reported on a daily basis on this form
CLR	Catch Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels not using the CELR or NCELR forms to report landings
CPUE	Catch Per Unit Effort
daily stratum or daily effort stratum	summarisation within a trip by day of fishing with the modal statistical area of occupancy and modal declared target species assigned to the day of fishing; only trips that used a single capture method are used
destination code	code indicating how each landing was directed after leaving vessel (see Table 4)
EDW	Enterprise Data Warehouse: name for Fisheries New Zealand database designed to bring together a number of disparate fisheries data sets, including legacy paper-based data, the developing electronically collected catch and effort data and various administrative data sets (e.g., vessel registration, permits, etc...). It will replace the existing Warehou data warehouse.
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 flatfish captured, which is then recorded as part of the ‘fishing event’. Only the top five species are required for any fishing event in the CELR and TCEPR data (expanded to eight for the TCER form type)
fishing event	a record of activity in a 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 flatfish
FMA	Fishery Management Areas: 10 legal areas used to define large scale stock management units; with the inshore QMAs consisting of one or more of these regions
landing event	weight of flatfish off-loaded from a vessel at the end of a trip. Every landing has an associated destination code and there can be multiple landing events with the same or different destination codes for a trip
LCER	Lining Catch Effort Return (Ministry of Fisheries 2010): active since October 2003 for lining vessels larger than 28 m and reports set-by-set fishing events
LFR	Licensed Fish Receiver: processors legally allowed to receive commercially caught species
LTCER	Lining Trip Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for lining vessels between 6 and 28 m and reports individual set-by-set fishing events
MHR	Monthly Harvest Return: monthly returns used after 1 October 2001. Replaced QMRs but have same definition and utility
MLS	Minimum Legal Size
MPI	New Zealand Ministry for Primary Industries (now referred to as Fisheries New Zealand)
NCELR	Netting Catch Effort Landing Return (Ministry of Fisheries 2010): active since October 2006 for inshore vessels between 6 and 28 m using setnet gear and reports individual fishing events
QMA	Quota Management Area: legally defined unit area used for flatfish management (Figure 1)
QMR	Quota Management Report: monthly harvest reports submitted by commercial fishers. 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 Fisheries New Zealand data unit
residual implied coefficient plots	plots that mimic interaction effects between the year coefficients and a categorical variable by adding the mean of the categorical variable residuals in each fishing year to the year coefficient, creating a plot of the ‘year effect’ for each value of the categorical variable
rollup	a term describing the average number of records per ‘trip-stratum’ or ‘daily stratum’
RTWG	Recreational Technical Working Group
SINSWG	Southern Inshore Fisheries Assessment Working Group: Fisheries New Zealand Working Group overseeing the work presented in this report

Term/Abbreviation	Definition
standardised CPUE	procedure used to remove the effects of explanatory variables such as vessel, statistical area and month of capture from a data set of catch/effort data for a species; annual abundance is usually modelled as an explanatory variable representing the year of capture and, after removing the effects of the other explanatory variables, the resulting year coefficients represent the relative change in species abundance
statistical area	sub-areas (Appendix B) within an FMA that 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. Fisheries New Zealand 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
Warehou	name for Fisheries New Zealand data warehouse that holds historical paper-based catch and effort data

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

Code	Definition
BLL	Bottom longlining
BPT	Bottom trawl – pair
BS	Beach seine/drag nets
BT	Bottom trawl – single
CP	Cod potting
DL	Drop/dahn lines
DS	Danish seining – single
HL	Handlining
MW	Midwater trawl – single
RLP	Rock lobster potting
SLL	Surface longlining
SN	Setnetting (includes gill nets)
T	Trolling
TL	Trot lines

Code	Description
BAR	Barracouta
BNS	Bluenose
BUT	Butterfish
ELE	Elephant fish
FLA	Flatfish (mixed species)
GMU	Grey mullet
GSH	Ghost shark
GUR	Red gurnard
HOK	Hoki
HPB	Hapuku & Bass
JDO	John Dory
JMA	Jack mackerel
KAH	Kahawai
KIN	Kingfish
LEA	Leatherjacket
LIN	Ling
MOK	Moki
POR	Porae
FLA	Flatfish
SCH	School shark
SCI	Scampi
SKI	Gemfish
SNA	Snapper
SPD	Spiny dogfish
SPE	Sea perch
FLA	Flatfish
SQU	Arrow squid
STA	Giant stargazer
SWA	Silver warehou
TAR	Tarakihi
TRE	Trevally
WAR	Blue warehou

Appendix B. MAP OF FISHERIES NEW ZEALAND STATISTICAL AND MANAGEMENT AREAS

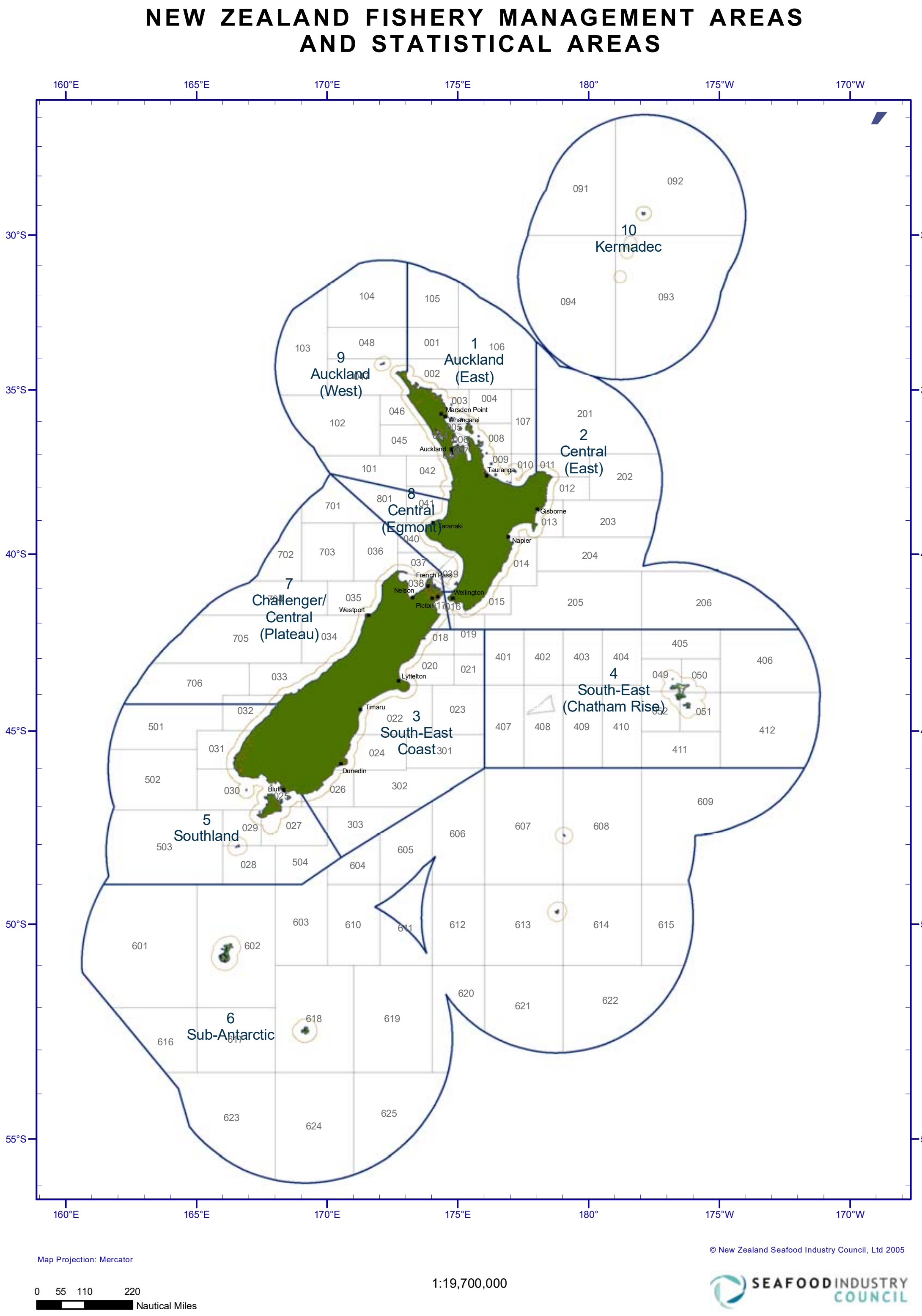

Figure B.1: Map of Fisheries New Zealand General Statistical Areas and Fishery Management Area (FMA) boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries

Appendix C. MAP OF WEST COAST NORTH ISLAND REGULATIONS PROTECTING MAUI'S DOLPHINS

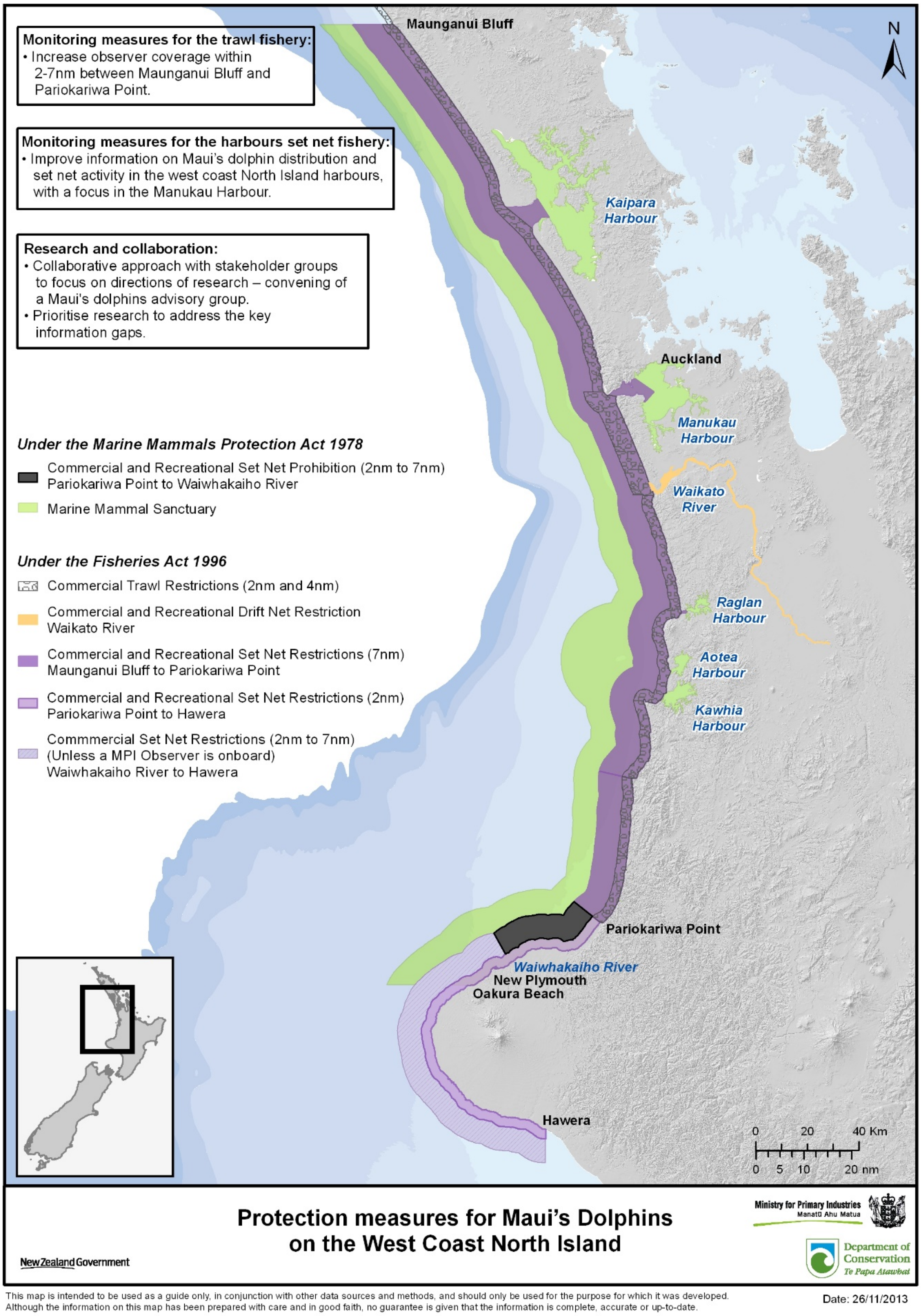

Figure C.1: Map of Fisheries New Zealand regulations for the protection of Maui's dolphins (https://www.mpi.govt.nz/dmsdocument/7674/loggedIn).

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

D.1 Introduction

The method described in this section was used to identify "implausibly large" landings due to data errors (possibly at the data entry step), with landings from single trips occasionally exceeding 300 t for FLA 1. These errors can result in substantial deviations from the accepted QMR/MHR catches and affect the credibility of the characterisation and CPUE analyses.

D.2 Methods

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

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

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

A two-way grid search was implemented, applying this procedure across a range of empirical quantiles (Step 1) and test ratio values (Step 2) (Starr et al. 2018). However, this search method resulted in a very large number of discarded trips in the FLA 1 landing data (462 trips) which was considered excessive and which could potentially lead to bias. Consequently the grid search approach was dropped. Instead an approach that set the threshold ratio ($rat_{t,s}$: Eq. D.2) to a fixed high value (9) and the upper end of the trip landing distribution (99.99% quantiles) was investigated.

D.3 Equations

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

Eq. D.1
$$G^d_{t,s} = \sum_{i=1}^{n_t} gwt_{t,s,i}$$
$$G^c_{t,s} = \sum_{i=1}^{n_t} CF_s * W_{t,i} * B_{t,i}$$
$$G^e_{t,s} = \sum_{j=1}^{m_t} est_{t,s,j}$$

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

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

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

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

$$r1_{t,s} = G^d_{t,s} \Big/ G^c_{t,s}$$

Eq. D.2
$$r2_{t,s} = G^d_{t,s} \Big/ G^e_{t,s}$$
$$rat_{t,s} = \min(r1_{t,s}, r2_{t,s})$$

where $G^d_{t,s}$, $G^c_{t,s}$ and $G^e_{t,s}$ are defined in Eq. D.1, and ignoring $r1_{t,s}$ or $r2_{t,s}$ if missing when calculating $rat_{t,s}$.

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

Eq. D.3
$$gg^z_y = \sum_{1}^{p^z_y} L^z_y$$
$$Ssq^z = \sum_{y=89/90}^{y=14/15} \left(gg^z_y - MHR_y \right)^2$$

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

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

MHR_y is the corresponding MHR/QMR landing total for FLA 1 in year y.

D.4 Results

An initial comparison of the landings totals for FLA 1 with the equivalent QMR/MHR totals indicated that every year from 1990–91 to 2007–08 had more than 20 t greater than the QMR/MHR landings for the same year, with five years having more than 100 t of overage and three years with more than 300 t of overage (Figure D.1). Overall, there was nearly 2 000 t of overage relative to the total landings of 20 156 t between 1989–90 to 2016–17. This level of over-reporting required investigation before proceeding with the characterisation and CPUE analyses.

The landing data were examined for the presence of non-standard flatfish codes when reporting landings. Over 1100 t of non-standard landings were found in the data set, even though none of these codes have any legal standing, with all flatfish landings required to use the generic code "FLA" (Table D.1). When annual landings that had been totalled with and without these additional Fishstocks were compared with the equivalent QMR/MHR totals, it was clear that the presence of these additional flatfish landings were not the source of the overages observed in the 1990s. Furthermore, these additional landings allowed the landings to match the reported MHR totals after 2010–11 (Figure D.1). Consequently these additional flatfish landings were added to the landings data set.

The landing data were then examined for potentially incorrect landing information. Twenty-five trips were identified where $rat_{t,s}$, defined in Eq. D.2, was greater than 9.0 in the set of trips whose total landings were in the top 99.99% quantile of total greenweight (Table D.2). These 25 trips represented a total of just over 1300 t of greenweight landings (Table D.3) which could be justifiably dropped from the landing data set. Three of these trips accounted for over 800 t of landings, with two landing over 300 t in 1996–97 and 1997–98 respectively. The annual total landings resulting from discarding these trips are plotted in Figure D.1 and tabulated in Table D.4. Although there remain overages in the 1990s and early 2000s, it would require removing several hundred trips to match the QMR/MHR totals, which was considered to be excessive and was therefore not done.

Table D.1: Total landings (t) for non-standard flatfish codes found in the FLA 1 landing data, summed over the period 1989–90 to 2016–17.

	Fishstock code									
Species	0	1	2	3	4	5	7	8	9	Total
BFL		1.5	0.0				0.1			1.6
BRI		28.9	0.7	0.2		0.0	1.9	0.2	0.2	32.2
ESO		116.3	1.3	4.7			0.2	0.0	0.1	122.6
FLO		1.1	1.1						0.0	2.2
GFL		47.3		0.1			0.0	0.0		47.4
LSO		12.8	0.4	2.2			0.1	0.0	0.0	15.4
MAN		0.3								0.3
SFI		5.8	1.8	0.1	0.5		0.1		0.6	9.0
SFL		357.8	1.6	0.6		0.0	0.6	0.0	0.7	361.4
SOL		3.9	3.5					0.0	0.0	7.4
TUR		11.0	0.2	0.2			0.2	0.0		11.5
WIT		4.7	0.6	0.6	0.0	0.0	0.4	0.0	0.5	6.8
YBF	0.0	541.7	0.1				1.5	0.2	1.1	544.7
Total	0.0	1 133.1	11.4	8.6	0.5	0.0	5.1	0.6	3.1	1 162.5

Table D.2: Information associated with each trip that was discarded from this FLA 1 analysis on the basis of having "out-of-range" landing information. Equation references are to Eq. D.1.

Fishing year	Trip number	Total trip landing $\left(G_{t,s}^{d}\right)$	Calculated trip landing $\left(G_{t,s}^{c}\right)$	Sum of estimated catch $\left(G_{t,s}^{e}\right)$	Number landing records	Ratio 1	Ratio 2	Minimum ratio
91/92	295384	21.3	1.07	0.18	1	20	118	20
90/91	210783	23.8	0.37	0.33	1	64	72	64
90/91	26747	29.3	0.29	0.27	1	100	108	100
90/91	211789	17.5	0.16	0.16	1	107	110	107
92/93	710600	20.8	0.19	0.13	1	108	160	108
98/99	3033029	15.0	0.04	0.01	1	430	1074	430
93/94	745014	14.8	0.03	0.03	1	528	493	493
93/94	745012	14.8	0.03	0.03	1	548	493	493
96/97	1898017	50.2	0.10	0.05	1	496	1090	496
93/94	745019	14.8	0.03	0.02	1	528	740	528
93/94	745013	14.8	0.03	0.03	1	528	592	528
92/93	744997	14.8	0.03	0.02	1	592	740	592
93/94	745020	14.8	0.02	0.02	1	822	740	740
98/99	2966668	19.2	0.02	0.02	1	969	1066	969
96/97	2063309	26.1	0.03	0.02	1	990	1089	990
96/97	1897984	24.1	0.02	0.02	1	997	1096	997
93/94	745657	15.7	0.01	0.01	1	1045	1045	1045
93/94	745000	14.8	0.01	0.01	1	1056	1479	1056
91/92	397535	14.8	0.01	0.01	1	1479	1232	1232
93/94	745008	14.8	0.01	0.01	1	1643	1479	1479
96/97	2096065	343.1	0.10	0.11	1	3466	3268	3268
97/98	2091715	344.4	0.04	0.06	1	8461	5554	5554
96/97	1224225	55.9	0.00	0.01	2.		5585	5585
90/91	2073786	15.7	0.00	0.00	1	7836	7836	7836
93/94	745001	147.9	0.01	0.01	1	16433	18487	16433
Total		1303.0	2.7	1.6				

Table D.3: Statistics associated with the selected minimum in each QMA. MHR_y = QMR/MHR landings in year *y*; $gg_y^0 =$ unedited landings in year *y*; $gg_y =$ edited landings at selected minimum in year *y*; $rat_{t,s}$ as defined in Eq. D.2.

Fishstock	Quantile	$rat_{t,s}$	Number trips dropped	Total trips in data set	Sum landings dropped (t)	$\sum_{y=89/90}^{y=16/17} MHR_y$	$\sum_{y=89/90}^{y=16/17} gg_y^0$	$\sum_{y=89/90}^{y=16/17} gg_y$	$\sum_{y=89/90}^{y=16/17} gg_y - \sum_{y=89/90}^{y=16/17} MHR_y$
FLA 1	99.99	9	25	254 382	1 303	20 156	22 139	20 836	679

Table D.4: Annual statistics for the raw and groomed (after removing 25 trips with out-of-range landings) landings data in FLA 1. MHR_y = QMR/MHR landings in year *y*; $gg_y^0 =$ unedited landings in year *y*; $gg_y =$ edited landings at selected minimum in year *y*. The final two columns are the annual result of applying Eq. D.3 to the unedited landings and to the selected QMA "minimum" defined in Table D.3.

	FLA 1				
Fishing year	MHR_y	gg_y^0	gg_y	$Ssq^{unedited}$	Ssq^{edited}
89/90	791	627	627	26 831	26 831
90/91	850	966	880	13 503	898
91/92	937	1 003	967	4 320	878
92/93	1 111	1 152	1 117	1 694	31
93/94	1 136	1 445	1 178	95 377	1 742
94/95	965	1 036	1 036	5 089	5 089
95/96	629	732	732	10 700	10 700
96/97	733	1 268	769	286 261	1 270
97/98	722	1 120	776	158 292	2 862
98/99	703	790	756	7 655	2 838
99/00	752	844	844	8 494	8 494
00/01	793	847	847	2 924	2 924
01/02	596	625	625	852	852
02/03	686	718	718	1 028	1 028
03/04	784	804	804	414	414
04/05	1 038	1 087	1 087	2 377	2 377
05/06	964	993	993	802	802
06/07	922	956	956	1 179	1 179
07/08	705	732	732	746	746
08/09	640	645	645	26	26
09/10	652	656	656	12	12
10/11	487	506	506	372	372
11/12	445	448	448	6	6
12/13	480	481	481	1	1
13/14	511	520	520	73	73
14/15	427	424	424	11	11
15/16	277	284	284	44	44
16/17	421	430	430	88	88
Total	20 156	22 139	20 836	629 170	72 588

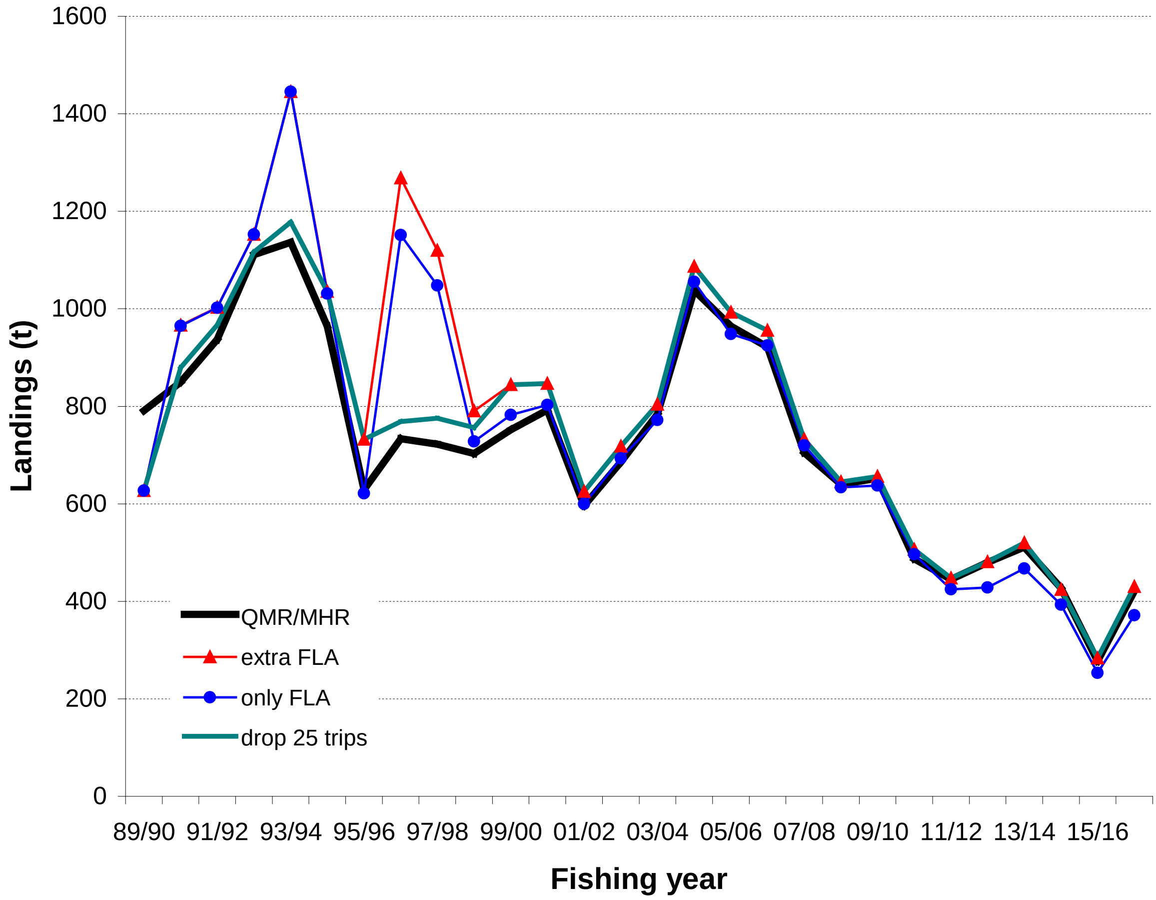

Figure D.1: Comparison of QMR/MHR annual total landings for FLA 1 with three extracts: A: 'extra FLA': unedited landings where all flatfish landings including those coded with non-FLA codes were converted to FLA; B: 'only FLA', where only landings coded as 'FLA' are included (same as series A from 1989–90 to 1994–95); C: 'drop 25 trips': same as 'extra FLA' (series A) totals except that 25 trips identified using the procedure summarised in Table D.3 have been dropped from the landings.

Appendix E. INVESTIGATING THE "FALSE ZEROS" PROBLEM

E.1 Introduction

McKenzie & Vaughan (2008) noted an apparent problem in the grey mullet data collected in the west coast North Island harbour setnet fisheries, fisheries that have considerable overlap with the FLA 1 fisheries described in this report. In these records, there were no estimated catches for GMU (code for grey mullet) recorded in the columns for the top five species caught even though GMU was indicated to be the target species and there were GMU landings for the trip. They termed trips with no GMU in the landing data and zero estimated catch to be "plausible zeros", even if GMU was indicated to be the target species. For the "false zero" records (i.e., GMU was the target, GMU was landed but no estimated catch in the top five species), they appropriated the field [`total_catch_weight`], which records the estimated weight of the entire catch from the fishing event across all species and used it as their estimate of the GMU estimated catch.

Kendrick & Bentley (2011, 2012a) made the same correction for FLA 1, although they were not able to distinguish between "plausible" and "false" zeros through the use of the landing data, given the high incidence of intermediate Destination codes which break the link between the effort and landing sections of the CELR form (see Section 2.3.2.1). Kendrick & Bentley(2011) defined "false zeros" and made the following correction (where "total catch" is the [`total_catch_weight`] field used by McKenzie & Vaughan (2008)):

> "*The estimated catch of FLA was corrected to equal the total catch where, the method was setnet, the target species was among the suite of flatfish species codes, and the estimated catches for all flatfish species were zero, but the total catch was not zero.*"

E.2 Implementation of the Kendrick & Bentley (2011) algorithm

The following algorithm was applied to the setnet data prepared for the CPUE standardisation (Section 2.3.1.3):

```
if:
- target species: any flatfish species
- gear=SN
- estimated catch of all FLA species=0|=NULL
- [total_catch_weight]~=0|~=NULL
then:
- estimated[FLA]=[total_catch_weight]
```

Nearly 3 000 records were identified through applying the above algorithm, adding about 200 t of estimated catch to the data set (Table E.1). There were 15 800 t of estimated FLA catches (all species combined) in this data set (SN only) before running this algorithm, so the addition appears to be minor. Kendrick & Bentley (2011, 2012a) do not provide the actual quantum of their correction, but plots show that the effect, while visually detectable, is minimal in their analyses.

The Fisheries New Zealand data extract (replog 11700) contained, for every fishing event, the complete set of estimated catches reported on the form, regardless of the species. Consequently, it was possible to compare the value in the [`total_catch_weight`] field with the sum of the estimated catches provided by the fisher in appropriate fields. This was done for the 2 834 records (Table E.1) identified by the above algorithm. This analysis indicated that nearly 100 t of the "false zero" records had sufficient information in the estimated catch fields to match the catch entered in the [`total_catch_weight`] field when all species (including those that are not FLA) were included (Table E.2). It would be inappropriate to assign this catch to FLA. The [`total_catch_weight`] field exceeds the sum of the estimated catches in most of the remaining records (Table E.2). These records would be candidates to be included in the "false zeros" category, but at most this would add 65 t of FLA catch to the data set (Table E.2). This total represents less than 0.5% of the 15 800 t estimated FLA catch in the data set, and there is no guarantee that species catch not reported (only the top five species are reported) could make up some of the difference. It was decided to abandon this adjustment because of the problematic status of the additional catch and the small amount of catch involved.

Table E.1: “False zero” statistics resulting from applying the algorithm described in Section E.2.

Fishing year	Stat_area 001	Manukau Harbour	Kaipara Harbour	Lower Waikato	Northwest	East Northland	Hauraki Gulf	Bay of Plenty	Total
	Total estimated catch in “false zero” records (t)								
89/90	0.6	0	0.2	0	0.1	2	1.4	0.5	4.8
90/91	0.2	0.1	0.8	0	0.1	1	4.4	0.8	7.3
91/92	0	0.1	0.4	–	0.4	0.5	7.5	2.6	11.5
92/93	0.6	0.7	0.7	–	0.1	0.1	28.2	0.9	31.4
93/94	–	1	0	–	0	0.3	3.7	1	6
94/95	–	0	0.2	0.4	–	0.1	2	0	2.7
95/96	–	1	4.7	0.1	0.7	4.7	2.8	0.8	14.7
96/97	–	0.5	8	0	1.8	5.6	1	0.3	17.1
97/98	–	0.3	12.1	0	3	0.9	0.2	0.1	16.6
98/99	–	0.4	7.8	0.3	0.9	2.7	0.5	0.6	13.3
99/00	–	0.5	5.8	0.2	1.4	1.5	0.5	1.3	11.2
00/01	0.1	0.1	0.8	0.5	0.5	0	1.4	0.2	3.7
01/02	–	0.1	0.9	–	0	0.3	0.8	0.2	2.3
02/03	–	–	1.7	1	–	0.1	1.6	1	5.4
03/04	–	0	1.2	1.3	–	0.1	0.4	0.4	3.3
04/05	–	0	0.8	0.5	–	0.1	0.1	0	1.5
05/06	–	0.1	0.1	2.4	–	0.3	0.1	0.2	3.2
06/07	–	–	0.4	1.4	0	0.1	0.2	–	2.2
07/08	–	0.1	0.2	3.5	0.1	0.1	0.8	0.3	5.1
08/09	–	0	0.2	5.6	0.1	0	0.5	0.1	6.5
09/10	–	0.1	0.7	3	–	0	0.9	0.1	4.8
10/11	0	0.1	0.6	1	–	0.1	0.5	0.1	2.4
11/12	–	0	0.1	2	0.1	0.2	0.2	0.1	2.6
12/13	–	0	0.2	1.3	–	0.1	0.3	0.1	2.1
13/14	–	0.1	0.1	1.7	–	0	0.1	0.5	2.6
14/15	–	0.1	0.1	1.3	0.1	0.1	0.1	0.8	2.5
15/16	–	0	0.2	0.6	0	0.2	0.3	7.5	8.9
16/17	–	0	0.1	0	–	0	0.1	0	0.3
Total	1.5	5.5	48.9	28.1	9.3	21.3	60.6	20.7	195.9
	Number of “false zero” records								
89/90	7	2	6	6	1	17	8	6	53
90/91	5	3	9	2	1	5	18	13	56
91/92	1	2	9	–	3	3	14	12	44
92/93	4	5	7	–	3	9	65	4	97
93/94	–	4	2	–	1	10	18	4	39
94/95	–	1	4	3	–	8	17	2	35
95/96	–	18	61	1	7	66	8	35	196
96/97	–	7	161	2	27	85	10	17	309
97/98	–	9	234	4	36	34	6	4	327
98/99	–	8	202	7	21	80	7	26	351
99/00	–	9	140	10	31	23	17	27	257
00/01	3	5	21	10	13	3	17	9	81
01/02	–	2	22	–	2	12	34	4	76
02/03	–	–	41	12	–	4	26	13	96
03/04	–	2	25	21	–	1	6	3	58
04/05	–	1	15	15	–	5	4	2	42
05/06	–	2	4	32	–	6	3	6	53
06/07	–	–	7	19	2	3	5	–	36
07/08	–	2	4	46	3	2	12	5	74
08/09	–	1	8	64	2	1	9	3	88
09/10	–	1	12	34	–	1	15	2	65
10/11	1	3	10	13	–	5	13	2	47
11/12	–	1	4	32	2	6	12	2	59
12/13	–	1	3	29	–	4	8	1	46
13/14	–	2	4	37	–	4	5	11	63
14/15	–	2	4	29	4	2	8	7	56
15/16	–	1	8	8	1	10	8	81	117
16/17	–	2	5	1	–	2	2	1	13
Total	21	96	1,032	437	160	411	375	302	2 834

Table E.2: Summary statistics for “false zero” records identified in Table E.1. Bold value indicates the maximum amount of “false zero” catch that could be added.

	N[records]	Sum[total catch weight] (t)	Sum[estimated catch] (t)	Sum([total catch weight]-Sum(estimated catch))(t)
[total catch weight]<Sum(estimated catch)	275	7.1	15.4	-8.3
[total catch weight]=Sum(estimated catch)	998	99.0	99.0	0
[total catch weight]>Sum(estimated catch)	1 561	89.8	24.8	**65.1**
Total	2 834	195.9	139.1	56.8

Appendix F. ALGORITHM USED TO CORRECT ESTIMATED CATCHES IN FLA 1

F.1 Introduction

Estimated catches in the setnet (SN) CPUE data set were adjusted to landed catches using the following algorithm described in Paragraph F.2. This algorithm was originally proposed by Kendrick & Bentley (2012b) and has been implemented for rock lobster CPUE analyses (Starr 2018).

F.2 Algorithm

Step 1: Calculate vessel correction factors (*vcf*) $\left(v_{iy}\right)$ for each vessel and fishing year:

Eq. F.1
$$v_{iy} = \frac{\sum_{g=1}^{n_{iy}^{l}} L_{giy}}{\sum_{h=1}^{n_{iy}^{c}} C_{hiy}}$$

where L_{giy} = landed weight in record *g* for vessel *i* in year *y*; there are n_{iy}^{l} such records;
C_{hiy} = estimated catch weight in record *h* for vessel *i* in year *y*; there are n_{iy}^{c} such records.

Step 2: Truncate *vcf* by setting lower lb and upper ub bounds for the FLA 1 fleet:

Eq. F.2
$$\text{replace} \quad \begin{array}{l} v_{iy} = \text{NULL if } v_{iy} < lb \\ v_{iy} = \text{NULL if } v_{iy} > ub \end{array};$$

Note 1: data for vessels outside these bounds are dropped: $\left(lb = 0.97; ub = 1.95\right)$ (these bounds represent lower 10% and upper 90% percentiles of the empirical *vcf* $\left(v_{iy}\right)$ distribution).

Step 3: Apply the *vcf* to every estimated catch record *h* for vessel *i* in fishing year *y*:

Eq. F.3
$$\hat{L}_{hiy} = v_{iy} C_{hiy}$$

where $\hat{L}_{hiy}$ = estimated landed weight for record *h* associated with estimated catch weight C_{hiy}.

F.3 Summary statistics for SN *vcf*

Of the 10 171 annual *vcf* records (Eq. 1), 3 934 had no match in either the landing or the effort data sets (Table F.1), resulting in *vcf* estimates of NULL. A further 275 records were matched but had no associated estimated catch. Consequently, there was a total of 4 209 NULL *vcf* records (41%). However, Table F.1 shows that the catches or landings associated with these NULL *vcf* records were relatively minor, with the lack of estimated catches to match with the realised landings likely to be the result of the five species rule, where operators are only required to report estimated catches for the top five species taken in a day.

There are many outliers in the empirical vcf distribution (see Figure F.1), but the majority of the distributions appear to be below *vcf*=1.5, with very few values below *vcf*=1.0, indicating that fishers more often than not tend to underestimate the catch on the forms. Figure F.1 indicates that there appears to be little in the way of annual trend in the *vcf* distributions as well as similar *vcf* distributions across the three major regions used for CPUE.

Table F.1: Summary statistics for the *vcf* variable in the FLA 1 SN CPUE data set.

	Number of records		Sum of catch (t)	
Data category	**Estimated catch**	**Landed catch**	**Estimated catch**	**Landed catch**
In effort data but not in landing data	1 689	0	29.4	0.0
In landing data but not in effort data	0	2 406	0.0	1 675.0
In both data sets (vcf=NULL)	241	241	0.0	107.1
In both data sets (vcf<>NULL)	6 010	6 010	15 792.3	19 334.9
Total	7 940	8 657	15 821.7	21 117.0

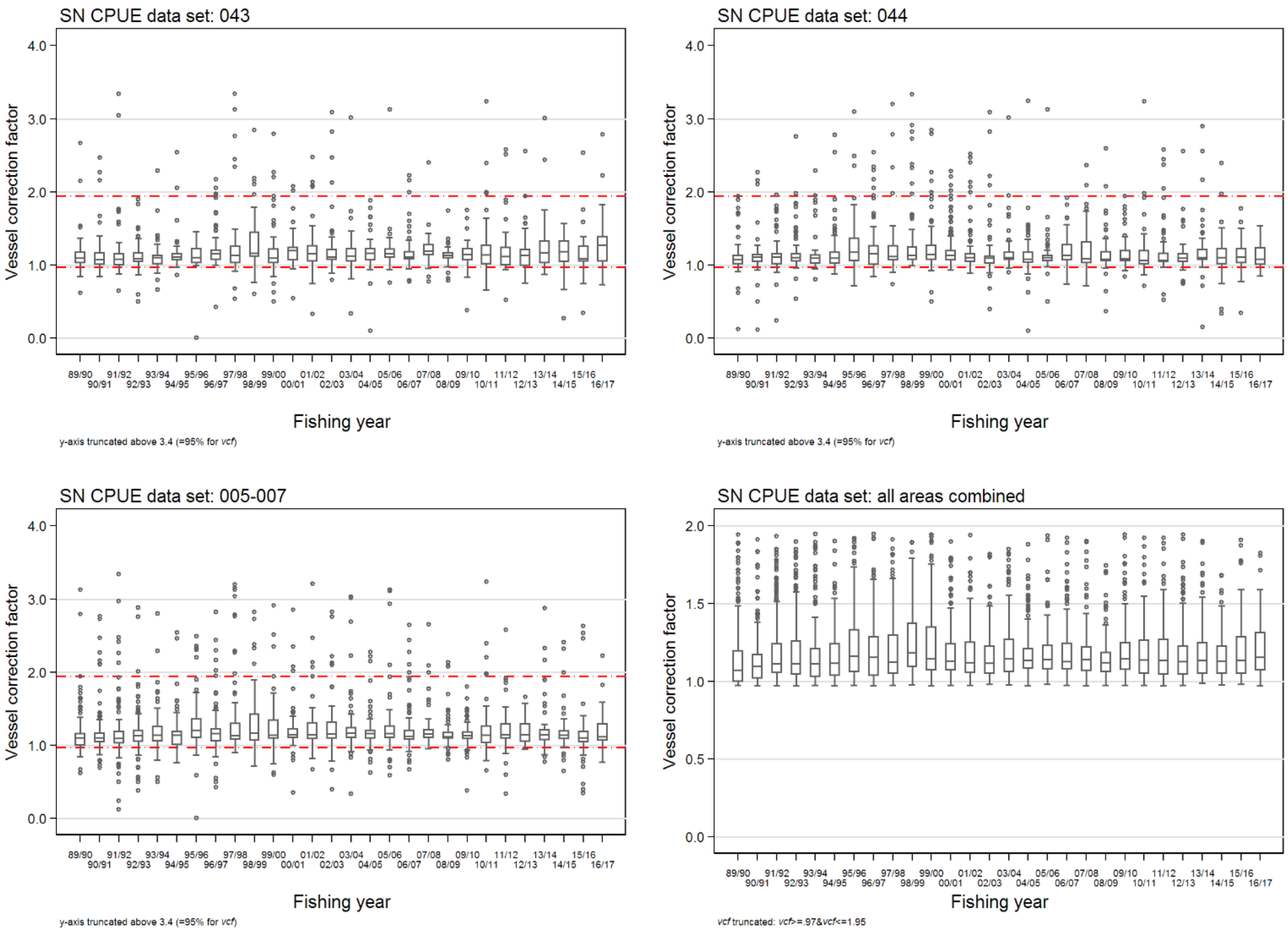

Figure F.1: Sub-plots [upper left], [upper right], [lower left]: total annual *vcf* distributions (with the final 5% suppressed for clarity) for each of the three major FLA 1 SN CPUE regions. Horizontal dashed red lines mark the 10% (0.97) and 90% (1.97) of the empirical *vcf* distribution for the full SN CPUE data set. The plot in the lower right corner ([lower right]) shows the extent of the annual *vcf* truncated distribution across all trips within the SN CPUE data set.

Appendix G. DATA SUMMARIES BY FLA 1 FISHERY STRATA

Table G.1A: Distribution in tonnes of scaled (Eq. 1) estimated flatfish catches by fishing year and capture method for the first four of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which captured flatfish. These values are plotted in Figure 5 and Figure 6.

Fishing	Capture method (t)						Capture method (t)						Capture method (t)						Capture method (t)					
year	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total
	Area 001						Manukau Harbour						Kaipara Harbour						Lower Waikato					
89/90	14.26	0.07	0.00	–	0.00	14.33	95.3	–	0.00	0.12	2.14	97.6	272.3	–	–	0.00	0.00	272.3	18.0	–	4.02	–	0.03	22.1
90/91	31.99	0.11	0.00	–	0.00	32.10	92.7	–	–	1.69	0.08	94.5	193.8	–	–	0.19	0.03	194.0	14.2	–	1.56	–	0.02	15.8
91/92	12.01	0.00	0.01	0.00	0.01	12.03	97.3	–	–	2.21	0.00	99.5	205.1	–	0.00	0.00	0.03	205.1	16.0	–	0.79	0.00	0.00	16.8
92/93	8.85	0.51	0.01	–	0.01	9.39	133.8	–	0.00	2.37	0.07	136.2	207.1	0.02	0.00	0.01	0.07	207.2	19.9	–	1.88	0.05	0.00	21.8
93/94	8.60	0.75	0.01	–	0.00	9.37	142.2	–	0.00	2.71	0.04	145.0	168.1	–	–	0.02	0.21	168.3	15.4	–	1.42	0.00	0.00	16.8
94/95	1.63	0.00	0.07	–	0.01	1.71	127.1	–	0.00	0.12	0.05	127.2	217.2	–	–	0.00	0.00	217.2	19.6	–	1.53	0.00	0.01	21.1
95/96	4.42	0.59	0.03	–	–	5.04	91.0	–	0.00	0.58	0.00	91.6	186.4	–	0.00	0.03	0.05	186.5	22.6	0.00	2.20	0.00	0.00	24.8
96/97	1.79	0.14	0.00	–	–	1.93	107.7	–	–	0.36	0.06	108.1	226.0	–	–	0.01	0.01	226.0	40.0	0.03	3.66	0.00	0.00	43.7
97/98	3.34	0.02	0.06	0.01	–	3.42	142.7	–	0.00	0.23	0.05	142.9	216.5	–	0.00	0.01	0.00	216.5	35.5	–	2.14	0.31	0.00	38.0
98/99	0.31	–	–	0.00	–	0.31	121.2	–	–	2.87	0.05	124.1	204.3	–	–	0.05	0.05	204.4	36.0	–	1.34	0.04	0.01	37.4
99/00	6.75	–	0.00	0.00	–	6.75	133.8	–	0.00	2.90	0.07	136.8	290.1	–	–	0.13	0.05	290.3	31.3	–	0.56	0.02	0.00	31.9
00/01	0.37	–	–	–	0.00	0.37	130.0	–	–	5.78	0.00	135.8	310.8	–	0.00	0.07	0.00	310.8	32.9	–	2.50	0.00	0.03	35.4
01/02	4.04	–	–	–	–	4.04	97.7	–	–	1.77	0.00	99.4	237.3	–	0.00	0.08	0.03	237.4	27.9	0.01	0.55	0.00	0.00	28.5
02/03	4.72	–	–	–	0.00	4.72	69.5	–	0.00	1.33	0.00	70.9	217.3	–	–	0.06	–	217.3	28.4	–	0.97	0.00	0.00	29.4
03/04	4.48	–	–	–	0.00	4.48	85.3	–	–	2.62	0.00	87.9	246.0	0.05	–	0.21	0.00	246.3	30.0	–	1.36	0.00	0.04	31.4
04/05	1.93	–	–	–	–	1.93	95.9	–	0.00	4.32	–	100.2	205.3	–	0.00	0.08	0.10	205.5	26.4	0.00	2.28	0.00	0.15	28.8
05/06	0.56	–	0.07	–	0.00	0.64	87.5	–	–	2.90	0.00	90.4	152.4	–	0.00	0.02	0.00	152.4	27.8	–	4.48	0.00	0.00	32.3
06/07	0.51	–	–	–	–	0.51	100.5	–	–	2.88	0.00	103.3	153.1	–	–	0.11	0.01	153.3	26.8	0.80	4.84	0.00	0.00	32.5
07/08	0.84	–	–	–	0.00	0.84	83.5	–	0.00	3.04	0.00	86.5	182.4	–	–	0.06	0.00	182.4	30.2	1.05	9.55	0.00	0.06	40.9
08/09	0.72	–	–	–	–	0.72	36.2	–	0.02	2.23	0.00	38.4	195.5	–	0.00	0.14	0.00	195.6	28.1	0.46	12.52	0.00	0.00	41.1
09/10	0.52	–	–	–	–	0.52	30.5	–	–	0.96	0.00	31.5	173.6	–	–	0.05	0.00	173.7	20.2	0.01	9.34	0.00	0.03	29.6
10/11	0.37	–	–	–	0.00	0.37	40.5	–	–	1.34	–	41.8	132.5	–	–	0.02	0.00	132.5	20.1	0.11	9.25	0.00	0.00	29.4
11/12	0.07	0.01	–	–	–	0.08	28.2	–	0.00	0.95	0.00	29.1	102.2	–	0.00	0.05	0.01	102.3	25.4	0.35	9.01	0.00	1.78	36.6
12/13	2.13	0.00	–	–	0.00	2.13	36.1	–	0.01	1.14	0.00	37.3	142.5	–	0.00	0.02	0.00	142.5	27.7	0.07	9.37	0.00	0.00	37.2
13/14	2.23	–	–	–	–	2.23	52.6	–	–	2.51	0.00	55.1	129.6	–	–	0.06	0.00	129.7	28.9	0.64	8.64	0.00	0.00	38.2
14/15	1.31	–	0.00	–	–	1.31	37.2	–	–	0.58	0.00	37.8	112.2	–	–	0.03	0.02	112.3	18.3	0.08	7.90	0.00	–	26.3
15/16	0.06	–	–	–	–	0.06	24.3	–	–	0.03	0.00	24.3	85.5	–	–	0.04	0.00	85.6	17.9	–	1.56	0.00	0.00	19.4
16/17	–	–	–	–	–	–	21.5	–	0.00	0.22	0.00	21.7	65.2	–	–	0.02	0.00	65.2	17.7	0.00	1.90	0.01	0.00	19.6
Total	118.8	2.21	0.25	0.01	0.04	121.3	2 341.5	–	0.04	50.77	2.63	2394.9	5 230.4	0.07	0.00	1.59	0.68	5 232.7	703.2	3.6	117.1	0.4	2.2	826.5
last 5 years	5.73	0.00	0.00	0.00	0.00	5.73	171.7	0.00	0.01	4.49	0.00	176.2	535.1	0.00	0.00	0.18	0.02	535.3	110.4	0.79	29.37	0.01	0.00	140.6

Table G.1B: Distribution in tonnes of scaled (Eq. 1) estimated flatfish catches by fishing year and capture method for the final four of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which landed flatfish. These values are plotted in Figure 5 and Figure 6.

Fishing	Capture method (t)						Capture method (t)						Capture method (t)						Capture method (t)					
year	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total	SN	DS	BT	RN	Other	Total
	Northwest						East Northland						Hauraki Gulf						Bay of Plenty					
89/90	31.6	–	0.00	0.09	0.11	31.8	38.2	0.01	0.01	0.00	0.25	38.5	275.0	3.3	0.07	0.12	0.10	278.6	33.0	0.43	2.6	–	0.00	36.0
90/91	28.6	–	0.00	0.25	0.07	29.0	30.7	0.20	0.10	0.10	0.03	31.1	394.9	8.4	0.11	0.09	0.07	403.6	44.2	1.0	4.4	0.02	0.01	49.6
91/92	39.9	–	0.00	0.04	0.10	40.0	39.1	0.03	0.64	0.00	0.03	39.8	438.0	41.0	1.07	0.01	0.12	480.2	32.4	8.0	3.2	–	0.10	43.7
92/93	37.2	1.94	3.47	0.41	0.05	43.1	53.6	0.05	1.52	–	0.01	55.1	474.9	92.3	2.78	0.05	0.99	571.0	49.3	12.2	4.6	0.00	1.11	67.2
93/94	35.2	0.92	3.87	0.00	0.04	40.0	44.0	0.05	0.28	0.01	0.04	44.4	484.8	157.9	3.85	0.00	0.77	647.3	36.9	19.0	8.9	0.00	0.55	65.3
94/95	59.9	–	2.32	–	0.09	62.3	42.0	0.22	0.13	0.01	0.04	42.4	348.2	86.7	1.56	0.02	0.11	436.6	38.0	12.9	4.9	0.00	0.05	55.9
95/96	48.3	1.48	1.76	–	0.09	51.6	32.9	0.00	0.29	0.00	0.03	33.3	148.1	6.7	0.09	0.00	0.00	154.9	51.3	10.4	19.5	0.00	0.02	81.2
96/97	43.7	0.10	1.34	–	0.14	45.3	32.9	0.00	0.01	0.00	0.00	32.9	182.3	3.7	0.64	0.15	0.09	186.8	59.9	17.4	11.2	–	0.11	88.6
97/98	36.2	0.00	2.63	–	0.01	38.8	33.7	0.06	0.17	–	0.00	33.9	172.2	1.2	0.51	0.05	0.04	174.0	55.0	18.4	1.2	0.02	0.03	74.7
98/99	54.3	–	2.42	0.00	0.18	56.9	36.1	0.00	0.05	–	0.00	36.1	184.8	0.40	0.33	0.01	0.02	185.6	55.6	1.4	1.0	–	0.00	58.1
99/00	25.1	0.06	0.81	0.05	0.04	26.0	42.6	0.04	0.04	–	0.01	42.7	184.9	0.37	0.70	0.06	0.00	186.0	28.1	0.64	2.1	–	0.52	31.4
00/01	37.6	0.09	1.16	0.01	0.01	38.9	41.8	0.03	0.21	–	0.00	42.0	213.8	0.53	0.00	0.00	0.72	215.0	13.9	0.01	0.31	–	0.00	14.2
01/02	31.3	0.17	1.14	–	0.00	32.6	56.7	0.03	1.15	–	0.00	57.9	122.3	1.4	0.04	0.00	0.01	123.8	11.7	0.35	0.26	0.00	0.02	12.3
02/03	18.6	0.29	2.17	0.01	0.01	21.1	57.5	0.03	0.23	0.00	0.01	57.8	259.6	2.1	0.09	0.10	0.05	262.0	20.7	1.0	1.2	0.00	0.02	22.9
03/04	35.6	0.26	2.71	0.00	0.00	38.6	70.2	0.02	0.34	–	0.00	70.5	272.6	3.4	0.20	0.01	0.02	276.3	18.4	7.0	3.0	–	0.00	28.3
04/05	37.9	0.79	3.29	–	0.57	42.5	82.0	0.16	1.15	0.00	0.02	83.4	497.1	2.3	1.63	0.01	2.5	503.6	49.5	8.6	13.4	–	0.44	71.9
05/06	25.8	1.65	3.03	–	0.05	30.6	59.2	0.62	0.78	–	0.08	60.7	470.6	7.3	0.82	0.00	5.7	484.5	86.0	12.0	14.8	0.00	0.00	112.8
06/07	21.6	2.51	2.31	–	0.06	26.5	49.8	1.15	0.19	–	0.02	51.1	443.5	7.4	2.73	0.13	8.2	461.9	67.5	15.6	9.3	0.00	0.00	92.4
07/08	19.4	4.09	2.51	–	0.59	26.6	36.1	0.57	0.41	0.03	0.01	37.1	268.8	1.7	0.58	0.01	10.1	281.2	45.1	1.1	2.6	–	0.25	49.0
08/09	23.5	1.45	0.60	–	0.20	25.8	41.9	0.05	0.07	–	0.00	42.0	262.1	0.46	0.09	0.01	0.14	262.8	31.9	0.65	1.1	0.00	0.07	33.7
09/10	17.1	0.92	0.47	0.00	0.33	18.8	40.3	0.01	0.01	0.00	0.07	40.4	330.7	0.38	0.09	0.08	0.01	331.3	23.9	0.90	1.9	–	0.00	26.7
10/11	12.1	0.62	0.29	–	0.13	13.1	43.2	0.02	0.03	0.03	0.00	43.2	204.4	0.22	0.04	0.01	0.02	204.7	18.0	1.7	2.1	0.00	0.01	21.8
11/12	10.4	0.15	4.34	0.00	0.00	14.9	39.1	0.04	0.00	0.01	0.01	39.1	194.4	1.1	0.07	0.01	0.00	195.6	23.3	1.7	2.5	0.02	0.00	27.5
12/13	12.4	0.09	2.78	–	0.00	15.2	35.0	0.00	0.02	–	0.01	35.0	190.5	0.16	0.02	0.03	0.00	190.7	16.0	1.1	2.6	–	0.00	19.8
13/14	19.9	0.30	2.27	0.00	0.02	22.5	34.6	0.06	0.01	0.00	0.00	34.7	213.6	0.09	0.06	0.02	0.00	213.7	12.7	0.21	2.2	0.00	0.02	15.1
14/15	6.2	0.13	2.25	0.00	0.00	8.6	28.7	0.00	0.11	–	0.00	28.8	203.3	0.01	0.01	0.01	0.00	203.3	8.3	0.10	0.41	0.00	0.00	8.8
15/16	10.3	0.04	1.79	0.00	0.00	12.1	30.2	0.00	0.06	0.00	0.00	30.3	99.8	0.00	0.04	0.00	0.00	99.9	4.7	0.59	0.18	–	0.00	5.5
16/17	7.7	0.20	0.82	0.00	0.00	8.7	32.2	0.00	0.08	0.00	0.02	32.3	252.6	0.01	0.01	0.00	0.00	252.6	20.2	0.14	0.27	0.00	0.00	20.6
Total	787.3	18.2	52.6	0.87	2.89	861.9	1 204.1	3.4	8.1	0.19	0.70	1 216.5	7 787.9	430.6	18.2	1.0	29.9	8 267.5	955.3	154.4	121.8	0.06	3.3	1 234.9
last 5 years	56.5	0.75	9.9	0.00	0.02	67.2	160.7	0.06	0.28	0.00	0.04	161.1	959.8	0.26	0.13	0.06	0.00	960.2	61.9	2.15	5.65	0.00	0.02	69.7

Table G.2: Distribution in km of total length of net set by fishing year and the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which caught flatfish. These values are plotted in Figure 6.

	Manukau Harbour	Kaipara Harbour	Lower Waikato	Northwest	East Northland	Hauraki Gulf	Bay of Plenty	Total
89/90	784.3	2 131.9	194.6	319.5	560.7	2 407.6	425.2	6 823.8
90/91	1 111.6	2 755.3	197.1	400.4	542.4	4 528.4	1 203.3	10 738.5
91/92	1 059.6	2 774.5	213.9	533.2	571.0	4 721.6	1 004.4	10 878.2
92/93	1 161.6	2 565.6	228.3	530.0	748.3	5 225.8	1 069.1	11 528.6
93/94	1 369.0	2 350.6	162.6	441.3	750.0	4 825.1	1 018.6	10 917.1
94/95	1 287.2	2 356.3	227.1	678.5	708.3	3 637.9	1 310.9	10 206.2
95/96	1 022.5	1 860.4	270.6	557.0	782.0	2 096.1	1 453.7	8 042.3
96/97	1 103.1	2 156.6	713.1	468.6	615.0	2 232.1	1 575.1	8 863.7
97/98	1 383.8	2 775.4	453.9	569.8	750.3	2 161.1	1 052.1	9 146.3
98/99	1 439.6	3 155.2	386.3	660.5	900.2	2 179.0	1 189.1	9 909.9
99/00	1 755.7	4 481.3	373.2	930.3	841.1	2 442.4	1 079.6	11 903.5
00/01	1 895.7	4 982.2	414.4	1 046.5	753.6	2 785.0	668.2	12 545.7
01/02	1 563.6	4 113.3	390.3	760.1	800.9	2 331.1	534.6	10 493.8
02/03	1 342.6	3 514.4	389.4	578.8	1 000.5	3 907.0	715.2	11 447.8
03/04	1 476.5	3 264.3	430.0	739.4	1 264.7	4 022.2	668.0	11 865.1
04/05	1 362.0	2 908.9	368.1	844.1	1 395.8	4 809.1	668.8	12 356.7
05/06	1 271.9	2 731.6	492.4	678.6	1 309.0	3 820.0	1 178.7	11 482.2
06/07	1 525.3	2 014.8	666.6	545.1	1 203.2	3 865.6	1 142.6	10 963.1
07/08	1 171.3	2 089.7	599.1	416.7	842.4	2 382.4	883.2	8 384.7
08/09	743.0	2 500.9	508.1	563.2	690.5	2 735.4	845.6	8 586.7
09/10	688.6	2 531.9	432.1	489.4	739.0	3 532.5	913.2	9 326.6
10/11	883.1	2 490.5	483.4	374.0	811.9	2 894.3	495.3	8 432.5
11/12	733.3	1 976.6	527.9	441.1	883.4	2 649.8	568.9	7 780.9
12/13	750.8	2 395.1	553.8	359.9	956.2	2 959.7	505.3	8 480.7
13/14	884.3	2 239.3	345.5	439.8	884.7	2 578.3	655.3	8 027.1
14/15	831.8	2 105.7	395.6	207.9	579.0	2 066.3	373.6	6 559.9
15/16	515.6	1 840.6	224.6	237.4	588.2	1 744.1	298.4	5 448.9
16/17	513.6	1 468.3	181.3	209.6	532.9	1 993.5	443.5	5 342.6
Total	31 631.2	74 530.8	10 823.2	15 020.2	23 005.1	87 533.3	23 939.4	266 483.2
last 5 year	3 496.1	10 048.9	1 700.7	1 454.5	3 541.1	11 341.8	2 276.1	33 859.2

Table G.3A: Distribution in percent of estimated flatfish setnet catches by fishing year and month for two of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which caught flatfish. Annual total setnet catches (t) for these FLA 1 fishery strata are available in Table G.1A. These values are plotted in Figure 7.

Manukau Harbour

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89/90	1.8	8.8	7.5	12.2	10.3	15.2	14.4	9.6	4.6	4.5	1.8	9.3
90/91	4.5	4.5	6.1	9.1	16.2	17.1	10.5	10.0	5.0	6.3	3.3	7.3
91/92	9.9	5.2	9.8	13.7	11.9	15.0	14.4	6.0	5.8	1.7	1.3	5.4
92/93	4.5	8.4	10.5	11.6	17.8	13.0	11.6	4.5	4.6	6.6	4.0	3.0
93/94	3.3	6.0	12.0	7.3	10.6	17.9	15.1	5.8	8.6	3.6	6.7	3.1
94/95	7.7	12.3	11.8	9.1	14.4	10.8	9.3	8.6	3.0	3.3	5.6	4.1
95/96	4.6	8.6	6.4	13.6	14.8	14.8	14.5	7.8	3.0	2.0	4.0	5.9
96/97	2.7	3.1	5.9	8.7	10.3	14.2	14.1	18.3	5.3	8.5	5.1	3.9
97/98	3.4	9.0	12.3	10.2	8.8	14.7	13.2	6.9	4.9	4.8	5.1	6.7
98/99	4.4	8.5	5.1	7.9	10.5	8.9	10.1	10.4	9.7	7.7	7.7	9.2
99/00	7.4	15.3	8.5	10.3	9.2	20.6	10.0	6.0	4.4	3.8	2.1	2.3
00/01	3.9	3.8	5.2	7.4	9.0	11.1	12.6	10.6	10.6	8.1	8.4	9.3
01/02	8.5	13.9	12.8	17.6	16.1	14.5	7.8	1.9	1.0	2.5	2.1	1.4
02/03	2.2	3.3	5.1	6.7	12.1	13.3	14.3	12.5	7.9	8.9	7.7	5.9
03/04	9.5	6.9	7.8	8.1	9.2	16.5	12.2	8.5	5.9	5.7	5.2	4.3
04/05	6.5	5.7	4.6	10.3	6.9	14.1	14.0	8.8	7.8	7.9	9.0	4.5
05/06	5.6	6.9	5.3	12.4	16.8	13.1	8.9	6.9	6.9	6.7	4.9	5.4
06/07	5.3	6.4	5.0	4.6	6.7	12.3	16.0	13.0	8.4	11.6	5.1	5.7
07/08	5.7	8.8	5.8	8.0	12.0	18.7	9.8	10.4	4.0	4.1	6.1	6.5
08/09	7.1	12.5	14.1	13.4	8.7	11.6	11.6	4.4	5.4	3.5	2.5	5.2
09/10	6.9	7.2	6.0	9.5	9.5	12.5	20.7	8.4	7.5	5.2	3.8	2.8
10/11	5.1	8.2	8.3	6.0	14.1	14.0	12.2	13.9	8.9	2.9	3.3	3.1
11/12	4.6	6.5	13.3	14.5	8.9	13.2	19.4	5.0	5.2	4.7	2.1	2.6
12/13	3.9	5.9	9.7	8.9	16.3	15.5	12.2	11.6	7.4	3.7	3.0	1.9
13/14	4.7	7.9	11.7	6.5	14.1	17.9	11.9	10.1	5.6	3.2	3.7	2.8
14/15	5.6	5.9	10.8	13.9	13.6	14.2	10.4	5.8	6.1	4.3	4.7	4.8
15/16	7.1	14.2	9.5	14.5	8.6	11.3	16.1	7.5	4.5	1.5	2.6	2.7
16/17	7.0	4.4	6.7	7.3	9.6	12.6	19.0	9.4	11.6	2.2	5.1	5.1
Mean	5.3	7.9	8.4	9.9	11.7	14.4	12.5	8.6	6.0	5.4	4.8	5.1

Kaipara Harbour

Fishing year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89/90	2.1	6.6	5.7	11.9	9.5	10.7	12.2	13.8	11.5	7.4	2.2	6.3
90/91	7.1	8.7	7.4	9.3	9.0	8.3	10.3	15.8	6.2	6.4	4.6	7.0
91/92	6.4	5.9	9.2	8.0	8.2	12.7	13.8	9.8	9.7	5.9	4.7	5.8
92/93	8.5	7.8	8.1	9.8	9.9	14.8	13.8	10.6	5.3	5.3	3.0	3.0
93/94	5.6	5.7	4.2	7.0	7.3	12.1	15.5	12.7	10.3	6.3	8.0	5.3
94/95	6.1	9.3	6.8	7.6	8.7	10.5	8.3	13.1	9.3	6.6	7.3	6.4
95/96	4.7	10.2	5.6	11.4	10.5	13.6	13.2	7.7	4.5	6.1	5.1	7.4
96/97	6.1	5.3	6.2	7.0	9.7	9.3	17.8	14.8	7.3	6.2	4.4	5.9
97/98	9.1	10.7	15.3	10.7	7.4	4.6	10.1	10.1	7.8	5.4	4.7	4.1
98/99	4.0	5.3	4.8	7.1	7.3	11.5	10.0	10.7	11.1	9.8	9.7	8.7
99/00	7.7	9.1	7.7	8.7	8.5	9.1	10.3	11.2	7.5	6.3	8.2	5.7
00/01	5.2	5.9	8.1	8.3	9.9	11.1	12.8	9.6	8.5	8.2	6.4	6.1
01/02	8.7	17.5	11.2	14.8	10.7	10.7	8.2	5.4	3.8	3.6	2.9	2.3
02/03	3.2	5.2	5.6	7.0	9.3	10.8	14.7	13.5	8.9	8.9	7.3	5.6
03/04	10.9	11.9	11.5	8.5	5.5	11.8	9.4	6.9	7.2	6.6	5.0	4.9
04/05	8.1	19.3	9.7	13.2	7.3	6.4	6.5	6.5	7.1	5.5	6.5	3.9
05/06	7.4	9.2	9.9	10.2	9.2	7.5	10.3	10.7	8.9	6.2	5.5	5.0
06/07	3.4	6.2	8.0	8.6	7.7	8.1	13.2	11.9	7.3	7.4	8.6	9.6
07/08	5.7	13.4	10.3	5.5	5.7	8.4	7.5	10.7	5.9	8.3	8.6	10.0
08/09	9.4	11.1	12.0	9.8	8.9	8.9	9.0	5.9	7.3	5.8	5.5	6.4
09/10	7.5	10.9	9.4	7.7	8.5	8.0	10.4	9.4	9.9	7.9	5.9	4.5
10/11	9.1	15.9	9.4	5.9	9.0	9.4	8.7	14.2	7.5	3.4	4.5	2.8
11/12	5.0	8.7	12.2	13.2	11.2	8.3	12.4	9.5	7.9	4.7	3.9	3.0
12/13	4.9	7.3	6.4	6.7	9.4	10.4	13.6	11.1	10.0	9.9	5.1	5.1
13/14	10.3	13.6	12.0	10.9	12.3	10.5	9.4	7.5	5.4	3.5	2.7	2.0
14/15	5.7	7.1	11.0	13.0	10.7	10.2	9.5	10.4	10.9	4.8	4.1	2.6
15/16	6.2	9.5	10.2	11.5	11.4	10.9	10.7	8.4	7.5	6.1	4.3	3.3
16/17	5.5	8.7	10.4	8.2	8.5	8.8	13.7	12.5	10.3	4.6	5.6	3.1
Mean	6.6	9.4	8.7	9.3	8.8	10.0	11.3	10.5	8.0	6.5	5.6	5.4

Table G.3B: Distribution in percent of estimated flatfish setnet catches by fishing year and month for two of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which caught flatfish. Annual total setnet catches (t) for these FLA 1 fishery strata are available in Table G.1A. These values are plotted in Figure 7.

Fishing												Month												Month
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Lower Waikato												Northwest											
89/90	5.9	10.8	4.9	7.9	7.5	4.2	10.4	11.4	13.9	9.8	1.8	11.5	3.1	5.4	2.6	9.3	5.0	8.9	9.8	16.7	14.6	13.3	4.6	6.7
90/91	5.5	5.4	7.1	10.2	9.3	8.5	6.4	16.2	7.5	7.5	7.0	9.3	4.6	6.1	4.9	4.7	3.3	4.0	16.4	20.5	9.1	7.6	6.8	12.1
91/92	10.7	11.0	8.4	3.8	3.6	6.0	12.1	6.6	9.4	7.6	6.7	14.0	5.2	4.7	11.2	6.2	5.5	15.2	14.6	9.9	12.0	6.7	4.5	4.3
92/93	11.6	10.3	5.1	8.5	8.3	12.1	6.6	7.6	4.7	9.6	5.5	10.2	5.8	4.8	5.2	7.5	17.0	12.8	9.6	13.5	7.6	6.9	3.9	5.3
93/94	6.9	11.6	6.0	4.5	11.6	13.3	6.1	5.5	10.7	11.3	7.8	4.7	3.4	4.5	3.5	7.2	7.3	11.2	15.5	13.2	9.3	10.0	9.3	5.7
94/95	7.8	7.8	9.0	6.9	8.6	10.0	8.9	8.1	4.9	6.0	12.6	9.3	5.1	8.5	5.3	8.1	7.2	9.0	6.9	10.5	8.8	11.4	12.1	7.1
95/96	2.7	6.4	5.3	8.1	7.7	9.1	10.8	9.1	5.1	12.4	9.9	13.5	6.0	5.8	5.9	8.7	8.1	9.8	10.2	10.6	6.5	12.0	9.0	7.3
96/97	6.4	6.2	8.2	4.6	6.9	4.4	7.5	15.8	8.6	10.2	9.8	11.4	5.4	3.2	4.0	4.1	5.9	7.9	19.8	21.5	8.5	7.7	6.0	6.0
97/98	11.4	10.9	15.4	8.9	4.2	8.0	6.7	8.6	7.2	6.9	5.4	6.3	7.9	6.3	4.8	8.2	3.6	3.8	13.4	18.9	14.1	7.3	7.3	4.4
98/99	3.4	7.2	5.0	3.3	4.9	6.0	7.2	14.1	9.8	12.2	11.8	14.9	3.1	3.0	2.7	3.7	9.4	16.3	14.7	16.5	10.5	9.5	6.4	3.9
99/00	7.3	10.8	7.6	5.0	10.1	6.2	8.2	8.3	10.1	9.8	10.5	6.2	6.7	6.5	5.0	12.9	8.5	11.5	6.5	8.2	6.4	8.1	7.1	12.6
00/01	7.2	7.3	10.6	4.7	8.1	3.5	8.1	6.6	10.6	8.9	8.1	16.3	6.6	4.2	7.7	6.4	6.3	12.4	11.9	12.3	7.6	7.6	8.6	8.3
01/02	7.3	13.3	8.9	10.6	7.9	6.5	7.7	5.6	6.4	7.8	10.4	7.4	10.1	12.3	6.1	6.3	7.1	9.0	10.0	11.8	8.5	7.3	7.5	4.1
02/03	6.2	9.3	9.2	7.9	8.2	6.1	7.6	9.4	7.4	9.6	13.3	5.8	5.3	6.8	4.4	4.4	6.0	8.3	14.0	10.7	6.9	6.5	15.4	11.2
03/04	12.1	10.4	12.4	5.8	5.3	8.5	8.3	7.3	8.1	8.2	6.0	7.5	4.3	3.8	8.2	7.4	6.4	10.1	9.9	8.6	11.1	11.3	11.4	7.5
04/05	8.5	10.6	6.3	7.5	4.5	7.3	10.0	6.4	6.2	12.5	11.6	8.6	7.2	4.4	3.1	8.1	5.3	6.2	11.5	17.3	13.3	10.8	8.4	4.4
05/06	8.8	8.1	5.1	8.4	7.0	6.1	5.7	11.9	6.3	11.8	9.3	11.6	6.0	7.5	7.4	8.0	7.6	6.6	7.3	7.7	8.6	10.2	12.2	11.0
06/07	6.9	8.5	8.4	7.2	7.3	8.7	7.5	9.1	3.4	8.6	8.5	15.9	8.6	9.9	6.8	12.3	9.6	7.2	1.6	6.6	12.1	11.4	8.0	6.0
07/08	7.2	8.1	4.7	7.2	6.8	8.9	7.8	13.6	8.9	9.9	6.8	10.2	2.3	2.3	5.6	6.7	3.4	5.8	14.1	23.2	9.4	9.9	8.5	8.8
08/09	7.2	7.3	6.9	6.9	7.0	8.4	8.9	13.8	11.1	6.8	7.0	8.8	5.8	7.0	6.1	6.3	5.3	7.0	17.6	11.4	7.7	5.5	11.3	9.0
09/10	5.9	4.7	7.6	7.8	6.9	5.0	13.6	13.9	8.9	6.8	6.2	12.9	6.0	7.2	7.9	6.7	6.7	7.4	10.8	11.5	13.4	8.1	6.5	7.9
10/11	10.2	9.1	5.9	4.4	5.1	8.3	8.6	8.5	12.5	5.7	12.2	9.3	7.7	6.9	10.5	5.6	7.4	5.4	12.5	16.7	11.9	4.5	5.9	4.8
11/12	6.7	6.6	6.3	7.2	9.5	9.5	12.5	12.3	8.0	5.7	10.6	5.0	5.7	4.7	3.8	8.8	1.9	4.7	20.6	16.3	9.9	11.8	9.1	2.7
12/13	11.6	11.4	7.1	8.1	6.5	7.2	5.6	9.8	7.0	9.6	10.0	6.0	1.6	5.7	4.0	8.0	2.6	2.3	2.3	6.2	17.4	19.5	17.1	13.1
13/14	8.3	11.1	10.2	8.0	8.2	9.3	8.0	13.5	6.4	7.1	6.2	3.6	10.2	6.5	6.9	6.8	6.3	14.7	17.5	9.6	9.9	4.6	4.7	2.1
14/15	6.8	6.0	7.8	7.8	7.6	9.6	12.9	13.2	10.3	8.5	4.9	4.7	5.1	7.2	14.3	5.3	4.9	8.3	6.1	3.6	20.2	6.6	10.5	7.9
15/16	5.5	6.7	12.3	8.5	5.7	5.5	10.1	8.8	11.5	9.4	10.9	5.2	6.7	7.6	4.8	1.3	4.5	6.0	11.7	11.8	19.2	13.5	7.3	5.4
16/17	6.9	5.4	5.7	11.1	10.7	6.2	9.1	12.1	7.9	8.1	8.8	8.1	3.8	10.5	7.4	6.1	10.0	6.0	4.8	6.4	3.4	12.5	17.0	12.3
Mean	7.6	8.7	8.0	7.0	7.2	7.4	8.5	10.4	8.2	9.0	8.7	9.3	5.6	5.8	5.7	7.1	6.9	9.4	11.8	13.2	10.1	9.3	8.3	6.8

Table G.3C: Distribution in percent of scaled (Eq. 1) estimated flatfish setnet catches by fishing year and month for two of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which caught flatfish. Annual total setnet catches (t) for these FLA 1 fishery strata are available in Table G.1B. These values are plotted in Figure 7.

Fishing												Month
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	East Northland											
89/90	2.6	7.8	5.0	10.4	15.7	5.3	4.8	8.1	9.8	12.9	5.0	12.6
90/91	8.6	6.9	7.7	6.7	9.7	6.8	7.7	11.1	10.2	8.2	7.7	8.6
91/92	4.6	5.0	4.8	5.8	7.3	9.3	8.8	8.9	14.6	8.6	11.9	10.5
92/93	11.8	13.6	7.4	11.8	6.1	10.5	10.2	8.1	7.3	5.5	3.8	3.9
93/94	5.7	9.4	8.0	14.5	8.8	13.9	7.4	6.8	7.0	3.8	10.5	4.1
94/95	6.1	8.9	6.6	15.0	12.4	11.0	6.5	5.4	7.2	6.5	9.2	5.2
95/96	5.9	5.5	7.5	7.2	8.0	12.8	8.9	7.8	11.3	8.6	7.6	8.8
96/97	5.5	4.5	7.4	6.8	14.7	6.4	6.7	12.9	13.1	9.1	7.5	5.4
97/98	9.1	6.9	14.9	13.4	14.3	5.9	5.6	6.8	6.7	4.0	5.3	7.0
98/99	4.8	4.8	5.3	10.7	9.3	8.1	7.1	10.2	12.3	9.0	9.7	8.7
99/00	6.3	8.4	5.3	9.5	13.0	6.6	7.0	9.9	9.2	6.9	9.7	8.0
00/01	4.9	6.0	5.3	11.0	13.3	10.2	7.3	7.9	9.3	6.3	8.5	10.1
01/02	7.7	8.5	7.7	10.0	12.5	8.6	7.7	7.9	7.8	7.3	7.5	6.7
02/03	5.1	8.8	7.9	9.2	8.3	9.8	9.6	7.4	8.2	9.3	8.8	7.5
03/04	6.6	6.7	10.0	9.2	9.2	12.5	8.7	6.5	9.5	7.9	6.3	6.9
04/05	5.8	8.4	6.9	10.2	10.1	8.9	9.2	9.4	8.7	7.9	8.1	6.4
05/06	6.0	8.9	9.6	11.6	13.1	8.6	8.0	7.1	6.4	5.2	6.8	8.7
06/07	7.8	5.8	5.4	14.5	8.6	7.0	12.9	11.8	7.1	6.4	6.8	5.8
07/08	6.0	6.9	6.3	13.3	9.8	6.6	8.2	8.6	8.1	6.4	10.9	8.9
08/09	8.0	7.4	7.7	15.9	11.1	7.6	5.6	7.3	8.5	7.4	7.2	6.2
09/10	6.5	7.2	8.4	10.1	9.8	6.2	5.9	7.4	10.3	12.0	8.0	8.3
10/11	7.1	11.9	10.8	16.0	8.5	4.9	7.9	7.3	7.0	5.0	7.7	5.8
11/12	8.2	7.3	8.2	11.5	8.8	5.8	8.2	7.9	6.5	6.7	10.8	10.0
12/13	10.7	10.6	7.8	5.9	7.5	6.7	7.7	8.3	9.5	9.6	8.0	7.7
13/14	7.8	8.5	8.0	9.5	7.3	9.5	8.7	7.8	9.3	8.8	6.9	7.8
14/15	9.5	9.6	8.1	14.3	7.9	5.2	6.1	7.5	10.4	7.6	6.0	7.8
15/16	9.1	8.9	8.9	13.1	11.2	4.6	6.2	6.1	8.5	8.0	6.2	9.2
16/17	8.7	7.4	7.5	19.4	13.6	10.6	4.9	4.7	3.3	6.4	7.8	5.7
Mean	6.9	8.0	7.7	11.2	10.3	8.5	7.9	8.1	8.7	7.5	7.8	7.4

Fishing												Month
year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
	Hauraki Gulf											
89/90	3.8	11.3	11.4	14.8	7.7	12.8	11.8	8.9	6.7	4.1	1.0	5.8
90/91	4.5	11.7	15.9	15.0	10.6	12.4	7.2	8.6	4.5	4.0	2.6	3.1
91/92	6.6	16.9	16.3	12.1	14.5	11.9	8.2	2.6	3.8	3.4	1.9	2.0
92/93	4.8	10.5	13.0	13.7	15.9	13.2	9.7	5.6	4.5	4.3	1.9	3.0
93/94	5.8	9.1	12.8	14.0	16.2	12.9	12.5	6.0	4.7	2.2	2.8	1.2
94/95	2.3	12.7	17.5	12.3	15.8	11.2	9.3	8.9	3.0	2.0	2.4	2.6
95/96	6.3	10.8	17.8	17.5	9.6	9.7	6.7	7.1	3.9	2.2	3.7	4.8
96/97	4.8	9.5	13.8	16.1	10.7	9.4	9.6	8.2	7.6	5.4	2.4	2.4
97/98	10.2	10.9	18.7	13.5	7.8	5.4	5.8	6.1	7.2	2.5	4.8	7.1
98/99	4.3	11.0	14.3	8.1	8.6	14.9	9.3	7.2	5.3	5.0	5.4	6.5
99/00	6.1	16.1	20.4	10.5	8.7	8.8	7.4	5.3	6.5	1.6	3.1	5.5
00/01	6.5	11.1	13.9	15.5	12.9	13.0	10.4	3.8	3.8	1.9	2.5	4.7
01/02	12.4	10.6	14.2	15.8	8.9	6.6	7.4	10.0	4.0	2.3	3.4	4.5
02/03	4.7	12.4	11.9	10.9	12.1	10.7	12.6	9.0	4.1	4.1	3.6	3.9
03/04	3.6	9.6	18.5	15.0	5.3	14.3	9.7	6.9	6.1	4.1	3.2	3.6
04/05	8.3	11.5	5.0	10.2	10.4	7.9	13.1	7.2	6.2	6.0	8.0	6.1
05/06	7.7	12.6	10.0	10.9	10.1	8.8	8.6	7.9	4.8	2.6	7.1	8.9
06/07	5.2	8.5	12.1	17.3	11.9	8.0	12.3	10.3	2.8	3.1	3.2	5.3
07/08	5.6	19.8	15.7	18.0	7.8	6.9	5.2	7.4	3.4	2.3	2.5	5.4
08/09	9.1	13.8	17.8	14.2	7.1	10.5	8.5	3.3	3.0	2.3	3.6	6.8
09/10	8.4	15.0	15.6	17.0	9.2	7.6	9.3	5.3	3.5	3.8	2.4	2.8
10/11	11.5	16.3	16.2	15.9	6.1	5.8	8.4	4.3	2.9	3.6	4.9	4.1
11/12	6.1	14.2	17.5	16.7	7.1	8.0	9.1	5.5	3.1	4.1	4.6	3.9
12/13	6.6	23.2	12.9	14.3	7.4	7.4	6.0	2.7	3.5	8.2	4.0	3.8
13/14	7.4	21.5	14.5	15.3	10.7	8.3	3.9	3.4	3.9	4.7	2.9	3.5
14/15	7.6	22.0	21.0	22.5	8.2	6.5	3.3	2.9	1.5	1.2	1.5	1.8
15/16	9.1	17.3	17.9	12.8	7.1	5.9	5.4	1.1	2.8	3.4	5.9	11.4
16/17	12.3	18.8	17.0	11.5	11.1	8.2	5.5	4.3	2.6	1.0	4.2	3.6
Mean	6.5	13.4	14.4	14.1	10.7	9.9	9.0	6.3	4.3	3.4	3.6	4.4

Table G.3D: Distribution in percent of estimated flatfish setnet catches by fishing year and month for one of the FLA 1 fishery strata (Table 11) from 1989–90 to 2016–17 based on trips which caught flatfish. Annual total setnet catches (t) for this FLA 1 'Fishery stratum' are available in Table G.1B. These values are plotted in Figure 7.

Fishing												Month
year	Bay of Plenty											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89/90	2.7	6.4	4.5	8.0	4.7	4.7	7.3	9.2	14.0	12.5	6.3	19.5
90/91	13.7	10.6	11.7	10.6	11.9	6.2	7.1	8.3	3.0	4.2	4.7	8.0
91/92	9.8	14.4	6.2	6.1	6.3	10.1	8.2	3.5	7.8	7.5	9.4	10.7
92/93	6.7	10.5	10.4	6.8	6.7	7.0	3.4	6.2	8.5	15.3	8.7	9.9
93/94	0.4	9.5	14.1	6.9	6.5	7.9	8.0	6.4	9.4	11.8	14.5	4.6
94/95	6.6	6.3	10.2	15.6	8.9	5.0	6.7	10.6	4.9	6.0	9.8	9.4
95/96	3.0	4.5	3.0	13.6	4.6	15.5	15.5	8.6	11.0	7.9	3.8	8.9
96/97	4.6	3.6	5.3	9.5	7.1	10.8	17.3	13.0	10.5	8.5	4.6	5.3
97/98	3.6	2.6	3.5	13.0	6.8	16.1	16.9	11.0	6.1	4.1	7.7	8.6
98/99	3.4	12.7	8.3	8.4	11.5	13.6	8.0	5.4	8.3	7.4	7.9	5.2
99/00	7.1	13.2	17.2	18.4	17.8	4.9	1.7	1.9	2.5	1.4	5.9	8.0
00/01	13.1	8.9	7.2	12.9	9.2	9.0	8.3	5.9	4.9	6.0	4.6	9.9
01/02	7.5	7.7	3.5	5.4	6.7	4.7	5.3	5.3	6.5	15.4	14.7	17.4
02/03	13.3	10.0	6.2	13.5	6.6	8.2	12.8	5.4	2.8	4.8	6.6	9.8
03/04	7.3	9.6	11.7	9.8	1.9	13.8	6.4	5.0	6.7	13.6	8.2	5.9
04/05	5.0	4.8	1.6	7.5	6.7	9.9	11.5	8.4	7.7	12.5	13.2	11.1
05/06	7.3	5.4	3.2	5.8	6.0	5.4	5.7	10.8	7.4	8.0	13.2	21.9
06/07	10.0	14.9	5.4	11.3	12.9	5.4	6.6	6.8	3.4	6.3	5.3	11.7
07/08	8.0	12.6	5.3	13.5	13.0	9.7	2.5	3.8	4.9	4.2	9.7	12.7
08/09	19.8	12.7	8.2	9.1	4.8	4.3	3.8	7.4	5.7	8.0	7.2	9.2
09/10	7.3	6.4	10.7	14.2	5.2	5.4	7.8	6.5	3.0	18.6	6.2	8.7
10/11	13.3	26.4	9.0	8.2	8.0	9.7	2.2	2.6	3.5	2.6	7.3	7.2
11/12	9.2	6.9	9.4	5.5	8.7	5.8	5.3	4.4	5.1	12.4	14.6	12.8
12/13	11.7	17.9	4.8	8.7	8.3	5.6	3.2	3.4	8.2	10.5	11.1	6.8
13/14	23.2	12.6	11.6	4.9	4.3	7.9	2.0	2.0	3.0	7.8	4.4	16.5
14/15	15.8	10.5	11.6	12.2	9.3	3.6	4.0	4.2	5.5	10.5	9.1	3.8
15/16	0.1	10.2	4.3	3.9	10.0	0.1	4.4	3.7	3.2	5.6	27.9	26.6
16/17	7.0	9.8	16.4	5.7	3.3	6.0	3.3	3.2	6.4	14.6	11.9	12.4
Mean	7.6	9.2	7.2	9.8	8.0	8.5	8.0	7.3	6.7	8.5	8.6	10.7

Appendix H. FLATFISH CPUE ANALYSIS–INTRODUCTION

H.1 General overview

Results and diagnostics for seven FLA 1 SN CPUE standardisations are presented below: four major SN fishery strata (Table H.1) and three minor fishery strata (Table H.2). These analyses support the descriptions and conclusions presented in Section 3 of the main report. This appendix contains the procedures followed in data preparation, the equations used, and definitions of each standardisation analysis. The following Appendices provide tables and figures with statistics and diagnostics, and final tables giving the estimated indices with the standard error for each of the analyses defined in Table H.1 and Table H.2. Diagnostics are also presented for the rejected `HG(SFL)-est` analysis (Appendix P).

H.2 Methods

H.2.1 Data Preparation

The identification of candidate trips for these analyses and the methods used to prepare them are described in Section 2.3.1 in the main report. All records were processed through the "daily effort stratum" resolution procedure described in Section 2.3.1.3. However, this resulted in very little change to the data because most trips in these fisheries are daily, with no change to the area fished or to the target species. The CPUE data set was prepared using the "Statistical Area" expansion procedure, whereby all expansions are made relative to the statistical area of capture without regard to the QMA of origin. However, given the geographical configuration of FLA 1, there is little opportunity for data from other FLA QMAs to be included in these analyses (only Area 041 is shared with FLA 2; Appendix B).

These analyses are based on effort data which provided an estimated flatfish catch, using a code listed in Table 16 or recorded a flatfish code in the target species field. Consequently, zero catch records are rare (usually less than 1%) and may be due to data errors, either by the operator or at the data entry step. Zero catch records are ignored in these analyses. The landings data are not used because of the extensive use of intermediate destination codes in these fishery strata (see Section 2.3.2.1 for a discussion of this issue).

The potential explanatory variables available from each record in these data sets include fishing year, the length of net set, the duration of fishing, month of landing, and a unique vessel identifier. For those analyses that include multiple statistical areas, the area of capture is included. Target species is not included as the incidence of species other than FLA is minor in these fisheries (see Table 15). Since these are exclusively positive catch analyses, the dependent variable is always log(catch), where catch is the declared estimated catch for the day.

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

H.2.2 Analytical methods for standardisation

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

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

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

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

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

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

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

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

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

As these models were all repeats of previous models reported by Kendrick & Bentley (2011, 2012a, 2015), the underlying positive catch distribution used in the previous version of each model was used here to ensure comparability with previous work. The only exception to this was the `HG(TOT)-est` model (Table H.1), which was a new model requested by the NINSWG to replace the discarded HG(SFL) model. In this instance, a range of alternative positive catch distributions were tested with the data and the distribution providing the best fit was selected (see Figure L.3).

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

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

H.3 Fishery definitions

The following selection criteria were used for defining the setnet fishery models described in this report. Data were prepared using the "daily effort-stratum" method of Langley (2014) (described in Section 2.3.1.3) without scaling the estimated catches to represent landings.

Table H.1: List of specifications for modelled FLA 1 setnet (SN) major fishery strata (Table 11). FLA(TOT): amalgamation of all FLA estimated catch species codes.

Model label	Location	Statistical area definition	FLA species definition	Core fleet definition	Number vessels and % retained catch	Positive catch distribution	Document reference
`MH(TOT)-est`	Manukau Harbour	043	FLA(TOT)	10 trips/6 years	42 vessels/84%	log-logistic	Appendix I
`KH(TOT)-est`	Kaipara Harbour	044	FLA(TOT)	10 trips/4 years	68 vessels/90%	log-logistic	Appendix J
`HG(YBF)-est`	Hauraki Gulf	005–007	YBF	10 trips/4 years	40 vessels/86%	gamma	Appendix K
`HG(TOT)-est`[1]	Hauraki Gulf	005–007	FLA(TOT)	10 trips/4 years	103 vessels/87%	gamma	Appendix L

[1] new model: created at request of NINSWG

Table H.2: List of specifications for modelled FLA 1 setnet (SN) minor fishery strata (Table 11). FLA(TOT): amalgamation of all FLA estimated catch species codes.

Model label	Location	Statistical area definition	FLA species definition	Core fleet definition	Number vessels and % retained catch	Positive catch distribution	Document reference
`LW(TOT)-est`	Lower Waikato	041 & 042	FLA(TOT)	10 trips/4 years	16 vessels/87%	log-logistic	Appendix M
`NW(TOT)-est`	Northwest	045–047	FLA(TOT)	10 trips/3 years	19 vessels/85%	log-logistic	Appendix N
`EN(TOT)-est`	East Northland	002 & 003	FLA(TOT)	10 trips/4 years	25 vessels/80%	log-logistic	Appendix O

The positive catch distributions listed above were selected for continuity with earlier versions of the same analyses (see Kendrick & Bentley 2011, 2012a, 2015). The only exception to this was the new `HG(TOT)-est` model, where a range of alternative positive catch distributions were tested with the data and the gamma distribution was selected because it gave the best fit (Figure L.3).

Appendix I. DIAGNOSTICS AND SUPPORTING ANALYSES FOR MANUKAU HARBOUR ESTIMATED CATCH CPUE

I.1 Model definition and preliminary analyses

This CPUE analysis was accepted by the NINSWG for monitoring Manukau Harbour YBF (assumed) in 2018 (Fisheries New Zealand 2018).

I.1.1 Fishery definition

`MH(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Area 043 capturing flatfish using any species code in Table 16 (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

I.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 6 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 42 vessels which took 84% of the catch (Figure I.1).

I.1.3 Data summary

Table I.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 6 years) in the `MH(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	17	563	571	609	1.07	326.31	2 346	33.68	99.8	99.8
1991	20	746	766	854	1.11	487.61	3 067	42.98	99.7	99.7
1992	22	899	933	1 001	1.07	632.33	3 587	62.87	100.0	100.0
1993	26	1 143	1 227	1 302	1.06	787.03	4 397	94.02	99.7	99.8
1994	26	1 330	1 333	1 406	1.05	889.10	5 266	95.32	99.7	99.7
1995	23	1 207	1 222	1 277	1.05	860.16	4 725	89.73	100.0	100.0
1996	25	1 064	1 081	1 102	1.02	711.86	4 580	56.13	99.1	99.1
1997	22	1 046	1 068	1 149	1.08	743.95	4 343	62.40	99.7	99.7
1998	20	1 062	1 065	1 169	1.10	728.92	4 128	68.79	99.7	99.7
1999	22	1 283	1 283	1 418	1.11	887.95	5 190	63.70	99.8	99.8
2000	24	1 541	1 556	1 672	1.07	1 099.32	6 526	80.13	99.6	99.6
2001	25	1 645	1 666	1 854	1.11	1 254.91	7 963	82.60	99.8	99.7
2002	24	1 318	1 338	1 472	1.10	1 013.19	5 938	68.19	99.9	99.9
2003	23	1 373	1 425	1 561	1.10	1 034.97	8 031	50.63	99.9	99.9
2004	22	1 452	1 493	1 701	1.14	1 082.76	7 980	59.11	99.9	99.9
2005	23	1 376	1 412	1 581	1.12	976.35	7 847	65.06	99.9	99.9
2006	24	1 336	1 370	1 561	1.14	980.79	8 271	63.47	99.6	99.6
2007	25	1 491	1 531	1 792	1.17	1 137.55	9 622	70.82	99.9	99.9
2008	28	1 193	1 208	1 396	1.16	822.80	5 996	57.10	99.8	99.8
2009	24	828	833	922	1.11	542.24	3 608	26.83	99.8	99.8
2010	17	668	679	749	1.10	468.36	3 188	21.91	99.9	99.9
2011	18	795	803	893	1.11	551.33	3 854	27.24	99.6	99.6
2012	15	645	651	724	1.11	435.48	2 890	17.95	100.0	99.9
2013	13	705	713	776	1.09	470.57	3 517	23.94	100.0	100.0
2014	13	753	765	840	1.10	525.50	4 046	33.46	100.0	100.0
2015	12	786	802	885	1.10	492.48	3 795	25.15	99.8	99.6
2016	11	568	577	618	1.07	335.37	2 923	17.85	99.8	99.8
2017	11	470	475	490	1.03	271.81	2 302	13.88	99.8	99.8

I.1.4 Core vessel plots

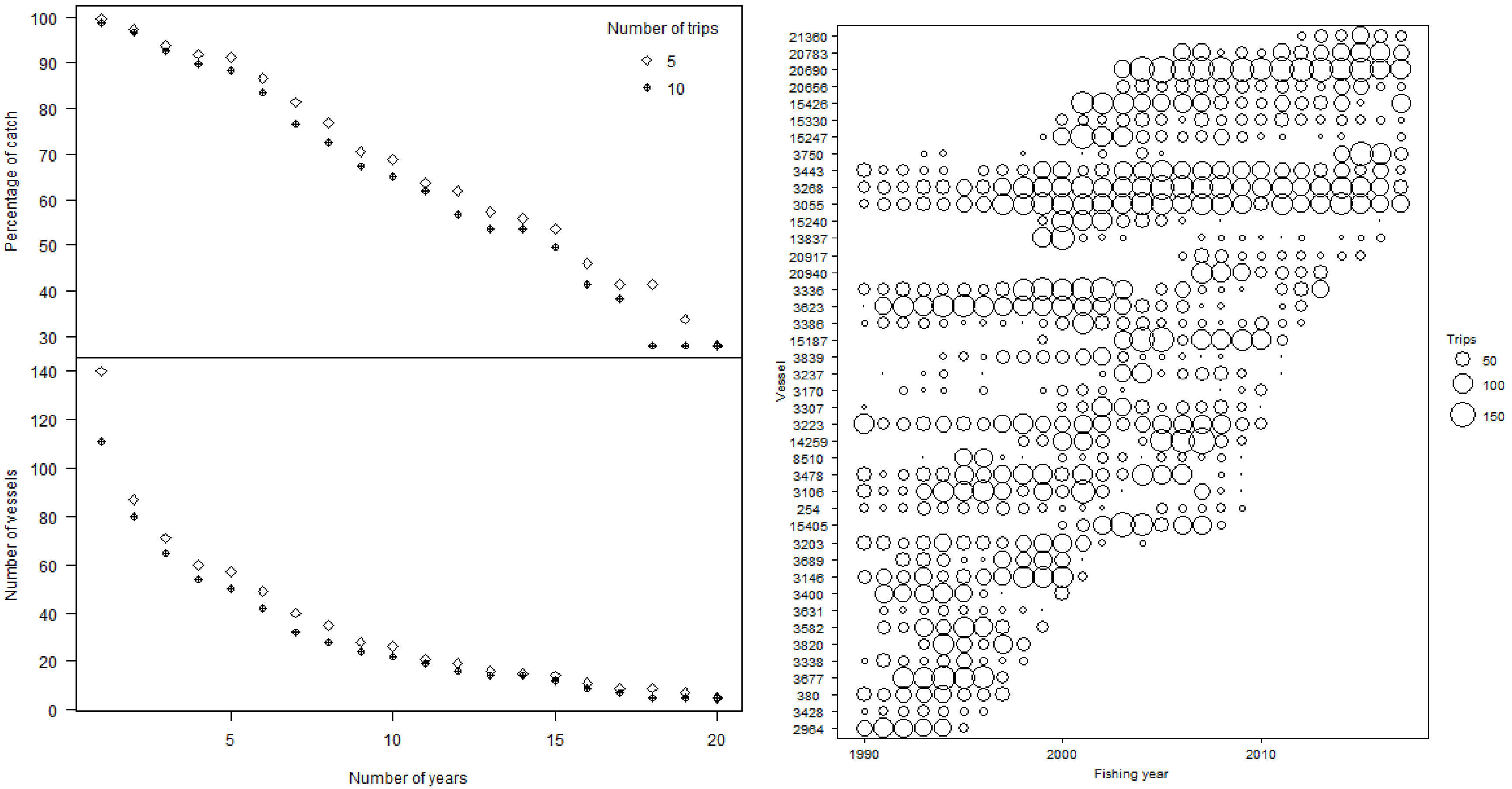

Figure I.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `MH(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 6 or more fishing years) by fishing year.

I.1.5 Exploratory data plots for core vessel data set

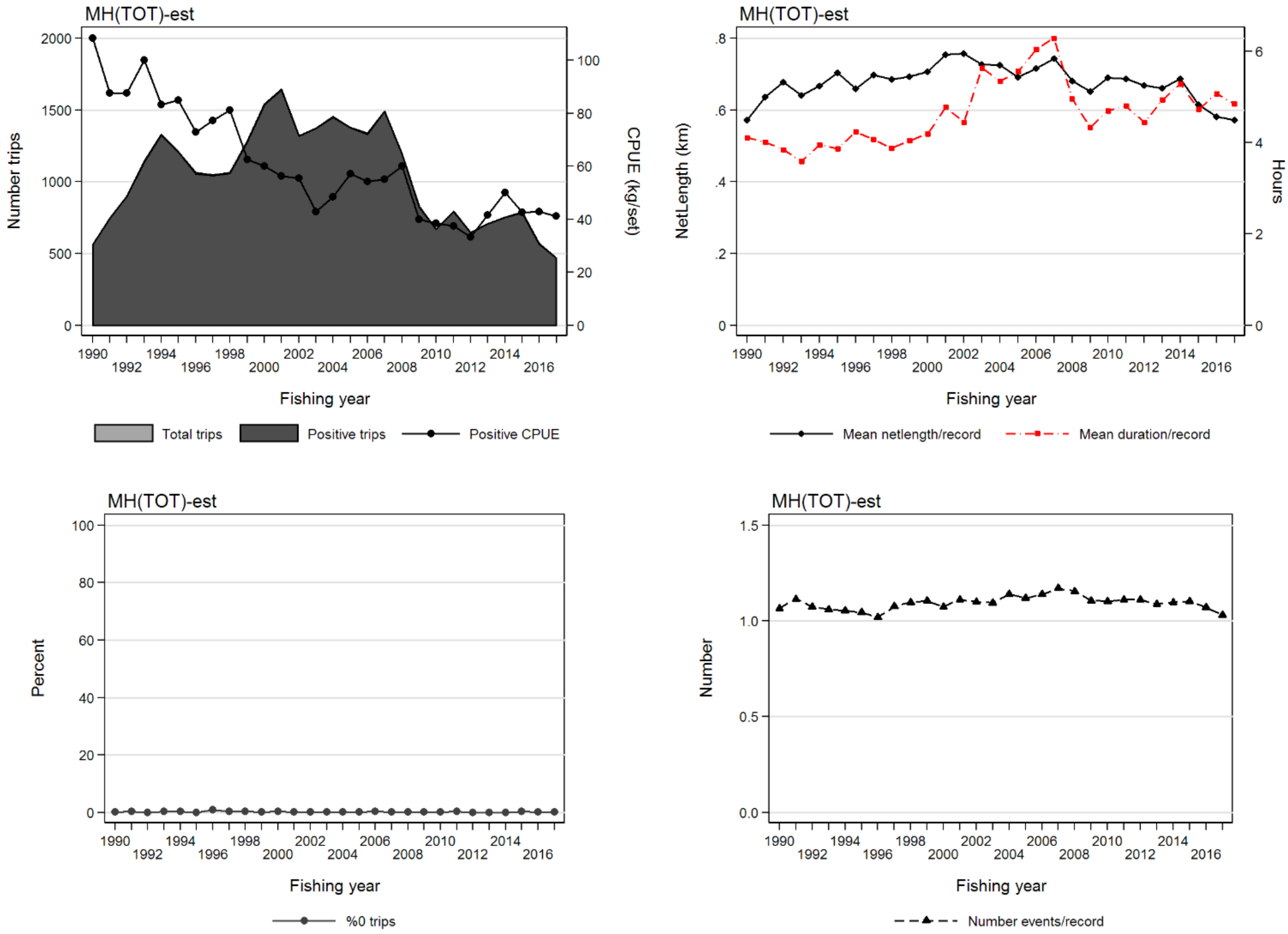

Figure I.2: Core vessel summary plots by fishing year for model `MH(TOT)-est`: [upper left panel]: total trips (light grey) and trips with flatfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of flatfish; [lower right panel]: mean number of events per daily-effort stratum record.

I.2 Positive catch model

All four explanatory variables entered the model after fishing year (vessel, length of net set, month, and duration fishing; Table I.2), with no non-significant variables. A plot of the model is provided in Figure I.3 and the CPUE indices are listed in Table I.3.

Table I.2: Order of acceptance of variables into the log-logistic model of successful catches in the `MH(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 6 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	29	-142 442	284 941	8.5	*
vessel	70	-138 392	276 924	30.3	*
poly(log(net_length), 3)	73	-137 101	274 349	36.1	*
month	84	-136 620	273 409	38.1	*
poly(log(duration, 3)	87	-136 095	272 365	**40.3**	*

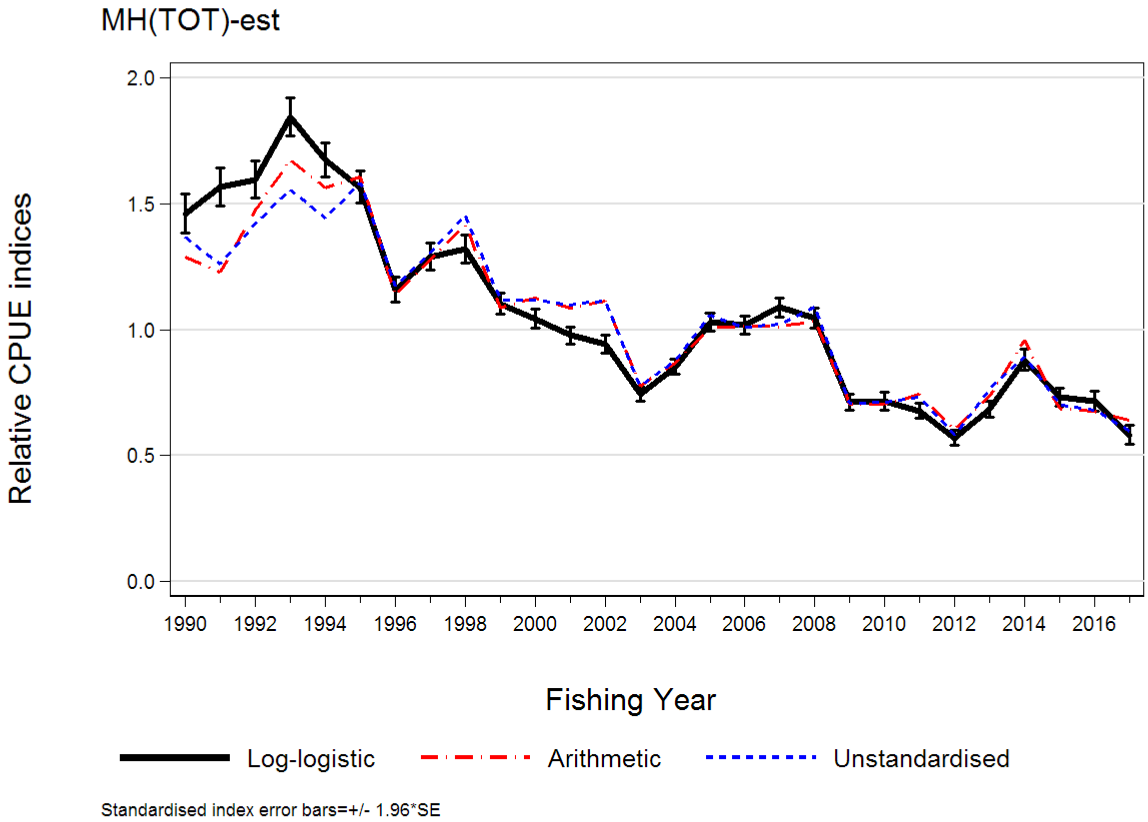

Figure I.3: Relative CPUE indices for estimated FLA catch using the log-logistic non-zero model based on the `MH(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

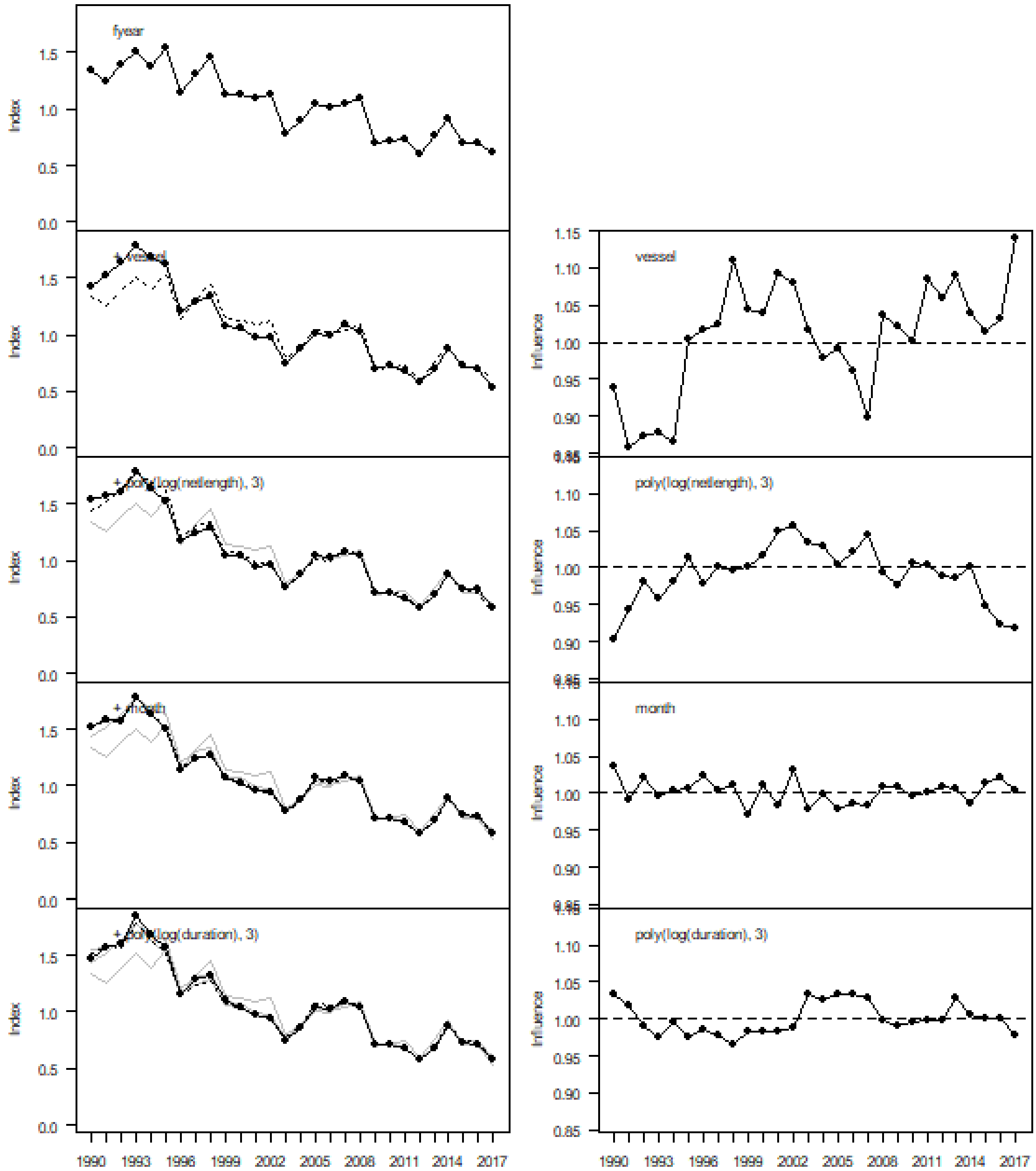

Figure I.4: [left column]: annual indices from the log-logistic model of `MH(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

I.2.1 Residual and diagnostic plots

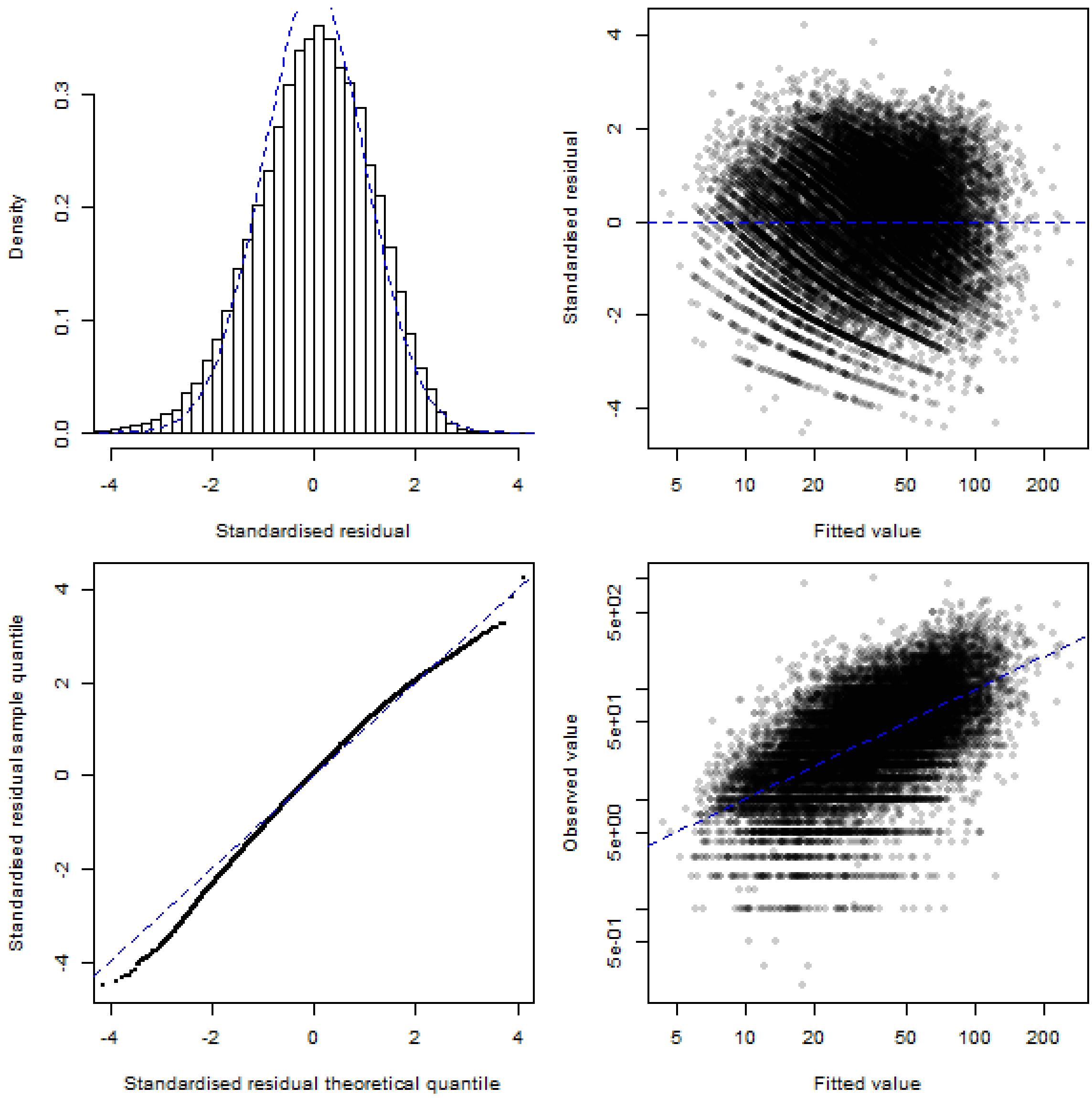

Figure I.5: Plots of the fit of the log-logistic standardised CPUE model of successful estimated FLA catches in the `MH(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a log-logistic distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

I.2.2 Model coefficient plots

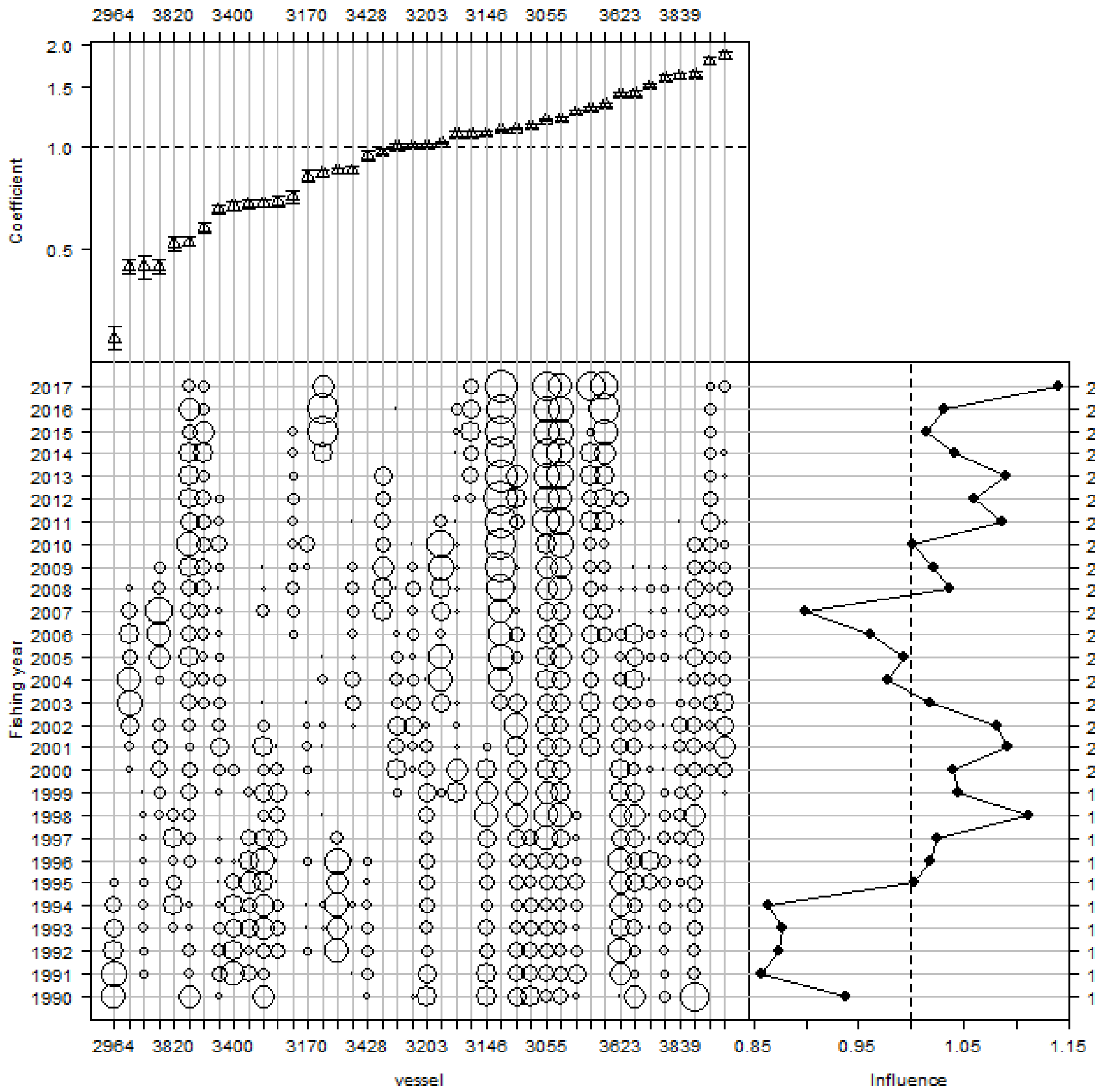

Figure I.6: Effect of vessel in the log-logistic model for the flatfish `MH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

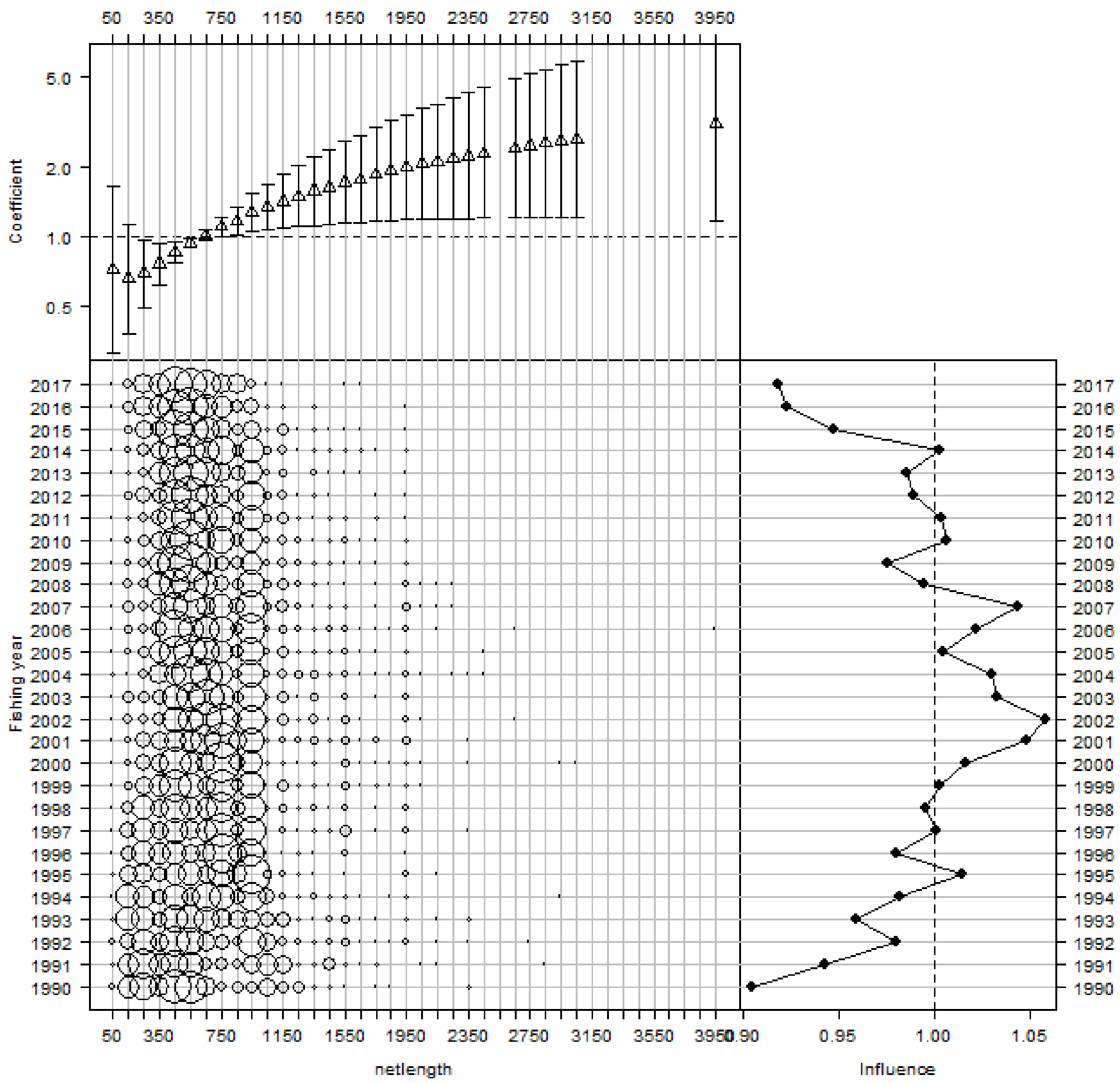

Figure I.7: Effect of log(net_length) in the log-logistic model for the flatfish `MH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

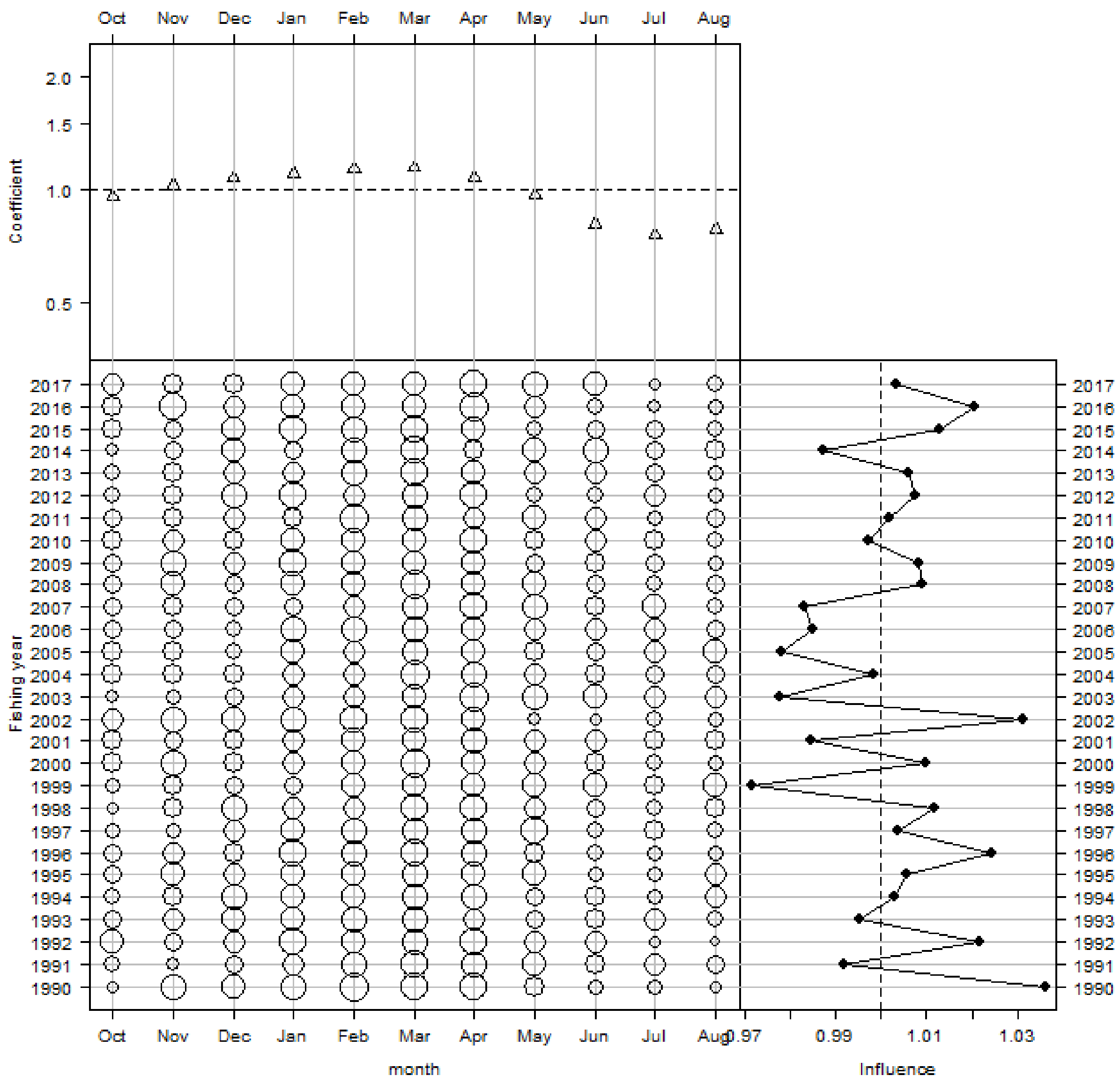

Figure I.8: Effect of month in the log-logistic model for the flatfish MH(TOT)-est fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

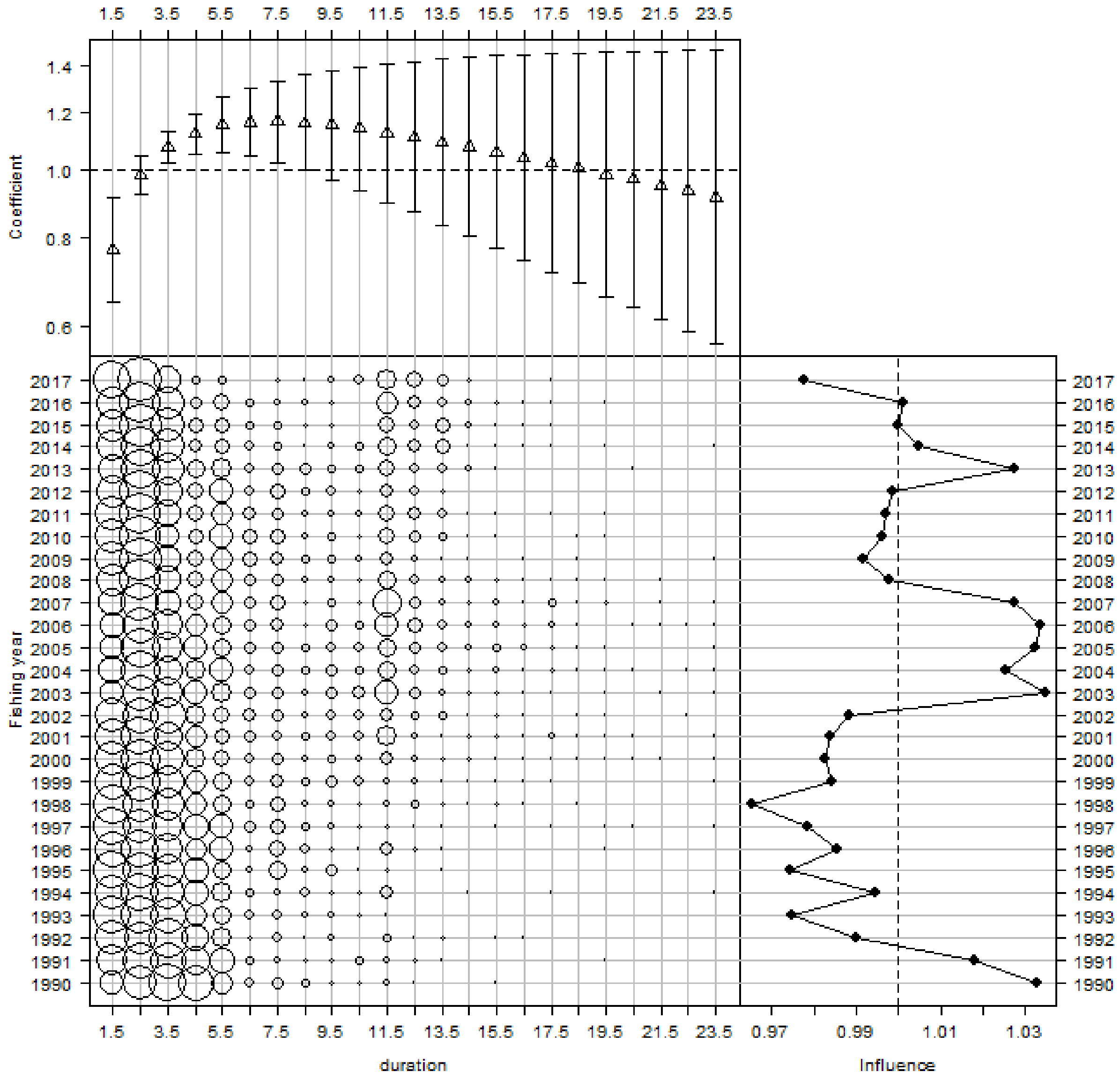

Figure I.9: Effect of log(duration) in the log-logistic model for the flatfish `MH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

I.3 CPUE indices

Table I.3: Arithmetic indices for the total and core data sets, geometric and log-logistic standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `MH(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels			Core vessels	
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.362	1.291	1.367	1.460	0.0273
1991	1.241	1.228	1.261	1.566	0.0250
1992	1.315	1.474	1.422	1.595	0.0234
1993	1.574	1.676	1.558	1.845	0.0208
1994	1.523	1.564	1.443	1.674	0.0204
1995	1.551	1.606	1.584	1.565	0.0205
1996	1.116	1.136	1.172	1.158	0.0214
1997	1.201	1.278	1.306	1.290	0.0209
1998	1.327	1.413	1.455	1.320	0.0209
1999	1.122	1.086	1.120	1.104	0.0192
2000	1.135	1.127	1.117	1.043	0.0179
2001	1.080	1.085	1.099	0.977	0.0173
2002	1.052	1.115	1.116	0.943	0.0191
2003	0.776	0.777	0.777	0.743	0.0180
2004	0.899	0.866	0.875	0.852	0.0177
2005	1.064	1.008	1.057	1.031	0.0176
2006	1.049	1.014	1.008	1.018	0.0183
2007	1.032	1.012	1.022	1.089	0.0180
2008	1.057	1.034	1.091	1.045	0.0193
2009	0.722	0.705	0.706	0.710	0.0234
2010	0.704	0.706	0.712	0.717	0.0256
2011	0.743	0.742	0.732	0.678	0.0235
2012	0.623	0.603	0.582	0.569	0.0262
2013	0.750	0.735	0.763	0.684	0.0245
2014	1.012	0.957	0.892	0.880	0.0247
2015	0.691	0.686	0.703	0.731	0.0247
2016	0.692	0.677	0.680	0.714	0.0287
2017	0.648	0.639	0.597	0.582	0.0320

Appendix J. DIAGNOSTICS AND SUPPORTING ANALYSES FOR KAIPARA HARBOUR ESTIMATED CATCH CPUE

J.1 Model definition and preliminary analyses

This CPUE analysis was accepted by the NINSWG for monitoring Kaipara Harbour YBF (assumed) in 2018 (Fisheries New Zealand 2018).

J.1.1 Fishery definition

`KH(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Area 044 capturing flatfish using any species code in Table 16 (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

J.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 68 vessels which took 90% of the catch (Figure J.1).

J.1.3 Data summary

Table J.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the `KH(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	24	1 269	1 438	1 528	1.06	1 447.82	14 335	133.51	99.8	99.9
1991	21	1 404	1 595	1 733	1.09	1 603.84	15 008	117.71	99.6	99.6
1992	24	1 370	1 713	1 860	1.09	1 682.98	17 204	133.42	99.9	99.8
1993	29	1 396	1 841	1 962	1.07	1 794.35	19 401	144.09	99.8	99.8
1994	28	1 549	2 003	2 201	1.10	1 888.17	20 165	133.61	99.9	99.9
1995	29	1 462	1 935	2 103	1.09	1 820.48	19 623	168.46	100.0	100.0
1996	31	1 237	1 566	1 670	1.07	1 404.93	13 882	122.64	95.8	96.7
1997	29	1 349	1 570	1 680	1.07	1 423.08	15 278	125.69	97.9	98.0
1998	32	1 839	2 243	2 453	1.09	2 011.23	23 835	125.32	94.2	95.2
1999	37	2 429	2 802	3 026	1.08	2 483.57	30 634	130.34	95.8	96.1
2000	41	3 521	3 927	4 283	1.09	3 461.68	38 832	198.24	96.9	97.2
2001	41	3 824	4 291	4 765	1.11	3 865.24	45 033	215.04	99.8	99.8
2002	39	3 227	3 495	3 869	1.11	2 982.17	34 453	162.28	100.0	100.0
2003	34	2 617	2 935	3 184	1.08	2 581.06	28 993	146.91	99.9	99.9
2004	33	2 727	2 938	3 159	1.08	2 581.68	28 110	173.89	99.9	99.9
2005	33	2 415	2 646	3 102	1.17	2 403.21	24 792	150.47	99.9	99.9
2006	32	2 371	2 602	2 981	1.15	2 373.54	24 632	115.83	99.9	99.9
2007	28	1 998	2 129	2 411	1.13	1 583.01	19 000	106.34	99.7	99.7
2008	27	2 009	2 140	2 339	1.09	1 740.01	18 660	133.80	100.0	99.9
2009	30	2 325	2 451	2 787	1.14	2 122.60	22 607	150.96	99.9	99.9
2010	31	2 304	2 447	2 808	1.15	2 129.38	21 917	136.65	99.8	99.8
2011	34	2 404	2 546	2 925	1.15	2 113.27	24 766	107.30	99.6	99.6
2012	32	1 876	2 050	2 338	1.14	1 648.54	20 673	81.14	99.8	99.8
2013	29	2 305	2 522	2 874	1.14	1 966.44	26 123	109.69	99.9	99.8
2014	31	2 120	2 293	2 619	1.14	1 841.58	23 467	102.28	99.9	99.9
2015	30	1 833	2 038	2 190	1.07	1 745.76	20 390	85.15	100.0	100.0
2016	25	1 702	1 848	1 957	1.06	1 582.90	19 799	65.19	99.8	99.8
2017	23	1 231	1 357	1 548	1.14	1 160.64	16 885	48.85	99.9	99.9

J.1.4 Core vessel plots

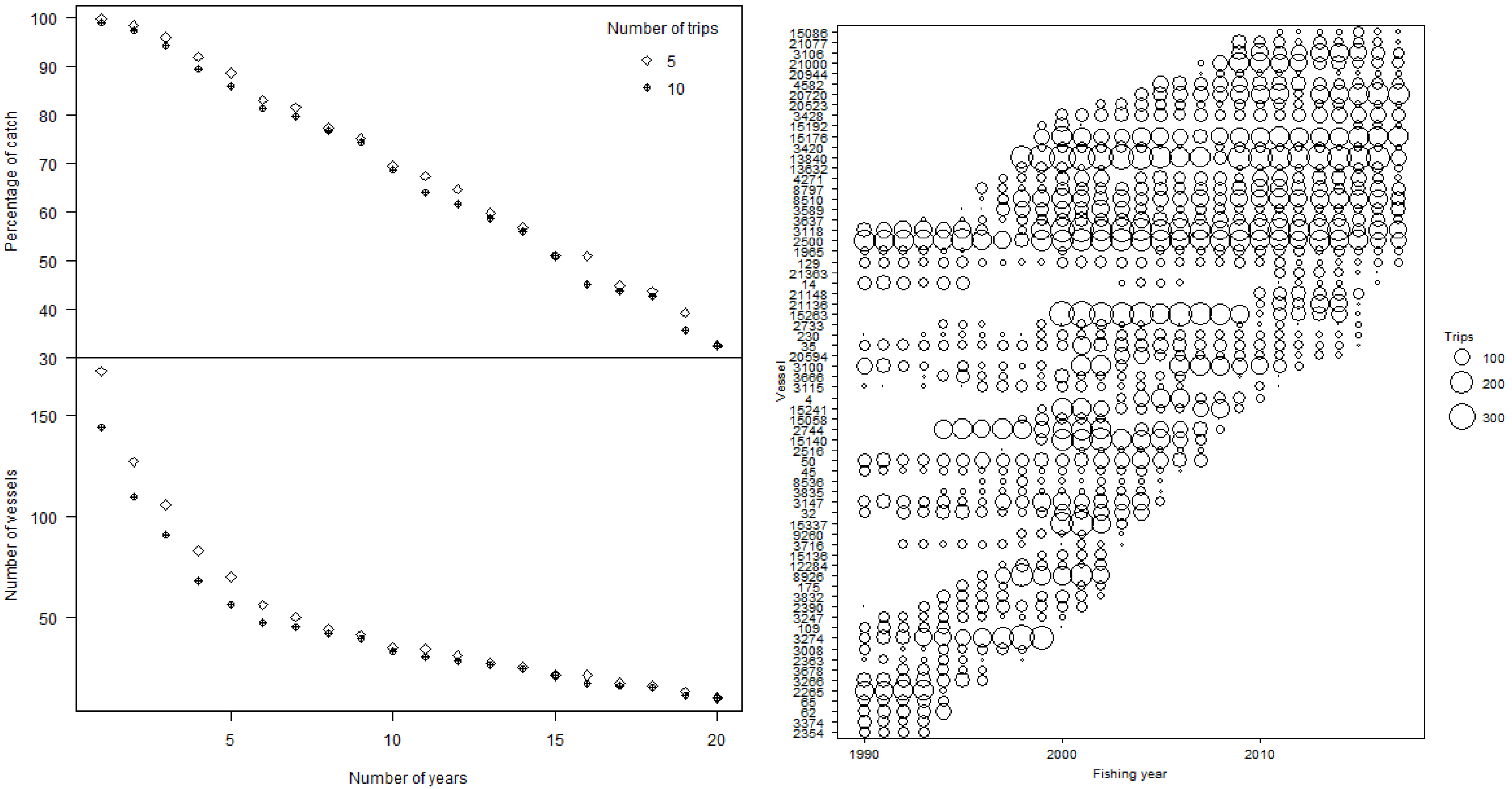

Figure J.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `KH(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

J.1.5 Exploratory data plots for core vessel data set

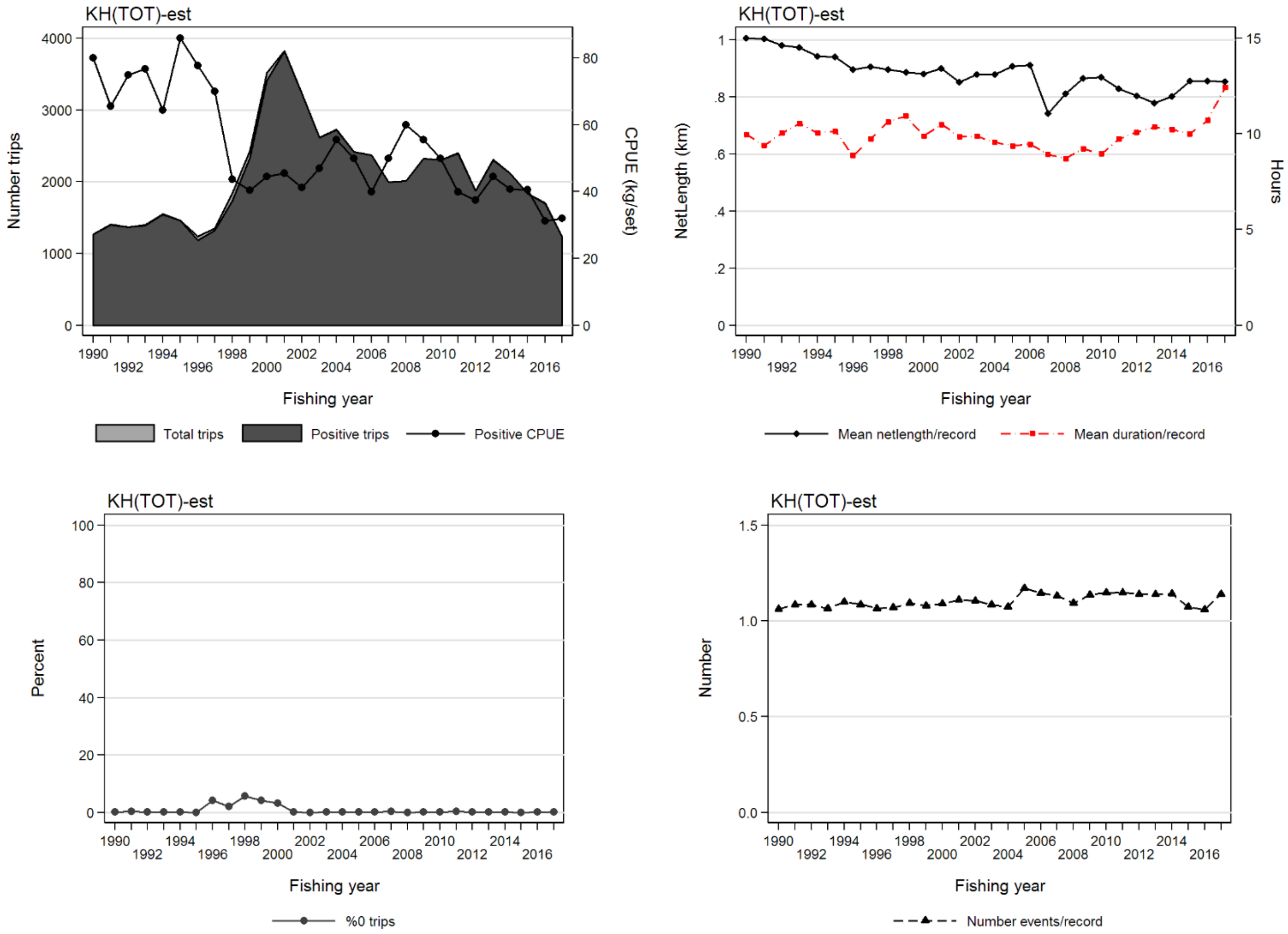

Figure J.2: Core vessel summary plots by fishing year for model `KH(TOT)-est`: [upper left panel]: total trips (light grey) and trips with flatfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of flatfish; [lower right panel]: mean number of events per daily-effort stratum record.

J.2 Positive catch model

All four explanatory variables entered the model after fishing year (vessel, length of net set, month, and duration fishing; Table J.2), with no non-significant variables. A plot of the model is provided in Figure J.3 and the CPUE indices are listed in Table J.3.

Table J.2: Order of acceptance of variables into the log-logistic model of successful catches in the `KH(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 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	29	-312 687	625 433	9.4	*
vessel	96	-304 383	608 958	30.1	*
poly(log(net_length), 3)	99	-303 393	606 985	32.2	*
month	110	-302 593	605 407	33.8	*
poly(log(duration, 3)	113	-301 832	603 890	35.4	*

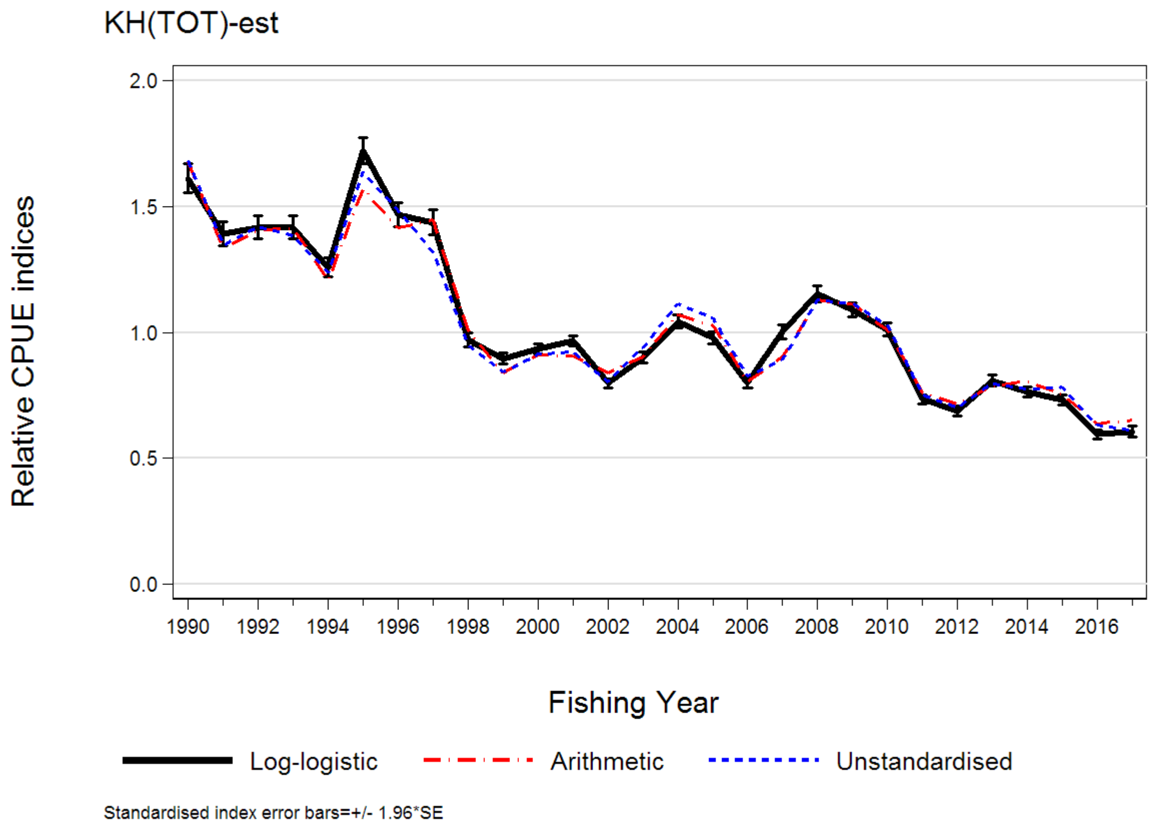

Figure J.3: Relative CPUE indices for estimated FLA catch using the log-logistic non-zero model based on the `KH(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

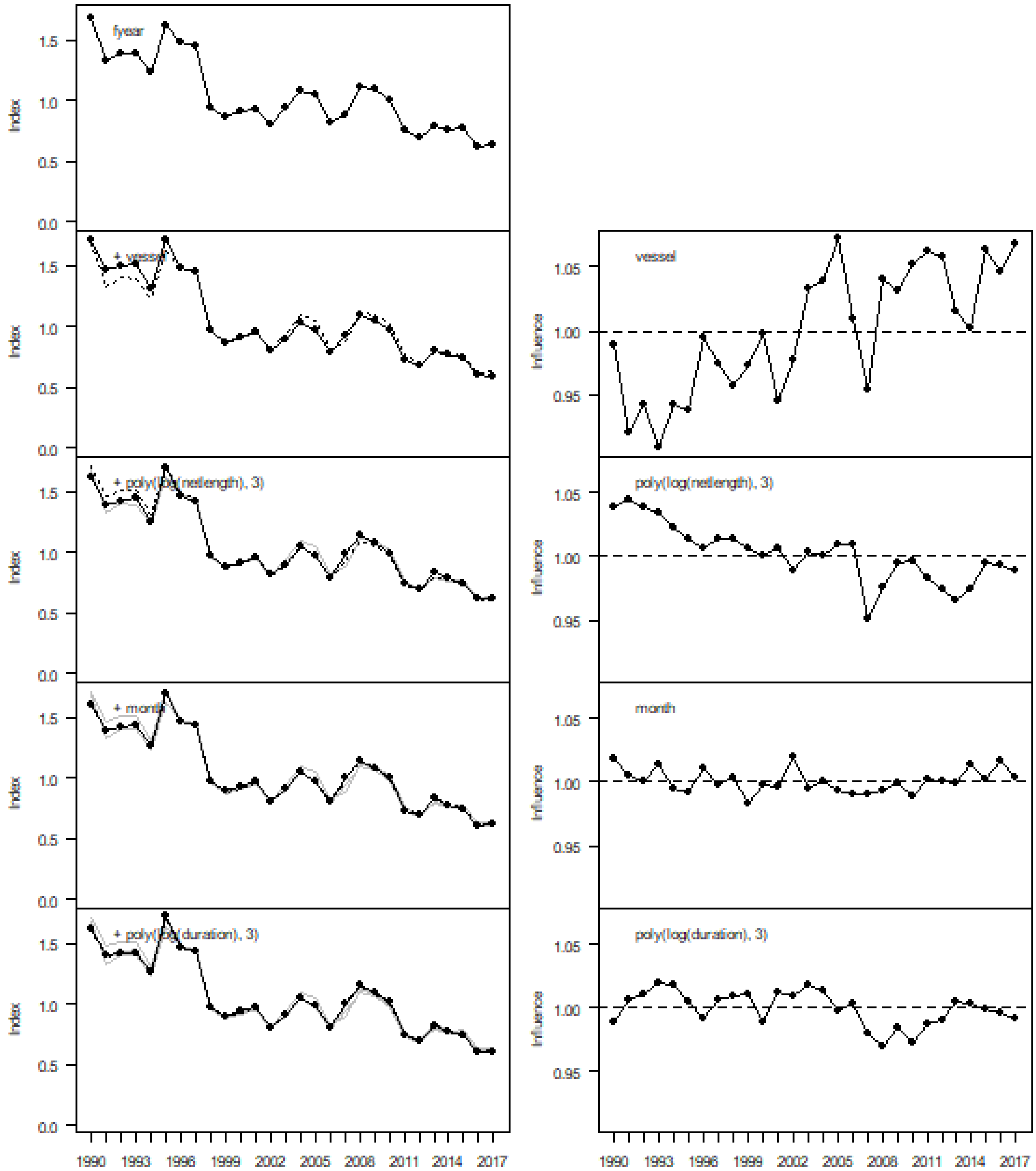

Figure J.4: [left column]: annual indices from the log-logistic model of `KH(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

J.2.1 Residual and diagnostic plots

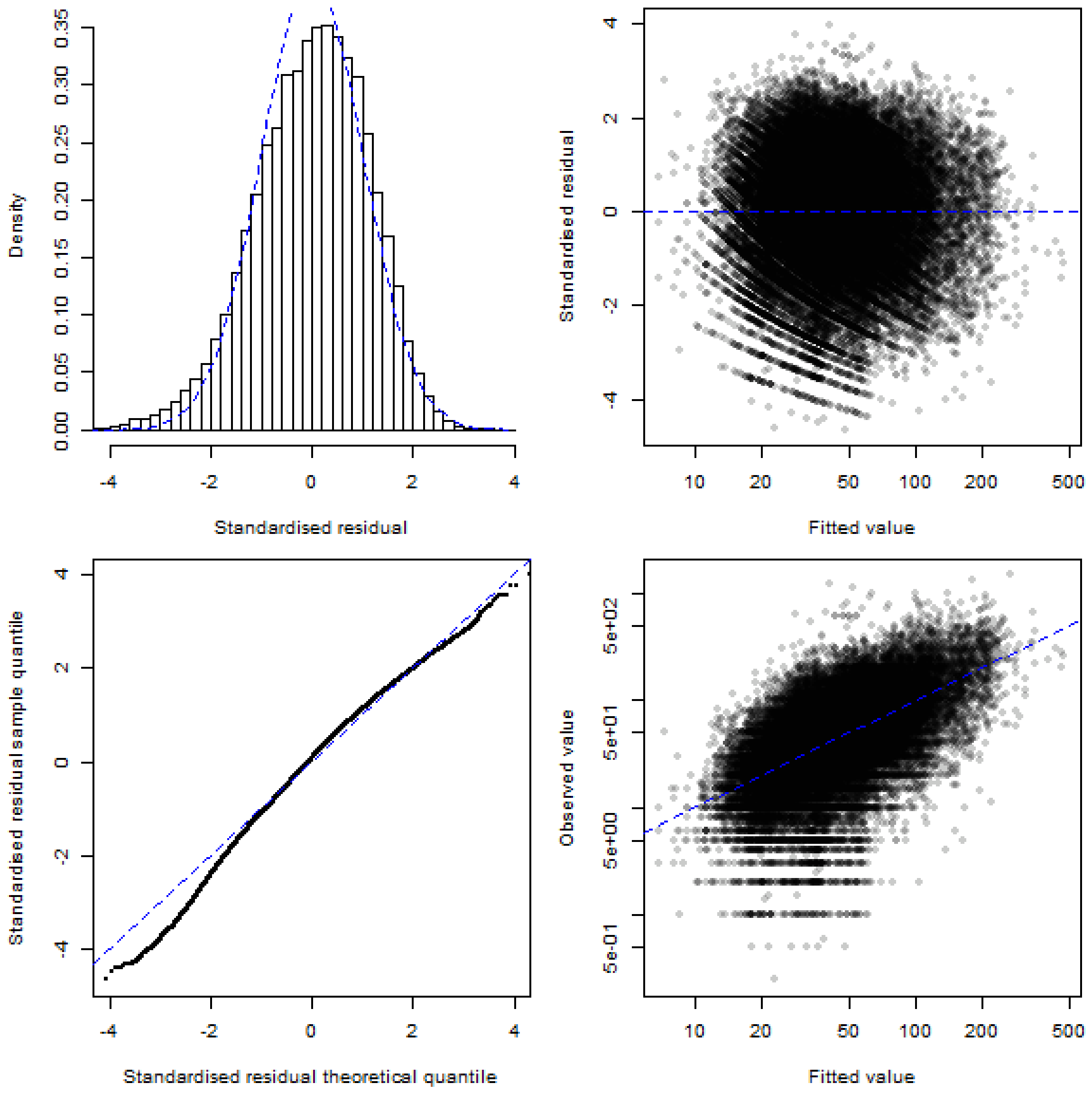

Figure J.5: Plots of the fit of the log-logistic standardised CPUE model of successful estimated FLA catches in the `KH(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a log-logistic distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

J.2.2 Model coefficient plots

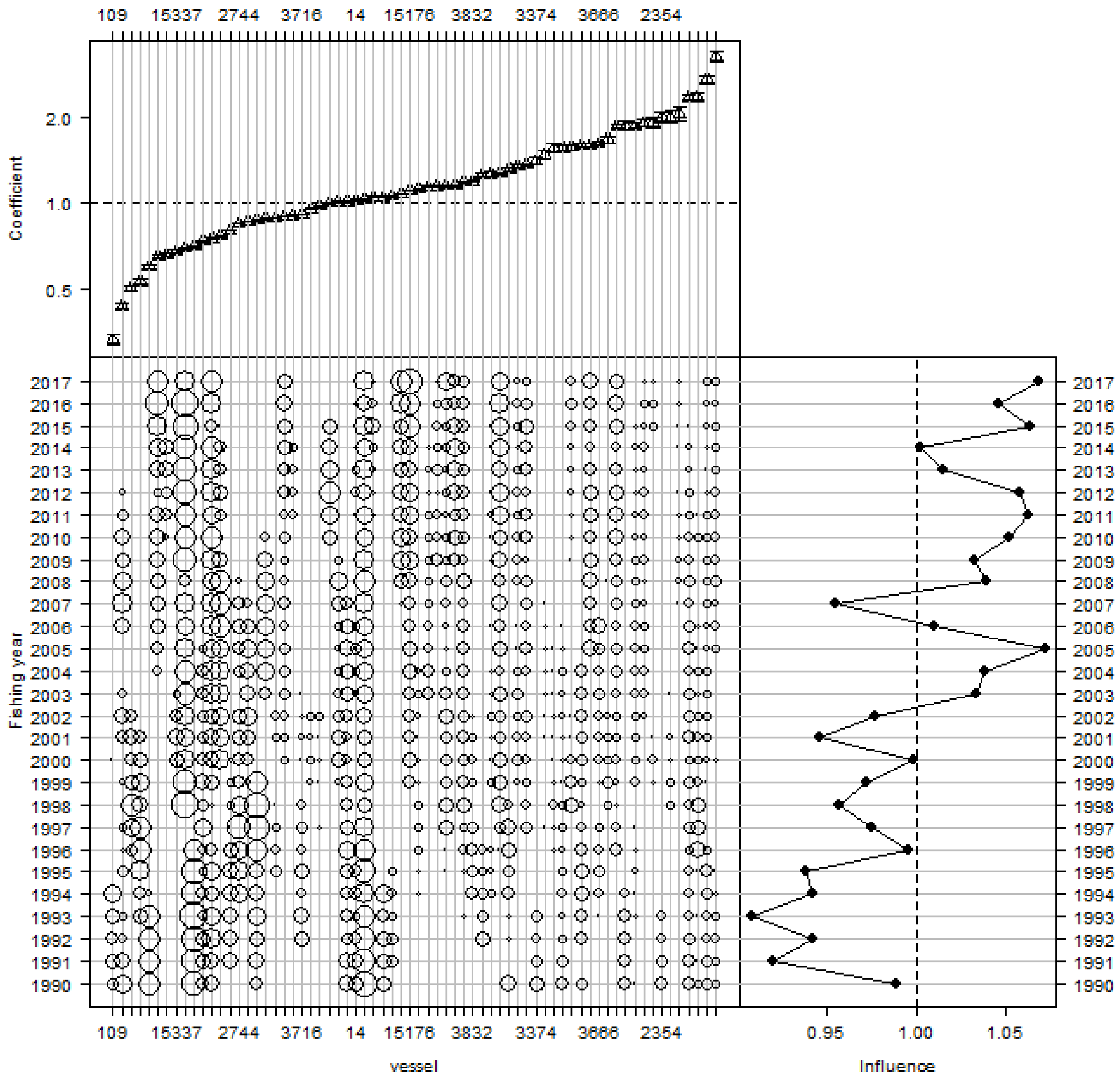

Figure J.6: Effect of vessel in the log-logistic model for the flatfish `KH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

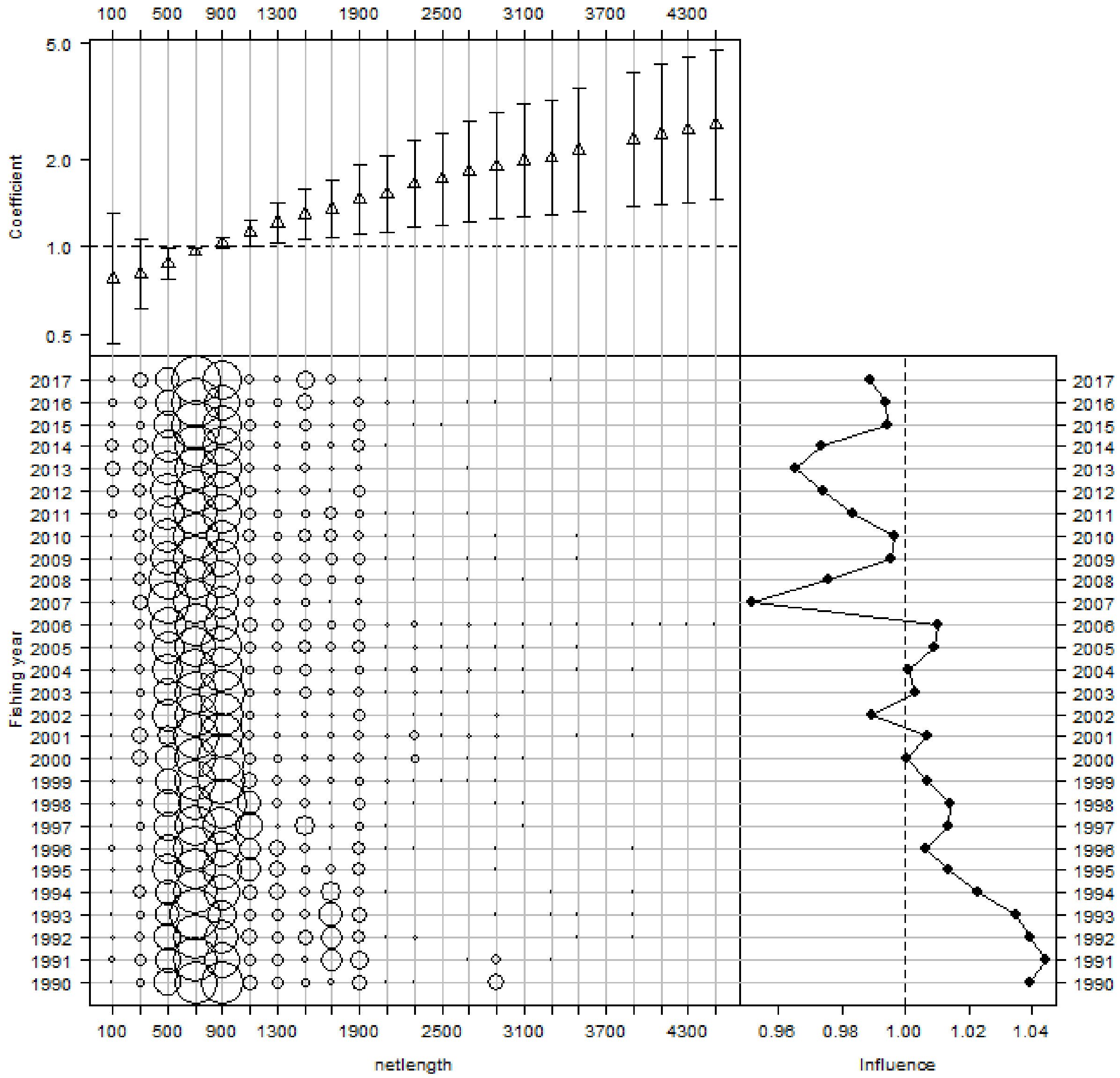

Figure J.7: Effect of log(net_length) in the log-logistic model for the flatfish `KH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

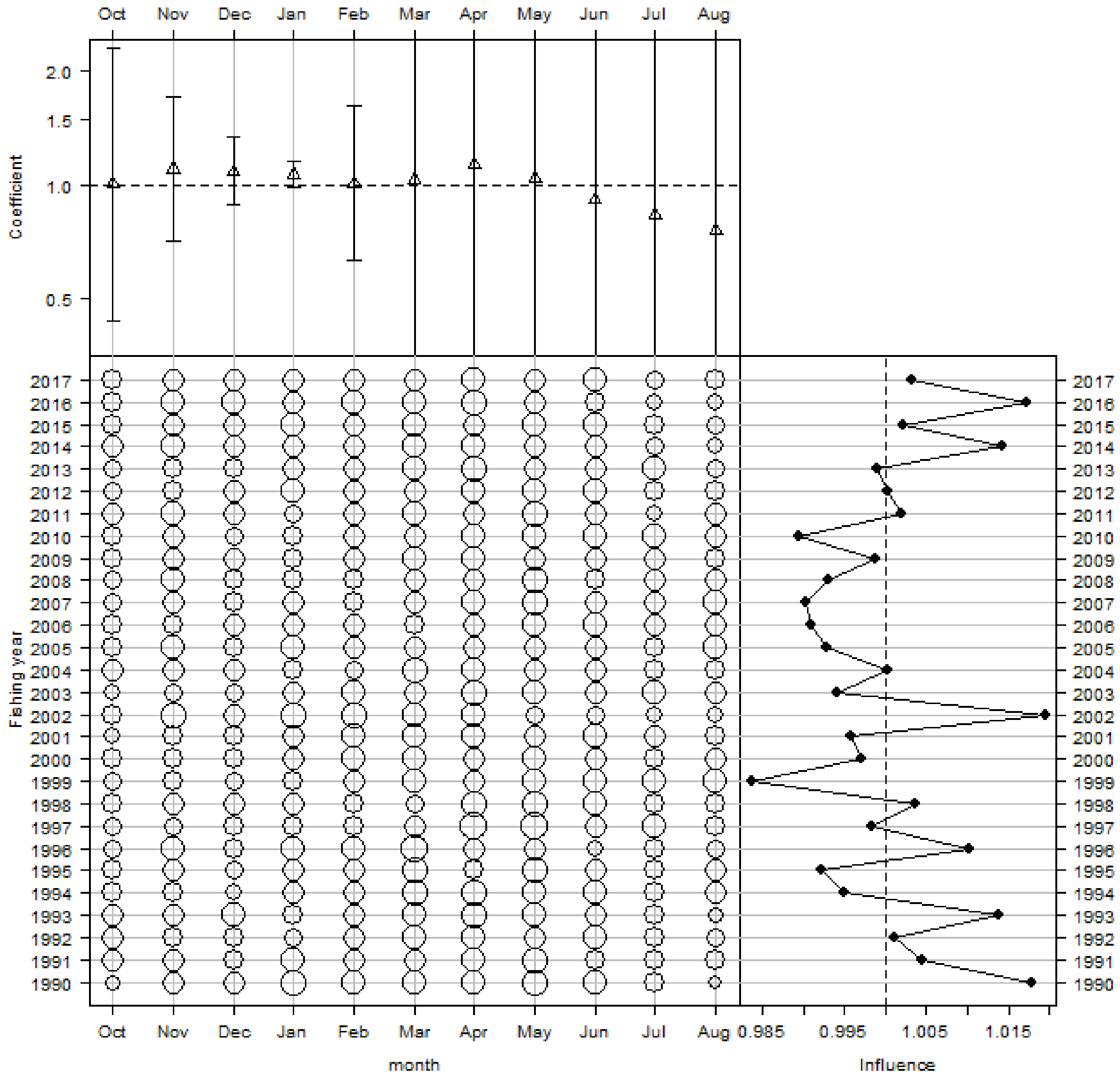

Figure J.8: Effect of month in the log-logistic model for the flatfish `KH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

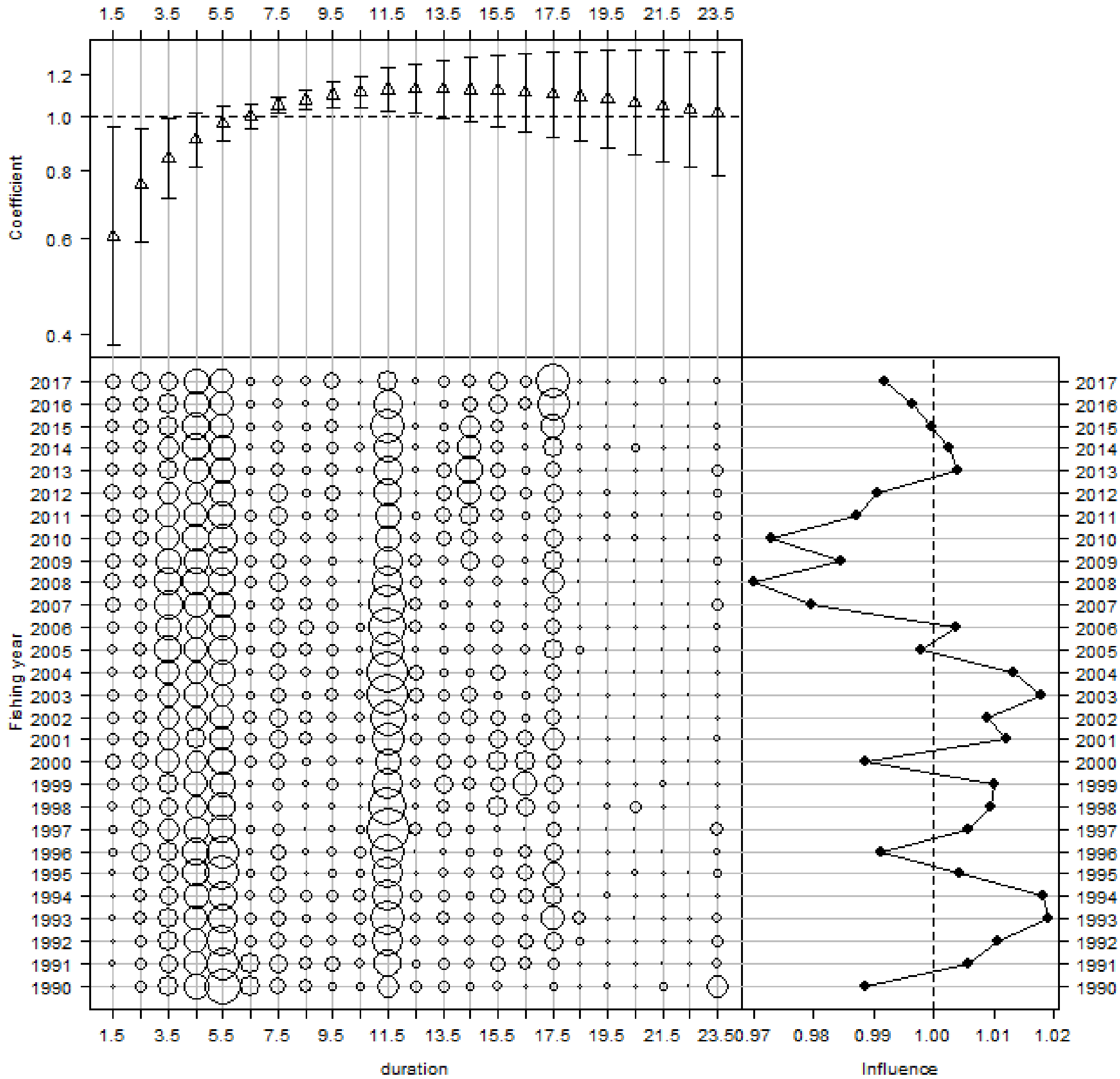

Figure J.9: Effect of log(duration) in the log-logistic model for the flatfish `KH(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

J.3 CPUE indices

Table J.3: Arithmetic indices for the total and core data sets, geometric and log-logistic standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `KH(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.566	1.677	1.683	1.613	0.0182
1991	1.307	1.333	1.347	1.393	0.0173
1992	1.302	1.407	1.420	1.418	0.0166
1993	1.388	1.414	1.386	1.417	0.0161
1994	1.231	1.205	1.239	1.258	0.0154
1995	1.576	1.573	1.640	1.722	0.0150
1996	1.401	1.415	1.486	1.468	0.0167
1997	1.373	1.446	1.322	1.438	0.0176
1998	0.981	1.009	0.951	0.971	0.0148
1999	0.834	0.840	0.842	0.896	0.0130
2000	0.937	0.912	0.913	0.933	0.0110
2001	0.953	0.905	0.923	0.966	0.0102
2002	0.874	0.839	0.803	0.799	0.0114
2003	0.893	0.904	0.939	0.900	0.0120
2004	1.055	1.069	1.114	1.044	0.0118
2005	1.068	1.027	1.057	0.980	0.0126
2006	0.819	0.804	0.826	0.801	0.0126
2007	0.937	0.902	0.892	1.002	0.0143
2008	1.145	1.130	1.129	1.154	0.0140
2009	1.122	1.113	1.113	1.089	0.0130
2010	1.008	1.009	1.029	1.011	0.0130
2011	0.768	0.761	0.752	0.734	0.0130
2012	0.711	0.715	0.701	0.689	0.0144
2013	0.787	0.786	0.798	0.809	0.0132
2014	0.826	0.806	0.775	0.763	0.0138
2015	0.777	0.755	0.782	0.731	0.0146
2016	0.630	0.637	0.631	0.596	0.0152
2017	0.654	0.650	0.611	0.606	0.0184

Appendix K. DIAGNOSTICS AND SUPPORTING ANALYSES FOR HAURAKI GULF YBF ESTIMATED CATCH CPUE

K.1 Model definition and preliminary analyses

This CPUE analysis was accepted by the NINSWG for monitoring Hauraki Gulf yellow-belly flounder (YBF) in 2018 (Fisheries New Zealand 2018).

K.1.1 Fishery definition

`HG(YBF)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 005, 006 and 007 using the YBF species code for the estimated catch (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

K.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of YBF catch. These criteria resulted in a core fleet size of 40 vessels which took 86% of the catch (Figure K.1).

K.1.3 Data summary

Table K.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch YBF (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the `HG(YBF)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1991	18	1 232	1 293	1 443	1.12	1 122.99	8 024	75.06	83.4	83.7
1992	19	1 157	1 181	1 348	1.14	994.46	7 009	88.78	83.2	83.3
1993	21	1 535	1 566	1 735	1.11	1 461.74	9 036	90.36	83.1	83.3
1994	22	1 522	1 572	1 723	1.10	1 489.43	9 168	78.48	88.7	89.0
1995	22	1 505	1 542	1 660	1.08	1 441.59	8 510	84.51	89.0	89.0
1996	21	910	929	1 015	1.09	811.47	5 500	28.96	90.2	90.0
1997	20	1 171	1 199	1 381	1.15	1 161.35	6 192	52.80	91.9	90.8
1998	21	1 030	1 049	1 200	1.14	1 023.13	5 088	44.83	88.9	87.9
1999	20	1 132	1 146	1 317	1.15	1 032.96	5 869	59.89	91.4	90.9
2000	21	1 233	1 248	1 398	1.12	1 140.74	6 413	54.88	91.5	90.7
2001	23	1 518	1 550	1 799	1.16	1 470.65	8 529	74.53	91.0	90.2
2002	24	1 231	1 291	1 489	1.15	1 248.96	7 900	37.64	83.4	79.9
2003	24	1 836	1 914	2 279	1.19	2 158.80	13 070	78.21	65.9	63.9
2004	24	1 636	1 674	2 042	1.22	1 853.99	11 288	74.31	71.8	71.2
2005	24	2 029	2 046	2 412	1.18	2 281.27	13 988	143.67	76.7	76.8
2006	20	1 764	1 777	2 014	1.13	1 900.70	12 372	111.20	72.5	72.5
2007	21	1 569	1 579	1 863	1.18	1 670.05	10 317	86.89	65.2	65.0
2008	19	1 101	1 105	1 314	1.19	1 083.47	6 414	72.83	78.4	78.1
2009	18	1 128	1 152	1 359	1.18	1 091.86	5 978	73.55	83.9	83.9
2010	21	1 261	1 378	1 613	1.17	1 334.91	7 011	95.77	83.2	83.5
2011	18	1 079	1 202	1 382	1.15	1 076.18	5 391	68.94	87.1	87.9
2012	20	1 107	1 264	1 444	1.14	1 151.86	5 726	65.37	84.6	86.1
2013	21	1 358	1 527	1 759	1.15	1 370.45	7 304	72.19	92.5	93.1
2014	19	1 312	1 448	1 643	1.13	1 282.90	6 838	84.32	93.1	93.3
2015	20	1 104	1 219	1 420	1.16	1 096.44	6 351	81.20	94.5	94.8
2016	19	953	1 047	1 207	1.15	924.65	4 934	40.98	93.9	93.8
2017	16	968	1 059	1 238	1.17	873.88	4 636	80.13	94.9	94.7

K.1.4 Core vessel plots

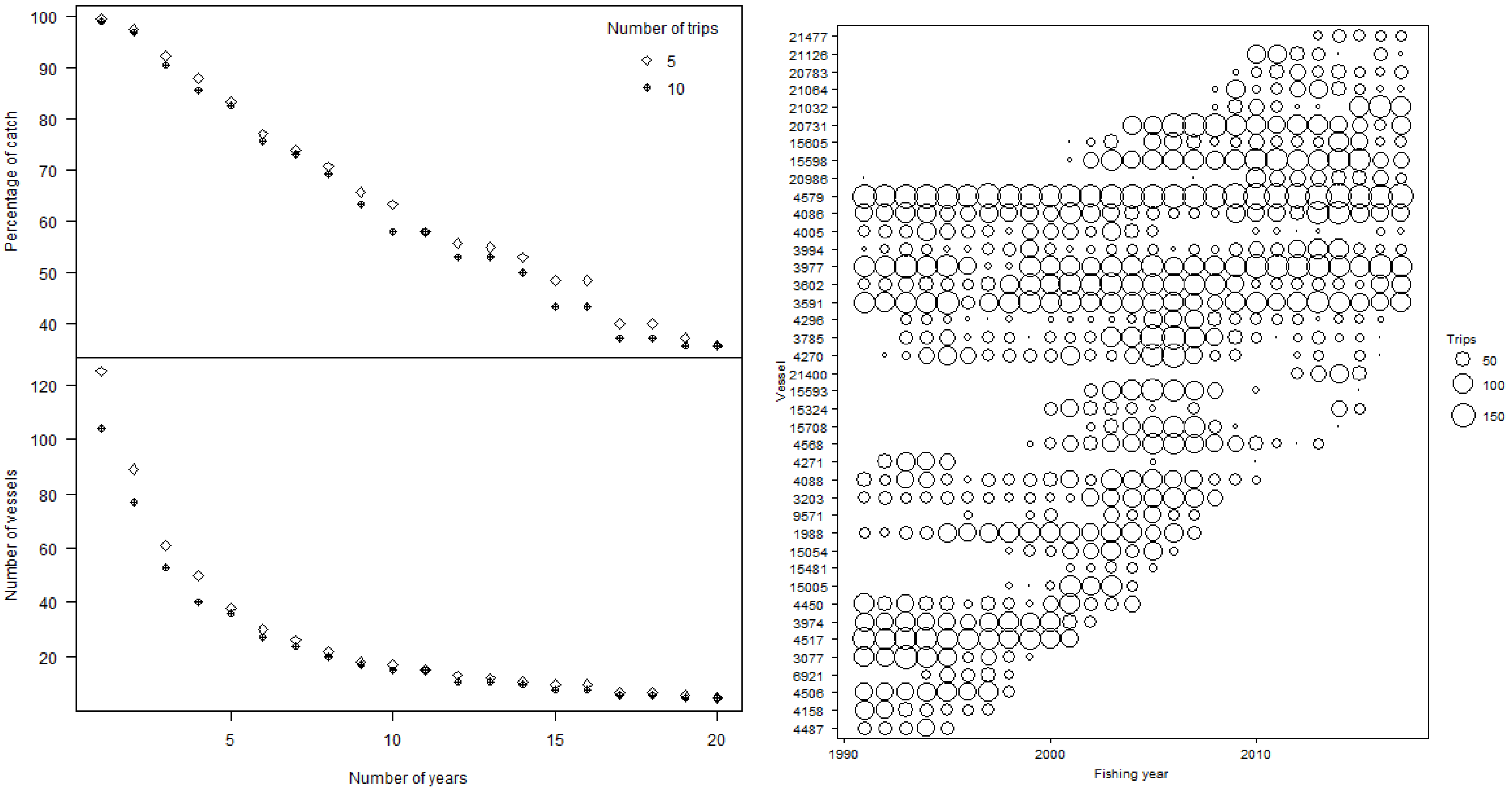

Figure K.1: [left panel]: total estimated YBF catch and number of vessels plotted against the number of years used to define core vessels participating in the `HG(YBF)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

K.1.5 Exploratory data plots for core vessel data set

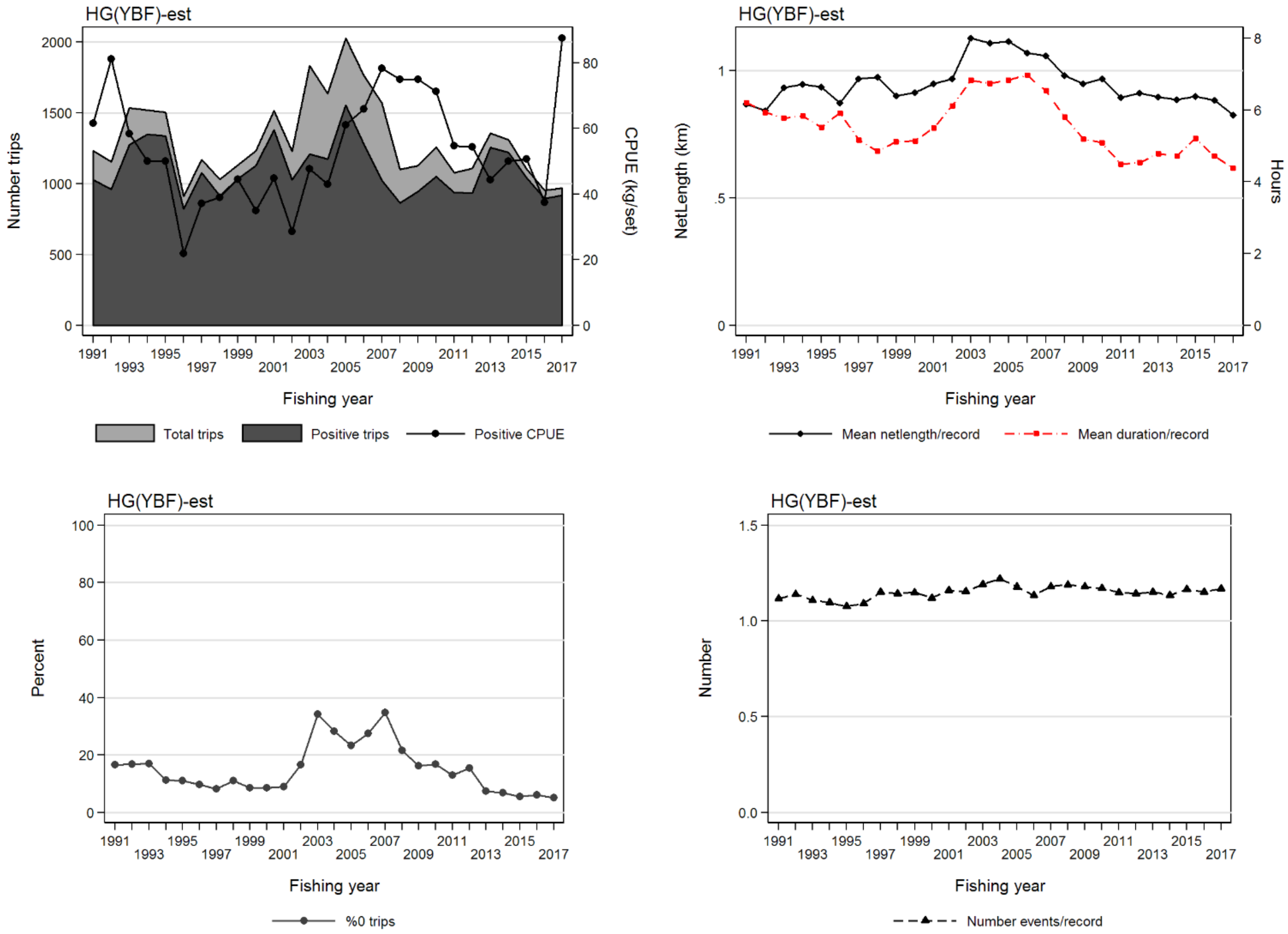

Figure K.2: Core vessel summary plots by fishing year for model `HG(YBF)-est`: [upper left panel]: total trips (light grey) and trips with yellowbelly flounder catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of YBF; [lower right panel]: mean number of events per daily-effort stratum record.

K.2 Positive catch model

All four explanatory variables entered the model after fishing year (vessel, month, length of net set, and duration fishing; Table K.2), with no non-significant variables. A plot of the model is provided in Figure K.3 and the CPUE indices are listed in Table K.3.

Table K.2: Order of acceptance of variables into the gamma model of successful catches in the `HG(YBF)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-157 815	315 686	7.7	*
vessel	66	-154 545	309 224	25.3	*
month	76	-151 940	304 034	36.9	*
poly(log(net_length), 3)	79	-149 405	298 970	46.5	*
poly(log(duration, 3)	82	-148 873	297 913	48.3	*

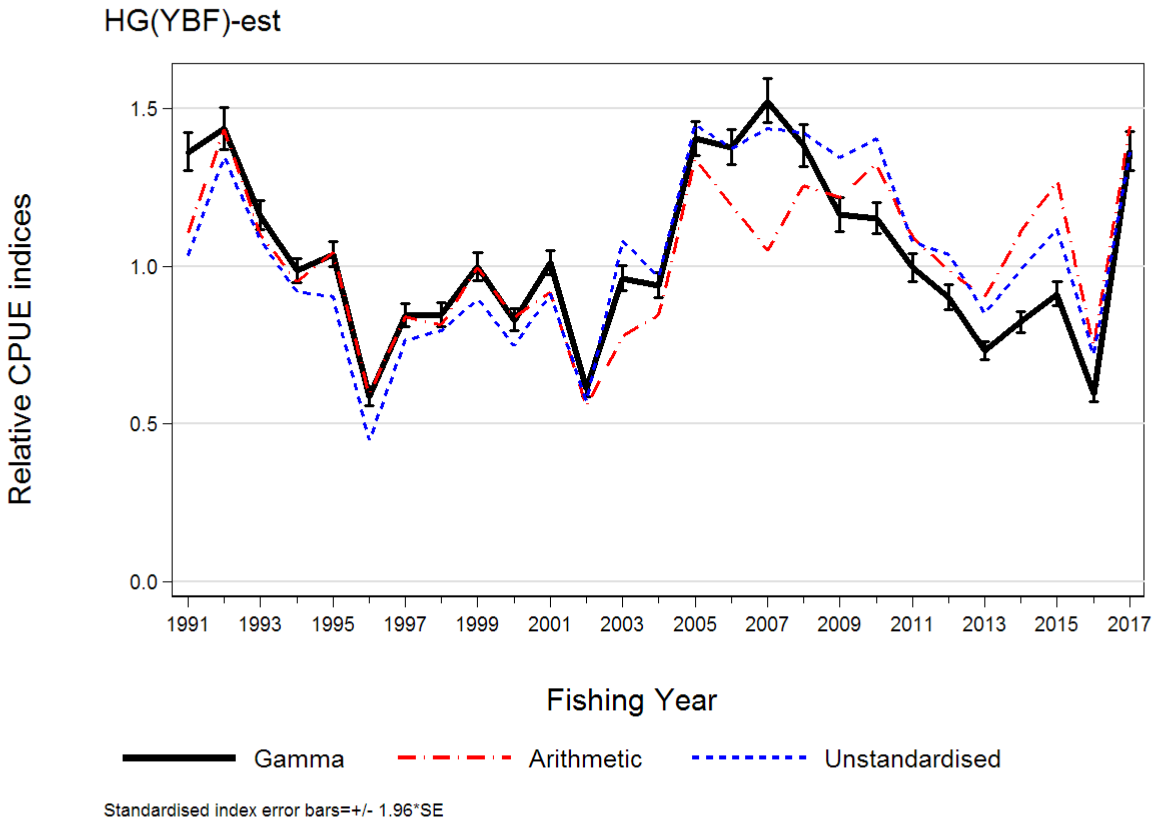

Figure K.3: Relative CPUE indices for estimated YBF catch using the gamma non-zero model based on the `HG(YBF)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

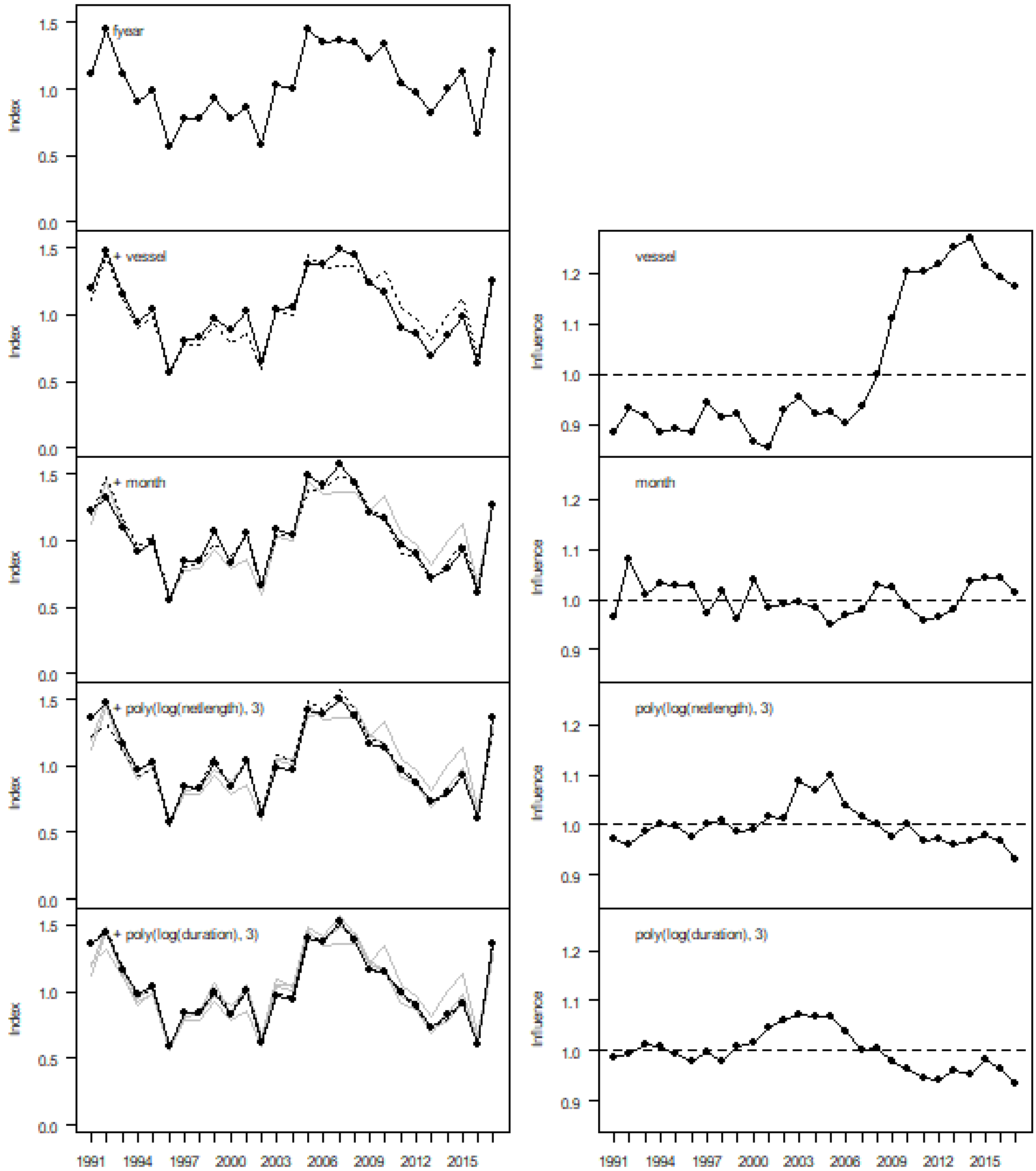

Figure K.4: [left column]: annual indices from the gamma model of `HG(YBF)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

K.2.1 Residual and diagnostic plots

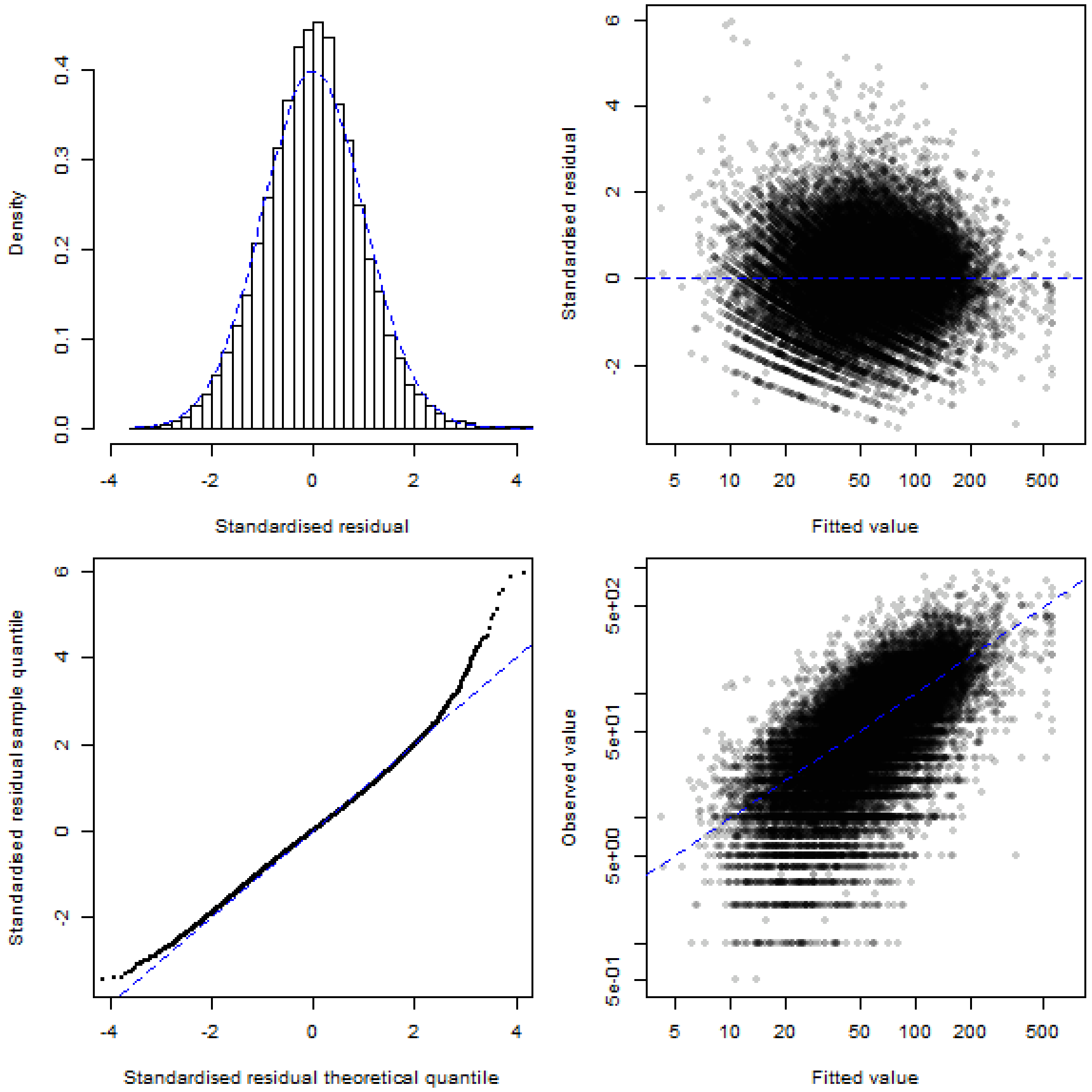

Figure K.5: Plots of the fit of the gamma standardised CPUE model of successful estimated YBF catches in the `HG(YBF)-est` fishery. [Upper left] histogram of the standardised residuals compared to a gamma distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

K.2.2 Model coefficient plots

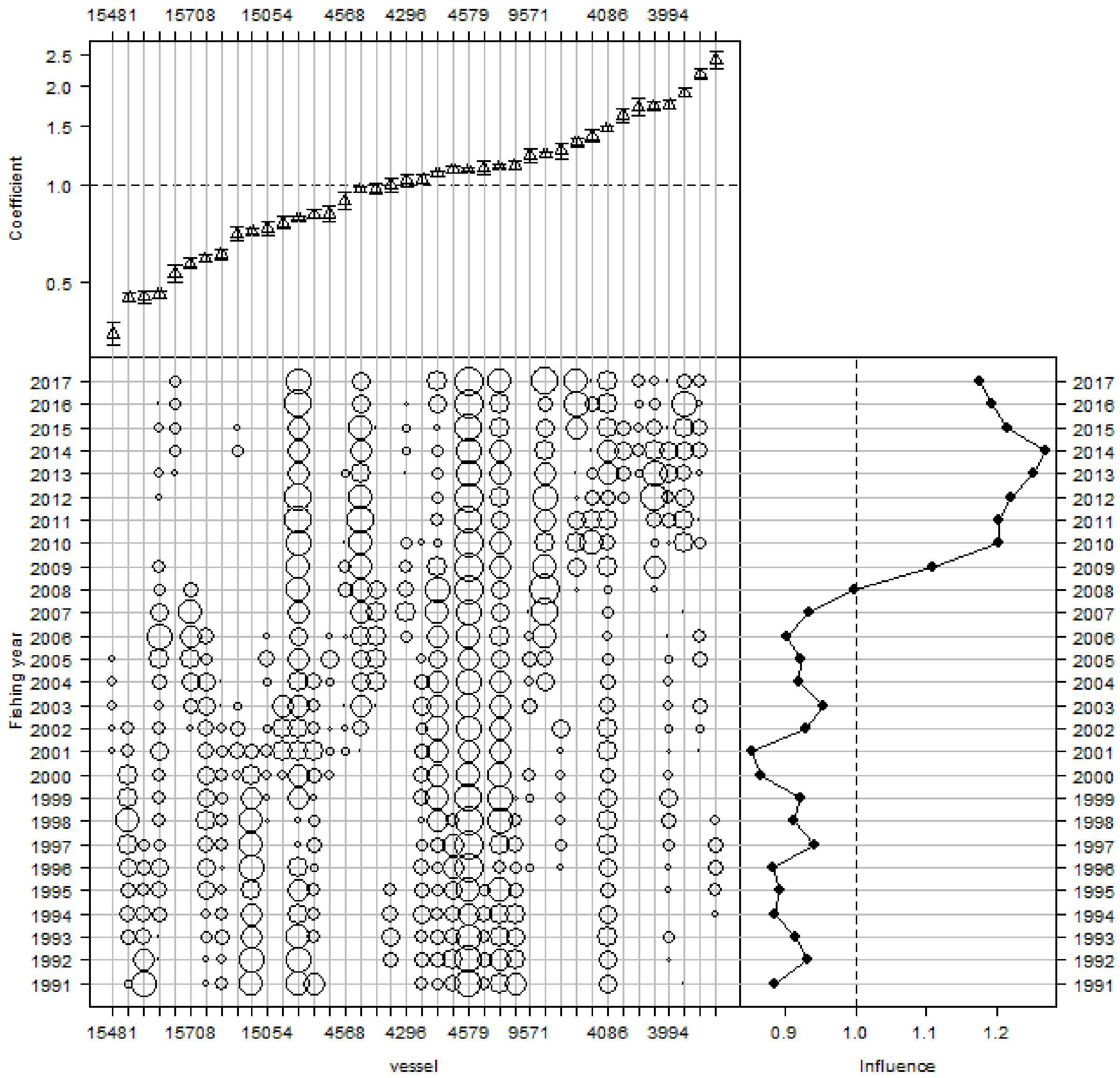

Figure K.6: Effect of vessel in the gamma model for the `HG(YBF)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

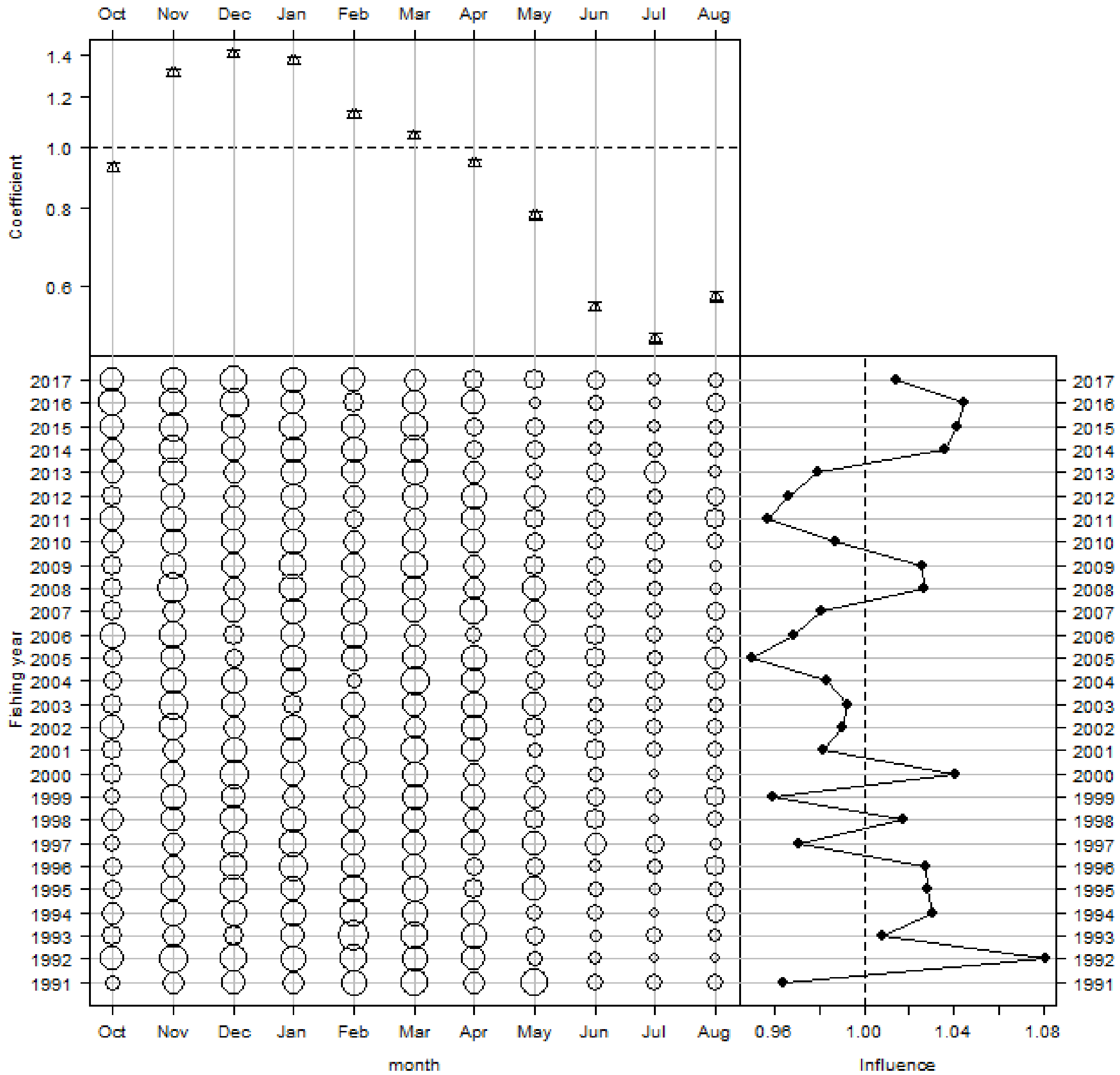

Figure K.7: Effect of month in the gamma model for the `HG(YBF)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

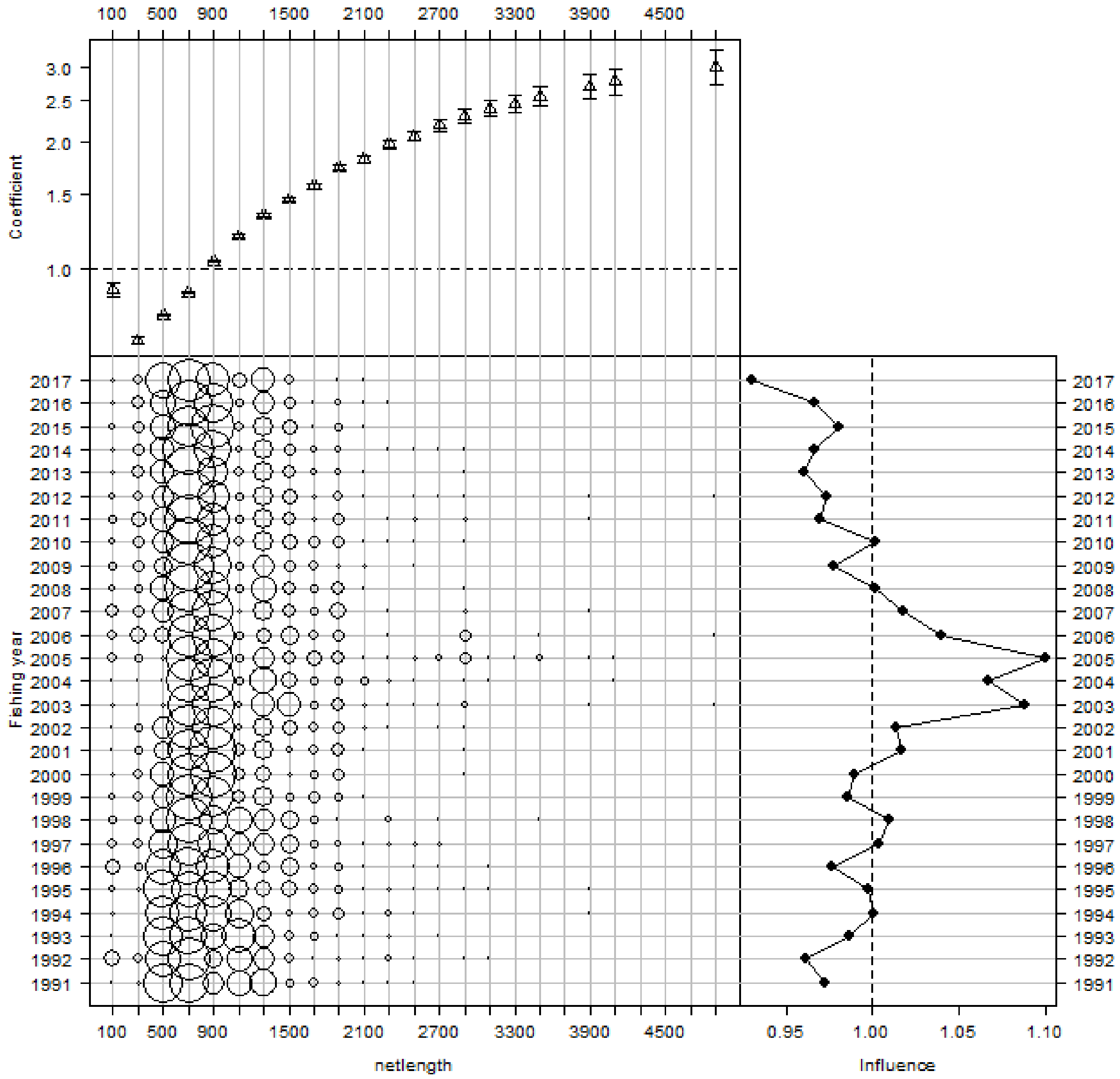

Figure K.8: Effect of log(net_length) in the gamma model for the `HG(YBF)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

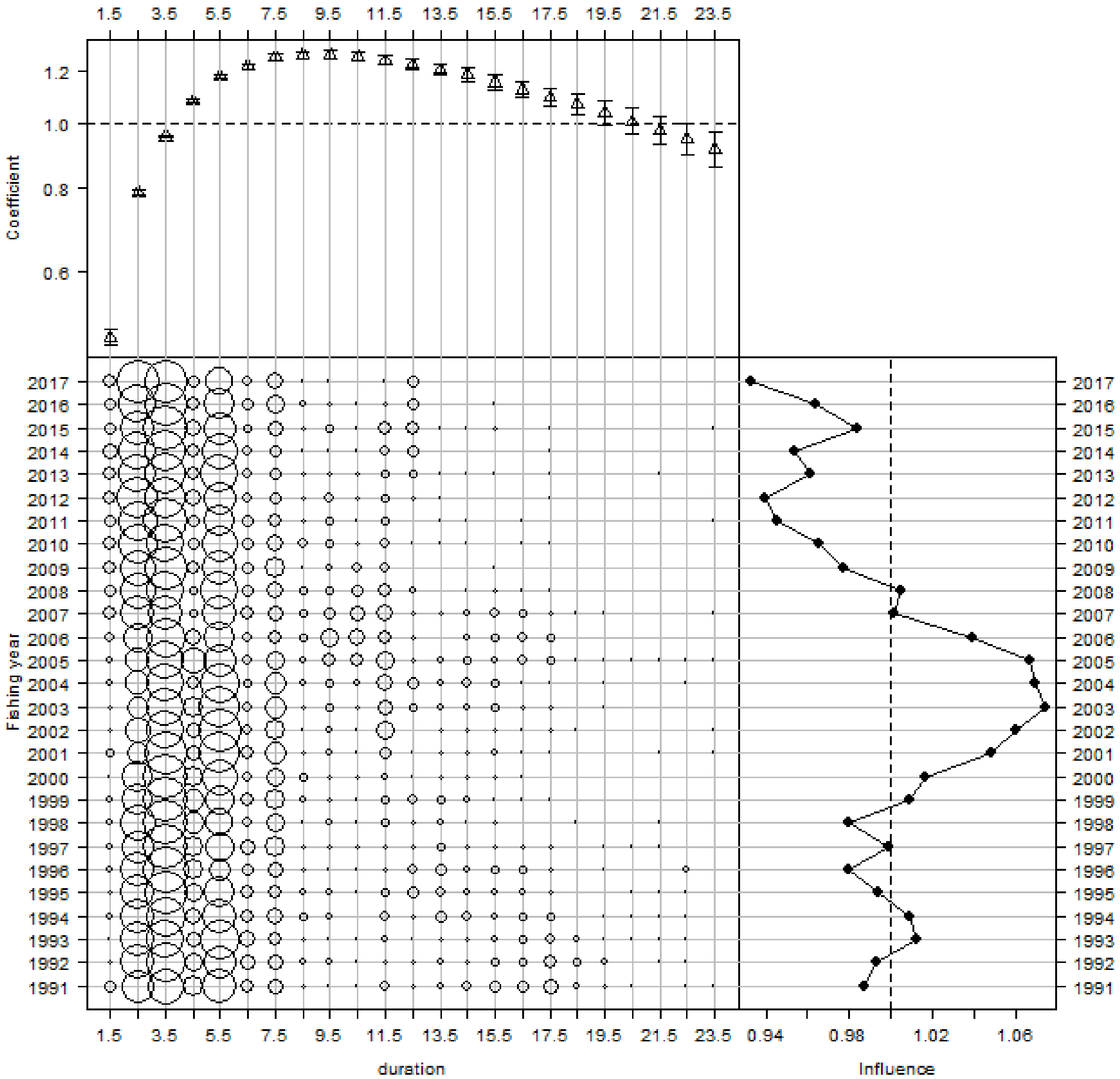

Figure K.9: Effect of log(duration) in the gamma model for the flatfish `HG(YBF)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

K.3 CPUE indices

Table K.3: Arithmetic indices for the total and core data sets, geometric and gamma standardised indices and associated standard error (SE) for the core data set by fishing year for the `HG(YBF)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1991	0.887	1.107	1.035	1.362	0.0225
1992	1.053	1.434	1.347	1.437	0.0235
1993	1.005	1.100	1.083	1.162	0.0203
1994	0.971	0.952	0.919	0.987	0.0199
1995	1.020	1.045	0.905	1.038	0.0198
1996	0.652	0.594	0.447	0.588	0.0251
1997	0.914	0.840	0.767	0.845	0.0220
1998	0.910	0.815	0.797	0.846	0.0235
1999	1.031	0.997	0.896	0.999	0.0221
2000	0.845	0.839	0.748	0.830	0.0214
2001	1.046	0.917	0.912	1.011	0.0197
2002	0.699	0.556	0.573	0.613	0.0226
2003	0.849	0.779	1.083	0.963	0.0209
2004	0.967	0.847	0.966	0.940	0.0209
2005	1.505	1.339	1.451	1.405	0.0192
2006	1.296	1.193	1.374	1.377	0.0204
2007	0.896	1.049	1.438	1.525	0.0228
2008	1.077	1.257	1.423	1.382	0.0244
2009	1.097	1.218	1.344	1.164	0.0230
2010	1.090	1.325	1.406	1.152	0.0216
2011	0.870	1.094	1.077	0.995	0.0223
2012	0.923	0.986	1.039	0.901	0.0220
2013	0.937	0.902	0.851	0.732	0.0195
2014	1.237	1.111	0.988	0.824	0.0201
2015	1.380	1.270	1.119	0.912	0.0215
2016	0.864	0.746	0.719	0.597	0.0232
2017	1.523	1.443	1.361	1.364	0.0227

Appendix L. DIAGNOSTICS AND SUPPORTING ANALYSES FOR HAURAKI GULF FLA(TOT) ESTIMATED CATCH CPUE

L.1 Model definition and preliminary analyses

This CPUE analysis was accepted by the NINSWG for monitoring Hauraki Gulf total FLA in 2018 (Fisheries New Zealand 2018).

L.1.1 Fishery definition

`HG(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 005, 006 and 007 using any FLA species code in Table 16 for the estimated catch (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

L.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 103 vessels which took 87% of the catch (Figure L.1).

L.1.3 Data summary

Table L.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA(TOT) (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the `HG(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	36	1 123	1 218	1 311	1.08	968.93	7 601	106.73	99.9	99.9
1991	45	2 567	2 705	3 002	1.11	2 185.63	19 802	228.32	99.8	99.8
1992	46	2 565	2 652	2 981	1.12	2 206.47	18 563	274.02	99.9	99.9
1993	49	3 007	3 109	3 402	1.09	2 665.50	20 294	281.80	99.7	99.7
1994	47	2 859	3 005	3 250	1.08	2 604.01	18 261	307.33	99.8	99.8
1995	49	2 709	2 805	3 033	1.08	2 417.77	16 517	260.22	99.7	99.7
1996	42	1 499	1 554	1 657	1.07	1 276.95	9 524	94.56	99.6	99.6
1997	36	1 677	1 735	1 949	1.12	1 522.32	9 374	112.29	99.6	99.5
1998	37	1 542	1 590	1 808	1.14	1 475.13	8 643	102.41	99.6	99.6
1999	36	1 741	1 821	2 057	1.13	1 544.79	10 072	123.73	99.6	99.6
2000	39	1 902	1 999	2 215	1.11	1 659.35	11 165	135.72	99.4	99.1
2001	38	2 357	2 461	2 801	1.14	2 117.89	14 693	159.07	99.3	99.3
2002	40	1 861	1 954	2 193	1.12	1 699.52	12 016	91.13	99.4	99.3
2003	48	2 976	3 107	3 590	1.16	3 127.95	22 314	207.49	99.2	99.2
2004	47	2 745	2 854	3 380	1.18	2 868.71	20 862	208.87	99.7	99.1
2005	50	3 451	3 492	4 082	1.17	3 767.73	26 926	362.95	99.8	99.8
2006	45	3 075	3 104	3 464	1.12	3 208.72	25 030	346.49	99.9	99.9
2007	45	2 955	2 979	3 422	1.15	3 007.78	23 343	319.88	99.8	99.8
2008	44	2 035	2 064	2 338	1.13	1 908.38	13 820	209.96	99.8	99.8
2009	43	2 127	2 170	2 426	1.12	2 063.54	14 170	197.52	99.5	99.5
2010	47	2 484	2 628	2 978	1.13	2 540.74	16 337	244.08	99.6	99.6
2011	42	2 269	2 419	2 796	1.16	2 221.65	16 076	156.21	99.3	99.4
2012	45	2 150	2 328	2 653	1.14	2 138.17	13 427	156.83	99.7	99.7
2013	44	2 336	2 523	3 027	1.20	2 301.60	16 803	151.57	99.7	99.7
2014	39	2 133	2 277	2 662	1.17	2 000.53	13 789	169.34	99.8	99.8
2015	38	1 722	1 849	2 140	1.16	1 642.40	10 898	153.62	99.5	99.5
2016	33	1 435	1 536	1 784	1.16	1 419.98	8 647	79.77	99.8	99.8
2017	31	1 554	1 650	1 931	1.17	1 472.96	9 161	191.44	99.9	99.9

L.1.4 Core vessel plots

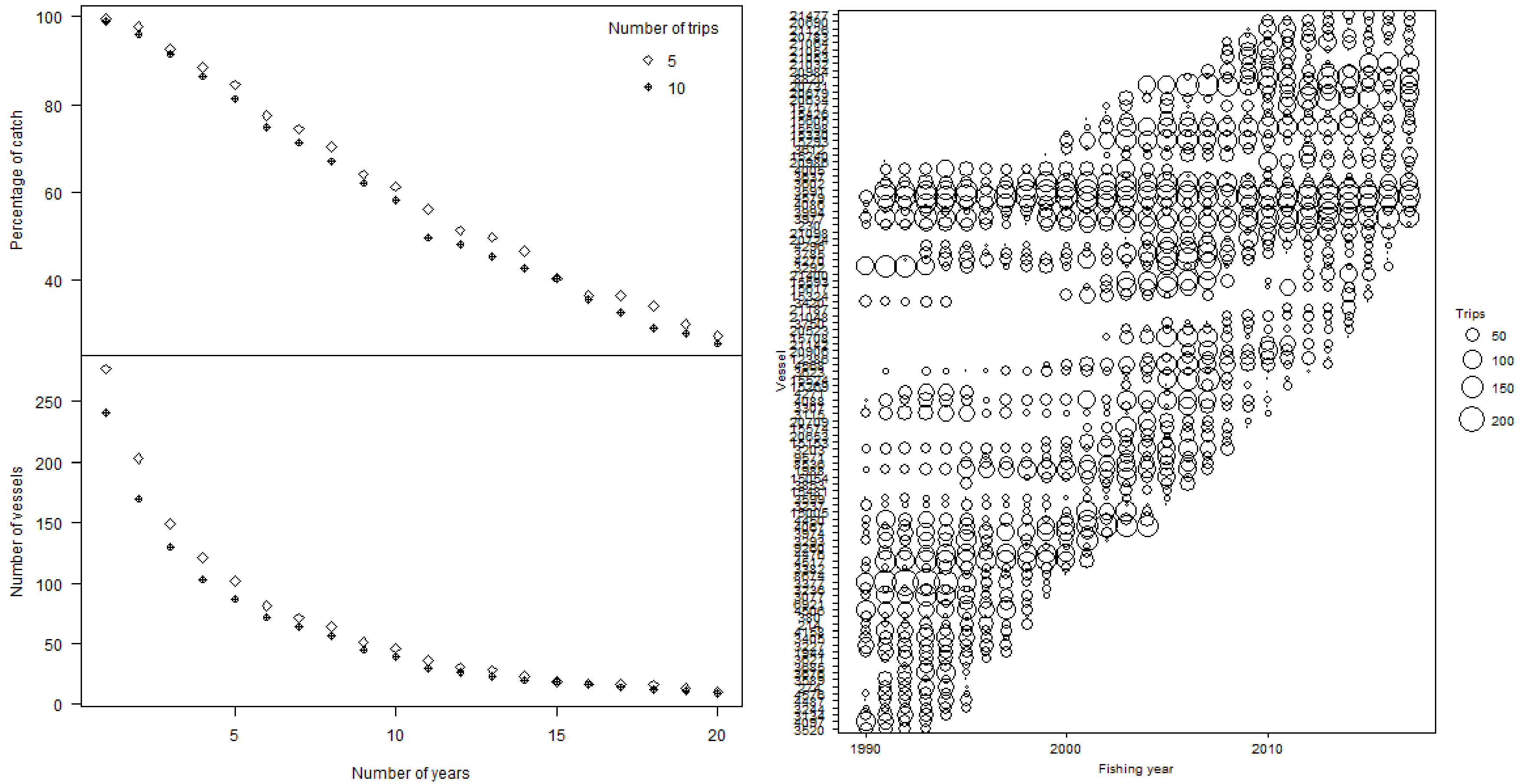

Figure L.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `HG(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

L.1.5 Exploratory data plots for core vessel data set

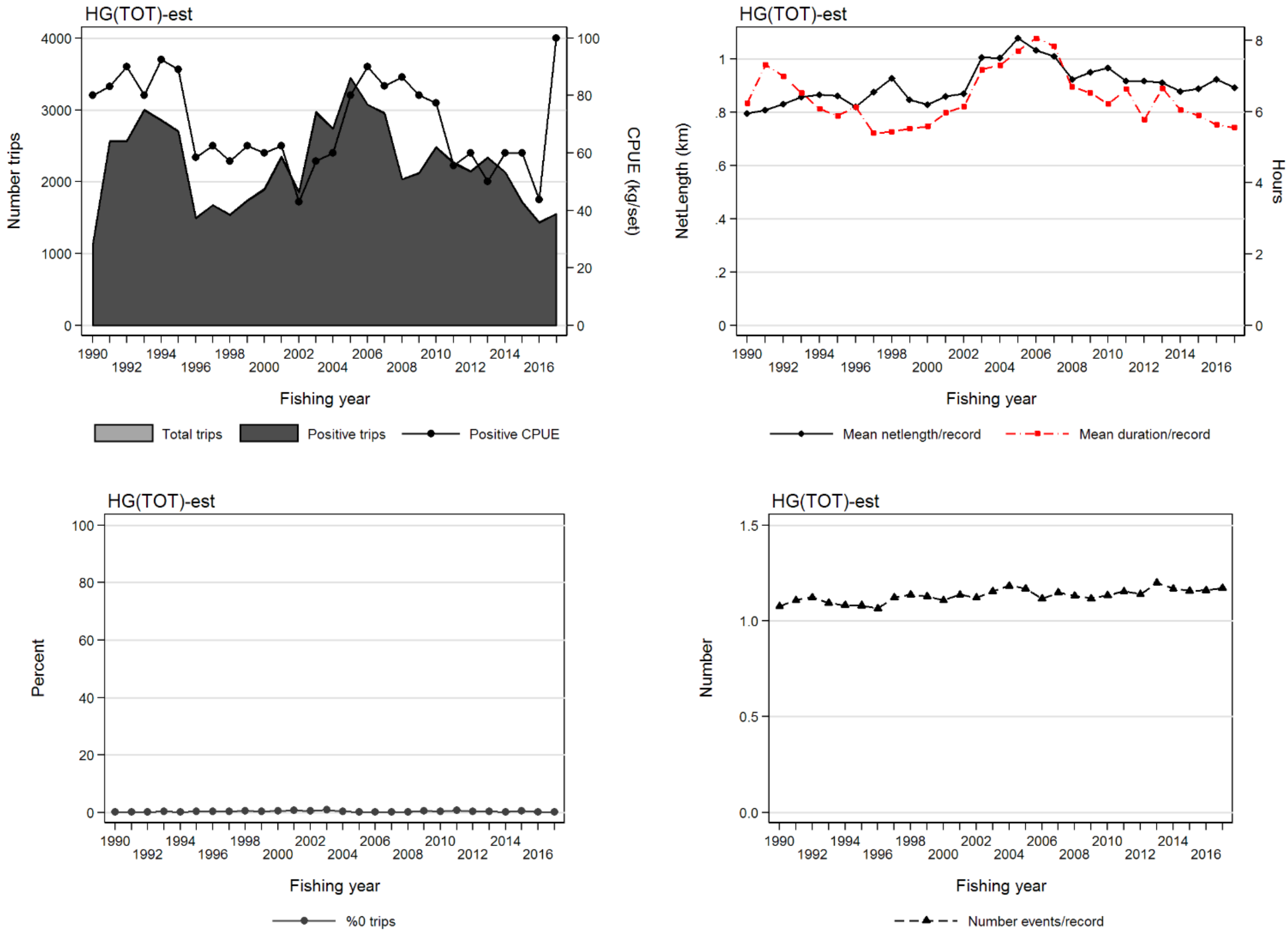

Figure L.2: Core vessel summary plots by fishing year for model `HG(TOT)-est`: [upper left panel]: total trips (light grey) and trips with yellowbelly flounder catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$ **; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated flatfish catch; [lower right panel]: mean number of events per daily-effort stratum record.**

L.2 Selection of distribution for positive catch records

The best distribution was gamma.

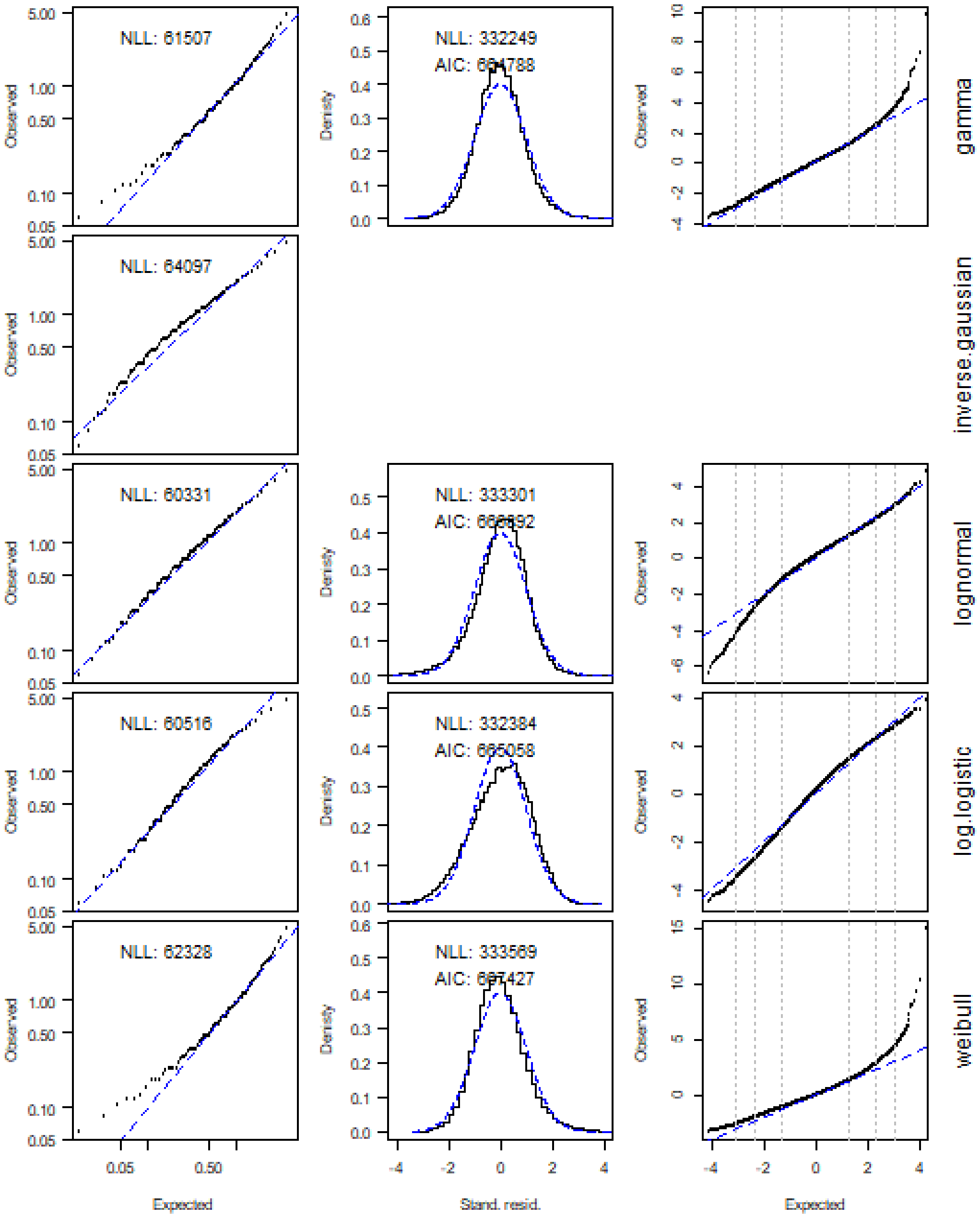

Figure L.3: Diagnostics for alternative distributional assumptions for estimated FLA(TOT) catch in the `HG(TOT)-est` model. Left: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation) in log space) versus maximum likelihood fit of distribution (missing panel indicates that 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 that 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.

L.3 Positive catch model

Four of five explanatory variables entered the model after fishing year (vessel, month, length of net set, and duration fishing; Table L.2), with area as a non-significant variable (there are virtually no data from Areas 005 or 006 in this model). A plot of the model is provided in Figure L.4 and the CPUE indices are listed in Table L.3.

Table L.2: Order of acceptance of variables into the gamma model of successful catches in the `HG(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-347 962	695 982	7.0	*
vessel	130	-337 768	675 798	32.1	*
poly(log(net_length), 3)	133	-334 387	669 042	38.8	*
month	144	-332 249	664 788	42.7	*
poly(log(duration, 3)	147	-331 092	662 480	44.7	*
area	149	-331 083	662 466	44.8	

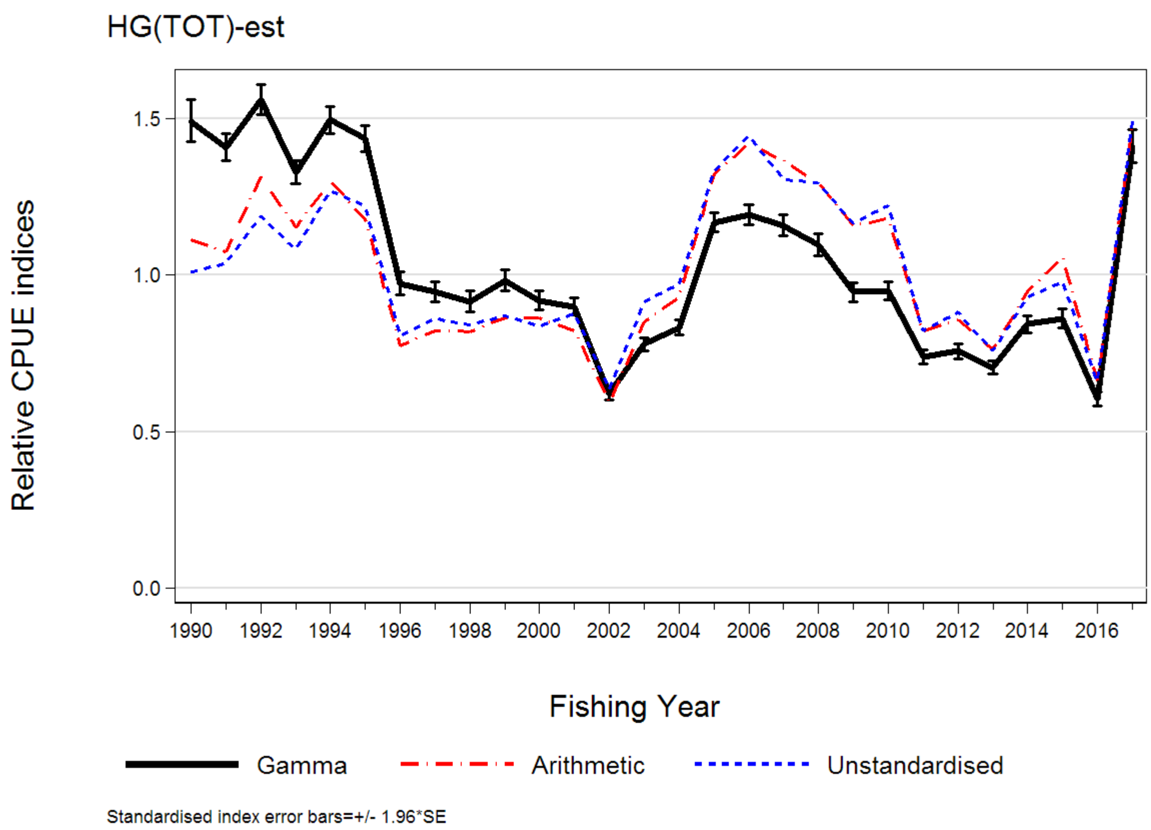

Figure L.4: Relative CPUE indices for estimated FLA(TOT) catch using the gamma non-zero model based on the `HG(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

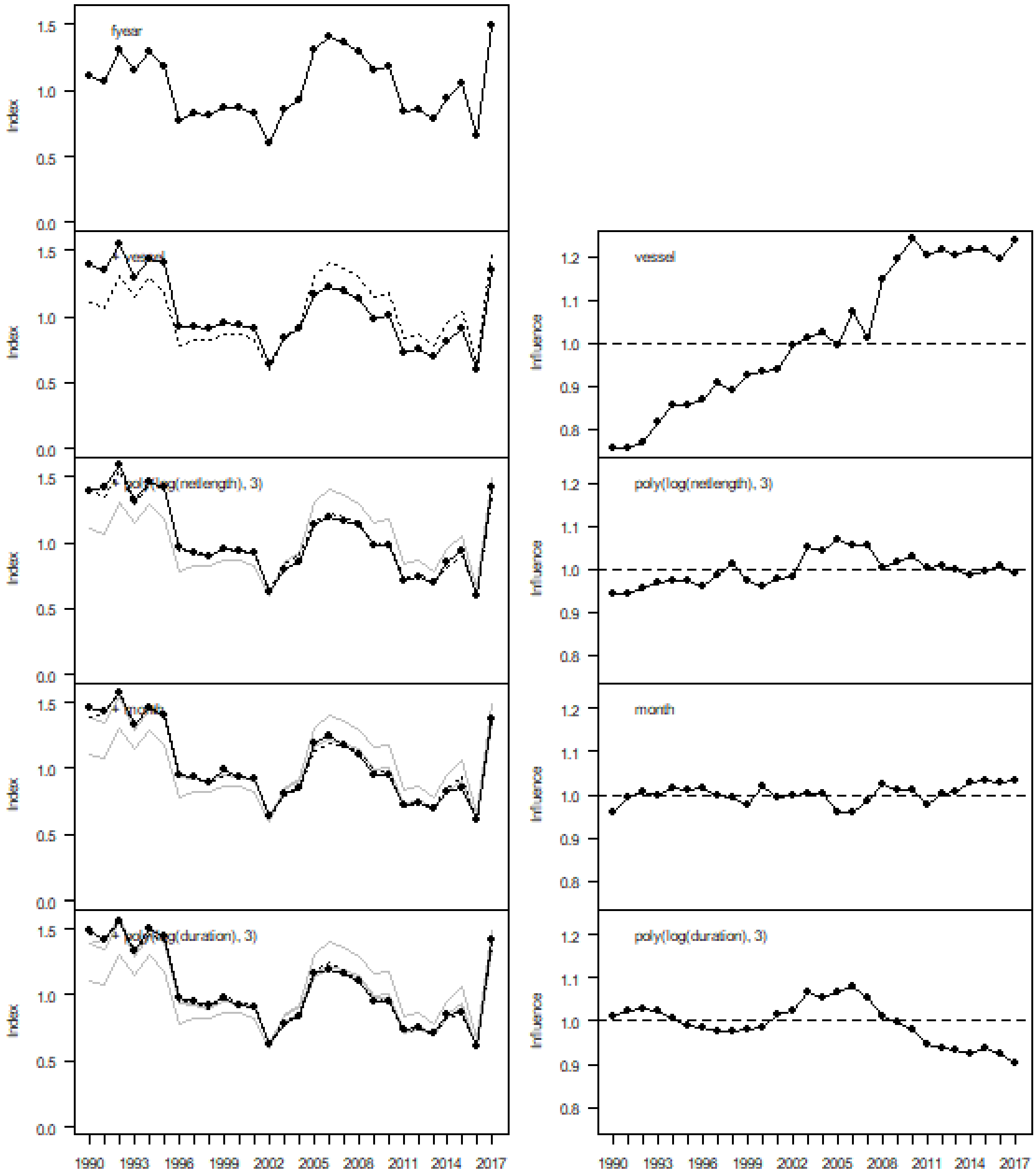

Figure L.5: [left column]: annual indices from the gamma model of `HG(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

L.3.1 Residual and diagnostic plots

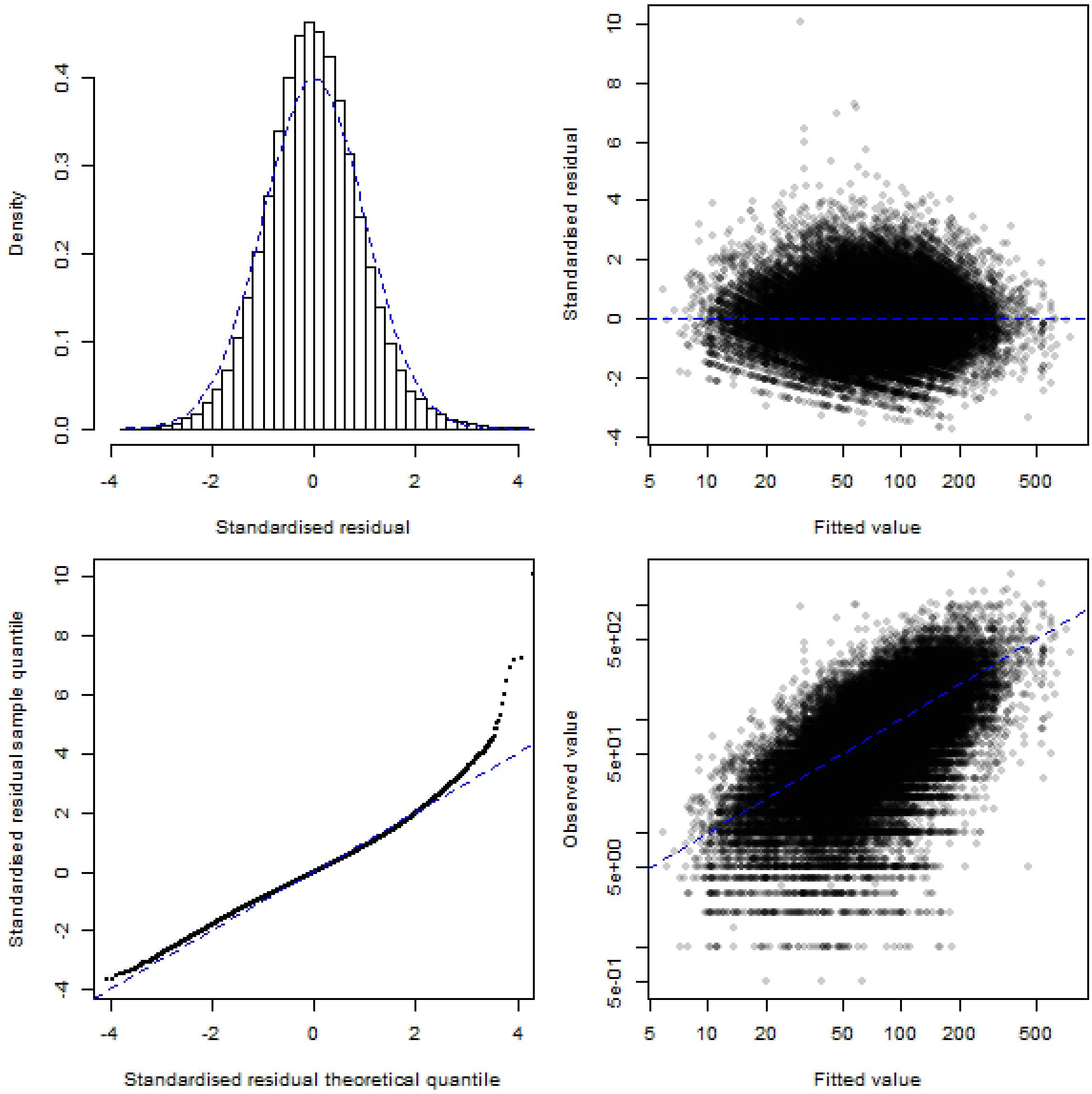

Figure L.6: Plots of the fit of the gamma standardised CPUE model of successful estimated FLA catches in the `HG(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a gamma distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

L.3.2 Model coefficient plots

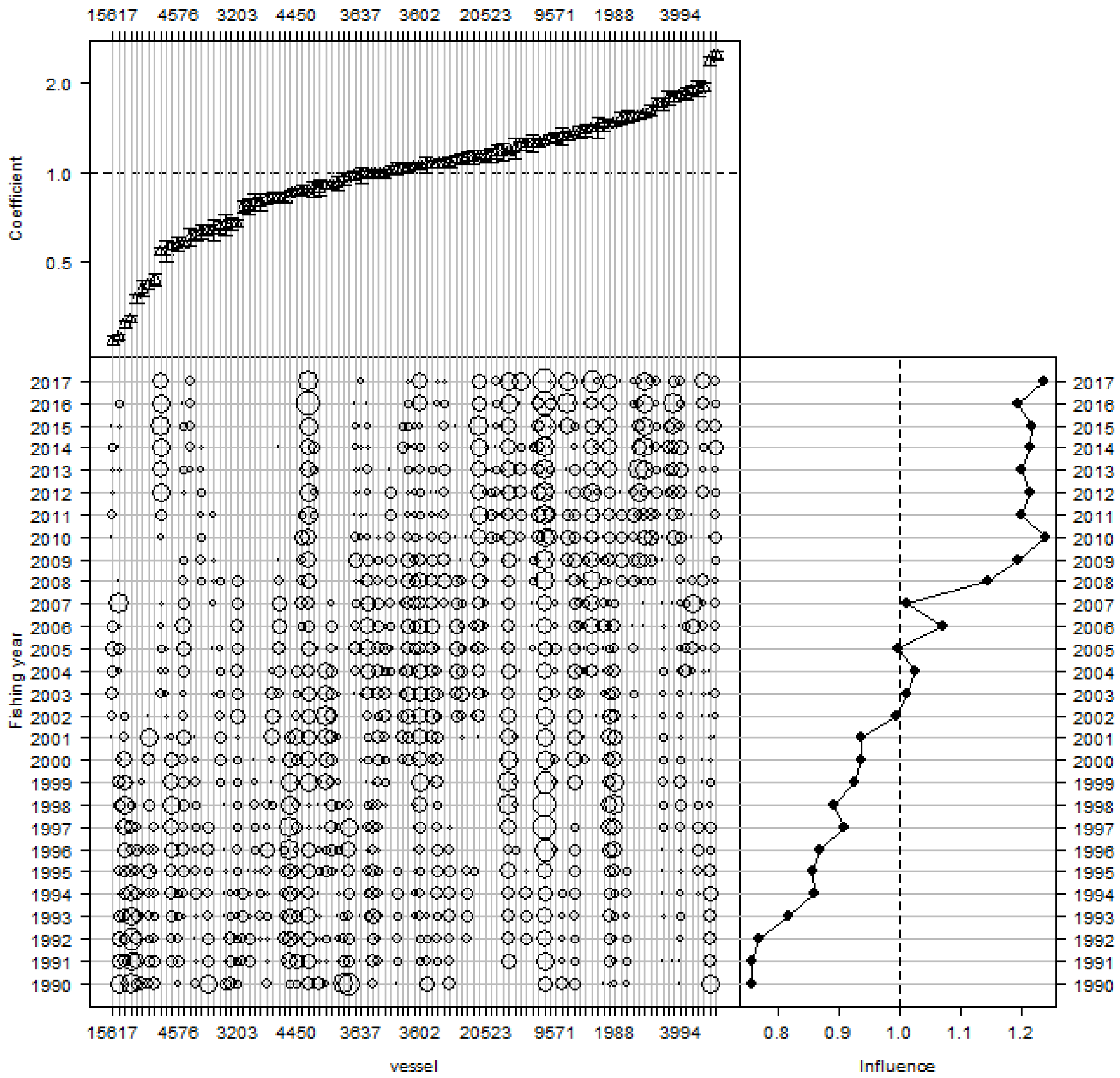

Figure L.7: Effect of vessel in the gamma model for the flatfish `HG(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

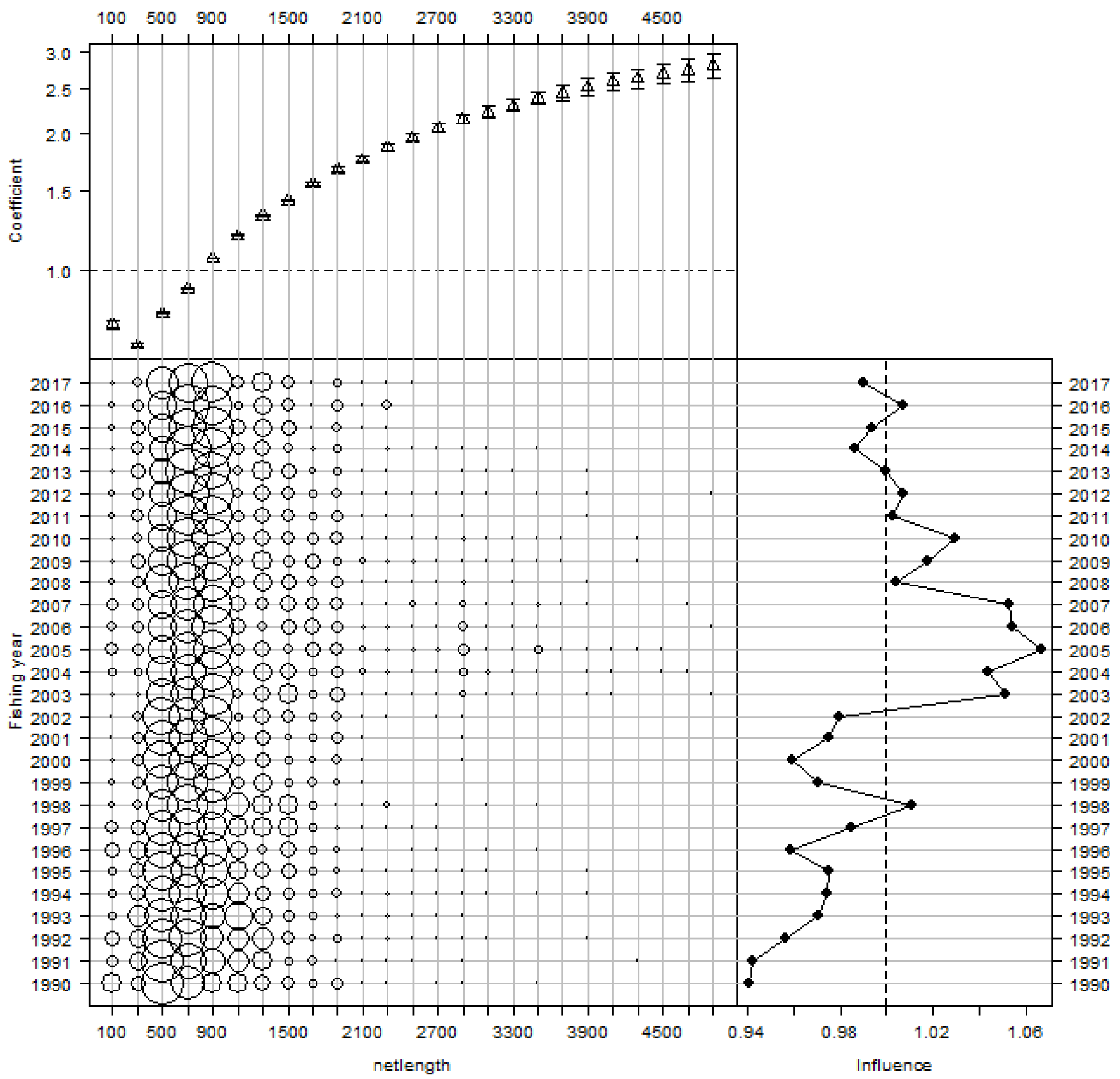

Figure L.8: Effect of log(net_length) in the gamma model for the flatfish `HG(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

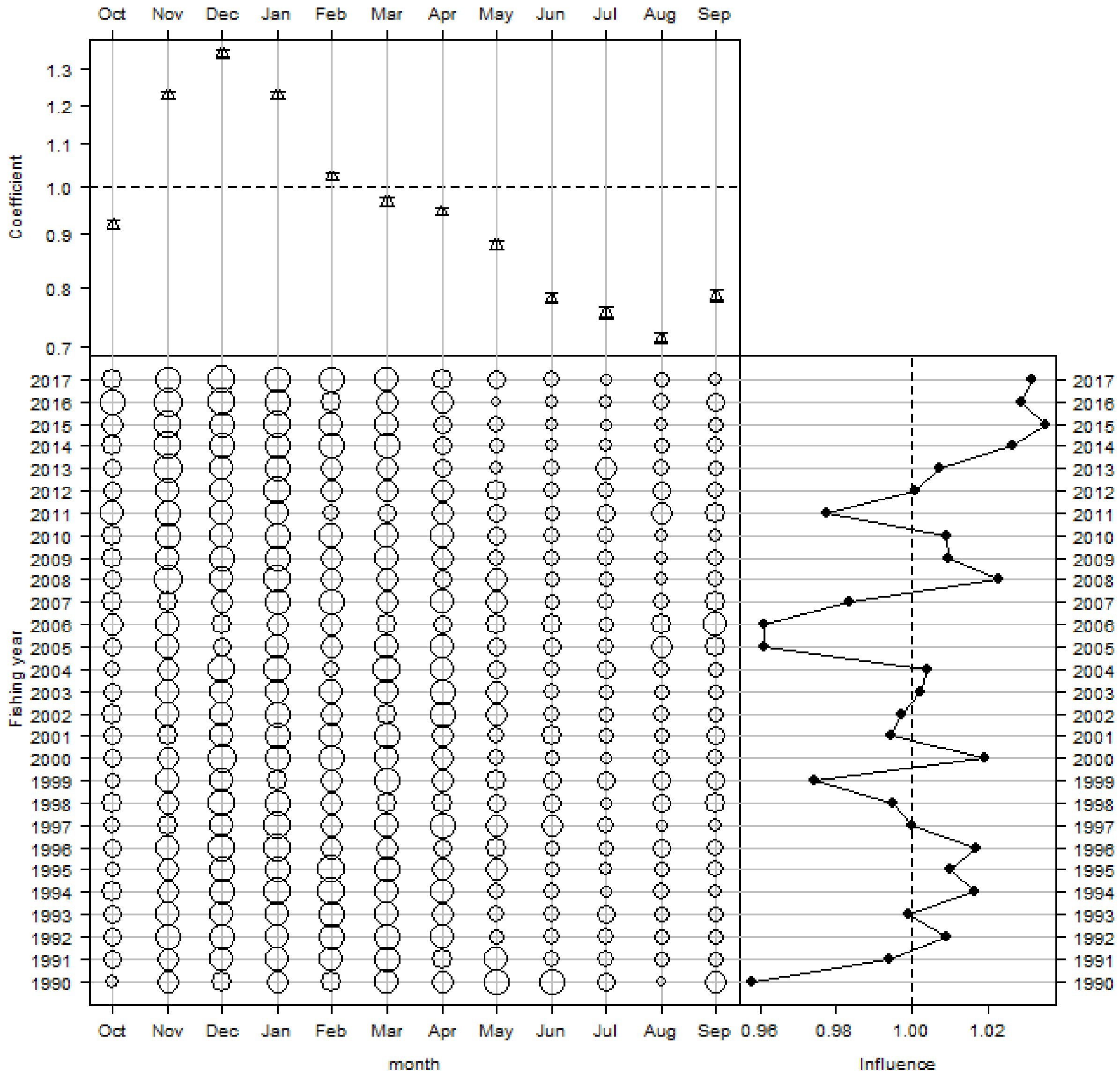

Figure L.9: Effect of month in the gamma model for the flatfish `HG(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

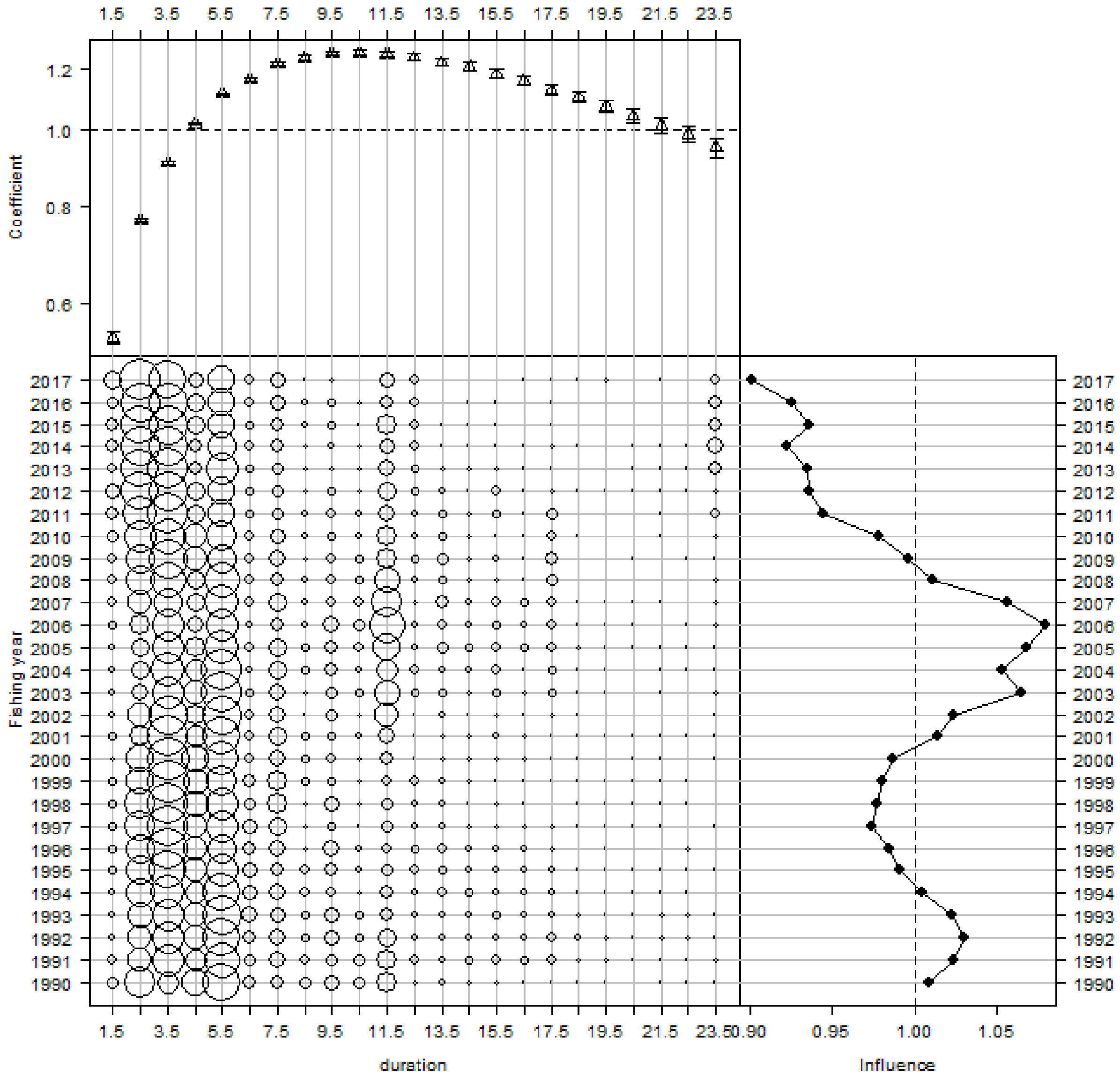

Figure L.10: Effect of log(duration) in the gamma model for the flatfish `HG(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

L.4 CPUE indices

Table L.3: Arithmetic indices for the total and core data sets, geometric and gamma standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `HG(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.164	1.115	1.010	1.492	0.0227
1991	1.138	1.074	1.038	1.409	0.0154
1992	1.300	1.315	1.189	1.560	0.0156
1993	1.168	1.153	1.083	1.329	0.0143
1994	1.350	1.301	1.270	1.496	0.0146
1995	1.209	1.180	1.220	1.437	0.0146
1996	0.797	0.774	0.807	0.972	0.0192
1997	0.815	0.823	0.861	0.946	0.0181
1998	0.822	0.819	0.840	0.916	0.0187
1999	0.860	0.864	0.871	0.982	0.0174
2000	0.829	0.864	0.838	0.918	0.0167
2001	0.848	0.822	0.877	0.900	0.0154
2002	0.595	0.593	0.635	0.621	0.0170
2003	0.830	0.850	0.916	0.779	0.0139
2004	0.941	0.931	0.970	0.832	0.0144
2005	1.347	1.322	1.331	1.167	0.0132
2006	1.448	1.420	1.445	1.193	0.0140
2007	1.349	1.366	1.307	1.159	0.0143
2008	1.285	1.294	1.295	1.097	0.0166
2009	1.143	1.158	1.165	0.945	0.0164
2010	1.125	1.182	1.223	0.950	0.0154
2011	0.790	0.822	0.821	0.739	0.0160
2012	0.847	0.857	0.883	0.757	0.0161
2013	0.749	0.764	0.758	0.705	0.0156
2014	0.951	0.946	0.929	0.843	0.0163
2015	1.053	1.057	0.979	0.861	0.0177
2016	0.654	0.661	0.659	0.603	0.0193
2017	1.427	1.476	1.489	1.411	0.0188

Appendix M. DIAGNOSTICS AND SUPPORTING ANALYSES FOR LOWER WAIKATO ESTIMATED CATCH CPUE

M.1 Model definition and preliminary analyses

This CPUE analysis was not accepted by the NINSWG for monitoring Lower Waikato YBF (assumed) in 2018 (Fisheries New Zealand 2018).

M.1.1 Fishery definition

`LW(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 041 or 042 capturing flatfish using any species code in Table 16 (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

M.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 16 vessels which took 87% of the catch (Figure M.1).

M.1.3 Data summary

Table M.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the `LW(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	8	272	280	304	1.09	119.30	1 449	9.24	100.0	100.0
1991	8	333	369	381	1.03	133.85	1 778	9.54	100.0	100.0
1992	9	391	420	451	1.07	136.92	2 034	11.02	100.0	100.0
1993	10	406	445	474	1.07	150.63	2 210	15.74	100.0	100.0
1994	9	330	349	362	1.04	124.34	1 743	11.92	100.0	100.0
1995	10	395	415	454	1.09	171.58	2 205	14.87	100.0	100.0
1996	10	350	406	449	1.11	166.04	2 118	13.87	100.0	100.0
1997	10	402	445	484	1.09	189.36	2 284	19.52	99.8	99.8
1998	8	400	436	479	1.10	172.30	2 235	16.84	100.0	100.0
1999	8	404	405	487	1.20	191.05	2 257	20.35	100.0	100.0
2000	8	411	411	561	1.36	235.62	2 522	19.34	100.0	100.0
2001	9	529	530	666	1.26	269.17	2 823	23.60	99.4	99.4
2002	9	497	497	609	1.23	245.36	2 696	20.61	100.0	100.0
2003	10	639	640	731	1.14	300.59	3 352	22.20	98.0	98.0
2004	9	610	610	699	1.15	298.83	3 305	22.44	97.4	97.4
2005	8	514	517	556	1.08	237.95	2 507	18.28	98.4	98.5
2006	9	515	520	570	1.10	236.36	2 900	19.12	94.6	94.6
2007	8	410	411	426	1.04	157.08	1 994	14.74	94.6	94.7
2008	7	481	482	490	1.02	207.21	2 374	17.55	90.4	90.5
2009	7	404	404	418	1.03	173.78	2 309	17.12	85.2	85.2
2010	6	287	287	295	1.03	126.65	1 460	13.32	88.2	88.2
2011	8	215	215	219	1.02	102.49	1 029	11.61	94.4	94.4
2012	6	365	365	383	1.05	154.44	1 886	16.18	92.6	92.6
2013	6	382	382	397	1.04	166.55	2 091	17.94	93.5	93.5
2014	6	474	474	511	1.08	207.26	2 506	22.80	94.7	94.7
2015	6	325	325	340	1.05	137.37	1 855	14.87	90.5	90.5
2016	4	220	220	228	1.04	100.27	1 159	13.54	95.0	95.0
2017	5	231	232	235	1.01	87.90	1 169	14.06	100.0	100.0

M.1.4 Core vessel plots

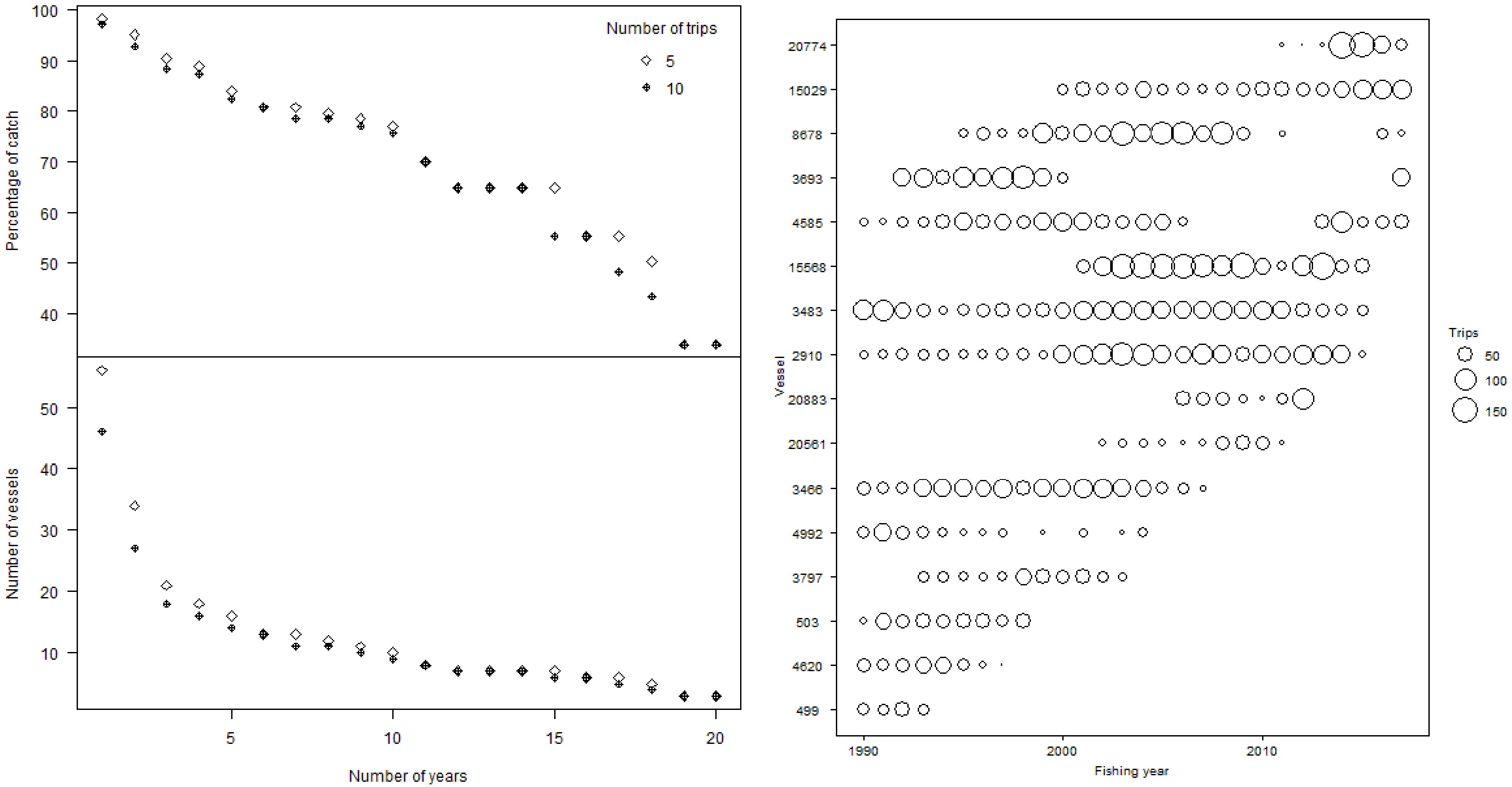

Figure M.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `LW(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

M.1.5 Exploratory data plots for core vessel data set

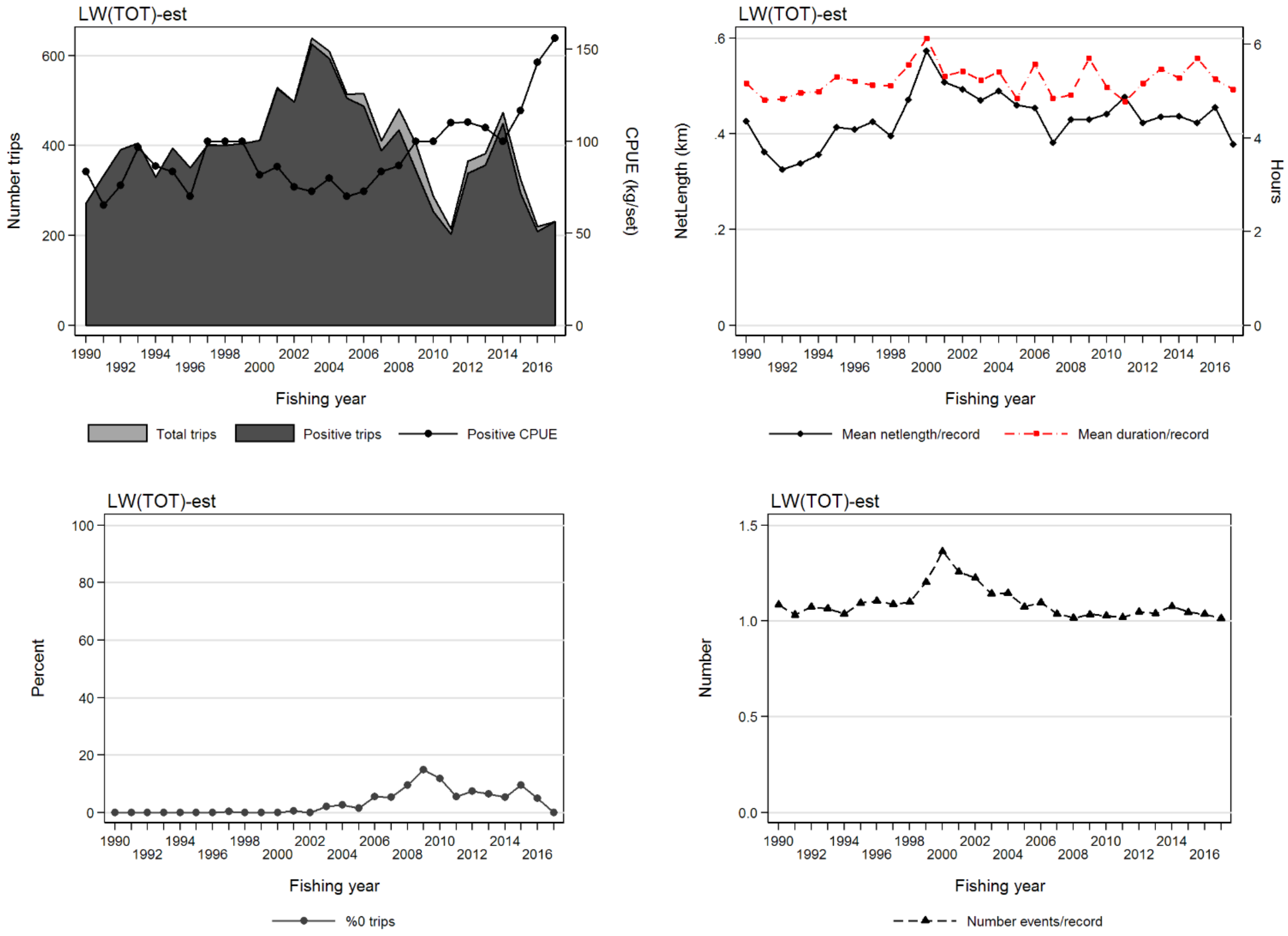

Figure M.2: Core vessel summary plots by fishing year for model `LW(TOT)-est`: [upper left panel]: total trips (light grey) and trips with flatfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \mathrm{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of flatfish; [lower right panel]: mean number of events per daily-effort stratum record.

M.2 Positive catch model

Three of five explanatory variables entered the model after fishing year (vessel, length of net set and duration fishing; Table M.2), with month and area non-significant variables. A plot of the model is provided in Figure M.3 and the CPUE indices are listed in Table M.3.

Table M.2: Order of acceptance of variables into the log-logistic model of successful catches in the `LW(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 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	29	-50 568	101 195	8.9	*
vessel	44	-49 188	98 465	29.0	*
poly(log(net_length), 3)	47	-48 669	97 432	35.3	*
poly(log(duration, 3)	50	-48 568	97 236	36.5	*
month	61	-48 540	97 202	36.8	
area	62	-48 537	97 198	36.8	

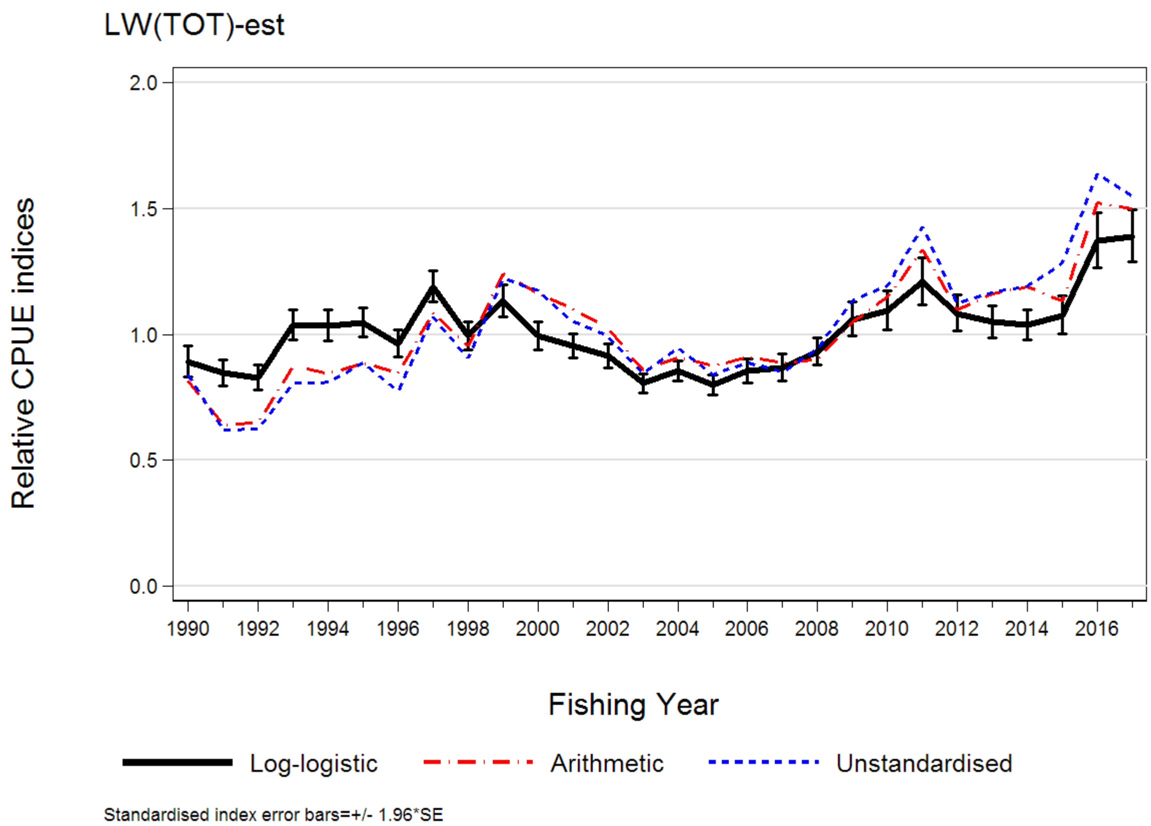

Figure M.3: Relative CPUE indices for estimated FLA(TOT) catch using the log-logistic non-zero model based on the `LW(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

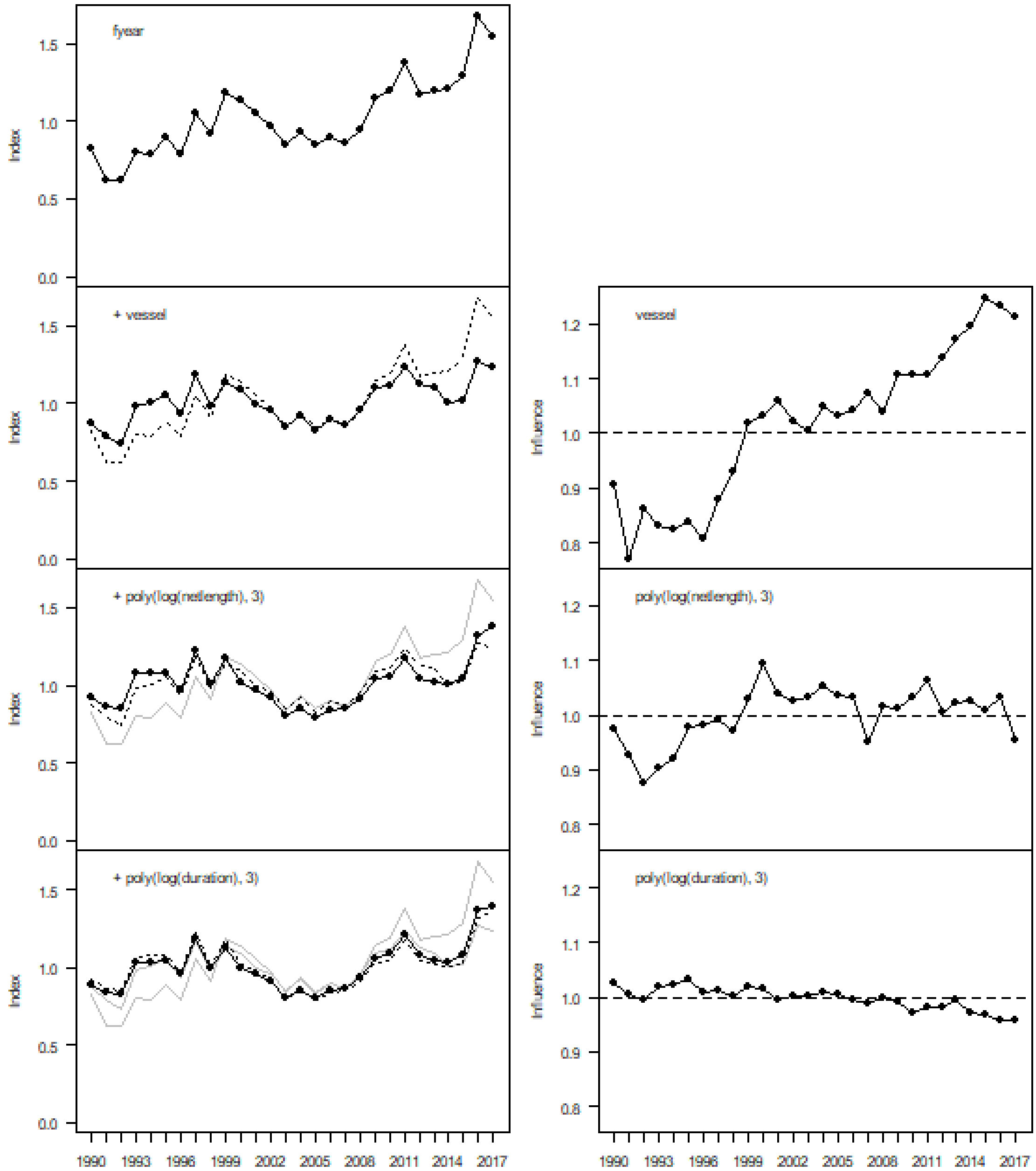

Figure M.4: [left column]: annual indices from the log-logistic model of `LW(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

M.2.1 Residual and diagnostic plots

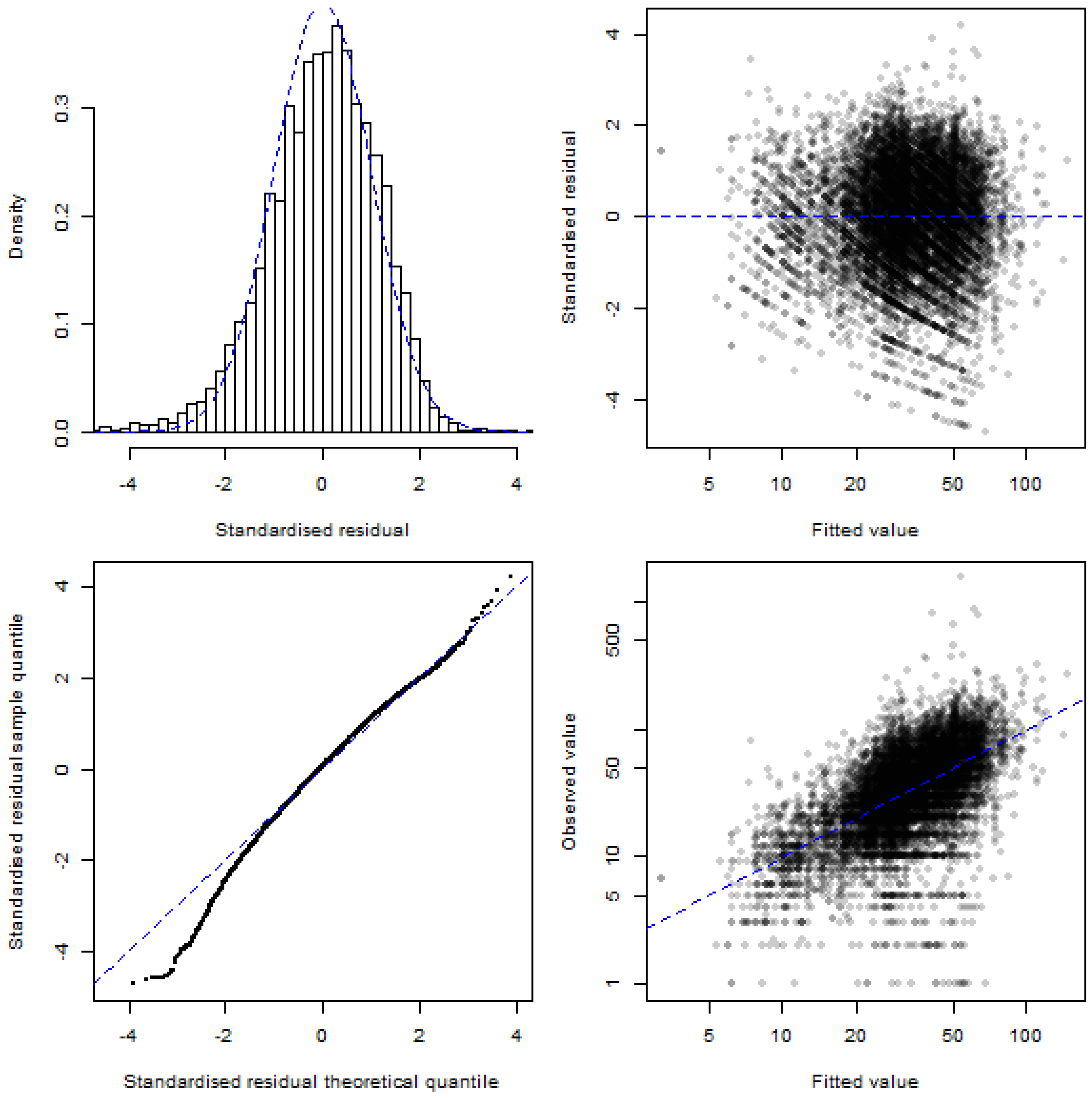

Figure M.5: Plots of the fit of the log-logistic standardised CPUE model of successful estimated FLA(TOT) catches in the `LW(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a log-logistic distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

M.2.2 Model coefficient plots

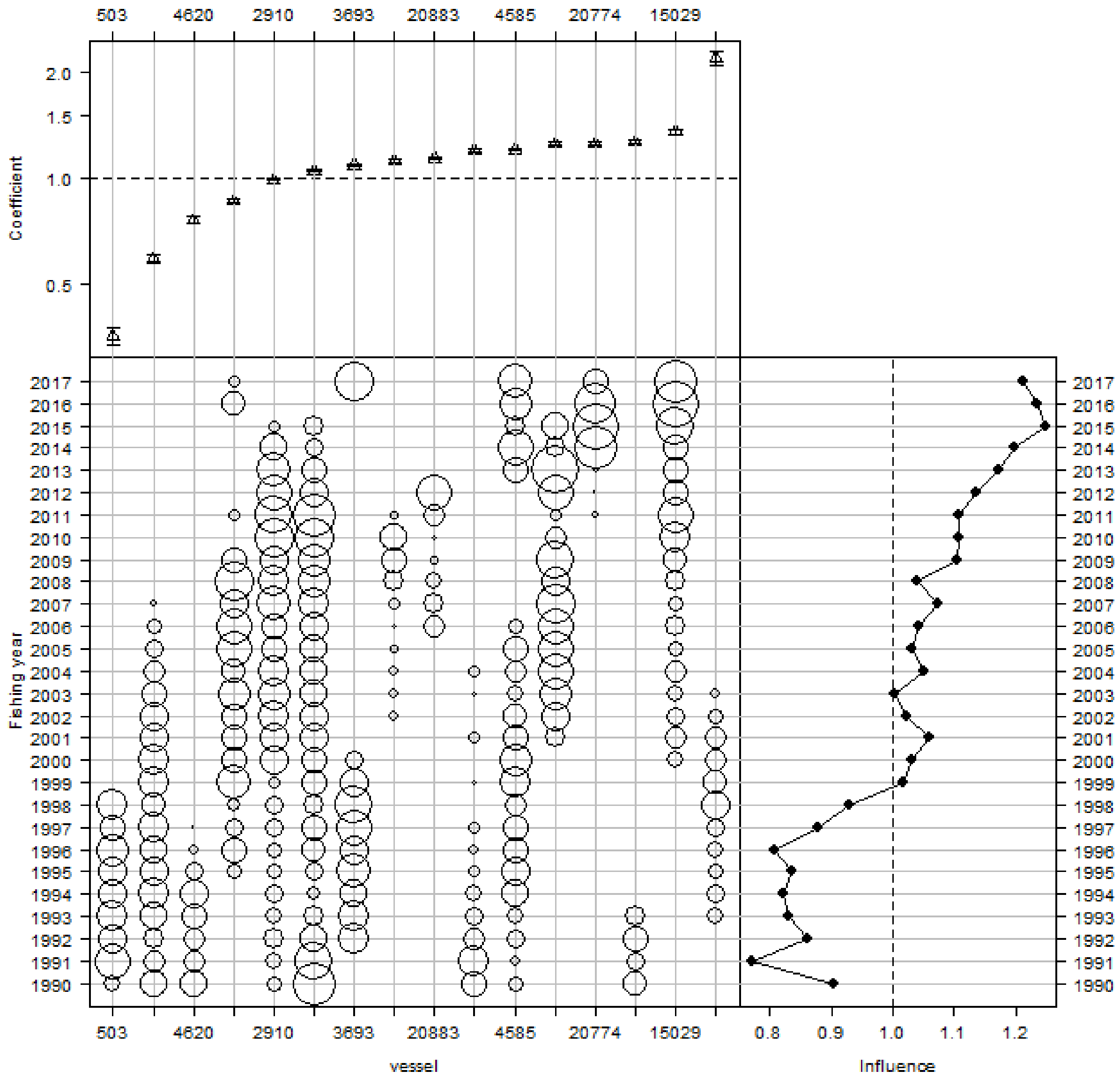

Figure M.6: Effect of vessel in the log-logistic model for the flatfish `LW(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

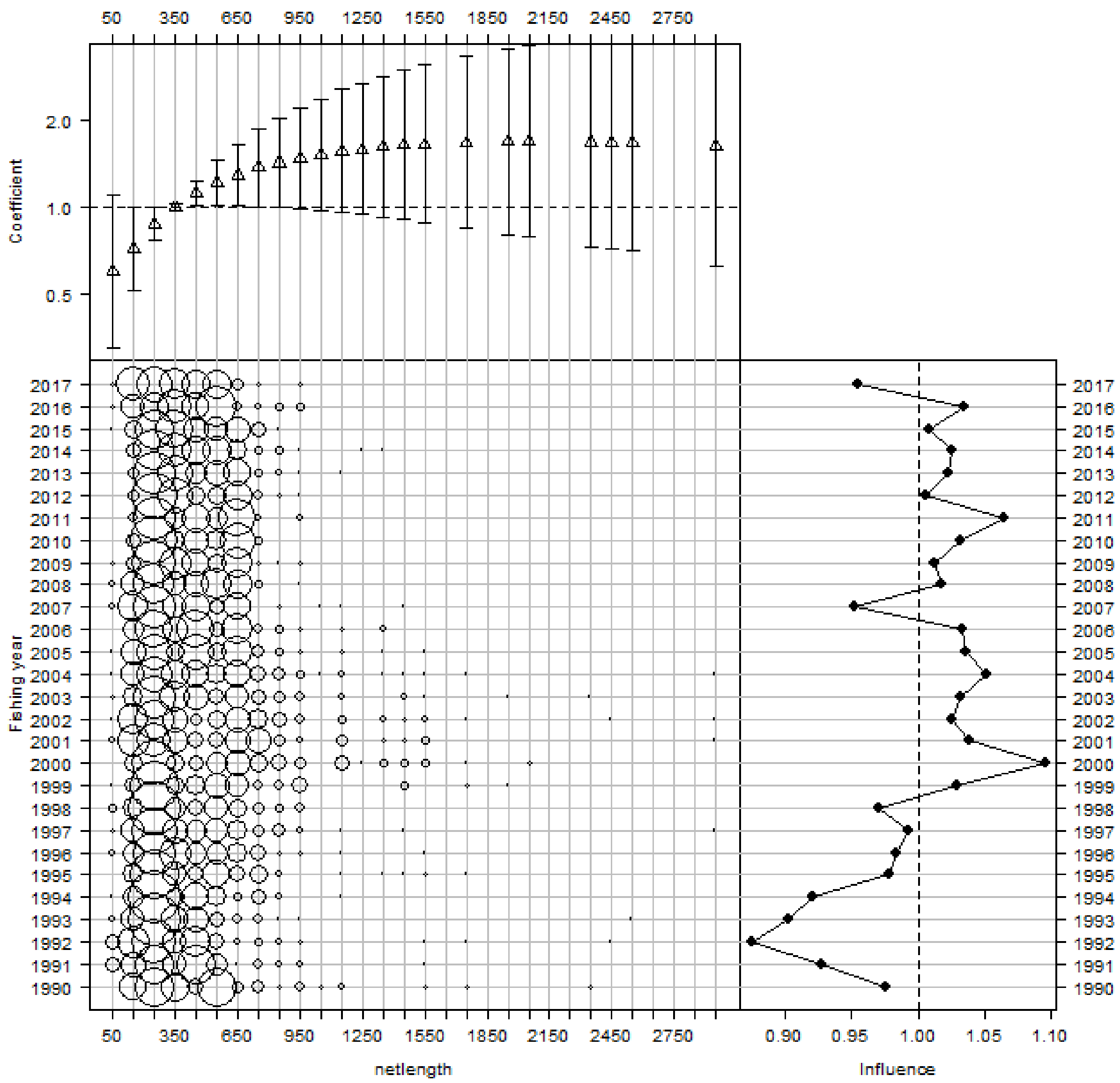

Figure M.7: Effect of log(net_length) in the log-logistic model for the flatfish `LW(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

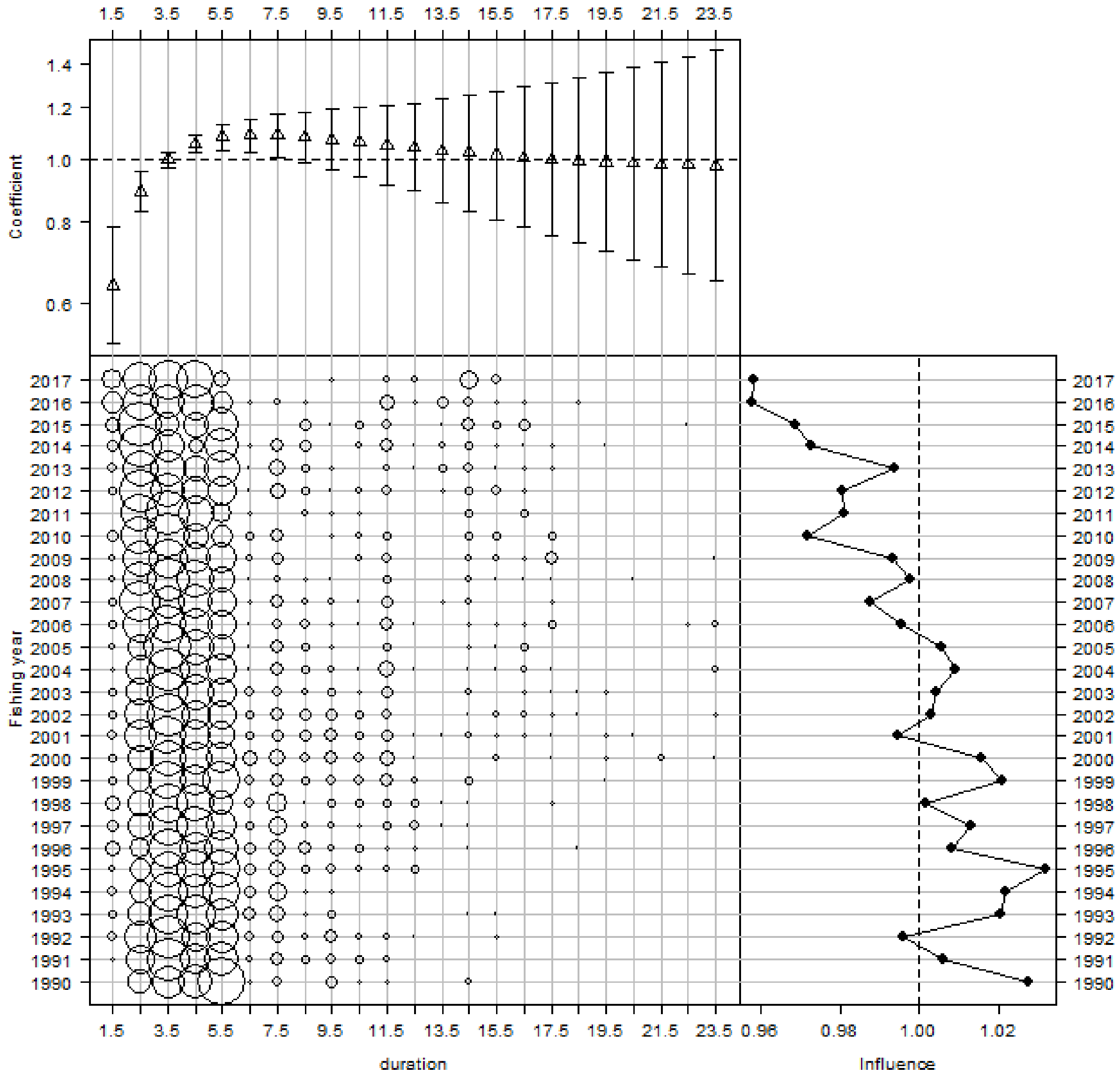

Figure M.8: Effect of log(duration) in the log-logistic model for the flatfish `LW(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

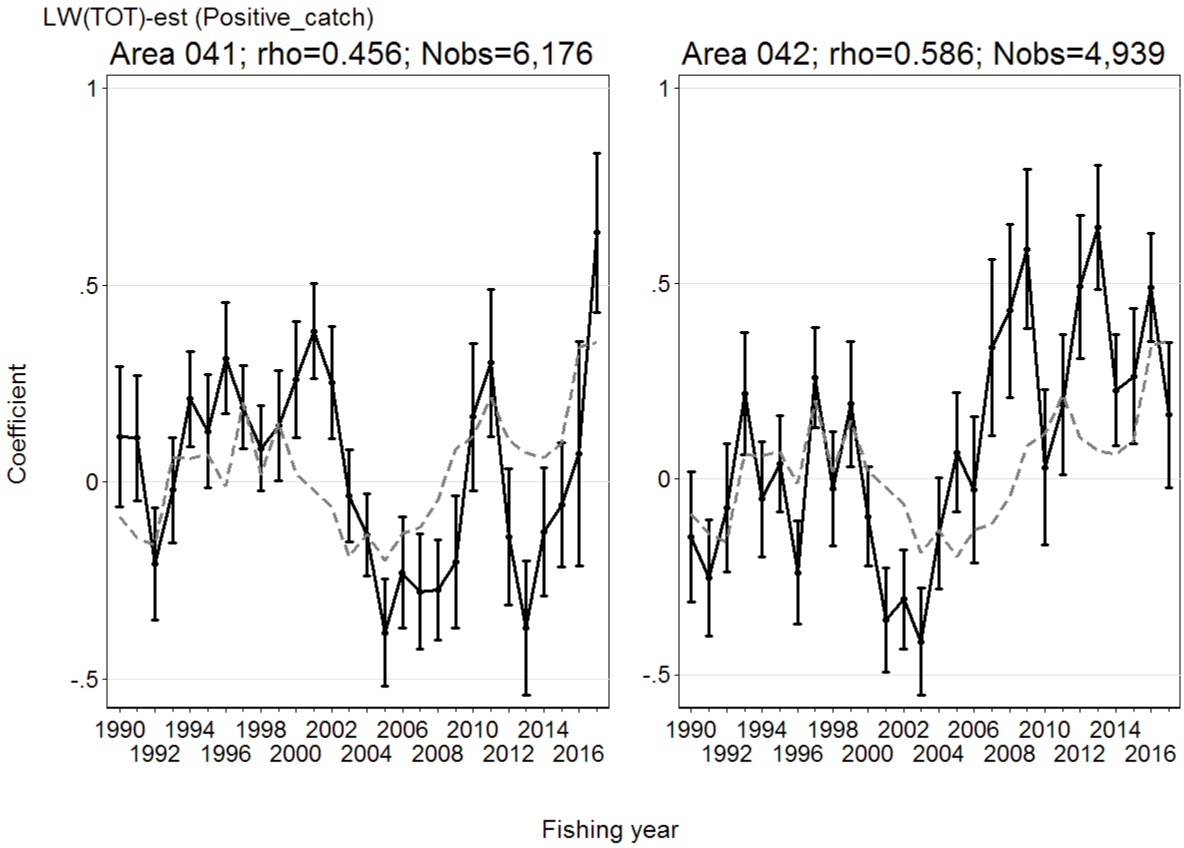

Figure M.9: Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the `LW(TOT)-est` SN log-logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised 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. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.

M.3 CPUE indices

Table M.3: Arithmetic indices for the total and core data sets, geometric and log-logistic standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `LW(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.901	0.816	0.838	0.892	0.0356
1991	0.668	0.639	0.619	0.846	0.0319
1992	0.688	0.649	0.625	0.829	0.0302
1993	0.868	0.875	0.806	1.037	0.0291
1994	0.883	0.845	0.810	1.034	0.0309
1995	0.923	0.887	0.886	1.045	0.0283
1996	0.885	0.845	0.775	0.962	0.0288
1997	1.073	1.085	1.070	1.190	0.0269
1998	0.938	0.955	0.905	0.993	0.0278
1999	1.193	1.243	1.222	1.132	0.0292
2000	1.046	1.164	1.176	0.993	0.0286
2001	1.043	1.102	1.052	0.954	0.0256
2002	0.935	1.026	0.995	0.914	0.0262
2003	0.857	0.858	0.846	0.806	0.0236
2004	0.920	0.910	0.945	0.855	0.0239
2005	0.833	0.875	0.840	0.798	0.0265
2006	0.887	0.910	0.887	0.854	0.0278
2007	0.949	0.887	0.852	0.868	0.0307
2008	0.957	0.901	0.944	0.931	0.0289
2009	1.073	1.049	1.135	1.060	0.0327
2010	1.137	1.148	1.193	1.094	0.0358
2011	1.355	1.336	1.429	1.208	0.0390
2012	1.069	1.097	1.124	1.083	0.0337
2013	1.229	1.162	1.167	1.048	0.0312
2014	1.174	1.190	1.192	1.037	0.0298
2015	1.111	1.132	1.284	1.074	0.0359
2016	1.459	1.523	1.639	1.371	0.0407
2017	1.443	1.500	1.550	1.388	0.0380

Appendix N. DIAGNOSTICS AND SUPPORTING ANALYSES FOR NORTHWEST ESTIMATED CATCH CPUE

N.1 Model definition and preliminary analyses

This CPUE analysis was not accepted by the NINSWG for monitoring Northwest YBF (assumed) in 2018 (Fisheries New Zealand 2018).

N.1.1 Fishery definition

`NW(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 045, 046 or 047 capturing flatfish using any species code in Table 16 (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

N.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 3 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 19 vessels which took 85% of the catch (Figure N.1).

N.1.3 Data summary

Table N.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 3 years) in the `NW(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	6	246	288	318	1.10	209.60	2 216	17.54	100.0	100.0
1991	8	304	337	361	1.07	286.73	2 677	24.21	100.0	100.0
1992	9	574	601	619	1.03	430.94	5 650	30.22	99.7	99.5
1993	10	487	506	543	1.07	404.02	5 231	25.81	99.8	99.8
1994	10	575	602	638	1.06	414.25	6 752	30.47	100.0	100.0
1995	11	525	600	708	1.18	370.41	6 738	31.11	100.0	100.0
1996	8	418	517	595	1.15	313.23	5 573	26.64	99.8	99.8
1997	8	291	393	419	1.07	240.59	3 698	27.46	97.9	98.5
1998	8	295	397	429	1.08	233.94	4 026	21.33	96.6	97.5
1999	5	277	420	442	1.05	265.30	3 842	29.52	93.1	95.0
2000	7	322	457	512	1.12	308.70	4 922	15.93	91.3	93.2
2001	7	356	510	619	1.21	365.90	4 647	22.12	97.2	97.8
2002	5	253	375	421	1.12	259.00	3 713	22.37	100.0	100.0
2003	6	200	293	326	1.11	189.22	3 263	14.51	100.0	100.0
2004	7	353	490	543	1.11	322.10	5 175	28.79	100.0	100.0
2005	6	305	540	639	1.18	360.90	7 410	28.54	100.0	100.0
2006	5	173	425	503	1.18	287.50	5 554	17.18	100.0	100.0
2007	4	138	351	386	1.10	236.52	4 047	10.76	100.0	99.4
2008	4	133	335	388	1.16	217.90	3 627	12.07	100.0	100.0
2009	4	140	436	479	1.10	309.10	4 531	15.96	100.0	100.0
2010	4	128	434	501	1.15	336.73	4 510	13.58	100.0	100.0
2011	4	157	364	378	1.04	242.70	3 295	9.59	100.0	100.0
2012	3	198	318	363	1.14	208.20	2 923	6.59	99.0	99.4
2013	4	163	267	290	1.09	170.50	2 472	9.35	100.0	100.0
2014	4	282	458	463	1.01	315.50	4 988	15.19	100.0	100.0
2015	3	83	194	213	1.10	106.90	1 473	4.25	98.8	99.5
2016	3	126	230	252	1.10	150.80	2 173	7.29	99.2	99.6
2017	2	139	210	246	1.17	147.70	2 114	6.04	100.0	100.0

N.1.4 Core vessel plots

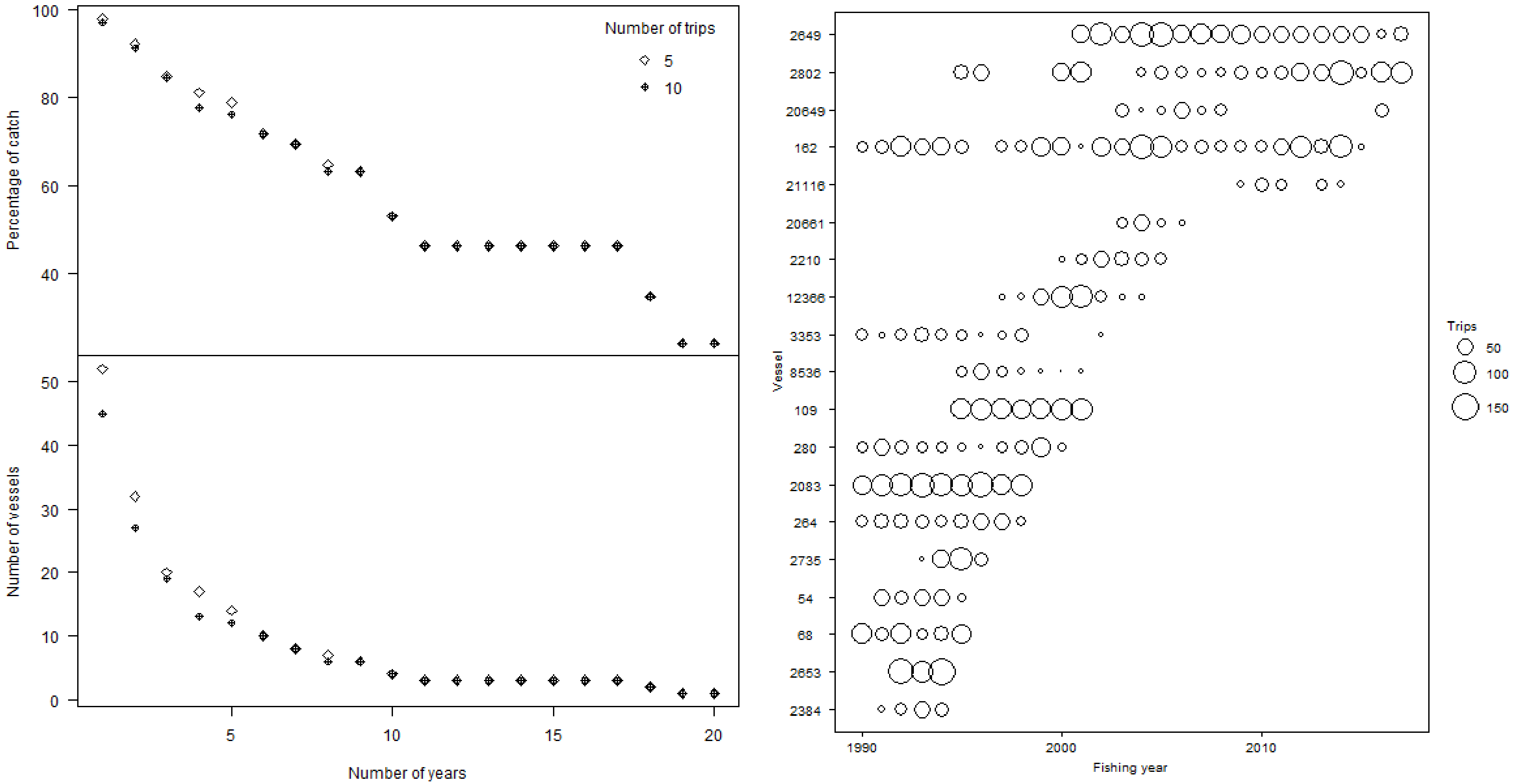

Figure N.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `NW(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 3 or more fishing years) by fishing year.

N.1.5 Exploratory data plots for core vessel data set

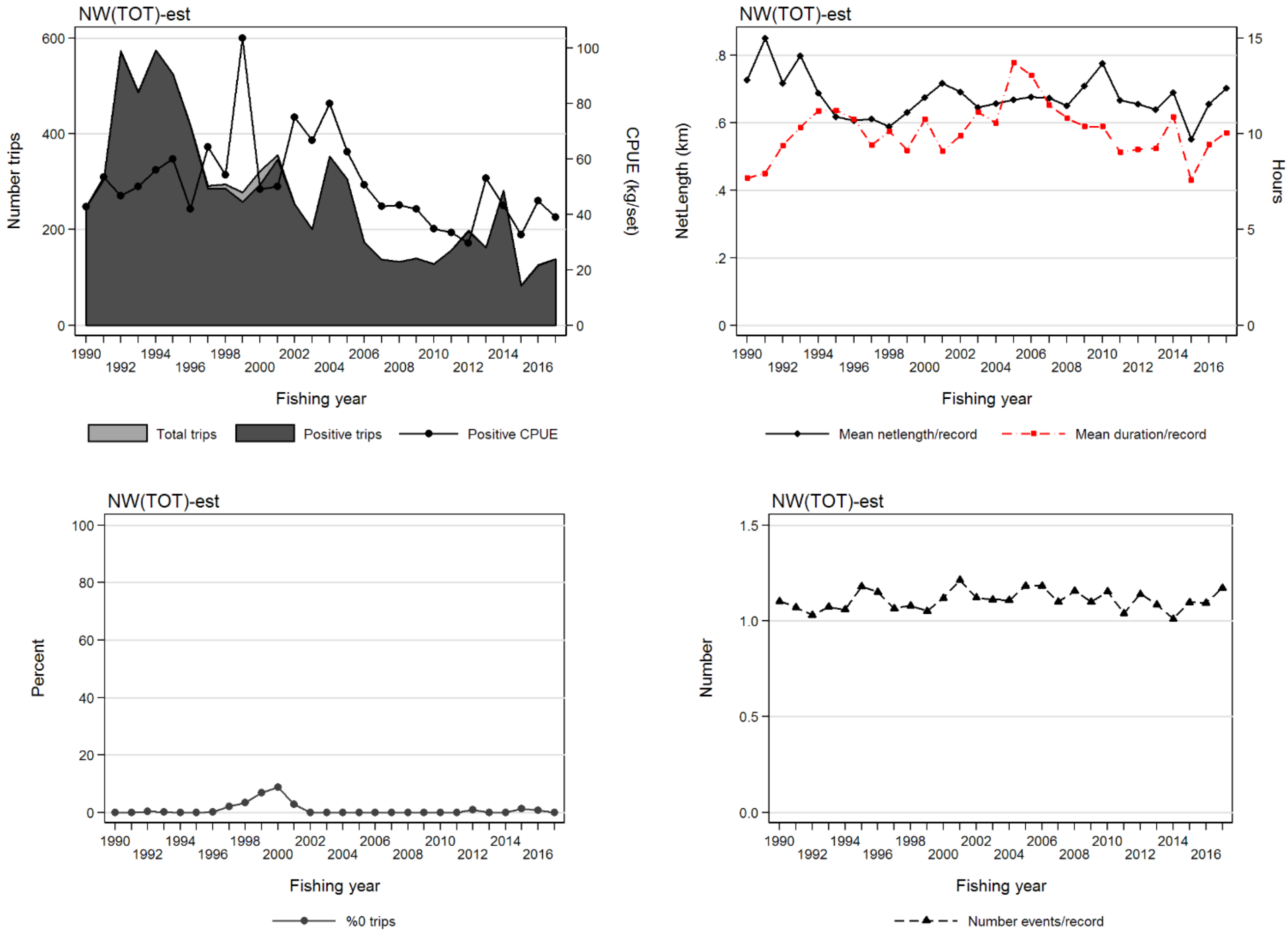

Figure N.2: Core vessel summary plots by fishing year for model `NW(TOT)-est`: [upper left panel]: total trips (light grey) and trips with flatfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of flatfish; [lower right panel]: mean number of events per daily-effort stratum record.

N.2 Positive catch model

Two of five explanatory variables entered the model after fishing year (vessel and length of net set; Table N.2), with duration and month non-significant variables. The area variable was dropped by the software before the fitting procedure because Area 046 appears to have supplied the main signal (see Figure N.8). A plot of the model is provided in Figure N.3 and the CPUE indices are listed in Table N.3.

Table N.2: Order of acceptance of variables into the log-logistic model of successful catches in the `NW(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 3 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	29	-52 677	105 413	6.4	*
vessel	47	-48 089	96 271	58.8	*
poly(log(net_length), 3)	50	-47 674	95 448	61.7	*
poly(log(duration, 3)	53	-47 606	95 319	62.2	
month	64	-47 547	95 222	62.6	
area [dropped]	–	–	–	–	

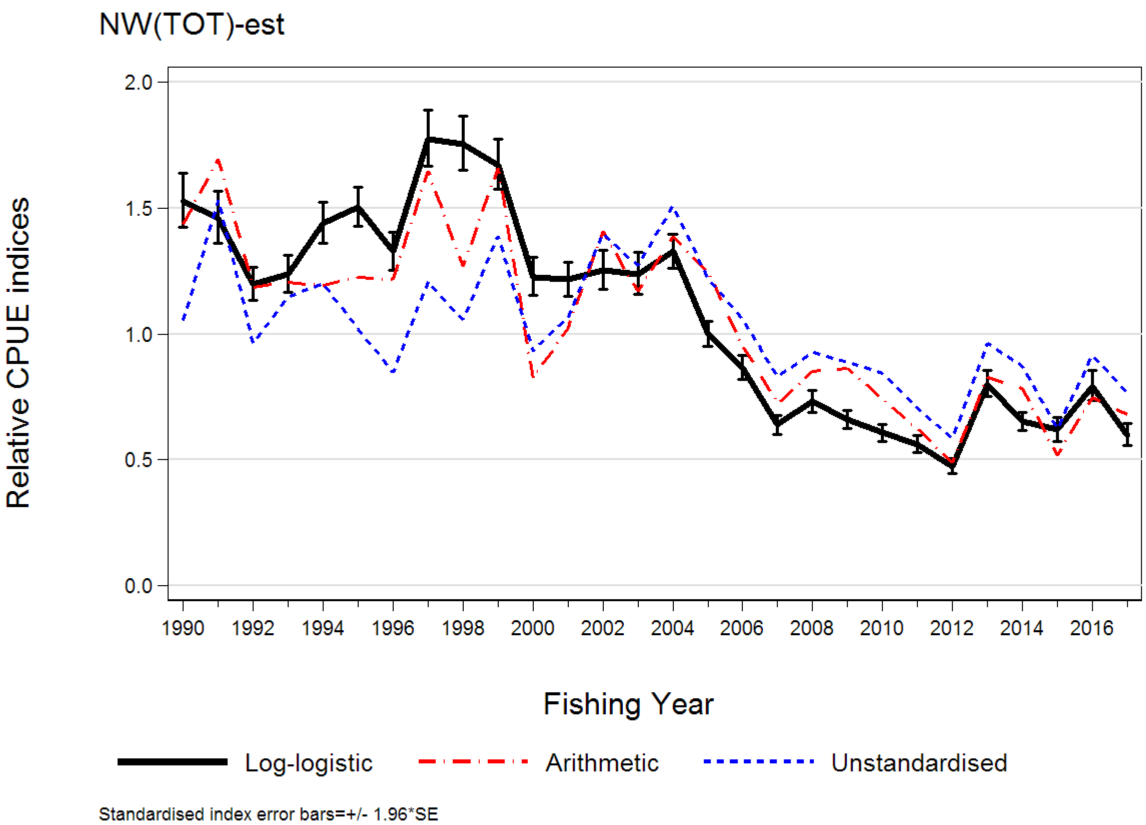

Figure N.3: Relative CPUE indices for estimated FLA(TOT) catch using the log-logistic non-zero model based on the `NW(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

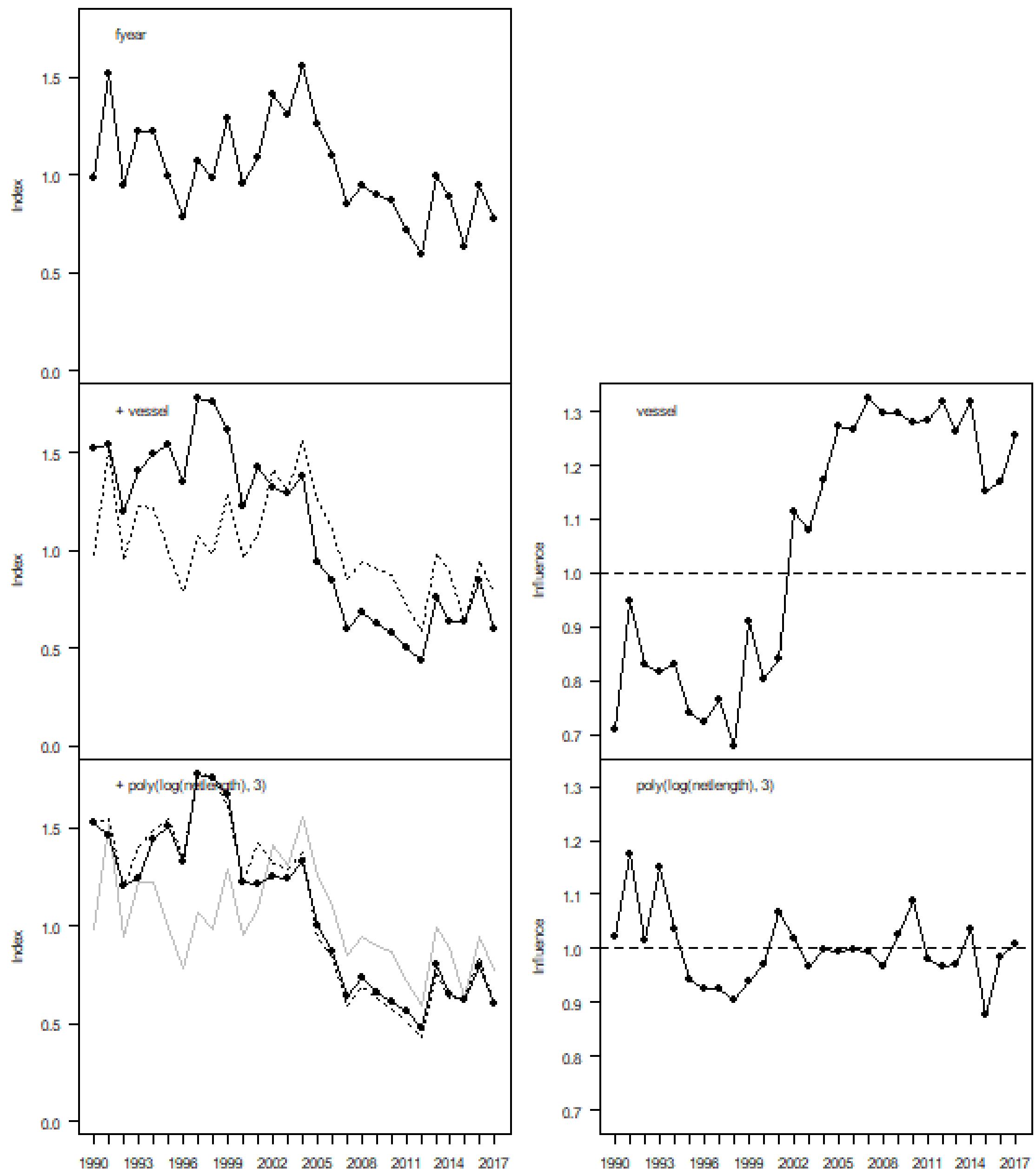

Figure N.4: [left column]: annual indices from the log-logistic model of `NW(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

N.2.1 Residual and diagnostic plots

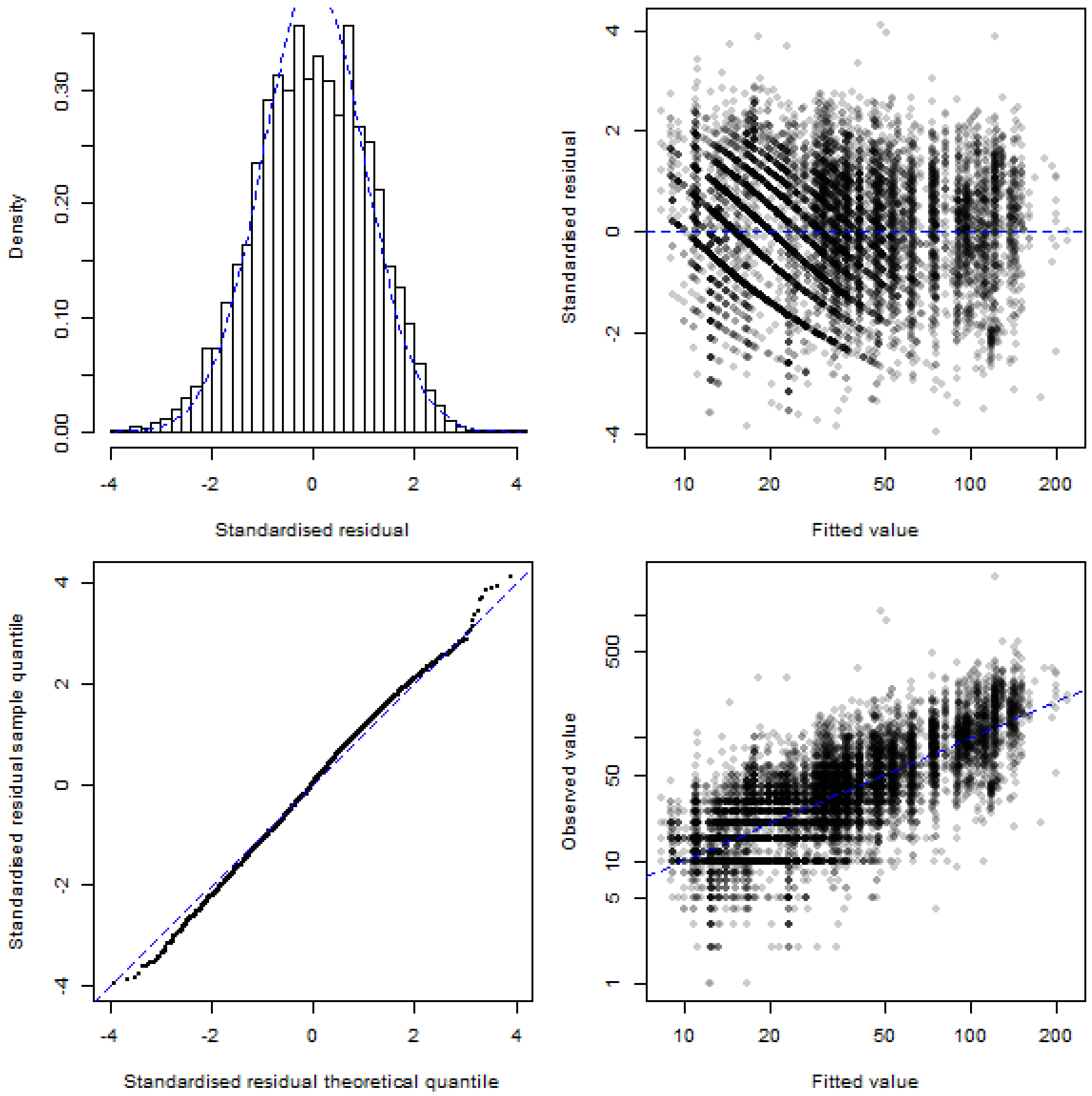

Figure N.5: Plots of the fit of the log-logistic standardised CPUE model of successful estimated FLA(TOT) catches in the `NW(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a log-logistic distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

N.2.2 Model coefficient plots

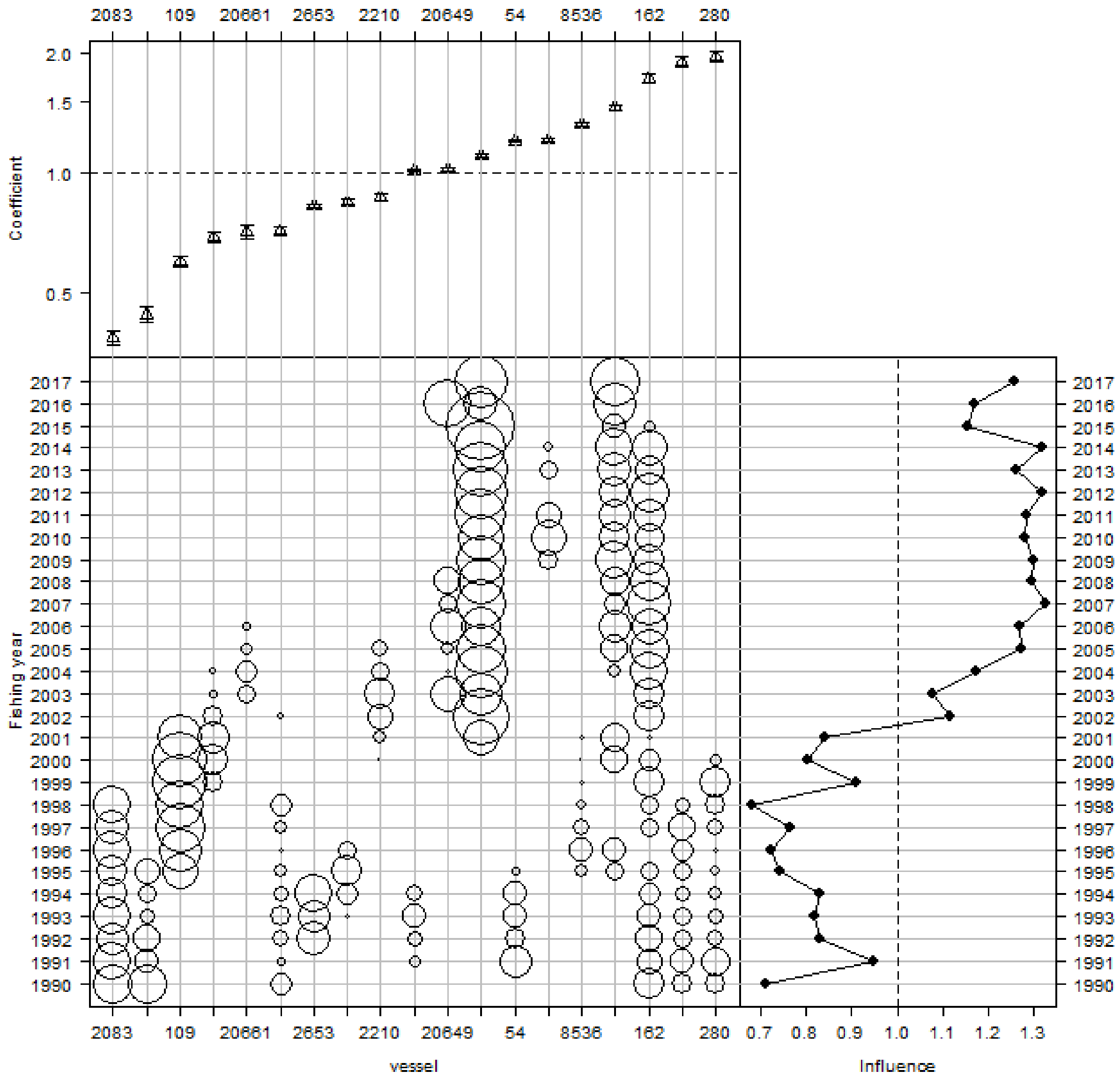

Figure N.6: Effect of vessel in the log-logistic model for the flatfish `NW(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

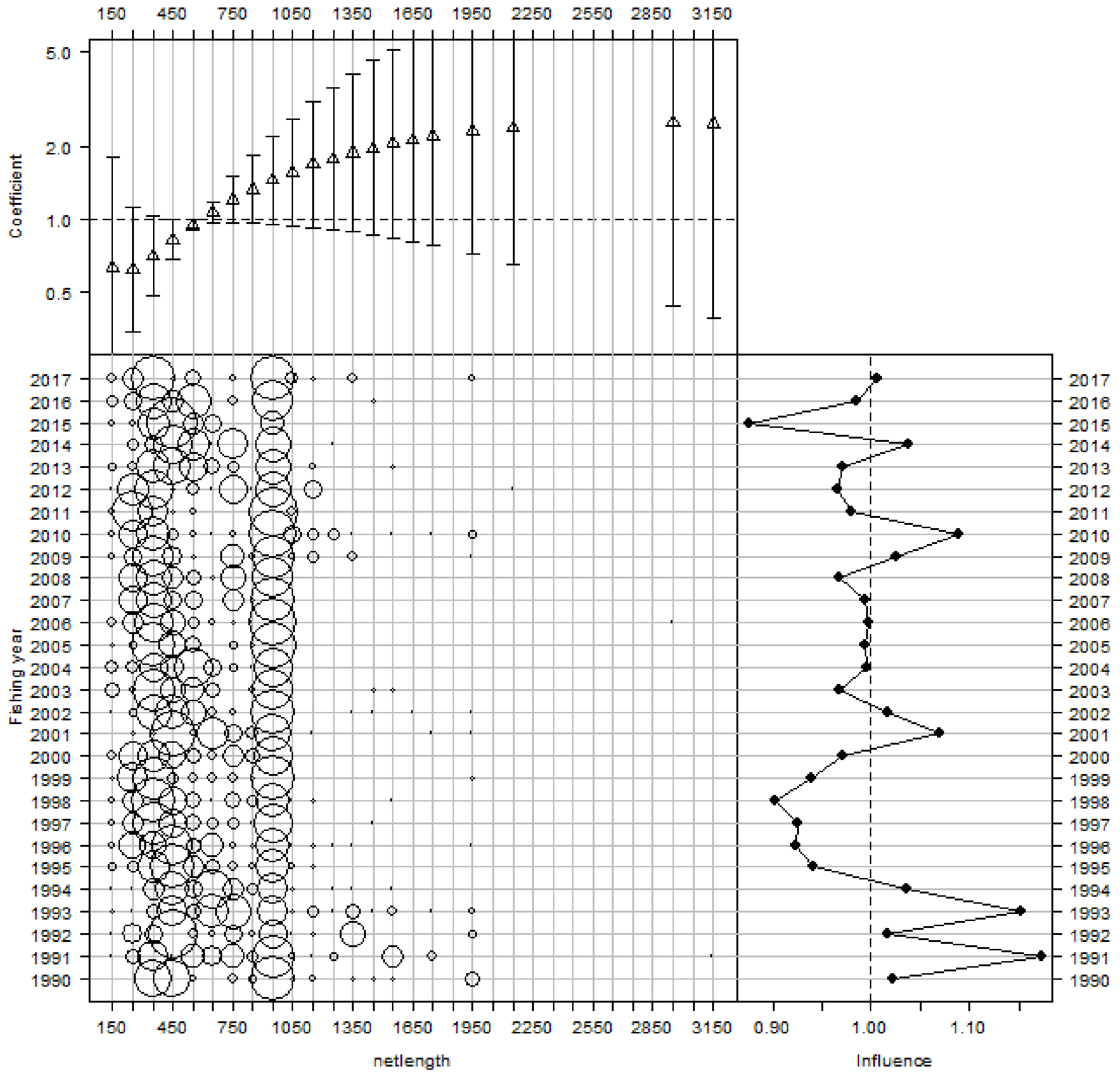

Figure N.7: Effect of log(net_length) in the log-logistic model for the flatfish `NW(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

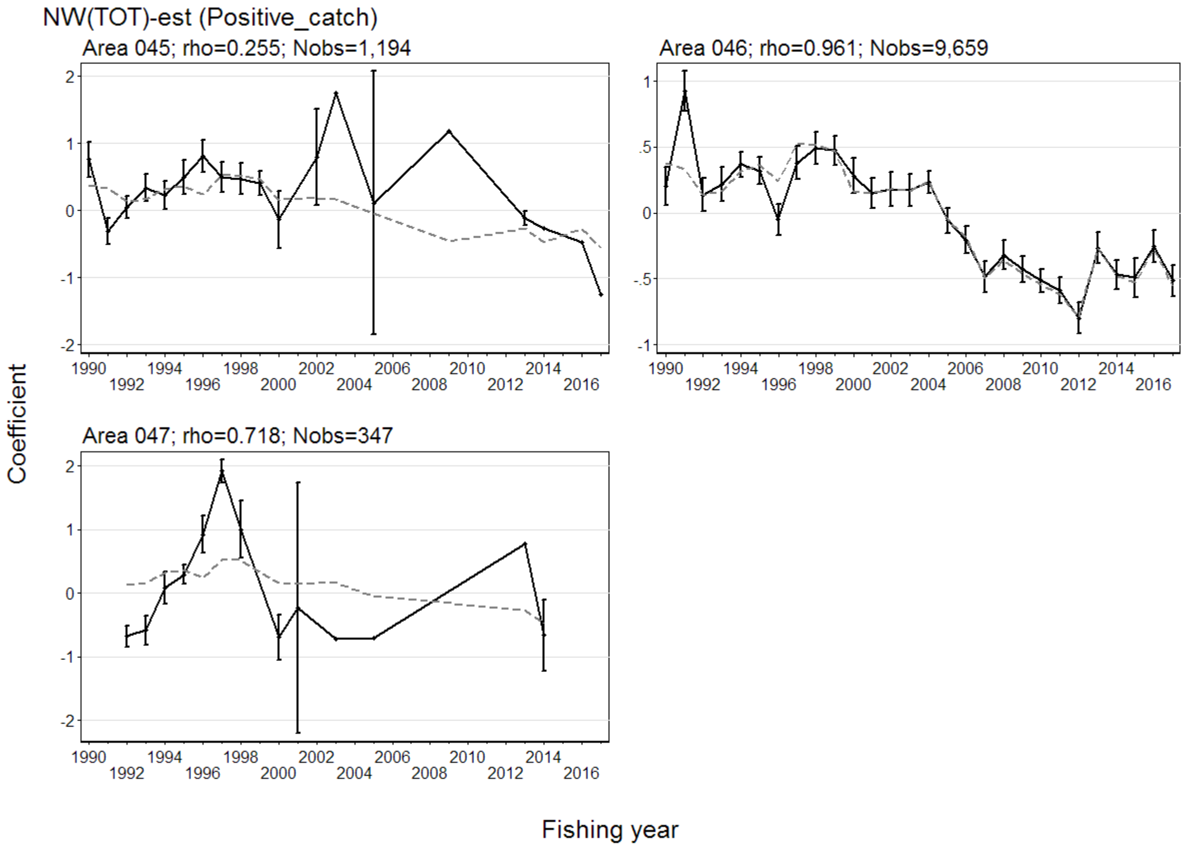

Figure N.8: Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the `NW(TOT)-est` SN log-logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised 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. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.

N.3 CPUE indices

Table N.3: Arithmetic indices for the total and core data sets, geometric and log-logistic standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `NW(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels			Core vessels	
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.408	1.438	1.053	1.527	0.0360
1991	1.667	1.696	1.533	1.461	0.0363
1992	1.117	1.187	0.964	1.198	0.0285
1993	1.260	1.204	1.147	1.237	0.0310
1994	1.185	1.195	1.201	1.439	0.0288
1995	1.462	1.224	1.020	1.504	0.0264
1996	1.336	1.216	0.848	1.328	0.0291
1997	1.583	1.649	1.209	1.775	0.0318
1998	1.171	1.268	1.056	1.755	0.0313
1999	1.618	1.659	1.390	1.671	0.0303
2000	0.854	0.823	0.932	1.226	0.0319
2001	1.056	1.024	1.065	1.216	0.0285
2002	1.322	1.408	1.399	1.253	0.0311
2003	1.127	1.169	1.272	1.238	0.0342
2004	1.323	1.387	1.509	1.327	0.0260
2005	1.220	1.247	1.225	0.999	0.0253
2006	0.948	0.954	1.057	0.866	0.0284
2007	0.724	0.724	0.830	0.638	0.0301
2008	0.825	0.850	0.926	0.731	0.0308
2009	0.812	0.864	0.888	0.661	0.0276
2010	0.722	0.738	0.845	0.607	0.0280
2011	0.614	0.622	0.707	0.562	0.0290
2012	0.538	0.489	0.585	0.475	0.0312
2013	0.809	0.827	0.962	0.800	0.0332
2014	0.797	0.783	0.872	0.650	0.0280
2015	0.550	0.517	0.625	0.619	0.0408
2016	0.742	0.748	0.915	0.793	0.0379
2017	0.696	0.679	0.769	0.598	0.0370

Appendix O. DIAGNOSTICS AND SUPPORTING ANALYSES FOR EAST NORTHLAND ESTIMATED CATCH CPUE

O.1 Model definition and preliminary analyses

This CPUE analysis was not accepted by the NINSWG for monitoring East Northland total flatfish in 2018 (Fisheries New Zealand 2018).

O.1.1 Fishery definition

`EN(TOT)-est`: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 002 or 003 capturing flatfish using any species code in Table 16 (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

O.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of FLA(TOT) catch. These criteria resulted in a core fleet size of 25 vessels which took 80% of the catch (Figure O.1).

O.1.3 Data summary

Table O.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch FLA (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the `EN(TOT)-est` fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1990	6	382	416	477	1.15	263.05	8 129	13.07	99.7	99.5
1991	6	188	265	275	1.04	153.82	3 416	10.62	100.0	100.0
1992	10	382	386	413	1.07	218.65	4 291	16.96	100.0	100.0
1993	10	582	596	612	1.03	372.69	6 476	25.30	99.3	99.3
1994	10	819	838	904	1.08	548.05	9 940	25.62	99.2	99.1
1995	9	780	798	850	1.07	588.93	10 241	31.40	99.5	99.5
1996	9	489	558	586	1.05	354.15	7 701	17.72	94.7	95.2
1997	10	218	287	337	1.17	212.06	4 052	17.55	96.8	97.2
1998	8	437	466	504	1.08	362.94	5 025	20.24	99.1	99.1
1999	10	617	625	676	1.08	460.53	7 149	22.62	91.3	91.4
2000	11	712	735	785	1.07	585.17	8 510	29.51	98.2	98.2
2001	10	807	825	886	1.07	638.44	9 358	32.66	99.8	99.8
2002	12	724	729	771	1.06	532.32	7 931	35.45	100.0	100.0
2003	12	1 191	1 198	1 235	1.03	875.02	12 732	41.47	99.7	99.7
2004	16	1 397	1 535	1 587	1.03	1 103.93	21 359	52.13	99.9	99.9
2005	15	1 514	1 717	1 763	1.03	1 193.08	24 386	63.62	99.9	99.9
2006	16	1 196	1 363	1 419	1.04	1 026.09	18 542	45.68	99.6	99.6
2007	15	1 040	1 146	1 206	1.05	775.01	17 328	37.30	99.6	99.7
2008	14	867	915	980	1.07	638.37	14 888	28.79	99.9	99.9
2009	11	810	844	898	1.06	566.02	13 871	34.35	100.0	100.0
2010	11	748	786	876	1.11	548.78	12 168	30.50	100.0	100.0
2011	13	840	869	963	1.11	642.22	14 724	32.47	99.8	99.8
2012	11	816	879	986	1.12	692.65	14 866	31.09	99.6	99.7
2013	10	822	860	992	1.15	657.55	14 774	27.84	99.8	99.8
2014	10	839	844	930	1.10	645.22	14 612	25.84	99.8	99.8
2015	9	552	554	613	1.11	416.09	10 145	21.10	99.8	99.8
2016	7	596	598	659	1.10	421.32	10 493	20.92	100.0	100.0
2017	8	486	489	562	1.15	327.87	8 641	19.17	99.8	99.8

O.1.4 Core vessel plots

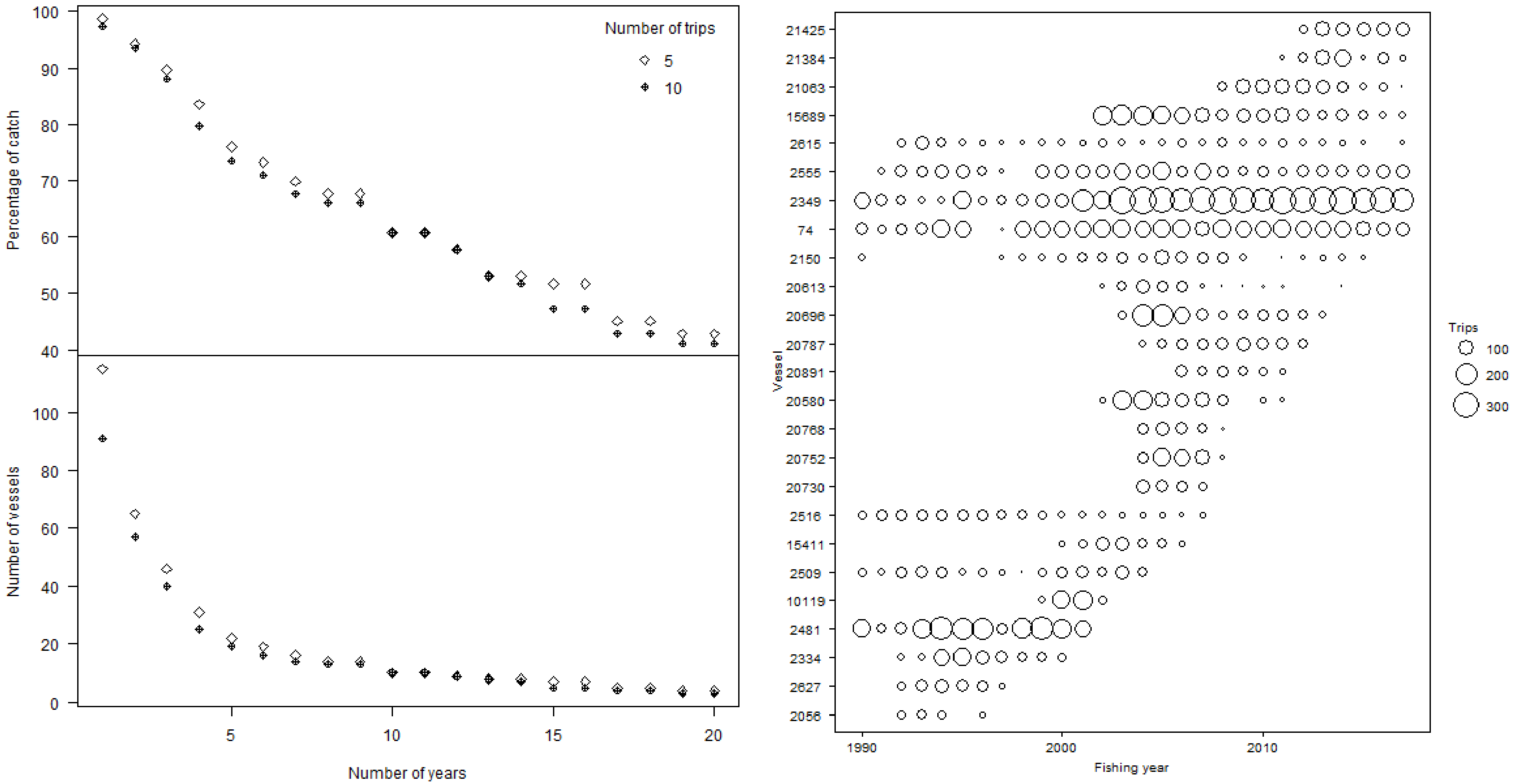

Figure O.1: [left panel]: total estimated FLA catch and number of vessels plotted against the number of years used to define core vessels participating in the `EN(TOT)-est` dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

O.1.5 Exploratory data plots for core vessel data set

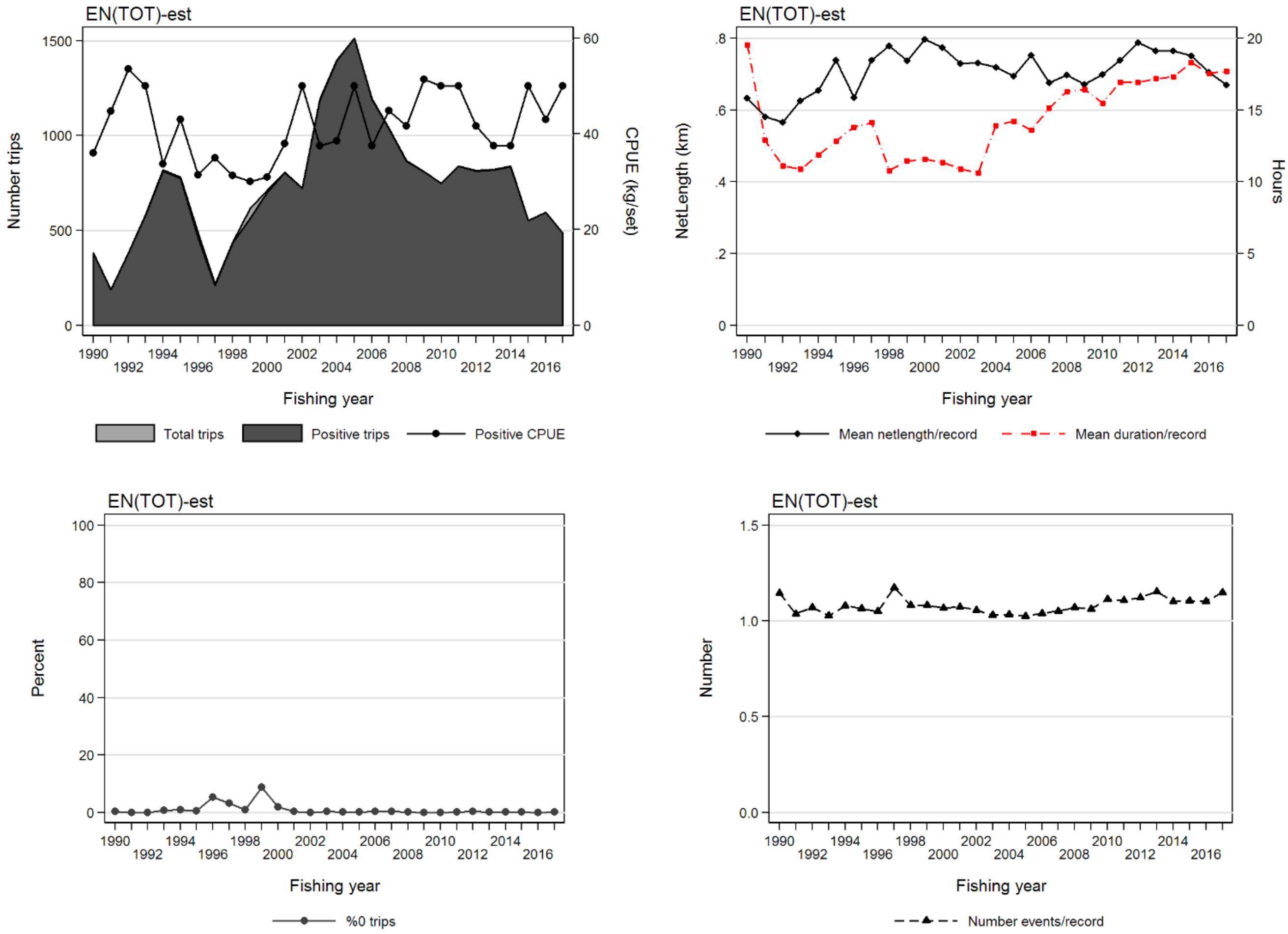

Figure O.2: Core vessel summary plots by fishing year for model `EN(TOT)-est`: [upper left panel]: total trips (light grey) and trips with flatfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of flatfish; [lower right panel]: mean number of events per daily-effort stratum record.

O.2 Positive catch model

Three of five explanatory variables entered the model after fishing year (vessel, length of net set and duration of fishing; Table O.2), with month and area non-significant variables. A plot of the model is provided in Figure O.3 and the CPUE indices are listed in Table O.3.

Table O.2: Order of acceptance of variables into the log-logistic model of successful catches in the `EN(TOT)-est` fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 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	29	-95 842	191 742	3.4	*
vessel	53	-94 580	189 266	14.0	*
poly(log(net_length), 3)	56	-93 497	187 107	22.1	*
poly(log(duration, 3)	67	-93 162	186 458	24.5	*
month	70	-93 131	186 402	24.7	
area	71	-93 105	186 352	24.9	

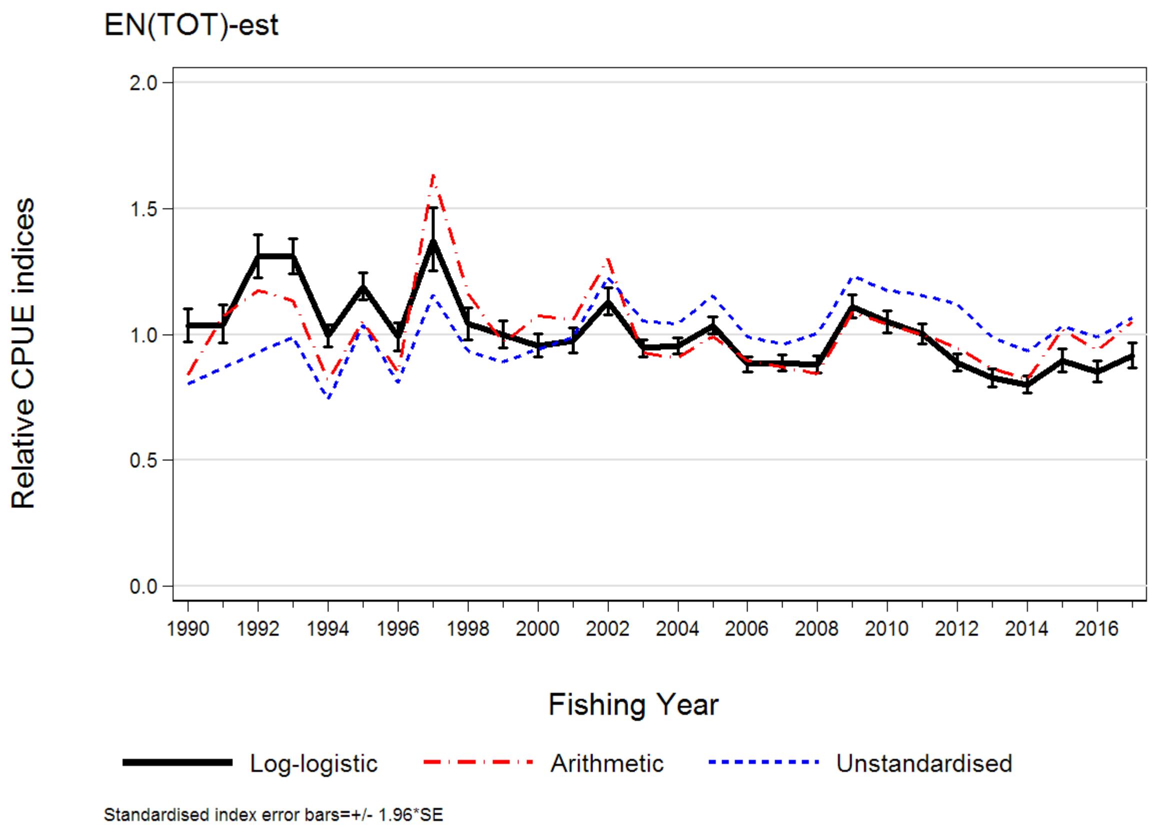

Figure O.3: Relative CPUE indices for estimated FLA(TOT) catch using the log-logistic non-zero model based on the `EN(TOT)-est` fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

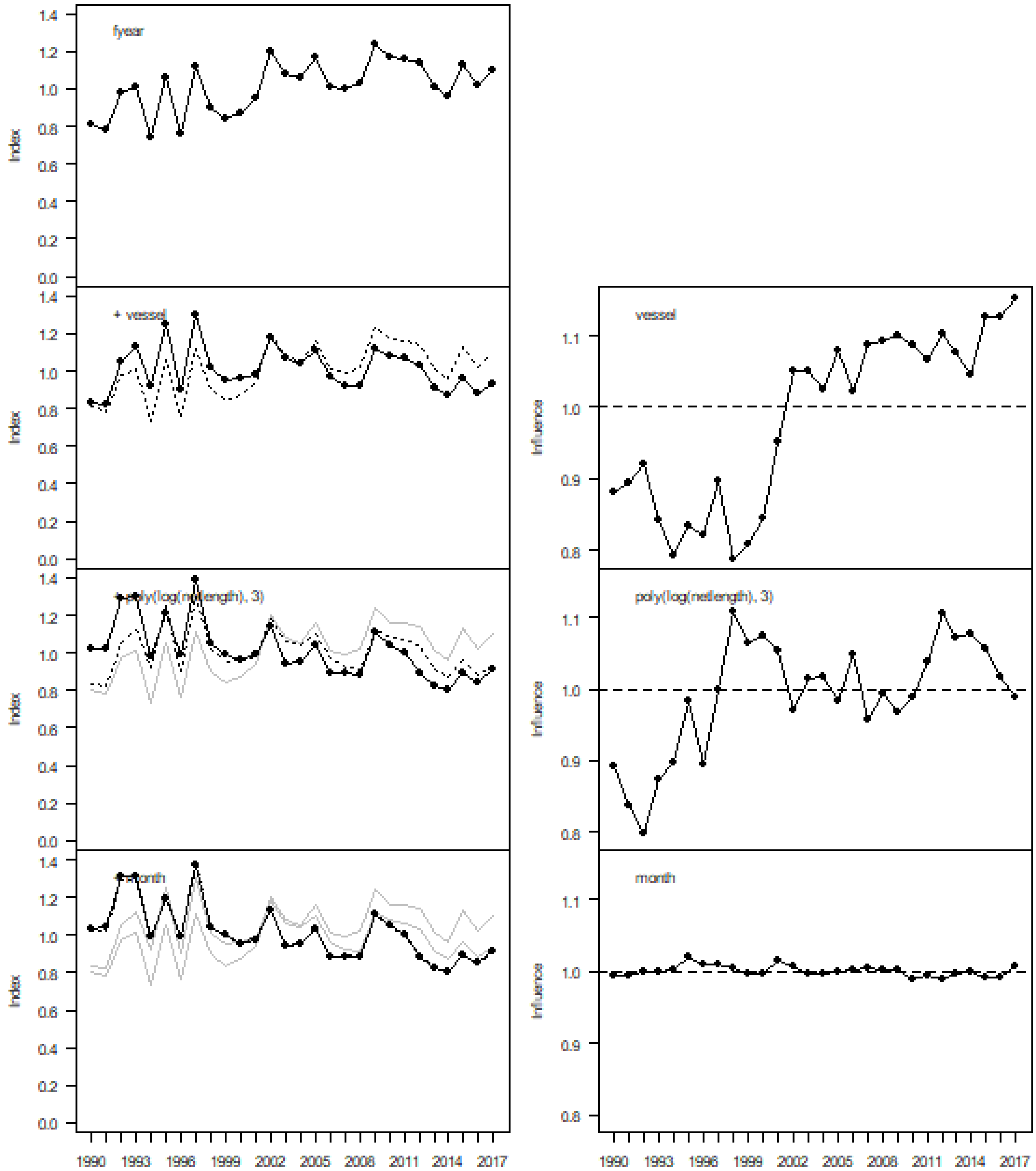

Figure O.4: [left column]: annual indices from the log-logistic model of `EN(TOT)-est` at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

O.2.1 Residual and diagnostic plots

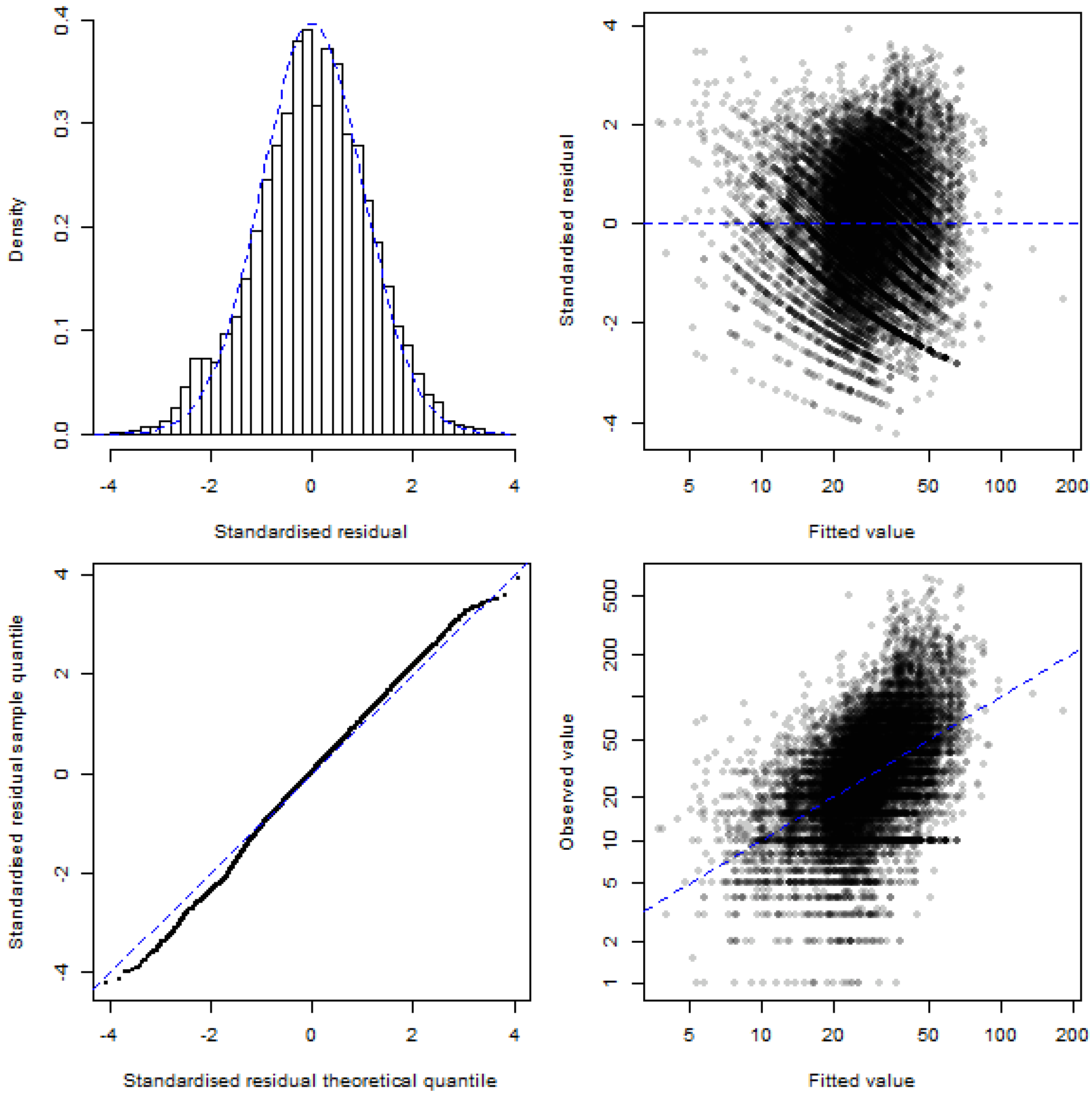

Figure O.5: Plots of the fit of the log-logistic standardised CPUE model of successful estimated FLA(TOT) catches in the `EN(TOT)-est` fishery. [Upper left] histogram of the standardised residuals compared to a log-logistic distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

O.2.2 Model coefficient plots

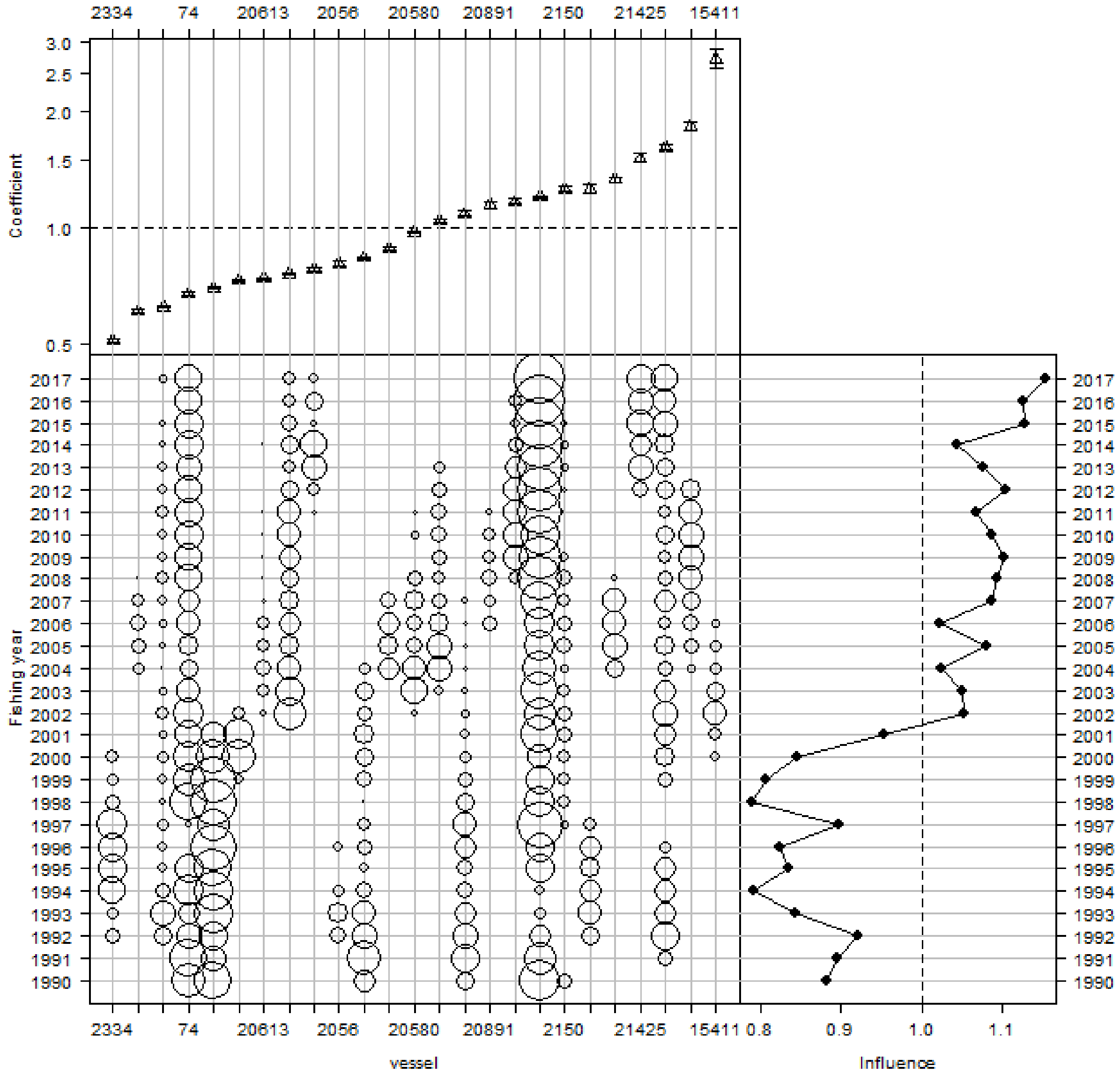

Figure O.6: Effect of vessel in the log-logistic model for the flatfish `EN(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

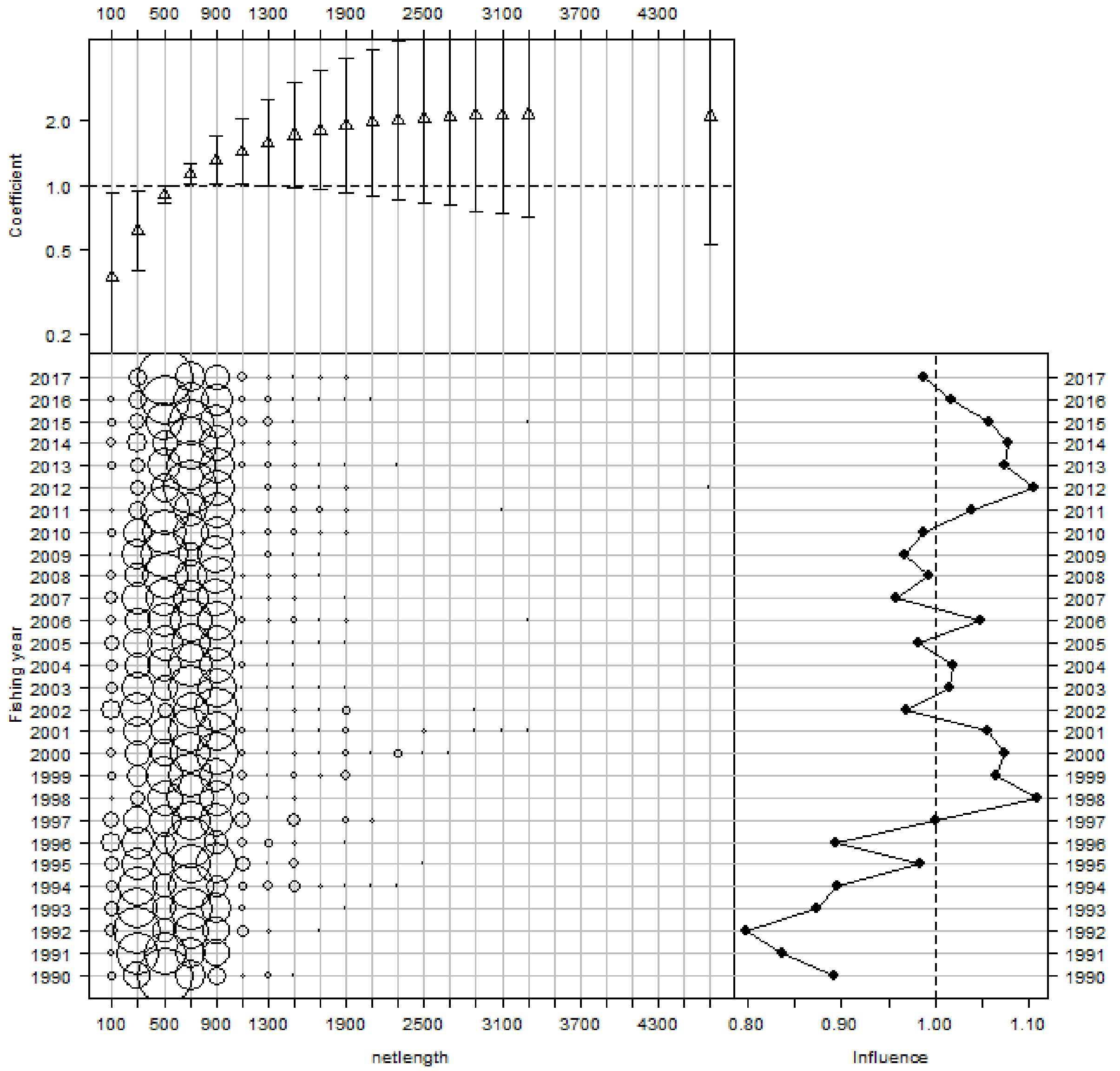

Figure O.7: Effect of log(net_length) in the log-logistic model for the flatfish `EN(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

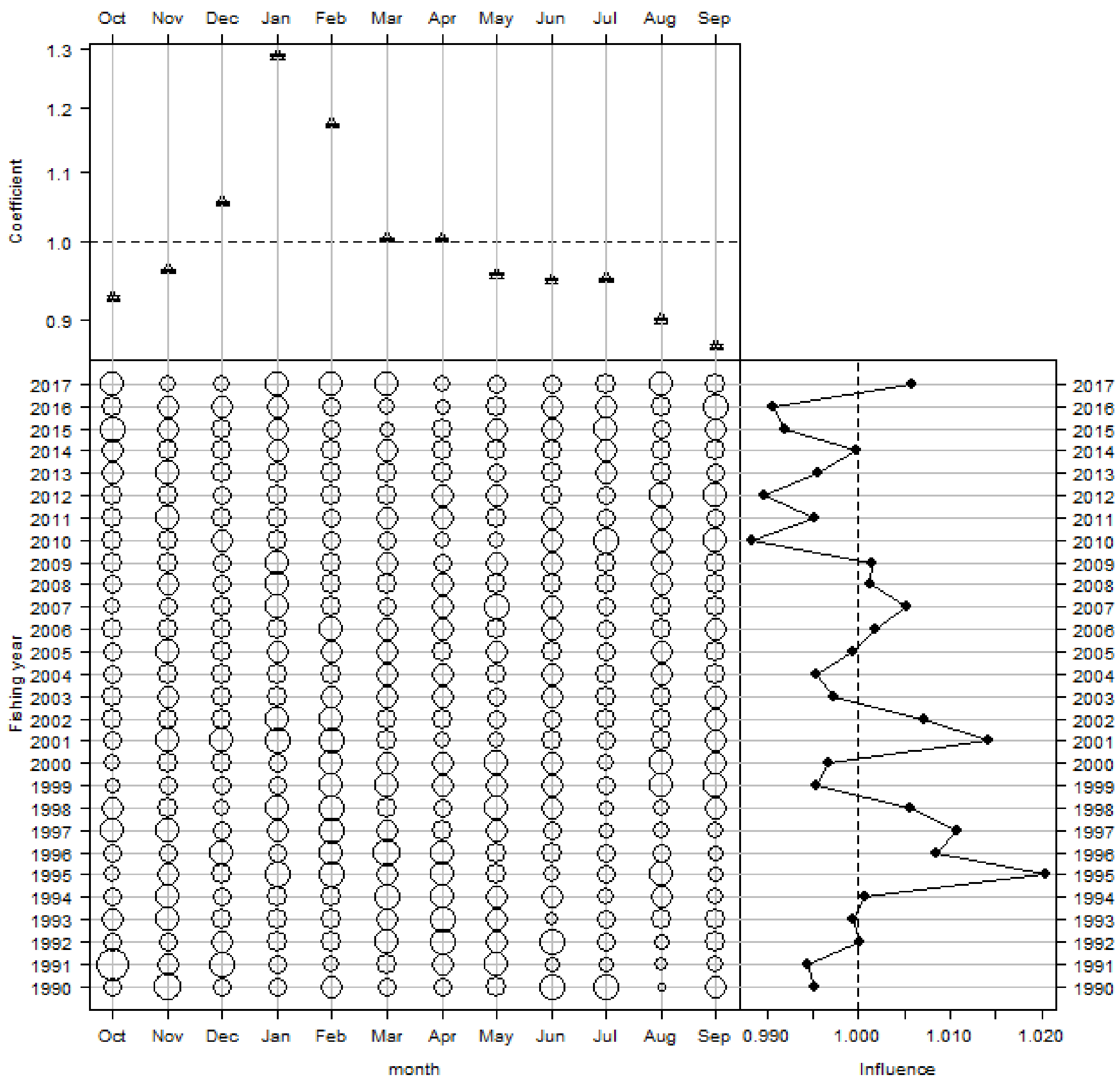

Figure O.8: Effect of month in the log-logistic model for the flatfish `EN(TOT)-est` fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

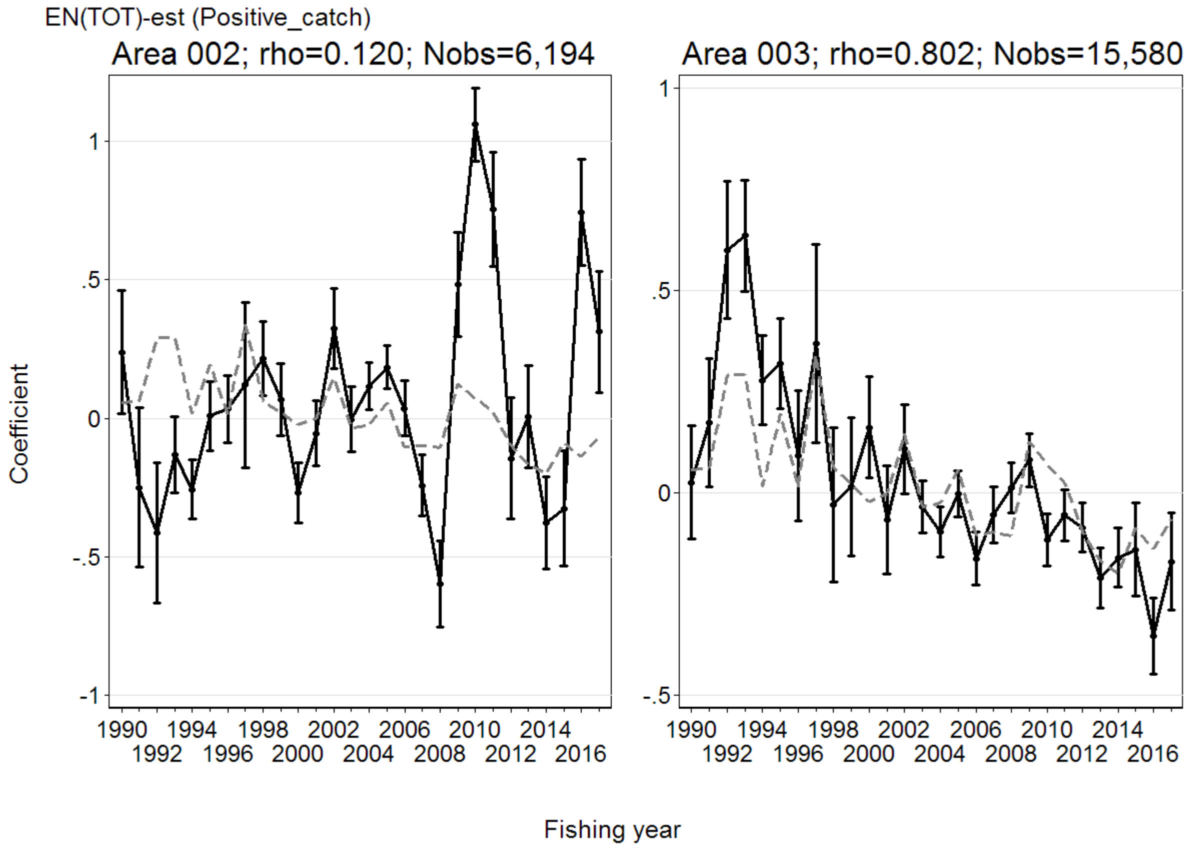

Figure O.9: Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the `EN(TOT)-est` SN log-logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised 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. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (*rho*) between the category year index and the overall model index, and the number of records supporting the category.

O.3 CPUE indices

Table O.3: Arithmetic indices for the total and core data sets, geometric and log-logistic standardised indices and associated standard error (SE) for the core data set by fishing year for the flatfish `EN(TOT)-est` analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.900	0.841	0.803	1.035	0.0325
1991	1.020	1.072	0.867	1.039	0.0377
1992	1.241	1.175	0.929	1.308	0.0340
1993	1.237	1.136	0.990	1.310	0.0271
1994	0.998	0.818	0.742	0.994	0.0227
1995	1.069	1.053	1.037	1.189	0.0232
1996	1.014	0.850	0.809	0.990	0.0286
1997	1.457	1.636	1.158	1.374	0.0461
1998	1.063	1.162	0.935	1.041	0.0308
1999	0.907	0.968	0.891	0.999	0.0276
2000	1.028	1.074	0.941	0.956	0.0246
2001	1.022	1.059	0.988	0.976	0.0257
2002	1.181	1.301	1.228	1.130	0.0236
2003	0.964	0.926	1.054	0.945	0.0182
2004	0.943	0.909	1.042	0.953	0.0171
2005	0.987	0.991	1.152	1.035	0.0162
2006	0.894	0.897	0.990	0.881	0.0179
2007	0.857	0.871	0.962	0.887	0.0184
2008	0.824	0.842	1.004	0.880	0.0199
2009	1.064	1.089	1.233	1.111	0.0205
2010	1.004	1.038	1.175	1.050	0.0214
2011	0.941	1.000	1.155	1.002	0.0203
2012	0.903	0.946	1.122	0.889	0.0203
2013	0.844	0.866	0.988	0.826	0.0214
2014	0.833	0.819	0.934	0.801	0.0212
2015	1.047	1.019	1.031	0.896	0.0268
2016	0.905	0.936	0.989	0.851	0.0252
2017	1.098	1.049	1.066	0.916	0.0284

Appendix P. DIAGNOSTICS AND SUPPORTING ANALYSES FOR HAURAKI GULF SFL ESTIMATED CATCH CPUE

P.1 Model definition and preliminary analyses

This CPUE analysis was not accepted by the NINSWG for monitoring Hauraki Gulf sand flounder (SFL) in 2018 (Fisheries New Zealand 2018). This was because reporting of SFL catches diminished considerably in the 2000s, leading to a large proportion of zero-catch records and concerns about possible bias in the reporting of this species (see upper and lower left panels in Figure P.2).

P.1.1 Fishery definition

HG(SFL)-est: The fishery is defined from setnet daily fishing events for fishing in Statistical Areas 005, 006 or 007 capturing flatfish using species code SFL (positive catch analysis). Criteria for excluding records: net length <10 m or >5000 m; duration <1 hour or >24 hours.

P.1.2 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 4 years using trips with at least 1 kg of SFL catch. These criteria resulted in a core fleet size of 43 vessels which took 81% of the catch (Figure P.1).

P.1.3 Data summary

Table P.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been "rolled up" into daily effort strata, events per daily-effort stratum, length of net set (in km), hours fished, estimated catch SFL (t), and percentage of trips and daily records with catch for the core vessel data set (based on a minimum of 10 trips per year in 4 years) in the HG(SFL)-est fishery.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net length [km])	Sum (hours)	Estimated catch (t)	% trips with catch	% records with catch
1991	21	1 339	1 401	1 556	1.11	1 223.48	8 631	28.57	68.5	67.7
1992	22	1 235	1 259	1 429	1.14	1 076.29	7 471	28.45	67.3	66.6
1993	24	1 661	1 693	1 866	1.10	1 582.21	9 782	38.65	75.3	74.1
1994	24	1 682	1 732	1 883	1.09	1 623.12	9 988	84.41	85.6	84.1
1995	23	1 468	1 505	1 622	1.08	1 400.70	8 271	52.18	86.6	86.2
1996	20	854	873	959	1.10	802.40	5 267	24.99	87.7	87.6
1997	19	1 116	1 146	1 326	1.16	1 124.35	5 987	21.02	77.2	76.3
1998	20	1 011	1 031	1 182	1.15	1 013.25	5 057	18.31	67.4	66.5
1999	21	1 158	1 179	1 355	1.15	1 073.05	6 064	20.18	71.5	71.3
2000	22	1 268	1 294	1 444	1.12	1 180.27	6 645	37.11	84.9	84.3
2001	24	1 570	1 604	1 855	1.16	1 522.36	8 828	26.59	81.2	80.9
2002	25	1 198	1 258	1 457	1.16	1 243.38	7 375	11.48	57.4	56.1
2003	26	1 851	1 929	2 315	1.20	2 197.80	13 258	9.12	41.1	40.3
2004	27	1 670	1 730	2 140	1.24	1 920.81	12 720	17.19	54.5	53.2
2005	27	2 024	2 041	2 407	1.18	2 298.89	13 801	34.94	56.7	56.5
2006	22	1 799	1 813	2 057	1.13	1 965.30	12 953	38.93	49.7	49.5
2007	23	1 615	1 626	1 916	1.18	1 744.25	11 141	14.27	32.5	32.4
2008	21	1 165	1 173	1 395	1.19	1 161.56	6 996	7.11	27.6	27.5
2009	20	1 192	1 197	1 370	1.14	1 141.02	6 524	6.62	28.0	27.9
2010	22	1 200	1 227	1 425	1.16	1 165.75	6 014	7.23	41.3	40.8
2011	18	1 031	1 123	1 278	1.14	959.61	4 818	4.76	37.3	36.2
2012	19	1 098	1 251	1 429	1.14	1 098.31	5 510	10.42	54.5	51.2
2013	20	1 273	1 442	1 670	1.16	1 282.05	6 837	22.25	68.6	68.2
2014	18	1 240	1 376	1 567	1.14	1 209.00	6 483	24.46	66.6	64.5
2015	19	954	1 069	1 264	1.18	955.64	5 726	20.10	56.8	56.1
2016	17	780	874	1 028	1.18	755.25	4 124	8.24	55.0	53.1
2017	14	864	955	1 134	1.19	781.48	4 303	31.07	74.3	73.4

P.1.4 Core vessel plots

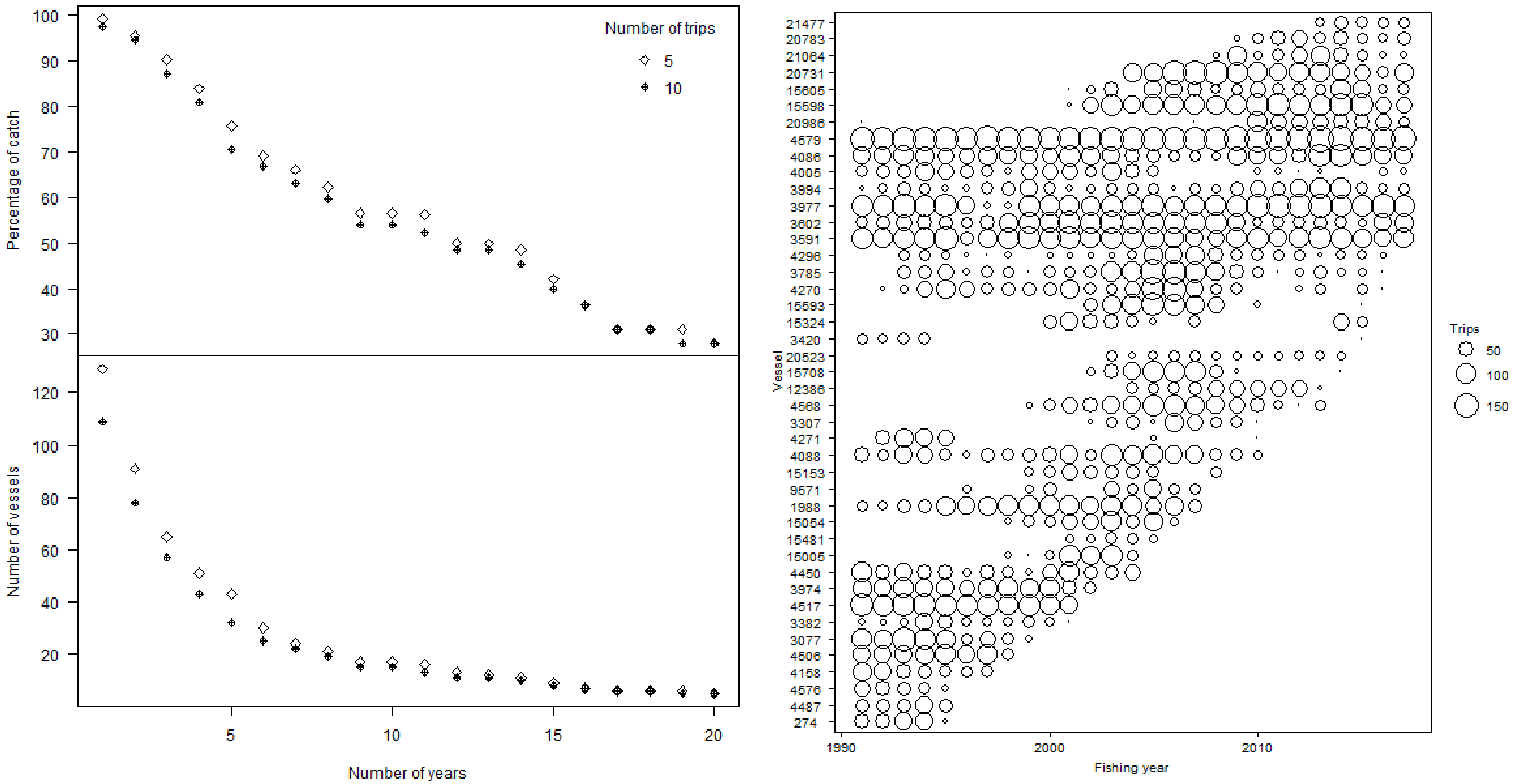

Figure P.1: [left panel]: total estimated SFL catch and number of vessels plotted against the number of years used to define core vessels participating in the HG(SFL)-est dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 4 or more fishing years) by fishing year.

P.1.5 Exploratory data plots for core vessel data set

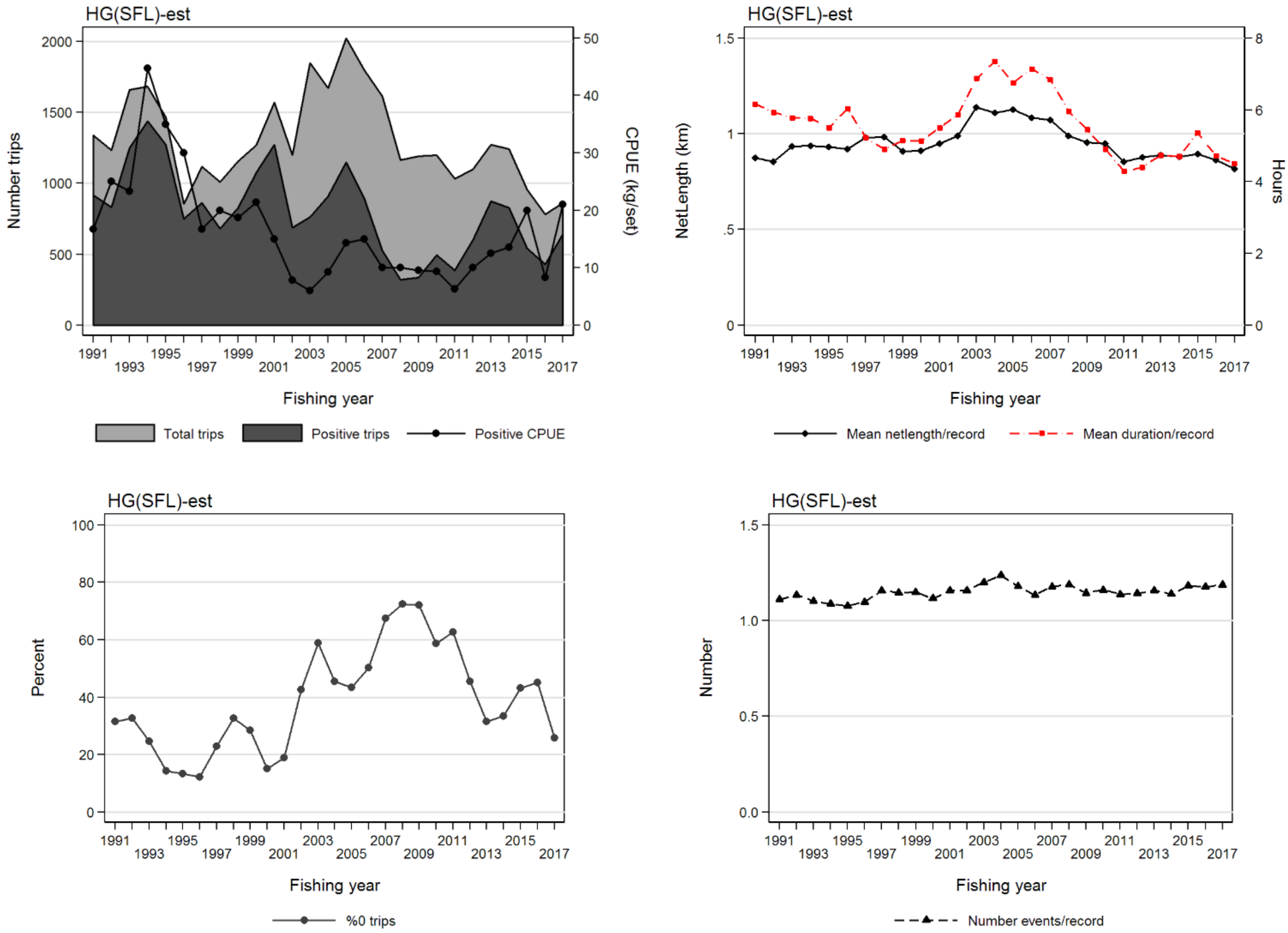

Figure P.2: Core vessel summary plots by fishing year for model HG(SFL)-est: [upper left panel]: total trips (light grey) and trips with SFL catch (dark grey) overlaid with median annual arithmetic CPUE (kg/net_set) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean length of net set and mean duration per daily-effort stratum record; [lower left panel]: percentage of trips with no estimated catch of SFL; [lower right panel]: mean number of events per daily-effort stratum record.

P.2 Positive catch model

The underlying positive catch distribution was forced to lognormal for consistency with Kendrick & Bentley (2015). Three of four explanatory variables entered the model after fishing year (vessel, month and duration of fishing; Table P.2), with length of net set a non-significant variable. A plot of the model is provided in Figure P.3and the CPUE indices are listed in Table P.3.

Table P.2: Order of acceptance of variables into the lognormal model of successful catches in the HG(SFL)-est fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 4 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-22 162	44 377	17.2	*
vessel	69	-18 117	36 373	40.5	*
month	79	-17 455	35 069	43.9	*
poly(log(duration, 3)	82	-17 229	34 623	45.0	*
poly(log(net_length), 3)	85	-17 209	34 588	45.1	

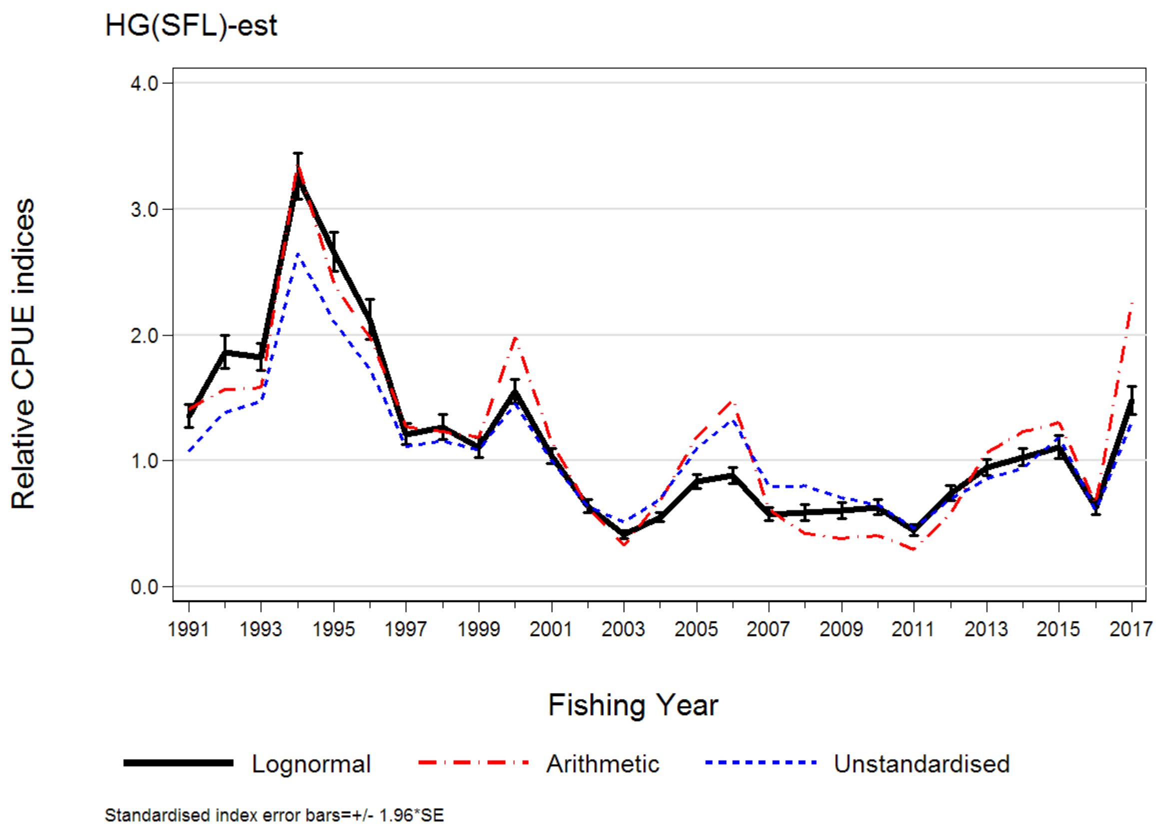

Figure P.3: Relative CPUE indices for estimated SFL(TOT) catch using the lognormal non-zero model based on the HG(SFL)-est fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. H.1) and b) Unstandardised (Eq. H.2).

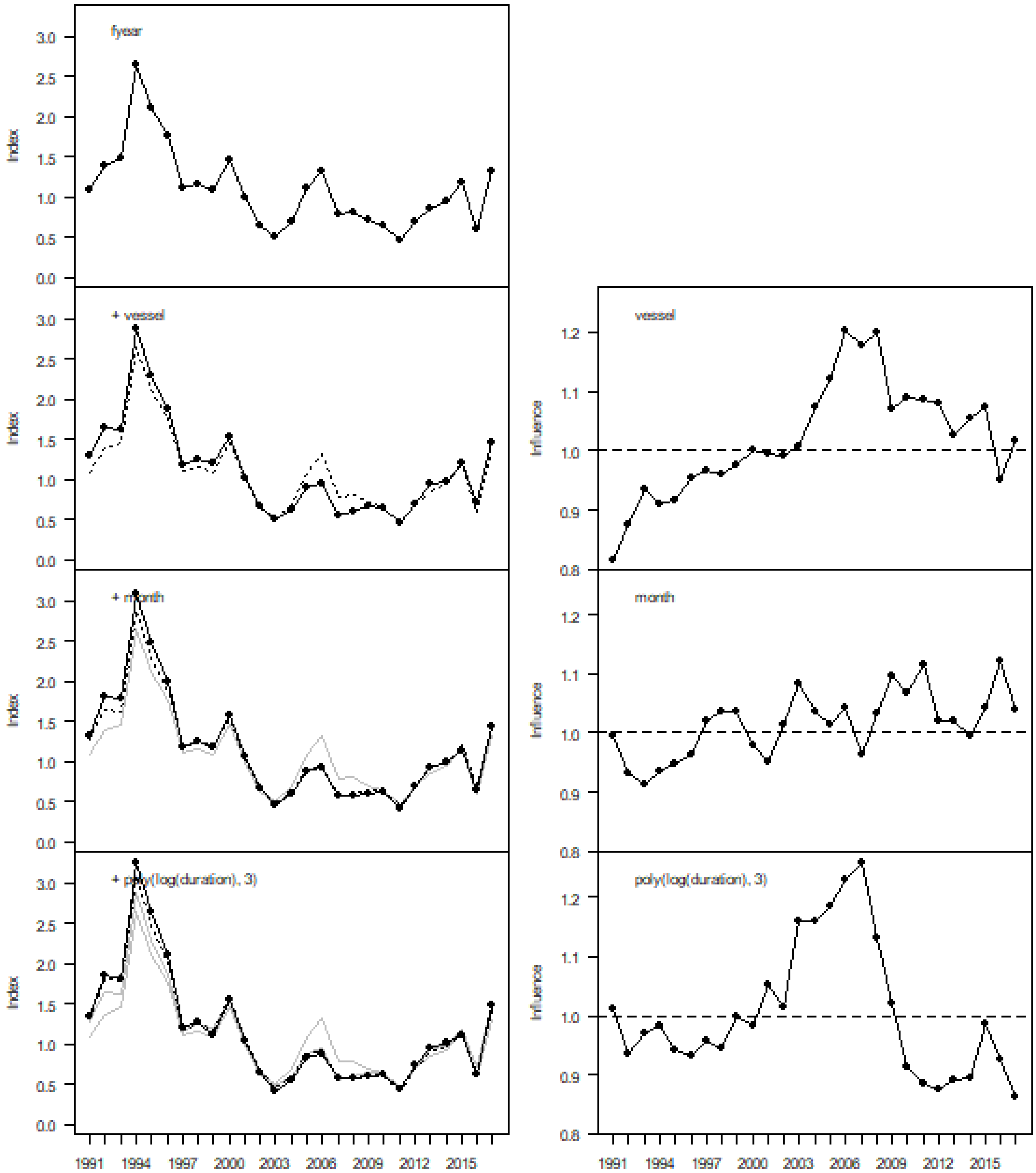

Figure P.4: [left column]: annual indices from the lognormal model of HG(SFL)-est at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

P.2.1 Residual and diagnostic plots

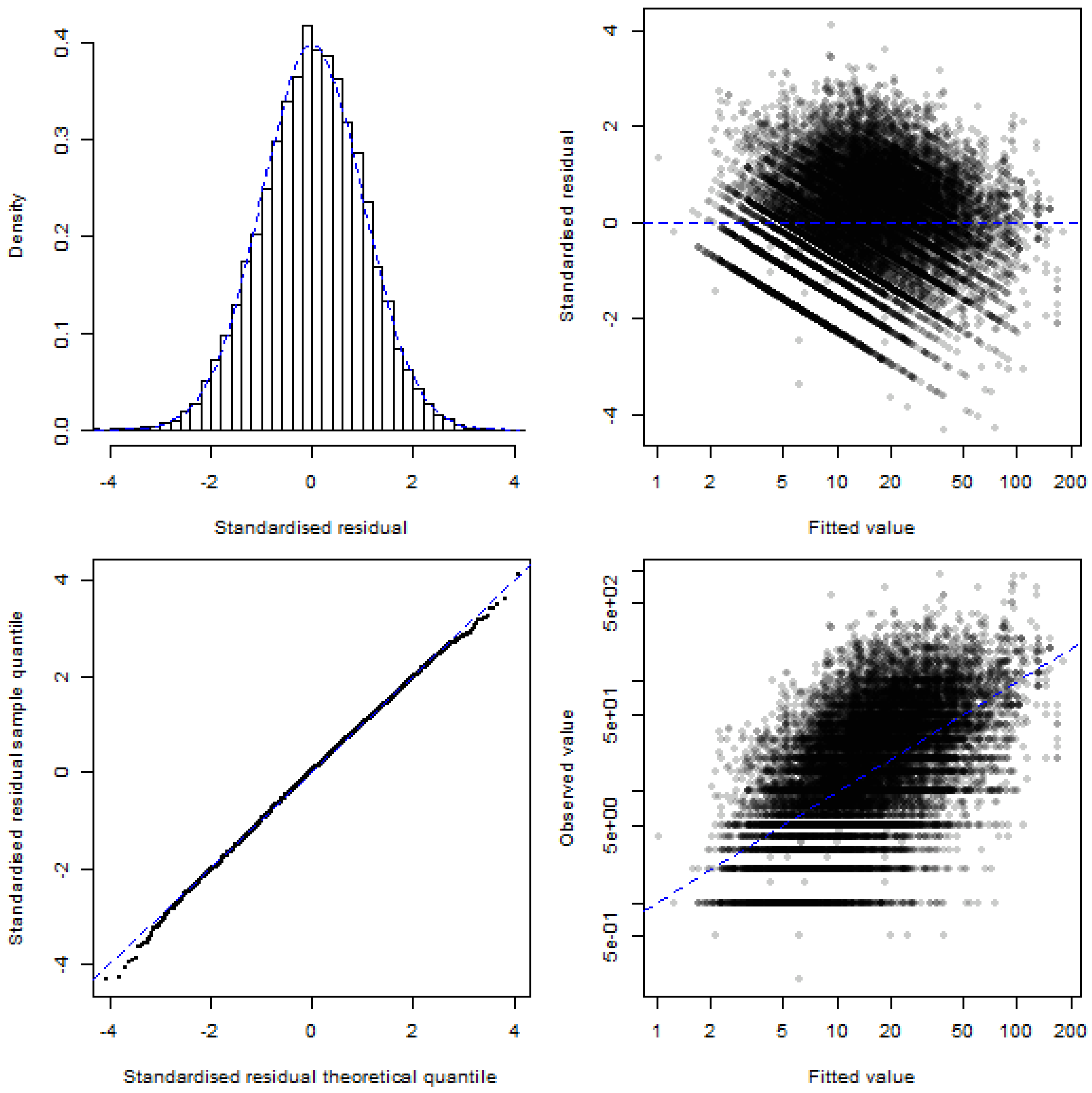

Figure P.5: Plots of the fit of the lognormal standardised CPUE model of successful estimated SFL(TOT) catches in the HG(SFL)-est fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

P.2.2 Model coefficient plots

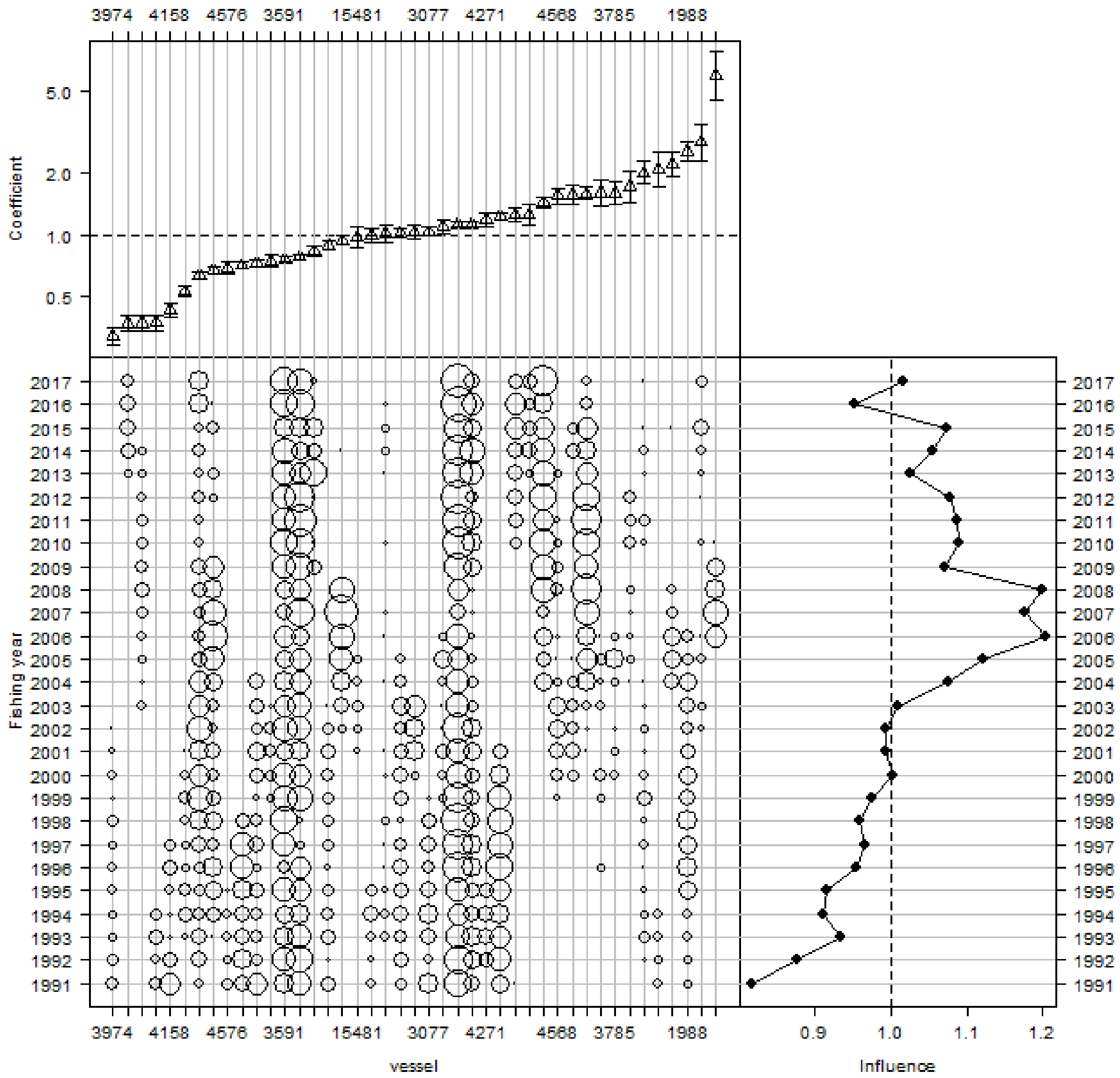

Figure P.6: Effect of vessel in the lognormal model for the HG(SFL)-est fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

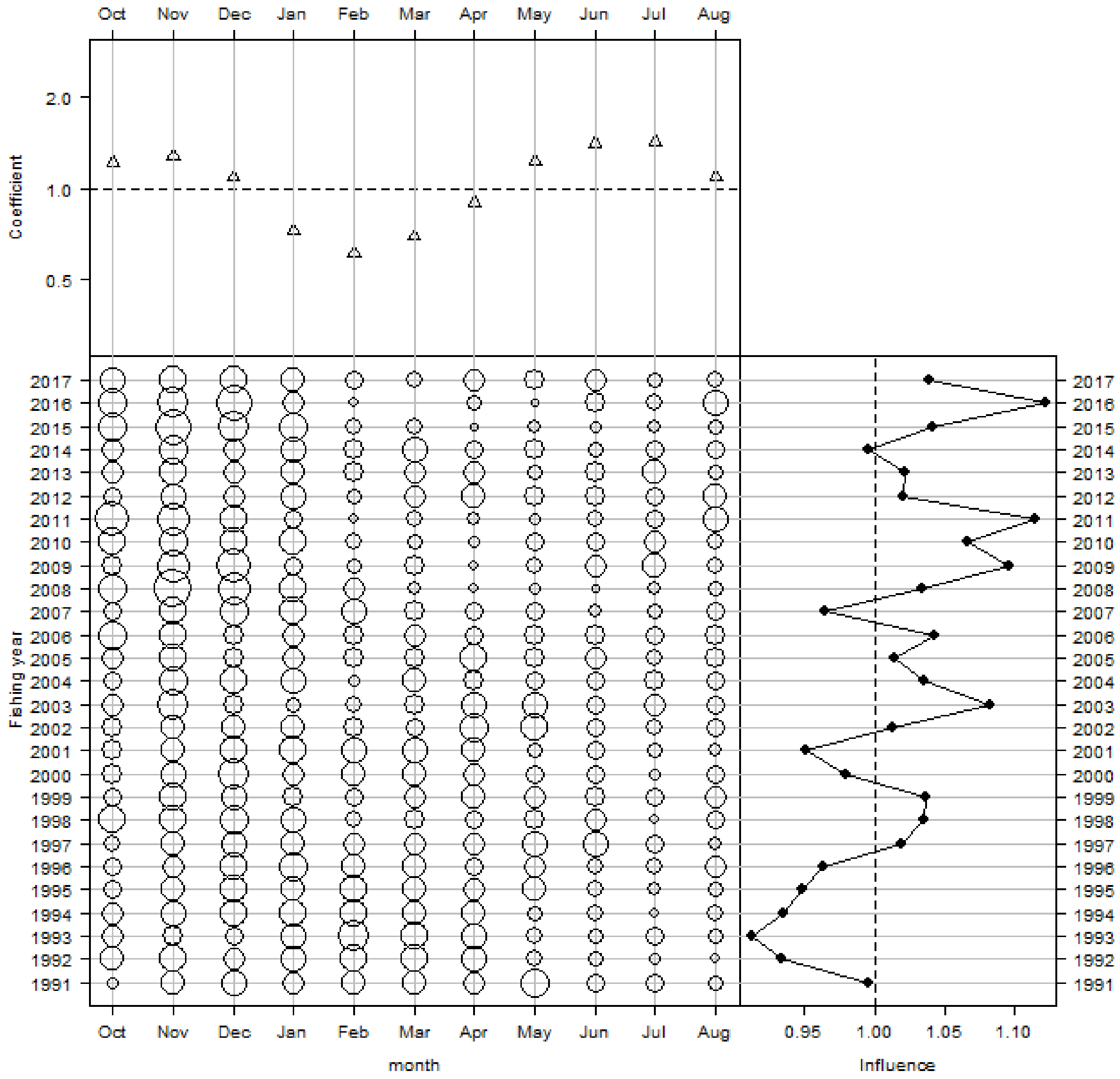

Figure P.7: Effect of month in the lognormal model for the HG(SFL)-est fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

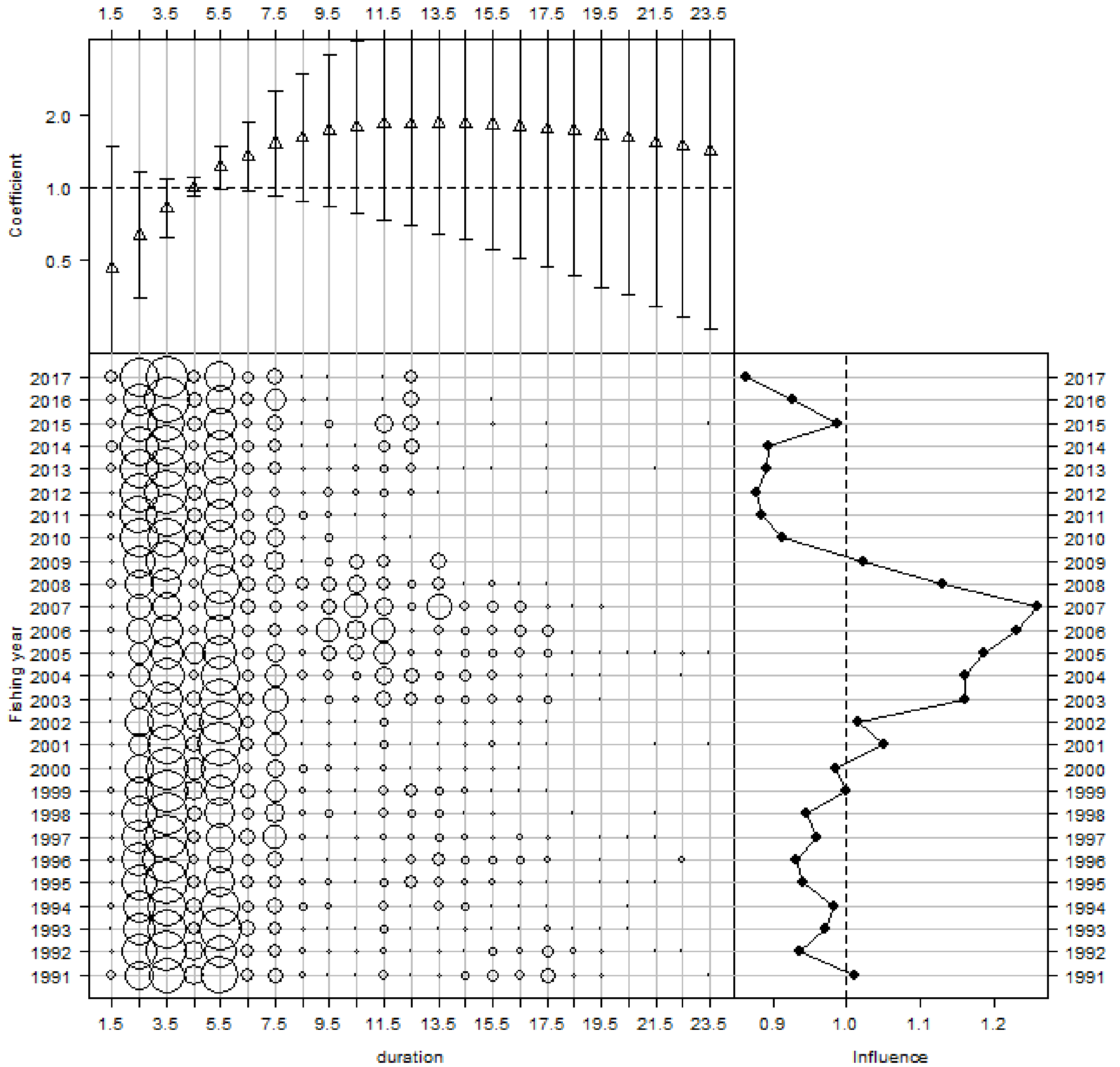

Figure P.8: Effect of log(duration) in the lognormal model for the HG(SFL)-est fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

P.3 CPUE indices

Table P.3: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the HG(SFL)-est analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels				Core vessels
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1991	1.186	1.412	1.077	1.352	0.0347
1992	1.403	1.564	1.386	1.858	0.0357
1993	1.327	1.580	1.469	1.824	0.0302
1994	3.532	3.373	2.648	3.257	0.0288
1995	2.538	2.400	2.109	2.654	0.0295
1996	1.929	1.981	1.726	2.120	0.0376
1997	1.369	1.270	1.114	1.209	0.0350
1998	1.406	1.229	1.157	1.266	0.0387
1999	1.288	1.185	1.085	1.103	0.0351
2000	2.013	1.985	1.454	1.550	0.0315
2001	1.304	1.147	1.001	1.036	0.0298
2002	0.702	0.632	0.634	0.638	0.0386
2003	0.342	0.327	0.513	0.412	0.0374
2004	0.727	0.688	0.694	0.551	0.0338
2005	1.388	1.185	1.097	0.834	0.0321
2006	1.440	1.486	1.329	0.883	0.0355
2007	0.510	0.608	0.792	0.570	0.0460
2008	0.381	0.419	0.800	0.586	0.0562
2009	0.336	0.383	0.703	0.602	0.0544
2010	0.310	0.408	0.651	0.629	0.0449
2011	0.254	0.293	0.462	0.443	0.0498
2012	0.672	0.577	0.696	0.740	0.0402
2013	1.239	1.068	0.858	0.945	0.0339
2014	1.527	1.231	0.938	1.027	0.0348
2015	1.327	1.302	1.186	1.105	0.0424
2016	0.635	0.653	0.605	0.629	0.0469
2017	2.092	2.252	1.310	1.477	0.0387

Appendix Q. COMPARISON OF CPUE SERIES BASED ON ESTIMATED CATCH WITH SCALED CATCHES USING THE F2 ALGORITHM

Q.1 Introduction

This report implemented a catch correction algorithm (Appendix F) developed by Kendrick & Bentley (2012b) to correct for rig (SPO 1) being landed using intermediate destination codes and subsequently sold to a LFR at a later date. This catch correction algorithm has also been adopted by the rock lobster CPUE analyses in order to correct for similar behaviour by the parts of the rock lobster fleet which store lobsters in holding pots for subsequent sale (Starr 2018), where it is known as the "F2" algorithm.

Q.2 Comparison plots

Figure Q.1 and Figure Q.2 compare series analysed using data where the catch vector has been prepared with the F2 algorithm (Appendix F) with series prepared using the same data except that the catch vector was based on unmodified estimated catch.

When these comparisons were reviewed in April 2018, the NINSWG noted that, while the F2 algorithm represented a potential improvement in the analysis of these data, the correspondence between series prepared using the alternative catch vectors was sufficiently good that "... *this additional step appeared to be unnecessary at this time but may become more important in future years*" (Fisheries New Zealand, 2018 – Chapter 20).

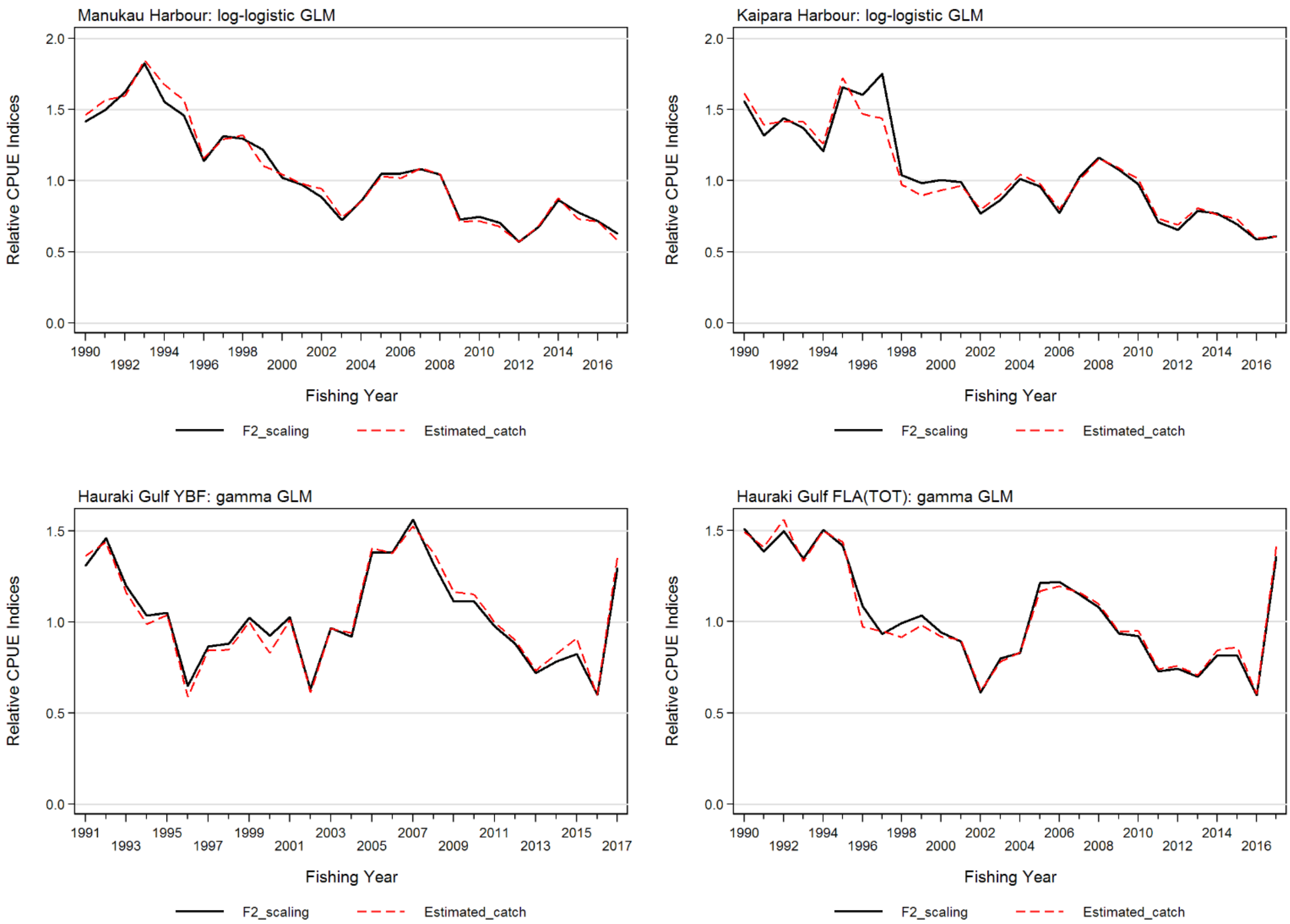

Figure Q.1: Comparison of series based on catch data prepared using the F2 algorithm and from estimated catch; [upper left panel]: Manukau Harbour; [upper right panel]: Kaipara Harbour; [lower left panel]: Hauraki Gulf YBF; [lower right panel]: Hauraki Gulf FLA(TOT);

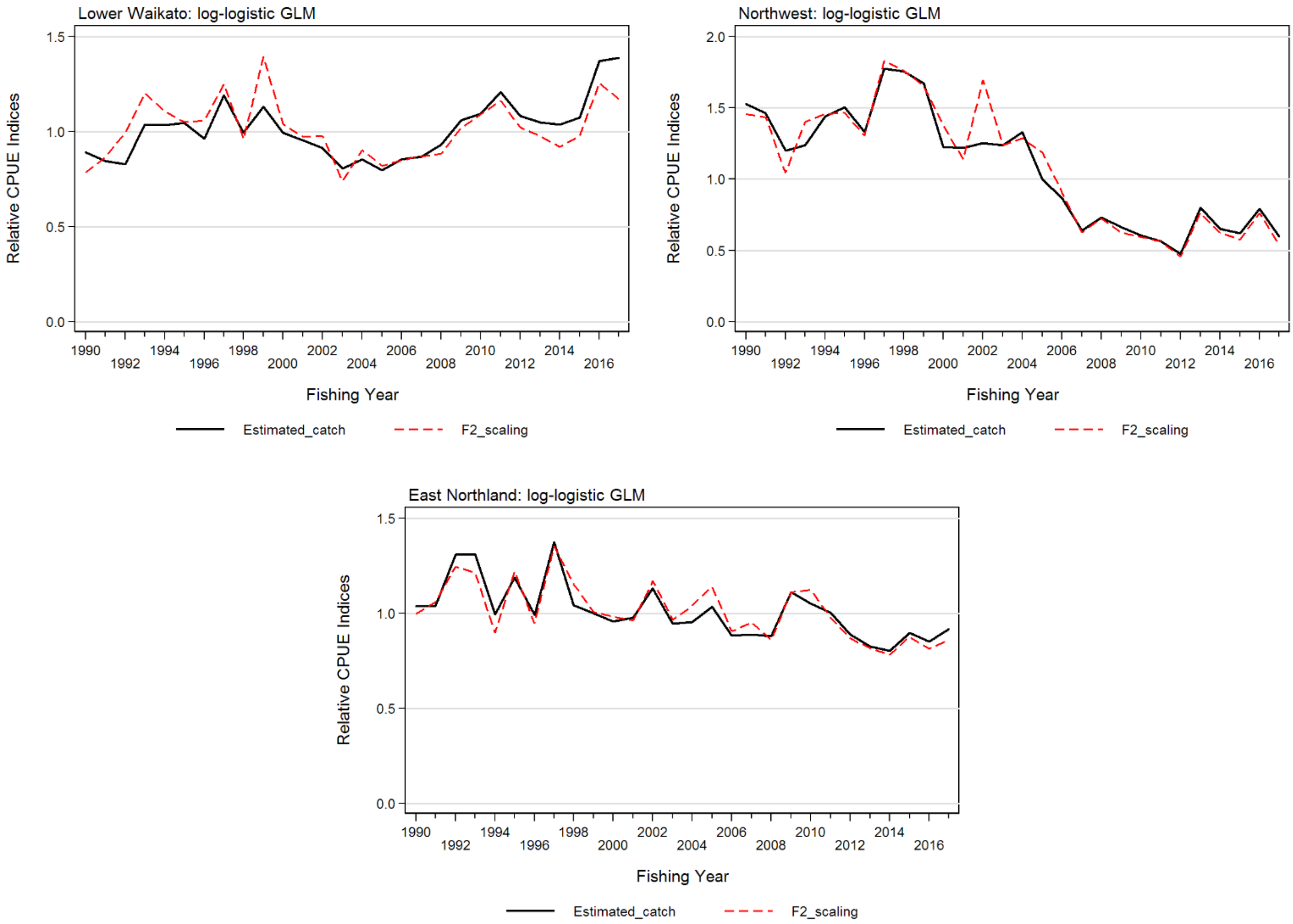

Figure Q.2: Comparison of series based on catch data prepared using the F2 algorithm and from estimated catch; [upper left panel]: Lower Waikato; [upper right panel]: Northwest; [lower central panel]: East Northland.