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SPO 1, 2, 3, 7 and 8 Fishery Characterisation and CPUE Report

New Zealand Fisheries Assessment Report 2017/62

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EXECUTIVE SUMMARY

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***New Zealand Fisheries Assessment Report 2017/62*. 244 p.**

The fisheries taking rig (*Mustelus lenticulatus*) around the New Zealand North and South Islands are described from 1989–90 to 2014–15, based on compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI). A number of setnet and bottom trawl fisheries take rig throughout New Zealand. The setnet fisheries tend to be fisheries targeted at rig or, less frequently, at school shark. Smaller rig (usually less than 1 m long) are taken incidentally in mixed target species bottom trawl fisheries off the North and South Islands. Detailed characteristics of the landing data associated with these fisheries, as well as the spatial, temporal, target species and depth distributions relative to the catch of rig in these fisheries are presented for all SPO QMAs. Annual performance of the SPO QMA catches and some regulatory information are also presented.

Commercial Catch Per Unit Effort (CPUE) analyses for eight setnet (SN) and five bottom trawl (BT) fisheries were considered as candidates for use as biomass indices to track population trends in these QMAs. These analyses were also based on the compulsory reported commercial catch and effort data that are collected by MPI. One fishery (SPO 3_BT) was the amalgamation of two previously reported fisheries [SPO 3_BT(FLA) and SPO 3_BT(MIX)]. One BT fishery [SPO 1E_BT(coast)] was rejected for lack of data and three SN fisheries were rejected [SPO 1E_SN(coast), SPO 1W_SN(041–047) and SPO 7_SN(STB)] for having too few data and with continuity affected by regulations designed to protect endemic dolphins. CPUE series for the four remaining BT fisheries (SPO 1W_BT, SPO 2_BT, SPO 3_BT, SPO 7_BT) and two of the five SN fisheries [SPO 3_SN(SHK) and SPO 7_SN(038)] were deemed to be of High Quality (Research Ranking=1) and consequently could be used for monitoring rig abundance. CPUE series from the remaining three SN fisheries [SPO 1E_SN(007), SPO 1W_SN(043) and SPO 1W_SN(044)] were given a Research Ranking of 2 (Medium or Mixed Quality). CPUE series for these fisheries were downgraded because of concern that the coverage in these fisheries was too restricted to monitor the full area.

The five BT fisheries all show similar increasing trends, particularly in recent years, while the three SN fisheries covering the east coasts of the North and South Islands show no overall trend and the five SN west coast North/South Islands have been declining over the same period. The increasing trends in the BT fisheries are interpreted as indicating good recruitment, an observation that seems to be corroborated by the two fishery independent surveys on the east and west coasts of the South Island. The declining or flat trends in the SN fisheries are worrisome because these fisheries tend to occur in harbours or confined areas where they target large mature females. These contradictory signals are difficult to reconcile and suggest that the fisheries that capture this species need to be closely monitored.

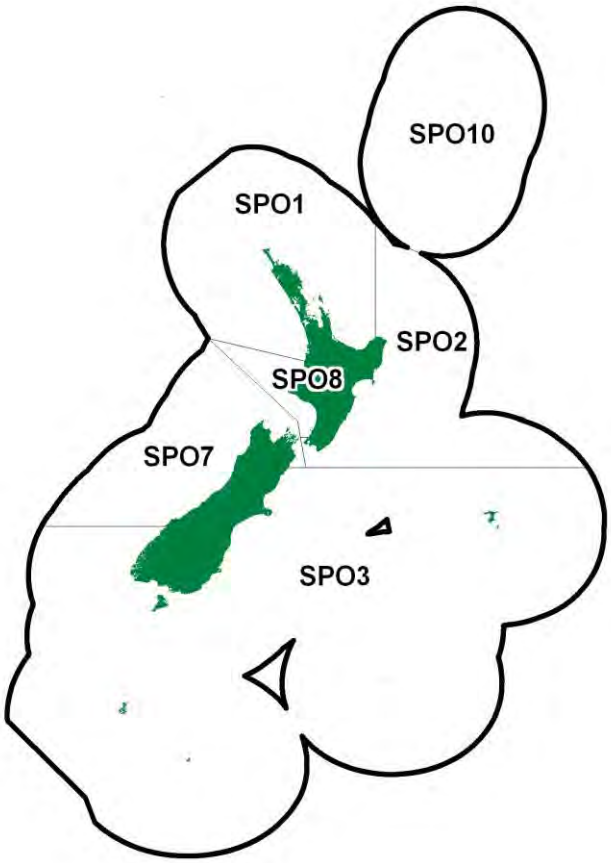

Figure 1: Map of SPO QMAs.

1. INTRODUCTION

This document describes work conducted under Objectives 1 and 2 of the Ministry for Primary Industries (MPI) contract SPO2015-01.

Overall Objective:

1. To characterise all rig (*Mustelus lenticulatus*) fisheries and undertake CPUE analyses in SPO 1, 2, 3, 7 and 8.

Specific Objectives:

1. To characterise the SPO 1, 2, 3, 7 and 8 fisheries.
2. To analyse existing commercial catch and effort data to the end of the 2014/15 fishing year and undertake CPUE standardisations for each stock.

This project extends the following previous projects:

Fishstock	Reference	Last fishing year in analysis
SPO 1	Starr & Kendrick (2016)	2011–12
SPO 2	Starr & Kendrick (2015a)	2013–14
SPO 3	Starr & Kendrick (2016)	2011–12
SPO 7	Starr & Kendrick (2015b)	2013–14
SPO 8	Starr & Kendrick (2016)	2011–12

This report summarises fishery and landings characterisations for SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8, as well as presenting CPUE standardisations derived from trawl and setnet data originating from each of the above QMAs. This work is part of the MPI schedule for Group 5 stocks: chondrichthian stocks that are monitored using indices of relative abundance. Abbreviations and definitions of terms used in this report are presented in Appendix A. A map showing the rig MPI QMAs is presented in Figure 1. Appendix B presents the MPI FMAs in the context of statistical reporting areas.

2. INFORMATION ABOUT THE STOCK/FISHERY

2.1 Catches

The TACC for rig in SPO 1 was set at 540 t when this Fishstock was first put in the QMS in 1986, but increased through the process of quota appeals to 688 t by 1990–91 (Figure 2; Table C.1). The TACC was increased to 829 t in 1991–92 under the provisions of the Adaptive Management Programme (AMP) (Table C.1). The TACC was reduced to 692 t in 1997–98 when SPO 1 was removed from the AMP and has since remained at that level. Catch levels declined after 1991–92 to below 300 t in 2007–08, after which catches remained steady at levels slightly above 300 t/year (Figure 2; Table C.1).

The TACC for rig in SPO 2 was set at 64 t when this Fishstock was first put in the QMS in 1986 and it then increased in each successive year to 71 t in 1990–91 due to quota appeals. It was increased to 86 t in 1991–92 under the provisions of the AMP (Figure 2; Table C.1). Catch levels began to exceed the TACC in the early 1990s and have since remained above the TACC in every year from 1991–92 to 2012–13 (Figure 2; Table C.1). The TACC was reduced in 1997–98 to 72 t when SPO 2 was removed from the AMP, but was raised back to 86 t in 2004–05 and raised again to 108 t in 2011–12. Landings have exceeded the SPO 2 TACC between 8% and 32% since 2001–02, except for 2012–13 when the TACC was undercaught by 2% (Table C.1).

The TACC for SPO 3 was increased from 364 to 430 t for the 1991–92 fishing year when it was increased under the provisions of the AMP (Figure 2; Table C.1). Landings increased but did not approach the new TACC until 1994–95. The TACC was again increased under the AMP to 600 t/year in 2000–01 but landings never approached this level until 2014–15, when 550 t were landed. Landings varied between 350 and 450 t/year from the mid-1990s to 2008–09, which was the lowest annual catch after 1993–94 (Table C.1; Figure 2). Landings then increased steadily to the highest level in the series at 556 t in 2014–15.

The TACC for SPO 7 was increased from 294 to 350 t for the 1991–92 fishing year under the provisions of the AMP (Figure 2; Table C.1). Landings increased but did not exceed the higher TACC until 1995–96 and 1996–97. Catches dropped below the TACC after 1997–98 and subsequently dropped to below 300 t per year after the 2001–02 fishing year (Figure 2; Table C.1). The TACC was lowered to 221 t for the 2006–07 fishing year in response to a stock assessment that was based on the west coast South Island trawl survey indices and two CPUE series, one from the Statistical Area 038 (Tasman/Golden Bays) and the other from the west coast of the South Island. Landings have exceeded the new, lower, TACC in each year since then, by 20% in 2006–07 and then by 3% to 6% from 2007–08 to 2014–15.

The TACC for SPO 8 increased gradually from 240 to 310 t through quota appeals between 1986–87 and 1990–91 (Figure 2; Table C.1). The TACC was then increased to 370 t for the 1991–92 fishing year under the provisions of the AMP. Catches more than doubled by 1995–96, but never reached the new, higher, TACC. The TACC was reduced back to 310 t in 1997–98 when SPO 8 was removed from the AMP. Catches dropped to 174 t in 2000–01 and have since fluctuated around 200 t/year, ranging from 163 t in 2005–06 and a maximum of 246 t in 2009–10 (Table C.1; Figure 2). An important exception to this was the very low annual catch in 2012–13 of 120 t, which coincided with the introduction of very severe restrictions to the North Taranaki Bight setnet in response to low

population numbers in the endemic Maui dolphin. Landings have since recovered to near 200 t/year in 2013–14 and 2014–15.

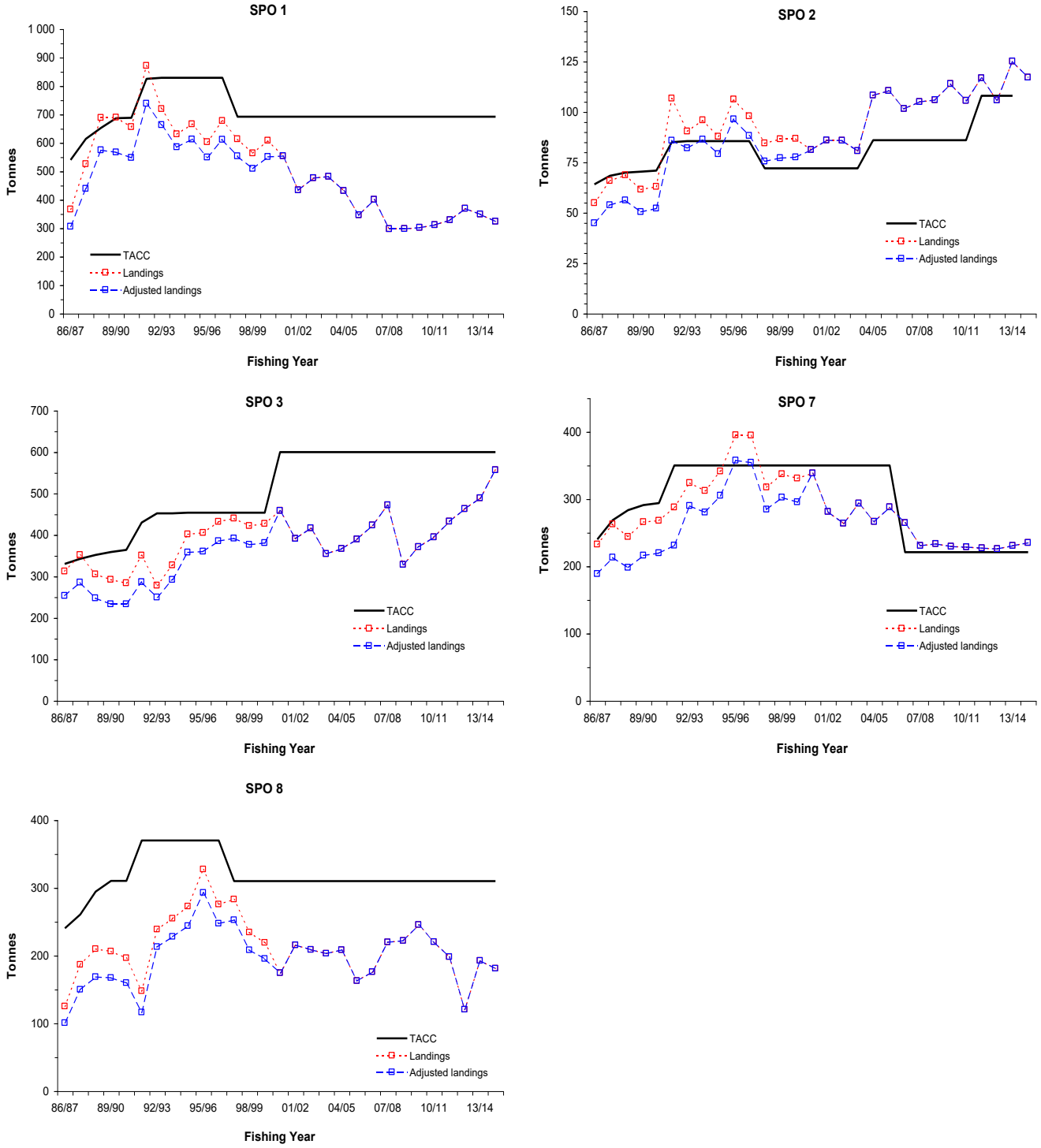

Figure 2: **Plots of SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 landings and TACCs from 1986–87 to 2014–15 (see Table C.1 for list of landings and TACCs by SPO QMA). 'Adjusted landings' before 2000–01 have been adjusted to reflect changes in historical conversion factors (see Eq. 2 in Section 2.3.2.2).**

2.2 Regulations affecting the fishery

Rig are usually processed at sea shortly after they have been captured, by removing the head and tail and then eviscerated. This processing procedure, termed 'headed & gutted' or HGU, has been industry practice for at least twenty years and there has been no known systematic change in processing procedure over that period (P. Dawson *pers. comm.*). What has changed is the 'conversion factor' used to translate the processed HGU (and DRE or 'dressed') weight back into green weight (GRE). The conversion factor in use for these landing states, from at least 1960 to the 1991–92 fishing year, was 2.0 (information presented in Section 2.3.2.2). The HGU and DRE conversion factors were dropped to 1.75 from 1992–93 to 1999–2000, and then to 1.55 until present. This means that landings of rig are not directly comparable across years unless a correction is made for the changes in conversion factor.

2.3 Analysis of SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 catch and effort data

2.3.1 Methods used for 2016 analysis of MPI catch and effort data

2.3.1.1 Obtaining data extracts

Three data extracts were obtained from the Ministry for Primary Industries (MPI) Warehou database (Ministry of Fisheries 2010). One extract consisted of the complete data set (all fishing event information along with all rig landing information) from every trip that recorded landing rig in any New Zealand rig QMA (SPO 1, SPO 2, SPO 3, SPO 7 or SPO 8, starting from 1 October 1989 and extending to 30 September 2015). Two further extracts were obtained: one consisting of all New Zealand trips using the methods BT (bottom trawl), BPT (bottom pair trawl), MW (midwater trawl) or MWPT (midwater pair trawl) and that did **not** target ORH (orange roughy), OEO (oreo) or CDL (cardinalfish). The final extract requested data pertaining to all New Zealand trips that used the setnet method, with regard to target species. Once these trips were identified, all fishing event data and rig landing data from the entire trip, regardless of method of capture, were obtained. These data extracts (MPI replog 10380) were received 22 January 2016. The first data extract was used to characterise and understand the fisheries taking rig. These characterisations are reported in Sections 2.3.2 and 2.3.3, plus detailed summary tables in Appendix H. The remaining two extracts were used to calculate CPUE standardisations (Section 3).

2.3.1.2 Preparation of data extracts

Data were prepared by linking the effort ('fishing event') section of each trip to the landing section, based on trip identification numbers supplied in the database. Effort and landing data were groomed to remove 'out-of-range' outliers (the method used to groom the landings data is documented in Appendix D; the remaining procedures used to prepare these data are documented in Starr [2007]). See Section 2.3.2 (below) for a description of how the linking of landings and effort was modified to accommodate the increased use of intermediate landing codes in SPO 1.

The original level of time stratification for a trip is either by tow or day of fishing, depending on the type of form used to report the trip information. These data were amalgamated into a common level of stratification known as a 'trip stratum' (see table of definitions: Appendix A) for the characterisation part of this report. Depending on how frequently an operator changed areas, method of capture or target species, a trip could consist of one to several 'trip strata'. This amalgamation was required so that these data could be analysed at a common level of stratification across all reporting form types. Landed catches of rig by trip were allocated to the 'trip strata' in proportion to the estimated rig catches in each 'trip stratum'. In situations when trips recorded landings of rig without any associated estimates of catch in any of the 'trip strata' (operators were only required to report the top five species in any fishing event), the rig landings were allocated proportionally to effort (tows for trawl data and length of net set for setnet data) in each 'trip stratum'.

Table 1: Comparison of the total adjusted QMR/MHR catch (t) with the sum of the corrected landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data ('analysis' data set) using the SPO QMA expansion rule and the sum of the estimated catches from the analysis data set, all representing the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 QMAs. Data source: MPI replog 10380: 1989–90 to 2014–15. Landings and QMR/MHR totals have been adjusted to consistent conversion factors across years (see Section 2.3.2.2).

Fishing year	QMR/ MHR (t)	Total landed catch (t)[1]	% landed/ QMR/ MHR	Total analysis catch (t)	% analysis /landed	Total estimated catch (t)	% estimated /analysis
89/90	1 233	938	76	904	96	818	91
90/91	1 212	1 064	88	1 027	97	886	86
91/92	1 457	1 277	88	1 237	97	1 059	86
92/93	1 497	1 397	93	1 365	98	1 107	81
93/94	1 471	1 535	104	1 488	97	1 193	80
94/95	1 598	1 640	103	1 617	99	1 323	82
95/96	1 656	1 699	103	1 609	95	1 266	79
96/97	1 686	1 647	98	1 557	95	1 186	76
97/98	1 557	1 518	97	1 419	94	1 100	77
98/99	1 473	1 446	98	1 389	96	1 027	74
99/00	1 500	1 523	102	1 456	96	1 101	76
00/01	1 606	1 655	103	1 584	96	1 166	74
01/02	1 407	1 454	103	1 398	96	1 058	76
02/03	1 451	1 469	101	1 431	97	1 039	73
03/04	1 413	1 403	99	1 341	96	935	70
04/05	1 380	1 355	98	1 280	94	892	70
05/06	1 296	1 277	99	1 211	95	845	70
06/07	1 366	1 360	100	1 273	94	900	71
07/08	1 324	1 311	99	1 197	91	927	77
08/09	1 187	1 159	98	1 022	88	781	76
09/10	1 262	1 223	97	1 101	90	846	77
10/11	1 260	1 222	97	1 120	92	842	75
11/12	1 303	1 267	97	1 180	93	911	77
12/13	1 284	1 257	98	1 176	94	889	76
13/14	1 386	1 355	98	1 260	93	958	76
14/15	1 413	1 404	99	1 300	93	1 009	78
Total	36 681	35 857	98	33 942	95	26 064	77

[1] Includes all SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 landings in replog 10380 except for 85 trips excluded for being 'out of range' (Table D.1).

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

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

where $\mathbf{QMR}_y$ is the annual QMR/MHR landings, AL_y is the corresponding total annual landings from the analysis data set and $L_{i,y}$ are the landings for record i in year y.

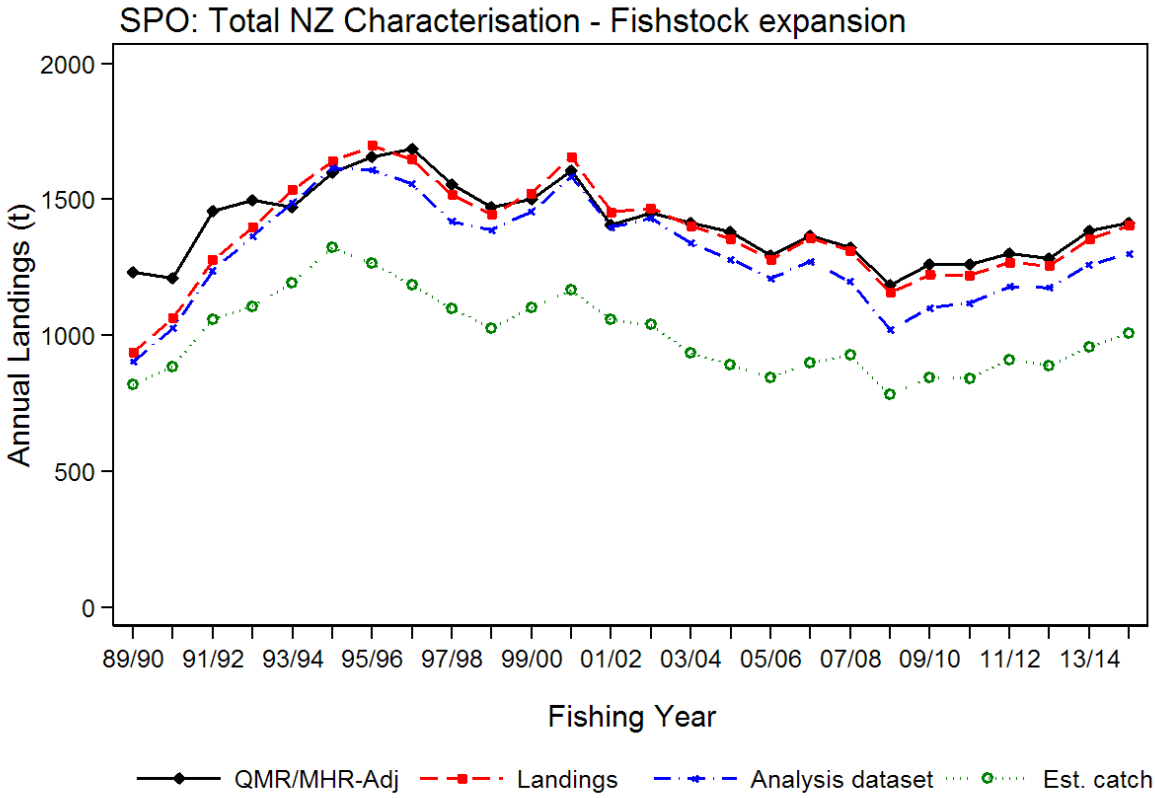

Figure 3: **Plot of the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 catch data set for totals presented in Table 1. Note that both the QMR/MHR totals and the landings have been adjusted to consistent conversion factors for all years.**

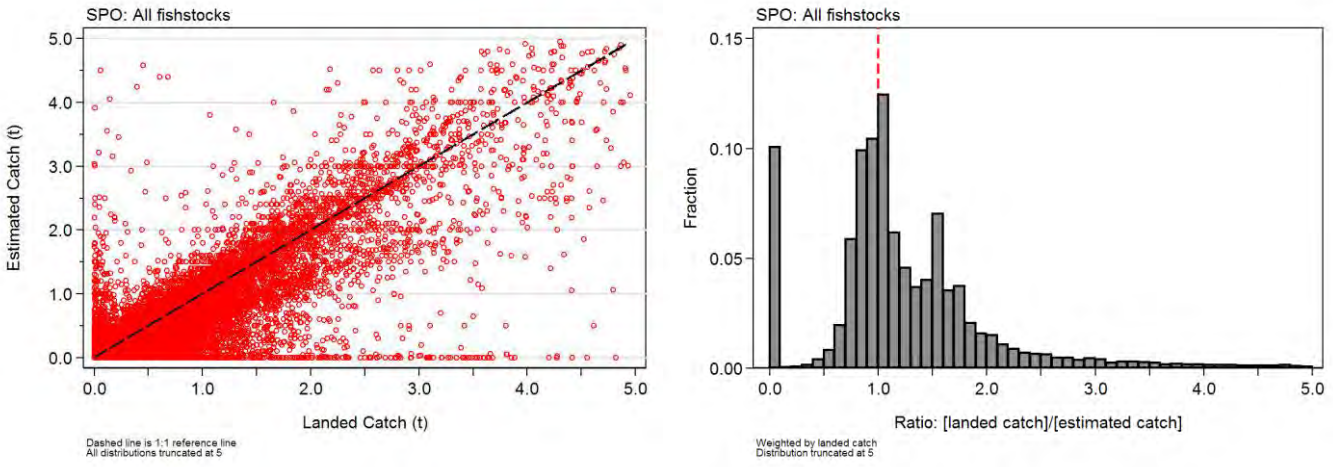

Figure 4: **[left panel]: Scatter plot of the sum of landed and estimated rig catch for each trip in the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 analysis data set; [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.**

Table 2: Summary statistics pertaining to the reporting of estimated catch from the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 analysis data set.

	Trips with landed catch but that report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	35	14	173	0.47	0.93	1.37	2.33
90/91	33	13	158	0.50	0.98	1.32	2.33
91/92	34	12	177	0.47	1.00	1.27	2.43
92/93	35	12	176	0.50	1.00	1.45	2.66
93/94	36	11	162	0.50	1.00	1.44	2.83
94/95	37	11	184	0.50	1.01	1.60	3.10
95/96	37	14	232	0.52	1.03	1.58	3.00
96/97	38	15	248	0.52	1.04	1.58	2.97
97/98	37	12	194	0.50	1.10	1.65	3.06
98/99	36	13	193	0.47	1.10	1.57	3.10
99/00	33	12	185	0.50	1.14	1.73	3.19
00/01	31	11	178	0.56	1.20	1.65	3.15
01/02	31	9	129	0.54	1.18	1.58	3.33
02/03	33	10	142	0.58	1.23	1.77	3.55
03/04	36	11	151	0.50	1.32	1.91	4.03
04/05	38	11	152	0.52	1.28	1.83	4.42
05/06	39	11	144	0.56	1.33	2.09	4.27
06/07	36	11	151	0.56	1.31	2.32	4.50
07/08	18	4	59	0.50	1.24	1.81	4.00
08/09	19	5	53	0.47	1.23	1.82	4.50
09/10	19	4	50	0.48	1.27	1.84	4.65
10/11	19	4	53	0.45	1.25	2.11	4.67
11/12	19	4	46	0.49	1.24	1.87	4.30
12/13	20	3	41	0.49	1.27	1.92	4.97
13/14	21	3	42	0.50	1.28	1.97	4.85
14/15	20	3	48	0.50	1.29	2.00	5.02
Total	31	10	3 521	0.50	1.14	1.71	3.60

2.3.1.3 Characteristics and summary information from data extracts

The annual totals at different stages of the data preparation procedure are presented in Table 1 and Figure 3. Total landings in the data set are similar to the landings in the QMR/MHR system, except for a 7% to 24% shortfall in landings in the first four years of data (1989–90 to 1992–93: see Table 1). Landings by year in the subsequent fishing years vary from –3% to +4% relative to the QMR/MHR annual totals (Table 1). The shortfall between landed and estimated catch by trip varies from –31% to –9% by fishing year and has averaged at –24% over the most recent 10 years (Table 1), indicating that there has not been any recent change in rig reporting practices. A scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip ([left panel] Figure 4). The distribution of the ratios of the landed relative to estimated catch shows a skewed distribution with many ratios greater than 1.0 and with a mode slightly above 1.0 and a lesser mode near 1.5, the conversion factor for DRE and HGU ([right panel] Figure 4).

Similar plots and tables are provided for each SPO QMA in Appendix E, showing the shortfall in landings by QMA in the analysis data sets relative to the QMR/MHR catches (see Table E.1 for SPO 1 and SPO 2, Table E.2 for SPO 3 and SPO 7 and Table E.3 for SPO 8). Only SPO 8 shows relatively large shortfalls between the actual landings and the landings in the analysis data set, ranging from 39% in 2008–09 to 3% in 1994–95 (see SPO 8 in Figure E.1). The average shortfall of 29% in the 10 years from 2005–06 to 2014–15 for SPO 8, prepared using the method of Starr (2007), seems quite large. That is because trips that land multiple Fishstocks and fish in statistical areas that are valid for more than one Fishstock are discarded and all of the SPO 8 statistical areas that take rig fall into this category. However, this data set was used for the descriptive characterisation analyses presented

in Section 2.3.3 because this matching procedure is the only known way to get this kind of information on a QMA basis.

For the entire SPO data set across all years, 31% of all trips that landed rig estimated no catch of rig but reported SPO in the landings (Table 2). This occurred because operators using the CELR form were only required to estimate the catch of the top five species in any single day (8 species by fishing event since the introduction of the TCER forms in 2007–08 and the NCELR forms in 2006–07). These landings represented 10% of the total SPO landings over the period, for a total of 3 521 t over all years (Table 2). The introduction of the new inshore forms (NCELR and TCER), which record fishing activity at the level of a fishing event and report more species, has more than halved the proportion of trips that estimated nil rig while landing this species, and has reduced the proportion of SPO landings in this category, which now account for less about 3% of the total SPO landings in the past four years (Table 2).

There is a strong tendency in the SPO data set to underestimate the landings of rig, with the 5% to 95% quantiles for the ratio of landed to estimated catch (in the total SPO data set excluding trips where there was no estimated catch) ranging from 0.50 to 3.60. The median and mean ratios have the landed catch at 14% and 71% higher, respectively, than the estimated catch (Table 2), with an increasing trend in these statistics over time. This behaviour is thought to be linked with some operators reporting processed weights for rig rather than green weight when estimating catches. The mode near 1.5 in the right panel of Figure 4 is evidence that this behaviour is occurring (the conversion factor for DRE and HGU is 1.55 – see discussion in Section 2.3.2 below). This large and consistent shortfall between estimated and landed catches (see Figure 3 and Figure E.1) means that estimated catches must be adjusted to reflect actual landings in the characterisation and CPUE analyses.

Tables equivalent to Table 2 have been prepared for each SPO QMA and are presented in Appendix E (see Table E.4 for SPO 1 and SPO 2; Table E.5 for SPO 3 and SPO 7; Table E.6 for SPO 8). Unsurprisingly, all the SPO QMAs show a strong tendency to underestimate landings, but to differing degrees, with SPO 3 and SPO 8 showing narrower 5% and 95% quantiles and lower medians and means for the ratio landed divided by estimated catch compared to those in Table 2 (see Table E.5 for SPO 7 and Table E.6 for SPO 8) while the values for SPO 2 have much wider quantiles and higher median and mean values, perhaps reflecting the large proportion of rig catch taken in the trawl fishery off the east coast of the North Island. Although SPO 1 has a lower proportion of trips that report no SPO catch compared to the overall average (22% of SPO 1 trips compared to the overall value of 33%), this average shows no response to the change in reporting form, with Table E.4 showing no drop in proportion of trips with nil SPO after 2007–08, unlike the other four SPO QMAs. This is probably due to the large numbers of small vessels fishing in this QMA that are exempt from using the NCELR form type because the vessel length is less than 6 m (see discussion in Section 2.3.2 below).

2.3.1.4 Scaling estimated catches

The method of Starr (2007) was modified to scale estimated catches to the level of landings by statistical area, without regard to the reported QMA, for the CPUE analyses because of the large loss of landings in some QMAs (especially for SPO 8, see Figure E.1; retention statistics for this procedure are provided in Appendix F). This modification resulted in much better retention of the landings but at the cost of losing the capacity to link captures and effort to a specific QMA, thus requiring that QMA-specific CPUE analyses be defined on the basis of statistical area rather than QMA.

2.3.1.5 'Daily effort stratum' data preparation procedure

Data used for CPUE analysis were prepared using the 'daily effort stratum' (Appendix A) procedure proposed by Langley (2014). As noted above, catch/effort data must be summarised to a common level of stratification in order to construct a time series of CPUE indices that spans the change in reporting forms instituted in the late 2000s. Although the 'trip-stratum' procedure proposed by Starr

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

- discard trips that used more than one method in the trip (except for rock lobster potting, cod potting and fyke nets where just these methods were dropped) or that used more than one form type;
- sum effort for each day of fishing in the trip;
- sum estimated catch for each day of fishing in the trip and only use the estimated catch from the top five species sorted by weight in descending order;
- calculate the modal statistical area and target species for each day of fishing, each weighted by the number of fishing events: these are the values assigned to the effort and catch for that day of fishing;
- discard entire trips that report target species that are not on a list of 'most relevant' target species for the fishery, based on the characterisation analysis (this is done to avoid the potential bias of assigning landings to effort from a partial trip – it is better to drop the entire trip);
- distribute landings proportionately to each day of the trip based on the species estimated catch or to the daily effort when there is no species estimated catch.

Note that the above procedure was also applied to the daily effort (CELR) forms to ensure that each of these trips was also reduced to 'daily strata' if fishers report more than one statistical area or target species in a day of fishing.

Table 3: Destination codes in the unedited landing data received for the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 analysis data set. The 'how used' column indicates which destination codes were included in the characterisation analysis. These data summaries have been restricted to SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 over the period 1989–90 to 2011–12.

Destination code	Number events	Green weight (t)	Description	How used
L	372 304	39 776.8	Landed in NZ (to LFR)	Keep
A	244	71.6	Accidental loss	Keep
X	713	48.5	QMS returned to sea (except 6A)	Keep
C	523	32.8	Disposed to Crown	Keep
W	2 326	27.3	Sold at wharf	Keep
O	16	11.1	Conveyed outside NZ	Keep
E	323	9.9	Eaten	Keep
F	1 020	8.4	Section 111 Recreational Catch	Keep
J	61	1.4	Returned to sea [Section 72(5)(2)]	Keep
U	110	0.9	Bait used on board	Keep
M	2	0.6	QMS returned to sea (Part 6A)	Keep
S	17	0.6	Seized by Crown	Keep
H	10	0.1	Loss from holding pot	Keep
Q	27 976	1 708.8	Holding receptacle on land	Drop
R	4 745	194.7	Retained on board	Drop
D	215	174.6	Discarded (non-ITQ)	Drop
T	274	121.5	Transferred to another vessel	Drop
[NULL]	229	21.6	Missing	Drop
B	175	5.0	Bait stored for later use	Drop
P	15	0.4	Holding receptacle in water	Drop

2.3.2 Description landing information for SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8

2.3.2.1 Destination codes in the SPO landing data

Landing data for rig were provided for every trip that landed SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 at least once, with one record for every reported SPO landing from the trip. Each of these records contained a reported green weight (in kg), 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 3), 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 3). However, other codes (e.g., 'A', 'C' or 'W'; Table 3) 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' and 'R'; Table 3) were not included because it was felt that 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 (notably 'P', 'Q' and 'R') 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. However, because these intermediate landing destination codes are dropped (due to the potential for double counting), it is quite possible that 'L' landings reported for a trip may have been taken by another trip where the landings were declared by an intermediate code. This issue cannot be resolved within the current MPI catch reporting system because there is no MPI requirement to maintain the integrity of catches from a trip. Consequently, in these situations, the linking method of Starr (2007) may result in biased estimates of CPUE, with landings associated with an incorrect measure of effort. The use of intermediate landings has been common in the rock lobster fishery, where catches have been left in holding pots (destination code 'P') beginning in the early 2000s (Starr 2016). Kendrick & Bentley (2012) noted that this was a particular problem in the SPO 1 setnet fishery, where an increasing proportion of landings (Figure 5) use the intermediate code 'Q' because operators in this QMA hold landings in freezers before taking them to a LFR, mostly likely due to economic reasons. For instance, the LFRs may limit the amount of landings permitted in a time period or the operators may wait for a more favourable beach price. Destination codes for the other SPO QMAs have been examined, and, apart from a minor increase in the quantity of destination code 'Q' in SPO 3, beginning around 2009–10 (Figure 5), there seems to be little evidence of this type of behaviour in the other SPO QMAs (Table 4).

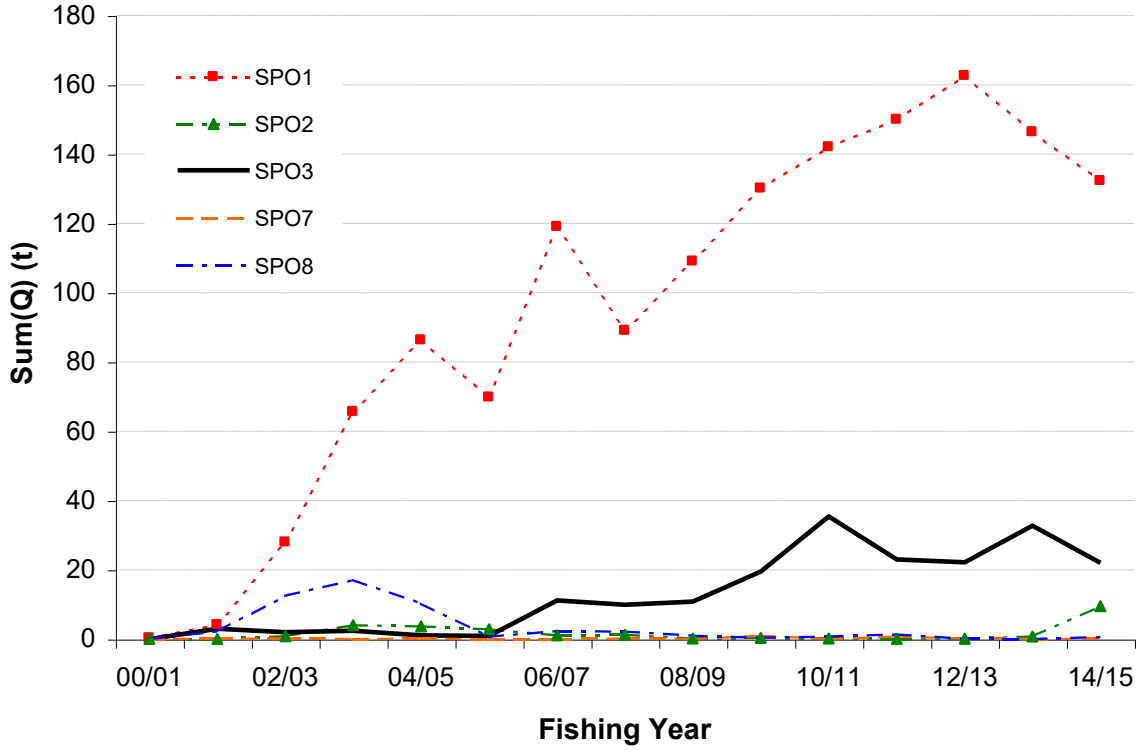

Figure 5: **Annual totals for landings with destination code 'Q' by QMA from 2000–01 to 2014–15.**

Table 4: **Total landings (t) over the period 1989–90 to 2014–15 by destination codes in the unedited landing data for SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8. The 'how used' column indicates which destination codes were included in the characterisation analysis. '–': no landings in the QMA for the indicated destination code.**

Destination code	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8	How used	Description
L	13 050.3	2 497.3	11 049.1	7 700.0	5 478.9	Keep	Landed in NZ (to LFR)
A	0.6	4.9	28.9	33.4	3.8	Keep	Accidental loss
X	1.0	4.4	1.4	39.9	1.9	Keep	Disposed to Crown
C	2.3	15.8	9.3	3.8	1.6	Keep	Sold at wharf
W	18.2	2.3	1.8	0.8	4.1	Keep	Conveyed outside NZ
O	0.2	–	6.0	4.7	0.2	Keep	Eaten
E	0.3	0.1	8.4	1.0	0.2	Keep	Section 111 Recreational Catch
F	1.8	2.5	2.0	1.8	0.3	Keep	QMS returned to sea, except 6A
J	–	–	1.3	0.1	–	Keep	Returned to sea [Section 72(5)(2)]
U	0.2	0.1	0.2	0.4	0.0	Keep	Bait used on board
M	–	–	0.2	0.5	–	Keep	Seized by Crown
S	0.2	0.0	–	0.3	0.1	Keep	QMS returned to sea (Part 6A)
H	0.0	–	0.0	–	–	Keep	Loss from holding pot
Q	1 433.9	24.7	196.1	2.6	51.5	Drop	Holding receptacle on land
R	37.6	10.2	95.5	34.2	17.3	Drop	Retained on board
D	0.6	24.9	69.3	70.8	9.0	Drop	Discarded (non-ITQ)
T	3.6	0.2	105.1	8.2	4.5	Drop	Transferred to another vessel
[NULL]	6.8	0.7	10.6	1.5	1.9	Drop	Nothing
B	3.7	0.2	0.0	0.9	0.2	Drop	Bait stored for later use
P	0.3	–	–	0.1	–	Drop	Holding receptacle in water

Table 5: **Total green weight reported and number of events by state code in the landing file used to process the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 characterisation and CPUE data, arranged in descending landed weight (only for destination codes indicated as 'Keep' in Table 3). These data summaries have been restricted to SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 from 1989–90 to 2014–15.**

State code	Number events	Total reported green weight (t)	Description
DRE	223 250	27 208.1	Dressed
HGU	90 709	8 106.5	Headed and gutted
GRE	37 673	2 969.5	Green (or whole)
GUT	5 765	696.6	Gutted
HGT	3 983	323.8	Headed, gutted, and tailed
MEA	74	291.1	Fish meal
FIN	1 218	224.5	Fins
GGO	348	87.0	Gilled and gutted tail-on
FIL	563	54.1	Fillets: skin-on
Other	14 686	88.7	Other[1]

[1] Includes (in descending order): Gilled and gutted tail-on; Dressed-V cut(stargazer); [NULL]; Shark fins; Headed, gutted, and finned; Fillets: skin-off; Flaps.

Table 6A: **Median conversion factor for the five most important state codes reported in (in terms of total landed green weight). These data summaries include all of the NZ EEZ over the period 1989–90 to 2014–15. '–': no observations. Cells with the same colour and font indicate periods with consistent conversion factors.**

Fishing year	Landed state code					
	DRE	HGU	GRE	GUT	HGT	Other
	Median conversion factor					
89/90	1.6	**2**	1	1.1	2	1.1
90/91	**2**	**2**	1	1.1	2	1.1
91/92	**2**	**2**	1	1.1	–	2.7
92/93	***1.75***	***1.75***	1	1.1	–	2.3
93/94	***1.75***	***1.75***	1	1.1	–	17.8
94/95	***1.75***	***1.75***	1	1.1	–	30
95/96	***1.75***	***1.75***	1	1.1	–	30
96/97	***1.75***	***1.75***	1	1.1	–	30
97/98	***1.75***	***1.75***	1	1.1	–	2.1
98/99	***1.75***	***1.75***	1	1.1	–	1
99/00	***1.75***	***1.75***	1	1.1	1	1
00/01	**1.55**	**1.55**	1	1.1	1	1
01/02	**1.55**	**1.55**	1	1.1	1	30
02/03	**1.55**	**1.55**	1	1.1	–	30
03/04	**1.55**	**1.55**	1	1.1	1	30
04/05	**1.55**	**1.55**	1	1.1	1	30
05/06	**1.55**	**1.55**	1	1.1	–	2.3
06/07	**1.55**	**1.55**	1	1.1	–	17.8
07/08	**1.55**	**1.55**	1	1.1	–	30
08/09	**1.55**	**1.55**	1	1.1	–	2.1
09/10	**1.55**	**1.55**	1	1.1	–	5.6
10/11	**1.55**	**1.55**	1	1.1	–	30
11/12	**1.55**	**1.55**	1	1.1	–	30
12/13	**1.55**	**1.55**	1	1.1	–	2.3
13/14	**1.55**	**1.55**	1	1.1	–	2.3
14/15	**1.55**	**1.55**	1	1.1	–	1

Because it is essential to correct estimated rig catches to reflect the landed catch for catch/effort analyses (see above and Figure 3), we have adopted the solution proposed by Kendrick & Bentley (2012) when they analysed SPO 1 CPUE. A similar solution has also been adopted for adjusting estimated catches put into holding pots for rock lobster CPUE (Starr 2016). This approach involves estimating, for every vessel participating in the fishery in a year, the ratio of landed/estimated catch.

This ratio is then used to correct all estimated catch records without regard to the landed destination code on the form. A description of this algorithm is provided in Appendix G.

Table 6B: Total reported green weight for the five most important state codes by fishing year in the edited file used to process SPO landing data. These data summaries include all of the NZ EEZ over the period 1989–90 to 2014–15. '–': no observations. Cells with the same colour indicate periods with consistent conversion factors.

Fishing year	Landed state					
	DRE	HGU	GRE	GUT	HGT	Other
	Total landings (t)					
89/90	1.5	920.4	116.0	15.5	43.9	63.9
90/91	573.6	463.7	148.3	137.6	9.0	23.9
91/92	597.2	666.4	206.4	126.1	–	33.0
92/93	692.4	614.2	220.6	82.1	–	3.1
93/94	799.2	565.2	275.3	43.6	–	15.8
94/95	1 030.4	515.7	228.4	41.0	0.0	12.0
95/96	1 115.7	546.3	186.4	59.0	2.1	22.4
96/97	1 177.7	531.1	132.1	41.8	5.5	34.2
97/98	1 124.1	452.2	110.3	16.8	17.1	27.0
98/99	1 112.7	335.0	87.8	21.0	74.3	48.5
99/00	1 215.4	257.4	132.1	25.6	73.2	12.9
00/01	1 212.6	252.1	95.5	24.1	51.5	37.2
01/02	1 149.2	214.3	63.7	4.9	18.3	25.5
02/03	1 164.8	240.0	55.6	3.9	15.6	16.8
03/04	1 130.9	199.9	77.2	8.6	5.2	15.3
04/05	1 116.3	202.5	54.5	1.6	3.3	25.0
05/06	1 062.0	179.7	54.0	2.4	1.9	5.2
06/07	1 239.4	86.2	62.2	1.6	–	17.1
07/08	1 210.1	71.6	62.3	1.7	–	17.4
08/09	1 069.1	82.0	30.6	2.8	–	8.0
09/10	1 152.9	71.8	31.3	5.6	–	4.9
10/11	1 157.2	66.0	28.6	3.3	–	9.4
11/12	1 176.9	94.2	28.8	2.8	–	12.1
12/13	1 124.3	134.8	34.3	5.3	–	9.7
13/14	1 235.9	111.7	33.0	5.3	–	3.1
14/15	1 291.2	99.0	47.8	7.2	–	21.4
Total	26 932.4	7 973.4	2 603.3	691.1	320.8	524.8

2.3.2.2 State codes in the SPO landing data

Almost all (89%) of the valid landing data for SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 were reported using state code DRE or HGU, with the majority (7%) of the remaining landings using the state code GRE (Table 5). The few remaining landings (less than 4%) were spread out among GUT, HGT, MEA and FIN codes. There have been substantial changes in the conversion factors for the two primary state codes (DRE and HGU) used for processing SPO (Table 6A and Table 6B). These changes occurred twice in the first 12 years of data and lead to important changes in how the landings data are interpreted for this species. Consequently, all landings have been converted (Eq. 2) to a consistent conversion factor, representing the conversion factors that have been in place from 2000–01 onward.

Green weight landings $\left(G'_{i,y}\right)$ were adjusted for the CPUE analysis and for some parts of the characterisation analysis for state codes DRE, HGU, FIL and HGT to a consistent conversion factor using the following equation:

Eq. 2 $$G'_{i,s,y} = G_{i,s,y} \, cf_{i,s,2000-01} \Big/ cf_{i,s,y}$$

where

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

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

$cf_{i,s,2000-01}$ is the conversion factor for record *i* using landed state code *s* in year 2000–01 (=1.55 for DRE and HGU)

A convention adopted in previous versions of this analysis was to drop the landings for state codes FIN, FLP (flaps), SHF (shark fins) and ROE when there was greater than one landing in a trip (Starr, 2007). The latter three state codes are considered 'secondary' and thus should not enter into the calculation of landed green weight, but these were all dropped to avoid potential double counting.

Total landings available in the data set are primarily from SPO 1, SPO 3, SPO 7, SPO 8 and finally SPO 2 (in descending order of importance) (Table 7).

Table 7: Distribution of total adjusted (Eq. 2) landings (t) by rig Fishstock and by fishing year for all trips that recorded SPO landings, regardless of QMA. Landing records with improbable green weights have been dropped (see Appendix D). The 'Total' column in this table is plotted as a red line in Figure 3.

Fishing year	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8	Total
89/90	346.9	40.9	206.2	208.4	141.2	943.6
90/91	467.1	39.0	246.5	224.8	142.7	1 120.1
91/92	626.3	69.8	309.1	234.4	104.1	1 343.7
92/93	638.3	80.8	255.0	289.9	198.6	1 462.5
93/94	632.0	88.6	313.0	287.4	220.0	1 540.9
94/95	612.6	76.3	384.7	333.9	239.8	1 647.4
95/96	562.5	111.0	405.7	372.4	278.2	1 729.8
96/97	611.3	86.6	419.3	361.0	222.5	1 700.8
97/98	527.3	70.5	407.3	297.1	241.3	1 543.6
98/99	500.6	77.3	381.6	311.1	198.6	1 469.2
99/00	555.5	78.5	404.6	309.0	186.6	1 534.3
00/01	563.3	80.1	496.9	350.0	167.1	1 657.4
01/02	464.5	89.3	403.9	289.1	212.2	1 459.1
02/03	486.2	88.0	438.0	266.0	206.0	1 484.2
03/04	474.4	80.7	374.8	298.0	201.7	1 429.7
04/05	435.4	109.1	378.0	263.3	207.5	1 393.4
05/06	347.5	112.5	385.7	290.1	166.2	1 302.0
06/07	405.8	100.7	452.2	263.4	176.5	1 398.7
07/08	303.7	102.3	482.6	242.1	221.0	1 351.7
08/09	295.0	106.0	333.4	233.5	222.8	1 190.8
09/10	298.9	112.9	377.9	230.0	245.1	1 264.8
10/11	315.8	104.4	392.2	233.5	216.3	1 262.2
11/12	324.7	118.2	436.4	228.8	200.0	1 308.1
12/13	367.7	106.1	468.0	234.4	123.3	1 299.4
13/14	347.1	127.2	485.6	235.0	192.0	1 386.8
14/15	330.0	120.1	562.4	250.2	183.8	1 446.4
Total	11 840.6	2 377.0	10 201.0	7 136.7	5 115.2	36 670.4

Table 8: Distribution by form type for landed catch by weight for each fishing year in the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 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 combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 data set. See Appendix A for definitions of abbreviations used in this table.

	Landings (%)[1]			Days fishing (%)[2]					Days fishing						
	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	LTCER	CELR	TCEPR	TCER	NCELR	LTCER	LCER	Total
89/90	97	3	0	92	8	–	–	–	19 915	1 790	–	–	–	–	21 705
90/91	98	2	0	93	7	0	–	–	23 082	1 788	1	–	–	–	24 871
91/92	96	4	0	93	7	–	–	–	27 302	1 979	–	–	–	–	29 281
92/93	98	2	0	94	6	–	–	–	30 740	1 900	–	–	–	–	32 640
93/94	97	3	0	92	8	–	–	–	28 625	2 649	–	–	–	–	31 274
94/95	97	3	0	90	10	–	–	–	28 592	3 109	–	–	–	–	31 701
95/96	93	7	0	82	18	–	–	–	25 424	5 471	–	–	–	–	30 895
96/97	93	7	0	84	16	–	–	–	26 240	5 092	–	–	–	–	31 332
97/98	94	6	0	81	19	–	–	–	24 407	5 622	–	–	–	–	30 029
98/99	94	6	0	83	17	–	–	–	25 572	5 139	–	–	–	–	30 711
99/00	93	7	0	84	16	–	–	–	26 187	4 957	–	–	–	–	31 144
00/01	93	7	0	82	18	–	–	–	25 310	5 665	–	–	–	–	30 975
01/02	92	8	0	79	21	–	–	–	21 980	5 811	–	–	–	–	27 791
02/03	91	9	0	81	19	–	–	–	23 266	5 626	–	–	–	–	28 892
03/04	92	8	0	80	20	–	–	–	22 450	5 591	–	–	–	56	28 097
04/05	93	7	0	81	19	–	–	–	23 463	5 330	–	–	–	–	28 793
05/06	93	7	0	83	17	–	0	–	22 774	4 655	–	1	–	24	27 454
06/07	43	7	50	69	16	–	15	–	19 670	4 453	–	4 133	–	73	28 329
07/08	14	29	57	17	13	48	16	5	4 394	3 476	12 328	4 231	1 326	89	25 844
08/09	21	30	49	19	11	47	16	6	4 930	2 965	12 252	4 112	1 494	102	25 855
09/10	19	32	49	18	9	52	15	6	4 933	2 606	14 394	4 057	1 557	59	27 606
10/11	18	32	51	19	10	50	15	7	5 065	2 655	13 226	3 879	1 842	28	26 695
11/12	21	33	47	20	11	49	14	6	5 371	2 825	12 859	3 781	1 663	–	26 499
12/13	21	34	45	21	10	50	14	6	5 648	2 892	13 638	3 751	1 593	26	27 548
13/14	17	38	45	19	11	51	13	6	5 022	3 009	13 837	3 582	1 520	4	26 974
14/15	16	37	47	16	12	51	15	6	4 040	3 071	12 686	3 695	1 459	–	24 951
Total	71	14	16	66	14	14	5	2	484 402	100 126	105 221	35 222	12 454	461	737 886

[1] Percentages of landed green weight.
[2] Percentages of number of days fishing.

2.3.2.3 Form types used in the SPO landing and effort data

Just over 70% of the total SPO landings in the NZ EEZ have been reported on CELR forms over the 26 years of record, with the remaining landings split between the CLR and the new NCELR forms (Table 8). However, the proportion of landings reported on the CELR form dropped to near 20% or lower once both the NCELR and the TCER forms had been introduced in 2006–07 and 2007–08 respectively. The NCELR form is used exclusively to report setnet effort and landings while the TCER form reports the effort for bottom trawl vessels between 6 and 28 m in total length. The CLR form is used to report landings forms other than the CELR and NCELR forms, particularly the TCER and TCEPR trawl effort forms. The only exception to this change in form type preference has been in SPO 1, where the proportion of landings reported on the CELR form only dropped from around 90% to 50%, while in the other four SPO QMAs, the proportion of landings reported on the CELR form dropped to less than 20% in most QMAs and was often less than 10% (Figure 6). The reason for this difference in the use of form types in SPO 1 is that MPI allows an exemption from the NCELR and TCER form for vessels less than 6 m in length, with a relatively large proportion of SPO 1 setnet vessels being less than that length threshold, particularly those operating in the more protected waters of Manukau and Kaipara Harbours and the Firth of Thames. There was a corresponding drop in the usage of the CELR form in the effort data, beginning from 2006–07 (calculated as days fishing, Table 8) and an increase in the use of other form types in the effort data set after that year.

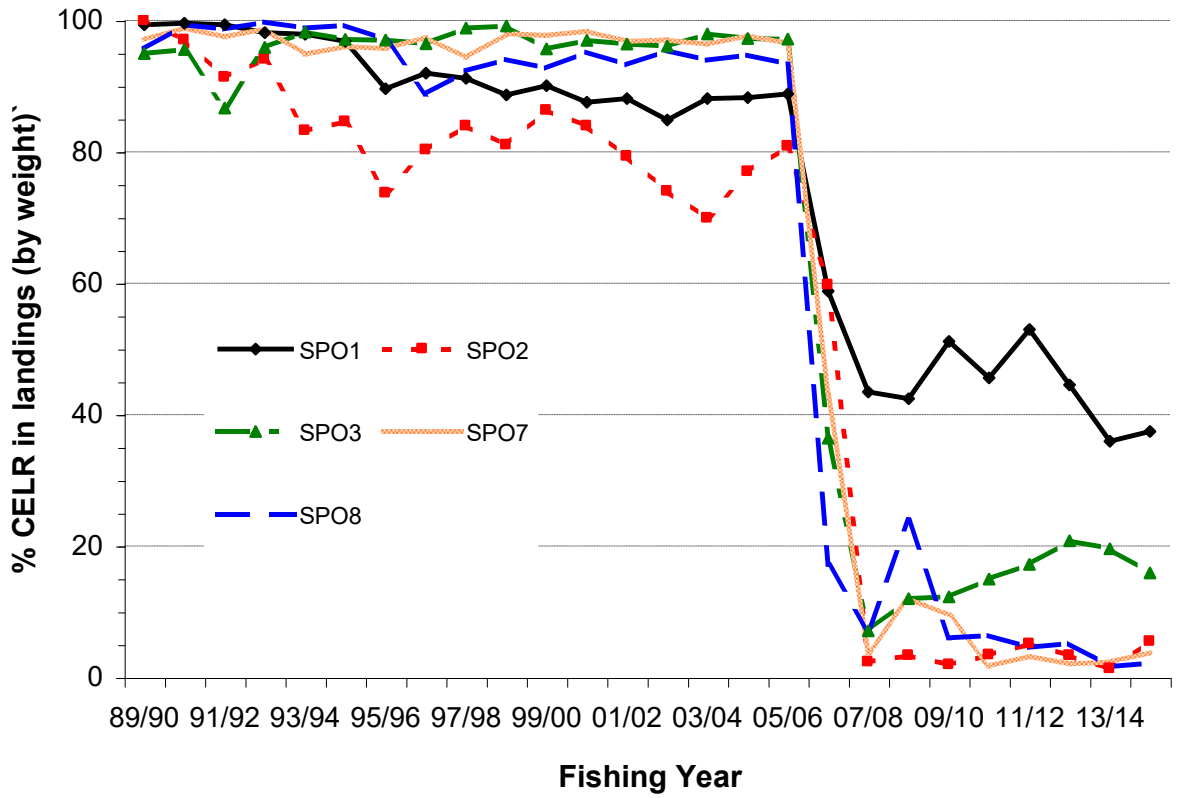

Figure 6: **Time series of the percentage of landings (by weight) reported on the CELR form for each QMA in the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 data set.**

2.3.3 Description of the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 fisheries

2.3.3.1 Introduction

As discussed in Section 2.3.1, landings were matched with effort for every trip while maintaining the integrity of the QMA-specific information. This procedure worked reasonably well for all SPO QMAs except for SPO 8, where nearly 30% of the catch was lost because trips were dropped that fished in shared statistical areas and reported landings from more than one QMA. The relatively high level of loss in SPO 8 occurs because all of the inshore SPO 8 statistical areas are shared with either SPO 1 or SPO 7 (Appendix B). This amount of lost landings was considered acceptable for the purposes of characterising the fishery, but was not accepted for CPUE analyses, where trips were assigned to statistical areas without maintaining the integrity of the QMA information. The CPUE analysis data were then selected on the basis of the statistical area fished rather than by the QMA.

The characterisation information in this section is presented by SPO QMA, except for SPO 1, which has been split into 'East' and 'West' components that correspond to FMAs 1 and 9 (see Appendix B for the locations of these FMAs):

SPO QMA reported	Statistical Area definition
SPO 1E	001–010, 105–107
SPO 2	–
SPO 3	–
SPO 7	–
SPO 8	–
SPO 1W	041–048, 101–104

Characterisation information from SPO 1E and SPO 1W in the following sections will be treated as if they come from separate QMAs in recognition that these fisheries are located in management areas that substantially differ from each other, at a level similar to the differences seen between the remaining SPO QMAs.

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

Rig in five of the six QMAs are primarily taken by the setnet method, except for SPO 2, where bottom trawl catches of rig exceed setnet landings in most years (Figure 7; Table 9; Table H.1). SPO 2 is also the QMA with the smallest amount of landings (6% of the total New Zealand rig landings; Table 9). Bottom trawl landings of rig are also relatively large in SPO 7, probably because of the existence of the considerable west coast South Island inshore trawl fisheries for barracouta, stargazer, red gurnard and red cod. Rig landings by other methods are extremely minor in most QMAs, with the combined setnet and bottom trawl landings accounting for over 95% of landings in all QMAs except for SPO 1E, where 85% of the total landings are taken by these two methods. Most of the remaining SPO 1E rig landings are taken by Danish seine (6%) and bottom longline (8%) (Table 9).

2.3.3.3 Fine scale distribution of landings for setnet

Fine scale landings and effort data are available for the setnet fleet from 1 Oct 2006 onwards. Plots (North Island: Figure 8; South Island: Figure 9) showing landings gridded into 0.1° X 0.1° cells, summed over nine years, show limited locations where rig have been taken using the setnet method, with concentrations of catch on the North Island in the North and South Taranaki Bights (Figure 8) and on the east coast in the western Bay of Plenty. Location information for the SPO 1E and SPO 1W setnet fisheries will be limited because of the high proportion of the landings that are reported on the CELR form (see Figure 6). While Figure 6 is based on landings, the majority of the vessels reporting on the CELR form will be small (less than 6 m in total length) vessels fishing in the Manukau and Kaipara Harbours on the west and the Thames estuary on the east coasts of the North Island.

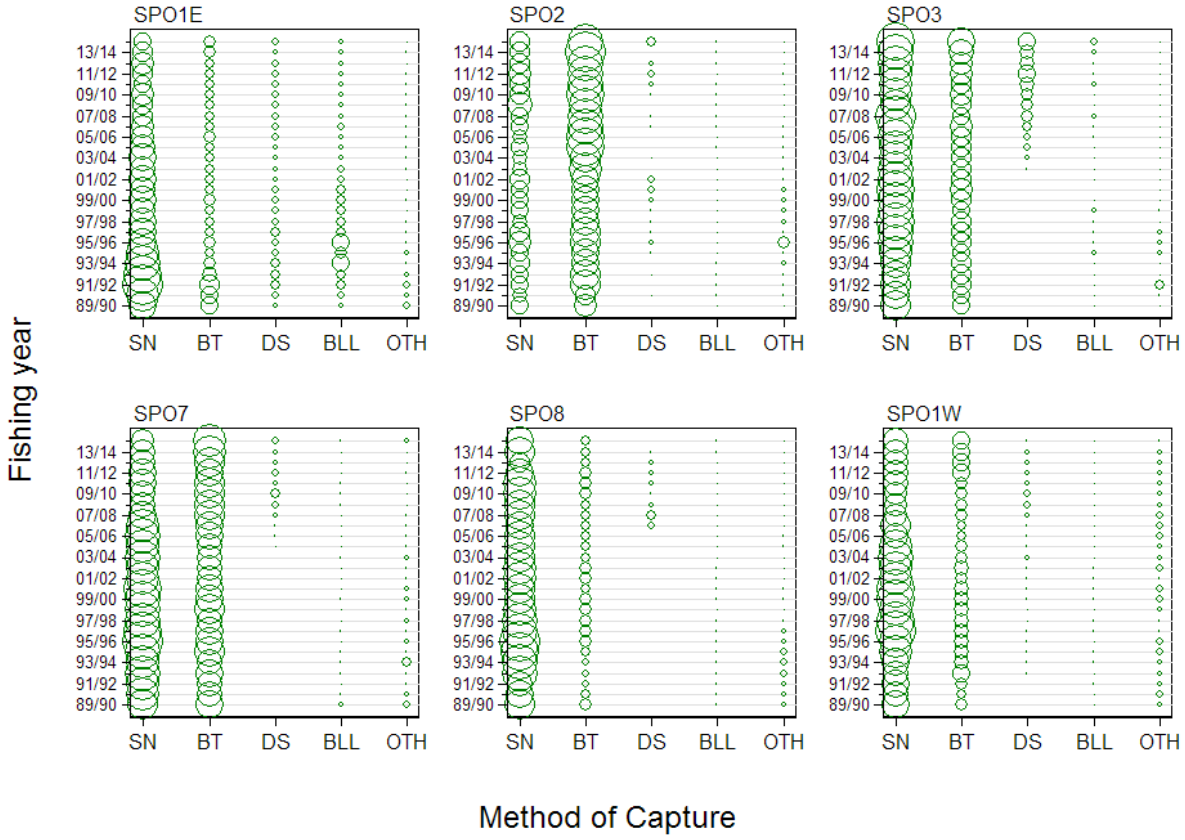

Figure 7: **Distribution of rig landings for the major fishing methods by fishing year by SPO QMA from 1989–90 to 2014–15. Circles are proportional to the catch totals by method and fishing year within each sub-graph: [SPO 1E]: largest circle=338 t in 91/92 for SN; [SPO 2]: largest circle=104 t in 13/14 for BT; [SPO 3]: largest circle=380 t in 07/08 for SN; [SPO 7]: largest circle=228 t in 95/96 for SN; [SPO 8]: largest circle=232 t in 95/96 for SN; [SPO 1W]: largest circle=314 t in 96/97 for SN. Data for these plots are presented in Table H.1.**

Table 9: **Total landings (t) and distribution of landings (%) for rig for important fishing methods over the SPO QMAs from trips that landed rig, summed from 1989–90 to 2014–15.**

	Method					
Major Area	SN	BT	DS	BLL	OTH	Total
	Total landings (t)					
SPO 1E	4 015.2	790.1	327.1	441.2	62.4	5 636.1
SPO 2	622.0	1 816.2	29.9	4.9	24.4	2 497.3
SPO 3	7 411.9	2 778.7	489.8	55.3	47.3	10 782.9
SPO 7	4 054.0	3 016.3	59.6	15.5	57.7	7 203.1
SPO 8	3 849.3	490.7	32.5	12.4	49.5	4 434.5
SPO 1W	4 754.2	1 106.3	72.1	11.9	182.4	6 126.8
Total	24 706.5	9 998.2	1 011.0	541.3	423.6	36 680.7
	Distribution of landings (%)					
SPO 1E	71.2	14.0	5.8	7.8	1.1	15.4
SPO 2	24.9	72.7	1.2	0.2	1.0	6.8
SPO 3	68.7	25.8	4.5	0.5	0.4	29.4
SPO 7	56.3	41.9	0.8	0.2	0.8	19.6
SPO 8	86.8	11.1	0.7	0.3	1.1	12.1
SPO 1W	77.6	18.1	1.2	0.2	3.0	16.7
Total	67.4	27.3	2.8	1.5	1.2	100.0

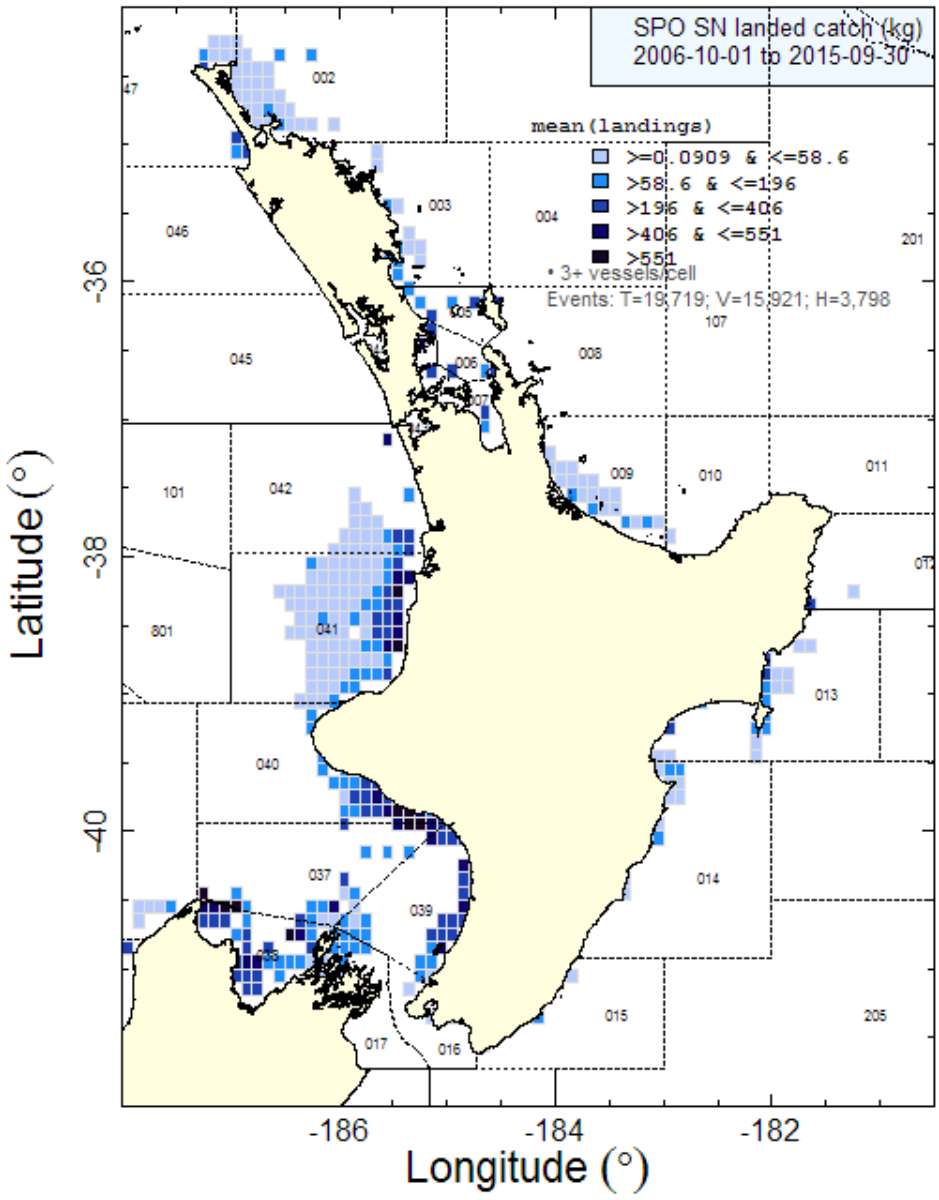

Figure 8: **Spatial distribution of rig setnet landings (t) on the North Island, arranged in 0.1° X 0.1° grids, summed from 2006–07 to 2014–15. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids have at least three reporting vessels are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B. Much of the setnet catch in the Kaipara and Manukau Harbours and Firth of Thames are reported on CELR forms, which do not require fine-scale position data, so do not appear on this map.**

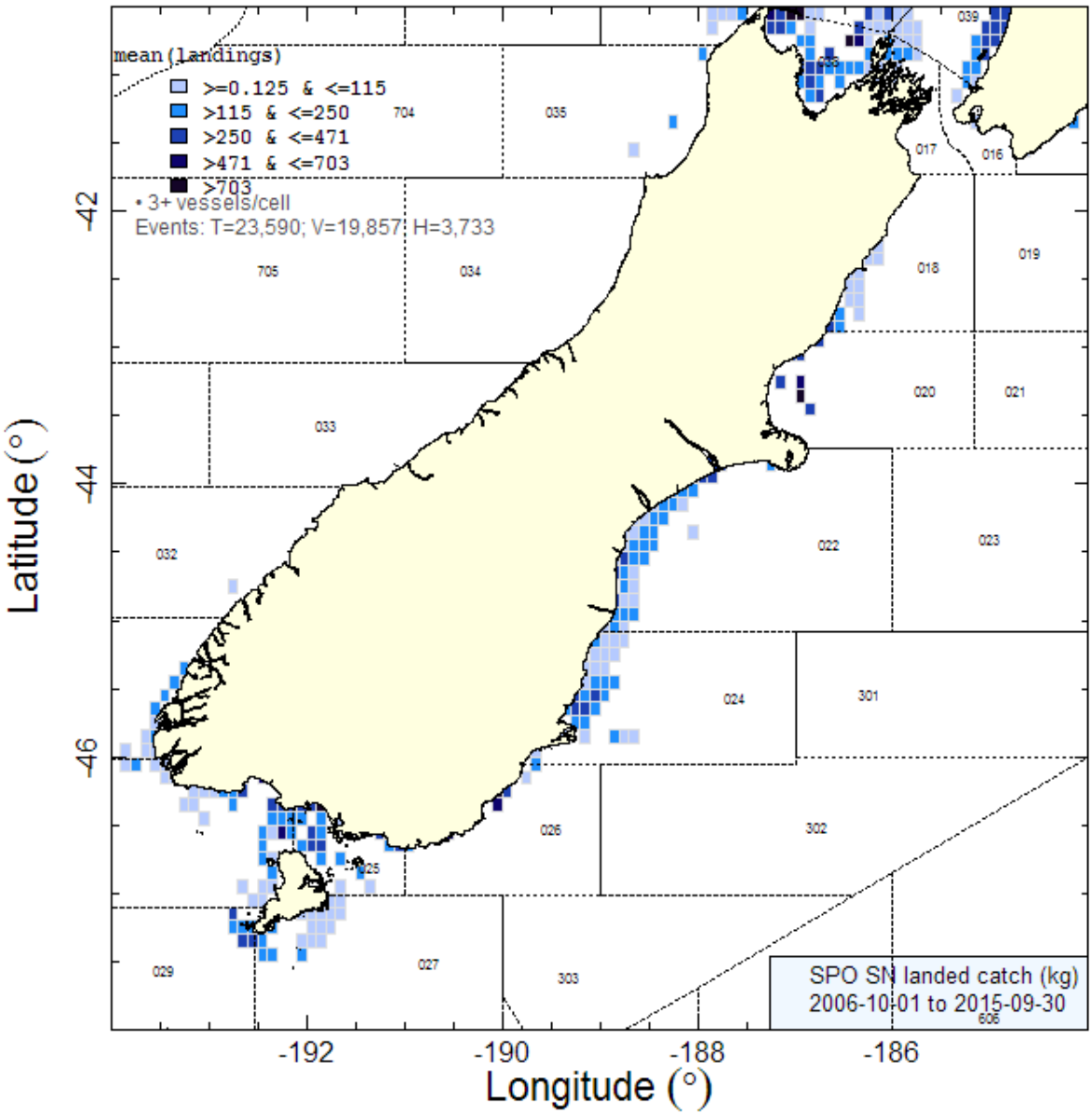

Figure 9: **Spatial distribution of rig setnet landings (t) on the South Island, arranged in 0.1° X 0.1° grids, summed from 2006–07 to 2014–15. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids that have at least three reporting vessels are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B.**

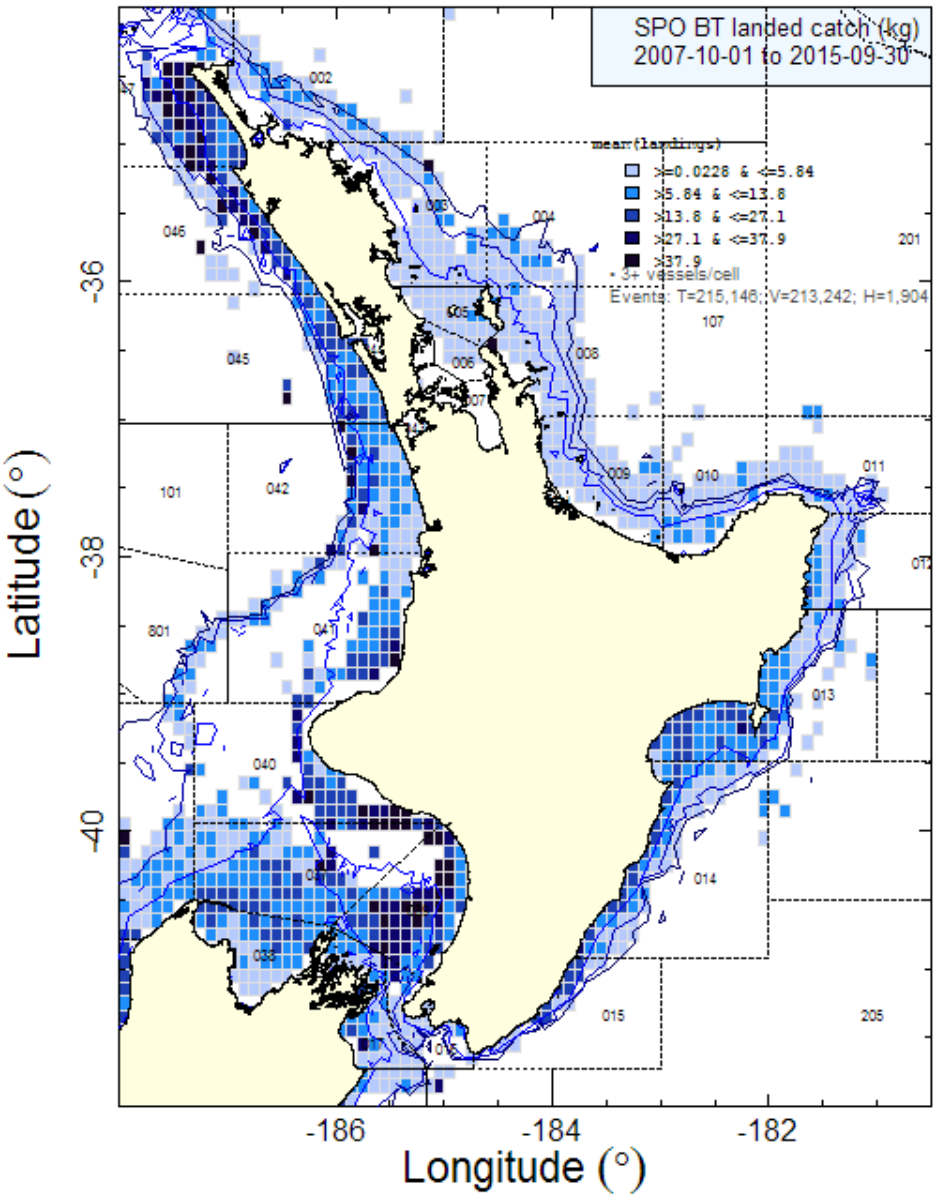

Figure 10: **Spatial distribution of rig bottom trawl landings (t) on the North Island, arranged in 0.1° X 0.1° grids, summed from 2007–08 to 2014–15. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids that have at least three reporting vessels are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

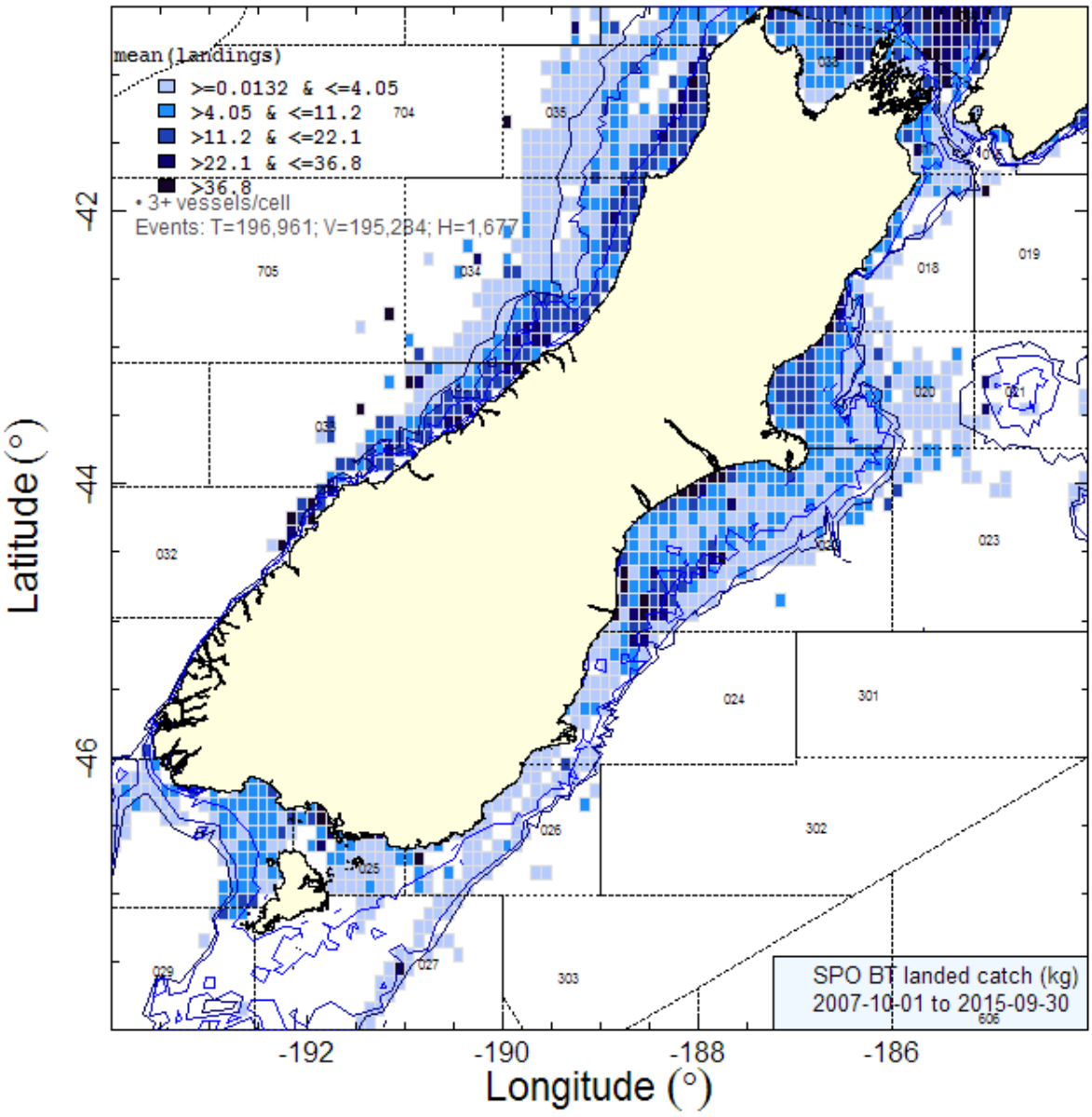

Figure 11: **Spatial distribution of rig bottom trawl landings (t) on the South Island, arranged in 0.1° X 0.1° grids, summed from 2007–08 to 2014–15. Legend colours divide the distribution of total landings into approximate 25%, 50%, 75%, 90% and 95% quantiles. Only grids that have at least three reporting vessels are plotted. Boundaries are shown for the general statistical areas plotted in Appendix B and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

Rig setnet landings in the South Island are concentrated in the lower part of the Canterbury Bight, extending down to Dunedin, in Foveaux Strait, and in Tasman and Golden Bays (Figure 9). The specific nature of the distribution of rig setnet landings may reflect where this species can be easily caught commercially with this gear, instead of the actual distribution of this species (given the ubiquitous nature of the distribution of trawl landings – see following paragraphs).

Bottom trawl landings of rig occur almost everywhere on both coasts of the North Island (Figure 10). There is a wide range of areas where landings are relatively concentrated, ranging from Hawke's Bay northward around East Cape and into the eastern Bay of Plenty. There are areas of relatively high concentrations of trawl landings of rig in North Cape and parts of the North and South Taranaki Bights.

As seen in the North Island, the distribution of rig landings on the South Island is broad and ubiquitous (Figure 11). The entire South Island west coast, extending from Tasman/Golden Bays to Fiordland, show strong concentrations of rig landings using trawl gear. East coast South Island trawl rig landings are less extensive, with concentrations in the eastern approach to Cook Strait, Pegasus Bay and parts of Canterbury Bight. The widespread distribution of rig along both coasts of the North and South Islands, as demonstrated by the broad and even spread of landings of this species by trawl gear, indicate the ubiquitous nature of rig distribution in New Zealand inshore waters.

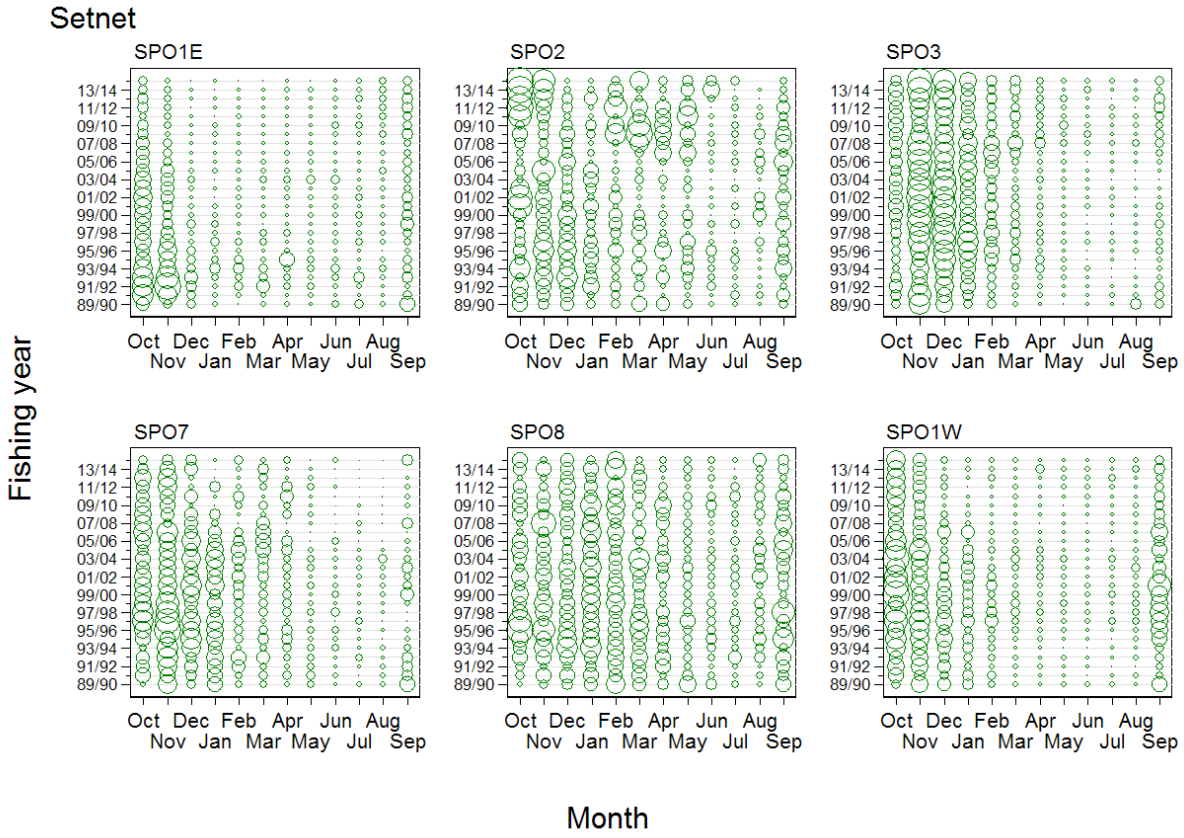

Figure 12: Distribution of landings by month and fishing year for setnet in each SPO QMA based on trips that landed rig. Circles sizes are proportional within each panel: [SPO 1E]: largest circle=128 t in 91/92 for Nov; [SPO 2]: largest circle=10 t in 13/14 for Oct; [SPO 3]: largest circle=114 t in 01/02 for Nov; [SPO 7]: largest circle=76 t in 95/96 for Nov; [SPO 8]: largest circle=52 t in 95/96 for Oct; [SPO 1W]: largest circle=101 t in 96/97 for Oct. Values for the plotted data are provided in Table H.2.

2.3.3.4 Seasonal distribution of landings

The rig setnet fishery tends to be seasonal, with the majority of landings taking place in the spring and early summer in four of the six QMAs (Figure 12; Table H.2). Setnet landings in SPO 2 and SPO 8 appear to have greater temporal spread, with landings in both SPO 2 and SPO 8 extending to May in most years. In general, landings in SPO 3 and SPO 7 appear to extend further into the year than in either SPO 1E or SPO 1W; with catches from the South Island QMAs extending to March in many years and those in SPO 1 tending to drop off in December or January (Figure 12). All six QMAs show an increase in landings in September, the final month in the statutory finfish fishing year (Figure 12; Table H.2). This increase in landings probably represents an attempt to catch residual ACE that remains in the fishing year.

The seasonal distribution of bottom trawl rig landings is much more uniform across all months in all six QMAs, particularly when compared to the seasonal setnet landings (Figure 13; Table H.3). This uniformity in the seasonality of trawl landings of rig reflects the timing of the target species of interest to the fishery, rather than having much to do with the availability of rig. This is because trawl fisheries rarely target rig (see following Section), but target a range of species throughout the year, and therefore tend to capture rig as an associated catch while targeting the more abundant or desirable species. There is some structure in the seasonal catch of rig in SPO 2, SPO 3 and SPO 7, with winter landings of rig tending to attenuate in the 1990s, but this effect appears to have diminished in recent years (Figure 13). However, the broad seasonal distribution of rig landings from the trawl fleet demonstrates that rig are likely to be present year-round in New Zealand inshore waters.

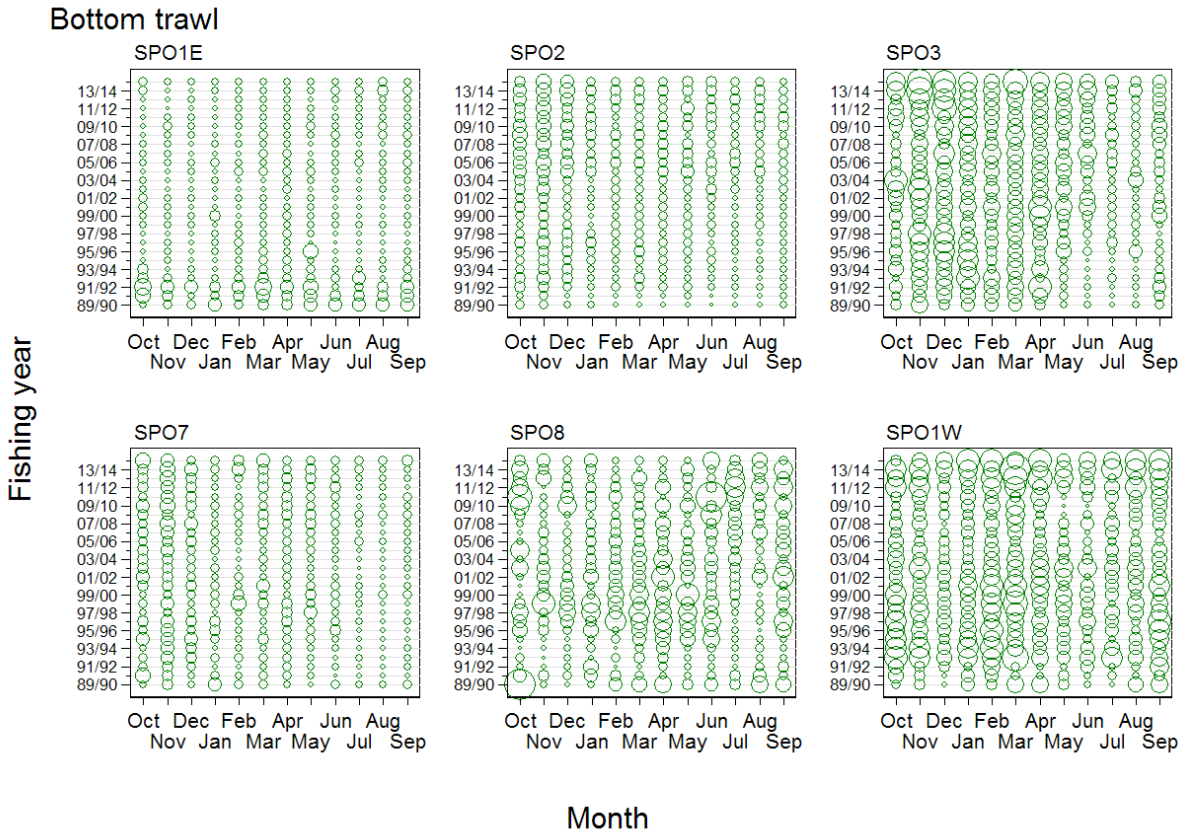

Figure 13: Distribution of landings by month and fishing year for bottom trawl in each SPO QMA based on trips that landed rig. Circles sizes are proportional within each panel: [SPO 1E]: largest circle=11 t in 91/92 for Oct; [SPO 2]: largest circle=16 t in 13/14 for Nov; [SPO 3]: largest circle=31 t in 13/14 for Nov; [SPO 7]: largest circle=25 t in 09/10 for Nov; [SPO 8]: largest circle=9.0 t in 89/90 for Oct; [SPO 1W]: largest circle=14 t in 13/14 for Mar. Values for the plotted data are provided in Table H.3.

2.3.3.5 Distribution of landings by declared target species

The setnet fisheries taking rig are almost exclusively targeted at SPO in each of the six QMAs (Table 10; Figure 14). The only exceptions to this are found in SPO 2, where the small setnet fishery also targets blue warehou and blue moki, and in SPO 3 where there is some targeting of school shark. The dominant target species in the remaining four setnet fisheries is rig (Table 10). This is particularly true for the two SPO 1 setnet fisheries, where there are virtually no other declared target species other than rig.

Target species for the bottom trawl fisheries are much more complex, with each QMA showing different prevalence (Figure 15; Table H.4). What is clear is that SPO is rarely declared a target in any of these areas, with the possible exception of SPO 3. The SPO 1E bottom trawl fishery is primarily targeted at snapper, with some targeting of tarakihi and red gurnard. The SPO 2 trawl fishery is mainly targeted at gurnard and tarakihi, with some minor targeting of flatfish species. The SPO 3 fishery is more diverse, targeting flatfish, red cod, stargazer and, more recently, elephant fish, while capturing rig as a bycatch and the occasional SPO target tow. The SPO 7 fishery targets flatfish, red cod, barracouta and tarakihi, while the SPO 8 fishery targets gurnard, trevally and tarakihi. Finally, the SPO 1W fishery targets snapper, trevally, gurnard and tarakihi.

Table 10: Total landings (t) and distribution of landings (%) for rig by target species and method of capture for each major area (Table H.1) from trips that landed rig, summed from 1989–90 to 2014–15. '–': no data for indicated QMA/method/target species cell. [Continued on next page]

Target species	Method of capture (t)						Method of capture (%)					
	SN	BT	DS	BLL	Other	Total	SN	BT	DS	BLL	Other	Total
SPO 1E												
SPO	3 266	4	5	112	1	3 388	96.4	0.1	0.1	3.3	0.0	60.1
SNA	231	381	168	308	47	1 135	20.4	33.6	14.8	27.1	4.1	20.1
TRE	181	74	3	0	8	266	68.1	28.0	1.0	0.0	2.9	4.7
FLA	185	2	7	0	0	194	95.2	0.9	3.8	0.0	0.1	3.5
TAR	16	134	8	1	1	161	10.0	83.3	5.2	0.7	0.8	2.9
GUR	29	52	75	4	1	160	18.1	32.2	47.0	2.3	0.4	2.8
JDO	2	95	60	0	0	156	1.1	60.7	38.0	0.0	0.1	2.8
KAH	36	0	0	0	1	37	97.4	0.3	0.0	0.0	2.2	0.7
SKI	1	21	0	0	0	21	3.4	96.1	0.0	0.1	0.3	0.4
OTH	68	26	1	17	4	116	58.9	22.7	0.8	14.5	3.1	2.1
Total	4 015	790	327	441	62	5 636	71.2	14.0	5.8	7.8	1.1	100.0
SPO 2												
GUR	12	875	28	0	0	915	1.3	95.6	3.0	0.0	0.1	36.6
TAR	6	612	0	0	0	618	1.0	99.0	0.0	0.0	0.0	24.7
SPO	231	1	–	–	0	233	99.5	0.3	–	–	0.2	9.3
FLA	65	116	1	–	0	182	35.8	63.8	0.4	–	0.0	7.3
WAR	119	25	–	0	0	144	82.6	17.3	–	0.0	0.0	5.8
MOK	99	4	–	–	0	103	96.2	3.8	–	–	0.0	4.1
SNA	0	42	1	1	0	44	0.5	95.0	3.1	1.3	0.1	1.8
SCH	43	0	–	0	0	43	98.7	0.4	–	0.9	0.0	1.7
SKI	0	38	–	0	1	39	0.5	97.3	–	0.0	2.2	1.6
OTH	46	104	0	4	23	177	26.2	58.8	0.1	2.2	12.7	7.1
Total	622	1 816	30	5	24	2 497	24.9	72.7	1.2	0.2	1.0	100.0
SPO 3												
SPO	4 753	254	220	28	6	5 261	90.3	4.8	4.2	0.5	0.1	48.8
SCH	1 703	10	1	3	0	1 717	99.2	0.6	0.0	0.2	0.0	15.9
FLA	2	1 001	93	0	0	1 096	0.2	91.3	8.5	0.0	0.0	10.2
RCO	6	602	108	0	0	716	0.9	84.0	15.1	0.0	0.0	6.6
ELE	253	186	13	0	0	452	55.9	41.2	2.8	0.0	0.0	4.2
SPD	311	24	3	0	0	338	91.9	7.2	0.9	0.0	0.0	3.1
TAR	80	111	50	–	0	242	33.1	46.1	20.7	–	0.1	2.2
STA	3	202	0	–	0	205	1.4	98.5	0.0	–	0.0	1.9
LIN	142	12	–	22	0	176	80.6	6.6	–	12.6	0.1	1.6
OTH	158	377	2	3	40	580	27.3	64.9	0.4	0.5	7.0	5.4
Total	7 412	2 779	490	55	47	10 783	68.7	25.8	4.5	0.5	0.4	100.0
SPO 7												
SPO	3 668	25	0	7	1	3 702	99.1	0.7	0.0	0.2	0.0	51.4
FLA	11	1 405	58	–	12	1 486	0.7	94.5	3.9	–	0.8	20.6
BAR	0	491	–	–	1	492	0.0	99.9	–	–	0.1	6.8
TAR	0	295	–	–	4	300	0.1	98.5	–	–	1.4	4.2
RCO	0	266	–	0	0	267	0.1	99.8	–	0.0	0.1	3.7
SCH	217	5	–	2	0	224	96.7	2.4	–	0.8	0.0	3.1
GUR	1	199	1	–	2	203	0.4	98.2	0.3	–	1.1	2.8
SPD	95	15	–	0	–	111	86.1	13.6	–	0.4	–	1.5

Table 10 [Continued]:

Target species	Method of capture (t)						Method of capture (%)					
	SN	BT	DS	BLL	Other	Total	SN	BT	DS	BLL	Other	Total
SPO 7												
SNA	8	56	0	2	7	75	11.2	75.4	0.5	3.1	9.8	1.0
OTH	53	257	0	4	30	343	15.3	74.8	0.0	1.2	8.7	4.8
Total	4 054	3 016	60	16	58	7 203	56.3	41.9	0.8	0.2	0.8	100.0
SPO 8												
SPO	3 297	6	2	1	1	3 306	99.7	0.2	0.1	0.0	0.0	74.6
SCH	258	10	–	1	0	269	95.9	3.6	–	0.5	0.0	6.1
GUR	46	165	28	2	19	261	17.7	63.3	10.9	0.9	7.1	5.9
TRE	45	102	–	0	10	157	28.6	65.1	–	0.0	6.3	3.5
WAR	150	3	–	0	0	152	98.3	1.7	–	0.1	0.0	3.4
TAR	1	64	1	0	0	66	0.9	96.8	1.4	0.7	0.2	1.5
SNA	12	33	–	3	18	66	18.3	50.6	–	3.9	27.2	1.5
BAR	0	28	–	–	0	28	0.0	99.2	–	–	0.7	0.6
FLA	3	20	1	–	0	25	12.9	80.6	5.0	–	1.4	0.6
OTH	38	59	0	5	2	103	36.5	57.3	0.1	4.5	1.5	2.3
Total	3 849	491	33	12	49	4 434	86.8	11.1	0.7	0.3	1.1	100.0
SPO 1W												
SPO	3 974	1	–	1	7	3 982	99.8	0.0	–	0.0	0.2	65.0
GUR	345	237	68	1	17	667	51.7	35.5	10.2	0.1	2.6	10.9
TRE	105	321	–	0	68	494	21.3	64.9	–	0.0	13.8	8.1
SNA	5	334	3	9	45	396	1.2	84.3	0.8	2.3	11.4	6.5
TAR	1	160	0	0	14	175	0.7	91.3	0.2	0.0	7.8	2.9
FLA	140	0	0	0	0	140	99.7	0.1	0.0	0.0	0.2	2.3
SCH	104	18	–	1	0	122	84.7	14.8	–	0.5	0.0	2.0
GMU	52	0	1	0	28	80	64.5	0.3	0.7	0.0	34.5	1.3
BAR	1	14	–	–	2	16	4.1	85.4	–	–	10.5	0.3
OTH	29	22	0	1	2	54	53.9	40.6	0.3	1.2	4.0	0.9
Total	4 754	1 106	72	12	182	6 127	77.6	18.1	1.2	0.2	3.0	100.0

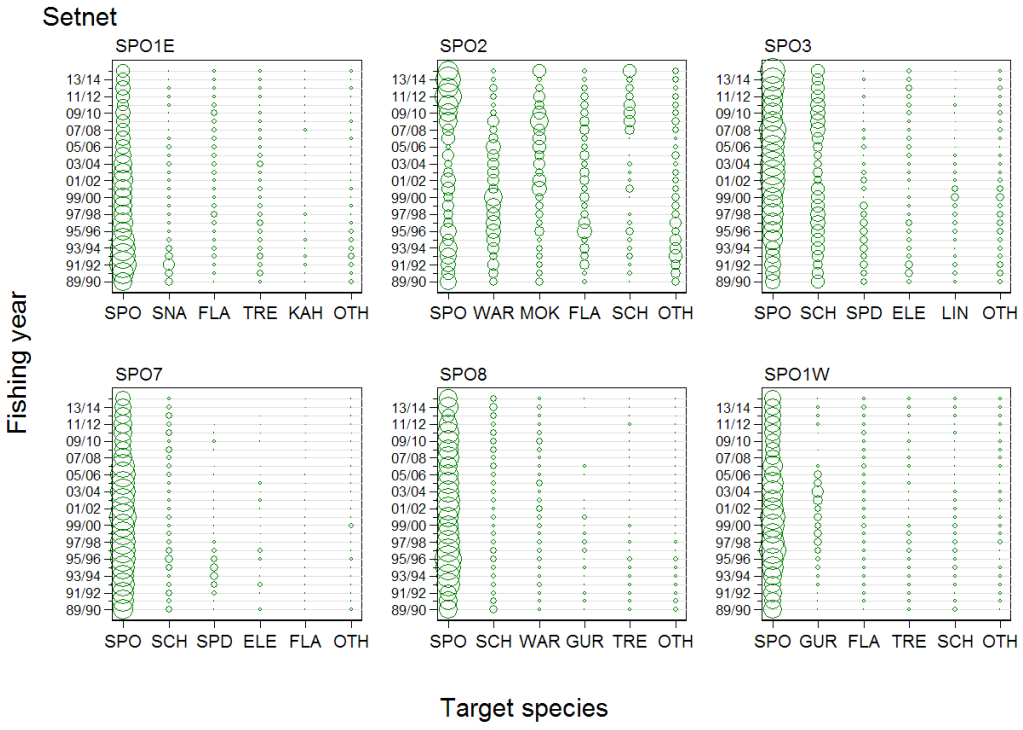

Figure 14: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for setnet in each SPO QMA based on trips that landed rig. Circles sizes are proportional within each panel: [SPO 1E]: largest circle=259 t in 91/92 for SPO; [SPO 2]: largest circle=25 t in 11/12 for SPO; [SPO 3]: largest circle=273 t in 07/08 for SPO; [SPO 7]: largest circle=207 t in 00/01 for SPO; [SPO 8]: largest circle=197 t in 95/96 for SPO; [SPO 1W]: largest circle=275 t in 96/97 for SPO. Values for the plotted data are provided in Table H.4.

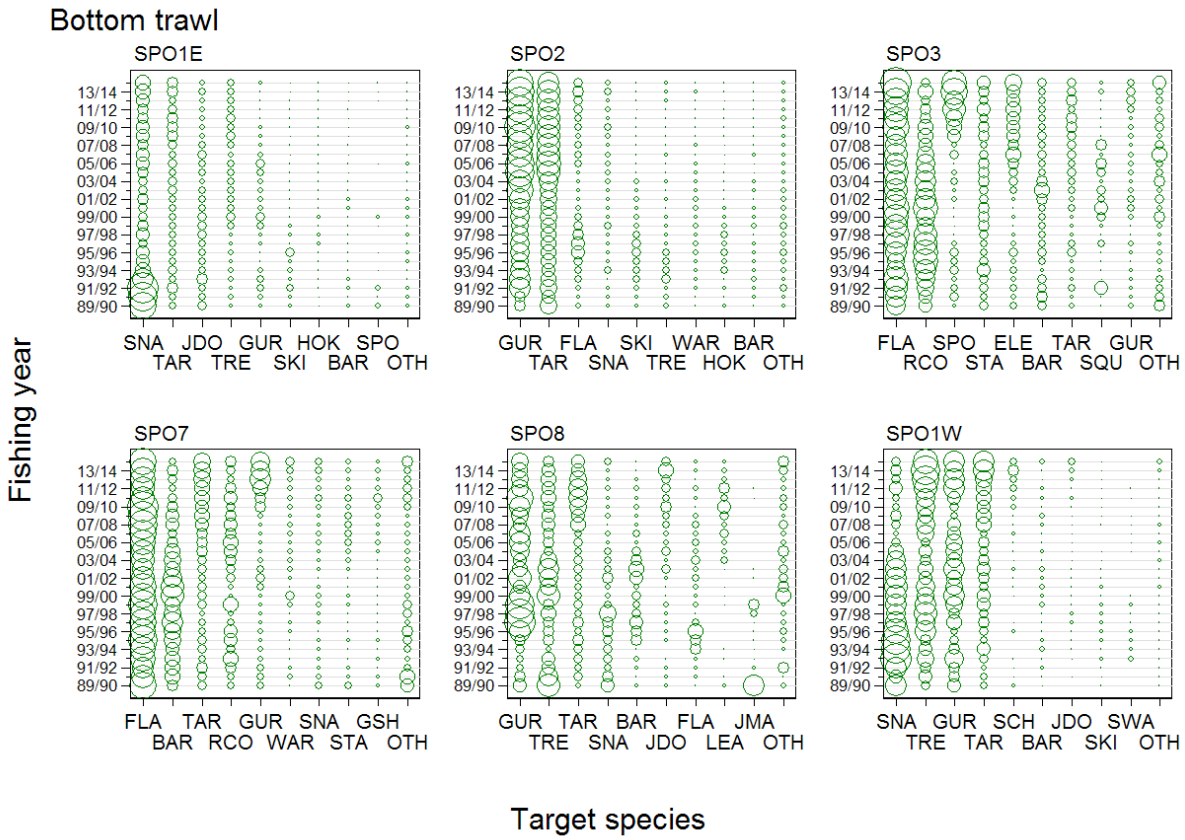

Figure 15: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for bottom trawl in each SPO QMA based on trips that landed rig. Circles sizes are proportional within each panel: [SPO 1E]: largest circle=55 t in 91/92 for SNA; [SPO 2]: largest circle=58 t in 09/10 for GUR; [SPO 3]: largest circle=64 t in 14/15 for FLA; [SPO 7]: largest circle=77 t in 09/10 for FLA; [SPO 8]: largest circle=16 t in 96/97 for GUR; [SPO 1W]: largest circle=34 t in 92/93 for SNA. Values for the plotted data are provided in Table H.5.

2.3.3.6 Preferred bottom trawl fishing depths for rig

The setnet forms (NCELR) introduced in 2006–07 do not request depth information from fishermen (Ministry of Fisheries 2010).

Depth information is available from TCEPR and TCER forms that report bottom trawl catches pertaining to rig (either recording an estimated catch of rig or declaring rig as the target species). These data come either from the recently introduced (1 October 2007) TCER forms or the longstanding TCEPR forms, which are primarily used by the larger offshore vessels but have been in operation since the first year of data in this report (1989–90). Approximately 80% of the depth observations reported in Table 11 originate from the TCER forms, accumulated in eight years. The remaining 20% of the trawl returns are on the older TCEPR forms, while less than 0.5% of the records use the CELR form. This predominance of TCER reports reflects the inshore nature of the rig bottom trawl fisheries. Only data from 2007–08 onwards are reported here, so that a complete picture will be obtained for the inshore bottom trawl rig fishery.

Reported depth observations, summarised over both form types, show that target rig bottom trawl fishing tends to be shallow in all QMAs, ranging from a minimum 5% quantile of 11 m in SPO 3 and SPO 7 to a maximum 95% quantile of 190 m for SPO 1E (Table 11). The distribution of tows that caught or targeted rig varies according to the target fishery in all six QMAs, with deep fisheries such

as tarakihi, ghost shark and stargazer taking rig at depths up to 200 m compared to the shallower depths for successful rig catches for fisheries like red cod and flatfish (Figure 16).

Table 11: Summary statistics by QMA from distributions from all records (combined TCER and TCEPR form types) using the bottom trawl method for effort that targeted or caught rig by target species category. Data are summarised by QMA from 2007–08 to 2014–15. [Continued on next page]

		Depth (m)			
Target species category	Number observations	Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Upper 95% of distribution
SPO 1E					
SNA	3 757	20	46	45	92
GUR	3 459	25	45	41	73
TAR	2 797	78	152	148	240
TRE	2 420	24	47	43	81
JDO	1 111	39	67	64	106
Other	249	25	174	148	435
Total	13 793	25	72	50	190
SPO 2					
GUR	12 358	22	45	41	80
TAR	9 839	40	88	80	154
FLA	3 145	10	22	18	48
GSH	891	44	115	100	200
RCO	647	13	61	55	137
SNA	548	27	48	45	81
JDO	246	36	82	82	119
BAR	236	30	83	75	160
WAR	225	50	100	96	151
MOK	165	27	84	94	148
TRE	116	24	43	40	86
STA	97	80	132	139	166
Other	228	16	130	99	350
Total	28 741	16	62	51	135
SPO 3					
FLA	11 559	9	27	20	58
ELE	1 855	11	29	20	65
RCO	1 848	17	49	48	95
STA	1 809	30	107	115	160
TAR	1 476	34	70	68	120
SPO	954	10	29	17	96
GUR	739	16	35	33	60
BAR	687	24	62	55	113
RSK	166	15	39	41	60
WAR	133	34	58	53	96
SPD	107	27	67	55	135
Other	291	25	102	90	238
Total	21 624	11	41	30	120
SPO 7					
FLA	17 218	10	24	22	45
TAR	5 429	30	97	90	185
GUR	4 361	22	45	43	75
RCO	1 922	16	49	42	116
BAR	1 439	29	66	53	147
SNA	1 404	10	29	22	74
JDO	1 006	35	89	81	158
GSH	1 000	44	112	97	200
WAR	719	39	80	65	155
STA	598	55	110	103	168
LEA	464	28	48	45	73
TRE	366	20	47	44	84

Table 11 [Continued]:

Target species category	Number observations	Depth (m) Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Upper 95% of distribution
SPO 7					
SCH	222	44	119	124	183
MOK	174	32	90	95	148
Other	315	12	98	54	350
Total	36 637	11	49	35	145
SPO 8					
TAR	2 213	56	119	123	183
GUR	2 114	24	47	45	76
JDO	821	40	89	80	158
TRE	640	22	44	42	72
BAR	363	26	62	54	136
FLA	355	14	39	38	65
LEA	261	36	52	48	74
SNA	238	20	52	44	114
SCH	174	70	125	128	182
WAR	144	50	69	66	117
GSH	90	59	89	74	184
Other	134	24	79	76	139
Total	7 547	26	76	60	163
SPO 1W					
GUR	3 276	25	44	40	70
TRE	1 736	27	49	45	80
TAR	1 196	90	139	137	195
SNA	399	28	57	50	112
JDO	229	35	71	60	121
SCH	90	100	168	176	218
BAR	38	48	100	93	153
Other	37	21	211	52	885
Total	7 001	26	66	48	158

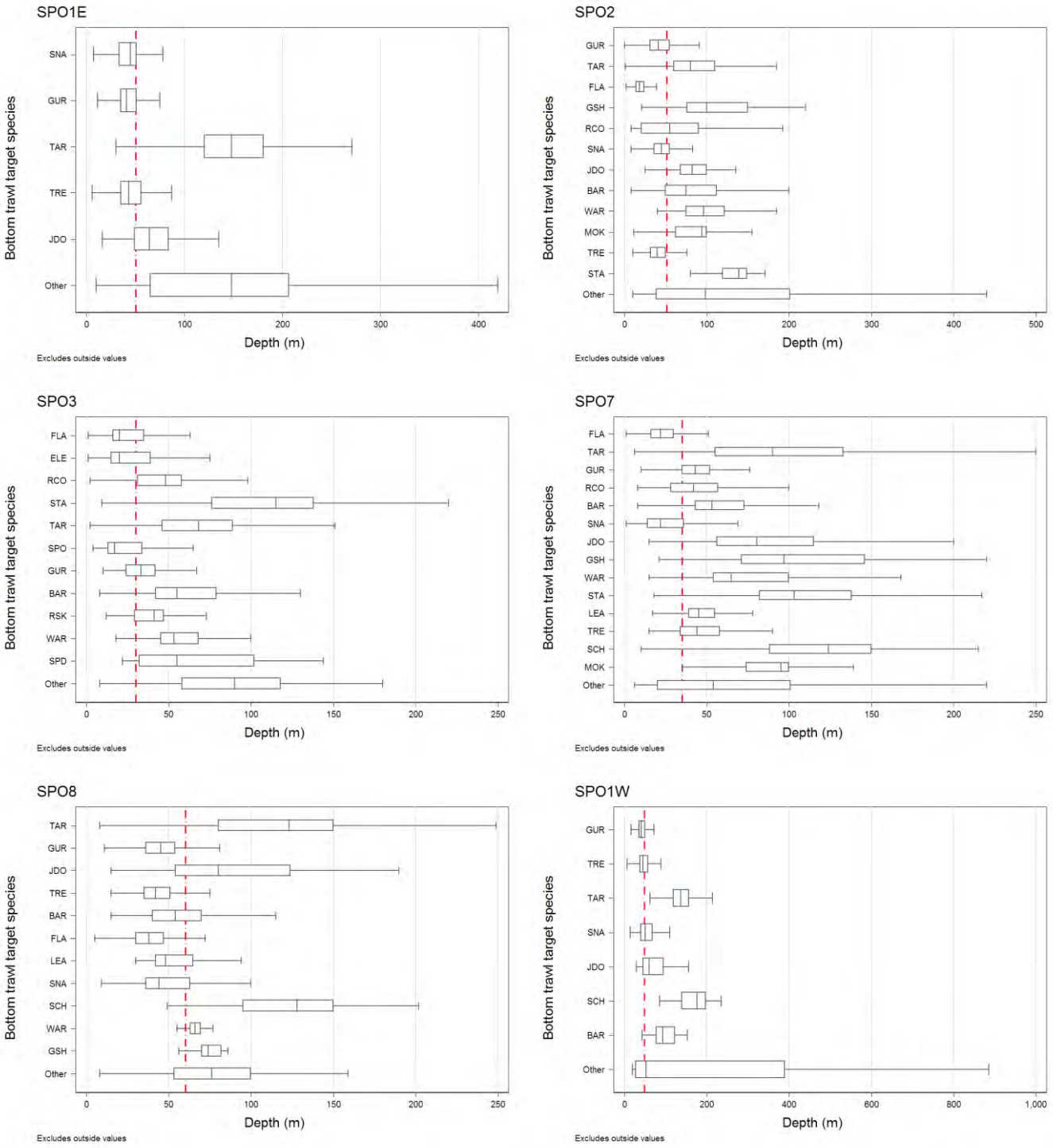

Figure 16: Box plot distributions by QMA of bottom depth from combined TCER and TCEPR form types using the bottom trawl method for effort that targeted or caught rig by target species category for the period 2007–08 to 2014–15. Vertical line in each sub graph indicates the median depth from all tows that caught or targeted rig in the indicated QMA.

3. STANDARDISED CPUE ANALYSIS

Thirteen fisheries were considered for detailed CPUE analysis to be included as biomass index series in this update of rig fisheries on the North and South Islands of New Zealand. See Appendix I for an introduction to the detailed standardised CPUE analyses, including equations and methodology along with links to the specific analyses and diagnostics.

Table 12 (bottom trawl) and Table 13 (setnet) define the 13 standardised CPUE analyses by capture method, showing the statistical areas used, the selected target species specifications and how these analyses have recently evolved. This table also shows the Science Information Quality ranking for each analysis, with 1=High Quality; 2=Medium or Mixed Quality; 3=Low Quality (not used – marked with grey shading).

Table 12: History of SPO bottom trawl (BT) CPUE standardisation analyses, showing the analysis years along with the statistical area and target species definitions. Standardised series that have been dropped are shaded grey and the new series is shaded yellow. Series adjustments made in 2013 (Starr & Kendrick 2016) are coloured red (italics) and adjustments made for this analysis are coloured blue (bold). Explanation of research ratings: 1=High Quality (accepted); 2=Medium or Mixed Quality (accepted with specified reservations); 3=Low Quality (rejected).

Model name	Statistical areas	Target species	Assessment years	Research rating
SPO 1E_BT	002–010	SNA, TRE, GUR, JDO, BAR, TAR	2011, 2013, 2016	3
SPO 1W_BT[1]	**041**, 042, 045, 046, 047	SNA, TRE, GUR, TAR	2011, 2013, **2016**	1
SPO 2_BT	011. 012, 013, 014, 015, (**016**[2])	**FLA, GUR, TAR**[3]	2009, 2011, 2013, 2015, **2016**	1
SPO 3_BT(FLA)[5]	018, 020, 022, 024–032	FLA (all species)	2005, 2007, 2008, 2011, 2013	3[4]
SPO 3_BT(MIX)[5]	018, 020, 022, 024–032	BAR, STA, RCO, SPD, TAR, SPO, ***ELE, GUR***	2005, 2007, 2008, 2011, ***2013***	1
SPO 3_BT[5]	018, 020, 022, 024–032	**FLA**, BAR, STA, RCO, SPD, TAR, SPO, ELE, GUR	**2016**	1
SPO 7_BT[6]	016–018, 032–037, 038, 039, ***040***	FLA, RCO, SPO, ***BAR, TAR, GUR,*** **TRE, SNA, WAR**	2007, 2010, ***2013***, 2015, **2016**	1
SPO 8_BT	039, 040, 041	TAR, SNA, TRE, BAR, JDO, GUR	2011, 2013	3

[1] Scope of SPO 1W_BT analysis expanded in 2016.
[2] Area 016 moved to SPO 7_BT in 2016.
[3] Target species definitions first applied to SPO 2_BT in 2016.
[4] This fishery was rejected by the SINSWG in 2013.
[5] SPO 3_BT(FLA) and (MIX) analyses were combined in 2016.
[6] Scope of SPO 7_BT analysis expanded in 2013 and again in 2016.

All five bottom trawl positive catch models were forced to the lognormal distribution to ensure continuity with previous analyses. A binomial model based on the presence/absence of rig in each data set was also calculated for all five models as there were high proportions of records with no rig in every analysis (see 3rd column from the right in Table J.1, Table K.1, Table L.1, Table M.1 and Table N.1). The two series were then combined using the delta-lognormal method (Eq. I.4). Detailed tables and figures are provided for each analysis (see Section I.3.1 for reference links), giving model statistics and diagnostics, along with tables summarising the underlying data and the estimated indices.

Table 13: History of SPO setnet (SN) CPUE standardisation analyses, showing the analysis years along with the statistical area and target species definitions. Standardised series that have been dropped are shaded grey. New series is shaded yellow. Series adjustments made for this analysis are coloured blue and italicised. Explanation of research ratings: 1=High Quality (accepted); 2=Medium or Mixed Quality (accepted with specified reservations); 3=Low Quality (rejected).

Model name	Statistical areas	Target species	Assessment years	Research rating
SPO 1E_SN(007)	007	SPO, SCH, SPD, NSD	2011, 2013 ,2016	2
SPO 1E_SN(coast)	002–006, 008–010	SPO, SCH, SPD, NSD	2011, 2013 ,2016	3
SPO 1W_SN(043)	043	SPO, SCH, SPD, NSD	2011, 2013, 2016	2
SPO 1W_SN(044)	044	SPO, SCH, SPD, NSD	2011, 2013, 2016	2
SPO 1W_SN(041–047)[1]	***041***, 042, 045, 046, 047	SPO, SCH, SPD, NSD	2011, 2013, ***2016***	3
SPO 2_SN	011–016	not restricted	2009, 2011, 2013	3
SPO 3_SN(SHK)	018, 020, 022, 024–032	SPO, SCH, SPD, ELE	2003, 2005, 2007, 2008, 2011, 2013, 2016	1
SPO 7_SN(038)	038	SPO, SCH, SPD, (***ELE***[2])	2006, 2010, 2013, 2015, ***2016***	1
SPO 7_SN(WC)	032–037	SPO, SCH, SPD, NSD	2006, 2010, 2013	3
SPO 7_SN(STB)[3]	037, 039, 040	SPO, SCH, SPD, NSD	***2016***	3
SPO 8_SN	039, 040, 041	SPO, SCH, SPD, NSD	2011, 2013	3

[1] Scope of SPO 1W_SN(041–047) analysis expanded in 2016.
[2] ELE removed as a target species from SPO 7_SN(038) in 2016.
[3] New analysis proposed in 2016.

All positive catch models were forced to the distributions used in previous analyses to ensure continuity, except for SPO 7_SN(STB), which is a new series, where the most appropriate distribution was selected as described in Section I.2.2 (see Figure V.3). No binomial models were run for these setnet fisheries because of the high proportion of records that successfully captured rig. Previous experience has shown there is little or no impact to the series trend when such positive catch series are combined with a binomial model. Detailed tables and figures are provided for each analysis (see Section I.3.2 for reference links), giving model statistics and diagnostics, along with tables summarising the underlying data and the estimated indices.

3.1 Standardised CPUE analyses of rig bottom trawl fisheries

3.1.1 SPO 1E_BT

This CPUE analysis was rejected in 2016 for monitoring SPO 1E by the NINSWG and the Plenary (MPI 2016) with a research rating of '3' (Low Quality: insufficient data with low annual catches) (Table 12). The WG also noted that the BT fisheries do not monitor large mature female rig.

There is a relatively high annual proportion of trips in the SPO 1E_BT core vessel data set that captured rig, ranging from 50–60% at the beginning of the series to 80–90% at the end (Table J.1); consequently there is an increasing trend in capture success ([lower left panel] Figure J.2). There is also a relatively annual high proportion (50–60%) of trips that land rig but do not report rig in the estimated catches, particularly before the switch to TCER forms in 2007–08 ([lower left panel] Figure J.2). This low annual proportion of estimated rig results from the requirement that catch from only the top five species per day of fishing needed to be reported before the form change in 2007–08. The annual proportion of trips with no estimated rig catch dropped to 30–40% after the reporting requirement changed to the top eight species per tow. The lognormal positive catch model explained

30% of the deviance (Table J.2), with vessel, number tows and statistical area entering the model after fishing year. The standardisation effect is minimal, with almost no change in the unstandardised CPUE trend with addition of the model explanatory variables (Figure J.4). The model fits the lognormal distribution well (Figure J.5), with the series showing an initial decline, a long period of no trend, and then a strong upturn at the end of the series (Figure J.3). There is reasonable correspondence with the model year effect for the implied residuals for most of the statistical areas, with Areas 003, 005, 008 and 010 all showing the upturn at the end of the series (Figure J.9). The binomial model accepted vessel and number tows into the model and explained 35% of the deviance (Table J.3) and shows a gradually increasing trend consistent with the increased proportion of trips capturing this species.

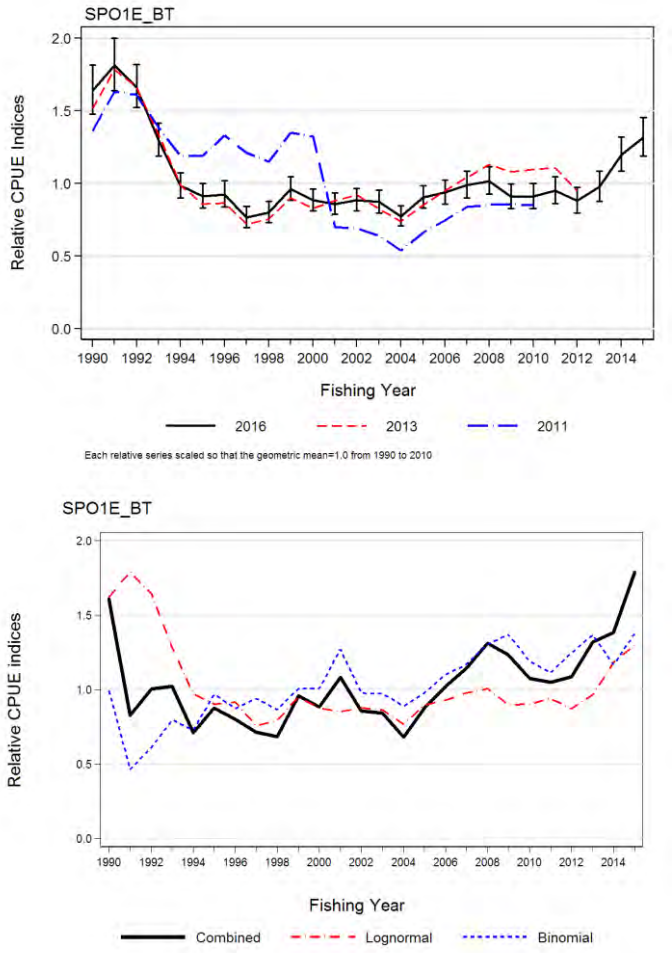

Figure 17: [left panel]: comparison of the SPO 1E_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 1E_BT series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012); [right panel]: relative CPUE indices for rig using the lognormal positive catch model based on the SPO 1E_BT fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. I.4).

The updated lognormal series compares moderately well with the equivalent series presented by Starr & Kendrick (2016) but the comparison is not as good with the Kendrick & Bentley (2012) series ([left panel] Figure 17). Both Kendrick & Bentley (2012) and Starr & Kendrick (2016) used the 'trip-stratum' method to scale estimated catch to landings, which may have led to possible bias because of the high proportion of trips with no estimated rig catch, but with associated landings (see penultimate column in Table J.1). The effect of combining the lognormal model with the binomial model is to lift

the CPUE indices from the mid-2000s ([right panel] Figure 17), resulting from the gradual increasing trend in the binomial series.

3.1.2 SPO 1W_BT

This CPUE analysis was accepted in 2016 for monitoring SPO 1W by the NINSWG and the Plenary (MPI 2016) with a research rating of '1' (High Quality) (Table 12). The WG also noted that the BT fisheries do not monitor large mature female rig.

There is a relatively high annual proportion of trips in the SPO 1W_BT core vessel data set that captured rig, ranging from 70–80% at the beginning of the series to 80–90% at the end (Table K.1); consequently there is an increasing trend in capture success ([lower left panel] Figure K.2). There is also a relatively high annual proportion (30–40%) of trips that land rig but do not report rig in the estimated catches, particularly before the switch to TCER forms in 2007–08 ([lower left panel] Figure K.2). This low annual proportion of estimated rig results from the requirement that catch from only the top five species per day of fishing needed to be reported before the form change in 2007–08. The annual proportion of trips with no estimated rig catch dropped to below 20% once the reporting requirement changed to the top eight species per tow. The lognormal positive catch model explained 58% of the deviance (Table K.2), with hours fished, vessel, month and statistical area entering the model after fishing year. The standardisation effect is strong, with a generally rising unstandardised CPUE trend changed to a U-shaped trend (declining to the early 2000s followed by an increasing trend to the end of the series) once the effect of lengthening tow duration is factored in (Figure K.4). The model fits the lognormal distribution well (Figure K.5), with the series showing a low point in around 2000, a short peak in 2002, and then an increasing trend to the end of the series (Figure K.3). There is good correspondence with the model year effect for the implied residuals for the three statistical areas with the majority of catch (041, 042 and 047) (Figure K.10). The binomial model accepted vessel, hours fished and month into the model and explained 32% of the deviance (Table K.3) and shows a gradually increasing trend consistent with the increased proportion of trips capturing this species.

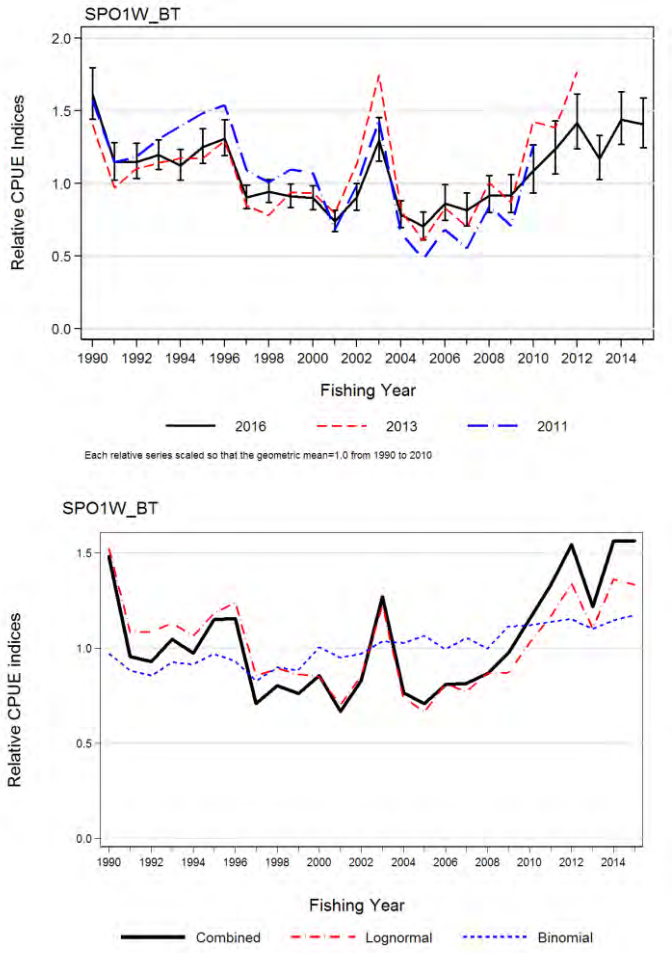

Figure 18: [left panel]: comparison of the SPO 1W_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 1W_BT series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012); [right panel]: relative CPUE indices for rig using the lognormal positive catch model based on the SPO 1W_BT fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. I.4).

The updated lognormal series compares moderately well with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) ([left panel] Figure 18). Both Kendrick & Bentley (2012) and Starr & Kendrick (2016) used the 'trip-stratum' method to scale estimated catch to landings, which may have led to possible bias because of the high proportion of trips with no estimated rig catch, but with associated landings (see penultimate column in Table K.1). The effect of combining the lognormal model with the binomial model is to slightly lift the CPUE indices from the mid-2000s ([right panel] Figure 18), probably resulting from the gradual increasing trend in the binomial series.

3.1.3 SPO 2_BT

This CPUE analysis was accepted in 2016 for monitoring SPO 2 by the NINSWG and the Plenary (MPI 2016) with a research rating of '1' (High Quality) (Table 12). The WG also noted that the BT fisheries do not monitor large mature female rig.

The annual proportion of trips in the SPO 2_BT core vessel data set that captured ranges from 40–50% at the beginning of the series to 60–70% at the end (Table L.1); consequently there is an increasing trend in capture success ([lower left panel] Figure L.2). There is also a relatively high annual proportion (average=54% from 1989–90 to 2006–07) of trips that land rig but do not report rig

in the estimated catches before the switch to TCER forms in 2007–08 ([lower left panel] Figure L.2). This low annual proportion of estimated rig results from the requirement that catch from only the top five species per day of fishing needed to be reported before the form change in 2007–08. The annual proportion of trips with no estimated rig catch dropped to an average of 9% (2007–08 to 2014–15) once the reporting requirement changed to the top 8 species per tow. The lognormal positive catch model explained 52% of the deviance (Table L.2), with hours fished, vessel, target species and month entering the model after fishing year. The standardisation effect is moderate, successively dampening the generally rising unstandardised CPUE trend with the addition of the first three explanatory variables (Figure L.4). The model fits the lognormal distribution well (Figure L.5), with the positive catch series showing a gradually increasing trend over the length of the series (Figure L.3). There is good correspondence with the model year effect for the implied residuals for two of the three target species (GUR and TAR), with weaker correspondence with FLA target trips (Figure L.10). The binomial model accepted vessel and hours fished into the model and explained 53% of the deviance (Table L.3) and shows a gradually increasing trend consistent with the increased proportion of trips capturing this species.

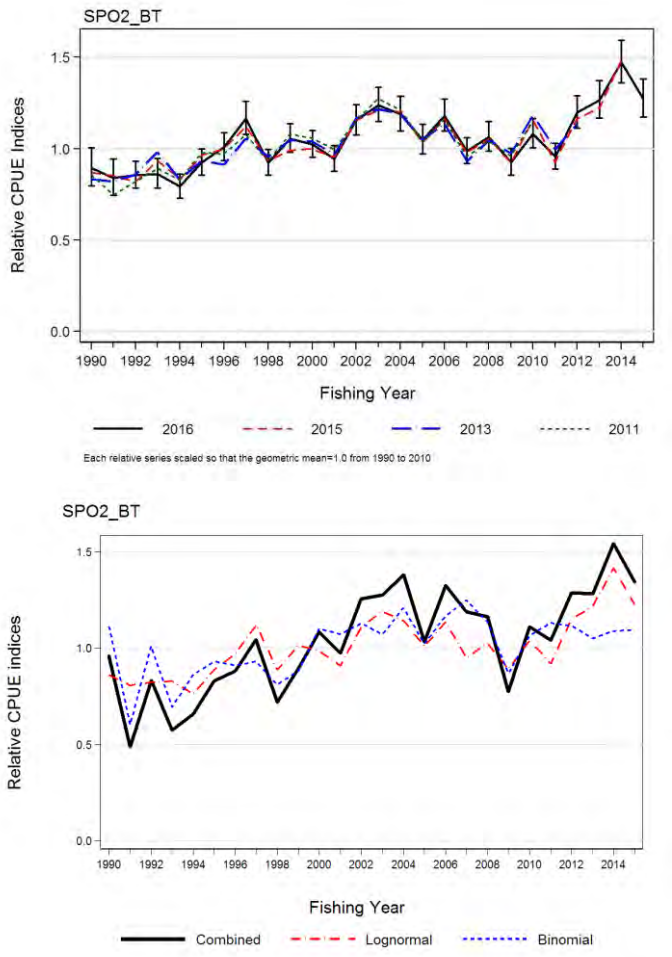

Figure 19: **[left panel]: comparison of the SPO 2_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 2_BT series: 2011: Kendrick et al. (2011), 2013: Starr & Kendrick (2016), 2015: Starr & Kendrick (2015a); [right panel]: relative CPUE indices for rig using the lognormal positive catch model based on the SPO 2_BT fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. I.4).**

The updated lognormal series compares well with the trip-based series presented by Kendrick et al. (2011), Starr & Kendrick (2016) and Starr & Kendrick (2015a) ([left panel] Figure 19). The three previous series also used a trip-based analysis because of the high proportion of trips with no rig estimated catch but this analysis was the first to assign the 'predominant' statistical area and target species to each trip. While the previous analyses ignored these explanatory factors, they differed little from the current analysis. The effect of combining the lognormal model with the binomial model is to slightly lift the CPUE indices from the early 2000s and to drop the early part of the series ([right panel] Figure 19), resulting from the gradual increasing trend in the binomial series.

3.1.4 SPO 3_BT

This CPUE analysis was accepted in 2016 for monitoring SPO 3 by the SINSWG and the Plenary (MPI 2016) with a research rating of '1' (High Quality) (Table 12) but noted that the method of capture used for the SPO 3_BT analysis does not representatively sample large mature female rig.

The annual proportion of trips in the SPO 3_BT core vessel data set that captured rig is much lower than in the SPO 1W_BT or the SPO 2_BT data sets, ranging from below 20% at the beginning of the series to nearly 60% at the end (Table M.1); consequently there is an increasing trend in capture success ([lower left panel] Figure M.2). There is also a relatively high annual proportion (60–70%) of trips that land rig but do not report rig in the estimated catches before the switch to TCER forms in 2007–08 ([lower left panel] Figure M.2). This low annual proportion of estimated rig results from the requirement that catch from only the top five species per day of fishing needed to be reported before the form change in 2007–08. The annual proportion of trips with no estimated rig catch dropped to 20–30% once the reporting requirement changed to the top eight species per tow. The lognormal positive catch model explained 25% of the deviance (Table M.2), with vessel, hours fished, and target species entering the model after fishing year. The standardisation effect is relatively small, with only minor changes to the trend with the addition of the explanatory variables (Figure M.4). The model fits the lognormal distribution well (Figure M.5), with the positive catch series showing almost no trend except for a small upturn at the end of the series (Figure M.3). There is only moderate correspondence with the model year effect for the target species implied residuals, with FLA target showing the best among the seven species modelled (Figure M.9). The binomial model accepted vessel, tows and month into the model and explained 37% of the deviance (Table M.3) and shows a strong increasing trend consistent with the increasing proportion of trips capturing this species.

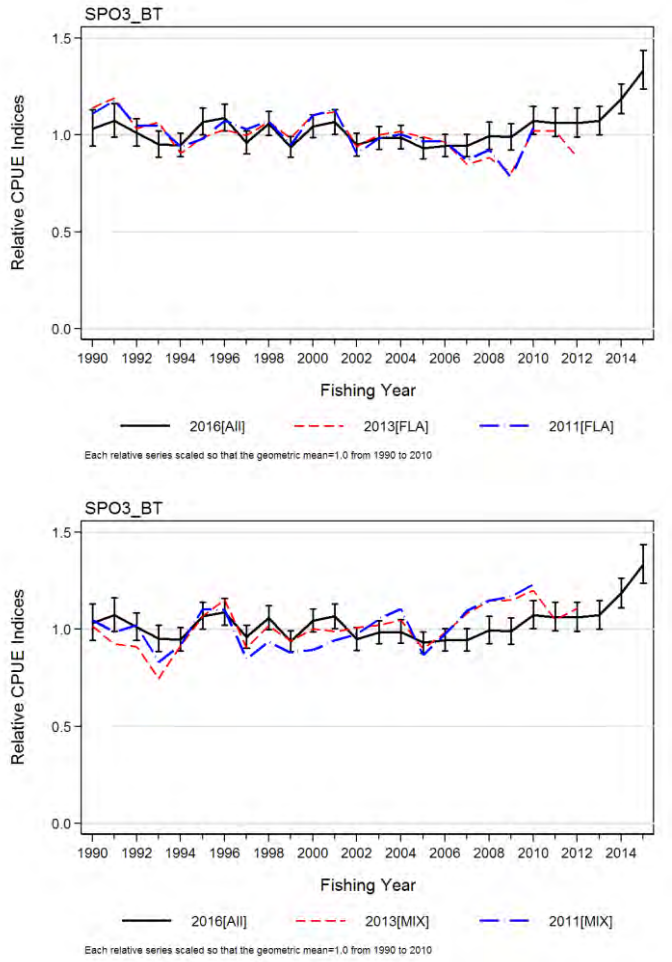

Figure 20: **[left panel]: comparison of the SPO 3_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 3_BT[FLA] series: 2011: Starr & Kendrick (2011), 2013: Starr & Kendrick (2016); [right panel]: comparison of the SPO 3_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 3_BT[MIX] series: 2011: Starr & Kendrick (2011), 2013: Starr & Kendrick (2016).**

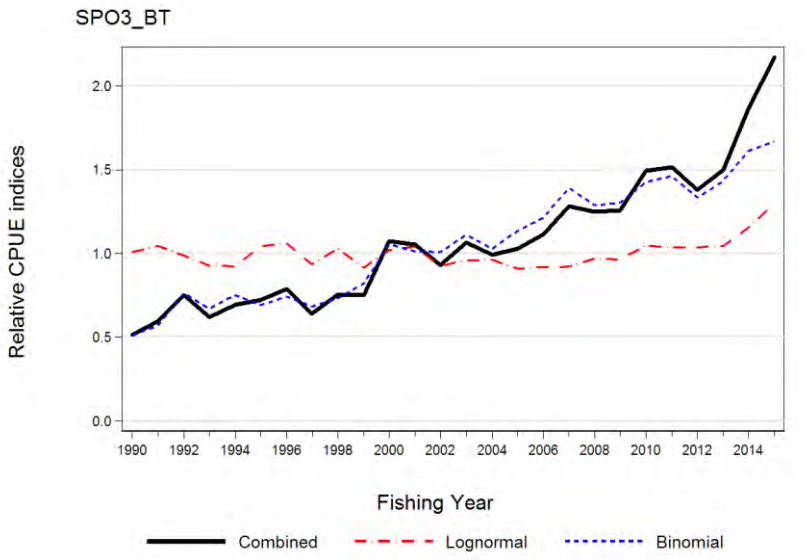

Figure 21: Relative CPUE indices for rig using the lognormal positive catch model based on the SPO 3_BT fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. I.4).

This new lognormal series lies above the previous [FLA] series ([left panel] Figure 20) and below the previous [MIX] series ([right panel] Figure 20 – 2011 series from Starr & Kendrick 2011; 2013 series from Starr & Kendrick 2016). The SINSWG had rejected the SPO 3_BT(FLA) series in 2013 because of the low headline height used in this fishery coupled with the observation that it is a specialist fishery with a restricted depth range. However, the WG accepted a revised analysis that added FLA to the suite of target species already used by the [MIX] series. This revised analysis now covers the full range of depths where rig are found and provides much better coverage (spatially and across all depths) for the species, resulting in a series that seems to provide an average of the previous two series. The effect of combining the lognormal model with the binomial model is to convert a nearly trendless lognormal series into an increasing trend that matches the trend in the binomial series (Figure 21).

3.1.5 SPO 7_BT

This CPUE analysis was accepted in 2016 for monitoring SPO 7 by the SINSWG and the Plenary (MPI 2016) with a research rating of '1' (High Quality) (Table 12). The WG also noted that the BT fisheries do not monitor large mature female rig.

The annual proportion of trips in the SPO 7_BT core vessel data set that captured rig ranged from around 50–60% at the beginning of the series to over 80% at the end (Table N.1); consequently there is an increasing trend in capture success ([lower left panel] Figure N.2). There is also a relatively high annual proportion (50–60%) of trips that land rig but do not report rig in the estimated catches before the switch to TCER forms in 2007–08 ([lower left panel] Figure N.2). This low proportion of estimated rig results from the requirement that catch from only the top five species per day of fishing needed to be reported before the form change in 2007–08. The annual proportion of trips with no estimated rig catch dropped to less than 20% once the reporting requirement changed to the top eight species per tow. The lognormal positive catch model explained 45% of the deviance (Table N.2), with vessel, number tows and month entering the model after fishing year. The standardisation effect is moderate, with a generally rising unstandardised CPUE trend dampened with the addition of the vessel explanatory variable (Figure N.4). The model fits the lognormal distribution well (Figure N.5), with the positive catch series showing little trend until around 2012 when the CPUE shoots upward

(Figure N.3). The binomial model accepted vessel and hours fished into the model and explained 53% of the deviance (Table N.3) and shows a slowly increasing trend consistent with the increased proportion of trips capturing this species.

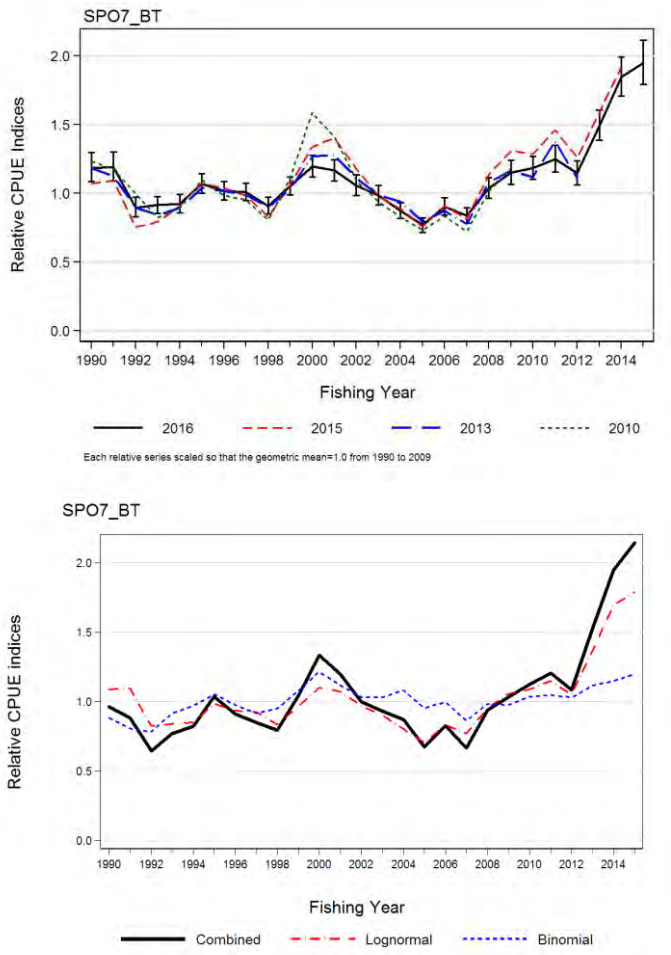

Figure 22: [left panel]: comparison of the SPO 7_BT standardised lognormal CPUE analysis prepared for this report with historical SPO 7_BT series: 2011: Starr & Kendrick (2011), 2013: Starr & Kendrick (2016), 2015: Starr & Kendrick (2015b); [right panel]: relative CPUE indices for rig using the lognormal positive catch model based on the SPO 7_BT fishery definition, the binomial standardised model using the logistic distribution and the combined model using the delta-lognormal procedure (Eq. I.4).

The updated lognormal series compares well with the historic series presented by Starr & Kendrick (2011, 2015b and 2016) ([left panel] Figure 22), including corroboration of the increase in CPUE documented in 2015 (Starr & Kendrick 2015b). The effect of combining the lognormal model with the binomial model is to track the lognormal series, except right at the end where the recent increasing trend is boosted slightly higher ([right panel] Figure 22).

3.2 Standardised CPUE analyses of rig setnet fisheries

3.2.1 SPO 1E_SN(007)

The NINSWG and Plenary accepted the SPO 1E_SN(007) series because this fishery targets mature female rig and the diagnostics were considered credible. However, it gave the series a research rating of '2' (MPI 2016) for the reason that it provides an index of abundance for only a relatively small portion of the total area of SPO 1E.

This updated log-logistic series compares reasonably well with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) (Figure 23). All three sets of analyses used the 'F2' procedure (described in Appendix G) to expand estimated catches by vessel and year into the equivalent of landed catches, although the current analysis is the first to apply the 'daily effort stratum' procedure when preparing the data for analysis (Section 2.3.1.5). This can be done because the proportion per year of trips and daily strata in the SPO 1E_SN(007) core vessel data set that captured rig ranged from 94% to 100% throughout the entire series ([lower left panel] Figure O.2). As well, there were no trips in a year that landed SPO but that did not estimate SPO catch, indicating that SPO was consistently in the top five species captured (Table O.1). The log-logistic positive catch model explained 44% of the deviance (Table O.2), with vessel, month and net length entering the model after fishing year. The standardisation effect is moderate, without materially changing an overall trendless unstandardised CPUE series (Figure O.4). The fit to the log-logistic distribution is skewed to the right, indicating some departure from the underlying distributional assumption (Figure O.5). The positive catch series shows no long-term trend, varying around the series mean over the 26 years of indices (Figure O.3).

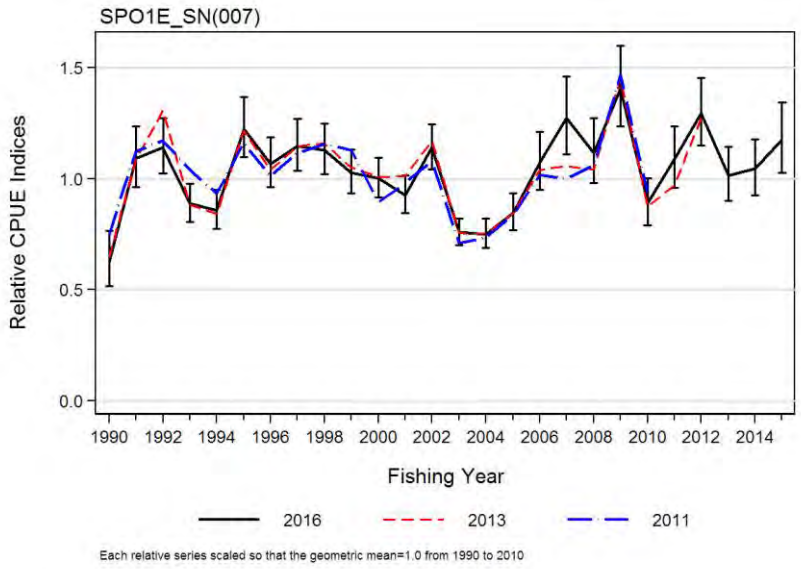

Figure 23: Comparison of the SPO 1E_SN(007) standardised positive catch CPUE analysis prepared for this report with historical SPO 1E_SN(007) series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012).

3.2.2 SPO 1E_SN(coast)

The NINSWG and Plenary rejected the SPO 1E_SN(coast) series with a research rating of '3' (MPI 2016) because annual catches were unacceptably low and the fishing locations were widely dispersed and occupied sporadically.

This updated lognormal series compares reasonably well with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) (Figure 24). All three sets of analyses used the 'F2' procedure (described in Appendix G) to expand estimated catches by vessel and year into the equivalent of landed catches, although the current analysis is the first to apply the 'daily effort stratum' procedure when preparing the data for analysis (Section 2.3.1.5). This can be done because the proportion per year of trips and daily strata in the SPO 1E_SN(coast) core vessel data set that captured rig ranged from 90% to 98% throughout the entire series ([lower left panel] Figure P.2). As well, there were no trips in a year that landed SPO but that did not estimate SPO catch, indicating that SPO was consistently in the top five species captured (Table P.1). The lognormal positive catch model explained 23% of the deviance (Table P.2), with vessel and net length entering the model after fishing year. The standardisation effect is moderate, taking out a few peaks in the series without materially

changing an overall nearly trendless unstandardised CPUE series (Figure P.4). The fit to the lognormal distribution is good, indicating consistency with the underlying distributional assumption (Figure P.5). The positive catch series shows no long-term trend up to around 2009–10, when it seems to step down to a slightly lower level (Figure P.3).

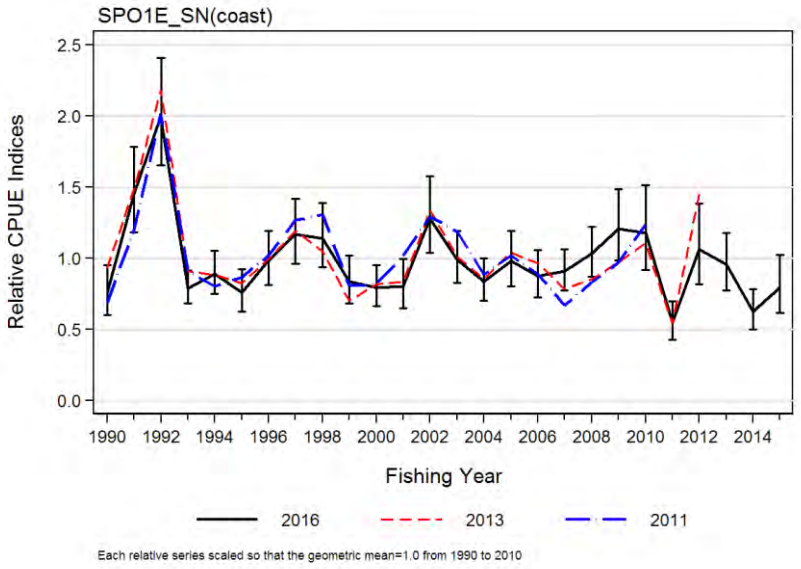

Figure 24: Comparison of the SPO 1E_SN(coast) standardised positive catch CPUE analysis prepared for this report with historical SPO 1E_SN(coast) series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012).

3.2.3 SPO 1W_SN(043)

The NINSWG and Plenary accepted the SPO 1W_SN(043) series because this fishery targets mature female rig and the diagnostics were considered credible. However, it gave the series a research rating of '2' (MPI 2016) for the reason that it provides an index of abundance for only a relatively small portion of the total area of SPO 1W.

This updated gamma series compares acceptably with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) (Figure 25). All three sets of analyses used the 'F2' procedure (described in Appendix G) to expand estimated catches by vessel and year into the equivalent of landed catches, although the current analysis is the first to apply the 'daily effort stratum' procedure when preparing the data for analysis (Section 2.3.1.5). This can be done because the proportion per year of trips and daily strata in the SPO 1W_SN(043) core vessel data set that captured rig ranged from 96% to 100% throughout the entire series ([lower left panel] Figure Q.2). As well, there were no trips in a year that landed SPO but that did not estimate SPO catch, indicating that SPO was consistently in the top five species captured (Table Q.1). The gamma positive catch model explained 45% of the deviance (Table Q.2), with vessel, month, duration and net length entering the model after fishing year. Target species was dropped by the model because only one species (SPO) made up nearly all of the data. The standardisation effect is moderate, without materially changing the unstandardised CPUE series (Figure Q.4). The fit to the gamma distribution is peaked in the centre, indicating some over-representation in the middle of the distribution, but it is not serious (Figure Q.5). The positive catch series drops steeply in the first decade, followed by a long period with little trend at a level below the series mean (Figure Q.3).

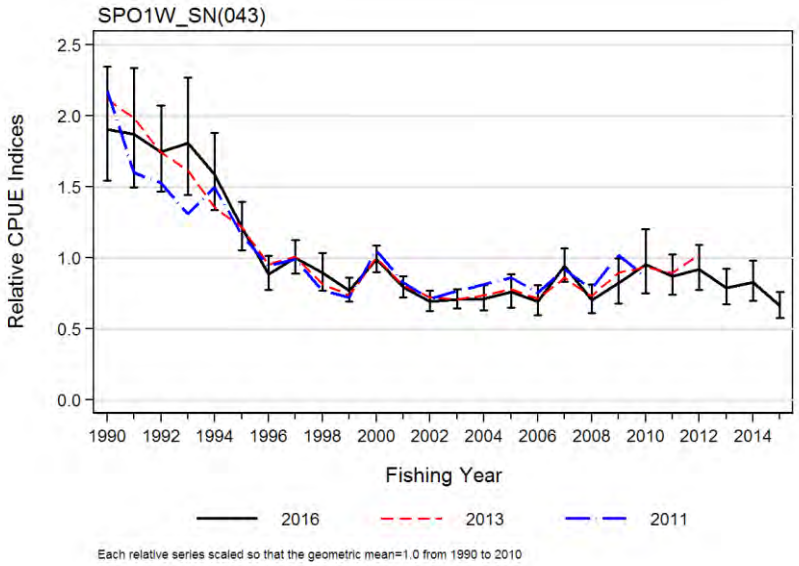

Figure 25: Comparison of the SPO 1W_SN(043) standardised positive catch CPUE analysis prepared for this report with historical SPO 1W_SN(043) series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012).

3.2.4 SPO 1W_SN(044)

The NINSWG and Plenary accepted the SPO 1W_SN(044) series because this fishery targets mature female rig and the diagnostics were considered credible. However, it gave the series a research rating of '2' (MPI 2016) for the reason that it provides an index of abundance for only a relatively small portion of the total area of SPO 1W.

This updated gamma series compares acceptably with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) (Figure 26). All three sets of analyses used the 'F2' procedure (described in Appendix G) to expand estimated catches by vessel and year into the equivalent of landed catches, although the current analysis is the first to apply the 'daily effort stratum' procedure when preparing the data for analysis (Section 2.3.1.5). This can be done because the proportion per year of trips and daily strata in the SPO 1W_SN(044) core vessel data set that captured rig ranged from 97% to 100% throughout the entire series ([lower left panel] Figure R.2). As well, there were no trips in a year that landed SPO but that did not estimate SPO catch, indicating that SPO was consistently in the top five species captured (Table R.1). The gamma positive catch model explained 39% of the deviance (Table R.2), with vessel, month and net length entering the model after fishing year. As with the SPO 1W_SN(043) model, target species was dropped because only one species (SPO) made up nearly all of the data. The standardisation effect is moderate, without materially changing the unstandardised CPUE series (Figure R.4). Again, as with the SPO 1W_SN(043) model, the fit to the gamma distribution is peaked in the centre, indicating some over-representation in the middle of the distribution, but it is not serious (Figure R.5). The positive catch series drops steadily in the first decade, followed by a long period with little trend at a level below the long-term series mean (Figure R.3).

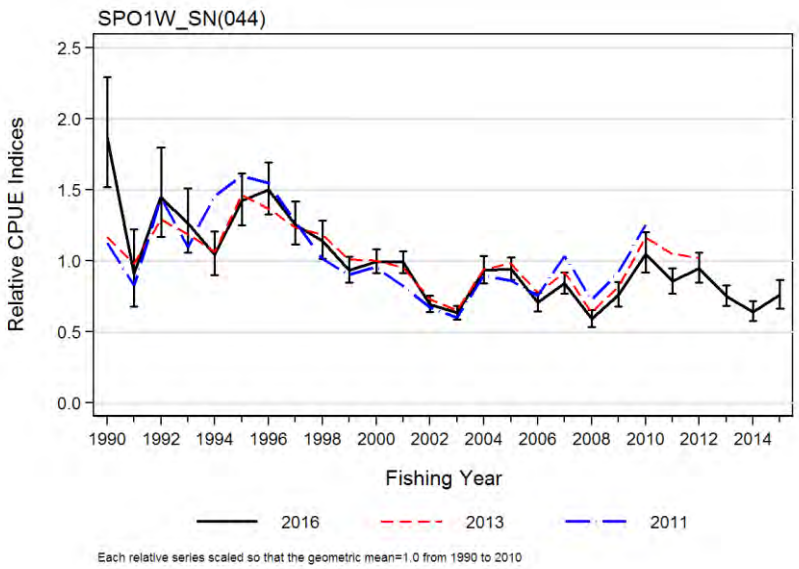

Figure 26: Comparison of the SPO 1W_SN(044) standardised positive catch CPUE analysis prepared for this report with historical SPO 1W_SN(044) series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012).

3.2.5 SPO 1W_SN(041–047)

The NINSWG and Plenary rejected the SPO 1W_SN(041–047) series with a research rating of '3' (MPI 2016) because of the considerable impact from the Maui dolphin closures.

This updated lognormal series compares reasonably with the equivalent series presented by Starr & Kendrick (2016) and Kendrick & Bentley (2012) (Figure 27), considering that the series presented in Appendix S has had an additional statistical area added (Area 041: see Table 13) compared to the two earlier series. All three sets of analyses used the 'F2' procedure (described in Appendix G) to expand estimated catches by vessel and year into the equivalent of landed catches, although the current analysis is the first to apply the 'daily effort stratum' procedure when preparing the data for analysis (Section 2.3.1.5). This can be done because the proportion per year of trips and daily strata in the SPO 1W_SN(041–047) core vessel data set that captured rig ranged from 84% to 95% throughout the entire series ([lower left panel] Figure S.2). As well, there were no trips in any year that landed SPO but that did not estimate SPO catch, indicating that SPO was consistently in the top five species captured (Table S.1). The lognormal positive catch model explained 50% of the deviance (Table S.2), with target species, vessel, month and net length entering the model after fishing year. The standardisation effect is moderately strong, changing an unstandardised CPUE series that declines slowly from the late 1990s to a continually declining series from the beginning of the analysis period. Most of this change occurs when the [*vessel*] explanatory variable was added to the model (Figure S.4). The fit to the lognormal distribution is good, indicating consistency with the underlying distribution (Figure S.5). The other target species of importance in this analysis is SCH, with the residual implied coefficients for this category showing a similar, but more variable, trend than the overall model year effect (Figure S.10). The positive catch series shows an overall declining trend over the full period of the series, dropping about 65% over the 26 years (Figure S.3).

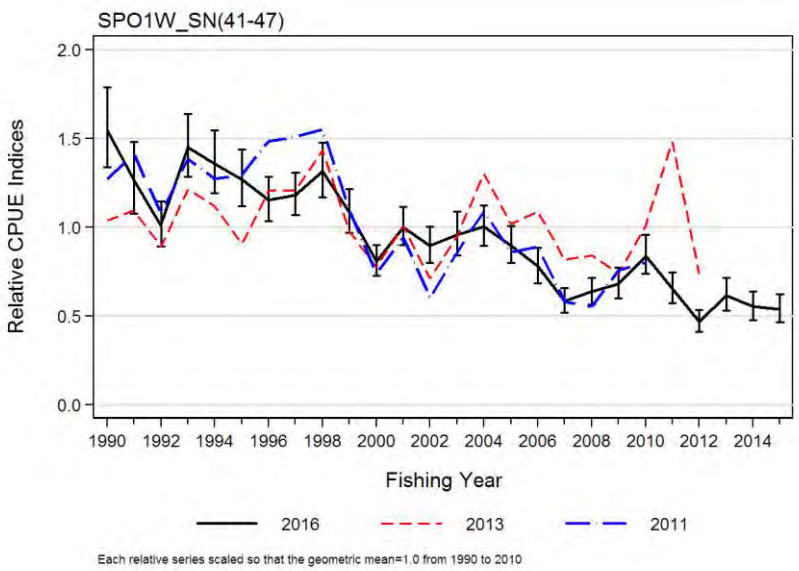

Figure 27: Comparison of the SPO 1W_SN(041–047) standardised positive catch CPUE analysis prepared for this report with historical SPO 1W_SN(042–047) series: 2013: Starr & Kendrick (2016), 2011: Kendrick & Bentley (2012).

3.2.6 SPO 3_SN(SHK)

This CPUE analysis was accepted in 2016 for monitoring SPO 3 by the SINSWG and the Plenary (MPI 2016), giving it a research rating of '1' (High Quality).

This updated log-logistic series compares acceptably with the equivalent series presented by Starr & Kendrick (2016) and Starr & Kendrick (2011) (Figure 28). All three sets of analyses used the 'trip matching' method (Section 2.3.1.2) to expand estimated catch to landed catch. Unlike the North Island CPUE analyses, there are proportionately more trips and daily strata that have no rig (trips with a successful catch of rig ranged between 60% and 90% of the annual total with mean=80%) (Table T.1). Just under 8% of trips per year (series average) report SPO in the landings but have no associated estimated catch ([lower left panel] Figure T.2), but these trips represent just 2% of the average annual landings of rig (Table T.1). The log-logistic positive catch model explained 45% of the deviance (Table T.2), with vessel, target species, month and net length entering the model after fishing year. The standardisation effect is strong, eliminating a strong drop in CPUE in the 1990s and flattening the CPUE series by depressing the recent CPUE indices (Figure T.4). The fit to the log-logistic distribution misses the central peak and is slightly fatter than expected in the main body of the distribution, but this departure seems minor (Figure T.5). The other target species in this analysis are SCH, SPD and ELE. While the annual residual implied coefficients for SPO and SCH are in agreement, both SPD and ELE (which have much fewer data) depart from the overall model year effect (Figure T.10). The positive catch series is essentially flat, showing no trend and is stable around the series long-term mean (Figure T.3).

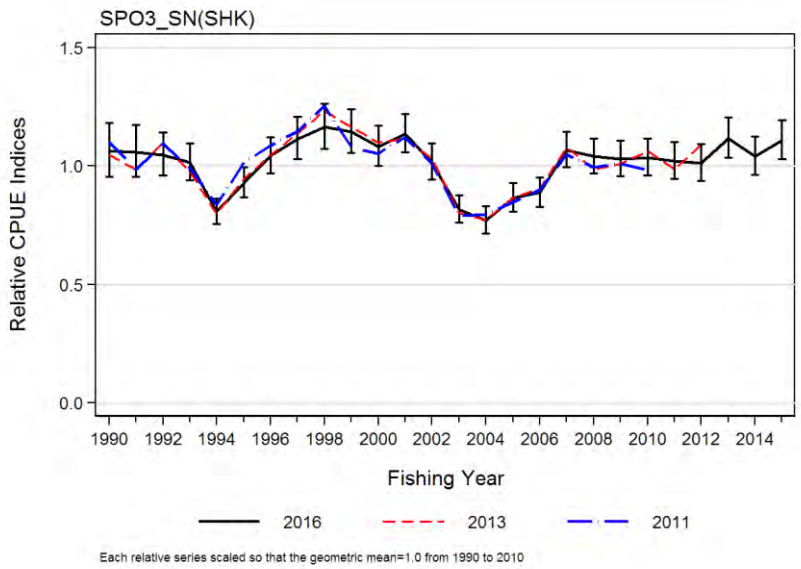

Figure 28: Comparison of the SPO 3_SN(SHK) standardised positive catch CPUE analysis prepared for this report with historical SPO 3_SN(SHK) series: 2013: Starr & Kendrick (2016), 2011: Starr & Kendrick (2011).

3.2.7 SPO 7_SN(038)

This CPUE analysis was accepted in 2016 for monitoring SPO 7 by the SINSWG and the Plenary (MPI 2016), giving it a research rating of '1' (High Quality).

This updated log-logistic series compares acceptably with the equivalent series presented by Starr et al. (2010), Starr & Kendrick (2015b) and Starr & Kendrick (2016) (Figure 29). The 2010 and 2013 analyses used the 'trip matching' method with trips reduced to 'trip strata' (2.3.1.2) to expand estimated catch to landed catch, while the 2015 and the current analyses reduce the trip data to 'daily effort strata' (Section 2.3.1.5) before converting estimated catches to landed catches. On average, about 7% of trips per year report no rig (maximum=17%; minimum=0%) (Table U.1). On an annual basis, 1% of trips (series average) report SPO in the landings but have no associated estimated catch ([lower left panel] Figure U.2), and these trips represent 1% of the average annual landings of rig (Table U.1). The log-logistic positive catch model explained 42% of the deviance (Table U.2), with vessel, month, target species and net length entering the model after fishing year. The standardisation effect is moderately strong, reducing a strong drop in CPUE at the beginning of the series and eliminating a CPUE peak towards the end of the 1990s, while maintaining a gradually increasing trend from the mid-2000s, which has now declined from a peak in 2010–11 (Figure U.4). The fit to the log-logistic distribution misses the central peak and is slightly fatter than expected in the main body of the distribution, but this departure seems minor (Figure U.5). The other target species in this analysis are SCH and SPD, but neither of these two species have enough years represented in the annual residual implied coefficients to make a judgement if they depart from the overall model year effect (Figure U.10). The positive catch series showed a continuous declining trend from the beginning of the series to a low in the mid-2000s, approximately coincident with the lowering of the SPO 7 TACC. This low point is followed by an increasing trend to a peak in 2010–11, after which the series began to drop, with the 2014–15 index 30% lower than the peak 2010–11 index (Figure U.3).

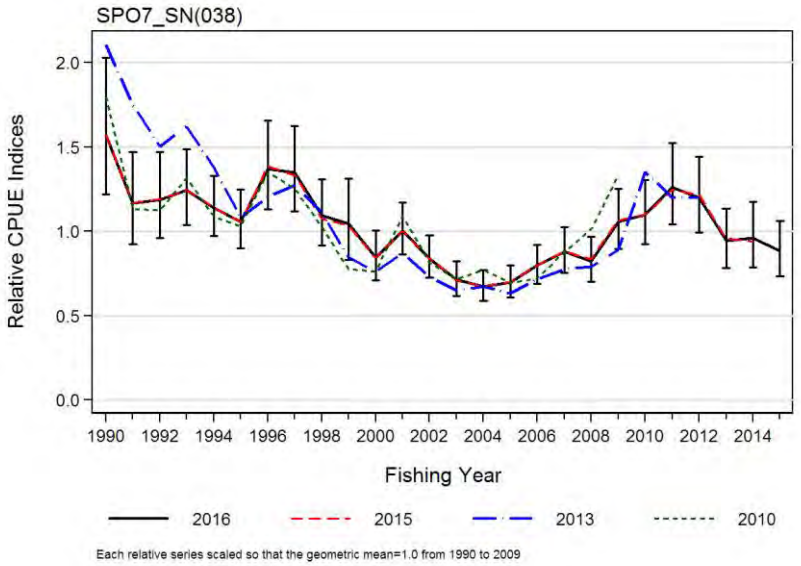

Figure 29: Comparison of the SPO 7_SN(038) standardised positive catch CPUE analysis prepared for this report with historical SPO 7_SN(038) series: 2015: Starr & Kendrick (2015b); 2013: Starr & Kendrick (2016); 2010: Starr et al. (2010).

3.2.8 SPO 7_SN(STB)

This CPUE analysis was rejected in 2016 for monitoring SPO 7 by the SINSWG and the Plenary (MPI 2016), giving it a research rating of '3' (Low Quality: affected by dolphin management regulations).

This is a new analysis that has not previously been presented for New Zealand rig (diagnostics presented in Appendix V, analysis defined in Table 13, and plotted in Figure 30). Data were prepared using 'daily effort strata' procedure (Section 2.3.1.5) before converting estimated catches to landed catches. On average, about 5% of trips per year report no rig (maximum=12%; minimum=0%) (Table V.1). On an annual basis, 4% of trips (series average) report SPO in the landings but have no associated estimated catch ([lower left panel] Figure V.2), and these trips represent about 2% of the average annual landings of rig (Table V.1). The Weibull positive catch model explained 44% of the deviance (Table V.2), with vessel, target species, month and net length entering the model after fishing year. The standardisation effect is moderately strong, converting an increasing trend in the unstandardised CPUE to a flat series to the early 2000s, followed by a declining trend to the present (Figure V.4). Most of this shift occurs with addition of the [*vessel*] explanatory variable. The fit to the Weibull distribution shows a small amount of skewness to the left, indicated a slight departure from the underlying distributional assumption (Figure V.5). The other target species in this analysis is SCH, with the annual residual implied coefficients showing a similar trend to the overall year effect (Figure V.11). The positive catch series has no trend from the beginning of the series to about 2003–04, followed by an overall declining trend up to 2014–15 (Figure V.3).

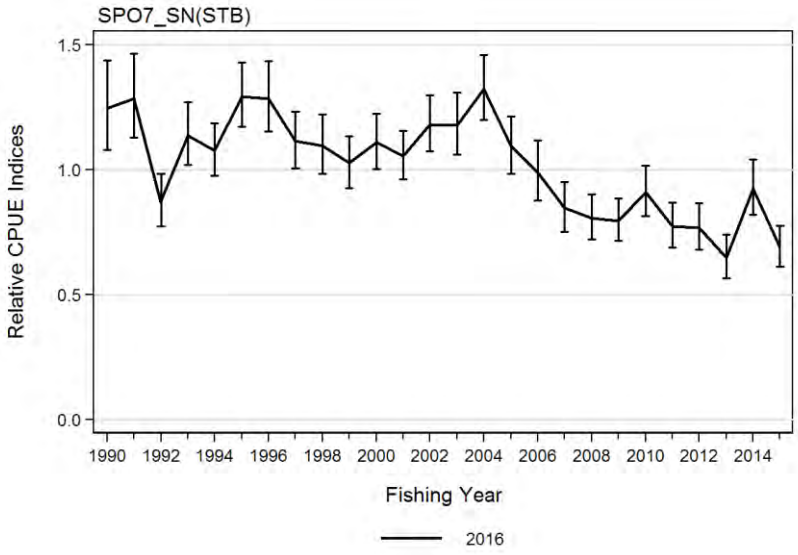

Figure 30: SPO 7_SN(STB) standardised positive catch CPUE analysis prepared for this report.

3.3 Comparison of CPUE series

These 13 series fall naturally into three categories, specified by fishery capture method and the coast in which the fishery is located. The five bottom trawl CPUE series all show similar trajectories when superimposed, with each series showing a generally increasing trend that appears to have accelerated after 2011–12 (Figure 31). On the other hand, none of the setnet series mirror this trend, with the three east coast fisheries showing no overall trend ([left panel] Figure 32) while the setnet fisheries on the west coast all appear to be declining ([right panel] Figure 32). These two capture methods are known to have considerably different selectivities, with the bottom trawl fisheries operating more in open water and catching rig that are less than a metre long, while most of the setnet fisheries are operating in harbours or confined waters and capture large mature females. Consequently, a declining trend in CPUE in these latter fisheries must not be overlooked as the mature females are an important component to the stock.

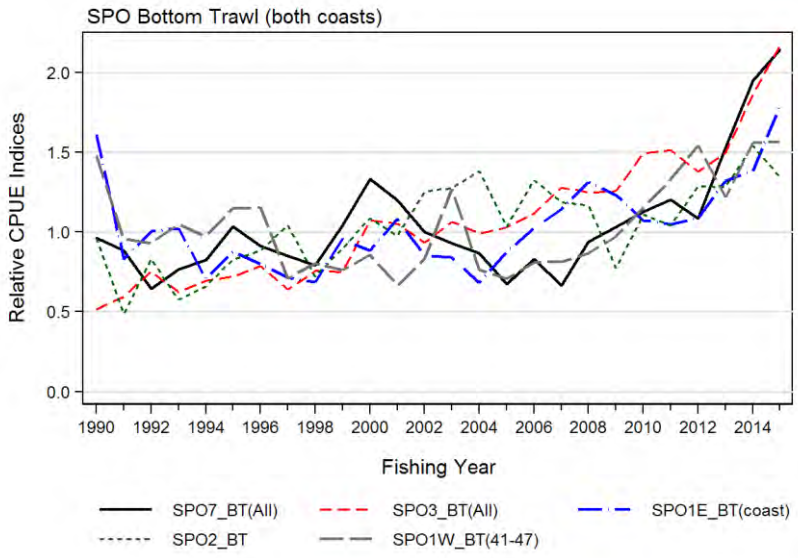

Figure 31: Comparison of the five bottom trawl CPUE series presented in this report. The plotted series are the combined lognormal/binomial series using Eq. I.4 with all series standardised to a geometric mean=1.0.

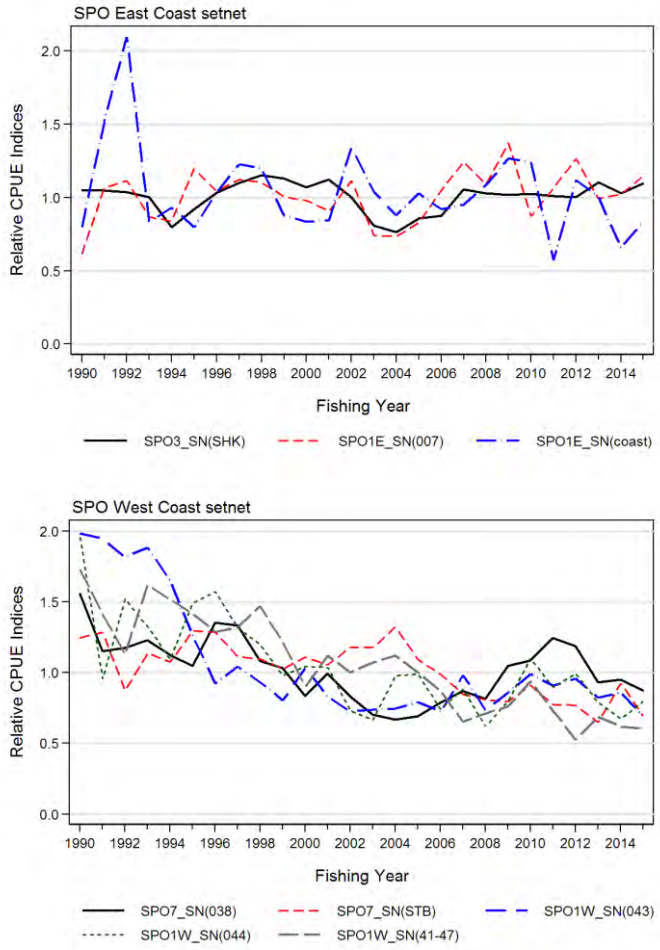

Figure 32: **Comparison of the eight setnet CPUE series presented in this report: [left panel]: showing the three east coast, North/South Island series; [right panel]: showing the five west coast, North/South Island series. All series have been standardised to a geometric mean=1.0.**

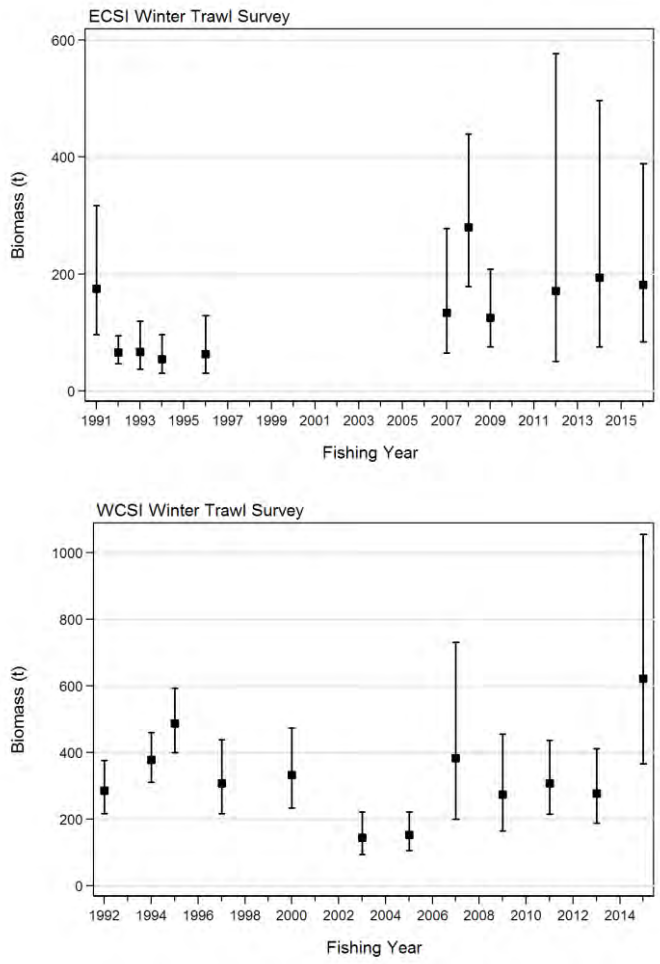

Figure 33: Rig biomass (± 95% confidence intervals) estimated by the two South Island Kaharoa trawl surveys: [left panel]: east coast South Island (ECSI) winter survey (Beentjes et al. 2016); [right panel]: west coast South Island (WCSI) winter survey (Stevenson et al. 2015).

However, this disparity in trend among capture methods is difficult to understand because these trends span several decades, so, if recruitment were being impaired through deprecation by the setnet harbour fisheries, then it seems unlikely that recent recruitment (as evidenced by the strong upturn in bottom trawl CPUE) would be very strong. These observations might be affected by the fishery dependent nature of the CPUE series, but both of the fishery independent surveys operating on the east and west coasts of the South Island show recent biomass levels that are elevated relative to the levels observed in the 1990s (Figure 33). As well, examination of length frequencies from these surveys indicates that there are high numbers of rig under 70 cm in the 2012 and 2014 surveys (ECSI) and in the 2015 survey (WCSI) (MPI 2016), with both sets of observations leading to the conclusion that there has been good rig recruitment on both coasts of the South Island.

There are several possible reasons why the setnet CPUE has declined, apart from a decline in the underlying abundance. These include interaction with extensive regulations imposed to protect endemic (Hector's and Maui) dolphins with a corresponding loss of fishing grounds and peak fishing periods, the disappearance of experienced fishers in many of these fisheries, and the legal discarding of rig (permitted under Section 6 of the Fisheries Act) but failing to record these discards on the catch/effort forms.

The contradictory but consistent signals from these two sets of CPUE series are difficult to reconcile and fully understand. However, it is clear that the fisheries that capture this species need to be closely monitored by repeating these CPUE analyses on a regular basis.

4. ACKNOWLEDGMENTS

This work was funded by MPI Research Project SPO2015/01. We thank the MPI 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. 2011)
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 3)
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 rig 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 rig
FMA	MPI Fishery Management Areas: 10 legal areas used by MPI to define large scale stock management units; QMAs consist of one or more of these regions
landing event	weight of rig off-loaded from a vessel at the end of a trip. Every landing has an associated destination code and there can be multiple landing events with the same or different destination codes for a trip
LCER	Lining Catch Effort Return (Ministry of Fisheries 2010): active since October 2003 for lining vessels larger than 28 m and reports set-by-set fishing events
LFR	Licensed Fish Receiver: processors legally allowed to receive commercially caught species
LTCER	Lining Trip Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for lining vessels between 6 and 28 m and reports individual set-by-set fishing events
MHR	Monthly Harvest Return: monthly returns used after 1 October 2001. Replaced QMRs but have same definition and utility
MPI	New Zealand Ministry for Primary Industries
NCELR	Netting Catch Effort Landing Return (Ministry of Fisheries 2010): active since October 2006 for inshore vessels between 6 and 28 m using setnet gear and reports individual fishing events
QMA	Quota Management Area: legally defined unit area used for rig management (Figure 1)
QMR	Quota Management Report: monthly harvest reports submitted by commercial fishermen to MPI. Considered to be best estimates of commercial harvest. In use from 1986 to 2001
QMS	Quota Management System: name of the management system used in New Zealand to control commercial and non-commercial catches
replog	data extract identifier issued by MPI data unit
residual implied coefficient plots	plots 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	MPI Recreational Technical Working Group
SINSWG	Southern Inshore Fisheries Assessment Working Group: MPI Working Group overseeing the work presented in this report
standardised CPUE	procedure used to remove the effects of explanatory variables such as vessel, statistical area and month of capture from a data set of catch/effort data for a species; annual abundance is usually modelled as an explanatory variable representing the year of capture and, after

Term/Abbreviation	Definition
	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. MPI generates a unique database code to identify each trip, using the trip start and end dates and the vessel code (Ministry of Fisheries 2010)
trip-stratum	summarisation within a trip by fishing method used, the statistical area of occupancy and the declared target species
unstandardised CPUE	geometric mean of all individual CPUE observations, usually summarised over a year within the stratum of interest

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

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
SPO 1E	the part of SPO 1 in FMA 1
SPO 1W	the part of SPO 1 in FMA 9

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
RCO	Red cod
SCH	School shark
SCI	Scampi
SKI	Gemfish
SNA	Snapper
SPD	Spiny dogfish
SPE	Sea perch
SPO	Rig
SQU	Arrow squid
STA	Giant stargazer
SWA	Silver warehou
TAR	Tarakihi
TRE	Trevally
WAR	Blue warehou

Appendix B. MAP OF MPI STATISTICAL AND MANAGEMENT AREAS

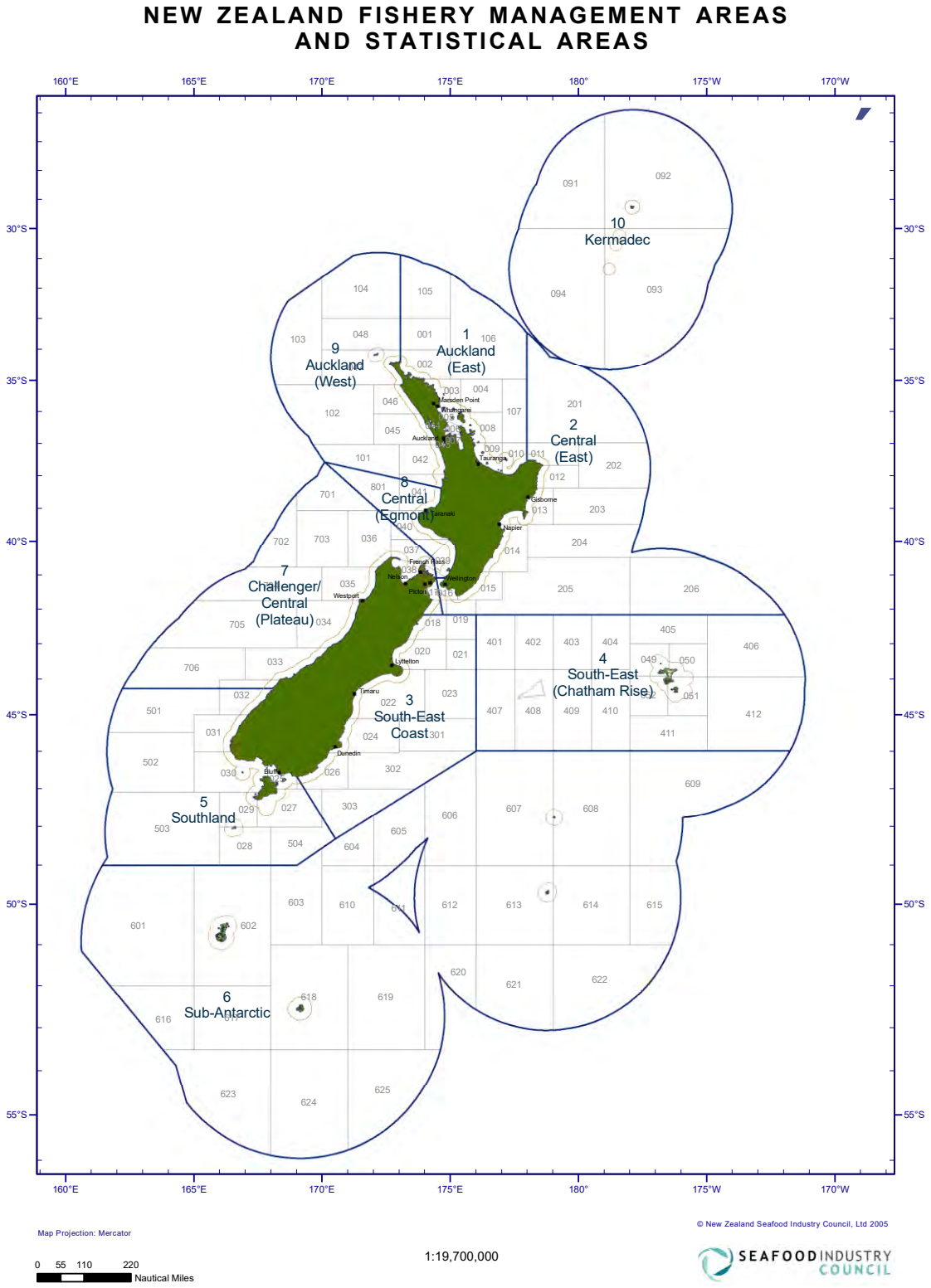

Figure B.1: Map of Ministry for Primary Industries statistical areas and Fishery Management Area (FMA) boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries.

Appendix C. QMR/MHR LANDINGS AND TACC BY QMA

Table C.1: Reported landings (t) and TACC (t) of rig in SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 from 1986–87 to 2014–15 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2014–15). $\tilde{SL}_{q,y}$ is the sum of landings for QMA *q* in year *y* adjusted for changes in conversion factor (Eq. 2) and $SL_{q,y}$ is the sum of the same landings for QMA *q* in year *y* without adjustment. [Continued on next page]

Fishing year	QMR/MHR$_{q,y}$						$R_{q,y} = \tilde{SL}_{q,y} / SL_{q,y}$				
	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8	Total	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8
1986–87	366.0	54.8	312.3	232.5	125.1	1 090.7	0.835[1]	0.818[1]	0.812[1]	0.812[1]	0.803[1]
1987–88	525.7	65.8	351.9	262.5	186.6	1 392.5	0.835[1]	0.818[1]	0.812[1]	0.812[1]	0.803[1]
1988–89	688.1	68.7	305.0	243.8	209.8	1 515.3	0.835[1]	0.818[1]	0.812[1]	0.812[1]	0.803[1]
1989–90	689.1	61.5	292.2	266.0	206.2	1 515.0	0.822	0.820	0.797	0.812	0.811
1990–91	655.9	62.9	283.9	267.8	196.4	1 466.8	0.835	0.829	0.821	0.820	0.813
1991–92	871.1	106.6	350.6	287.6	147.8	1 763.7	0.847	0.804	0.817	0.803	0.786
1992–93	719.3	90.4	278.1	324.0	238.7	1 650.5	0.922	0.908	0.897	0.895	0.891
1993–94	630.8	95.9	327.1	312.2	254.7	1 620.7	0.927	0.900	0.893	0.897	0.895
1994–95	665.6	87.7	401.6	341.3	272.6	1 768.8	0.920	0.901	0.891	0.894	0.895
1995–96	603.1	106.2	405.2	395.0	327.3	1 836.8	0.910	0.907	0.889	0.905	0.895
1996–97	677.4	97.9	431.9	394.6	275.7	1 877.6	0.903	0.900	0.892	0.897	0.897
1997–98	613.2	84.5	440.0	317.4	283.0	1 738.2	0.902	0.894	0.890	0.896	0.892
1998–99	563.6	86.5	422.0	337.1	234.4	1 643.7	0.903	0.891	0.893	0.897	0.888
1999–00	608.3	86.7	427.1	330.7	219.1	1 671.9	0.905	0.894	0.892	0.893	0.892
2000–01	553.9	81.1	458.5	338.3	174.3	1 606.1	1.000	1.000	1.000	1.000	1.000
2001–02	433.4	85.9	391.0	281.1	215.6	1 407.0	1.000	1.000	1.000	1.000	1.000
2002–03	476.6	85.8	416.5	263.7	208.6	1 451.1	1.000	1.000	1.000	1.000	1.000
2003–04	481.3	80.6	354.4	293.4	203.0	1 412.8	1.000	1.000	1.000	1.000	1.000
2004–05	431.2	108.2	366.5	266.2	208.3	1 380.3	1.000	1.000	1.000	1.000	1.000
2005–06	345.8	110.4	389.3	287.9	162.6	1 296.1	1.000	1.000	1.000	1.000	1.000
2006–07	400.3	101.5	423.3	264.6	175.9	1 365.6	1.000	1.000	1.000	1.000	1.000
2007–08	297.2	105.0	471.7	230.6	219.9	1 324.3	1.000	1.000	1.000	1.000	1.000
2008–09	297.6	105.9	328.4	233.4	221.8	1 187.1	1.000	1.000	1.000	1.000	1.000
2009–10	302.1	113.9	371.1	229.4	245.5	1 262.1	1.000	1.000	1.000	1.000	1.000
2010–11	311.2	105.6	394.7	228.5	220.2	1 260.2	1.000	1.000	1.000	1.000	1.000
2011–12	328.5	116.8	432.7	227.1	198.1	1 303.2	1.000	1.000	1.000	1.000	1.000
2012–13	368.9	105.7	462.9	225.8	120.3	1 283.6	1.000	1.000	1.000	1.000	1.000
2013–14	348.7	125.1	489.0	230.5	192.4	1 385.6	1.000	1.000	1.000	1.000	1.000
2014–15	323.5	117.1	556.5	234.9	181.0	1 412.9	1.000	1.000	1.000	1.000	1.000

[1] Average: 1989–90 to 1991–92.

Table C.1 [Continued]:

Fishing year	$\%QMR/MHR_{q,y} = QMR/MHR_{q,y} * R_{q,y}$						$TACC_{q,y}$					
	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8	Total	SPO 1	SPO 2	SPO 3	SPO 7	SPO 8	Total
1986–87	305.4	44.8	253.6	188.8	100.5	893.2	540.0	64.1	330.2	240.0	240.4	1 414.7
1987–88	438.7	53.8	285.8	213.1	149.9	1 141.4	614.2	68.3	342.4	268.7	260.8	1 554.4
1988–89	574.2	56.1	247.7	198.0	168.6	1 244.6	652.6	69.9	351.8	283.5	294.6	1 652.4
1989–90	566.4	50.4	233.1	216.1	167.3	1 233.3	686.7	70.4	358.8	291.0	310.4	1 717.3
1990–91	547.8	52.1	233.2	219.7	159.7	1 212.4	688.1	70.9	363.9	294.1	310.4	1 727.4
1991–92	737.2	85.8	286.6	230.9	116.2	1 456.8	825.0	85.0	430.0	350.0	370.0	2 060.0
1992–93	663.0	82.0	249.6	290.0	212.8	1 497.3	829.0	85.5	452.1	350.0	370.0	2 086.6
1993–94	585.0	86.3	292.1	280.2	227.8	1 471.4	829.0	85.5	452.1	350.0	370.0	2 086.6
1994–95	612.2	79.1	357.7	305.1	243.8	1 598.0	829.0	85.5	453.9	350.0	370.0	2 088.4
1995–96	549.1	96.3	360.3	357.1	292.8	1 655.7	829.0	85.5	453.9	350.0	370.0	2 088.4
1996–97	611.4	88.1	387.2	354.3	247.3	1 688.3	829.0	85.5	453.9	350.0	370.0	2 088.4
1997–98	553.1	75.5	391.6	284.3	252.5	1 556.9	692.0	72.0	453.9	350.0	310.0	1 877.9
1998–99	509.6	77.0	376.7	302.4	208.1	1 473.8	692.0	72.0	453.9	350.0	310.0	1 877.9
1999–00	551.0	77.3	380.9	295.4	195.4	1 500.1	692.0	72.0	453.9	350.0	310.0	1 877.9
2000–01	553.9	81.1	458.4	338.3	174.3	1 606.0	692.0	72.0	600.0	350.0	310.0	2 024.0
2001–02	433.4	85.9	391.0	281.1	215.6	1 407.0	692.1	72.0	600.0	350.0	310.0	2 024.1
2002–03	476.6	85.8	416.5	263.7	208.6	1 451.1	692.1	72.0	600.0	350.0	310.0	2 024.1
2003–04	481.3	80.6	354.4	293.4	203.0	1 412.8	692.1	72.0	600.0	350.0	310.0	2 024.1
2004–05	431.2	108.2	366.5	266.2	208.3	1 380.3	692.1	86.0	600.0	350.0	310.0	2 038.1
2005–06	345.8	110.4	389.3	287.9	162.6	1 296.1	692.1	86.0	600.0	350.0	310.0	2 038.1
2006–07	400.3	101.5	423.3	264.6	175.9	1 365.6	692.1	86.0	600.0	221.0	310.0	1 909.1
2007–08	297.2	105.0	471.7	230.6	219.9	1 324.3	692.1	86.0	600.0	221.0	310.0	1 909.1
2008–09	297.6	105.9	328.4	233.4	221.8	1 187.1	692.1	86.0	600.0	221.0	310.0	1 909.1
2009–10	302.1	113.9	371.1	229.4	245.5	1 262.1	692.1	86.0	600.0	221.0	310.0	1 909.1
2010–11	311.2	105.6	394.7	228.5	220.2	1 260.2	692.1	86.0	600.0	221.0	310.0	1 909.1
2011–12	328.5	116.8	432.7	227.1	198.1	1 303.2	692.1	108.0	600.0	221.0	310.0	1 931.1
2012–13	368.9	105.7	462.9	225.8	120.3	1 283.6	692.1	108.0	600.0	221.0	310.0	1 931.1
2013–14	348.7	125.1	489.0	230.5	192.4	1 385.6	692.1	108.0	600.0	221.0	310.0	1 931.1
2014–15	323.5	117.1	556.5	234.9	181.0	1 412.9	692.1	108.0	600.0	221.0	310.0	1 931.1

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

D.1 Introduction

The method described in this section was used to identify 'implausibly large' landings due to data errors (possibly at the data entry step), with landings from single trips occasionally exceeding 100–300 t for some species (near to 200 t for SPO). These errors can result in substantial deviations from the accepted QMR/MHR catches and affect the credibility of the characterisation and CPUE analyses.

D.2 Methods

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

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

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

Previously 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 & Kendrick 2016). However, this search method did not perform well with the SPO landing data, probably because of the changes that have occurred to the conversion factors for the primary landed states over the first decade or more of the fishery history (see Table 6 and the accompanying discussion in Section 2.3.2.2). Another contributing factor could be the tendency for fishers to report dressed weight instead of landed weight when estimating catches (see Figure 4). Consequently, ratios ($rat_{t,s}$: Eq. D.2) were fixed at high values (6 or 7) and only the upper end of the trip landing distribution (from 98% to 99.9% quantiles) was investigated.

D.3 Equations

For every trip, there exist three estimates of total green weight 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 green weight (*gwt*) for trip *t* over all n_t landing records;

$G^c_{t,s}$ = sum of calculated green weight 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 green weights. The set of trips to drop was selected on the basis of the pair of criteria (quantile and ratio threshold) that gave the lowest SSq^z (Eq. D.3) relative to the annual QMR/MHR totals:

$$gg^z_y = \sum_{1}^{p^z_y} L^z_y$$

Eq. D.3

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

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

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

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

D.4 Results

A total of 85 trips were dropped across the five QMAs, representing just over 1000 t of green weight landings (Table D.1). This represented fewer trips dropped than in 2013 (132 trips, Starr & Kendrick 2016) but a similar level of dropped catch (1056 t, Starr & Kendrick 2016). Two trips account for nearly one-half of the dropped landings, with one trip in SPO 1 landing over 300 t in 1990–91 and a second trip landing just over 200 t in SPO 3 in 1995–96. The results of these edits are plotted in Figure D.1 and tabulated in Table D.2. It is clear that it is not possible to make the landings data match the reported QMR/MHR totals, particularly in the earliest years before the mid-1990s.

Table D.1: Statistics associated with the selected minimum in each QMA. MHR_y = QMR/MHR landings in year *y*; gg^0_y = 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)	$\sum_{y=89/90}^{y=11/12} MHR_y$	$\sum_{y=89/90}^{y=14/15} gg^0_y$	$\sum_{y=89/90}^{y=14/15} gg_y$	$\sum_{y=89/90}^{y=14/15} gg_y - \sum_{y=89/90}^{y=14/15} MHR_y$
SPO 1	99.9	7	27	137 505	499	12 997	13 076	12 578	–420
SPO 2	99.9	7	11	37 777	40	2 515	2 528	2 488	–28
SPO 3	99.9	7	18	94 302	343	10 366	11 109	10 765	399
SPO 7	98	6	26	41 457	129	7 409	7 789	7 661	251
SPO 8	99	7	3	24 012	53	5 603	5 493	5 440	–164
Total	–	–	85	335 053	1 063	38 892	39 995	38 931	40

Table D.2: Annual statistics associated with the selected minima in SPO 1 and SPO 2. MHR_y = QMR/MHR landings in year *y*; gg_y^0 = unedited landings in year *y*; gg_y = edited landings at selected minimum in year *y*. The final two columns are the annual result of applying Eq. D.3 to the unedited landings and to the selected QMA 'minimum' defined in Table D.1. [Continued on next page]

	SPO 1					SPO 2				
Fishing year	MHR_y	gg_y^0	gg_y	Ssq^{unedited}	Ssq^{edited}	MHR_y	gg_y^0	gg_y	Ssq^{unedited}	Ssq^{edited}
89/90	689.1	424.7	421.6	69 887.8	71 564.3	61.5	49.8	49.8	137.9	137.9
90/91	655.9	871.2	559.0	46 335.3	9 397.9	62.9	47.0	47.0	250.7	250.7
91/92	871.1	745.7	739.3	15 719.0	17 359.0	106.6	88.8	86.7	316.9	396.7
92/93	719.3	692.2	692.2	730.4	730.4	90.4	91.0	88.9	0.4	2.0
93/94	630.8	680.9	680.9	2 512.3	2 512.3	95.9	98.4	98.4	6.4	6.4
94/95	665.6	670.6	665.5	25.0	0.0	87.7	84.7	84.7	9.3	9.3
95/96	603.1	636.2	617.8	1 098.7	218.2	106.2	134.1	122.4	780.5	260.7
96/97	677.4	681.8	678.5	19.2	1.3	97.9	98.2	98.2	0.1	0.1
97/98	613.2	656.1	584.8	1 845.2	803.3	84.5	78.8	78.8	31.6	31.6
98/99	563.6	585.8	554.4	490.8	85.4	86.5	86.7	86.7	0.0	0.0
99/00	608.3	626.9	613.8	345.4	29.8	86.7	87.9	87.9	1.5	1.5
00/01	553.9	569.0	564.3	227.5	108.9	81.1	87.0	80.4	34.4	0.6
01/02	433.4	466.2	466.2	1 074.0	1 074.0	85.9	89.4	89.4	12.0	12.0
02/03	476.6	486.9	486.9	106.4	106.4	85.8	90.2	88.0	19.2	5.0
03/04	481.3	487.5	474.5	37.7	46.6	80.6	85.4	80.8	22.9	0.0
04/05	431.2	441.6	441.6	108.5	108.5	108.2	109.1	109.1	0.9	0.9
05/06	345.8	347.5	347.5	2.9	2.9	110.4	112.5	112.5	4.2	4.2
06/07	400.3	406.0	406.0	32.1	32.1	101.5	100.7	100.7	0.7	0.7
07/08	297.2	307.7	303.6	110.3	41.8	105.0	102.3	102.3	6.9	6.9
08/09	297.6	295.0	295.0	6.5	6.5	105.9	113.1	106.0	52.7	0.0
09/10	302.1	307.3	298.9	26.6	10.6	113.9	112.9	112.9	1.0	1.0
10/11	311.2	315.8	315.8	21.5	21.5	105.6	104.3	104.3	1.5	1.5
11/12	328.5	324.7	324.7	14.4	14.4	116.8	121.9	118.2	26.5	2.2
12/13	368.9	368.1	368.1	0.6	0.6	105.7	106.1	106.1	0.1	0.1
13/14	348.7	351.5	347.1	7.5	2.7	125.1	127.2	127.2	4.4	4.4
14/15	323.5	329.6	329.6	36.8	36.8	117.1	120.1	120.1	9.3	9.3
Total	12 997.4	13 076.3	12 577.7	140 822.3	104 316.1	2 515.3	2 527.9	2 487.7	1 732.2	1 145.9

Table D.2 [Continued]: Annual statistics associated with the selected minima in SPO 3, SPO 7 and SPO 8. MHR_y **= QMR/MHR landings in year *y*;** gg_y^0 **= unedited landings in year *y*;** gg_y **= edited landings at selected minimum in year *y*. The final two columns are the annual result of applying Eq. D.3 to the unedited landings and to the selected QMA 'minimum' defined in Table D.1.**

	SPO 3					SPO 7					SPO 8				
Fishing year	MHR_y	gg_y^0	gg_y	Ssq^{unedited}	Ssq^{edited}	MHR_y	gg_y^0	gg_y	Ssq^{unedited}	Ssq^{edited}	MHR_y	gg_y^0	gg_y	Ssq^{unedited}	Ssq^{edited}
89/90	292.2	257.7	257.7	1 190.1	1 190.1	266.0	256.5	256.5	88.9	88.9	206.2	174.1	174.1	1 032.9	1 032.9
90/91	283.9	511.1	300.0	51 627.6	258.9	267.8	277.4	274.0	92.8	38.7	196.4	175.6	175.6	433.9	433.9
91/92	350.6	390.8	378.5	1 618.3	780.0	287.6	291.9	291.9	18.4	18.4	147.8	132.4	132.4	236.6	236.6
92/93	278.1	290.6	284.2	155.3	36.1	324.0	332.6	323.9	73.5	0.0	238.7	222.8	222.8	253.3	253.3
93/94	327.1	358.9	352.6	1 008.4	648.0	312.2	322.6	320.5	107.9	67.4	254.7	254.1	246.2	0.3	71.4
94/95	401.6	474.4	434.5	5 291.5	1 083.2	341.3	374.1	374.1	1 075.0	1 075.0	272.6	304.8	268.1	1 037.3	19.9
95/96	405.2	457.8	457.8	2 766.2	2 766.2	395.0	414.9	414.9	394.4	394.4	327.3	320.0	311.6	53.0	245.1
96/97	431.9	497.4	470.9	4 293.1	1 521.4	394.6	428.9	410.5	1 171.6	250.2	275.7	251.5	251.5	584.9	584.9
97/98	440.0	480.1	461.4	1 604.5	458.1	317.4	344.0	337.2	705.3	392.0	283.0	270.8	270.8	149.5	149.5
98/99	422.0	430.4	430.4	69.6	69.6	337.1	365.4	365.4	799.0	799.0	234.4	223.9	223.9	110.6	110.6
99/00	427.1	459.9	454.0	1 069.9	723.3	330.7	349.7	347.0	361.1	268.2	219.1	208.5	208.5	112.7	112.7
00/01	458.5	499.2	499.2	1 663.2	1 663.2	338.3	362.3	351.6	576.4	177.0	174.3	167.7	167.7	43.4	43.4
01/02	391.0	408.1	403.6	291.4	159.6	281.1	299.6	294.6	340.2	182.8	215.6	213.1	213.1	5.9	5.9
02/03	416.5	446.4	446.4	893.5	893.5	263.7	269.0	269.0	28.6	28.6	208.6	205.4	205.4	10.3	10.3
03/04	354.4	376.7	376.7	492.9	492.9	293.4	301.3	301.3	61.8	61.8	203.0	201.8	201.8	1.5	1.5
04/05	366.5	378.1	378.1	135.3	135.3	266.2	268.8	265.2	7.1	1.0	208.3	209.2	209.2	0.8	0.8
05/06	389.3	385.8	385.8	12.6	12.6	287.9	295.4	291.1	55.2	9.8	162.6	166.7	166.7	17.2	17.2
06/07	423.3	458.0	452.9	1 201.3	875.7	264.6	264.8	264.8	0.1	0.1	175.9	176.5	176.5	0.4	0.4
07/08	471.7	483.6	483.6	143.1	143.1	230.6	296.3	249.7	4 311.5	364.5	219.9	222.8	222.8	8.7	8.7
08/09	328.4	333.6	333.6	26.9	26.9	233.4	237.3	235.0	15.2	2.6	221.8	222.8	222.8	0.9	0.9
09/10	371.1	378.0	378.0	47.1	47.1	229.4	230.1	230.1	0.6	0.6	245.5	246.6	246.6	1.2	1.2
10/11	394.7	392.6	392.6	4.5	4.5	228.5	235.2	235.2	44.3	44.3	220.2	216.5	216.5	14.0	14.0
11/12	432.7	436.5	436.5	14.8	14.8	227.1	229.7	229.7	7.0	7.0	198.1	205.0	205.0	46.9	46.9
12/13	462.9	468.1	468.1	27.1	27.1	225.8	241.9	241.9	259.2	259.2	120.3	123.3	123.3	8.7	8.7
13/14	489.0	492.8	486.3	15.0	7.3	230.5	239.1	235.1	73.3	21.2	192.4	192.0	192.0	0.1	0.1
14/15	556.5	562.1	562.1	31.5	31.5	234.9	260.3	250.2	649.1	234.0	181.0	184.8	184.8	14.4	14.4
Total	10 366.3	11 108.5	10 765.4	75 694.5	14 069.9	7 409.2	7 789.1	7 660.5	11 317.3	4 786.4	5 603.4	5 492.7	5 439.8	4 179.3	3 425.0

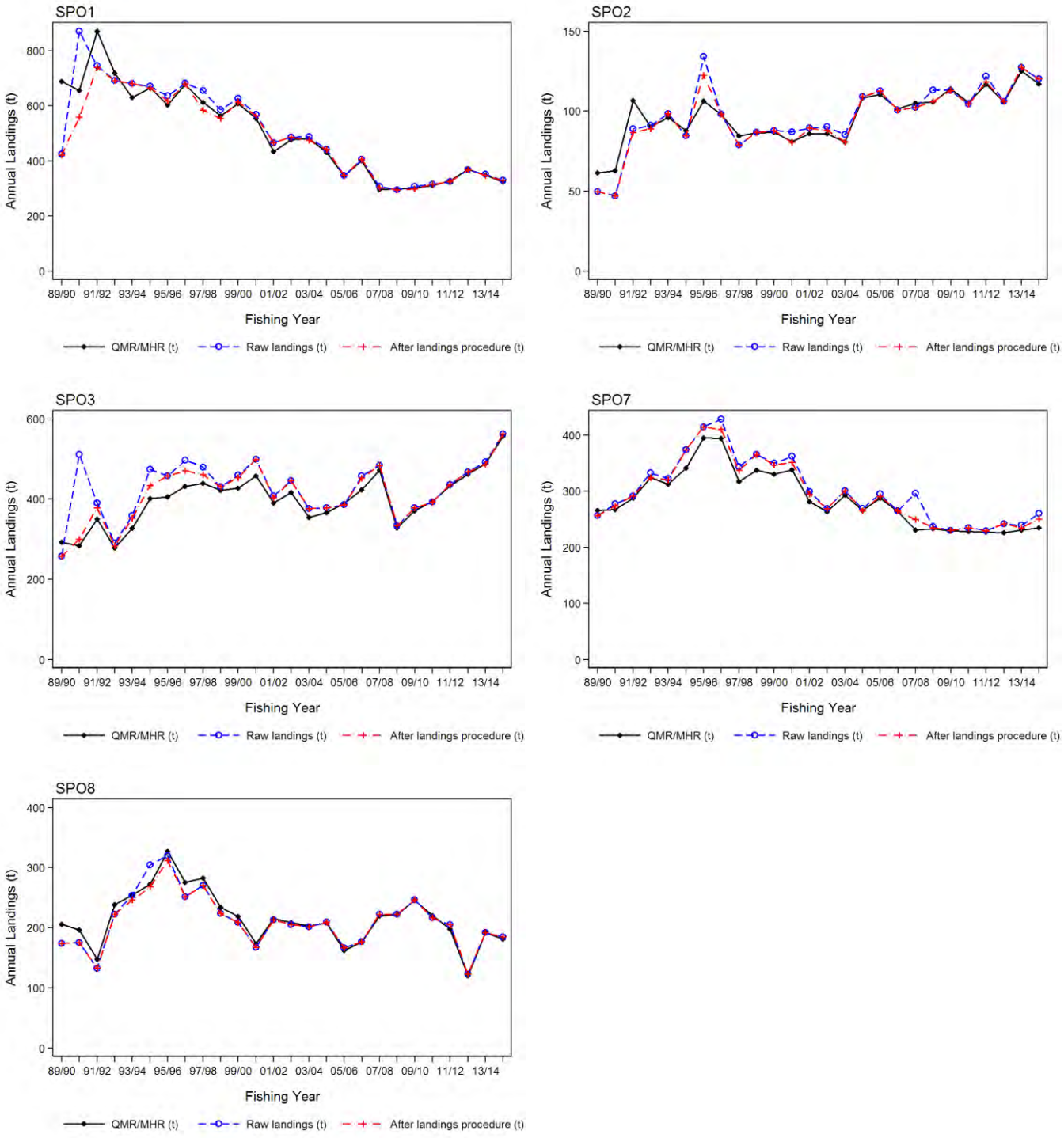

Figure D.1: Comparison of QMR/MHR annual total landings for SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 with two extracts: A: unedited or 'raw' landings; and B: total landings after dropping the trips identified at the selected QMA 'minimum' quantile/ratio pairing defined in Table D.1.

Appendix E. DATA PREPARATION INFORMATION BY QMA

Table E.1: Comparison of the total adjusted QMR/MHR catch (t) for SPO 1 and SPO 2 with the sum of the corrected landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data ('analysis' data set) based on a SPO QMA expansion rule and the sum of the estimated catches from the analysis data set. Data source: MPI replog 10380: 1989–90 to 2014–15. All catches and QMR/MHR totals have been adjusted to consistent conversion factors across years.

	SPO 1							SPO 2						
Fishing year	QMR/ MHR (t)	Total landed catch (t)[1]	% landed/ QMR/ MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis	QMR/ MHR (t)	Total landed catch (t)[2]	% landed/ QMR/ MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis
89/90	567	343	61	343	100	338	99	50	41	81	41	99	26	65
90/91	548	415	76	413	99	352	85	52	39	75	38	99	23	61
91/92	738	561	76	557	99	469	84	86	70	81	69	99	38	54
92/93	663	574	87	573	100	462	81	82	81	98	80	99	37	46
93/94	585	628	107	626	100	510	82	86	88	102	87	98	46	53
94/95	612	607	99	605	100	500	83	79	76	96	75	98	33	44
95/96	549	541	99	528	98	426	81	96	111	115	108	97	51	47
96/97	611	571	93	553	97	442	80	88	86	98	84	97	41	49
97/98	553	509	92	498	98	361	73	75	70	92	68	97	30	44
98/99	509	482	95	463	96	320	69	77	76	99	74	97	38	51
99/00	551	547	99	539	99	396	73	78	78	101	77	99	40	51
00/01	554	563	102	552	98	390	71	81	80	99	79	99	41	52
01/02	433	463	107	458	99	331	72	86	89	104	86	96	48	55
02/03	477	475	100	473	99	309	65	86	88	102	85	97	44	51
03/04	481	461	96	457	99	300	66	81	78	96	74	95	35	48
04/05	431	412	95	405	98	248	61	108	107	99	106	99	43	40
05/06	346	326	94	305	94	177	58	110	111	101	110	99	47	43
06/07	400	371	93	349	94	209	60	102	99	98	98	99	43	44
07/08	297	271	91	258	95	150	58	105	101	96	98	97	59	59
08/09	298	266	89	245	92	138	56	106	106	100	101	96	62	62
09/10	302	263	87	250	95	140	56	114	112	98	111	99	66	59
10/11	311	280	90	259	93	141	54	106	104	98	102	98	64	63
11/12	328	292	89	285	98	162	57	117	118	101	115	98	88	76
12/13	369	330	89	317	96	171	54	106	106	100	102	97	68	67
13/14	349	319	91	300	94	166	56	125	127	101	122	96	83	68
14/15	324	299	92	288	96	164	57	117	117	100	113	97	71	63
Total	12 187	11 169	92	10 899	98	7 774	71	2 399	2 358	98	2 305	98	1 265	55

[1] Includes all SPO 1 landings in replog 10380 except for 27 trips excluded for being 'out of range' (see Table D.1).
[2] Includes all SPO 2 landings in replog 10380 except for 11 trips excluded for being 'out of range' (see Table D.1).

Table E.2: Caption as for Table E.1, showing annual totals for SPO 3 and SPO 7.

	SPO 3							SPO 7						
Fishing year	QMR/ MHR (t)	Total landed catch (t)[1]	% landed/ QMR/ MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis	QMR/ MHR (t)	Total landed catch (t)[2]	% landed/ QMR/ MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis
89/90	233	205	88	201	98	158	78	216	207	96	197	95	189	96
90/91	233	245	105	242	99	214	88	220	223	101	216	97	184	85
91/92	286	308	108	302	98	265	87	231	234	101	216	92	201	93
92/93	250	254	102	251	99	217	87	290	290	100	279	96	236	85
93/94	292	312	107	308	99	266	86	280	287	103	267	93	196	73
94/95	358	384	107	375	98	321	85	305	334	109	329	99	270	82
95/96	360	404	112	388	96	316	81	357	365	102	335	92	250	75
96/97	385	413	107	400	97	325	81	354	355	100	318	90	220	69
97/98	392	406	104	394	97	349	89	284	296	104	266	90	192	72
98/99	377	380	101	379	100	332	88	302	309	102	294	95	201	68
99/00	381	403	106	398	99	341	86	295	309	105	293	95	212	73
00/01	458	495	108	476	96	389	82	338	350	103	336	96	235	70
01/02	391	403	103	397	98	350	88	281	289	103	270	93	171	63
02/03	417	438	105	434	99	369	85	264	266	101	251	94	164	65
03/04	354	373	105	372	100	296	80	293	297	101	284	96	180	63
04/05	366	369	101	367	99	307	84	266	263	99	250	95	166	66
05/06	389	385	99	381	99	314	83	288	290	101	282	97	193	68
06/07	423	452	107	442	98	355	80	265	263	99	252	96	181	72
07/08	472	477	101	460	96	406	88	231	242	105	222	92	174	79
08/09	328	332	101	328	99	299	91	233	233	100	212	91	160	76
09/10	371	374	101	371	99	336	90	229	229	100	204	89	157	77
10/11	395	390	99	383	98	327	85	229	233	102	212	91	163	77
11/12	433	434	100	432	99	372	86	227	228	101	214	94	175	82
12/13	463	466	101	460	99	402	87	226	233	103	217	93	173	80
13/14	489	483	99	478	99	406	85	230	234	101	219	94	168	77
14/15	556	558	100	552	99	480	87	235	249	106	229	92	180	79
Total	9 853	10 144	103	9 968	98	8 513	85	6 971	7 107	102	6 664	94	4 991	75

[1] Includes all SPO 3 landings in replog 8807 except for 63 trips excluded for being 'out of range' (see Table D.1).
[2] Includes all SPO 7 landings in replog 8807 except for 34 trips excluded for being 'out of range' (see Table D.1).

Table E.3: Caption as for Table E.1, showing annual totals for SPO 8.

Fishing year	QMR/MHR (t)	Total landed catch (t)[1]	% landed/ QMR/MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis
89/90	167	141	84	122	87	108	88
90/91	160	143	89	118	83	112	95
91/92	116	104	90	93	89	87	94
92/93	213	199	93	183	92	155	85
93/94	228	220	96	200	91	175	87
94/95	244	239	98	233	97	200	86
95/96	293	278	95	250	90	222	89
96/97	247	221	89	202	91	157	78
97/98	252	237	94	194	82	168	86
98/99	208	199	95	178	90	136	76
99/00	195	186	95	149	80	113	76
00/01	174	167	96	141	84	111	79
01/02	216	211	98	188	89	157	84
02/03	209	202	97	188	93	154	82
03/04	203	194	96	155	80	124	80
04/05	208	205	98	152	74	128	84
05/06	163	165	102	134	81	114	85
06/07	176	175	100	132	75	112	85
07/08	220	219	100	159	73	138	87
08/09	222	223	100	136	61	121	89
09/10	246	245	100	164	67	148	90
10/11	220	215	98	163	76	147	90
11/12	198	195	98	133	68	113	85
12/13	120	123	102	80	66	74	92
13/14	192	192	100	141	74	134	95
14/15	181	182	101	118	65	113	96
Total	5 271	5 078	96	4 107	81	3 522	86

[1] Includes all SPO 8 landings in replog 8807 except for 1 trip excluded for being 'out of range' (Table D.1).

Table E.4: Summary statistics pertaining to the reporting of estimated catch from the SPO 1 and SPO 2 analysis data sets.

	SPO 1							SPO 2						
	Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip				Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	27	10	56	0.47	0.92	1.15	2.12	48	34	17	0.61	1.00	1.21	2.29
90/91	23	9	52	0.47	1.00	1.36	2.33	56	39	20	0.50	0.98	1.17	2.57
91/92	22	9	66	0.48	1.00	1.30	2.49	51	39	33	0.39	1.00	1.37	3.15
92/93	24	9	58	0.50	1.00	1.43	2.66	52	34	28	0.60	1.10	1.83	4.43
93/94	23	7	43	0.51	1.00	1.45	2.83	53	29	25	0.59	1.22	1.77	4.19
94/95	25	7	45	0.53	1.00	1.69	3.00	53	37	29	0.62	1.39	1.83	4.43
95/96	26	9	52	0.53	1.03	1.43	2.82	52	34	33	0.60	1.43	1.91	5.31
96/97	27	9	56	0.53	1.03	1.47	2.66	52	32	29	0.53	1.46	1.79	4.50
97/98	25	10	58	0.54	1.15	1.57	2.80	51	32	24	0.58	1.50	1.83	4.72
98/99	24	10	52	0.50	1.18	1.54	3.10	48	31	24	0.62	1.42	1.72	4.22
99/00	19	7	37	0.57	1.24	1.85	3.10	51	32	25	0.45	1.30	1.89	4.65
00/01	19	6	30	0.60	1.28	1.65	3.00	45	25	20	0.60	1.55	1.97	4.06
01/02	20	5	23	0.62	1.26	1.59	3.07	39	18	16	0.52	1.55	2.16	5.98
02/03	20	6	28	0.64	1.40	1.69	3.40	40	20	17	0.55	1.50	3.27	5.43
03/04	22	5	26	0.60	1.48	2.11	4.13	42	17	13	0.53	1.56	2.26	6.03
04/05	26	7	30	0.54	1.50	2.02	4.69	45	19	21	0.48	1.54	2.29	6.51
05/06	28	10	34	0.57	1.50	2.60	4.75	43	18	20	0.56	1.63	2.33	5.97
06/07	25	7	29	0.58	1.40	3.03	5.00	40	20	21	0.60	1.71	2.40	6.10
07/08	18	8	23	0.50	1.36	2.10	4.80	17	4	4	0.50	1.42	1.95	5.47
08/09	20	8	25	0.48	1.33	1.95	5.25	15	4	4	0.47	1.45	1.95	5.00
09/10	22	8	23	0.49	1.32	2.03	5.50	14	5	6	0.55	1.50	2.02	5.17
10/11	21	7	21	0.47	1.33	2.74	5.92	14	4	5	0.53	1.47	1.87	4.65
11/12	22	6	20	0.47	1.26	2.27	5.52	12	2	3	0.52	1.36	1.71	3.88
12/13	23	5	20	0.50	1.33	2.24	6.40	14	3	3	0.52	1.40	1.76	4.19
13/14	25	5	18	0.48	1.28	2.43	6.68	13	2	3	0.60	1.49	2.00	4.65
14/15	25	6	18	0.52	1.34	2.24	5.70	12	2	3	0.53	1.55	2.25	6.00
Total	23	8	943	0.51	1.16	1.80	3.72	39	18	445	0.54	1.42	1.97	4.96

Table E.5: Summary statistics pertaining to the reporting of estimated catch from the SPO 3 and SPO 7 analysis data sets.

	SPO 3							SPO 7						
	Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip				Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	45	17	39	0.46	0.90	1.93	2.37	48	15	32	0.47	1.01	1.45	3.10
90/91	42	15	34	0.49	0.93	1.19	2.33	42	15	33	0.53	1.01	1.62	3.10
91/92	44	12	35	0.34	0.87	1.19	2.09	47	14	32	0.53	1.00	1.45	2.95
92/93	43	13	32	0.44	0.91	1.50	2.22	56	15	45	0.53	1.06	1.41	2.95
93/94	46	12	36	0.43	0.90	1.30	2.34	51	17	47	0.60	1.24	1.65	3.50
94/95	44	14	50	0.41	0.90	1.28	2.21	46	13	39	0.56	1.38	1.89	4.52
95/96	47	18	65	0.42	0.91	1.37	2.57	46	14	50	0.53	1.40	1.81	4.03
96/97	49	16	61	0.43	0.92	1.80	2.49	49	19	67	0.53	1.33	1.71	4.01
97/98	48	14	54	0.39	0.94	1.52	2.30	50	12	33	0.49	1.48	2.58	4.23
98/99	48	13	51	0.35	0.93	1.48	2.14	46	13	38	0.62	1.45	1.95	3.88
99/00	50	17	65	0.35	0.95	1.19	2.21	41	12	35	0.54	1.31	2.22	4.31
00/01	44	16	74	0.47	1.00	1.43	2.33	42	13	45	0.65	1.29	1.88	4.50
01/02	45	13	51	0.41	1.00	1.17	2.33	41	11	32	0.60	1.32	1.88	4.95
02/03	44	13	52	0.47	1.00	1.26	2.33	47	14	36	0.63	1.45	1.80	4.27
03/04	48	17	59	0.40	1.01	1.32	2.54	49	14	40	0.70	1.51	2.15	4.73
04/05	48	15	56	0.47	1.00	1.24	2.40	47	12	33	0.68	1.55	2.08	5.07
05/06	48	13	50	0.52	1.04	1.25	2.33	43	10	29	0.69	1.58	2.07	4.82
06/07	44	14	58	0.52	1.09	1.37	2.48	48	12	31	0.61	1.55	2.10	5.43
07/08	21	4	21	0.47	1.09	1.44	2.58	15	4	8	0.65	1.43	1.86	4.26
08/09	23	4	15	0.40	1.03	1.36	3.15	17	3	6	0.63	1.46	2.58	4.65
09/10	20	4	14	0.40	1.10	1.47	3.29	16	2	5	0.60	1.55	2.19	5.03
10/11	20	4	17	0.33	1.13	1.61	3.57	15	3	8	0.64	1.44	1.86	4.17
11/12	20	3	12	0.42	1.13	1.51	3.40	19	4	10	0.57	1.45	1.89	4.50
12/13	23	3	13	0.40	1.15	1.63	3.50	15	2	5	0.64	1.42	1.97	4.63
13/14	23	3	15	0.40	1.17	1.54	3.68	13	3	6	0.71	1.51	1.98	4.67
14/15	22	3	18	0.39	1.18	1.60	3.54	15	3	7	0.64	1.44	2.40	5.94
Total	40	11	1 046	0.41	1.00	1.42	2.68	40	11	750	0.60	1.37	1.94	4.29

Table E.6: Summary statistics pertaining to the reporting of estimated catch from the SPO 8 analysis data set.

	Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
Fishing year	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	17	13	23	0.60	0.97	1.20	2.33
90/91	18	10	16	0.60	0.96	1.16	2.02
91/92	19	7	9	0.52	0.93	1.12	1.94
92/93	22	4	10	0.65	1.00	1.25	2.07
93/94	21	4	10	0.66	1.00	1.23	2.04
94/95	27	9	21	0.59	1.03	1.35	2.17
95/96	29	9	26	0.62	1.04	2.33	2.23
96/97	28	14	34	0.64	1.00	1.31	2.31
97/98	27	9	23	0.52	0.98	1.26	2.36
98/99	29	13	28	0.44	0.93	1.37	2.66
99/00	30	11	22	0.53	1.00	1.33	2.48
00/01	18	4	6	0.59	1.16	1.57	2.80
01/02	22	3	7	0.71	1.26	1.49	2.53
02/03	24	4	8	0.59	1.16	1.91	4.26
03/04	25	4	8	0.57	1.25	1.61	3.85
04/05	27	4	9	0.56	1.14	1.59	3.59
05/06	34	5	9	0.69	1.19	1.54	3.40
06/07	28	4	7	0.55	1.10	1.39	2.96
07/08	9	1	2	0.60	1.16	1.60	3.10
08/09	10	1	3	0.60	1.10	1.40	3.17
09/10	11	1	2	0.53	1.12	1.35	2.67
10/11	12	1	2	0.60	1.17	1.56	3.41
11/12	14	2	3	0.59	1.20	1.52	3.10
12/13	17	2	2	0.51	1.20	1.54	3.20
13/14	12	1	1	0.60	1.18	1.44	2.59
14/15	18	1	2	0.70	1.16	1.42	2.85
Total	17	13	23	0.60	0.97	1.20	2.33

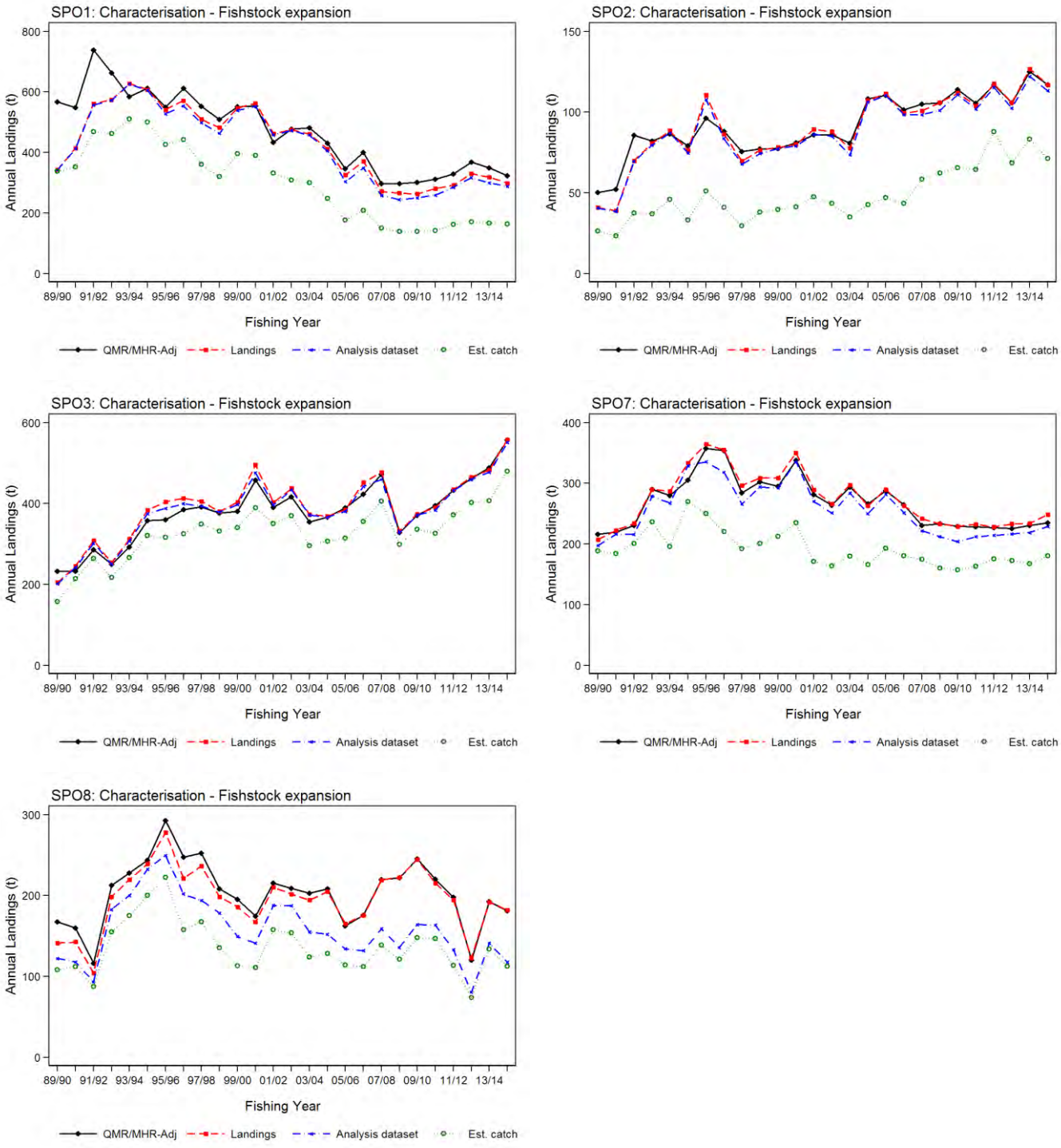

Figure E.1: Plots of the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 catch data sets using annual totals presented in Table E.1, Table E.2 and Table E.3. Note that both the QMR/MHR totals and the landings have been adjusted to consistent conversion factors in all subplots.

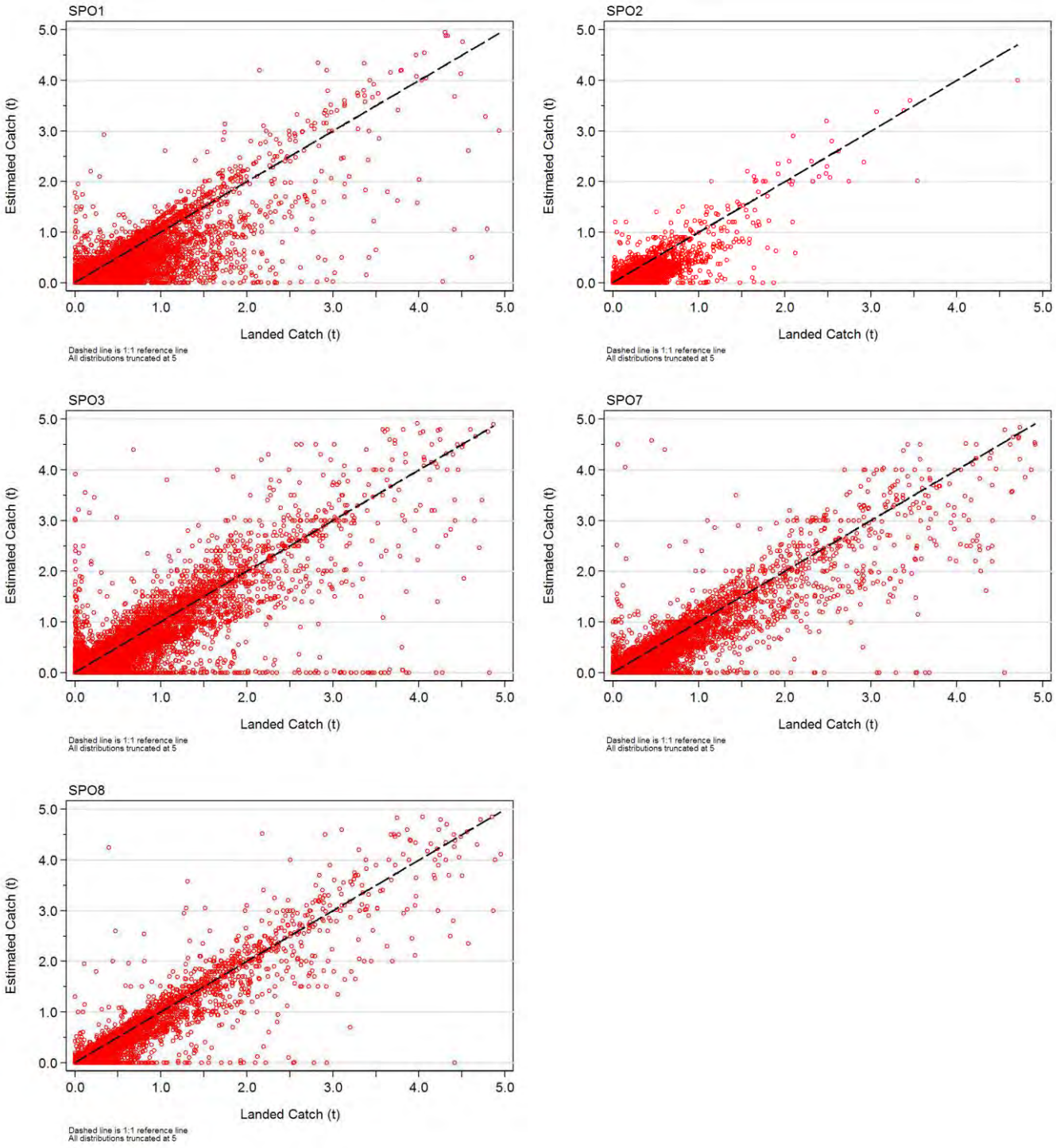

Figure E.2: Scatter plots of the sum of landed and estimated rig catch for every trip in each of the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 analysis data sets.

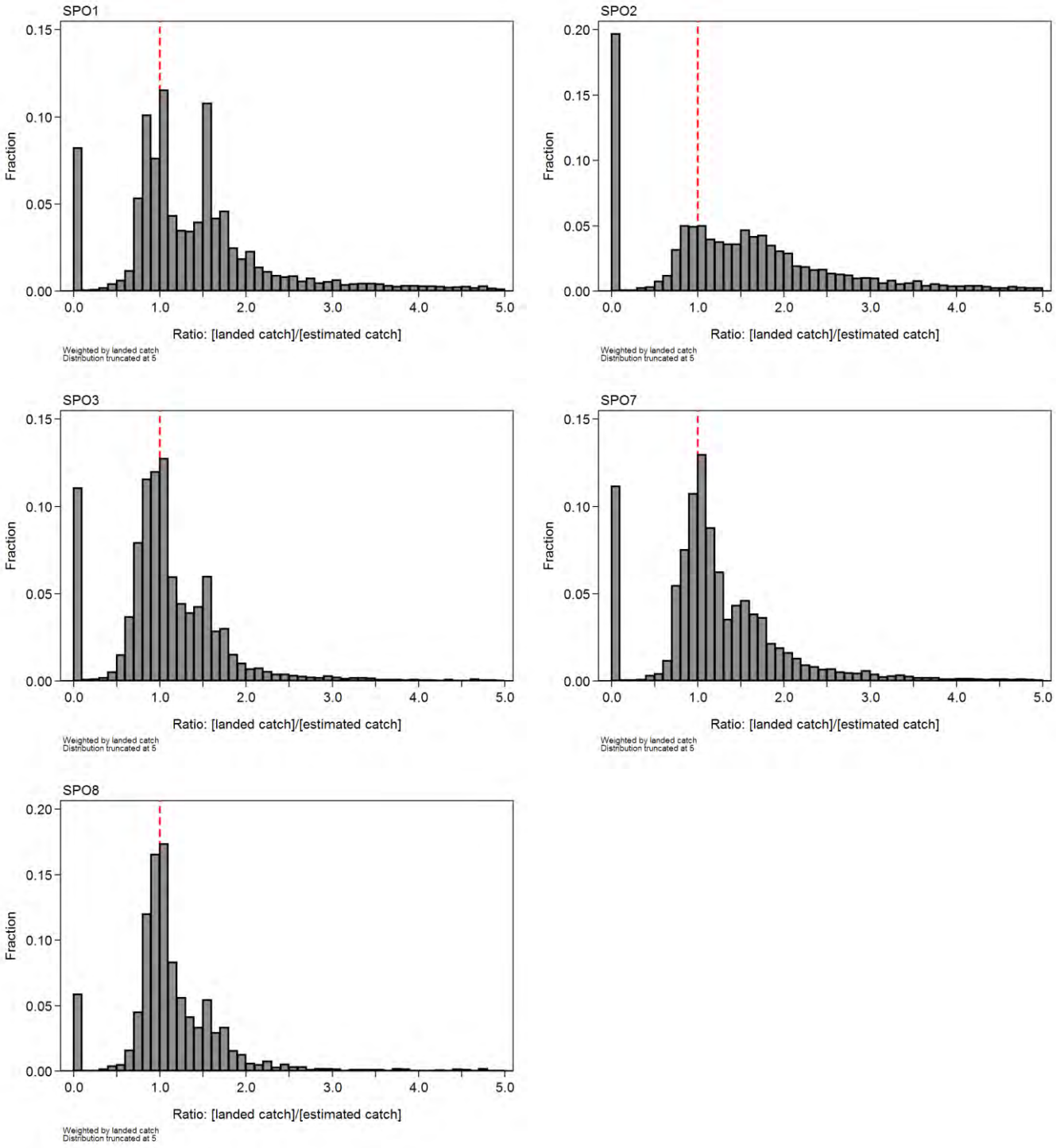

Figure E.3: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip in each of the SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 analysis data sets. Trips where the estimated catch=0 have been assigned a ratio=0.

Appendix F. RETENTION STATISTICS FOR DATA PREPARATION BASED ON STATISTICAL AREA RATHER THAN SPO QMA

Figure F.1 and Table F.1 provide retention statistics for data preparation of the total SPO data set based on expansion to statistical area rather than SPO QMA. Table F.1 shows a higher ratio of landings retained in the 'analysis' data set than in Table 1, particularly in recent years. Retention statistics obviously cannot be provided by SPO QMA because this information has been lost when using the statistical area expansion rule.

Table F.1: Comparison of the total adjusted QMR/MHR catch (t) with the sum of the corrected landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data ('analysis' data set) using a statistical area expansion rule rather than the SPO QMA expansion rule and the sum of the estimated catches from the analysis data set, all representing the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 QMAs. Data source: MPI replog 10380: 1989–90 to 2014–15. Landings and QMR/MHR totals have been adjusted to consistent conversion factors across years (see Section 2.3.2.2).

Fishing year	QMR/MHR (t)	Total landed catch (t)[1]	% landed/ QMR/MHR	Total analysis catch (t)	% Analysis /landed	Total estimated catch (t)	% Estimated /analysis
89/90	1 233	938	76	936	100	851	91
90/91	1 212	1 064	88	1 061	100	922	87
91/92	1 457	1 277	88	1 277	100	1 095	86
92/93	1 497	1 397	93	1 397	100	1 135	81
93/94	1 471	1 535	104	1 535	100	1 238	81
94/95	1 598	1 640	103	1 637	100	1 339	82
95/96	1 656	1 699	103	1 676	99	1 313	78
96/97	1 686	1 647	98	1 627	99	1 236	76
97/98	1 557	1 518	97	1 505	99	1 175	78
98/99	1 473	1 446	98	1 444	100	1 057	73
99/00	1 500	1 523	102	1 522	100	1 153	76
00/01	1 606	1 655	103	1 644	99	1 199	73
01/02	1 407	1 454	103	1 454	100	1 094	75
02/03	1 451	1 469	101	1 468	100	1 070	73
03/04	1 413	1 403	99	1 402	100	986	70
04/05	1 380	1 355	98	1 355	100	952	70
05/06	1 296	1 277	99	1 274	100	897	70
06/07	1 366	1 360	100	1 341	99	956	71
07/08	1 324	1 311	99	1 284	98	998	78
08/09	1 187	1 159	98	1 144	99	891	78
09/10	1 262	1 223	97	1 211	99	952	79
10/11	1 260	1 222	97	1 197	98	910	76
11/12	1 303	1 267	97	1 257	99	985	78
12/13	1 284	1 257	98	1 239	99	947	76
13/14	1 386	1 355	98	1 337	99	1 029	77
14/15	1 413	1 404	99	1 397	99	1 096	78
Total	36 681	35 857	98	35 620	99	27 476	77

[1] Includes all SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 landings in replog 10380 except for 85 trips excluded for being 'out of range' (Table D.1).

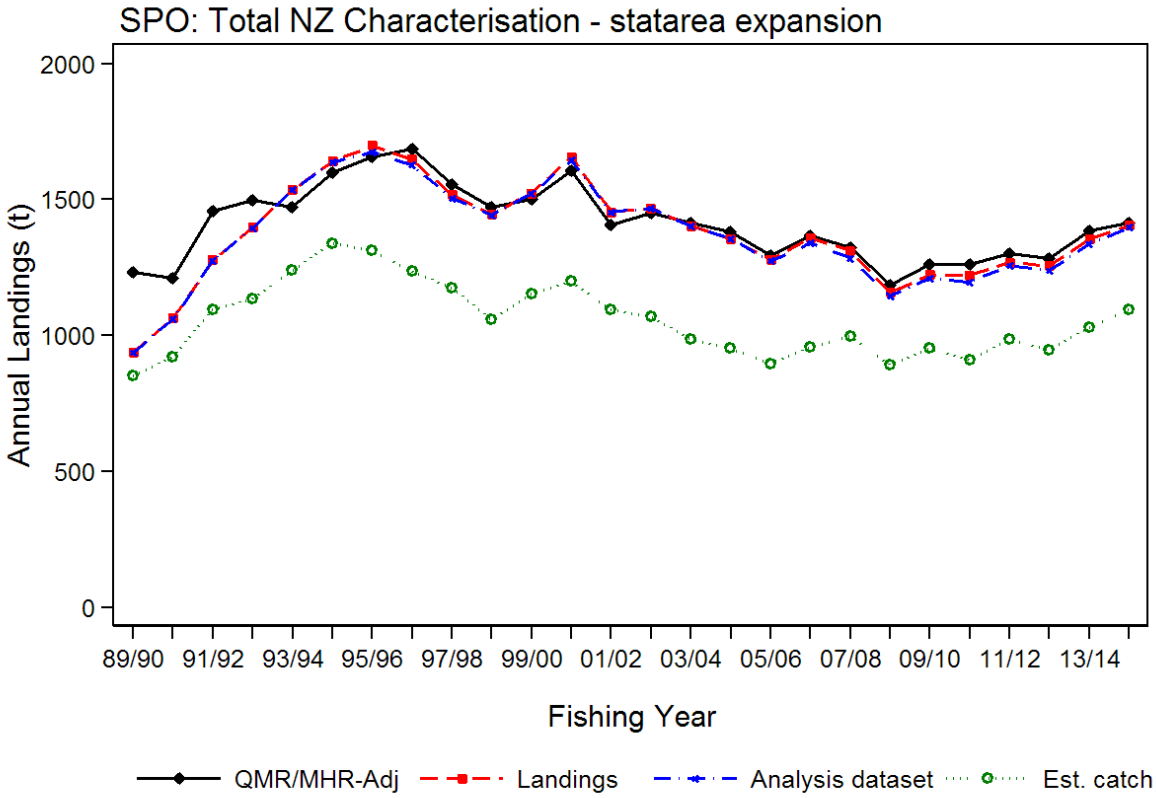

Figure F.1: Plot of the combined SPO 1, SPO 2, SPO 3, SPO 7 and SPO 8 catch data set for totals presented in Table F.1. Note that both the QMR/MHR totals and the landings have been adjusted to consistent conversion factors for all years.

Appendix G. ALGORITHM USED TO CORRECT ESTIMATED CATCHES IN THE SPO 1_SN FISHERIES

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

Eq. G.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_{iy} and upper ub_{iy} bounds:

Eq. G.2
$$\text{replace } \begin{matrix} v_{iy} = \text{NULL if } v_{iy} < lb_{iy} \\ v_{iy} = \text{NULL if } v_{iy} > ub_{iy} \end{matrix};$$

Note 1: data for vessels outside these bounds are dropped: $\left(lb_{iy} = 0.75; ub_{iy} = 2.0\right)$ (these are the bounds used by Kendrick & Bentley [2012]).

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

Eq. G.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}.

Note 2: every record *h* is used in the CPUE analysis because this algorithm was performed on data that have been previously selected as valid for the analysis.

Appendix H. DATA SUMMARIES BY QMA: SPO 1, SPO 2, SPO 3, SPO 7 AND SPO 8

Table H.1: Distribution of landings (%) by method of capture and fishing year by QMA based on trips that landed rig. The final column gives the annual total landings in each QMA. These values are plotted in Figure 7. [Continued on next pages]

Fishing	Distribution (t)						Distribution (%)					
year	SN	BT	DS	BLL	Other	Total	SN	BT	DS	BLL	Other	Total
SPO 1E												
89/90	177.1	61.3	8.5	8.0	13.4	268.2	66.0	22.9	3.2	3.0	5.0	4.8
90/91	223.9	63.8	17.1	9.1	8.0	322.0	69.5	19.8	5.3	2.8	2.5	5.7
91/92	338.0	79.7	23.0	18.1	11.4	470.2	71.9	17.0	4.9	3.8	2.4	8.3
92/93	322.1	44.1	24.2	22.8	4.7	418.0	77.1	10.6	5.8	5.5	1.1	7.4
93/94	269.8	31.8	20.2	68.9	2.3	392.9	68.7	8.1	5.1	17.5	0.6	7.0
94/95	238.6	23.3	15.4	29.5	5.6	312.4	76.4	7.5	4.9	9.4	1.8	5.5
95/96	160.7	30.0	16.0	67.1	1.3	275.2	58.4	10.9	5.8	24.4	0.5	4.9
96/97	176.4	17.9	18.7	19.8	1.0	233.8	75.4	7.6	8.0	8.5	0.4	4.1
97/98	162.9	21.9	11.3	21.2	0.4	217.7	74.8	10.1	5.2	9.7	0.2	3.9
98/99	145.0	25.5	11.9	23.8	0.3	206.4	70.2	12.4	5.8	11.5	0.1	3.7
99/00	155.1	28.8	9.7	26.7	0.4	220.7	70.3	13.1	4.4	12.1	0.2	3.9
00/01	140.3	21.0	9.7	21.7	0.2	193.0	72.7	10.9	5.0	11.3	0.1	3.4
01/02	160.4	22.2	6.2	11.3	0.2	200.3	80.1	11.1	3.1	5.6	0.1	3.6
02/03	150.4	19.0	5.3	9.6	0.7	185.1	81.3	10.3	2.9	5.2	0.4	3.3
03/04	159.0	19.3	7.8	7.3	1.6	195.0	81.5	9.9	4.0	3.7	0.8	3.5
04/05	130.8	26.0	6.5	8.6	0.6	172.5	75.8	15.1	3.8	5.0	0.4	3.1
05/06	101.1	30.5	9.5	7.7	1.2	150.0	67.4	20.4	6.3	5.1	0.8	2.7
06/07	105.0	24.7	14.6	14.5	1.6	160.4	65.5	15.4	9.1	9.0	1.0	2.8
07/08	89.6	22.4	11.8	7.5	1.3	132.6	67.6	16.9	8.9	5.6	1.0	2.4
08/09	95.0	27.1	8.9	6.1	1.9	139.0	68.3	19.5	6.4	4.4	1.4	2.5
09/10	101.2	26.7	10.0	6.4	1.9	146.2	69.2	18.3	6.9	4.4	1.3	2.6
10/11	72.1	23.7	14.5	6.7	0.6	117.6	61.3	20.2	12.3	5.7	0.6	2.1
11/12	85.4	20.6	13.9	4.8	0.4	125.0	68.3	16.4	11.1	3.8	0.3	2.2
12/13	101.2	21.2	14.7	5.6	0.3	143.0	70.7	14.9	10.3	3.9	0.2	2.5
13/14	84.6	28.8	7.6	4.0	0.6	125.7	67.4	22.9	6.1	3.2	0.5	2.2
14/15	69.8	28.4	10.1	4.5	0.3	113.1	61.7	25.1	8.9	4.0	0.3	2.0
Total	4 015.2	790.1	327.1	441.2	62.4	5 636.1	71.2	14.0	5.8	7.8	1.1	100.0
SPO 2												
89/90	19.3	35.8	–	0.1	0.1	55.3	34.9	64.8	–	0.2	0.1	2.2
90/91	15.6	28.7	0.1	0.2	0.7	45.3	34.5	63.2	0.2	0.5	1.6	1.8
91/92	23.1	57.9	–	0.2	0.5	81.7	28.2	70.9	–	0.3	0.6	3.3
92/93	23.5	63.2	0.1	0.3	0.3	87.3	26.9	72.4	0.1	0.3	0.3	3.5
93/94	29.1	54.0	–	0.4	2.5	86.0	33.8	62.8	–	0.5	2.9	3.4
94/95	18.8	53.8	0.5	0.0	0.7	73.8	25.4	72.9	0.6	0.1	1.0	3.0
95/96	34.7	65.9	1.5	0.0	8.7	110.8	31.3	59.4	1.3	0.0	7.9	4.4
96/97	24.7	64.9	0.6	0.0	0.3	90.5	27.3	71.7	0.7	0.0	0.3	3.6
97/98	16.6	56.4	0.3	0.0	1.1	74.4	22.4	75.8	0.4	0.0	1.4	3.0
98/99	20.2	56.6	0.6	0.0	1.4	78.9	25.6	71.8	0.8	0.0	1.8	3.2
99/00	23.5	51.2	2.3	0.0	2.6	79.6	29.5	64.4	2.8	0.0	3.3	3.2
00/01	22.8	50.4	5.0	0.1	2.0	80.3	28.4	62.8	6.2	0.1	2.6	3.2
01/02	26.0	56.4	3.7	0.1	0.5	86.7	30.0	65.0	4.3	0.1	0.6	3.5
02/03	16.1	69.7	–	0.0	0.6	86.4	18.7	80.7	–	0.0	0.6	3.5
03/04	14.4	62.4	0.1	0.0	0.5	77.5	18.6	80.6	0.1	0.0	0.6	3.1
04/05	19.7	93.9	–	0.2	0.8	114.5	17.2	82.0	–	0.2	0.7	4.6
05/06	16.4	101.3	–	0.1	0.3	118.0	13.9	85.8	–	0.1	0.2	4.7
06/07	19.2	85.2	0.4	0.5	0.2	105.5	18.2	80.7	0.4	0.5	0.2	4.2
07/08	20.7	87.3	0.5	0.2	0.1	108.8	19.1	80.2	0.5	0.2	0.1	4.4
08/09	38.9	77.7	–	0.9	0.0	117.5	33.1	66.1	–	0.7	0.0	4.7
09/10	28.3	97.5	0.6	0.5	0.1	127.0	22.3	76.8	0.5	0.4	0.0	5.1
10/11	26.6	85.4	2.1	0.5	0.0	114.6	23.2	74.5	1.8	0.4	0.0	4.6
11/12	38.2	84.7	4.3	0.0	0.1	127.4	29.9	66.5	3.4	0.0	0.1	5.1
12/13	24.6	85.4	1.6	0.2	0.0	111.9	22.0	76.3	1.5	0.2	0.0	4.5
13/14	30.0	104.0	–	0.2	0.1	134.3	22.4	77.4	–	0.1	0.1	5.4
14/15	31.0	86.4	5.6	0.2	0.0	123.2	25.2	70.1	4.5	0.1	0.0	4.9
Total	622.0	1 816.2	29.9	4.9	24.4	2 497.3	24.9	72.7	1.2	0.2	1.0	100.0

Table H.1 [Continued]:

Fishing	Distribution (t)						Distribution (%)					
year	SN	BT	DS	BLL	Other	Total	SN	BT	DS	BLL	Other	Total
SPO 3												
89/90	207.2	67.4	–	0.0	0.1	274.7	75.4	24.5	–	0.0	0.0	2.5
90/91	206.2	76.0	–	0.0	3.2	285.5	72.2	26.6	–	0.0	1.1	2.6
91/92	232.4	101.2	–	0.1	22.2	356.0	65.3	28.4	–	0.0	6.2	3.3
92/93	181.9	92.8	–	0.1	0.1	274.9	66.2	33.8	–	0.0	0.0	2.5
93/94	215.1	88.9	–	0.2	0.1	304.4	70.7	29.2	–	0.1	0.0	2.8
94/95	274.5	80.7	–	8.5	6.9	370.6	74.1	21.8	–	2.3	1.9	3.4
95/96	289.0	105.2	–	0.6	4.7	399.6	72.3	26.3	–	0.2	1.2	3.7
96/97	327.4	97.7	–	0.4	7.2	432.8	75.6	22.6	–	0.1	1.7	4.0
97/98	330.4	99.6	–	2.1	0.0	432.1	76.5	23.0	–	0.5	0.0	4.0
98/99	322.8	74.0	–	4.5	0.6	401.9	80.3	18.4	–	1.1	0.2	3.7
99/00	304.1	105.4	–	0.0	0.0	409.6	74.2	25.7	–	0.0	0.0	3.8
00/01	355.9	126.3	–	–	0.4	482.5	73.8	26.2	–	–	0.1	4.5
01/02	303.1	95.6	–	0.0	0.3	399.0	76.0	24.0	–	0.0	0.1	3.7
02/03	324.2	113.2	2.5	0.1	0.1	440.0	73.7	25.7	0.6	0.0	0.0	4.1
03/04	281.8	104.2	5.3	0.1	0.1	391.5	72.0	26.6	1.4	0.0	0.0	3.6
04/05	271.6	108.4	15.0	0.0	0.2	395.3	68.7	27.4	3.8	0.0	0.1	3.7
05/06	291.3	98.1	16.0	1.7	0.0	407.2	71.5	24.1	3.9	0.4	0.0	3.8
06/07	330.0	121.1	22.1	1.2	0.0	474.5	69.5	25.5	4.7	0.3	0.0	4.4
07/08	379.5	88.2	35.0	6.0	0.2	508.9	74.6	17.3	6.9	1.2	0.0	4.7
08/09	243.6	99.4	37.4	0.3	0.0	380.8	64.0	26.1	9.8	0.1	0.0	3.5
09/10	257.5	123.2	45.0	0.0	0.0	425.8	60.5	28.9	10.6	0.0	0.0	3.9
10/11	265.5	108.5	50.2	6.9	0.2	431.3	61.6	25.2	11.6	1.6	0.0	4.0
11/12	269.3	134.9	70.2	2.9	0.1	477.3	56.4	28.3	14.7	0.6	0.0	4.4
12/13	312.6	126.2	59.6	3.3	0.1	501.8	62.3	25.1	11.9	0.7	0.0	4.7
13/14	292.7	167.8	60.7	4.0	0.1	525.3	55.7	31.9	11.5	0.8	0.0	4.9
14/15	342.3	174.4	70.7	11.8	0.3	599.6	57.1	29.1	11.8	2.0	0.0	5.6
Total	7 411.9	2 778.7	489.8	55.3	47.3	10 782.9	68.7	25.8	4.5	0.5	0.4	100.0
SPO 7												
89/90	144.6	111.6	–	5.6	7.4	269.2	53.7	41.5	–	2.1	2.8	3.7
90/91	147.4	102.8	–	0.3	4.8	255.3	57.7	40.3	–	0.1	1.9	3.5
91/92	160.9	91.6	–	0.2	1.3	254.0	63.4	36.1	–	0.1	0.5	3.5
92/93	197.0	106.7	–	1.3	1.0	306.1	64.4	34.9	–	0.4	0.3	4.2
93/94	162.4	89.8	–	0.3	11.8	264.3	61.4	34.0	–	0.1	4.5	3.7
94/95	192.9	130.5	–	0.3	1.9	325.6	59.3	40.1	–	0.1	0.6	4.5
95/96	228.1	114.1	–	0.1	2.8	345.1	66.1	33.1	–	0.0	0.8	4.8
96/97	223.8	118.4	–	0.6	2.0	344.7	64.9	34.3	–	0.2	0.6	4.8
97/98	195.9	93.3	–	0.1	2.4	291.7	67.2	32.0	–	0.0	0.8	4.0
98/99	181.7	128.5	–	0.1	1.8	312.2	58.2	41.2	–	0.0	0.6	4.3
99/00	176.4	120.8	–	1.1	3.1	301.4	58.5	40.1	–	0.4	1.0	4.2
00/01	216.6	121.5	–	0.0	2.4	340.5	63.6	35.7	–	0.0	0.7	4.7
01/02	168.4	101.5	–	0.0	1.6	271.5	62.0	37.4	–	0.0	0.6	3.8
02/03	167.3	86.0	–	0.0	1.5	254.7	65.7	33.7	–	0.0	0.6	3.5
03/04	197.9	96.1	–	2.2	2.7	299.0	66.2	32.2	–	0.7	0.9	4.2
04/05	167.9	100.4	0.1	0.1	0.9	269.4	62.3	37.3	0.0	0.0	0.3	3.7
05/06	190.8	109.2	0.5	0.2	0.7	301.4	63.3	36.2	0.2	0.1	0.2	4.2
06/07	161.9	106.5	0.9	0.0	0.7	269.9	60.0	39.4	0.3	0.0	0.2	3.7
07/08	111.6	127.0	5.7	0.0	1.0	245.4	45.5	51.8	2.3	0.0	0.4	3.4
08/09	103.2	132.7	8.7	1.4	0.2	246.3	41.9	53.9	3.5	0.6	0.1	3.4
09/10	85.8	135.2	12.5	0.3	0.1	233.9	36.7	57.8	5.4	0.1	0.1	3.2
10/11	107.6	126.1	4.3	0.4	0.2	238.5	45.1	52.9	1.8	0.2	0.1	3.3
11/12	108.8	121.0	6.5	0.0	0.3	236.7	46.0	51.1	2.8	0.0	0.1	3.3
12/13	91.2	139.9	5.0	0.2	0.2	236.4	38.6	59.2	2.1	0.1	0.1	3.3
13/14	86.1	149.2	5.3	0.2	0.1	240.9	35.8	61.9	2.2	0.1	0.0	3.3
14/15	77.8	156.0	10.1	0.3	4.9	249.1	31.3	62.6	4.0	0.1	2.0	3.5
Total	4 054.0	3 016.3	59.6	15.5	57.7	7 203.1	56.3	41.9	0.8	0.2	0.8	100.0

Table H.1 [Continued]:

Fishing year	Distribution (t)						Distribution (%)					
	SN	BT	DS	BLL	Other	Total	SN	BT	DS	BLL	Other	Total
SPO 8												
89/90	135.6	26.6	–	0.9	3.6	166.7	81.3	16.0	–	0.6	2.1	3.8
90/91	120.7	13.4	–	0.9	4.3	139.2	86.7	9.6	–	0.6	3.1	3.1
91/92	93.4	9.6	–	0.8	5.8	109.6	85.2	8.8	–	0.7	5.3	2.5
92/93	181.0	8.9	–	1.4	9.2	200.5	90.3	4.4	–	0.7	4.6	4.5
93/94	181.2	8.3	–	0.6	7.7	197.8	91.6	4.2	–	0.3	3.9	4.5
94/95	206.6	14.1	–	0.5	8.8	230.0	89.8	6.1	–	0.2	3.8	5.2
95/96	232.0	21.0	–	0.9	3.1	257.0	90.3	8.2	–	0.4	1.2	5.8
96/97	186.4	27.8	–	0.7	3.9	218.8	85.2	12.7	–	0.3	1.8	4.9
97/98	182.6	27.8	–	1.5	0.9	212.7	85.8	13.0	–	0.7	0.4	4.8
98/99	163.6	25.3	–	0.3	0.2	189.3	86.4	13.3	–	0.1	0.1	4.3
99/00	129.3	23.8	–	0.3	0.3	153.7	84.1	15.5	–	0.2	0.2	3.5
00/01	128.7	13.2	–	0.6	0.5	142.9	90.0	9.2	–	0.4	0.3	3.2
01/02	162.4	26.1	–	0.5	0.1	189.1	85.9	13.8	–	0.3	0.0	4.3
02/03	167.2	22.4	–	0.6	0.0	190.3	87.9	11.8	–	0.3	0.0	4.3
03/04	144.9	17.9	–	0.1	0.1	163.0	88.9	11.0	–	0.1	0.1	3.7
04/05	146.7	17.0	–	0.1	0.5	164.2	89.3	10.3	–	0.0	0.3	3.7
05/06	128.1	15.1	–	0.1	0.3	143.6	89.2	10.5	–	0.0	0.2	3.2
06/07	117.6	17.0	6.4	0.2	0.1	141.3	83.2	12.0	4.6	0.1	0.0	3.2
07/08	149.0	14.6	12.0	0.2	0.1	175.9	84.7	8.3	6.8	0.1	0.1	4.0
08/09	139.8	15.0	3.0	0.2	0.0	158.0	88.5	9.5	1.9	0.1	0.0	3.6
09/10	164.1	22.8	1.3	0.1	0.0	188.3	87.1	12.1	0.7	0.0	0.0	4.2
10/11	153.2	27.4	3.1	0.1	0.1	183.9	83.3	14.9	1.7	0.1	0.0	4.1
11/12	120.4	22.9	3.6	0.2	0.0	147.1	81.8	15.6	2.4	0.1	0.0	3.3
12/13	66.8	18.1	2.8	0.1	0.0	87.9	76.0	20.6	3.2	0.1	0.0	2.0
13/14	136.2	18.7	0.3	0.3	0.0	155.5	87.6	12.1	0.2	0.2	0.0	3.5
14/15	111.9	15.8	–	0.4	0.0	128.1	87.3	12.4	–	0.3	0.0	2.9
Total	3 849.3	490.7	32.5	12.4	49.5	4 434.5	86.8	11.1	0.7	0.3	1.1	100.0
SPO 1W												
89/90	166.3	28.4	–	0.0	4.3	199.0	83.6	14.3	–	0.0	2.2	3.2
90/91	133.2	21.2	–	0.1	10.5	164.9	80.8	12.8	–	0.0	6.4	2.7
91/92	149.4	27.4	–	0.4	8.1	185.4	80.6	14.8	–	0.2	4.4	3.0
92/93	137.1	65.3	0.9	0.3	7.0	210.6	65.1	31.0	0.4	0.1	3.3	3.4
93/94	162.5	52.4	2.4	0.5	8.1	225.9	71.9	23.2	1.1	0.2	3.6	3.7
94/95	232.4	44.1	0.4	0.5	8.7	286.1	81.2	15.4	0.1	0.2	3.0	4.7
95/96	212.0	46.1	1.6	0.3	8.3	268.3	79.0	17.2	0.6	0.1	3.1	4.4
96/97	314.4	46.5	1.8	0.4	2.7	365.8	86.0	12.7	0.5	0.1	0.7	6.0
97/98	279.8	45.3	0.3	0.7	2.6	328.7	85.1	13.8	0.1	0.2	0.8	5.4
98/99	225.8	51.6	0.0	0.1	7.2	284.7	79.3	18.1	0.0	0.0	2.5	4.6
99/00	276.5	48.3	0.4	1.2	8.7	335.0	82.5	14.4	0.1	0.4	2.6	5.5
00/01	302.4	50.9	1.0	2.1	10.4	366.8	82.4	13.9	0.3	0.6	2.8	6.0
01/02	214.0	38.8	2.6	2.6	2.4	260.4	82.2	14.9	1.0	1.0	0.9	4.3
02/03	225.1	52.1	2.7	1.3	13.4	294.6	76.4	17.7	0.9	0.4	4.6	4.8
03/04	241.1	34.6	3.6	0.3	7.3	286.9	84.0	12.1	1.3	0.1	2.5	4.7
04/05	223.5	32.4	1.7	0.1	6.6	264.4	84.5	12.3	0.7	0.1	2.5	4.3
05/06	141.5	24.2	1.6	0.1	8.5	175.8	80.5	13.7	0.9	0.0	4.8	2.9
06/07	176.8	22.7	2.3	0.0	12.0	213.8	82.7	10.6	1.1	0.0	5.6	3.5
07/08	102.0	33.0	6.4	0.1	11.2	152.8	66.8	21.6	4.2	0.1	7.3	2.5
08/09	101.5	26.9	11.8	0.1	5.2	145.5	69.7	18.5	8.1	0.1	3.6	2.4
09/10	94.7	27.4	10.9	0.2	7.7	140.9	67.2	19.5	7.7	0.1	5.5	2.3
10/11	125.3	33.2	7.6	0.1	8.0	174.3	71.9	19.0	4.4	0.1	4.6	2.8
11/12	125.7	55.9	3.6	0.1	4.3	189.7	66.3	29.5	1.9	0.1	2.3	3.1
12/13	135.9	59.1	3.8	0.1	3.7	202.7	67.1	29.2	1.9	0.0	1.8	3.3
13/14	124.2	72.8	3.8	0.0	3.1	204.1	60.9	35.7	1.9	0.0	1.5	3.3
14/15	130.9	65.6	0.9	0.1	2.2	199.8	65.6	32.8	0.5	0.0	1.1	3.3
Total	4 754.2	1 106.3	72.1	11.9	182.4	6 126.8	77.6	18.1	1.2	0.2	3.0	100.0

Table H.2: Distribution of landings (%) by month and fishing year for setnet by QMA based on trips that landed rig. The final column gives the annual total landings for setnet in each QMA. These values are plotted in Figure 12. [Continued on next pages]

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 1E													
89/90	16.3	11.2	10.6	4.3	0.5	3.9	2.6	2.2	6.6	11.4	3.7	26.7	177
90/91	38.0	30.1	7.6	2.7	2.5	2.5	1.4	2.4	1.4	1.6	1.6	8.2	224
91/92	24.8	37.9	7.7	2.3	4.8	10.3	2.7	3.4	1.6	1.3	1.2	1.9	338
92/93	24.6	29.2	10.5	4.0	3.2	4.3	2.9	2.2	2.6	6.9	2.3	7.3	322
93/94	24.6	18.9	5.3	8.4	9.8	6.9	4.8	3.7	6.6	1.5	3.8	5.9	270
94/95	19.2	25.2	6.3	5.3	8.3	2.2	16.0	4.6	2.3	1.4	3.1	6.1	239
95/96	21.6	41.9	8.7	4.1	4.0	1.9	3.8	5.1	2.4	1.6	0.9	4.0	161
96/97	30.6	22.9	3.0	8.1	6.1	5.8	2.2	3.0	3.9	6.4	2.9	5.0	176
97/98	29.2	19.1	3.8	4.7	2.2	7.8	6.6	2.6	4.3	5.0	3.9	10.8	163
98/99	32.3	15.9	11.6	6.2	2.2	0.9	1.2	2.8	2.5	3.7	1.2	19.8	145
99/00	36.5	10.8	4.9	4.0	4.5	5.2	2.0	3.9	3.5	5.4	3.8	15.8	155
00/01	41.2	17.8	3.1	3.9	5.7	2.3	2.6	2.9	3.0	2.7	2.6	12.2	140
01/02	40.5	20.3	1.4	0.7	3.3	1.7	3.5	4.4	3.6	6.3	1.5	12.8	160
02/03	40.4	20.4	4.2	2.4	5.1	1.7	4.4	2.3	1.5	5.0	4.9	7.7	150
03/04	32.0	19.6	6.4	0.9	1.2	6.7	5.6	9.1	9.7	2.2	1.1	5.6	159
04/05	25.8	23.5	5.1	4.2	5.6	4.4	5.0	3.0	3.2	1.9	7.7	10.6	131
05/06	32.5	16.0	3.6	3.3	2.3	5.6	2.5	6.7	4.0	2.0	3.6	17.9	101
06/07	29.8	18.3	3.3	3.9	6.3	3.1	6.5	7.1	3.3	2.7	5.1	10.7	105
07/08	33.6	20.8	3.3	3.6	4.4	3.6	2.4	2.2	2.6	4.3	4.6	14.6	90
08/09	24.1	5.1	3.3	5.1	2.3	3.2	2.0	3.2	7.8	6.0	9.3	28.6	95
09/10	25.1	10.7	4.2	4.7	3.1	2.7	2.9	4.1	10.2	9.4	7.7	15.1	101
10/11	14.1	14.3	4.7	1.4	6.0	2.6	2.4	4.9	3.4	8.7	14.8	22.6	72
11/12	24.0	14.7	1.3	3.1	2.5	2.4	2.5	2.3	3.0	3.4	10.1	30.7	85
12/13	24.3	10.9	3.2	3.0	2.3	2.9	3.7	3.5	5.8	8.9	8.8	22.7	101
13/14	22.5	10.1	2.0	1.7	2.6	2.6	7.7	6.5	4.0	6.6	10.2	23.4	85
14/15	22.6	6.6	1.2	2.2	1.6	0.5	2.3	1.7	5.2	11.1	17.2	27.7	70
Mean	28.1	21.6	5.8	4.0	4.2	4.3	4.1	3.7	3.9	4.4	4.1	11.8	4 015
SPO 2													
89/90	15.4	9.8	14.6	7.2	7.3	14.9	12.4	5.4	3.2	1.9	0.6	7.3	19
90/91	19.0	13.9	16.2	5.4	9.9	0.3	1.6	3.9	1.2	8.2	5.7	14.9	16
91/92	19.6	14.1	14.0	16.1	8.4	9.3	1.5	3.6	5.1	2.7	2.2	3.4	23
92/93	5.0	22.8	24.9	11.1	3.7	4.0	9.7	8.6	3.1	2.1	0.7	4.3	23
93/94	20.3	12.6	12.2	6.5	3.8	11.3	3.4	9.5	3.2	1.2	0.5	15.6	29
94/95	8.8	18.4	16.1	15.6	4.2	3.3	1.3	10.9	3.4	6.5	1.2	10.4	19
95/96	6.7	16.6	15.0	10.3	9.3	7.5	12.7	5.8	4.9	2.3	1.1	7.8	35
96/97	7.8	20.1	18.0	9.9	4.1	0.9	7.2	14.9	2.2	1.2	5.2	8.6	25
97/98	11.8	22.0	17.5	6.9	11.7	19.6	4.1	1.4	1.0	0.1	0.4	3.7	17
98/99	6.2	11.0	14.3	6.5	13.6	12.4	1.6	7.2	3.2	6.9	2.1	15.0	20
99/00	10.9	12.2	21.7	8.4	11.2	6.9	6.3	6.7	0.2	0.4	10.3	4.6	23
00/01	39.1	13.5	9.0	13.7	1.9	1.3	1.3	1.2	2.1	4.0	6.4	6.5	23
01/02	35.0	17.1	11.0	3.9	9.0	2.4	1.2	0.8	0.6	0.0	7.6	11.3	26
02/03	30.0	10.5	12.7	10.6	6.5	3.6	3.2	7.3	0.7	5.5	0.6	8.9	16
03/04	5.9	15.3	14.7	23.0	4.1	10.2	9.5	5.7	0.7	0.4	1.9	8.6	14
04/05	8.9	39.2	9.1	18.0	4.2	5.2	0.5	1.0	0.9	1.1	3.8	7.9	20
05/06	4.9	4.0	26.6	1.9	1.3	2.8	3.8	8.2	3.0	4.7	10.4	28.3	16
06/07	4.0	8.9	9.4	4.9	3.1	7.8	20.9	21.1	3.2	2.4	7.3	6.9	19
07/08	8.9	5.1	8.3	2.9	4.1	24.5	12.1	5.8	4.8	2.8	0.6	20.1	21
08/09	8.8	5.3	8.8	3.3	14.9	24.7	9.8	7.5	1.5	1.9	4.6	9.0	39
09/10	5.3	6.7	7.4	7.5	15.2	28.0	15.5	2.3	0.9	3.2	0.6	7.3	28
10/11	27.9	10.3	3.3	1.8	1.4	8.8	11.2	23.2	2.0	1.1	3.5	5.4	27
11/12	24.4	9.2	4.7	1.5	19.4	10.8	7.9	11.9	0.3	1.8	1.2	6.8	38
12/13	32.9	19.8	6.7	10.0	13.2	3.4	1.4	2.2	2.9	2.4	0.2	5.0	25
13/14	32.3	19.4	3.2	2.1	11.7	3.4	2.5	8.3	13.5	0.2	0.7	2.7	30
14/15	30.2	24.1	2.0	1.3	4.6	15.6	3.5	5.8	6.7	3.7	0.0	2.6	31
Mean	17.2	14.5	11.5	7.5	8.4	9.9	6.6	7.5	3.0	2.4	2.9	8.5	622

Table H.2 [Continued]:

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 3													
89/90	7.3	33.6	23.0	5.9	7.9	2.7	1.8	0.6	0.9	0.7	9.1	6.4	207
90/91	8.9	38.8	19.5	10.0	4.0	3.3	2.6	1.5	1.1	1.9	2.3	6.1	206
91/92	12.6	21.4	27.8	15.4	7.7	3.8	2.0	1.2	0.7	0.6	0.7	6.0	232
92/93	12.9	19.4	28.3	16.3	8.2	3.8	3.4	2.2	1.1	0.6	0.8	3.1	182
93/94	4.8	25.3	26.0	18.3	6.9	5.1	6.2	1.9	1.9	0.3	0.6	2.6	215
94/95	4.4	15.5	32.1	18.9	11.5	7.3	4.6	2.4	0.3	0.7	0.3	2.1	274
95/96	4.8	20.6	26.0	20.4	13.8	5.6	2.3	1.1	0.2	0.7	1.4	3.2	289
96/97	5.4	25.0	28.0	20.9	5.6	2.5	2.5	2.1	1.8	1.5	0.9	3.7	327
97/98	7.1	21.4	28.7	18.3	10.5	6.7	2.4	0.6	0.9	0.8	0.6	2.1	330
98/99	6.0	33.3	23.5	16.3	7.1	5.0	2.1	0.7	0.3	0.3	0.9	4.5	323
99/00	8.8	32.4	29.5	11.2	4.7	5.3	1.7	2.3	0.4	1.0	0.6	2.0	304
00/01	10.9	25.4	29.4	13.2	8.3	3.7	3.1	0.7	1.2	0.7	0.9	2.5	356
01/02	8.8	37.5	25.0	13.0	4.9	3.9	2.1	0.8	1.0	1.7	0.4	0.7	303
02/03	9.9	31.5	30.7	12.0	7.5	3.1	1.1	0.7	0.7	1.0	0.9	0.8	324
03/04	9.8	31.6	29.5	15.0	6.3	1.8	2.8	1.7	0.7	0.2	0.4	0.4	282
04/05	8.5	24.9	21.2	22.5	14.4	2.5	1.9	1.2	1.2	0.6	0.3	0.8	272
05/06	9.6	36.6	18.9	15.5	9.5	3.3	1.3	1.4	0.4	0.6	0.6	2.3	291
06/07	6.1	30.3	20.6	14.6	13.2	6.6	1.3	1.1	1.6	0.6	0.7	3.2	330
07/08	7.7	25.0	15.6	14.6	11.0	10.0	4.9	2.3	1.5	1.0	3.0	3.4	380
08/09	13.6	24.1	23.8	9.9	4.7	4.8	6.3	1.7	3.9	0.6	1.3	5.3	244
09/10	14.1	16.0	20.9	17.2	9.4	3.7	4.6	6.6	1.5	0.6	1.8	3.5	257
10/11	16.3	19.0	23.2	12.0	6.3	7.2	3.2	1.8	1.1	2.7	2.1	5.1	265
11/12	10.8	24.3	23.1	11.1	6.2	5.3	5.3	2.6	0.9	2.1	0.4	7.9	269
12/13	12.6	21.8	26.8	12.2	6.8	3.8	3.2	3.3	1.0	0.4	1.6	6.7	313
13/14	11.8	33.0	21.9	8.8	4.4	8.2	4.1	1.3	3.0	0.7	1.2	1.6	293
14/15	6.9	29.1	26.2	13.0	5.8	5.5	3.1	2.0	1.1	1.5	1.0	4.7	342
Mean	9.1	26.9	25.0	14.6	8.0	4.9	3.0	1.7	1.2	0.9	1.3	3.4	7 412
SPO 7													
89/90	3.4	29.0	8.1	19.0	4.2	5.6	2.2	4.2	1.5	3.0	1.9	17.9	145
90/91	17.8	16.6	8.5	18.8	4.9	7.9	5.6	5.8	2.9	0.4	2.5	8.3	147
91/92	11.4	25.4	12.3	14.9	13.6	4.5	2.5	3.3	1.4	0.7	1.6	8.5	161
92/93	9.1	23.9	7.7	18.0	12.8	9.7	3.1	3.4	0.5	3.5	0.6	7.7	197
93/94	3.9	31.2	23.6	11.8	2.6	3.4	7.3	4.0	4.3	1.5	2.3	4.2	162
94/95	14.1	14.8	26.4	17.5	6.1	7.4	6.6	1.8	1.7	1.1	0.5	2.0	193
95/96	12.9	33.5	14.0	15.4	5.0	3.7	7.2	2.2	3.3	0.9	0.6	1.3	228
96/97	21.0	32.6	19.4	15.2	4.6	1.3	1.8	0.8	0.1	2.8	0.1	0.3	224
97/98	23.3	30.4	10.7	8.3	4.4	5.8	6.2	3.6	5.3	0.6	1.1	0.3	196
98/99	18.5	33.5	12.1	12.8	5.0	5.7	4.8	2.3	1.1	0.9	1.2	1.9	182
99/00	17.0	19.6	18.7	9.2	8.1	5.1	5.2	0.8	3.3	0.7	2.4	9.9	176
00/01	14.6	19.3	23.0	18.8	7.4	3.2	2.7	3.1	1.7	0.9	1.2	4.0	217
01/02	18.1	20.1	15.1	13.6	12.2	8.1	3.4	1.0	0.6	2.5	2.2	3.1	168
02/03	10.5	21.3	11.7	19.7	6.2	9.0	5.6	3.4	1.2	2.3	1.9	7.4	167
03/04	13.5	16.6	18.6	18.8	8.6	6.2	2.9	3.5	1.3	1.8	4.2	3.8	198
04/05	7.7	19.1	11.4	17.6	14.8	15.1	7.2	2.4	0.9	0.7	0.8	2.4	168
05/06	15.2	16.1	21.9	10.0	7.7	14.7	7.7	0.3	3.7	0.2	0.3	2.2	191
06/07	23.5	27.4	11.9	12.6	6.4	16.1	0.8	0.1	0.2	0.6	0.0	0.3	162
07/08	30.6	10.1	19.5	5.2	0.6	16.8	0.7	1.6	0.0	3.7	0.2	11.0	112
08/09	32.1	17.9	16.9	14.7	1.1	2.5	9.2	3.8	0.6	0.3	0.8	0.0	103
09/10	30.6	31.6	2.2	0.4	7.4	11.0	8.8	1.8	0.1	2.9	0.2	3.1	86
10/11	17.3	23.4	18.2	1.6	11.6	2.2	20.3	1.4	0.2	0.1	0.2	3.4	108
11/12	16.5	34.6	3.7	12.2	4.3	7.1	12.2	5.5	1.4	0.0	0.0	2.6	109
12/13	34.5	40.0	4.4	1.0	1.4	12.2	2.0	3.0	0.0	0.0	0.0	1.5	91
13/14	17.8	32.3	21.2	0.0	4.4	19.4	2.0	2.2	0.6	0.0	0.0	–	86
14/15	11.9	19.4	17.9	2.5	13.4	3.3	6.8	0.1	3.4	0.0	0.0	21.3	78
Mean	16.3	24.4	15.1	13.2	7.0	7.6	5.3	2.5	1.7	1.3	1.1	4.6	4 054

Table H.2 [Continued]:

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 8													
89/90	2.1	5.9	6.5	10.3	19.9	8.8	6.4	16.6	7.9	2.5	1.6	11.5	136
90/91	4.6	15.3	14.7	12.9	9.6	13.2	4.2	9.1	3.3	2.1	4.1	6.8	121
91/92	6.1	4.5	7.6	8.9	17.6	13.8	17.0	4.5	2.3	2.0	1.5	14.2	93
92/93	10.1	9.4	8.6	8.3	13.4	12.8	9.6	3.3	2.0	8.2	4.9	9.5	181
93/94	7.7	15.1	17.7	16.6	13.5	8.1	5.8	2.1	3.2	2.7	3.3	4.2	181
94/95	10.7	9.0	13.0	11.4	8.1	8.9	6.8	2.7	4.5	2.6	6.8	15.5	207
95/96	22.2	16.2	8.9	8.6	7.9	11.5	6.3	3.0	2.6	1.9	2.6	8.4	232
96/97	21.0	5.0	8.9	11.8	7.0	13.7	4.7	9.3	3.6	4.5	3.0	7.5	186
97/98	10.7	13.2	10.1	9.7	7.4	9.0	6.3	4.0	4.1	2.4	3.1	20.0	183
98/99	8.4	15.9	10.0	16.3	17.3	6.7	2.2	4.7	4.5	1.5	5.9	6.7	164
99/00	17.1	10.7	8.4	23.0	15.7	8.1	3.3	3.6	2.4	1.7	1.9	4.0	129
00/01	6.8	8.7	9.9	16.6	18.0	9.2	3.1	6.0	4.0	4.9	4.0	8.8	129
01/02	13.5	14.2	9.4	11.9	8.4	8.7	7.6	3.5	2.2	5.0	9.6	5.9	162
02/03	4.8	10.9	12.9	18.7	7.4	16.9	5.3	5.0	2.2	3.4	3.5	8.9	167
03/04	8.7	8.1	6.1	10.9	8.5	21.3	10.7	3.7	3.9	3.5	6.4	8.3	145
04/05	15.7	12.2	7.1	15.2	6.2	2.2	5.8	3.4	2.6	0.9	10.1	18.7	147
05/06	12.0	11.7	5.3	9.0	10.3	6.3	6.7	5.2	1.8	4.7	4.4	22.5	128
06/07	4.7	8.0	12.7	25.6	17.7	12.5	2.8	4.0	2.7	1.3	1.6	6.6	118
07/08	3.1	29.5	8.7	14.7	6.5	1.8	8.8	5.0	1.8	2.9	1.5	15.8	149
08/09	12.9	8.1	11.3	8.2	16.6	9.2	9.4	2.1	3.9	2.6	6.6	9.1	140
09/10	11.5	7.4	5.6	19.7	17.3	3.2	14.7	4.6	5.3	1.6	3.3	5.8	164
10/11	11.9	9.1	12.3	9.3	11.6	9.0	5.2	4.3	4.6	5.6	6.0	11.1	153
11/12	10.2	5.8	18.5	11.2	18.1	10.6	4.9	2.6	0.9	5.4	5.9	6.0	120
12/13	4.0	5.9	18.5	14.4	3.6	24.4	2.3	5.6	6.5	2.0	6.6	6.2	67
13/14	11.1	13.2	9.0	13.3	25.3	8.3	3.0	4.7	2.4	0.2	2.7	6.8	136
14/15	17.3	4.6	11.5	6.3	19.9	4.1	4.6	4.8	4.6	2.4	11.1	8.9	112
Mean	10.9	11.1	10.3	13.0	12.4	9.8	6.5	4.8	3.4	3.1	4.6	10.0	3 849
SPO 1W													
89/90	9.2	26.7	13.6	11.9	5.3	2.1	1.5	2.6	2.1	2.4	2.0	20.6	166
90/91	26.6	15.4	11.9	16.4	10.5	2.1	1.0	2.4	0.6	1.6	3.3	8.1	133
91/92	29.8	25.9	16.8	6.3	4.0	4.1	3.2	1.5	1.5	0.6	0.6	5.6	149
92/93	18.9	28.4	13.1	9.0	5.5	4.6	2.4	3.0	1.4	2.2	3.3	8.1	137
93/94	30.3	23.4	16.7	10.2	5.1	1.9	0.9	0.4	0.7	0.9	1.8	7.5	163
94/95	27.5	21.7	16.8	8.6	3.3	2.6	1.7	1.0	0.7	0.4	2.0	13.7	232
95/96	22.7	24.0	9.6	4.6	4.7	3.7	2.0	1.7	1.5	1.5	1.7	22.6	212
96/97	26.4	19.5	14.0	7.5	7.2	2.1	1.3	1.5	1.2	3.3	2.2	13.8	314
97/98	27.3	18.2	8.3	7.7	6.0	5.4	2.5	1.3	1.5	1.0	2.5	18.4	280
98/99	16.1	21.3	14.9	7.4	5.3	4.9	1.5	3.0	0.7	1.1	3.6	20.1	226
99/00	35.2	12.7	11.6	7.2	3.4	3.3	1.7	1.4	1.5	2.6	2.7	16.7	276
00/01	28.6	16.2	9.8	5.4	5.6	2.0	1.6	1.2	1.1	1.8	1.7	25.1	302
01/02	38.2	15.2	6.3	11.3	5.7	2.9	3.1	1.6	0.9	0.8	2.3	11.6	214
02/03	25.8	20.6	8.1	10.2	4.6	4.2	3.0	1.5	1.2	2.3	6.2	12.1	225
03/04	41.9	18.3	5.8	7.8	0.7	5.7	3.8	3.0	1.3	3.5	2.5	5.7	241
04/05	28.5	28.4	4.8	8.8	3.2	3.5	3.4	1.4	1.0	0.8	2.3	13.9	224
05/06	43.9	17.3	6.9	2.3	3.9	3.9	2.3	1.2	1.0	0.4	1.4	15.5	141
06/07	21.8	14.2	16.2	13.7	2.1	2.1	0.8	1.4	1.2	0.9	1.6	24.0	177
07/08	29.4	23.3	10.9	3.8	1.8	1.6	1.1	1.2	0.9	2.2	2.1	21.8	102
08/09	36.0	18.8	6.8	4.0	2.2	2.1	1.7	2.3	2.1	1.6	5.7	16.6	101
09/10	41.1	21.7	1.7	2.6	2.8	2.5	2.5	1.2	3.4	1.3	4.2	15.0	95
10/11	41.6	20.7	2.7	1.7	1.2	4.4	2.3	2.7	4.1	2.0	2.6	14.2	125
11/12	46.4	18.7	6.2	0.3	1.8	2.9	1.6	3.1	3.2	2.7	1.4	11.6	126
12/13	40.7	21.8	6.6	1.9	5.9	1.3	1.0	3.3	2.6	5.4	2.1	7.4	136
13/14	33.2	20.1	2.6	3.3	4.1	1.1	8.9	3.3	3.1	1.7	5.3	13.3	124
14/15	41.9	19.2	7.3	3.3	3.7	4.2	1.5	1.2	2.0	3.8	3.0	9.0	131
Mean	30.2	20.1	10.1	7.3	4.4	3.2	2.2	1.8	1.5	1.9	2.6	14.8	4 754

Table H.3: Distribution of landings (%) by month and fishing year for bottom trawl by QMA based on trips that landed rig. The final column gives the annual total landings by QMA for bottom trawl. These values are plotted in Figure 13. [Continued on next pages]

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 1E													
89/90	3.0	5.5	4.8	10.6	6.1	8.9	8.3	9.7	9.8	11.0	11.0	11.1	61
90/91	12.6	7.7	4.3	6.1	6.6	11.2	8.6	11.6	7.2	7.9	6.5	9.9	64
91/92	13.8	8.8	7.5	5.3	8.4	13.5	9.4	11.2	3.4	5.1	5.7	7.8	80
92/93	10.6	7.2	5.8	5.4	9.2	11.5	8.1	7.8	8.7	13.3	3.7	8.7	44
93/94	17.0	5.0	5.5	3.6	7.3	11.3	9.7	11.0	5.8	7.6	5.8	10.4	32
94/95	6.8	7.3	6.2	6.8	8.0	17.4	12.9	8.0	5.9	5.1	7.6	7.9	23
95/96	5.4	6.8	3.2	6.4	8.1	12.4	7.8	29.7	5.5	4.3	3.7	6.8	30
96/97	6.3	10.3	6.3	11.0	17.2	9.7	10.9	4.3	4.2	6.0	5.7	7.9	18
97/98	5.2	7.5	4.6	12.3	8.0	12.1	14.6	11.8	5.2	6.7	6.0	5.9	22
98/99	8.8	8.7	6.9	5.8	8.8	9.8	6.8	9.1	8.1	7.5	9.8	9.7	26
99/00	8.2	8.2	8.3	18.2	5.5	8.7	12.8	6.6	7.9	4.5	4.5	6.5	29
00/01	17.7	9.5	4.6	4.9	6.4	10.2	11.5	11.9	4.1	5.2	7.8	6.3	21
01/02	15.0	9.3	8.2	7.5	8.6	8.4	6.7	8.3	6.8	6.4	6.6	8.3	22
02/03	13.8	5.9	5.2	6.6	8.2	8.4	14.7	5.9	10.1	6.2	10.4	4.6	19
03/04	10.5	5.6	6.9	11.4	6.0	6.6	8.9	9.0	6.9	7.9	9.8	10.5	19
04/05	5.4	6.3	7.6	4.0	11.9	11.8	13.4	12.0	7.6	5.3	6.9	7.8	26
05/06	7.1	8.8	8.2	10.3	7.3	8.0	8.8	6.8	6.1	9.7	7.5	11.3	31
06/07	8.3	8.2	6.7	5.5	5.9	11.8	11.1	6.0	7.0	9.8	8.9	10.7	25
07/08	8.3	7.5	6.7	10.8	12.0	11.7	9.6	5.8	8.1	4.0	6.2	9.3	22
08/09	5.4	9.2	6.2	5.7	6.1	11.2	7.1	7.7	10.3	7.4	11.3	12.6	27
09/10	5.1	12.5	7.5	6.1	7.3	7.0	6.3	10.9	9.5	9.7	11.0	7.1	27
10/11	7.0	7.3	8.3	6.0	10.2	9.5	7.1	7.8	8.5	8.9	10.0	9.6	24
11/12	5.9	3.8	4.4	7.7	10.7	8.7	9.0	12.1	6.1	12.5	10.4	8.8	21
12/13	5.6	5.0	9.7	6.8	8.6	8.3	7.9	6.6	12.7	11.1	8.3	9.5	21
13/14	10.7	3.8	5.4	6.7	6.6	6.8	8.8	5.8	10.5	9.6	15.0	10.4	29
14/15	9.8	8.1	8.2	7.2	6.0	8.1	7.5	6.8	9.2	9.0	10.9	9.2	28
Mean	9.2	7.5	6.3	7.4	8.0	10.4	9.3	9.8	7.4	7.9	7.9	9.0	790
SPO 2													
89/90	13.3	16.7	11.0	9.9	6.3	7.4	6.8	5.5	3.4	5.8	4.8	9.2	36
90/91	9.6	16.4	6.4	7.0	7.2	8.5	6.5	10.4	4.6	4.9	7.3	11.2	29
91/92	12.4	14.7	8.6	5.5	8.3	7.8	9.2	7.9	6.6	6.3	6.4	6.3	58
92/93	10.9	15.3	12.9	6.8	6.7	12.9	5.6	6.4	6.3	6.6	4.0	5.6	63
93/94	11.9	12.6	12.4	6.0	6.6	7.9	9.7	7.3	7.1	4.8	6.4	7.5	54
94/95	8.9	14.0	8.6	8.6	6.3	11.5	9.2	7.5	9.7	3.7	4.9	7.0	54
95/96	7.4	13.1	12.7	6.7	7.9	13.8	9.2	8.5	7.1	4.4	3.9	5.3	66
96/97	12.2	15.7	10.7	10.3	6.7	8.2	8.3	7.9	4.1	6.0	4.3	5.6	65
97/98	9.6	12.2	12.7	10.2	8.0	8.7	6.7	9.0	7.1	5.6	4.6	5.5	56
98/99	7.4	8.4	10.1	4.5	10.5	10.5	8.8	10.1	9.5	5.9	8.2	6.1	57
99/00	9.4	13.7	9.6	5.0	7.0	11.0	9.7	10.9	7.8	4.1	5.4	6.3	51
00/01	14.2	11.4	5.6	5.5	6.6	10.3	9.3	8.1	7.6	7.8	7.7	5.9	50
01/02	10.3	13.3	8.1	7.1	10.4	7.2	9.5	7.5	10.8	4.7	5.7	5.4	56
02/03	11.7	15.9	9.2	5.9	7.4	6.9	6.0	7.1	9.6	8.1	4.1	8.1	70
03/04	14.1	14.2	7.7	4.2	8.5	6.2	9.6	7.8	6.0	5.7	6.2	9.7	62
04/05	9.8	12.2	11.8	7.6	3.4	5.4	9.1	11.5	9.5	5.9	7.7	6.1	94
05/06	10.2	12.1	11.9	8.9	6.6	8.1	5.2	7.9	8.8	8.8	5.8	5.6	101
06/07	13.8	9.7	10.6	5.4	5.8	7.1	8.8	10.2	5.0	9.1	7.1	7.5	85
07/08	10.8	14.2	12.5	6.6	7.3	7.0	7.9	7.6	5.5	5.8	6.3	8.6	87
08/09	17.2	14.8	10.4	11.7	9.5	8.6	6.9	2.9	3.9	3.8	4.9	5.6	78
09/10	10.3	13.9	12.2	8.0	4.4	6.5	7.2	6.7	9.1	6.1	8.2	7.3	98
10/11	10.7	12.8	10.4	7.8	5.1	6.9	6.5	6.0	8.7	7.2	10.3	7.7	85
11/12	9.9	14.4	8.9	6.2	5.9	6.4	6.8	11.8	10.4	6.7	6.0	6.6	85
12/13	10.7	12.9	12.4	7.3	7.8	9.4	6.0	4.9	5.8	7.8	7.8	7.0	85
13/14	11.2	15.0	12.5	6.9	6.6	7.3	7.0	7.2	8.0	5.7	6.4	6.2	104
14/15	9.1	16.0	11.2	7.3	6.4	7.2	5.9	9.2	9.6	7.0	7.1	3.9	86
Mean	11.0	13.6	10.7	7.2	6.9	8.2	7.6	8.0	7.6	6.3	6.3	6.6	1 816

Table H.3 [Continued]:

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 3													
89/90	9.7	19.4	8.3	11.1	10.7	12.5	9.3	4.1	3.9	2.7	2.9	5.4	67
90/91	5.4	9.8	13.4	13.6	12.3	13.7	12.0	4.6	2.4	2.0	2.3	8.6	76
91/92	7.9	10.1	12.4	9.8	9.2	12.2	21.3	3.1	2.7	1.3	2.1	7.8	101
92/93	3.4	14.6	14.9	23.6	12.5	9.0	3.6	3.8	2.0	3.9	2.3	6.2	93
93/94	10.2	15.1	10.1	15.4	5.0	14.0	15.9	5.0	2.1	2.0	1.7	3.6	89
94/95	6.7	15.3	16.2	25.0	6.8	12.1	7.3	2.8	1.1	1.9	1.7	3.1	81
95/96	6.6	13.7	18.5	16.1	6.2	8.4	4.7	9.6	3.1	2.0	6.6	4.4	105
96/97	5.8	14.7	18.2	15.1	8.7	7.6	10.7	7.6	1.9	4.9	2.0	2.7	98
97/98	6.4	23.4	18.1	8.2	7.3	13.4	8.5	4.4	4.3	2.2	2.4	1.5	100
98/99	4.5	11.3	12.2	12.1	6.7	13.0	14.0	7.4	4.1	4.7	6.2	3.7	74
99/00	7.3	10.1	9.1	6.3	7.5	12.0	19.3	6.9	5.7	3.5	3.7	8.7	105
00/01	4.4	10.5	10.4	10.2	9.3	8.0	17.6	9.3	9.5	3.1	2.2	5.5	126
01/02	11.6	15.3	9.5	8.3	6.3	10.9	11.0	4.7	9.6	3.8	2.1	6.9	96
02/03	10.9	20.3	12.2	8.7	8.4	6.3	11.9	9.8	3.5	3.2	2.2	2.7	113
03/04	20.2	15.5	7.3	5.0	5.9	9.7	10.2	5.8	4.4	2.7	9.5	3.8	104
04/05	4.9	9.0	11.6	12.6	10.4	9.4	10.6	10.5	7.3	3.2	5.8	4.6	108
05/06	6.1	10.0	8.4	13.3	8.5	10.6	9.9	11.9	7.6	4.9	2.3	6.4	98
06/07	3.9	9.3	15.1	8.7	12.0	10.1	10.8	4.4	13.4	5.5	3.8	3.0	121
07/08	6.5	13.7	6.6	18.6	9.3	8.8	8.2	9.0	4.6	4.1	2.7	8.0	88
08/09	3.1	6.3	9.7	10.2	5.8	15.8	10.6	6.5	11.1	7.6	3.6	9.7	99
09/10	6.2	10.2	13.1	12.5	6.4	8.9	10.1	10.4	8.3	3.7	3.1	7.2	123
10/11	11.2	13.4	7.3	11.1	10.3	10.0	9.9	9.0	7.5	2.0	3.7	4.7	108
11/12	7.6	10.0	21.3	11.2	7.3	6.4	10.3	10.4	3.9	4.3	2.4	5.1	135
12/13	5.0	15.5	15.4	10.1	8.9	10.2	7.5	6.4	8.8	3.3	3.5	5.5	126
13/14	8.9	18.6	13.4	7.2	7.6	8.1	6.8	7.5	8.6	3.5	5.0	4.9	168
14/15	9.0	14.7	13.3	10.0	6.1	14.2	8.3	6.8	6.5	4.1	3.1	4.0	174
Mean	7.5	13.5	12.7	11.6	8.2	10.4	10.7	7.2	6.0	3.5	3.5	5.2	2 779
SPO 7													
89/90	4.9	11.0	7.1	15.4	9.3	10.0	7.1	4.2	10.5	6.9	6.2	7.4	112
90/91	22.9	15.4	7.0	10.8	5.4	8.2	9.7	7.3	2.2	2.5	4.6	3.8	103
91/92	12.2	17.2	10.5	5.4	4.6	8.1	10.1	8.7	7.1	3.9	4.1	8.1	92
92/93	8.2	15.9	11.7	8.6	9.5	10.9	8.6	6.4	3.1	6.6	4.1	6.5	107
93/94	6.1	20.4	15.5	4.8	5.9	8.0	11.6	7.9	6.8	3.8	3.2	6.1	90
94/95	14.8	15.1	13.4	7.9	5.4	11.4	9.0	8.8	5.8	2.2	3.0	3.3	131
95/96	8.9	15.2	8.6	13.9	5.2	5.8	10.5	9.7	11.7	3.8	2.8	4.0	114
96/97	13.1	14.5	12.2	10.9	5.9	6.7	10.3	5.9	7.8	4.7	3.5	4.6	118
97/98	8.2	9.4	11.1	4.2	6.4	6.7	17.1	18.4	6.5	5.1	2.9	4.1	93
98/99	7.3	14.6	5.9	7.2	17.6	9.7	9.4	7.1	8.6	6.0	3.3	3.3	129
99/00	5.5	9.7	8.7	8.3	13.9	8.4	5.9	11.1	7.1	5.9	7.2	8.3	121
00/01	10.8	13.2	11.0	7.0	5.2	15.4	6.6	7.4	8.6	4.6	3.6	6.6	121
01/02	19.4	16.4	11.2	7.8	9.0	5.5	8.3	5.6	5.3	4.6	3.2	3.6	101
02/03	14.7	16.2	11.6	9.9	3.5	6.9	12.3	8.1	3.6	2.6	3.4	7.3	86
03/04	14.5	15.5	8.9	4.5	4.9	10.4	11.5	8.0	6.1	4.9	4.5	6.2	96
04/05	12.9	17.0	9.0	8.8	4.4	5.4	10.3	9.8	5.8	4.0	4.5	8.1	100
05/06	10.4	14.5	12.1	5.3	6.5	6.7	8.7	10.7	6.5	7.7	5.3	5.6	109
06/07	11.6	16.8	8.0	10.4	6.2	9.2	10.2	9.0	5.6	4.6	2.6	5.7	106
07/08	8.9	17.8	14.0	6.1	5.1	10.1	8.6	10.1	6.7	4.3	3.5	4.7	127
08/09	10.4	10.0	4.6	6.0	6.3	10.8	11.8	11.5	7.8	7.1	7.0	6.8	133
09/10	15.9	18.7	12.2	7.5	8.4	6.3	9.3	6.8	4.7	3.4	2.8	4.1	135
10/11	9.3	17.8	11.1	5.0	4.2	8.8	11.1	8.2	9.2	3.5	5.1	6.6	126
11/12	10.3	18.2	10.3	4.6	3.7	12.3	8.1	7.5	10.2	6.4	4.8	3.8	121
12/13	9.6	17.6	9.0	5.5	8.1	9.7	9.7	8.7	8.4	3.9	5.2	4.7	140
13/14	10.3	15.6	13.2	5.5	11.5	8.4	6.9	8.8	5.2	5.7	3.9	5.1	149
14/15	15.3	12.7	6.6	7.3	7.9	10.9	5.4	7.0	7.0	5.2	5.8	8.9	156
Mean	11.4	15.2	10.1	7.6	7.3	9.0	9.3	8.5	6.9	4.8	4.3	5.6	3 016

Table H.3 [Continued]:

Fishing year	Month												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
SPO 8													
89/90	33.8	2.6	1.2	2.4	5.9	9.0	10.8	4.9	6.4	5.0	10.1	8.0	27
90/91	11.7	8.9	6.8	12.2	9.1	5.8	5.0	5.2	7.7	8.2	11.7	7.8	13
91/92	6.5	2.9	7.1	26.5	2.1	3.5	9.9	6.7	7.6	4.5	10.0	12.7	10
92/93	9.5	2.1	6.4	4.9	9.6	16.7	14.6	7.8	5.6	6.8	7.7	8.3	9
93/94	2.0	2.9	5.5	10.9	2.0	12.5	19.1	7.9	12.9	7.0	9.3	7.9	8
94/95	3.3	2.1	2.6	3.2	6.7	12.2	18.2	14.8	23.2	4.3	4.7	4.7	14
95/96	12.2	6.1	4.9	12.5	2.6	11.5	13.8	12.2	9.4	2.5	0.6	11.8	21
96/97	6.1	4.9	5.8	4.7	15.7	10.9	12.1	10.6	13.8	0.9	1.8	12.7	28
97/98	11.9	3.6	9.9	13.6	6.8	15.3	11.8	13.4	5.7	2.2	3.0	2.7	28
98/99	5.2	19.8	8.5	13.9	9.4	6.6	7.2	6.9	8.9	3.7	1.9	8.0	25
99/00	1.8	6.9	8.3	4.1	11.9	14.0	12.3	21.5	4.8	5.4	1.6	7.3	24
00/01	1.5	9.1	12.5	4.2	15.1	12.7	11.1	3.3	9.8	10.5	3.4	6.8	13
01/02	2.7	6.4	5.5	8.6	6.6	7.7	19.3	6.2	5.3	5.8	9.2	16.6	26
02/03	14.7	9.0	4.3	6.5	8.9	8.2	7.4	10.0	7.0	6.6	6.2	11.4	22
03/04	3.0	7.1	5.2	6.4	6.8	13.7	20.0	10.7	9.0	9.7	2.2	6.0	18
04/05	23.5	5.2	5.6	4.4	7.1	10.7	6.9	8.4	2.7	6.0	4.7	14.8	17
05/06	3.3	5.2	4.3	9.1	12.7	9.4	8.1	7.0	9.6	13.0	3.6	14.5	15
06/07	1.8	6.7	4.9	4.7	7.6	4.6	9.8	10.0	11.3	13.8	15.5	9.3	17
07/08	4.0	4.8	2.4	8.8	8.1	9.0	16.1	5.0	8.4	13.0	7.5	12.9	15
08/09	8.3	4.4	3.8	2.7	5.9	11.3	4.6	3.9	28.6	12.1	8.7	5.8	15
09/10	15.5	4.5	15.0	5.7	2.8	4.6	9.3	11.6	5.9	5.1	7.5	12.5	23
10/11	22.1	2.5	5.7	5.2	6.2	4.4	1.6	3.7	32.7	10.1	3.6	2.2	27
11/12	13.5	0.6	4.9	5.5	5.6	3.6	10.3	4.5	5.4	18.4	11.8	15.9	23
12/13	8.6	11.8	4.4	3.7	4.1	11.4	4.5	7.7	6.0	18.9	7.7	11.2	18
13/14	17.6	6.5	3.2	7.3	2.8	1.8	2.7	9.2	5.1	12.3	13.7	17.8	19
14/15	7.2	10.4	4.7	12.9	2.9	6.4	5.1	4.2	16.9	8.5	14.7	6.2	16
Mean	10.6	6.2	6.0	7.5	7.3	9.0	10.2	8.6	10.3	7.9	6.6	9.8	491
SPO 1W													
89/90	5.7	7.2	2.3	8.9	7.3	14.6	14.7	6.4	3.9	1.7	12.0	15.4	28
90/91	18.4	7.9	2.8	12.6	13.2	7.1	4.0	9.5	3.3	6.6	3.7	10.8	21
91/92	11.9	8.1	6.3	5.2	16.5	5.6	3.9	3.0	11.0	2.6	5.1	20.8	27
92/93	11.4	11.0	5.2	8.8	8.2	16.9	6.5	4.7	4.8	10.3	4.9	7.3	65
93/94	13.4	13.1	5.4	12.9	14.9	8.2	4.7	5.1	4.5	7.4	4.6	5.8	52
94/95	15.3	8.9	5.0	11.0	10.2	11.1	8.1	6.2	2.8	2.4	5.5	13.4	44
95/96	10.5	9.0	6.6	9.3	17.0	7.2	6.7	6.6	4.0	5.2	3.4	14.5	46
96/97	13.1	5.2	8.1	6.7	8.2	8.8	9.2	4.9	9.2	5.3	3.1	18.2	46
97/98	10.6	11.4	5.7	6.4	12.1	12.7	4.9	7.6	3.8	6.9	7.4	10.4	45
98/99	9.2	8.5	5.4	7.0	13.8	17.2	6.8	8.9	4.6	1.9	7.8	8.9	52
99/00	14.4	6.0	5.2	6.6	11.3	12.3	9.3	10.0	8.2	5.6	4.7	6.2	48
00/01	4.9	5.1	3.7	10.1	15.7	15.0	11.4	4.2	5.5	4.6	7.0	12.9	51
01/02	7.7	6.0	6.8	10.0	11.5	9.0	10.9	10.3	2.4	7.1	9.6	8.5	39
02/03	5.8	13.4	5.0	5.1	9.3	9.4	10.5	9.8	10.2	6.9	9.2	5.3	52
03/04	12.7	8.5	5.2	6.6	10.2	12.3	12.3	4.9	5.5	6.1	6.7	8.9	35
04/05	11.0	10.2	5.6	6.4	11.6	7.7	7.4	7.6	4.9	8.2	7.7	11.8	32
05/06	14.4	7.8	7.3	7.7	9.8	8.7	9.8	7.6	6.3	4.8	9.4	6.3	24
06/07	10.2	6.6	5.7	11.5	9.4	16.5	8.8	6.8	2.1	12.2	4.6	5.8	23
07/08	7.9	9.9	2.0	8.1	10.2	12.1	8.2	6.9	7.3	10.6	7.7	9.2	33
08/09	8.2	10.8	6.6	7.4	8.5	19.5	5.8	2.3	5.3	4.6	9.6	11.4	27
09/10	5.4	7.9	5.8	9.6	15.3	19.7	10.3	1.2	0.7	3.8	9.0	11.2	27
10/11	5.9	10.5	5.3	10.6	7.3	5.8	16.1	1.6	5.9	8.2	9.1	13.7	33
11/12	11.0	12.0	5.0	4.8	10.8	11.8	6.9	4.5	6.1	5.9	12.7	8.6	56
12/13	8.0	7.1	3.6	7.6	11.4	16.9	15.9	8.5	4.9	2.6	4.5	9.0	59
13/14	9.3	9.7	6.3	6.9	5.5	18.6	6.1	5.5	6.2	8.5	8.5	8.9	73
14/15	3.5	5.6	6.5	12.4	11.8	6.9	13.0	4.3	7.1	7.4	10.8	10.8	66
Mean	9.7	8.8	5.4	8.4	11.1	12.2	9.0	6.2	5.6	6.1	7.2	10.3	1 106

Table H.4: Distribution of landings (%) by fishing year and by target species for setnet in each QMA (see Appendix A for definitions of codes in the table) based on trips that landed rig. The final column for each QMA gives the annual total setnet landings (t) in each QMA. These values are plotted in Figure 14. [Continued on next pages]

Fishing	SPO 1E										SPO 2									
year	SPO	SNA	FLA	TRE	KAH	GUR	POR	TAR	OTH	Total	SPO	WAR	MOK	FLA	SCH	KIN	BUT	GUR	OTH	Total
89/90	73.8	15.7	0.9	1.6	0.7	0.6	5.7	0.1	0.8	177	52.4	15.7	11.7	3.8	0.9	2.5	0.4	0.9	11.8	19
90/91	77.5	10.6	2.3	6.3	1.0	0.9	0.0	0.1	1.2	224	37.9	23.8	8.6	5.6	4.1	7.2	0.7	12.0	0.2	16
91/92	76.7	14.6	1.4	3.2	0.9	2.2	0.0	0.2	0.7	338	34.8	23.8	5.6	15.5	2.5	8.2	1.1	3.4	5.1	23
92/93	76.2	9.6	2.6	5.3	2.0	1.4	0.0	1.0	2.0	322	39.1	9.2	8.1	9.7	7.8	8.3	1.9	6.7	9.2	23
93/94	83.3	5.4	2.5	3.8	0.7	0.8	0.0	2.2	1.5	270	44.5	18.7	5.5	10.5	2.9	5.3	1.6	5.6	5.3	29
94/95	86.5	3.5	1.3	3.8	1.5	1.0	–	0.6	1.9	239	25.6	34.3	4.2	7.0	5.5	4.9	3.2	0.8	14.4	19
95/96	84.4	3.9	1.8	4.3	0.9	2.5	–	0.5	1.8	161	31.9	21.6	9.4	22.7	6.3	2.3	1.6	2.4	1.9	35
96/97	81.3	3.0	4.2	8.1	0.3	1.6	0.0	0.4	1.0	176	13.4	36.2	7.3	18.3	2.6	9.8	3.3	5.9	3.3	25
97/98	77.9	3.2	8.1	7.6	1.7	0.4	–	0.4	0.7	163	20.6	35.5	13.2	13.8	1.7	7.6	2.3	1.4	4.1	17
98/99	83.7	2.8	5.1	6.4	0.2	0.2	0.0	0.5	1.1	145	25.0	42.9	10.7	8.2	–	5.9	2.3	3.0	1.9	20
99/00	89.2	2.2	3.9	3.5	0.2	0.1	0.0	0.3	0.5	155	13.4	48.1	11.7	17.4	0.2	6.9	0.9	1.2	0.1	23
00/01	84.5	2.6	4.5	6.0	0.0	0.1	–	0.2	2.1	140	29.6	14.6	32.9	5.9	8.9	2.2	4.2	1.5	0.2	23
01/02	90.2	3.2	3.5	2.3	0.0	0.1	–	0.1	0.5	160	33.5	20.3	25.7	11.8	2.3	0.3	1.9	3.1	1.1	26
02/03	86.4	2.5	7.5	2.1	0.0	0.3	0.0	0.0	1.3	150	24.1	27.5	15.2	19.5	2.5	1.5	1.4	5.6	2.7	16
03/04	79.7	5.9	4.8	8.4	0.0	–	0.0	0.1	1.1	159	14.8	30.8	33.7	9.6	4.9	–	2.8	2.3	1.0	14
04/05	82.2	1.9	6.8	7.2	0.3	0.0	0.1	0.1	1.4	131	26.3	27.0	17.6	17.8	0.4	–	2.9	0.0	7.9	20
05/06	77.3	6.6	10.0	4.1	0.9	0.0	0.1	0.0	1.0	101	4.1	47.1	35.4	8.5	–	–	2.4	–	2.6	16
06/07	82.6	3.2	7.6	3.2	0.2	0.2	0.5	0.1	2.2	105	34.7	16.2	35.6	10.5	0.6	–	2.0	–	0.4	19
07/08	81.7	2.3	8.3	2.9	3.1	0.0	0.6	0.1	1.1	90	22.4	10.5	22.5	16.9	19.2	1.7	1.5	–	5.2	21
08/09	78.4	1.3	12.1	3.0	2.1	0.1	2.0	0.1	0.9	95	30.2	14.1	28.9	8.1	11.1	1.0	2.7	0.0	3.9	39
09/10	78.1	1.7	13.7	3.2	1.7	0.1	0.1	0.2	1.2	101	40.9	6.4	22.9	8.0	15.3	0.6	1.4	–	4.4	28
10/11	74.6	4.0	13.2	3.2	1.7	–	1.4	0.0	1.8	72	51.7	3.6	12.5	7.9	18.8	0.3	2.7	–	2.6	27
11/12	82.7	2.9	7.7	4.5	1.0	0.0	0.2	–	0.9	85	64.9	5.0	12.1	6.6	7.5	0.1	1.7	–	2.0	38
12/13	83.3	4.3	4.9	2.9	1.0	0.2	1.3	0.2	2.1	101	60.8	9.0	12.0	7.0	8.5	0.2	1.0	0.3	1.2	25
13/14	86.9	1.5	4.8	3.4	1.0	0.0	0.6	0.0	1.8	85	79.0	3.9	3.9	2.2	4.5	4.3	1.5	–	0.7	30
14/15	84.9	2.7	4.1	3.6	0.8	0.0	1.0	0.1	2.8	70	49.3	2.6	18.3	3.3	21.7	0.9	2.2	–	1.6	31
Mean	81.3	5.8	4.6	4.5	0.9	0.7	0.4	0.4	1.3	4 015[1]	37.2	19.1	15.9	10.5	6.9	3.0	2.0	1.9	3.5	622[1]

[1] Total landings for all years.

Table H.4 [Continued]:

Fishing	SPO 3										SPO 7									
year	SPO	SCH	SPD	ELE	LIN	TAR	WAR	MOK	OTH	Total	SPO	SCH	SPD	ELE	FLA	SNA	LIN	TRE	OTH	Total
89/90	48.1	30.0	9.8	3.8	2.5	3.0	0.9	0.2	1.6	207	84.1	11.2	0.5	1.7	0.5	0.3	0.4	0.0	1.3	145
90/91	40.2	27.6	8.0	12.8	4.0	3.8	1.8	0.6	1.2	206	91.3	6.5	0.7	–	0.2	–	0.9	–	0.3	147
91/92	48.3	20.1	11.1	10.0	3.6	2.7	0.5	0.1	3.4	232	85.4	7.1	5.8	0.2	0.3	0.1	0.4	–	0.7	161
92/93	45.8	29.3	11.8	6.1	1.9	2.7	0.0	0.3	2.2	182	83.9	4.4	6.4	4.2	0.5	0.2	0.0	–	0.4	197
93/94	44.4	29.4	15.5	5.9	1.1	1.1	0.7	0.3	1.6	215	82.5	1.4	13.8	1.0	0.8	0.0	0.2	–	0.3	162
94/95	56.4	24.3	9.0	4.6	1.2	0.7	2.0	0.2	1.5	274	83.8	6.7	8.8	0.1	0.3	–	0.0	–	0.2	193
95/96	52.6	26.7	8.5	4.5	2.7	1.2	2.4	0.3	1.2	289	80.2	8.4	6.7	2.1	0.4	0.0	0.1	1.7	0.4	228
96/97	47.4	29.8	8.3	6.3	2.8	0.8	1.2	0.8	2.5	327	88.9	5.2	2.8	2.6	0.4	–	0.1	–	0.2	224
97/98	59.2	27.6	4.6	1.7	2.6	1.9	0.6	0.7	1.1	330	93.8	3.9	1.3	0.1	0.2	0.3	0.0	–	0.4	196
98/99	61.2	22.5	8.1	1.4	3.7	1.5	0.2	0.1	1.2	323	94.9	3.7	0.3	0.1	0.6	0.1	0.0	–	0.4	182
99/00	56.6	25.5	0.4	1.2	8.3	2.2	4.2	0.1	1.5	304	93.1	2.5	0.3	0.0	0.2	1.4	2.4	0.0	0.1	176
00/01	64.8	20.5	2.7	0.4	6.3	2.0	1.7	0.0	1.7	356	95.7	2.9	0.4	0.0	0.3	0.1	0.0	–	0.6	217
01/02	77.7	10.5	5.8	1.0	1.5	1.5	0.7	0.0	1.4	303	96.9	1.8	0.7	0.2	0.0	0.3	–	–	0.1	168
02/03	81.2	12.1	2.8	0.9	1.4	1.2	0.0	0.0	0.2	324	95.4	1.9	0.7	1.7	0.2	–	0.0	–	0.0	167
03/04	83.1	10.6	2.0	1.1	1.8	0.7	0.0	0.0	0.5	282	98.0	1.1	0.2	0.1	0.1	0.4	0.0	–	0.1	198
04/05	81.3	11.4	0.6	3.2	2.2	0.6	0.1	0.1	0.5	272	95.2	2.8	–	1.2	0.1	0.7	–	–	0.1	168
05/06	78.3	14.5	2.7	3.6	0.0	0.2	0.0	0.1	0.6	291	94.1	5.2	0.1	0.0	0.5	0.2	0.0	–	0.0	191
06/07	77.2	17.8	1.7	2.2	0.1	0.3	0.0	0.1	0.5	330	96.0	3.7	0.0	0.1	–	0.1	0.0	–	0.1	162
07/08	72.0	24.0	0.7	1.3	0.0	0.2	0.1	1.4	0.3	380	92.9	7.0	–	–	0.0	0.1	–	–	0.0	112
08/09	60.5	35.0	0.3	2.7	0.1	0.3	–	0.9	0.2	244	83.4	16.1	0.2	–	0.1	–	–	–	0.1	103
09/10	58.9	33.9	1.0	3.0	0.4	0.2	0.0	1.6	1.0	257	89.9	5.6	3.1	0.3	0.1	0.9	–	–	0.1	86
10/11	59.3	32.2	0.2	4.7	1.1	0.1	0.0	2.1	0.3	265	89.8	9.8	0.2	0.0	0.0	–	0.0	–	0.1	108
11/12	64.2	28.8	1.8	3.0	0.2	0.3	0.1	1.2	0.6	269	90.3	9.0	0.0	0.2	0.1	–	–	–	0.5	109
12/13	67.7	24.1	0.1	5.5	0.0	0.4	0.0	1.7	0.5	313	86.8	11.8	–	0.1	0.1	0.0	–	–	1.3	91
13/14	72.4	21.0	1.5	3.1	0.0	0.4	–	1.2	0.4	293	91.4	7.9	–	–	0.1	–	–	–	0.6	86
14/15	75.7	20.2	0.4	2.3	0.0	0.2	0.1	0.6	0.5	342	94.0	5.5	–	–	0.1	–	–	–	0.3	78
Mean	64.1	23.0	4.2	3.4	1.9	1.1	0.7	0.6	1.0	7 412[1]	90.5	5.4	2.4	0.7	0.3	0.2	0.2	0.1	0.3	4 054[1]

[1] Total landings for all years.

Table H.4 [Continued]:

Fishing	SPO 8										SPO 1W									
year	SPO	SCH	WAR	GUR	TRE	SPD	SNA	KIN	OTH	Total	SPO	GUR	FLA	TRE	SCH	GMU	KAH	JMA	OTH	Total
89/90	76.0	14.7	1.6	0.5	2.5	0.6	0.6	2.9	0.6	136	88.0	1.1	1.1	2.0	6.7	0.5	0.6	–	0.1	166
90/91	78.0	8.7	2.0	2.2	2.7	1.0	2.6	2.7	0.1	121	88.1	1.2	2.3	3.0	2.5	1.7	0.4	–	0.8	133
91/92	78.0	7.7	5.3	2.6	2.1	0.7	0.9	2.2	0.5	93	87.6	1.4	3.1	4.3	1.1	1.7	0.4	0.0	0.4	149
92/93	85.8	5.3	3.8	0.6	2.2	0.1	1.1	0.5	0.6	181	84.5	4.5	2.7	3.3	2.6	1.4	0.5	–	0.4	137
93/94	88.3	3.9	2.8	0.5	2.0	1.4	0.8	0.2	0.1	181	87.6	2.8	2.8	2.3	2.0	0.7	1.5	–	0.4	163
94/95	89.6	3.2	2.1	1.1	1.6	1.2	0.7	0.0	0.4	207	86.4	5.4	1.6	1.9	3.3	0.5	0.2	0.4	0.3	232
95/96	85.1	6.2	3.0	0.6	2.3	1.3	0.3	0.0	1.2	232	85.8	5.8	1.2	3.0	3.1	0.2	0.6	0.0	0.3	212
96/97	85.3	6.2	3.4	3.9	0.8	0.2	0.1	0.1	0.0	186	87.3	5.3	1.4	3.1	2.4	0.2	0.0	0.0	0.2	314
97/98	84.8	3.4	3.3	5.0	1.2	0.8	0.2	0.0	1.3	183	76.3	10.2	2.3	4.7	3.1	1.0	0.0	1.3	1.1	280
98/99	88.9	5.7	1.9	2.4	0.8	0.2	0.2	0.0	0.0	164	75.0	12.5	3.0	5.0	2.1	0.5	0.0	0.4	1.4	226
99/00	86.7	3.3	6.7	1.1	1.5	–	0.1	–	0.6	129	83.4	8.0	3.7	1.2	2.6	0.7	0.0	–	0.5	276
00/01	83.0	5.0	5.9	4.5	0.7	0.1	0.0	–	0.8	129	87.3	8.8	1.7	0.2	1.1	0.6	0.0	–	0.3	302
01/02	89.9	3.1	6.5	0.4	0.1	0.1	0.0	–	0.0	162	86.0	7.9	2.3	0.8	1.9	0.9	0.1	–	0.1	214
02/03	91.3	3.5	4.1	0.1	0.6	0.3	0.0	–	0.0	167	77.0	18.0	2.3	0.3	1.2	0.5	0.0	–	0.6	225
03/04	90.0	6.4	3.0	–	0.1	–	0.3	–	0.1	145	73.9	20.6	2.3	0.3	1.7	1.0	–	–	0.1	241
04/05	86.8	4.8	7.7	–	0.3	–	–	–	0.5	147	78.8	14.8	2.8	2.3	0.3	0.7	0.1	–	0.2	224
05/06	89.5	5.3	3.4	1.0	0.1	–	0.1	–	0.5	128	76.9	16.5	3.3	1.6	0.3	1.2	0.0	–	0.2	141
06/07	82.6	11.2	1.9	3.4	0.4	–	–	–	0.4	118	87.9	3.4	4.0	1.6	1.2	1.3	0.2	–	0.5	177
07/08	91.4	5.5	2.4	–	0.2	–	0.0	–	0.4	149	87.3	–	5.5	2.6	1.4	2.6	0.2	–	0.3	102
08/09	84.9	8.0	5.4	–	0.8	0.0	–	–	0.9	140	86.0	0.1	6.5	2.3	2.3	2.7	0.1	–	0.0	101
09/10	85.1	6.5	7.1	–	1.0	–	–	–	0.3	164	86.2	–	6.0	2.7	1.1	3.3	0.5	–	0.2	95
10/11	86.8	8.7	3.8	–	0.3	0.3	–	–	0.1	153	88.1	0.2	6.5	1.3	2.7	1.1	0.0	–	0.1	125
11/12	87.8	7.6	2.5	–	1.8	–	–	–	0.3	120	88.0	2.3	4.5	0.8	1.8	2.4	0.0	–	0.1	126
12/13	68.6	22.3	7.1	–	1.8	–	–	–	0.3	67	83.2	3.3	4.7	2.2	2.7	2.7	0.6	–	0.6	136
13/14	81.9	12.4	4.4	0.1	0.8	–	–	–	0.3	136	82.9	2.8	5.7	3.1	2.4	2.8	0.1	–	0.2	124
14/15	82.0	12.1	3.0	0.6	1.3	0.6	0.0	–	0.4	112	88.1	0.7	3.0	3.2	2.6	1.5	0.6	–	0.2	131
Mean	85.6	6.7	3.9	1.2	1.2	0.4	0.3	0.3	0.4	3 849[1]	83.6	7.3	2.9	2.2	2.2	1.1	0.2	0.1	0.4	4 754[1]

[1] Total landings for all years.

Table H.5: Distribution of landings (%) by fishing year and by target species for bottom trawl in each QMA (see Appendix A for definitions of codes in the table) based on trips that landed rig. The final column for each QMA gives the annual total bottom trawl landings (t) in each QMA. These values are plotted in Figure 15. [Continued on next pages]

Fishing	SPO 1E										SPO 2									
year	SNA	TAR	JDO	TRE	GUR	SKI	HOK	BAR	OTH	Total	GUR	TAR	FLA	SNA	SKI	TRE	WAR	HOK	OTH	Total
89/90	73.2	5.5	10.1	2.1	1.5	1.9	0.0	1.8	3.9	61	23.9	49.0	7.1	4.0	3.2	6.1	1.1	1.8	3.9	36
90/91	79.1	6.6	4.7	2.9	4.1	1.0	0.0	0.2	1.4	64	32.6	45.5	4.1	2.0	2.9	5.2	1.0	1.3	5.4	29
91/92	69.1	11.6	3.9	1.1	5.1	4.2	0.3	1.3	3.4	80	48.2	29.6	4.5	1.4	4.2	2.1	1.4	1.2	7.4	58
92/93	56.6	9.5	16.0	3.6	10.0	2.3	0.4	1.4	0.2	44	48.0	25.5	5.4	0.5	5.2	8.0	2.1	0.7	4.6	63
93/94	50.4	15.2	13.6	6.3	4.9	7.0	0.3	1.0	1.2	32	39.6	23.7	7.4	5.4	6.3	6.1	1.1	5.6	4.7	54
94/95	51.2	18.8	18.1	2.8	1.1	2.5	2.2	0.9	2.5	23	33.9	30.7	13.0	1.8	6.3	5.4	2.1	2.8	3.9	54
95/96	38.2	13.9	14.1	5.2	0.7	22.2	1.4	0.7	3.6	30	34.0	20.2	17.9	1.5	7.4	5.0	3.3	4.4	6.4	66
96/97	34.7	19.5	22.1	6.0	5.9	2.3	6.1	1.3	2.2	18	35.3	22.2	19.0	1.5	7.5	1.9	3.6	3.8	5.2	65
97/98	44.2	14.1	21.5	5.0	3.2	3.1	3.9	1.6	3.4	22	34.9	27.8	14.2	2.4	5.4	2.2	1.6	8.2	3.3	56
98/99	32.4	14.9	18.8	13.3	12.4	3.5	1.1	1.9	1.6	26	35.1	28.0	11.3	5.7	3.5	1.3	4.0	3.2	7.9	57
99/00	21.3	10.0	17.6	19.2	22.7	1.6	2.3	1.2	4.0	29	41.4	34.1	7.7	1.8	3.0	1.4	2.7	1.8	6.0	51
00/01	24.9	13.9	18.2	19.2	11.9	2.0	1.8	3.5	4.5	21	48.6	31.6	3.5	2.2	2.1	0.9	3.6	1.1	6.4	50
01/02	31.0	14.4	16.1	17.6	9.6	1.8	0.5	2.9	6.2	22	54.2	30.3	2.4	1.2	3.2	1.3	2.7	0.5	4.0	56
02/03	24.2	26.2	16.6	16.1	10.6	2.6	0.9	1.1	1.7	19	61.4	26.7	1.6	2.1	1.8	0.4	1.8	0.2	4.0	70
03/04	29.5	24.4	10.6	22.4	9.3	0.6	0.9	1.3	1.0	19	52.3	35.4	1.4	3.4	2.6	1.2	0.9	0.3	2.7	62
04/05	35.5	16.4	14.0	14.3	16.7	0.6	1.9	0.1	0.5	26	55.4	38.1	1.2	2.3	0.2	0.3	1.4	0.2	0.9	94
05/06	32.4	21.3	11.4	9.3	20.9	1.0	0.4	0.3	2.9	31	51.6	41.1	2.8	1.9	0.1	0.5	1.3	0.0	0.7	101
06/07	41.8	18.1	19.5	10.7	7.3	0.1	1.4	0.2	0.9	25	46.2	41.9	4.8	2.9	0.4	1.3	0.6	0.0	1.8	85
07/08	38.2	24.7	19.0	12.3	3.6	0.3	0.4	0.4	1.1	22	49.2	41.5	4.8	1.2	0.1	0.3	0.9	0.0	1.9	87
08/09	40.0	28.7	9.0	18.1	2.9	0.1	0.2	0.0	0.9	27	50.6	41.2	3.0	2.1	0.2	0.6	0.4	0.3	1.5	78
09/10	37.2	31.7	7.8	14.4	3.9	0.5	1.5	0.0	2.9	27	59.1	32.4	3.0	3.2	0.1	0.3	0.3	0.3	1.2	98
10/11	32.8	34.3	8.1	19.7	2.0	0.3	1.0	0.0	1.9	24	54.4	37.3	4.3	1.1	0.1	0.3	0.3	0.2	2.0	85
11/12	42.5	30.7	8.3	13.7	1.1	0.8	0.9	0.3	1.8	21	57.0	32.2	6.6	2.0	0.0	0.2	0.2	0.1	1.7	85
12/13	48.7	20.9	9.1	16.2	2.3	0.5	1.2	0.2	1.0	21	50.4	38.1	7.8	1.3	0.1	0.9	0.2	0.1	1.0	85
13/14	48.6	27.2	9.7	11.9	1.1	0.2	0.4	0.0	0.9	29	52.0	33.0	8.5	3.6	0.1	0.8	0.8	0.1	1.2	104
14/15	49.9	25.3	9.5	11.0	2.9	0.0	0.5	0.1	0.7	28	54.2	33.4	6.1	2.9	0.3	1.0	0.2	0.1	1.9	86
Mean	48.3	17.0	12.0	9.4	6.5	2.6	1.0	0.9	2.2	790[1]	48.2	33.7	6.4	2.3	2.1	1.7	1.4	1.2	3.1	1 816[1]

[1] Total landings for all years.

Table H.5 [Continued]:

Fishing	SPO 3											SPO 7										
year	FLA	RCO	SPO	STA	ELE	BAR	TAR	SQU	GUR	OTH	Total	FLA	BAR	TAR	RCO	GUR	WAR	SNA	STA	GSH	OTH	Total
89/90	39.2	18.1	1.4	7.9	6.7	8.4	2.8	0.7	2.9	11.8	67	54.1	8.7	6.9	5.6	3.8	0.6	4.2	3.7	0.8	11.7	112
90/91	44.0	14.9	7.0	6.0	2.2	12.8	1.9	0.3	1.5	9.4	76	41.4	17.4	6.6	4.4	4.6	1.9	2.9	1.0	0.8	18.9	103
91/92	39.0	20.1	4.0	7.2	3.7	6.0	3.3	11.6	1.6	3.5	101	41.9	19.4	11.6	10.3	5.2	1.1	1.1	2.0	0.5	6.8	92
92/93	46.1	28.2	3.2	8.4	2.1	6.7	0.7	0.0	1.1	3.5	93	49.2	19.8	4.3	17.3	2.8	0.6	1.8	0.1	0.8	3.4	107
93/94	28.5	37.8	8.2	15.0	4.9	1.3	2.0	0.6	0.8	0.8	89	54.8	15.4	8.8	10.1	3.3	0.5	1.0	0.5	0.6	4.9	90
94/95	26.9	50.6	4.5	7.9	2.2	4.0	0.9	0.3	0.4	2.3	81	52.2	21.2	6.0	10.4	1.3	0.5	0.6	0.7	1.2	5.7	131
95/96	31.5	38.7	5.3	3.7	5.9	5.8	5.5	0.4	1.2	1.8	105	42.9	23.6	5.4	15.2	2.2	0.8	0.3	0.3	0.3	9.0	114
96/97	38.0	36.5	2.5	4.9	2.2	3.6	4.4	4.6	2.0	1.4	98	50.5	33.0	4.1	5.2	1.2	1.5	0.9	0.3	0.1	3.2	118
97/98	47.6	39.0	0.4	6.5	0.8	3.5	1.0	0.1	0.3	0.9	100	53.7	26.7	3.6	4.0	1.6	0.2	0.8	0.5	0.1	8.8	93
98/99	50.7	25.8	0.0	11.1	0.5	5.9	2.0	1.0	0.4	2.6	74	52.4	15.9	5.7	15.0	1.0	2.4	1.8	0.8	0.2	5.0	129
99/00	42.5	26.5	0.3	8.3	0.8	3.4	1.4	6.9	1.6	8.3	105	41.9	35.5	6.8	1.0	1.6	6.8	2.4	1.1	0.4	2.4	121
00/01	38.6	32.4	0.2	7.1	0.4	3.9	3.0	9.6	3.0	1.8	126	46.8	37.1	6.6	2.6	3.3	0.3	0.8	0.4	0.1	2.1	121
01/02	30.3	32.6	2.3	6.3	0.9	9.2	2.0	4.6	4.1	7.7	96	44.1	28.1	5.0	9.0	7.8	1.7	0.7	0.6	0.3	2.9	101
02/03	34.8	25.2	1.0	6.4	4.5	12.9	4.1	6.8	1.8	2.7	113	44.4	21.9	8.9	10.1	4.8	2.3	1.7	1.7	0.6	3.5	86
03/04	27.8	29.1	3.3	8.2	6.1	9.3	4.1	0.8	1.2	10.0	104	44.0	23.7	8.9	10.3	3.9	2.0	1.2	2.6	0.6	2.8	96
04/05	39.8	24.1	1.6	7.8	5.1	3.6	6.3	6.3	2.3	2.9	108	47.0	18.7	10.4	13.2	1.3	2.9	1.1	2.3	0.9	2.2	100
05/06	31.0	25.8	0.3	9.7	9.3	4.7	4.2	8.6	1.8	4.7	98	47.4	11.1	9.2	17.0	0.9	1.6	2.5	4.7	2.5	3.1	109
06/07	30.2	16.4	5.2	5.0	15.0	5.6	5.3	1.3	2.6	13.3	121	56.4	8.3	9.2	11.2	1.2	3.0	1.9	4.8	0.7	3.2	106
07/08	37.1	13.1	2.5	5.2	11.7	5.1	7.1	9.1	1.1	8.0	88	52.7	10.7	13.1	11.1	1.2	2.6	1.3	3.9	0.7	2.6	127
08/09	27.9	18.7	12.3	9.6	13.0	5.5	7.5	0.1	2.5	2.9	99	54.8	10.9	14.3	9.8	2.3	0.9	1.2	2.9	1.6	1.4	133
09/10	39.7	11.8	12.6	7.2	10.4	3.4	6.8	0.2	2.4	5.4	123	56.6	7.0	10.7	6.1	7.3	2.0	2.5	2.3	2.5	2.9	135
10/11	36.0	8.8	17.8	6.8	10.6	4.0	7.7	0.2	1.4	6.7	108	37.6	5.7	14.1	12.1	9.7	2.5	3.6	3.3	5.0	6.3	126
11/12	34.4	5.8	25.6	9.0	13.7	2.8	3.0	0.3	3.2	2.3	135	38.1	4.9	15.7	8.5	15.7	3.1	2.6	2.9	2.0	6.5	121
12/13	36.9	4.7	22.2	5.6	11.0	4.1	6.4	0.3	4.5	4.1	126	38.6	5.8	17.2	3.3	25.0	2.2	1.8	1.1	1.3	3.8	140
13/14	29.8	10.1	31.5	5.3	7.7	3.1	3.5	1.4	4.6	3.0	168	34.7	7.0	17.6	4.5	22.6	3.8	3.6	1.7	1.6	2.9	149
14/15	36.5	4.5	23.4	6.6	11.2	4.3	3.9	0.7	2.6	6.4	174	38.6	3.2	14.8	6.6	20.4	4.8	2.8	1.7	0.6	6.5	156
Mean	36.0	21.7	9.1	7.3	6.7	5.3	4.0	2.9	2.2	4.8	2 779[1]	46.6	16.3	9.8	8.8	6.6	2.1	1.9	1.8	1.1	5.0	3 016[1]

[1] Total landings for all years.

Table H.5 [Continued]:

Fishing	SPO 8											SPO 1W									
year	GUR	TRE	TAR	SNA	BAR	JDO	FLA	LEA	JMA	OTH	Total	SNA	TRE	GUR	TAR	SCH	BAR	JDO	SKI	OTH	Total
89/90	11.8	36.7	2.5	13.6	1.4	1.0	0.2	1.4	29.4	2.1	27	56.6	11.2	22.3	7.8	1.6	0.1	–	0.2	0.1	28
90/91	15.0	49.3	14.1	15.1	1.0	2.2	2.7	0.5	–	0.3	13	34.4	31.6	22.5	8.9	0.0	1.2	0.0	0.1	1.1	21
91/92	12.0	31.3	11.8	10.1	3.9	1.6	2.1	–	2.6	24.6	10	56.0	18.0	19.3	3.4	0.1	1.7	–	0.3	1.1	27
92/93	14.5	37.4	15.5	20.1	8.4	0.4	3.4	0.4	0.0	–	9	51.8	18.0	20.1	5.6	0.2	0.4	0.0	1.1	2.8	65
93/94	17.1	9.4	19.5	18.7	0.6	–	30.9	0.5	0.0	3.1	8	60.5	13.0	11.0	11.6	–	2.4	0.1	0.2	1.2	52
94/95	17.8	16.9	19.2	11.1	14.9	1.8	14.4	–	0.5	3.5	14	70.6	12.4	7.9	5.3	–	0.8	0.3	0.8	1.8	44
95/96	38.7	11.1	4.5	12.9	9.3	1.4	17.4	–	0.1	4.5	21	50.0	33.5	3.7	7.5	1.1	0.4	0.6	1.2	1.9	46
96/97	57.5	8.0	8.9	7.4	10.8	1.1	4.0	–	0.0	2.3	28	35.4	31.7	20.7	9.6	0.0	0.2	1.1	1.0	0.3	46
97/98	51.7	14.2	3.8	17.5	4.8	1.2	0.1	–	3.9	2.6	28	33.3	44.8	9.6	8.9	–	0.5	1.4	0.9	0.6	45
98/99	61.4	7.8	7.4	3.6	4.7	3.1	1.8	0.0	8.7	1.5	25	31.5	29.7	21.0	12.9	–	2.8	0.4	0.9	0.7	52
99/00	33.6	36.7	4.5	2.2	5.9	0.3	0.9	0.0	–	16.0	24	31.7	21.5	31.7	12.5	0.0	1.0	0.2	0.6	0.8	48
00/01	25.4	36.3	7.0	3.4	3.9	0.6	3.5	0.0	–	19.9	13	40.7	24.8	21.2	7.9	0.3	3.2	0.2	0.8	0.8	51
01/02	37.5	26.3	3.4	9.3	12.5	1.6	3.1	–	0.3	6.1	26	42.9	17.4	22.6	13.3	0.6	1.9	0.4	0.5	0.2	39
02/03	21.0	34.2	7.0	5.7	16.6	6.0	2.8	0.0	0.5	6.2	22	30.7	18.1	33.2	13.0	1.5	2.5	0.2	0.5	0.3	52
03/04	17.5	30.4	10.6	5.8	14.2	2.0	9.5	6.9	–	3.1	18	42.5	15.1	27.8	12.8	0.0	0.4	0.0	0.0	1.4	35
04/05	35.5	9.0	6.2	6.3	9.8	9.6	4.7	3.1	–	15.8	17	28.7	19.3	37.6	10.4	0.6	2.4	0.0	0.0	1.0	32
05/06	50.8	15.0	11.3	1.1	2.6	3.0	7.4	3.6	–	5.2	15	13.3	15.8	43.0	23.3	0.5	1.2	0.1	–	2.9	24
06/07	46.6	15.6	7.5	4.2	5.3	2.6	3.9	10.3	–	4.0	17	7.3	49.1	28.4	11.2	2.1	0.9	0.0	–	1.0	23
07/08	19.8	23.8	26.8	1.0	1.5	5.8	7.9	3.8	–	9.6	15	11.7	39.6	21.5	24.3	0.3	1.1	0.0	0.1	1.3	33
08/09	33.2	18.3	24.1	2.8	1.5	5.4	3.3	9.4	–	2.1	15	18.4	34.2	9.0	32.8	0.7	3.9	0.0	0.0	0.9	27
09/10	36.1	8.8	25.0	1.0	2.1	9.3	0.6	12.9	–	4.2	23	6.3	52.6	10.5	25.5	4.3	0.2	0.2	0.0	0.2	27
10/11	45.7	14.6	25.6	1.1	1.2	4.7	0.8	3.1	0.0	3.1	27	5.6	37.6	21.5	27.1	4.8	2.0	1.1	0.0	0.3	33
11/12	24.7	15.6	29.1	3.0	3.3	7.6	2.2	11.9	0.1	2.4	23	10.6	37.0	29.1	17.5	4.2	0.7	0.2	0.0	0.7	56
12/13	28.4	25.2	27.7	2.1	1.2	8.4	0.4	2.7	–	3.8	18	6.3	43.7	27.3	16.9	4.1	0.0	1.3	0.0	0.3	59
13/14	24.8	19.2	17.3	1.9	0.4	23.2	0.9	3.0	–	9.3	19	5.9	41.9	18.2	24.4	6.6	0.4	1.6	0.0	1.0	73
14/15	32.2	12.7	18.5	6.5	0.1	11.7	1.8	1.6	–	14.9	16	5.7	36.8	23.8	23.5	3.6	1.5	3.1	0.0	2.0	66
Mean	33.7	20.8	13.1	6.8	5.7	4.5	4.1	2.9	2.4	6.0	491[1]	30.2	29.0	21.4	14.4	1.6	1.3	0.6	0.4	1.1	1 106[1]

[1] Total landings for all years.

Appendix I. RIG CPUE ANALYSIS

I.1 General overview

Results and detailed diagnostics for 13 SPO CPUE standardisation analyses are presented from Appendix J to Appendix U. Twelve of these analyses are variants of previously published SPO CPUE analyses and one analysis is new. Table 12 (bottom trawl) and Table 13 (setnet) summarise how these analyses relate to the previous analyses (by providing the reference assessment years), including how the analyses have been specifically changed in 2013 and 2016. This Appendix contains the definitions for the modelled fisheries, equations used, along with the analytical and methodological procedures followed. Appendix J to Appendix U provide detailed tables and figures with statistics and diagnostics, and final tables giving the estimated indices with the standard error for each of the 13 analyses defined in Table 12 and Table 13.

I.2 Methods

I.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. Setnet landings were allocated to effort at the 'daily effort stratum' resolution procedure described in Section 2.3.1.5. However, it was noted that all the bottom trawl data sets had a very high proportion of trips that had no SPO estimated catches but that reported SPO landings (see 2nd column from the right in Table J.1, Table K.1, Table L.1, Table M.1 and Table N.1). In these situations, the procedures followed by Starr (2007) and Langley (2014) allocate landings to strata proportionate to the number of tows in the stratum. This is the default because there is no estimated catch to indicate which tows captured rig. Given the high proportion of trips that fall into this category and may bias the analysis, the bottom trawl data were analysed at the trip level, allocating to each trip the 'predominant' (most frequent) target species and statistical area, with each trip given its declared landings and not using the estimated catches.

The CPUE data sets were prepared using the 'Statistical Area' expansion procedure (Appendix F), whereby the landed catch in a statistical area was amalgamated without regard to the declared QMA. This procedure was used to maximise the number of data retained in the analysis. However, using this procedure means that these analyses pertain to the aggregation of statistical areas rather than to the indicated QMAs, with the inference to QMA being by preponderance of data and agreement by the Working Group rather than an analysis that is specific to the QMA.

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

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

This data set was further restricted to a 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.

I.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. I.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 $E_{i,y} = H_{i,y}$ ([*tows*]–for BT or [*net_length*]–for SN) 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. I.2 $$\hat{U}_y = \exp\left[\frac{\sum_{i=1}^{N_y} \ln\left(C_{i,y} / E_{i,y}\right)}{N_y}\right]$$

where C_i, $E_{i,y}$ and N_y are as defined for Eq. I.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 (if a lognormal distribution is assumed), when not using additional explanatory variables and using the same definition for $E_{i,y}$. Presenting the arithmetic and unstandardised CPUE indices in this report provides measures of how much the standardisation procedure has modified the series from these two sets of indices.

A standardised abundance index (Eq. I.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. I.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, and month (of landing), statistical area, target species, and a unique vessel identifier were also offered as categorical variables. Number of tows or length of net set $\left(\ln\left(S\right)_i\right)$ and fishing duration $\left(\ln\left(H_i\right)\right)$ were offered to the models as continuous third order polynomial variables.

For some models, trial regression models using five different distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) that predicted catch based on a fixed set of explanatory variables (year, month, area, vessel and $\ln\left(S\right)$) were evaluated by examining the residual diagnostics for each fitted model and then selecting the error distribution with the lowest negative log likelihood. The selected distribution was then used for the final stepwise positive catch regression.

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

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

The procedure described by Eq. I.3 is necessarily confined to the positive catch observations in the data set because the logarithm of zero is undefined. Observations with zero catch were modelled by fitting a linear regression model based on a binomial distribution and using the presence/absence of rig as the dependent variable (where 1 is substituted for $\ln(I_i)$ in Eq. I.3 if it is a successful catch record and 0 if it is not successful), using the same data set. Explanatory factors were estimated in the model in the same manner as described for Eq. I.3. Such a model provides an alternative series of standardised coefficients of relative annual changes that is analogous to the equivalent series estimated from the positive catch regression.

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

Eq. I.4
$$ {}^{C}Y_y = \frac{{}^{L}Y_y}{\left(1 - P_0\left[1 - {}^{1}\!/\!{}_{B}Y_y\right]\right)} $$

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

${}^{L}Y_y$ =positive catch index for year *i*

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

P_0 =proportion zero for base year *0*

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

I.3 Fishery definitions

I.3.1 Bottom trawl

The following selection criteria were used for defining the five bottom trawl fishery models described in this report. Because each record was a trip, scaling of landings was not required.

Table I.1: List of specifications for modelled SPO bottom trawl (BT) fisheries.

Model	Statistical areas	Target species	Core fleet definition	Positive distribution	Document reference
SPO 1E_BT	002–010	SNA, TRE, GUR, JDO, BAR, TAR	5 trips/4 years	lognormal	Appendix J
SPO 1W_BT	041, 042, 045, 046, 047	SNA, TRE, GUR, TAR	5 trips/4 years	lognormal	Appendix K
SPO 2_BT	011. 012, 013, 014, 015	FLA, GUR, TAR	10 trips/8 years	lognormal	Appendix L

Model	Statistical areas	Target species	Core fleet definition	Positive distribution	Document reference
SPO 3_BT	018, 020, 022, 024–032	FLA, BAR, STA, RCO, SPD, TAR, SPO	10 trips/8 years	lognormal	Appendix M
SPO 7_BT	016–018, 032–037, 038, 039, 040	FLA, RCO, SPO, BAR, TAR, GUR, TRE, SNA, WAR	5 trips/10 years	lognormal	Appendix N

All five bottom trawl positive catch models were forced to the lognormal distribution to ensure continuity with previous analyses (see Table 12). A binomial model based on the presence/absence of rig in each data set was also calculated for all five models as there were high proportions of records with no rig in every analysis (see 3rd column from the right in Table J.1, Table K.1, Table L.1, Table M.1 and Table N.1). The two series were then combined using the delta-lognormal method (Eq. I.4).

I.3.2 Setnet

The following selection criteria were used for defining the eight setnet fishery models described in this report. Estimated catches were scaled to landings using either the trip matching method of Starr (2007) or the F2 algorithm described in Appendix G, as indicated in the table below.

Table I.2: List of specifications for modelled SPO setnet (SN) fisheries.

Model	Expansion method	Statistical areas	Target species	Core fleet definition	Positive distribution	Document reference
SPO 1E_SN(007)	F2[1]	007	SPO, SCH, SPD, NSD	5 trips/4 years	log-logistic	Appendix O
SPO 1E_SN(coast)	F2[1]	002–006, 008–010	SPO, SCH, SPD, NSD	3 trips/3 years	lognormal	Appendix P
SPO 1W_SN(043)	F2[1]	043	SPO, SCH, SPD, NSD	5 trips/4 years	gamma	Appendix Q
SPO 1W_SN(044)	F2[1]	044	SPO, SCH, SPD, NSD	5 trips/4 years	gamma	Appendix R
SPO 1W_SN(041–047)	F2[1]	041, 042, 045, 046, 047	SPO, SCH, SPD, NSD	3 trips/3 years	lognormal	Appendix S
SPO 3_SN(SHK)	trip match[2]	018, 020, 022, 024–032	SPO, SCH, SPD, ELE	5 trips/5 years	log-logistic	Appendix T
SPO 7_SN(038)	trip match[2]	038	SPO, SCH, SPD,	3 trips/3 years	log-logistic	Appendix U
SPO 7_SN(STB)	trip match[2]	037, 039, 040	SPO, SCH, SPD, NSD	3 trips/3 years	Weibull	Appendix V

[1] See Appendix G.
[2] Starr 2007.

All positive catch models were forced to the indicated distributions to ensure continuity with previous analyses (see Table 13), except for SPO 7_SN(STB), which is a new series, where the most appropriate distribution was selected as described in Section I.2.2 (see Figure V.3). No binomial models were run for these setnet fisheries because of the high proportion of records that successfully captured rig. Previous experience has shown there is little or no impact to the series trend when such positive catch series are combined with a binomial model.

Appendix J. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1E_BT

J.1 Introduction

This CPUE analysis was not accepted in 2016 for monitoring SPO 1E by the NINSWG and the Plenary (MPI 2016) with a research rating of '3' (Low Quality: insufficient data with low annual catches). The WG also noted that the BT fisheries do not monitor large mature female rig.

J.2 Fishery definition

SPO 1E_BT: The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 002, 003, 004, 005, 006, 007, 008, 009, 010 and 106 and declared target species SNA, TRE, GUR, JDO, BAR, or TAR.

J.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in four years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 65 vessels, which took 93% of the catch (Figure J.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure J.1).

J.4 Data summary

Table J.1: Summaries by fishing year for core vessels, trips, number of events that have been 'rolled up' into trips, number of events per trip, total tows, total hours towed, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of five trips per year in four years) in the SPO 1E_BT fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch [1]	% catch: 0 estimated catch trips [1]
1990	38	684	2 458	3.59	8 261	20 185	31.25	65.8	55.1	32.7
1991	40	952	3 212	3.37	10 822	28 890	42.09	49.9	48.4	26.8
1992	45	1 095	3 673	3.35	12 062	35 065	49.18	55.6	47.1	28.0
1993	45	1 052	3 409	3.24	11 055	32 162	35.40	61.0	50.2	21.7
1994	43	1 061	4 125	3.89	10 591	30 160	24.10	58.8	62.5	39.3
1995	34	888	4 174	4.70	8 504	22 822	18.58	63.0	66.0	47.0
1996	38	726	6 322	8.71	7 414	19 852	16.23	63.9	61.4	45.3
1997	41	810	7 161	8.84	8 157	19 418	13.11	64.0	66.2	45.5
1998	40	788	8 967	11.38	9 603	23 554	15.63	69.7	65.6	44.4
1999	40	820	8 987	10.96	10 143	27 209	20.59	76.3	70.3	45.9
2000	35	819	8 433	10.30	10 158	27 671	27.24	76.7	67.2	47.4
2001	38	775	8 221	10.61	9 046	25 155	17.70	80.8	63.3	44.4
2002	34	780	7 604	9.75	8 746	24 671	18.71	76.8	65.9	45.1
2003	30	753	7 351	9.76	8 242	22 395	17.70	73.0	67.3	43.7
2004	31	784	7 767	9.91	8 975	24 670	16.01	69.1	65.5	41.9
2005	31	882	8 146	9.24	10 629	31 184	21.57	71.3	63.4	36.8
2006	31	817	7 115	8.71	9 586	27 759	19.54	74.1	63.5	39.4
2007	25	632	6 326	10.01	8 433	22 521	19.49	80.4	55.5	36.0
2008	22	594	7 261	12.22	7 261	22 058	19.25	87.7	42.0	24.1
2009	23	601	8 142	13.55	8 144	23 966	19.20	86.5	41.4	29.2
2010	20	596	7 784	13.06	7 784	23 427	18.46	85.7	38.6	20.0
2011	22	556	7 684	13.82	7 684	21 474	18.64	86.5	38.3	22.9
2012	18	495	7 002	14.15	7 002	18 720	15.38	89.3	42.3	17.7
2013	16	448	6 580	14.69	6 580	17 580	15.71	92.2	41.7	20.5
2014	19	507	6 794	13.40	6 794	18 388	22.64	90.9	36.0	16.0
2015	20	476	6 297	13.23	6 297	18 038	23.59	93.9	31.3	17.9

[1] See note following Figure J.2.

J.5 Core vessel selection

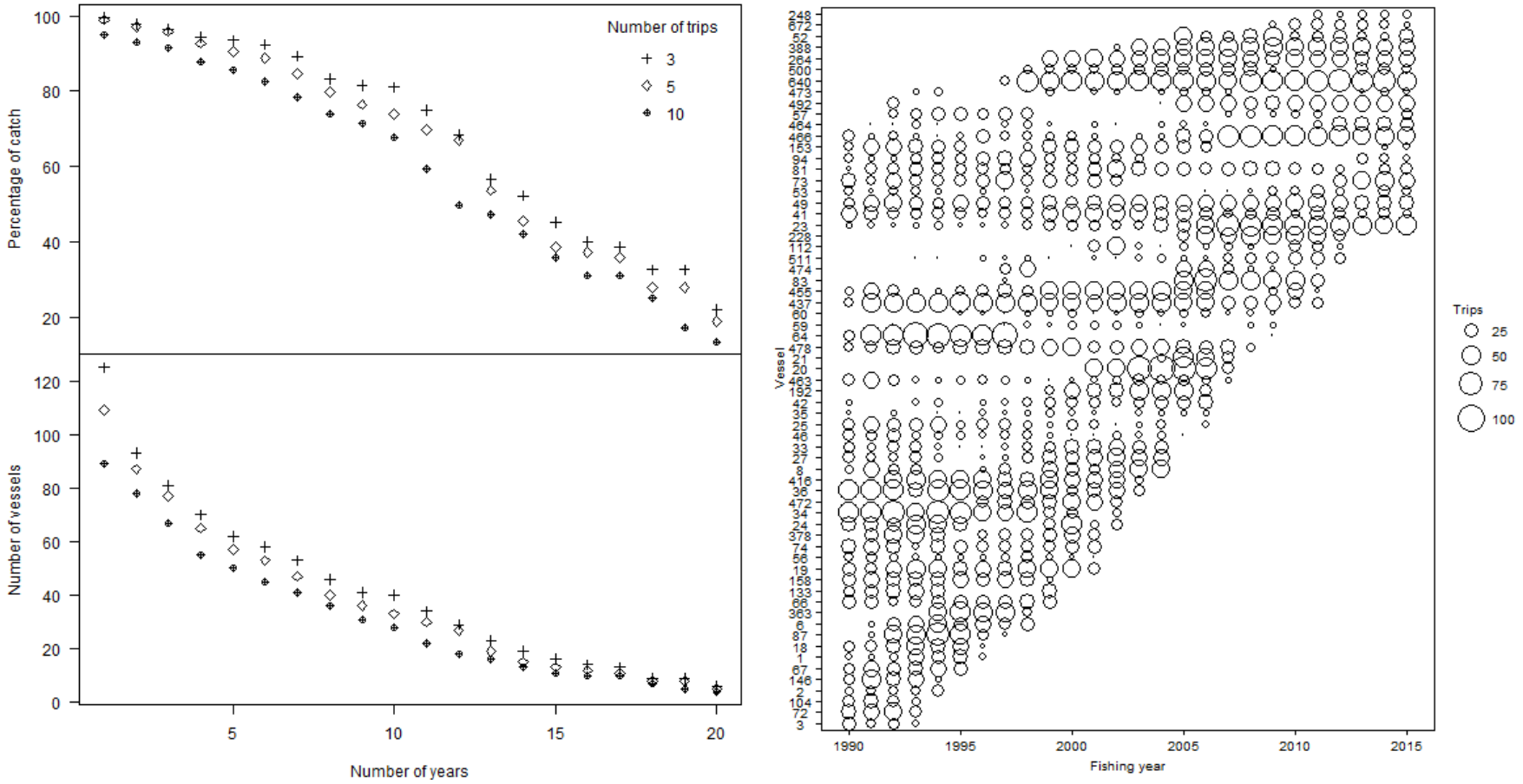

Figure J.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1E_BT data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in four or more fishing years) by fishing year.

J.6 Exploratory data plots for core vessel data set

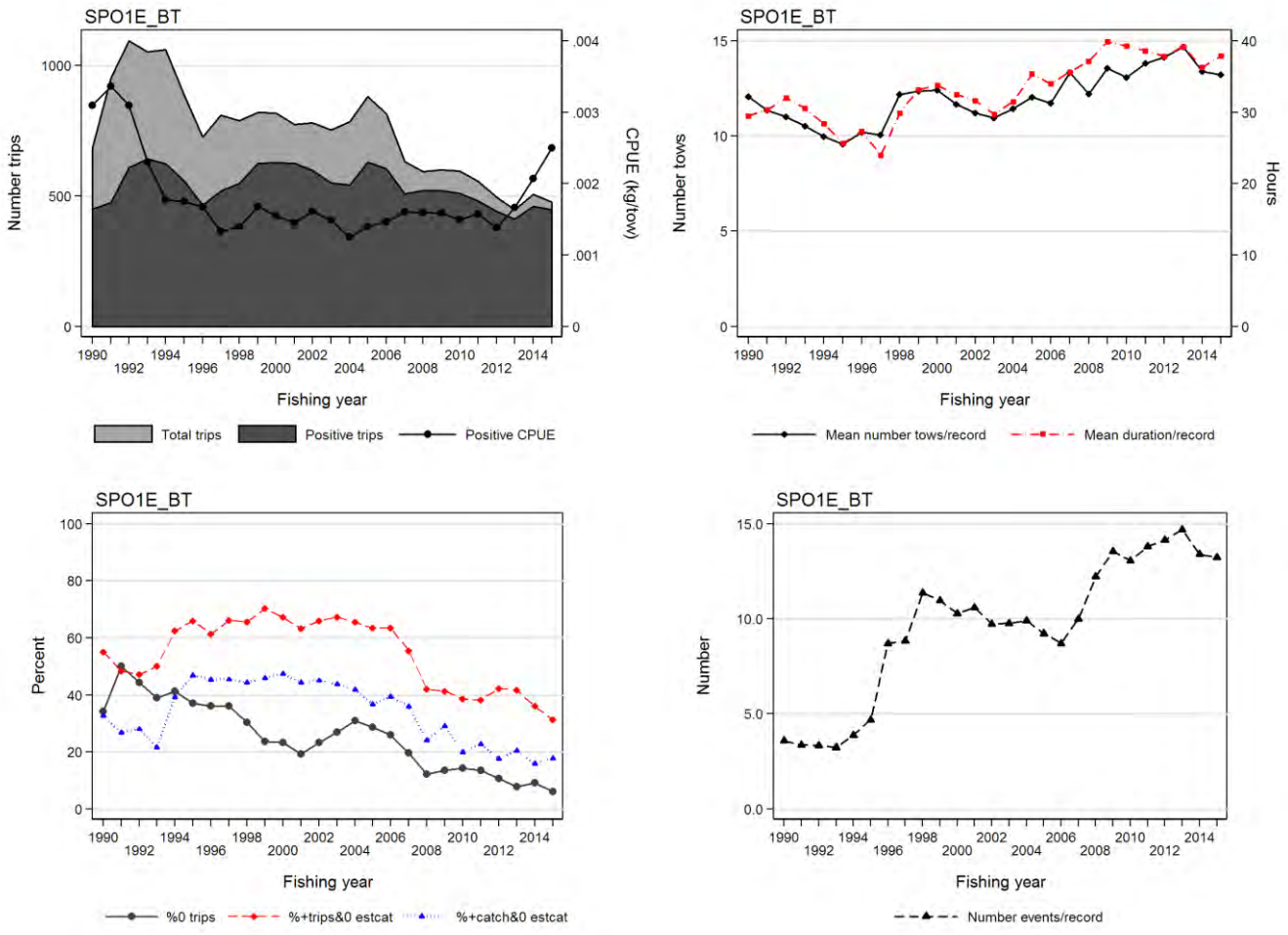

Figure J.2: Core vessel summary plots by fishing year for model SPO 1E_BT: [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$**; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.**

Note: the large decrease in the proportion of trips that did not report SPO from 2007–08 [lower left panel] and the corresponding increase in the number of events per trip [lower right panel] is due to the change to the TCER reporting form whereby the top eight species per tow were reported instead of the top five species per day of fishing. Because each record in this data set was [*trip*] and the estimated catch field was not used, it was not necessary to restrict the post 2007–08 data to the top five species per fishing day within a trip.

J.7 Selection of positive catch distribution

SPO 1E_BT is an existing analysis (see Table 12). The positive catch distribution was forced to lognormal for consistency with previous analyses.

J.8 Positive catch model selection table

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

Table J.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 1E_BT fishery model for core vessels (based on the vessel selection criteria of at least five trips in 4 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	26	-22 655	45 364	4.63	*
vessel	90	-21 250	42 682	22.68	*
poly(log(tows), 3)	93	-20 698	41 584	28.84	*
area	101	-20 564	41 331	**30.27**	*
poly(log(hours), 3)	104	-20 505	41 221	30.88	
month	115	-20 450	41 132	31.45	
target	120	-20 419	41 080	31.77	

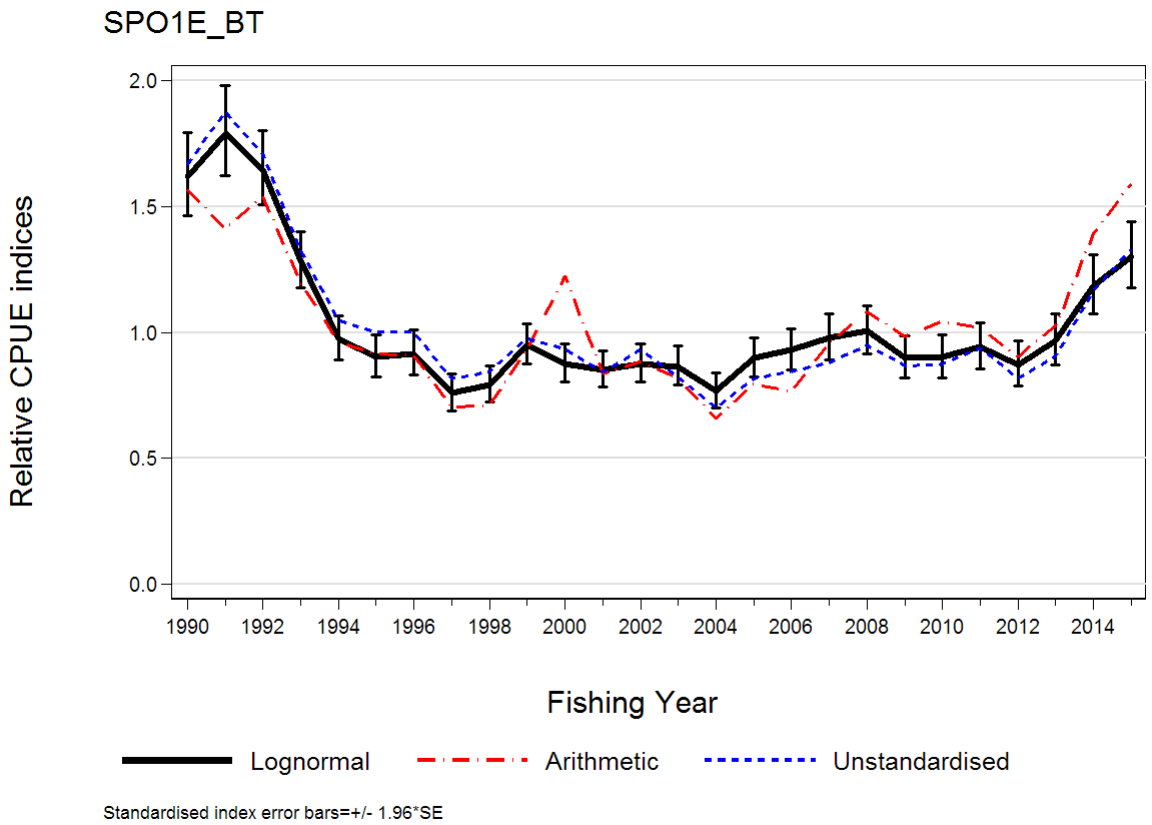

Figure J.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1E_BT fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

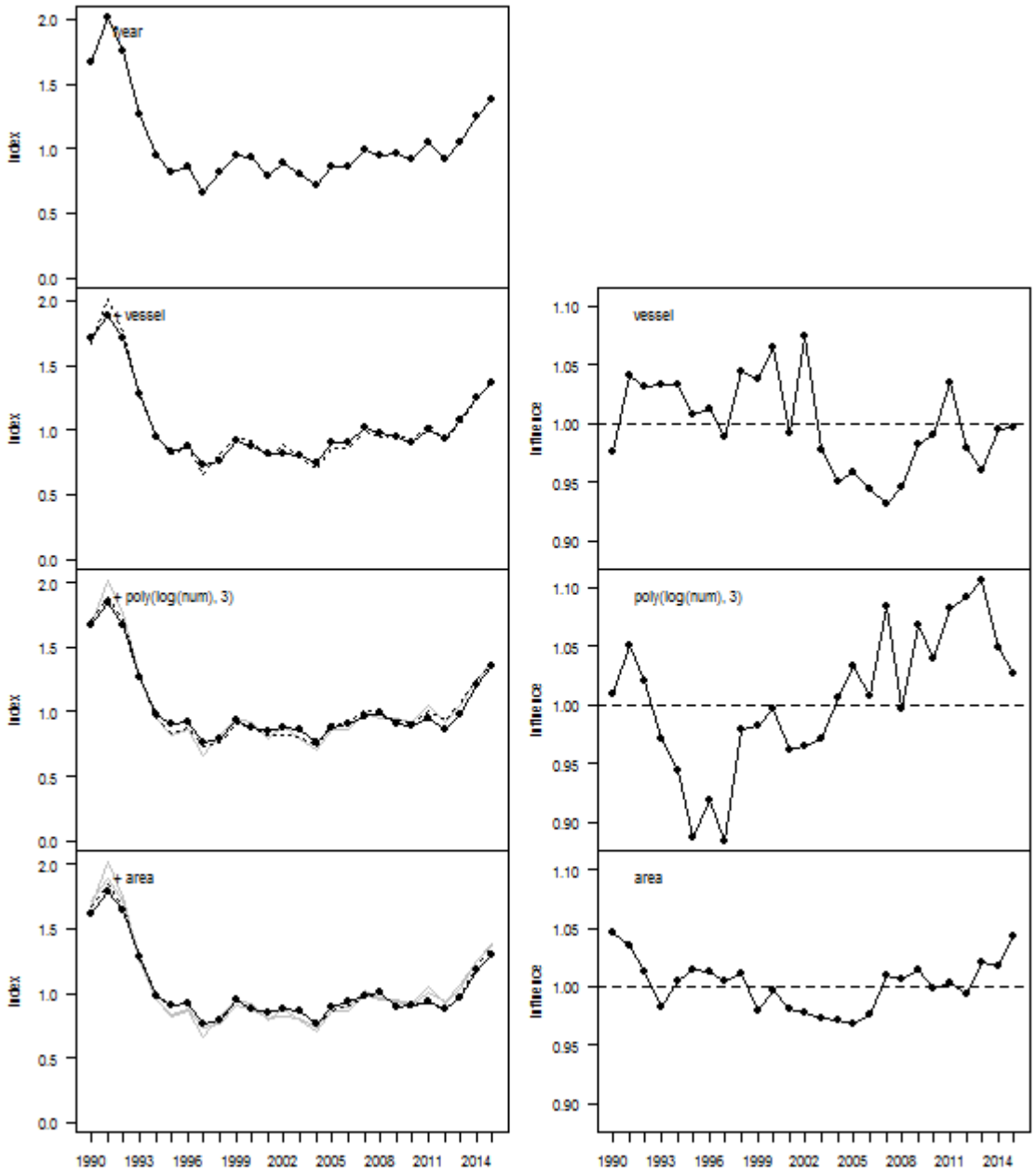

Figure J.4: [left column]: annual indices from the lognormal model of SPO 1E_BT at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

J.9 Residual and diagnostic plots

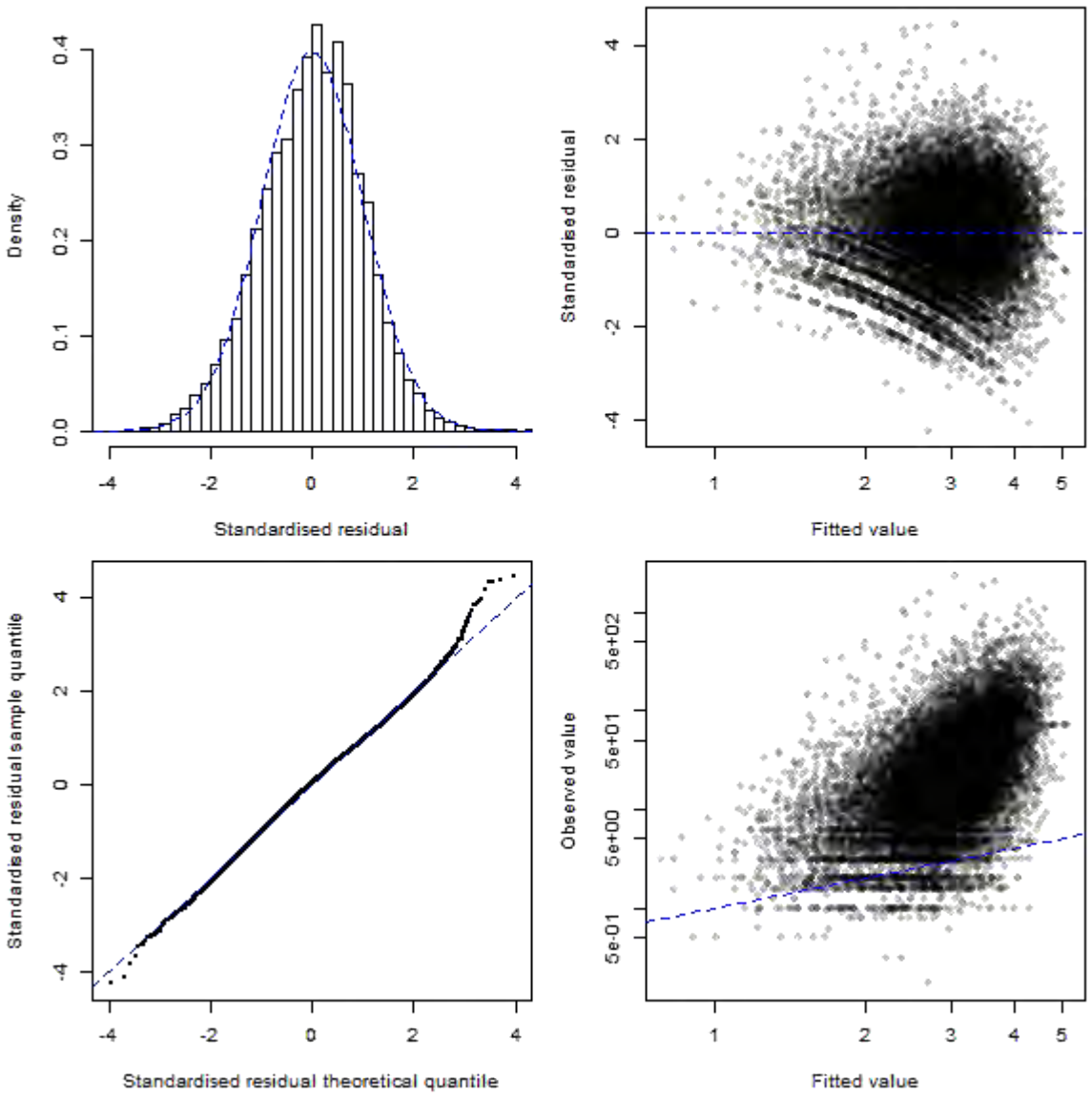

Figure J.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 1E_BT fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

J.10 Model coefficients

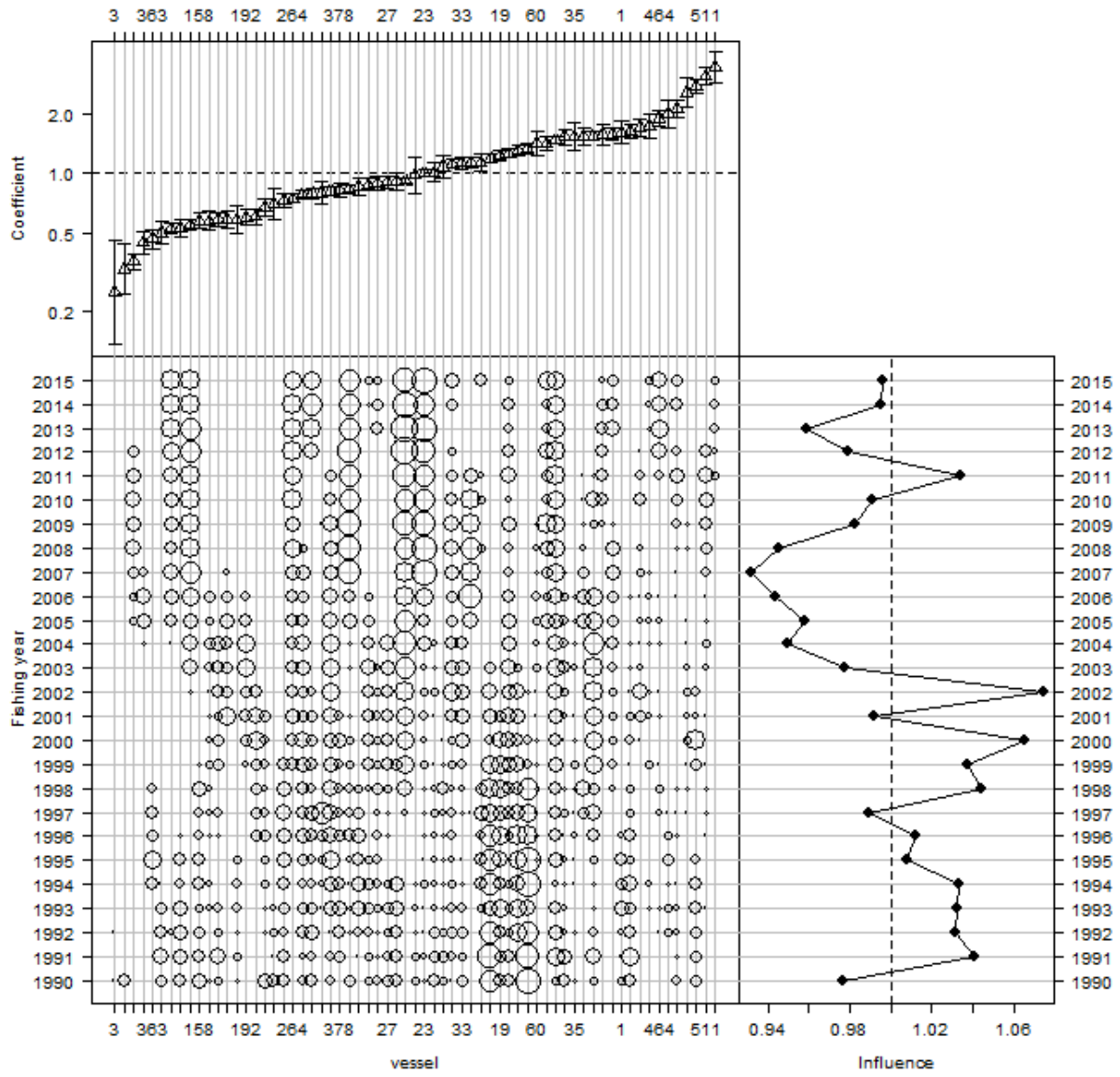

Figure J.6: Effect of vessel in the lognormal model for the rig SPO 1E_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

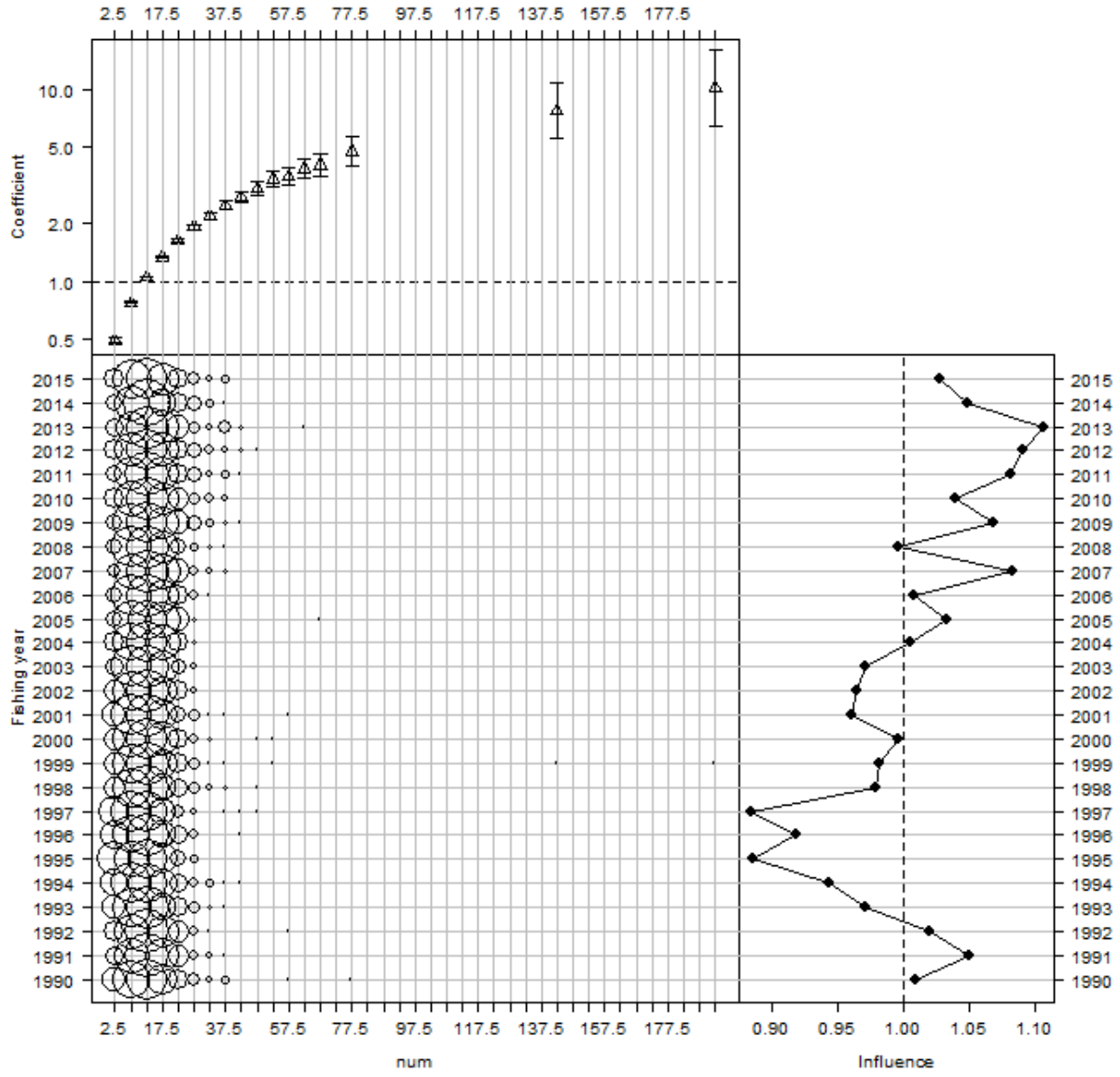

Figure J.7: Effect of number tows in the lognormal model for the rig SPO 1E_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

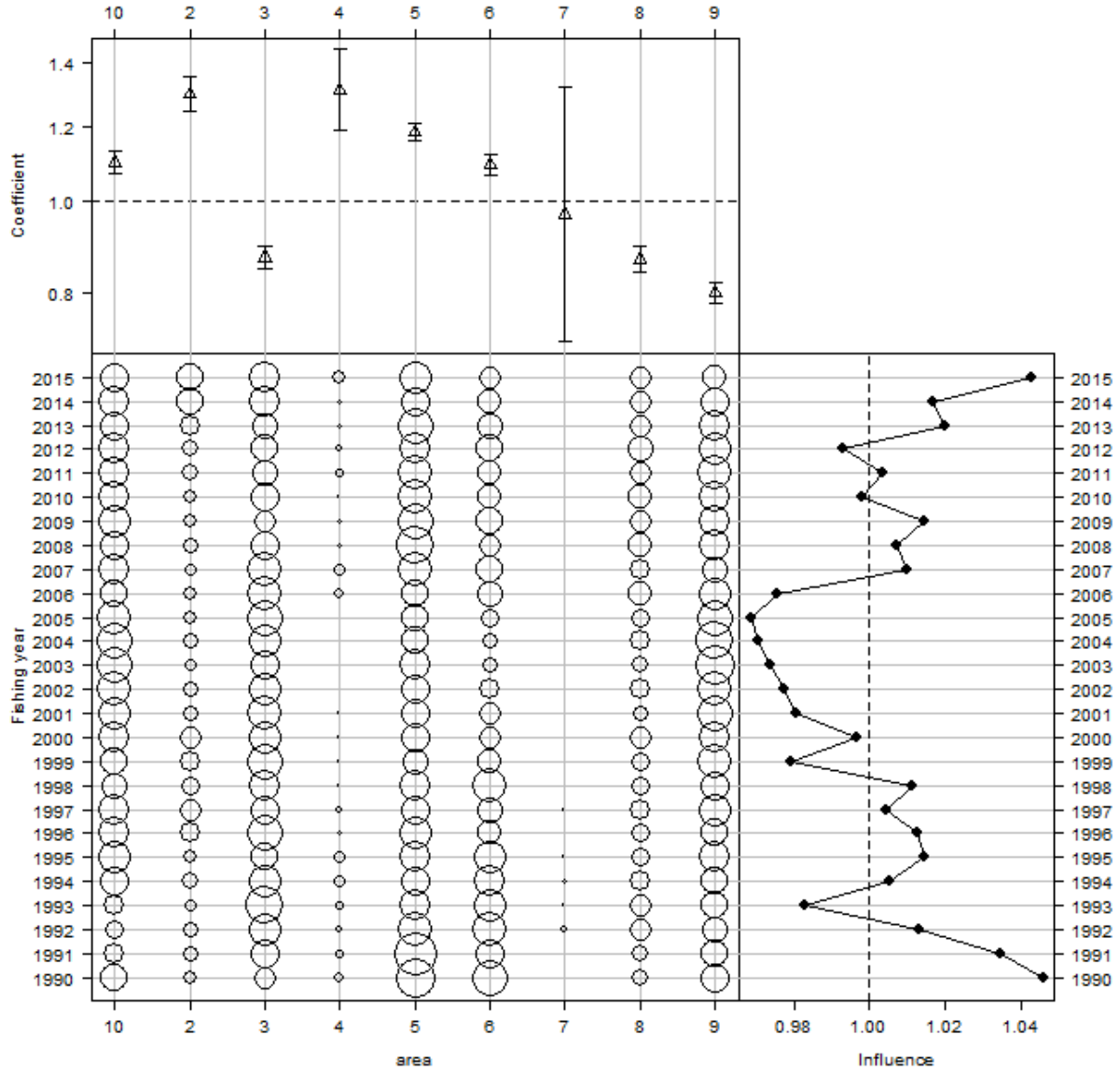

Figure J.8: Effect of statistical area in the lognormal model for the rig SPO 1E_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

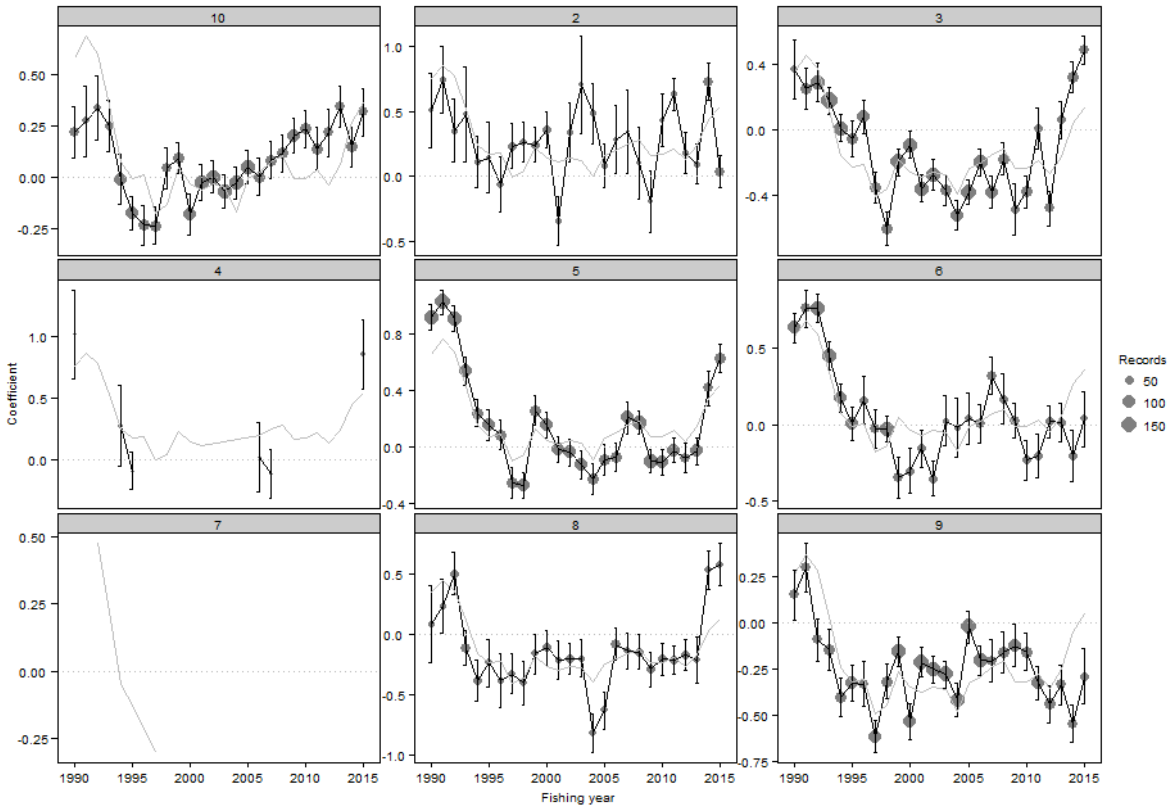

Figure J.9: **Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the rig SPO 1E_BT lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.**

J.11 Presence/absence (binomial) catch model selection table

Two explanatory variables (vessel and number tows) entered the model after fishing year (Table J.3), with the variables target, month, area and hours fished non-significant. A plot of the model is provided in Figure J.10 and the CPUE indices are listed in Table J.4.

Table J.3: Order of acceptance of variables into the binomial model of presence/absence of rig catches in the SPO 1E_BT fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	26	-10 753	21 557	10.18	*
vessel	90	-9 290	18 759	28.95	*
poly(log(tows), 3)	93	-8 784	17 753	**34.81**	*
target	98	-8 730	17 656	35.42	
month	109	-8 690	17 598	35.87	
area	117	-8 661	17 555	36.19	
poly(log(hours), 3)	120	-8 633	17 506	36.50	

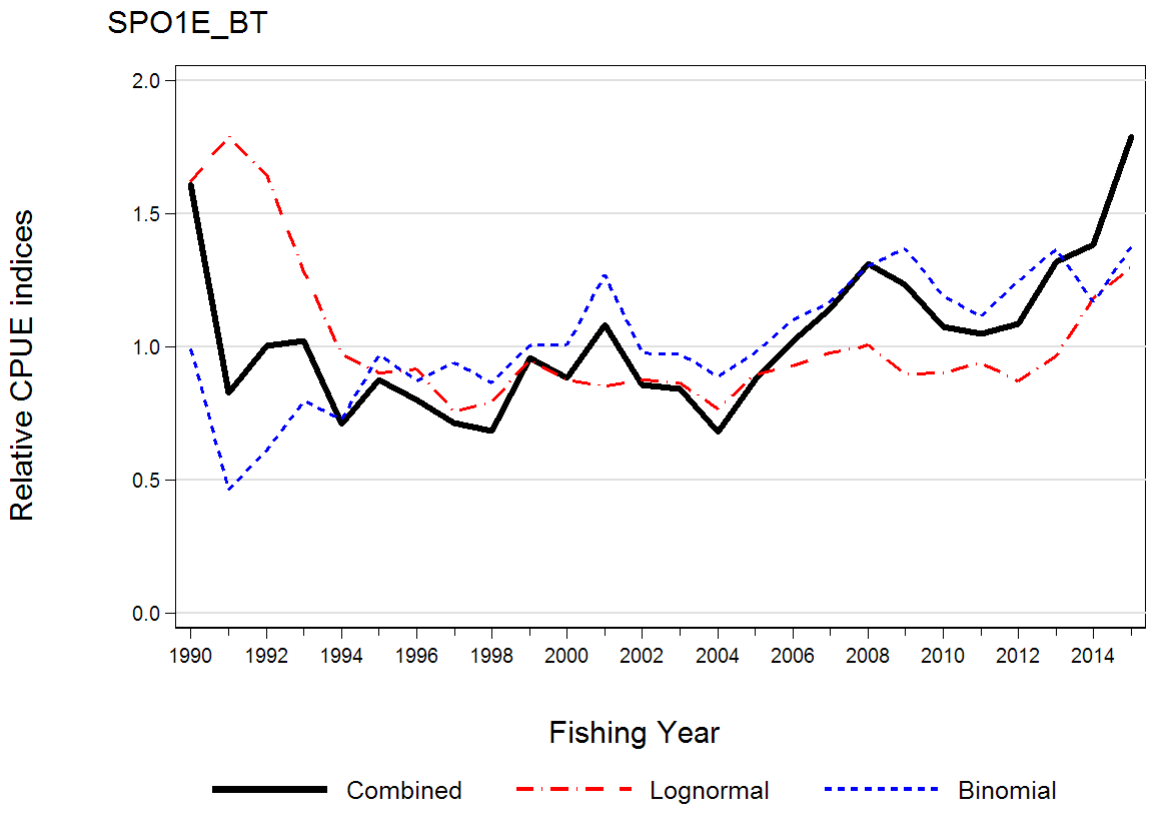

Figure J.10: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1E_BT fishery definition, the binomial standardised model using the logistic distribution, and the combined model using the delta-lognormal procedure (Eq. I.4).

J.12 CPUE indices

Table J.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE), as well as binomial and combined series for the core data set by fishing year for the SPO 1E_BT analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels					
year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	1.566	1.567	1.668	1.621	0.0524	0.994	1.611
1991	1.366	1.412	1.878	1.792	0.0508	0.462	0.829
1992	1.435	1.540	1.710	1.648	0.0452	0.609	1.004
1993	1.212	1.196	1.325	1.284	0.0444	0.797	1.023
1994	0.972	0.963	1.050	0.975	0.0450	0.727	0.709
1995	0.965	0.915	1.001	0.903	0.0474	0.970	0.876
1996	0.896	0.908	1.002	0.917	0.0501	0.873	0.801
1997	0.723	0.701	0.815	0.758	0.0483	0.942	0.714
1998	0.709	0.712	0.844	0.793	0.0462	0.865	0.686
1999	0.890	0.930	0.976	0.952	0.0426	1.006	0.958
2000	1.168	1.226	0.934	0.877	0.0433	1.007	0.882
2001	0.826	0.835	0.843	0.852	0.0429	1.273	1.084
2002	0.884	0.884	0.930	0.876	0.0439	0.977	0.856
2003	0.822	0.819	0.822	0.864	0.0457	0.974	0.842
2004	0.640	0.657	0.701	0.766	0.0461	0.890	0.682
2005	0.783	0.796	0.816	0.897	0.0434	0.977	0.877
2006	0.937	0.764	0.845	0.929	0.0445	1.101	1.023
2007	0.940	0.958	0.880	0.978	0.0479	1.169	1.143
2008	1.079	1.084	0.950	1.006	0.0477	1.304	1.312
2009	0.958	0.983	0.868	0.899	0.0477	1.371	1.233
2010	1.053	1.044	0.874	0.901	0.0482	1.192	1.075
2011	0.994	1.016	0.939	0.941	0.0495	1.114	1.048
2012	0.962	0.905	0.817	0.872	0.0515	1.246	1.087
2013	1.005	1.025	0.908	0.966	0.0533	1.367	1.321
2014	1.370	1.393	1.166	1.184	0.0504	1.168	1.384
2015	1.580	1.593	1.331	1.302	0.0510	1.375	1.791

Appendix K. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1W_BT

K.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 1W by the NINSWG (MPI 2016) with a research rating of '1' (High Quality).

K.2 Fishery definition

SPO 1W_BT: The fishery is defined from bottom trawl fishing events that fished in Statistical Areas 041, 042, 045, 046 and 047 and declared target species SNA, TRE, GUR or TAR.

K.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in four years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 44 vessels, which took 94% of the catch (Figure K.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure K.1).

K.4 Data summary

Table K.1: Summaries by fishing year for core vessels, trips, number of events that have been 'rolled up' into trips, number of events per trip, total tows, total hours towed, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of five trips per year in four years) in the SPO 1W_BT fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch [1]	% catch: 0 estimated catch trips [1]
1990	17	491	876	1.78	2 391	6 735	22.96	79.4	37.2	29.1
1991	17	525	968	1.84	2 663	7 474	17.70	72.2	40.4	33.3
1992	20	560	1 463	2.61	3 653	10 135	23.50	75.7	43.9	26.7
1993	26	810	3 010	3.72	6 985	19 540	57.23	82.5	41.3	22.8
1994	26	662	2 165	3.27	5 574	15 206	46.57	81.3	36.3	18.4
1995	26	595	2 301	3.87	4 715	13 517	42.94	85.4	30.9	14.6
1996	28	661	3 249	4.92	4 569	14 211	43.22	81.2	40.8	25.6
1997	26	787	4 188	5.32	5 191	15 607	46.76	74.6	52.3	23.2
1998	28	844	4 579	5.43	5 753	17 099	44.83	80.8	52.1	34.1
1999	24	726	4 047	5.57	5 575	15 946	46.00	78.4	45.9	19.3
2000	22	614	3 783	6.16	5 119	16 786	47.42	88.6	43.8	21.6
2001	23	566	3 830	6.77	4 687	15 684	47.27	84.8	40.2	15.8
2002	21	516	3 251	6.30	3 742	12 864	40.76	82.6	38.0	16.9
2003	21	369	3 192	8.65	3 709	13 687	54.20	89.4	32.7	16.3
2004	20	345	3 874	11.23	4 054	14 945	36.54	89.9	39.7	19.9
2005	19	267	3 216	12.04	3 297	12 475	32.59	91.4	56.2	34.9
2006	17	260	2 446	9.41	2 641	9 808	23.55	80.8	57.1	45.2
2007	14	272	2 439	8.97	2 716	9 419	22.48	84.2	60.3	48.1
2008	12	274	3 087	11.27	3 117	10 990	33.08	82.5	34.5	24.9
2009	11	232	2 883	12.43	2 883	10 512	30.06	92.2	29.4	17.4
2010	9	215	2 457	11.43	2 457	7 852	25.66	90.2	23.2	18.2
2011	11	221	2 402	10.87	2 402	7 797	34.42	93.7	18.8	13.8
2012	11	293	3 374	11.52	3 374	11 487	54.00	95.2	19.0	11.2
2013	11	338	3 588	10.62	3 588	11 850	55.10	88.8	18.7	6.9
2014	13	328	3 273	9.98	3 273	11 200	65.29	93.3	17.7	4.4
2015	14	333	3 449	10.36	3 449	11 983	63.85	96.7	14.0	3.1

[1] See note following Figure K.2.

K.5 Core vessel selection

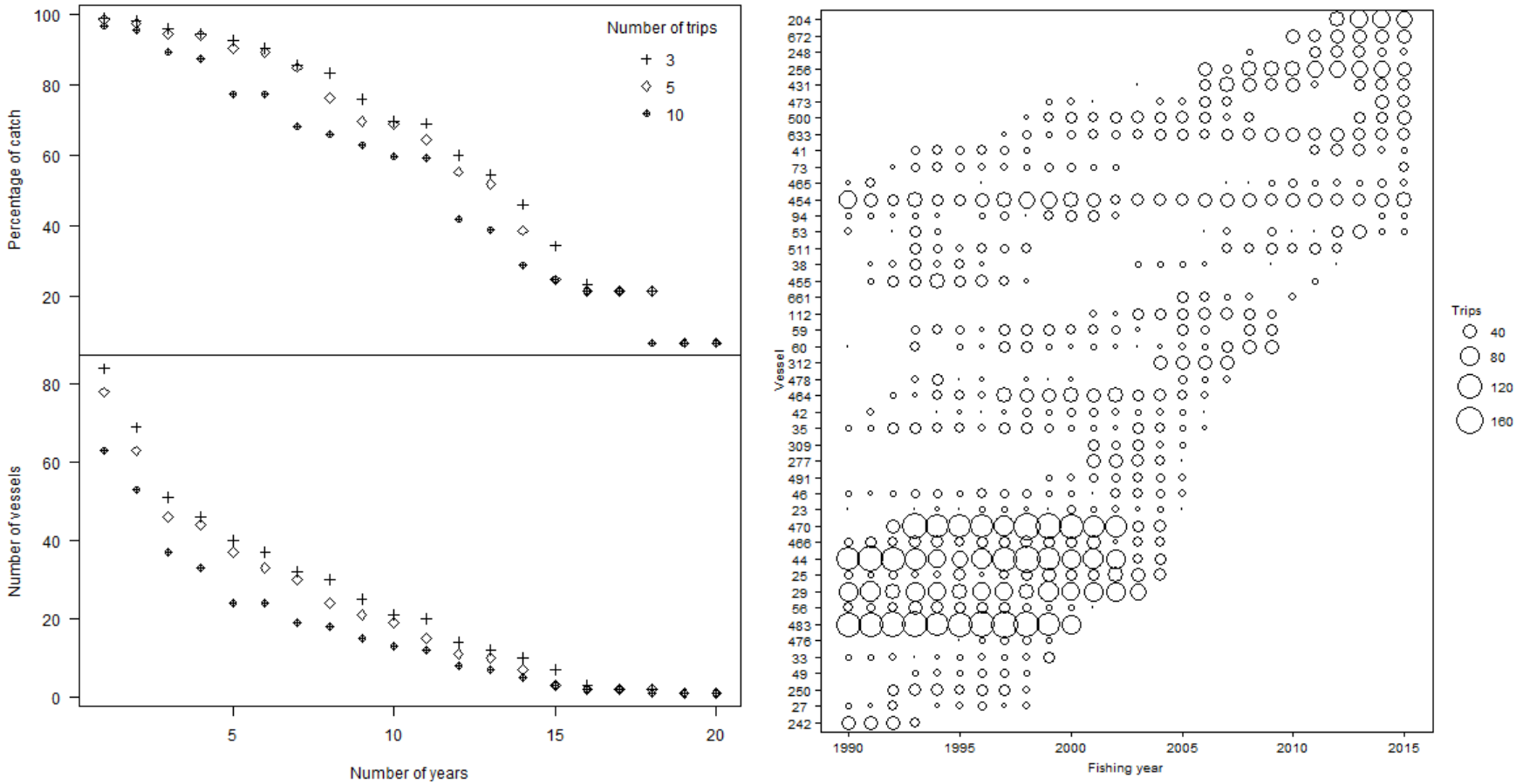

Figure K.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1W_BT data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in four or more fishing years) by fishing year.

K.6 Exploratory data plots for core vessel data set

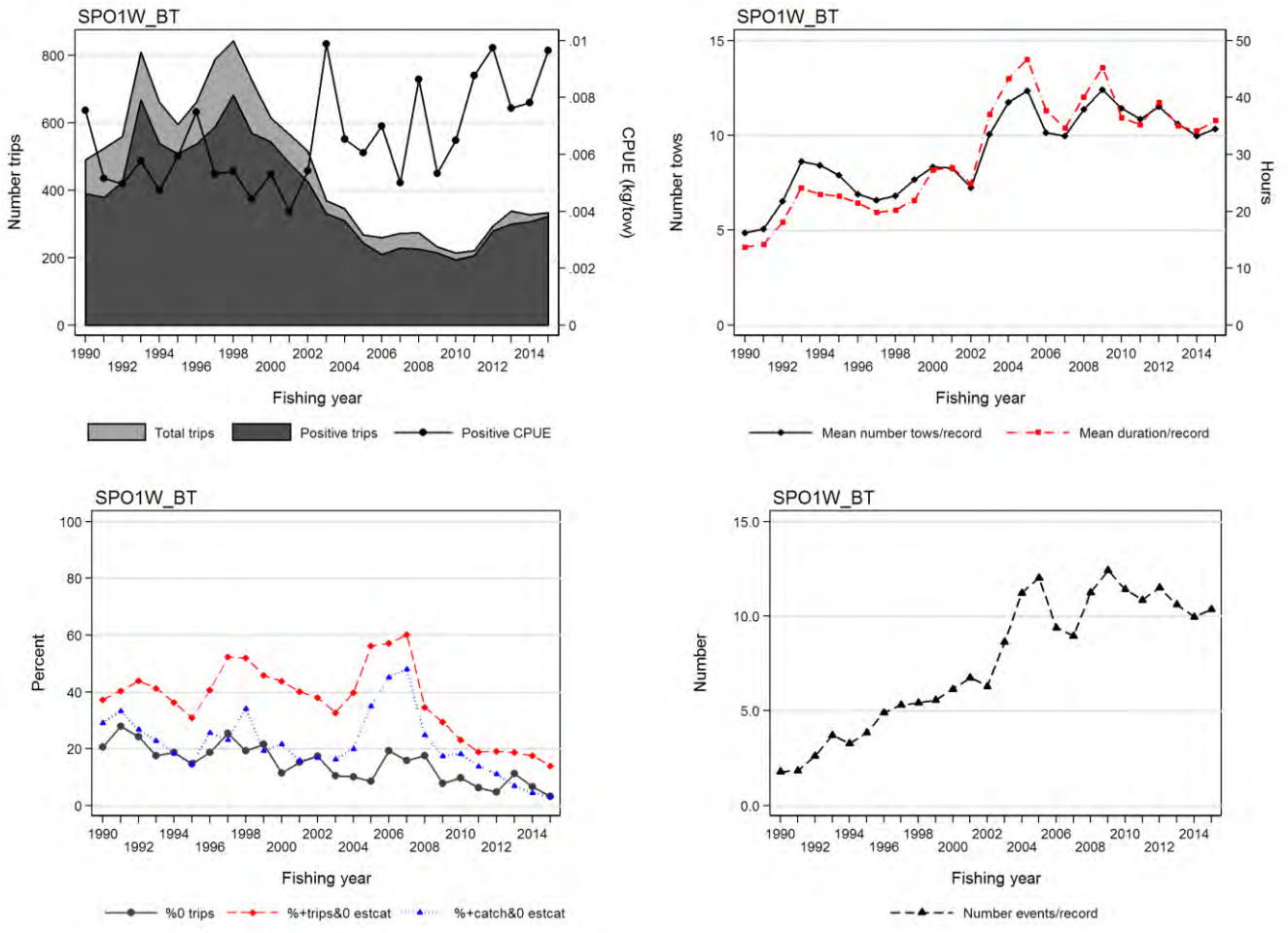

Figure K.2: Core vessel summary plots by fishing year for model SPO 1W_BT: [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$**; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.**

Note: the large decrease in the proportion of trips that did not report SPO from 2007–08 [lower left panel] and the corresponding increase in the number of events per trip [lower right panel] is due to the change to the TCER reporting form whereby the top eight species per tow were reported instead of the top five species per day of fishing. Because each record in this data set was [*trip*] and the estimated catch field was not used, it was not necessary to restrict the post 2007–08 data to the top five species per fishing day within a trip.

K.7 Selection of positive catch distribution

SPO 1W_BT is an existing analysis (see Table 12). The positive catch distribution was forced to lognormal for consistency with previous analyses.

K.8 Positive catch model selection table

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

Table K.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 1W_BT fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	26	-18 467	36 987	5.53	*
poly(log(hours), 3)	29	-16 008	32 076	42.90	*
vessel	72	-15 084	30 314	52.87	*
month	83	-14 692	29 553	56.57	*
area	87	-14 577	29 330	**57.61**	*
target	90	-14 551	29 283	57.84	
poly(log(tows), 3)	93	-14 534	29 255	57.99	

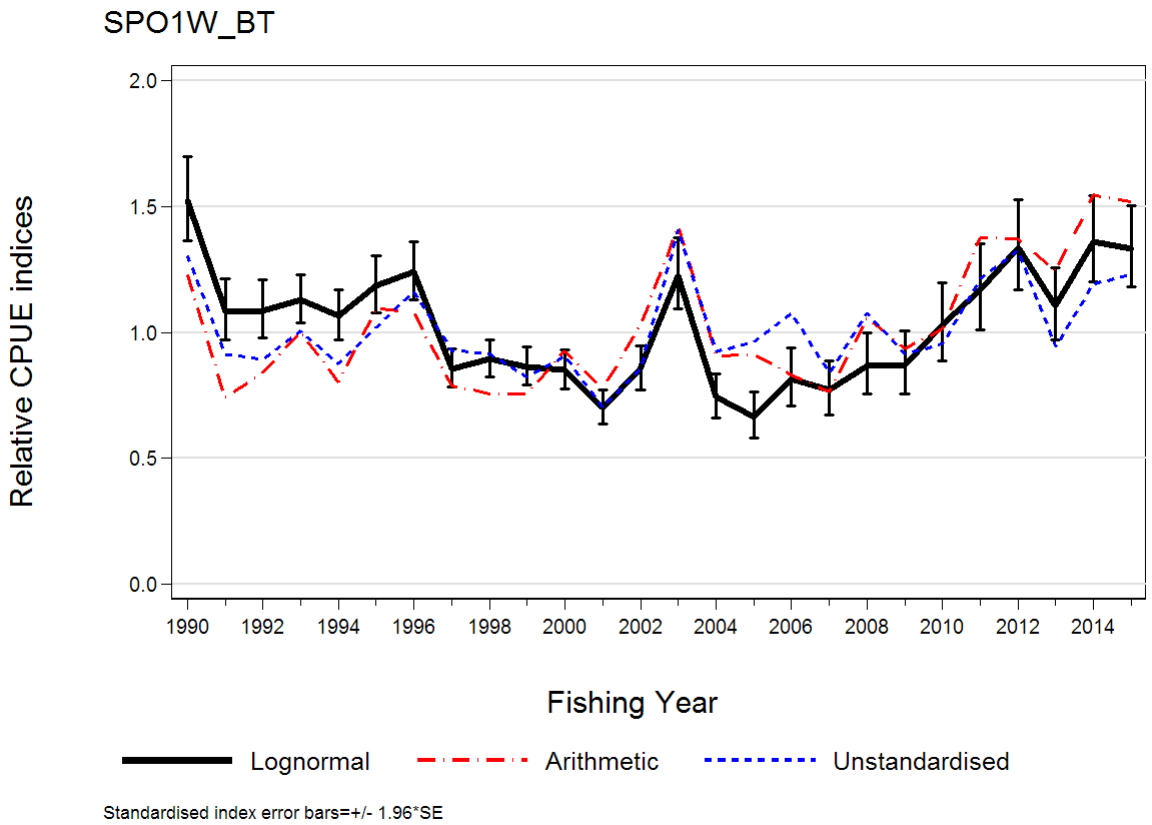

Figure K.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1W_BT fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

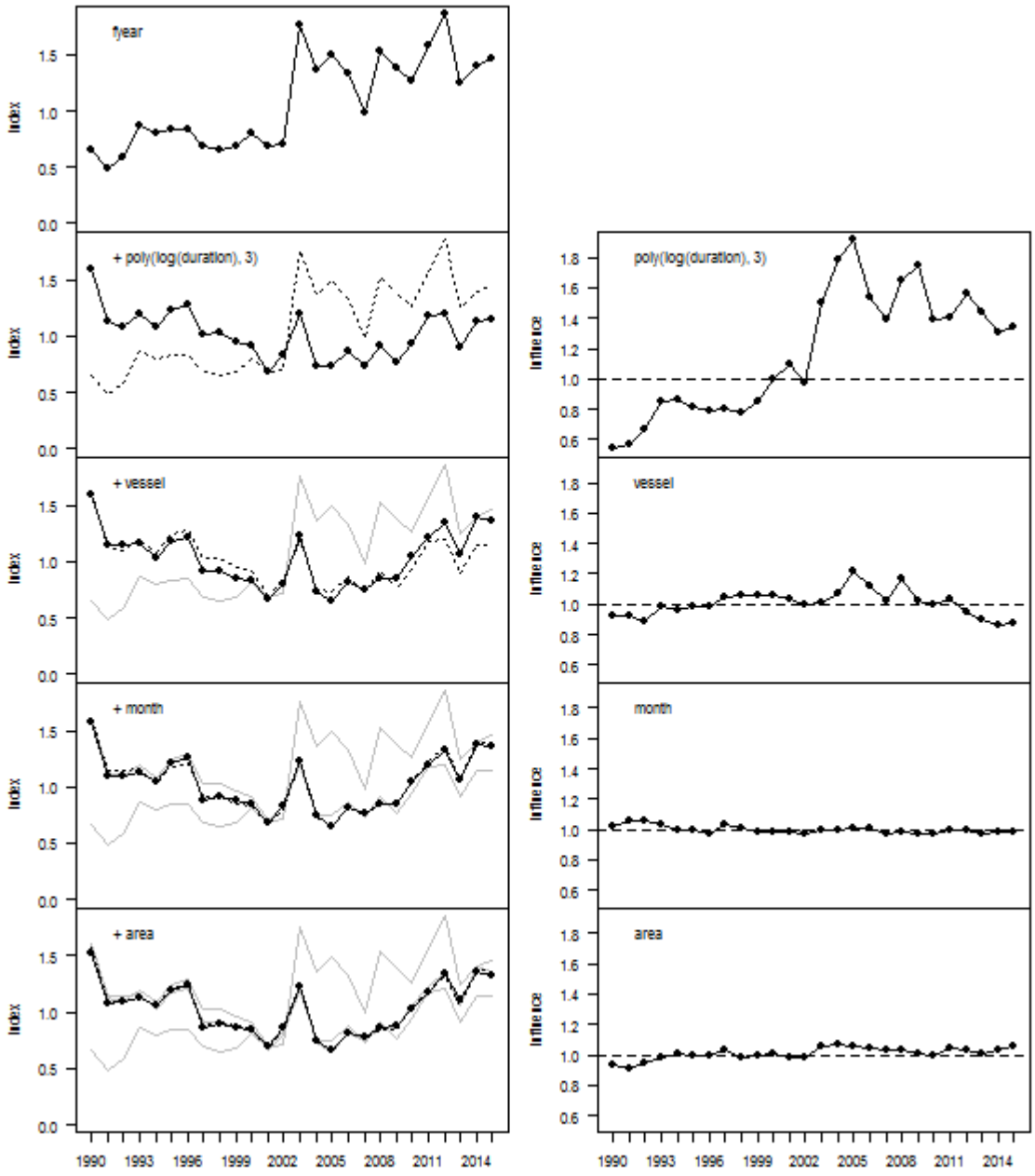

Figure K.4: [left column]: annual indices from the lognormal model of SPO 1W_BT at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

K.9 Residual and diagnostic plots

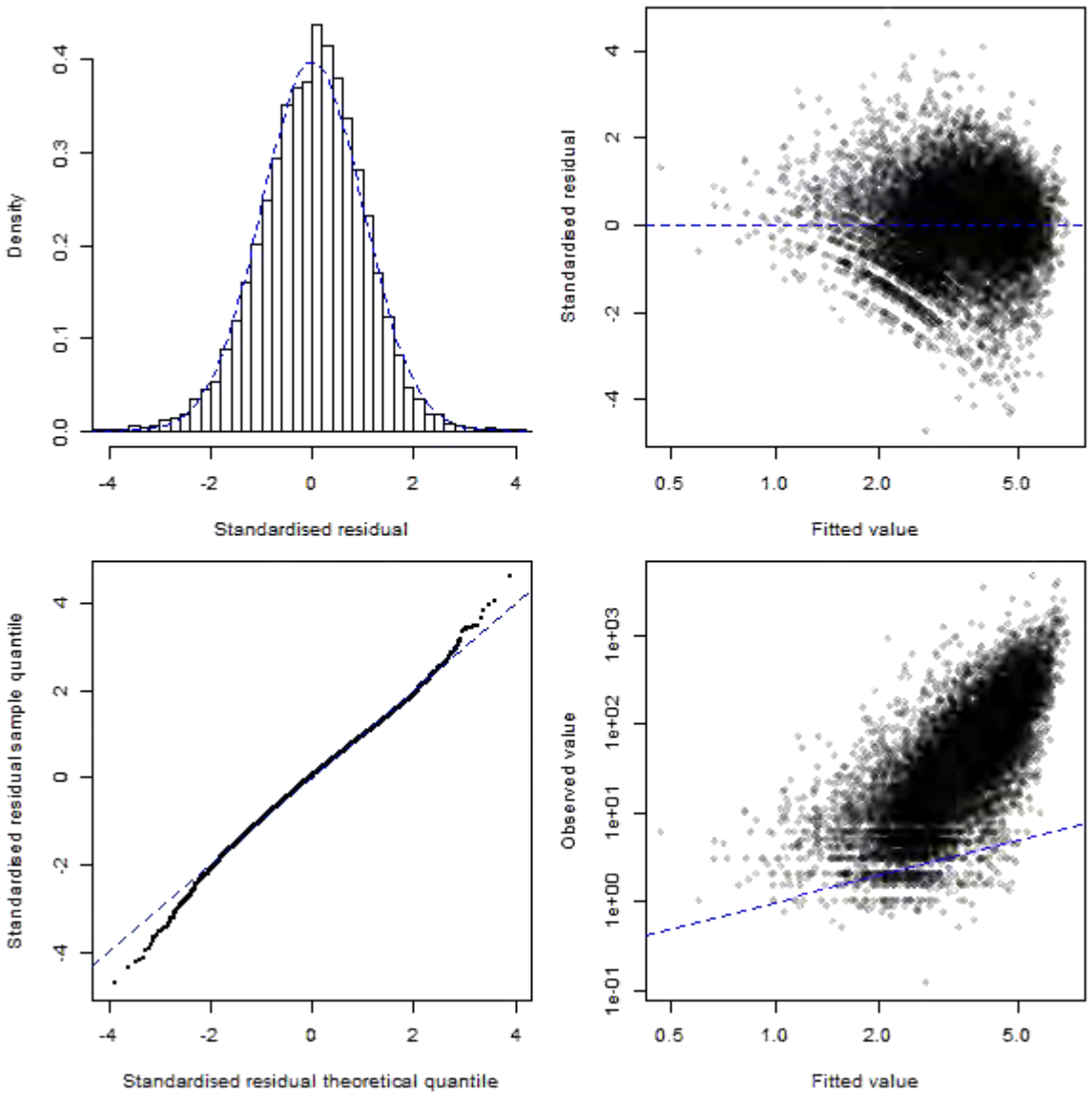

Figure K.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 1W_BT fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

K.10 Model coefficients

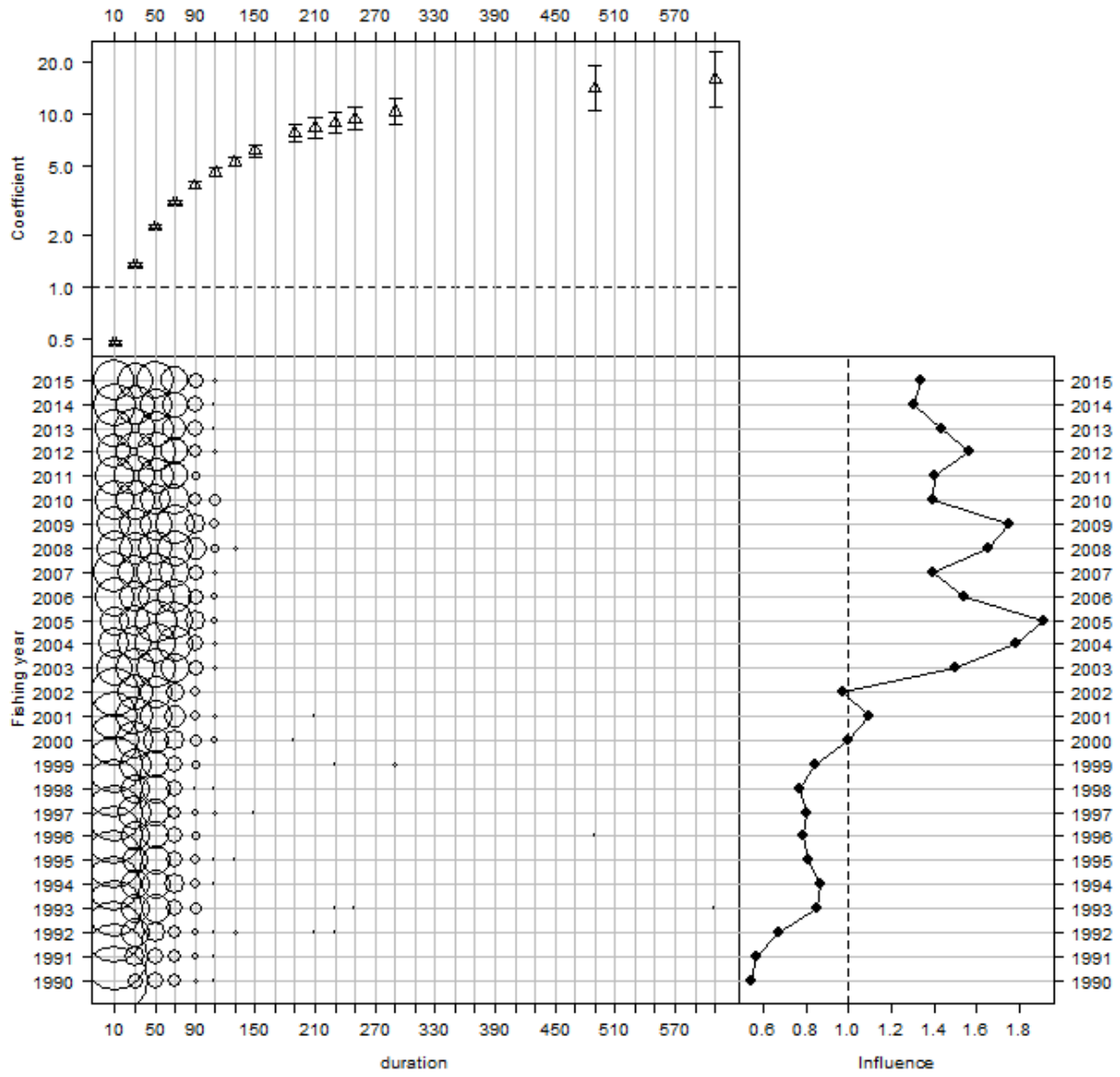

Figure K.6: Effect of hours fished in the lognormal model for the rig SPO 1W_BT fishery. [top]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

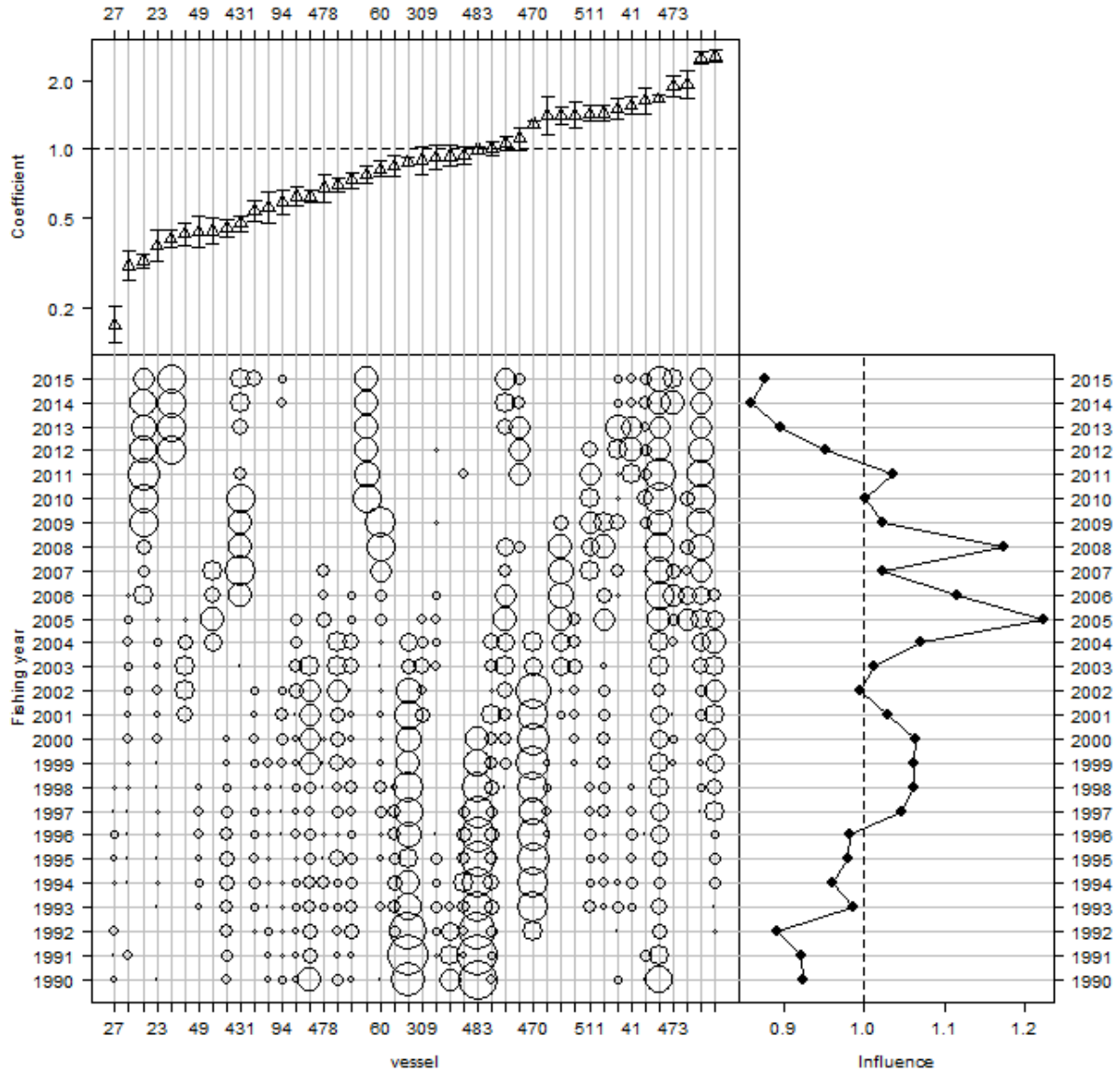

Figure K.7: Effect of vessel in the lognormal model for the rig SPO 1W_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

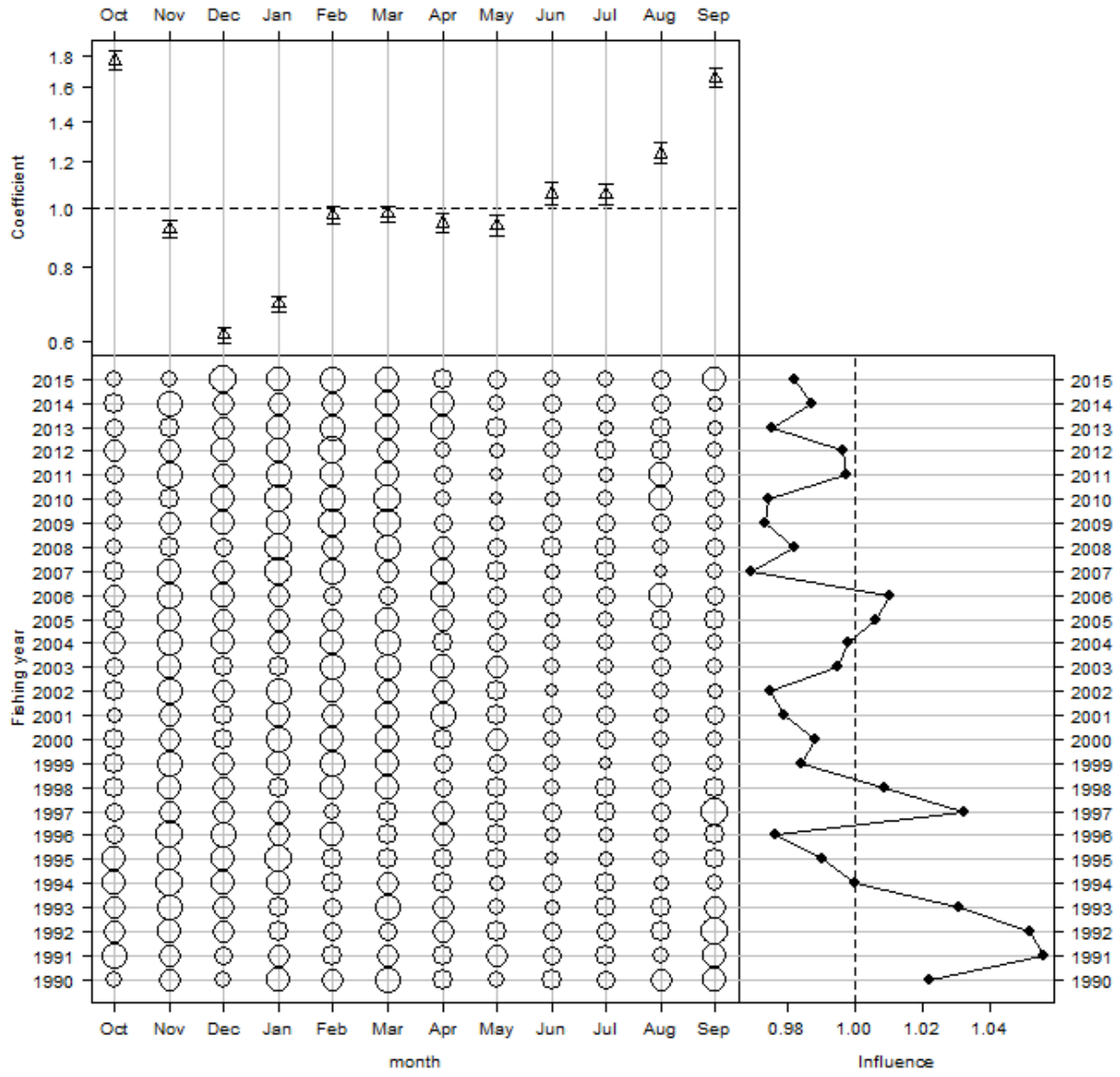

Figure K.8: Effect of month in the lognormal model for the rig SPO 1W_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

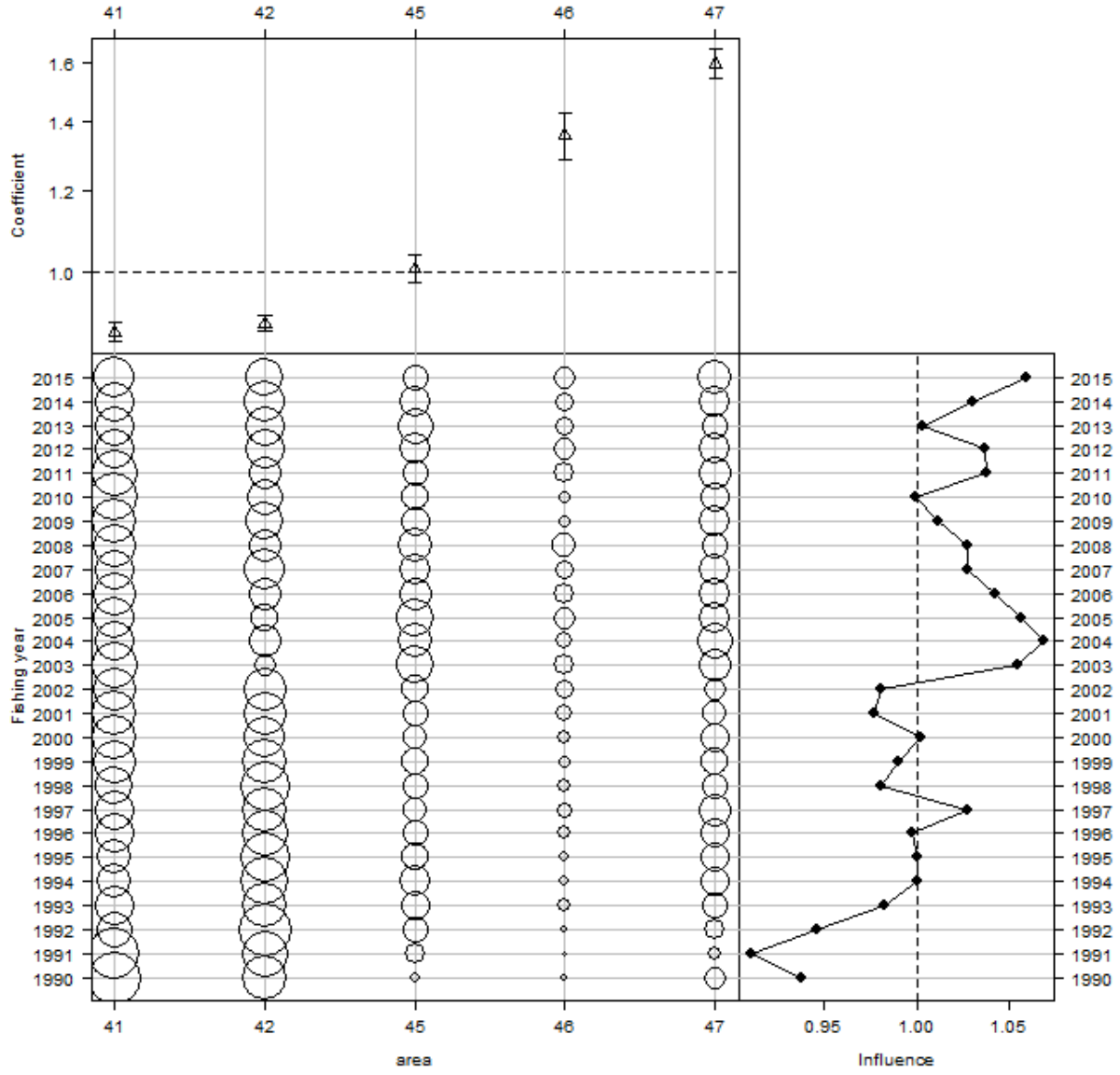

Figure K.9: Effect of statistical area in the lognormal model for the rig SPO 1W_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

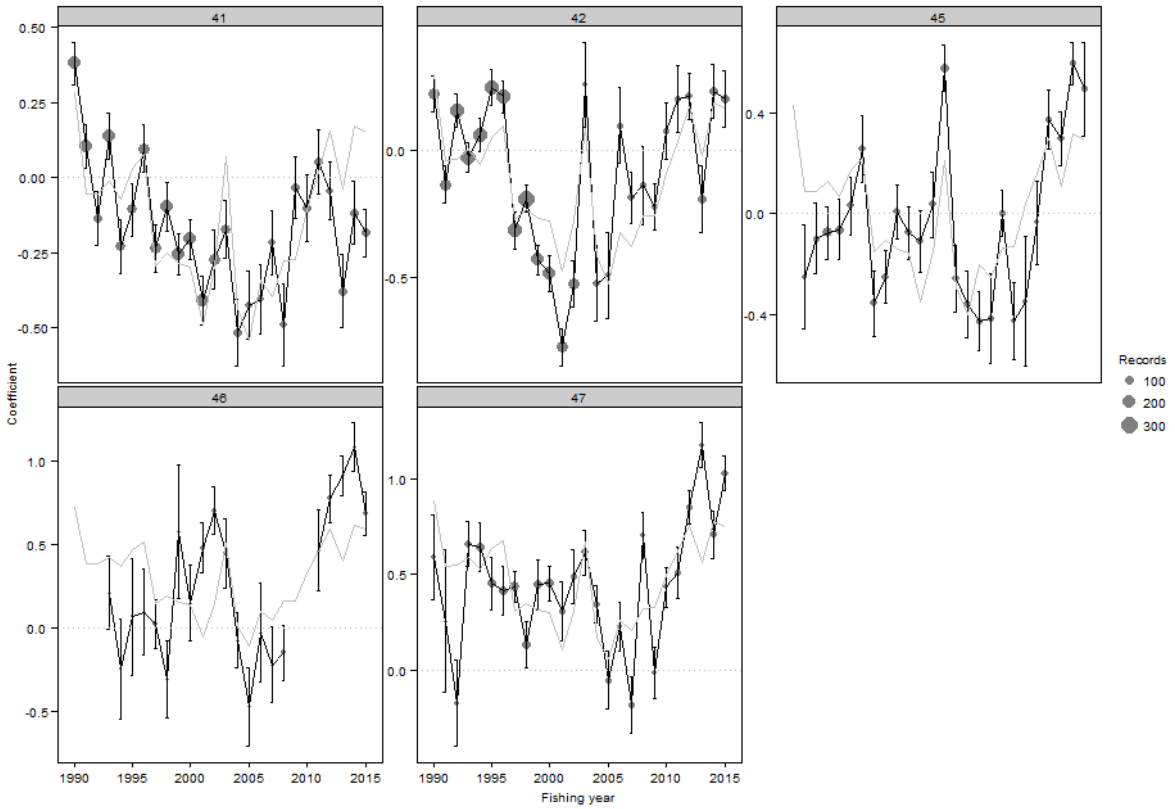

Figure K.10: Residual implied coefficients for area × fishing year interaction (interaction term not offered to the model) in the rig SPO 1W_BT lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and area. These values approximate the coefficients obtained when an area × year interaction term is fitted, particularly for those area × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

K.11 Presence/absence (binomial) catch model selection table

Three explanatory variables (vessel, hours fished and month) entered the model after fishing year (Table K.3), with the variables target species and statistical area non-significant. The model discarded the variable number tows. A plot of the model is provided in Figure K.11 and the CPUE indices are listed in Table K.4.

Table K.3: Order of acceptance of variables into the binomial model of presence/absence of rig catches in the SPO 1W_BT fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	26	-5 246	10 543	4.99	*
vessel	69	-4 544	9 225	22.94	*
poly(log(hours), 3)	72	-4 284	8 711	29.08	*
month	83	-4 177	8 521	**31.51**	*
target	86	-4 170	8 511	31.69	
area	90	-4 162	8 503	31.87	
poly(log(tows), 3)	–	–	–	–	

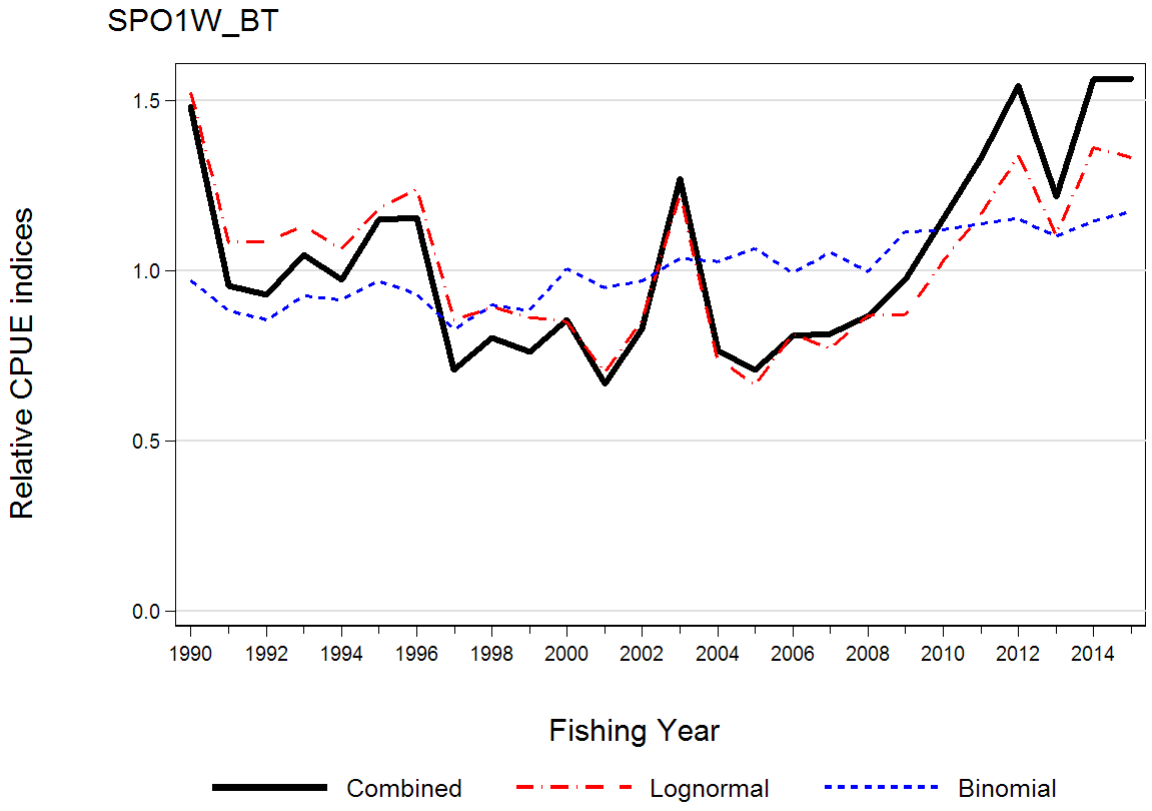

Figure K.11: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1W_BT fishery definition, the binomial standardised model using the logistic distribution, and the combined model using the delta-lognormal procedure (Eq. I.4).

K.12 CPUE indices

Table K.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE), as well as binomial and combined series for the core data set by fishing year for the SPO 1W_BT analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels					
year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	1.174	1.230	1.306	1.525	0.0558	0.972	1.482
1991	0.700	0.741	0.913	1.084	0.0569	0.884	0.958
1992	0.791	0.839	0.892	1.087	0.0538	0.856	0.931
1993	1.048	1.003	1.005	1.131	0.0430	0.927	1.048
1994	0.822	0.801	0.875	1.065	0.0480	0.915	0.975
1995	1.125	1.095	1.018	1.185	0.0488	0.971	1.150
1996	1.110	1.078	1.163	1.240	0.0476	0.932	1.155
1997	0.809	0.788	0.929	0.856	0.0456	0.829	0.710
1998	0.793	0.757	0.915	0.893	0.0425	0.899	0.803
1999	0.748	0.756	0.823	0.863	0.0457	0.884	0.763
2000	0.932	0.926	0.907	0.851	0.0464	1.007	0.857
2001	0.798	0.777	0.701	0.701	0.0496	0.951	0.666
2002	1.046	1.027	0.856	0.855	0.0526	0.971	0.830
2003	1.407	1.422	1.409	1.227	0.0589	1.037	1.272
2004	0.911	0.908	0.924	0.743	0.0601	1.028	0.763
2005	0.959	0.912	0.962	0.666	0.0691	1.066	0.709
2006	0.860	0.831	1.077	0.814	0.0729	0.994	0.810
2007	0.858	0.762	0.839	0.772	0.0708	1.055	0.814
2008	1.084	1.057	1.078	0.869	0.0703	0.999	0.868
2009	0.933	0.936	0.915	0.872	0.0725	1.115	0.973
2010	0.926	1.014	0.954	1.030	0.0769	1.120	1.153
2011	1.231	1.378	1.213	1.169	0.0746	1.139	1.332
2012	1.326	1.371	1.326	1.338	0.0680	1.154	1.545
2013	1.201	1.244	0.942	1.106	0.0661	1.101	1.218
2014	1.541	1.547	1.194	1.362	0.0643	1.146	1.562
2015	1.489	1.520	1.230	1.332	0.0621	1.174	1.564

Appendix L. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 2_BT

L.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 2 by the NINSWG (MPI 2016) with a research rating of '1' (High Quality).

L.2 Fishery definition

SPO 2_BT: The fishery is defined from bottom trawl fishing events that fished in Statistical Areas 011, 012, 013, 014 and 015 and declared target species FLA, GUR or TAR.

L.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in 8 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 37 vessels, which took 70% of the catch (Figure L.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure L.1).

L.4 Data summary

Table L.1: Summaries by fishing year for core vessels, trips, number of events that have been 'rolled up' into trips, number of events per trip, total tows, total hours towed, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of 10 trips per year in 8 years) in the SPO 2_BT fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch[1]	% catch: 0 estimated catch trips[1]
1990	12	666	1 067	1.60	2 557	8 610	11.22	46.7	56.9	46.7
1991	16	731	1 492	2.04	3 719	12 725	12.20	39.4	80.2	57.4
1992	20	1 090	1 999	1.83	4 776	16 768	22.46	51.7	59.0	39.8
1993	21	1 080	1 950	1.81	5 436	18 615	20.08	42.5	67.8	44.5
1994	22	1 247	2 423	1.94	5 608	20 600	22.91	46.1	63.3	37.0
1995	25	1 406	2 889	2.05	6 337	22 885	27.59	48.3	61.3	42.4
1996	26	1 463	3 257	2.23	6 601	23 279	32.42	48.3	59.0	33.9
1997	25	1 393	2 931	2.10	6 309	21 750	31.62	48.7	58.3	35.8
1998	26	1 516	3 212	2.12	6 989	24 769	31.33	46.4	55.4	28.7
1999	23	1 549	3 284	2.12	7 034	26 003	27.67	48.9	53.5	32.5
2000	21	1 458	2 865	1.97	6 529	25 098	28.07	55.2	54.4	44.2
2001	22	1 385	2 756	1.99	6 219	22 674	23.43	53.4	47.0	37.1
2002	22	1 387	2 807	2.02	6 287	22 392	27.97	56.4	40.5	26.3
2003	21	1 263	2 688	2.13	5 979	21 708	32.83	56.1	42.9	21.3
2004	20	1 072	2 386	2.23	5 548	19 882	29.63	59.2	44.3	24.0
2005	19	1 209	2 640	2.18	6 308	23 354	50.42	54.9	47.7	20.1
2006	20	1 312	2 900	2.21	6 827	24 322	48.65	58.2	42.7	24.5
2007	20	1 297	2 973	2.29	6 889	23 799	38.85	62.0	42.0	30.4
2008	21	1 103	6 553	5.94	6 599	22 427	44.26	63.9	12.5	4.3
2009	22	1 182	7 158	6.06	7 158	24 770	39.64	55.0	11.2	2.9
2010	21	1 217	7 483	6.15	7 483	25 864	54.16	62.1	10.6	3.1
2011	21	1 197	7 840	6.55	7 840	27 003	53.94	63.7	11.1	2.4
2012	20	1 177	7 182	6.10	7 182	24 872	59.43	63.9	8.5	1.8
2013	17	922	5 868	6.36	5 868	20 672	56.76	68.4	9.4	1.7
2014	18	930	6 402	6.88	6 402	22 357	66.20	71.4	6.0	0.9
2015	17	919	5 817	6.33	5 817	20 493	56.27	66.3	6.7	1.2

[1] See note following Figure L.2.

L.5 Core vessel selection

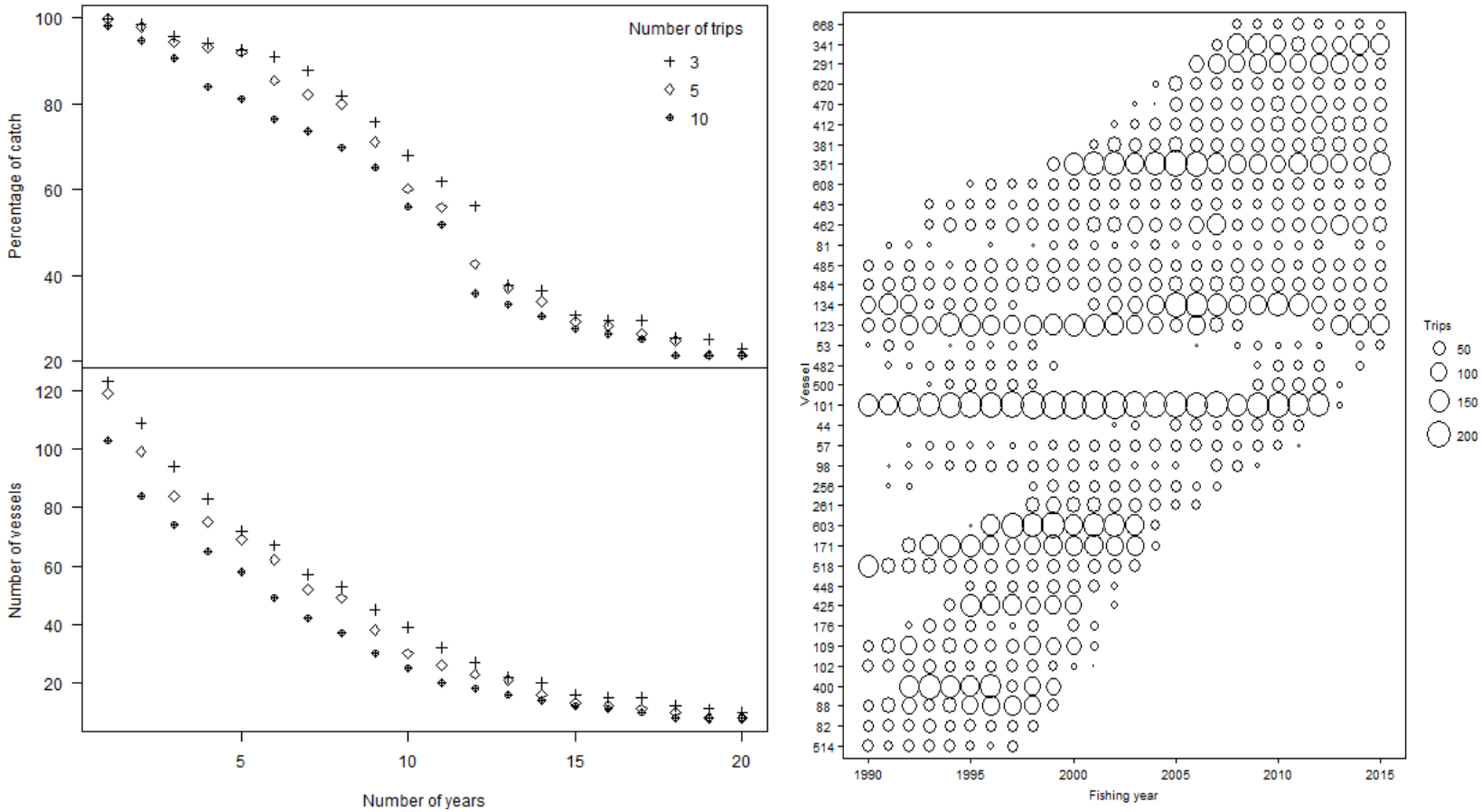

Figure L.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 2_BT data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least 10 trips in 8 or more fishing years) by fishing year.

L.6 Exploratory data plots for core vessel data set

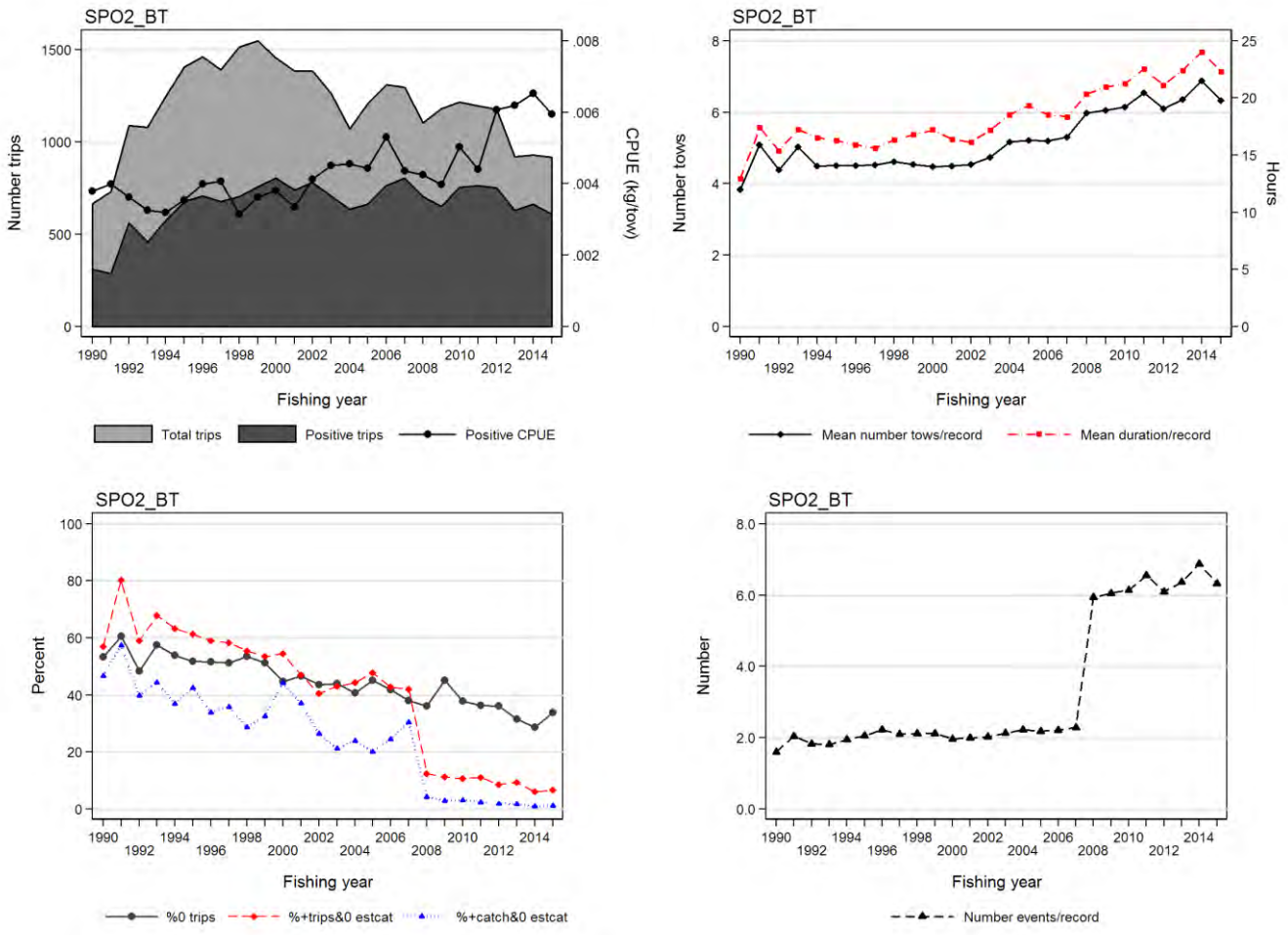

Figure L.2: Core vessel summary plots by fishing year for model SPO 2_BT: [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.

Note: the large decrease in the proportion of trips that did not report SPO from 2007–08 [lower left panel] and the corresponding increase in the number of events per trip [lower right panel] is due to the change to the TCER reporting form whereby the top eight species per tow were reported instead of the top five species per day of fishing. Because each record in this data set was [*trip*] and the estimated catch field was not used, it was not necessary to restrict the post 2007–08 data to the top five species per fishing day within a trip.

L.7 Selection of positive catch distribution

SPO 2_BT is an existing analysis (see Table 12). The positive catch distribution was forced to lognormal for consistency with previous analyses.

L.8 Positive catch model selection table

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

Table L.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 2_BT fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 8 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	26	-30 084	60 222	4.29	*
poly(log(hours), 3)	29	-26 301	52 662	39.48	*
vessel	65	-24 957	50 046	48.69	*
target	67	-24 668	49 473	50.48	*
month	78	-24 480	49 119	**51.62**	*
area	82	-24 386	48 938	52.18	
poly(log(tows), 3)	85	-24 376	48 924	52.24	

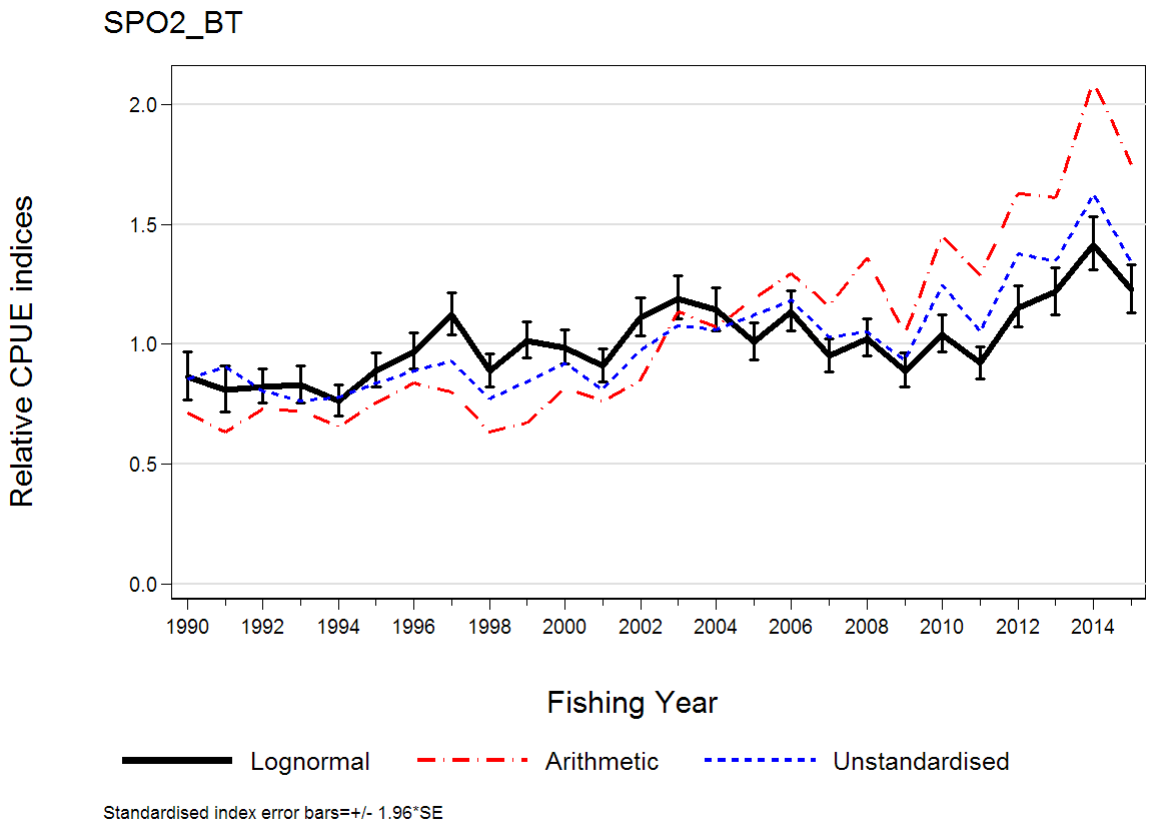

Figure L.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 2_BT fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

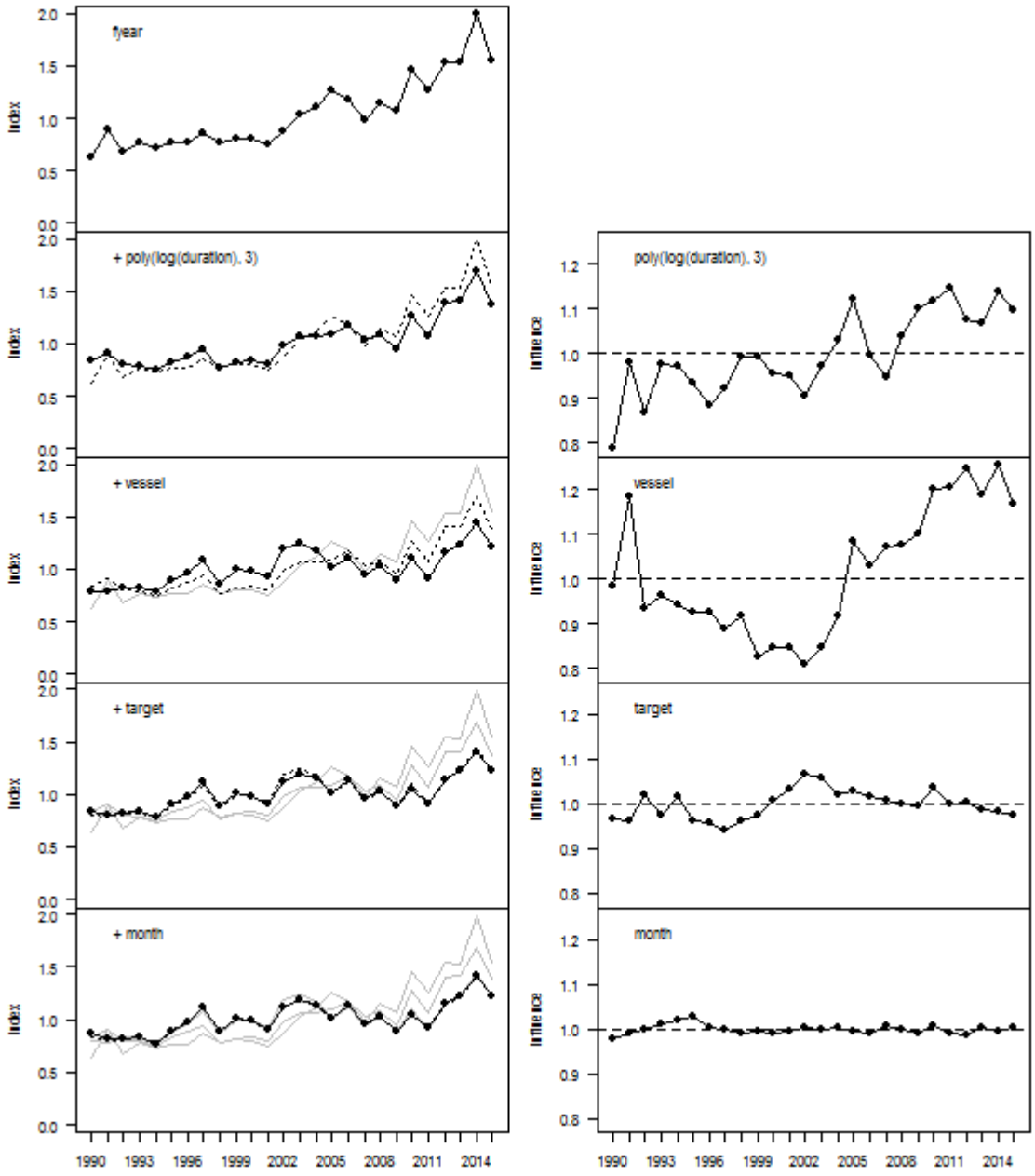

Figure L.4: [left column]: annual indices from the lognormal model of SPO 2_BT at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

L.9 Residual and diagnostic plots

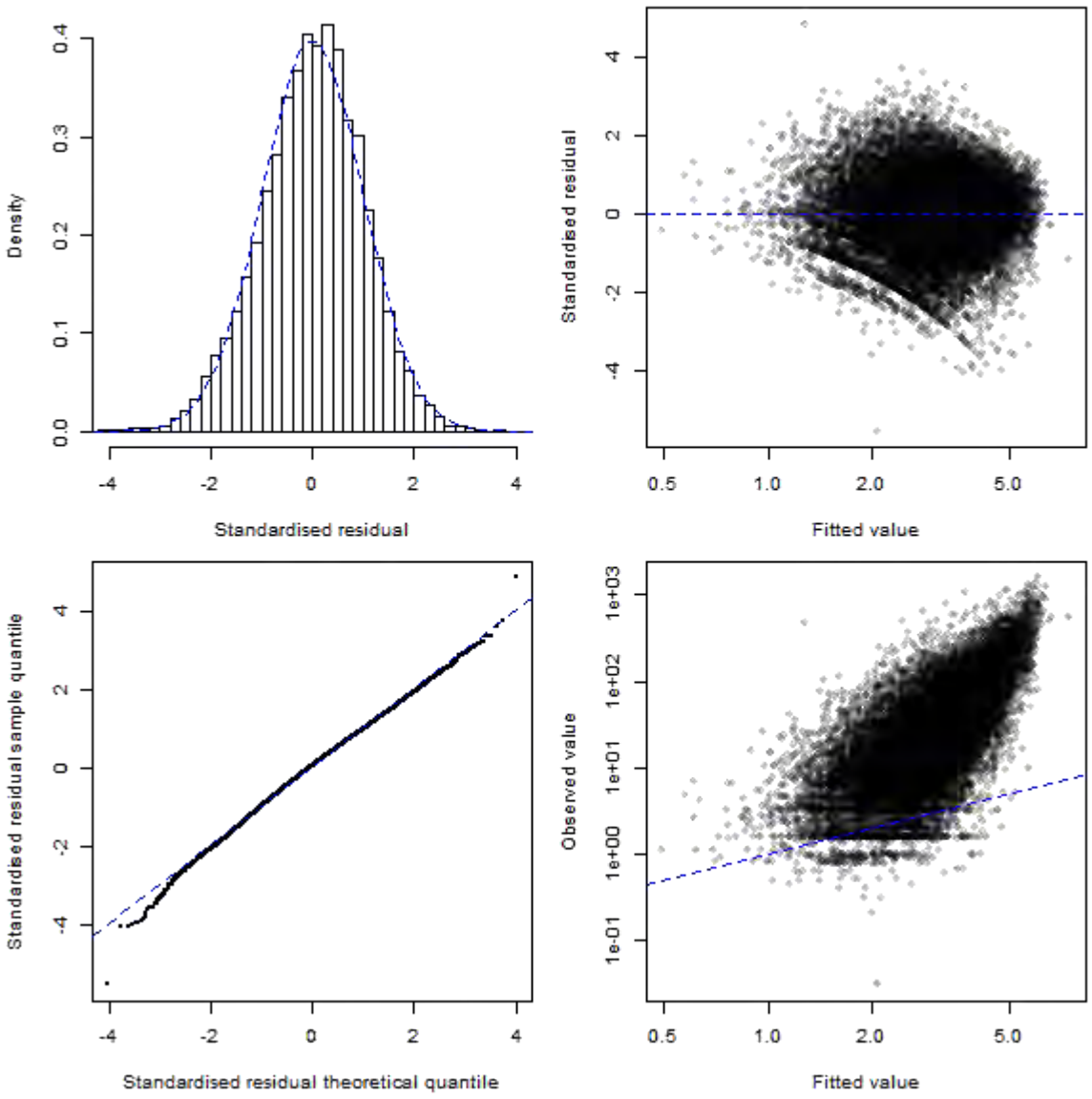

Figure L.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 2_BT fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

L.10 Model coefficients

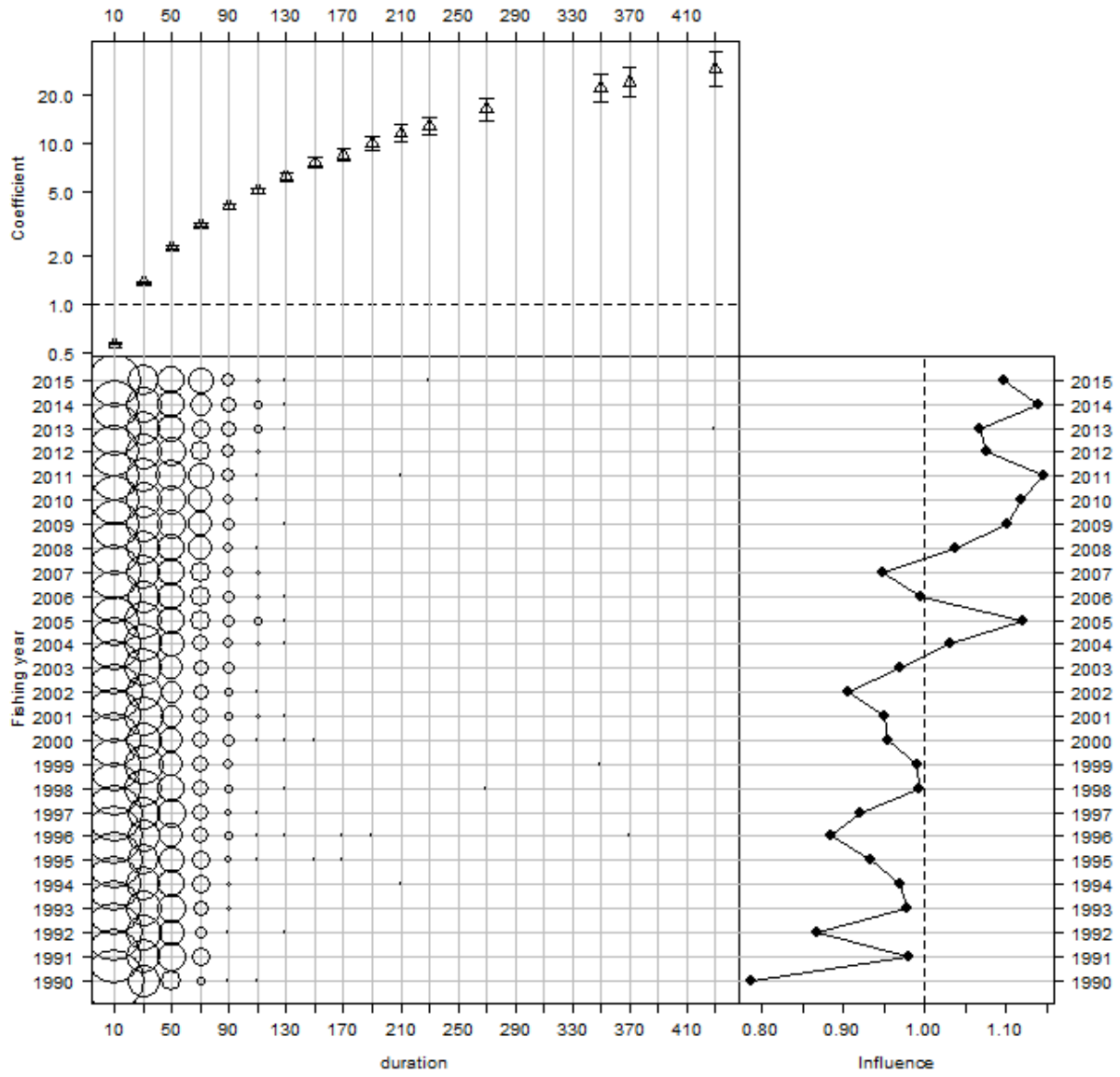

Figure L.6: Effect of hours fished in the lognormal model for the rig SPO 2_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

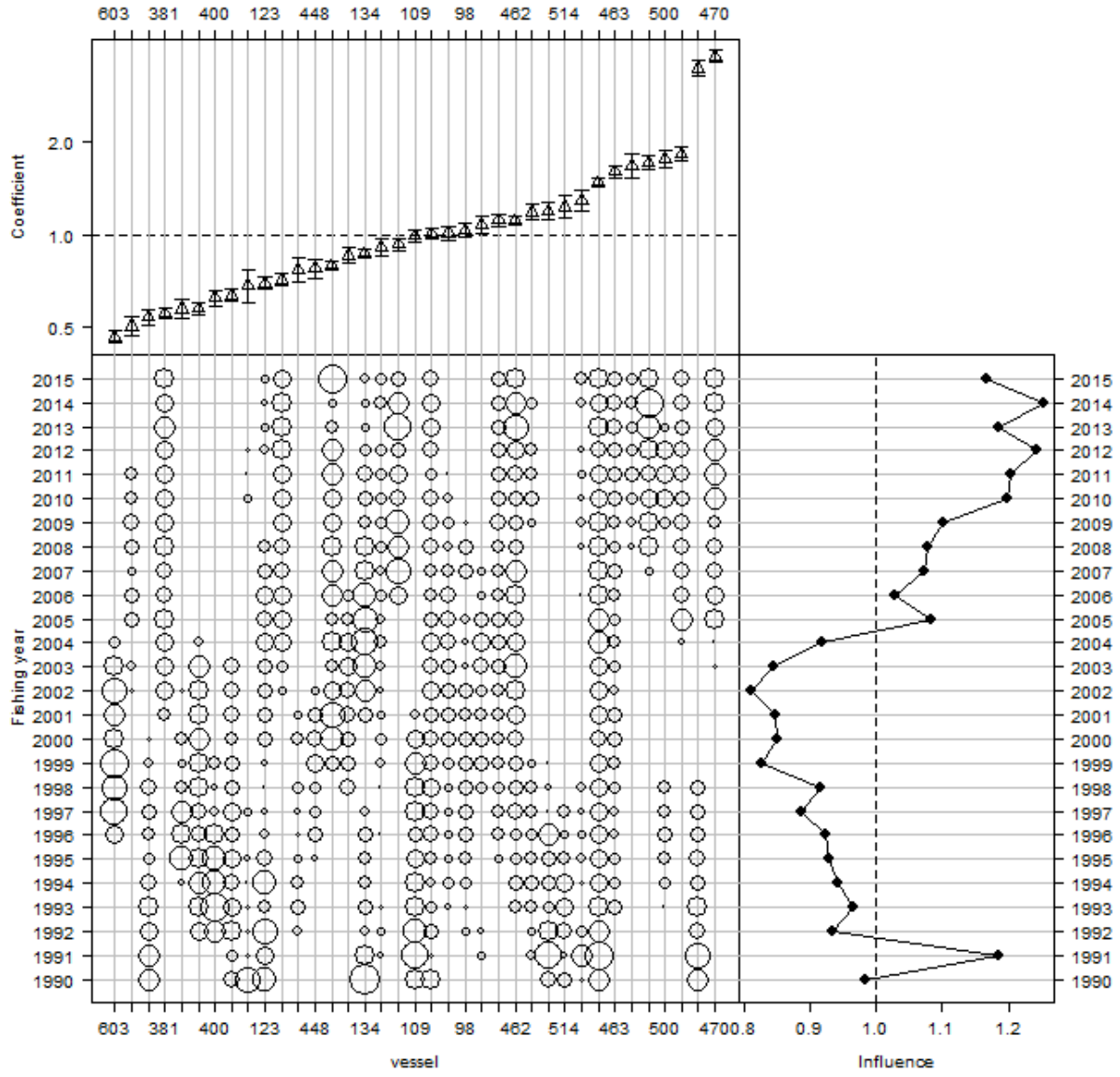

Figure L.7: Effect of vessel in the lognormal model for the rig SPO 2_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

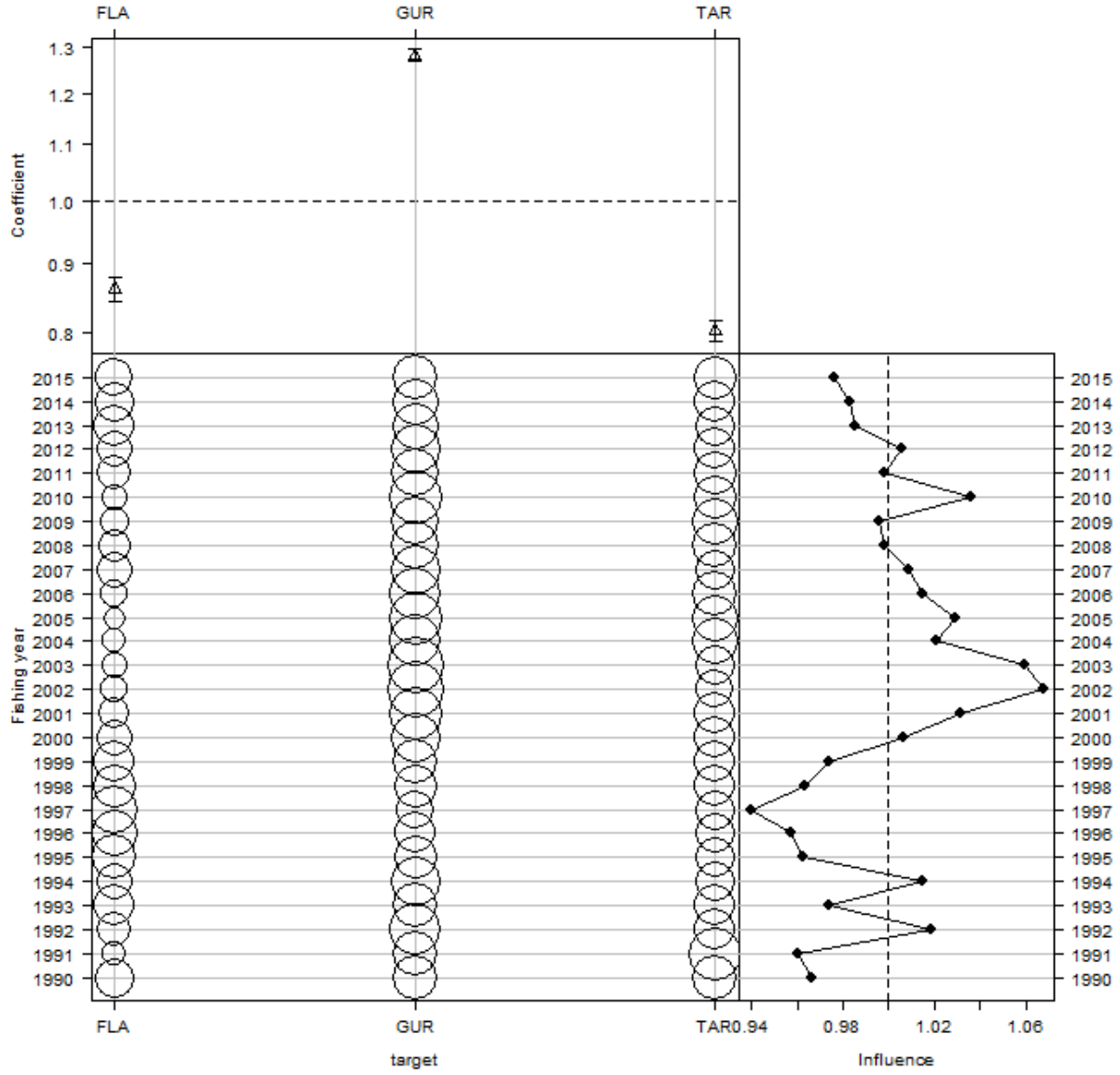

Figure L.8: Effect of target species in the lognormal model for the rig SPO 2_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

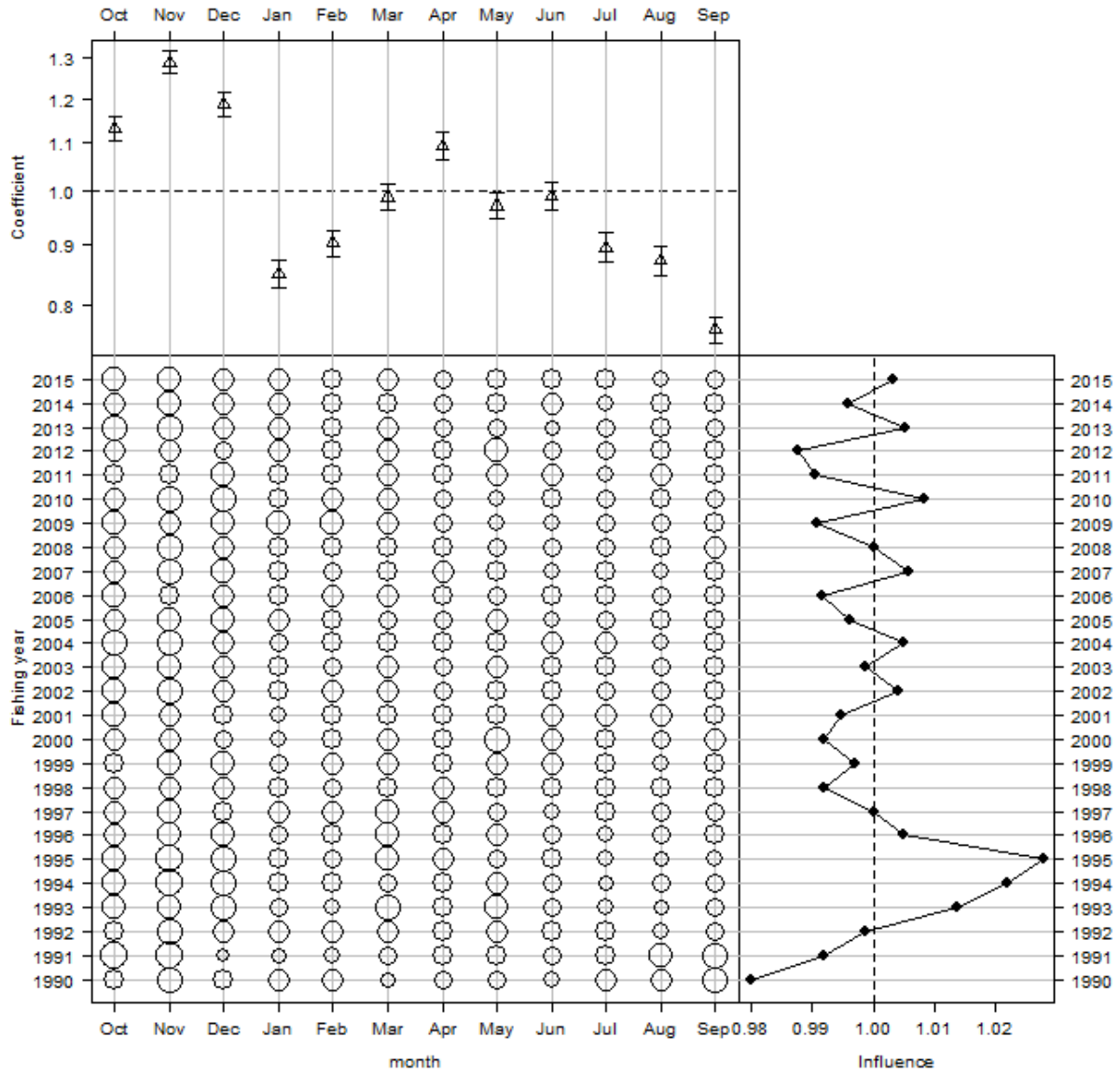

Figure L.9: Effect of month in the lognormal model for the rig SPO 2_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

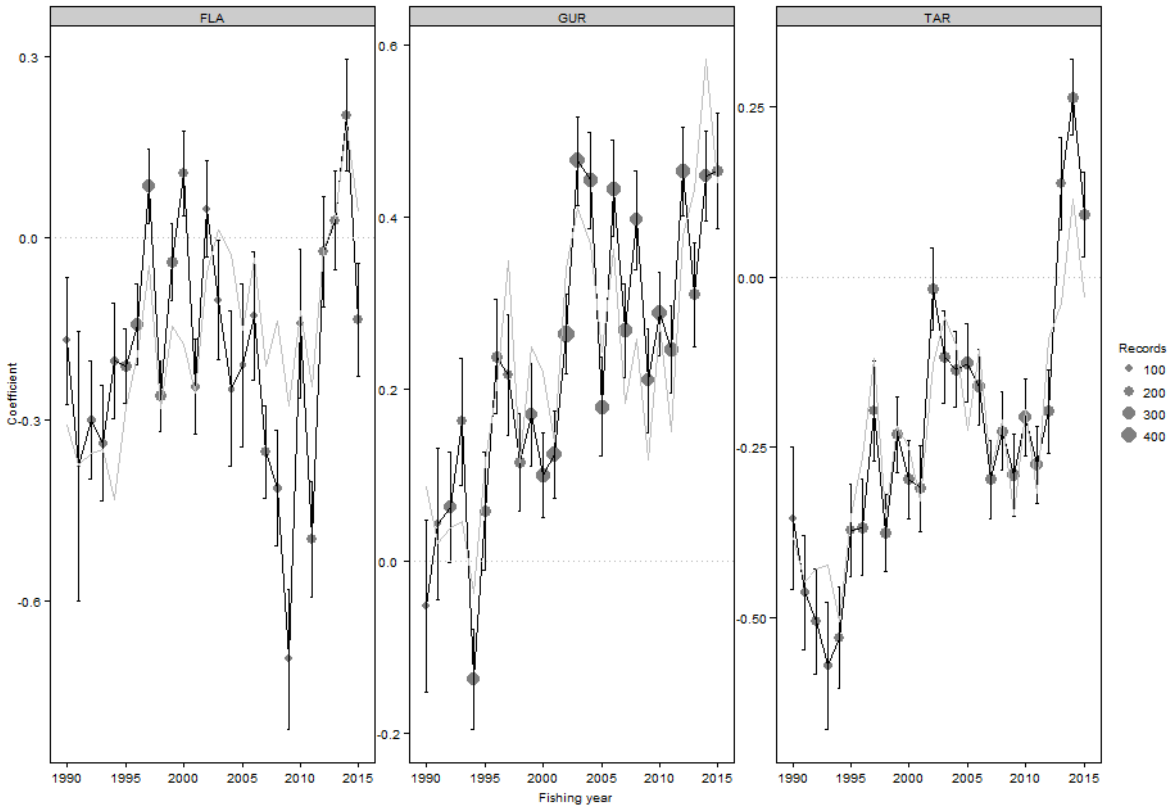

Figure L.10: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 2_BT lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

L.11 Presence/absence (binomial) catch model selection table

Two explanatory variables (vessel and hours fished) entered the model after fishing year (Table L.3), with the variables month, number tows and target species non-significant. The model discarded the variable statistical area. A plot of the model is provided in Figure L.11 and the CPUE indices are listed in Table L.4.

Table L.3: Order of acceptance of variables into the binomial model of presence/absence of rig catches in the SPO 2_BT fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 8 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	26	-21 075	42 202	3.16	*
vessel	62	-14 380	28 884	48.78	*
poly(log(hours), 3)	65	-13 549	27 228	**53.19**	*
month	76	-13 357	26 865	54.18	
poly(log(tows), 3)	79	-13 350	26 858	54.22	
target	82	-13 341	26 846	54.26	
area	–	–	–	–	

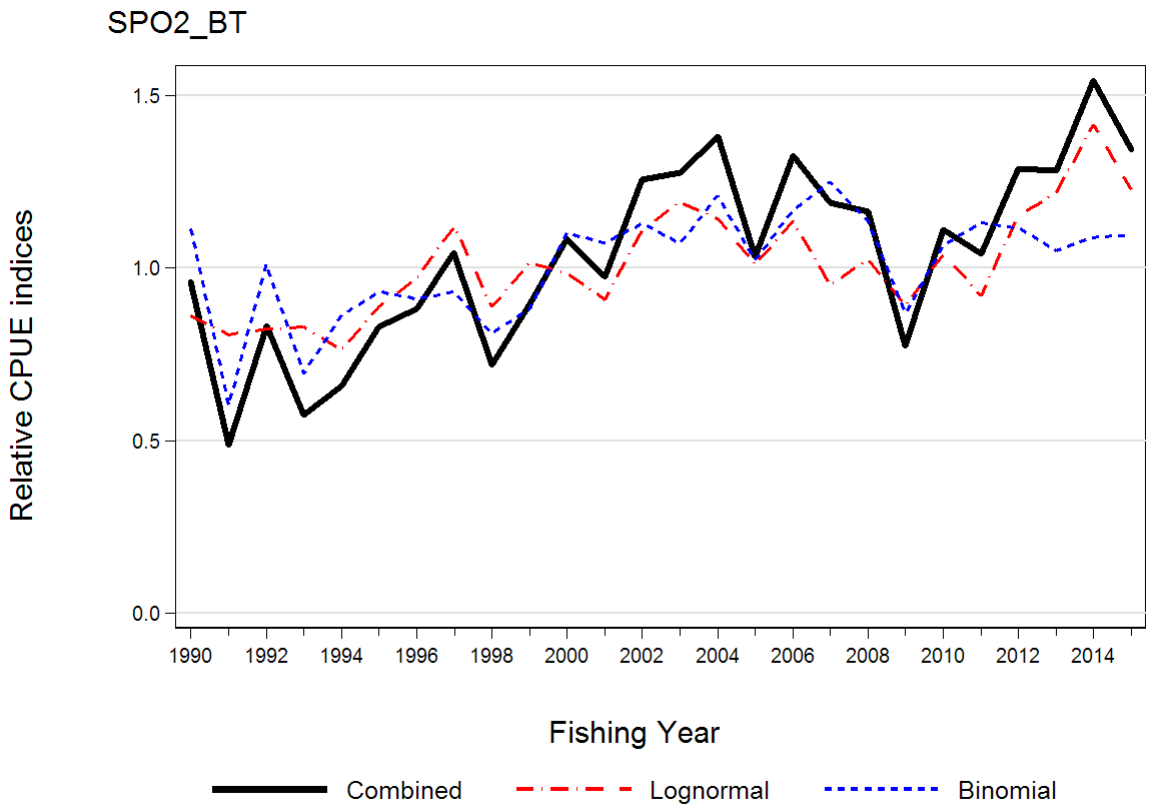

Figure L.11: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 2_BT fishery definition, the binomial standardised model using the logistic distribution, and the combined model using the delta-lognormal procedure (Eq. I.4).

L.12 CPUE indices

Table L.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE), as well as binomial and combined series for the core data set by fishing year for the SPO 2_BT analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels					
year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	0.586	0.712	0.857	0.862	0.0589	1.115	0.962
1991	0.493	0.634	0.905	0.808	0.0604	0.602	0.487
1992	0.824	0.732	0.806	0.823	0.0440	1.011	0.832
1993	0.889	0.722	0.764	0.829	0.0483	0.695	0.576
1994	0.708	0.657	0.778	0.763	0.0431	0.864	0.659
1995	0.769	0.757	0.838	0.889	0.0401	0.932	0.829
1996	0.804	0.837	0.889	0.970	0.0392	0.911	0.883
1997	0.846	0.803	0.931	1.122	0.0398	0.931	1.045
1998	0.616	0.633	0.774	0.888	0.0389	0.812	0.721
1999	0.662	0.673	0.844	1.015	0.0377	0.883	0.896
2000	0.789	0.818	0.921	0.986	0.0365	1.102	1.087
2001	0.818	0.763	0.810	0.909	0.0376	1.074	0.976
2002	0.873	0.847	0.976	1.112	0.0367	1.130	1.256
2003	1.140	1.136	1.077	1.192	0.0383	1.072	1.277
2004	1.166	1.073	1.062	1.143	0.0404	1.209	1.383
2005	1.253	1.190	1.121	1.009	0.0397	1.023	1.033
2006	1.405	1.296	1.185	1.136	0.0372	1.167	1.326
2007	1.305	1.158	1.029	0.951	0.0364	1.251	1.189
2008	1.349	1.361	1.053	1.025	0.0386	1.136	1.164
2009	1.093	1.043	0.933	0.891	0.0403	0.869	0.774
2010	1.476	1.453	1.249	1.041	0.0376	1.067	1.111
2011	1.316	1.287	1.051	0.920	0.0376	1.131	1.041
2012	1.594	1.630	1.377	1.153	0.0378	1.117	1.288
2013	1.563	1.610	1.347	1.218	0.0414	1.052	1.281
2014	1.684	2.099	1.626	1.417	0.0404	1.089	1.543
2015	1.514	1.749	1.342	1.227	0.0416	1.096	1.345

Appendix M. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 3_BT

M.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 3 by the SINSWG (MPI 2016) with a research rating of '1' (High Quality).

M.2 Fishery definition

SPO 3_BT: The fishery is defined from bottom trawl fishing events that fished in Statistical Areas 018, 020, 022, 024–032 and declared target species FLA, BAR, STA, RCO, SPD, TAR or SPO.

M.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in 8 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 119 vessels, which took 83% of the catch (Figure M.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure M.1).

M.4 Data summary

Table M.1: Summaries by fishing year for core vessels, trips, number of events that have been 'rolled up' into trips, number of events per trip, total tows, total hours towed, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of 10 trips per year in 8 years) in the SPO 3_BT fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Events	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch[1]	% catch: 0 estimated catch trips[1]
1990	71	4 069	6 072	1.49	14 826	42 204	21.52	18.3	63.8	49.3
1991	71	4 205	6 640	1.58	15 971	49 054	39.53	22.1	70.1	38.4
1992	78	4 419	7 504	1.70	17 805	57 429	47.05	28.8	71.7	42.5
1993	86	5 232	9 089	1.74	21 022	66 569	60.87	24.0	71.0	29.6
1994	90	5 862	8 886	1.52	22 284	64 827	66.66	25.7	76.5	33.5
1995	91	6 282	9 435	1.50	22 806	67 255	67.53	24.1	74.7	37.8
1996	94	5 919	9 674	1.63	23 521	68 601	83.07	26.7	75.6	39.5
1997	97	6 401	10 199	1.59	26 527	73 588	71.03	25.4	74.2	37.4
1998	93	6 591	10 456	1.59	27 590	74 607	81.19	27.2	73.1	39.8
1999	87	6 396	9 908	1.55	26 496	72 215	60.66	29.9	71.8	47.5
2000	88	5 584	9 069	1.62	24 179	67 228	74.85	35.5	71.9	46.8
2001	88	4 664	7 631	1.64	23 077	64 501	88.72	36.9	72.0	51.6
2002	82	4 103	7 005	1.71	20 582	54 969	64.93	36.7	73.2	47.2
2003	77	4 295	7 451	1.73	22 774	62 446	77.88	39.2	70.2	37.5
2004	83	4 317	7 120	1.65	20 482	56 389	72.82	36.7	71.8	53.8
2005	81	4 491	7 435	1.66	21 389	61 197	77.22	38.8	72.4	50.9
2006	76	3 840	6 626	1.73	18 783	56 739	66.86	42.7	70.3	43.1
2007	73	3 190	5 695	1.79	17 052	53 027	76.00	50.9	72.7	52.5
2008	71	2 721	12 998	4.78	13 365	40 184	58.96	46.1	29.7	12.0
2009	63	3 013	13 585	4.51	13 970	44 741	64.63	45.1	32.3	14.7
2010	62	2 854	14 000	4.91	14 160	45 081	71.84	48.4	26.9	8.0
2011	62	2 578	12 335	4.78	12 387	40 309	59.57	50.2	28.7	10.9
2012	59	2 643	12 791	4.84	12 921	41 044	81.95	46.1	27.0	5.4
2013	58	2 746	13 073	4.76	13 182	41 959	74.58	50.0	29.5	6.6
2014	55	2 756	12 456	4.52	12 509	42 439	101.68	55.2	27.7	5.3
2015	49	1 920	9 192	4.79	9 257	31 770	102.88	59.1	30.0	8.5

[1] See note following Figure M.2.

M.5 Core vessel selection

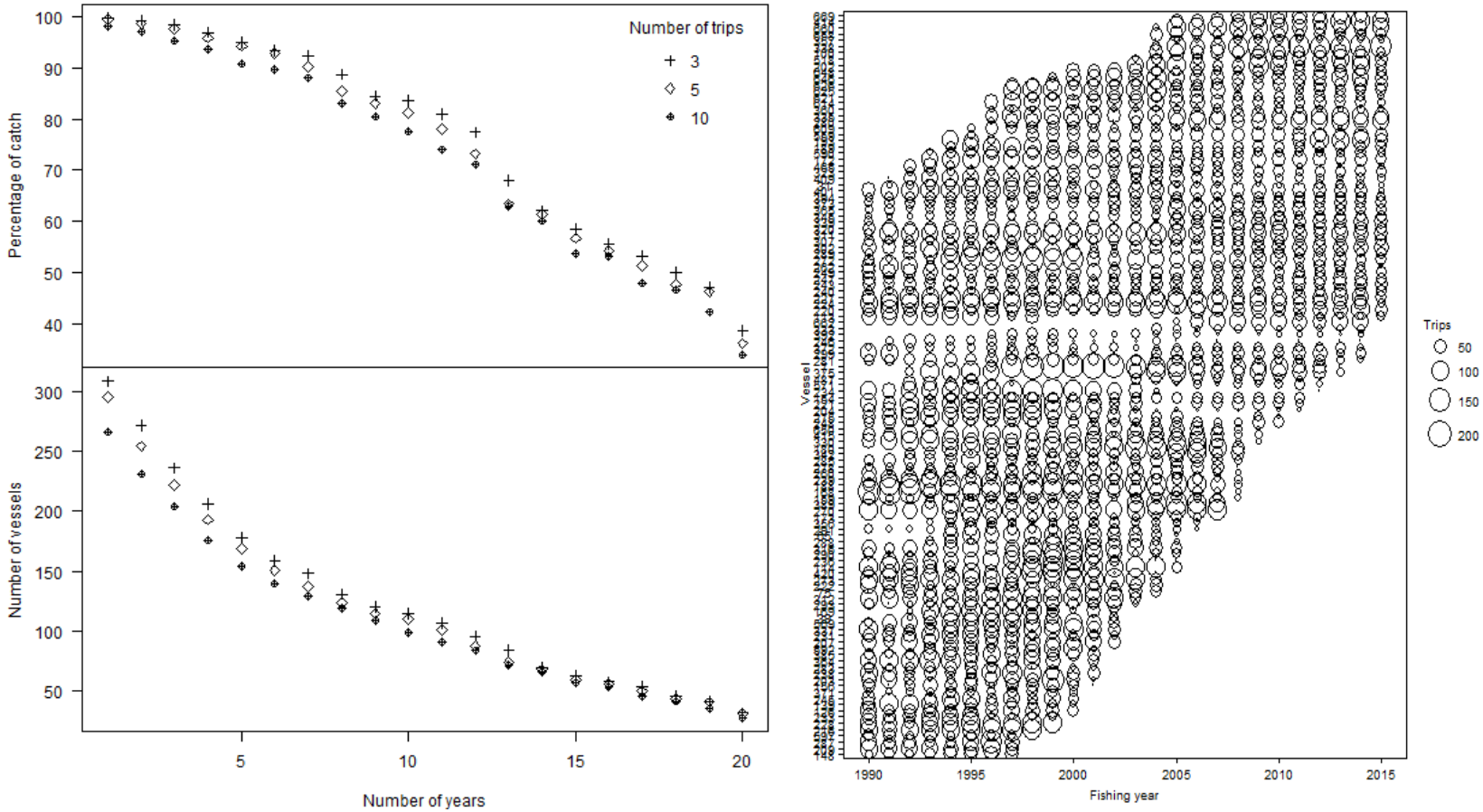

Figure M.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 3_BT data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least 10 trips in 8 or more fishing years) by fishing year.

M.6 Exploratory data plots for core vessel data set

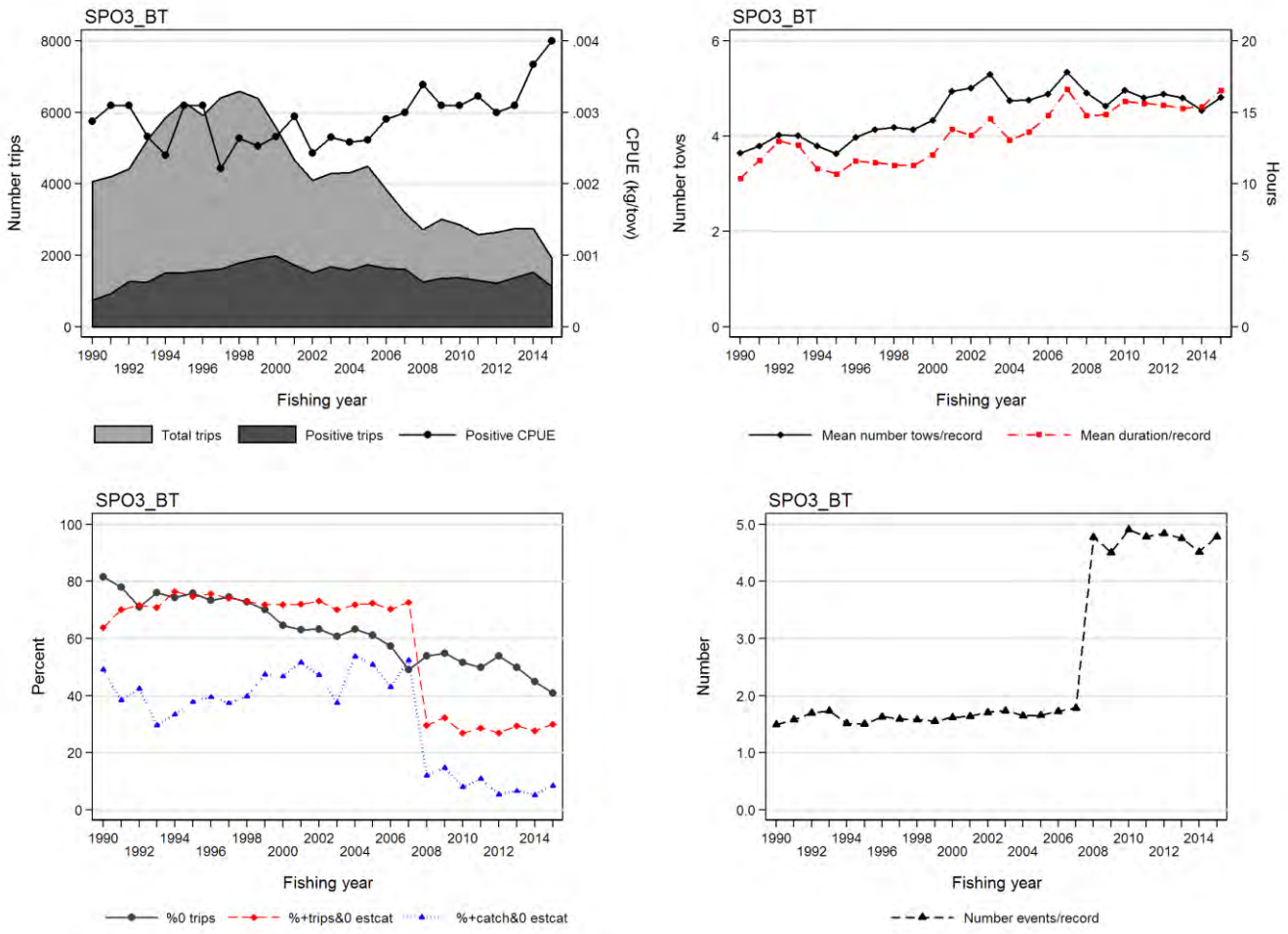

Figure M.2: Core vessel summary plots by fishing year for model SPO 3_BT: [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$**; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch (see note below); [lower right panel]: mean number of events per stratum record.**

Note: the large decrease in the proportion of trips that did not report SPO from 2007–08 [lower left panel] and the corresponding increase in the number of events per trip [lower right panel] is due to the change to the TCER reporting form whereby the top eight species per tow were reported instead of the top five species per day of fishing. Because each record in this data set was [*trip*] and the estimated catch field was not used, it was not necessary to restrict the post 2007–08 data to the top five species per fishing day within a trip.

M.7 Selection of positive catch distribution

SPO 3_BT is a new analysis (see Table 12) but it combines two previous analyses that used the lognormal distribution for positive catches. Therefore, positive catch distribution was forced to lognormal for consistency with previous analyses.

M.8 Positive catch model selection table

Three explanatory variables (vessel, hours fished and target) entered the model after fishing year (Table M.2), with the variables statistical area, month and number tows non-significant. A plot of the model is provided in Figure M.3 and the CPUE indices are listed in Table M.4.

Table M.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 3_BT fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 8 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	26	-67 982	136 017	0.60	*
vessel	144	-64 361	129 012	18.28	*
poly(log(hours), 3)	147	-63 177	126 650	23.38	*
target	153	-62 747	125 802	**25.15**	*
area	163	-62 551	125 430	25.94	
month	174	-62 396	125 142	26.57	
poly(log(tows), 3)	177	-62 336	125 027	26.81	

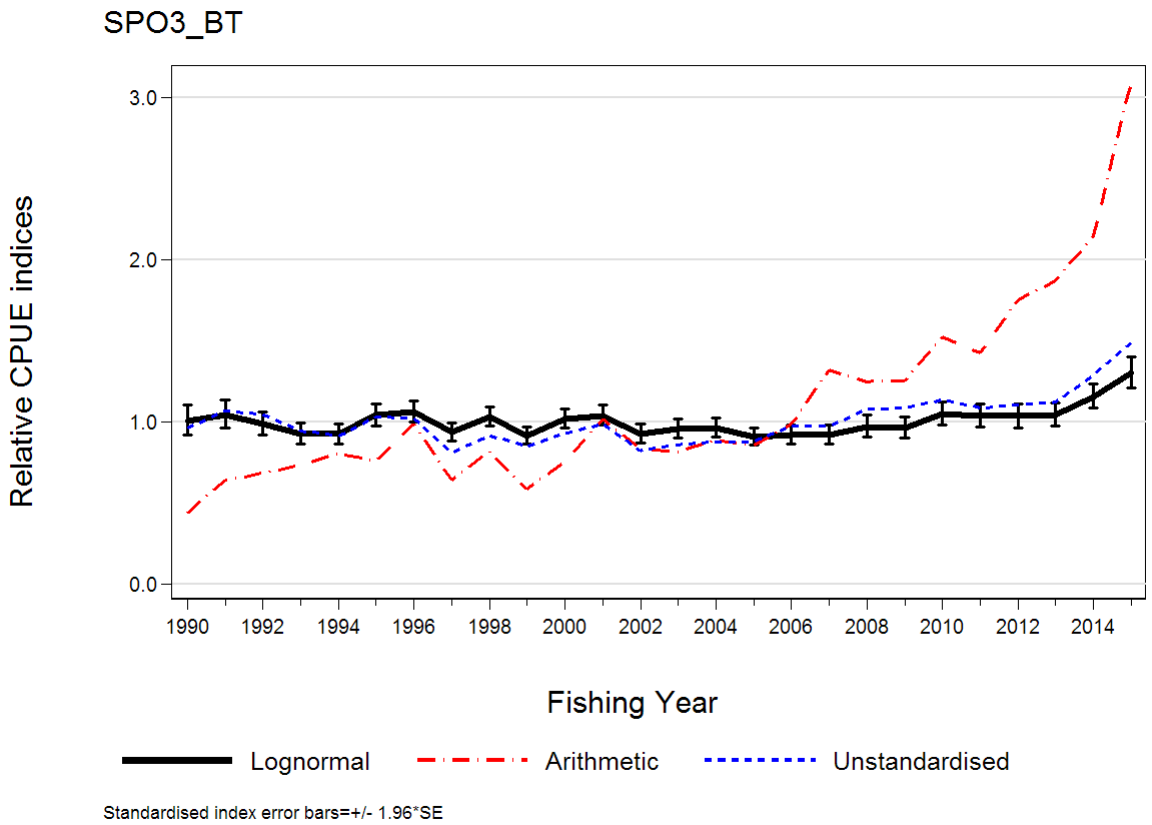

Figure M.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 3_BT fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

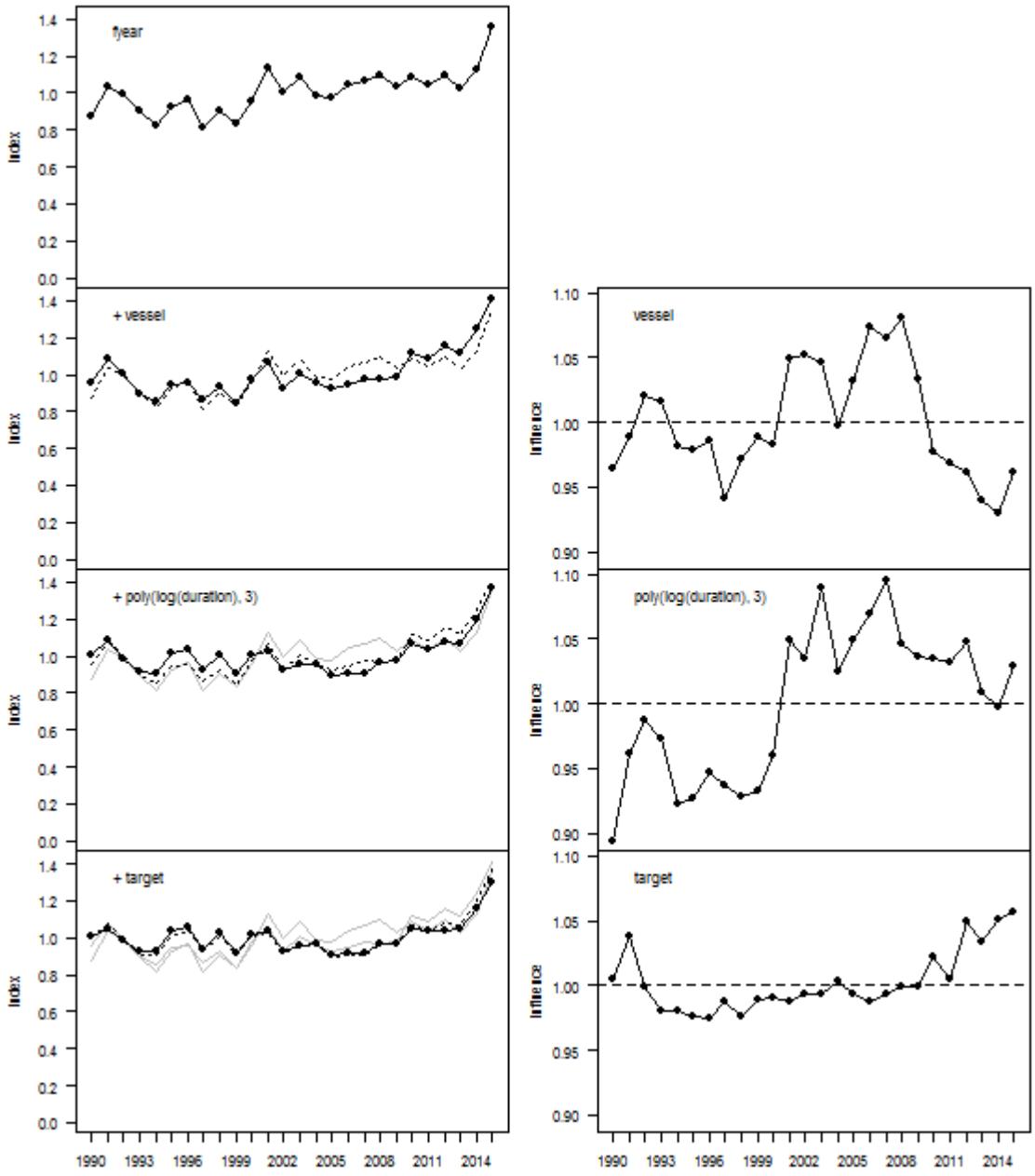

Figure M.4: [left column]: annual indices from the lognormal model of SPO 3_BT at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

M.9 Residual and diagnostic plots

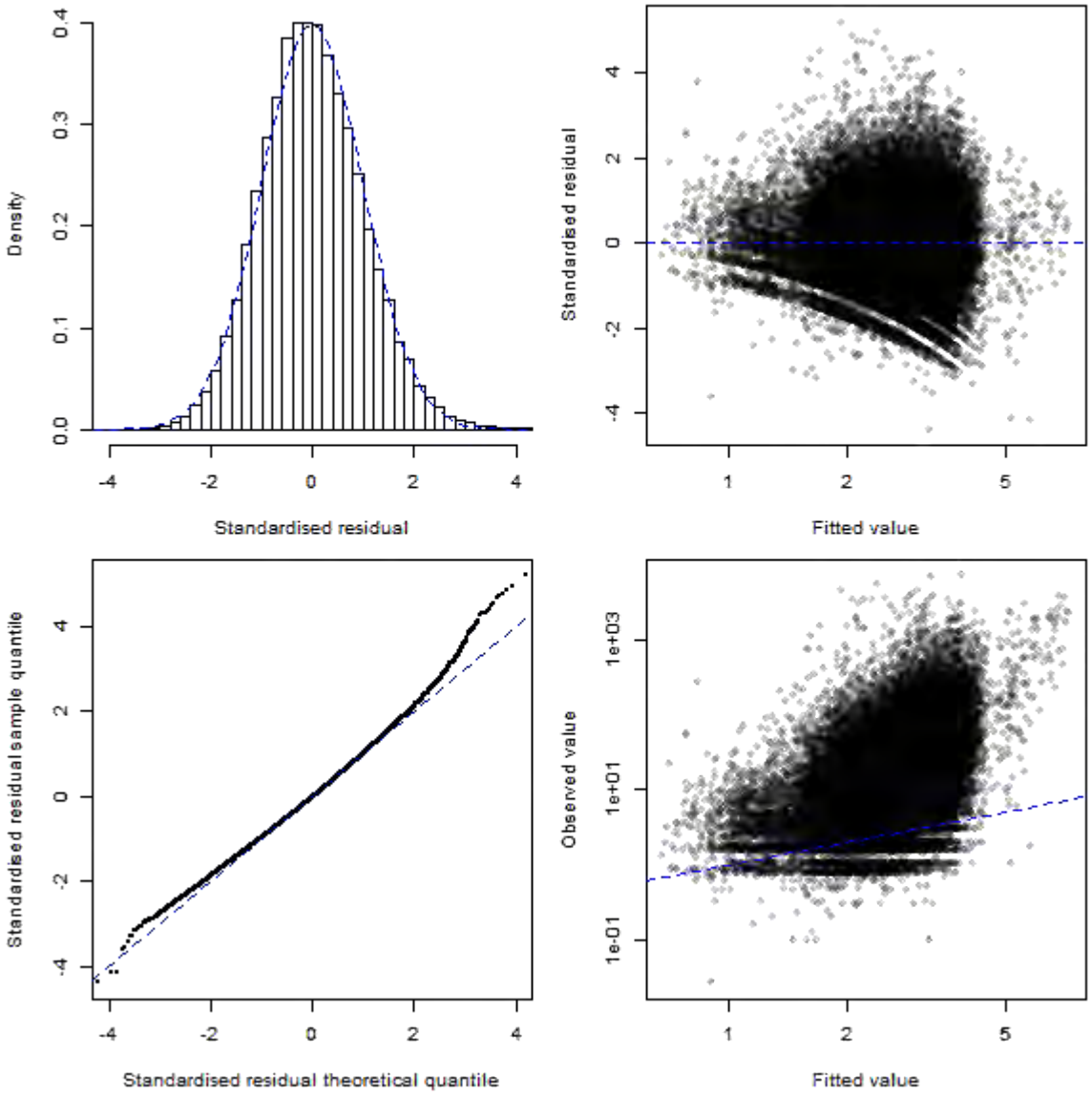

Figure M.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 3_BT fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

M.10 Model coefficients

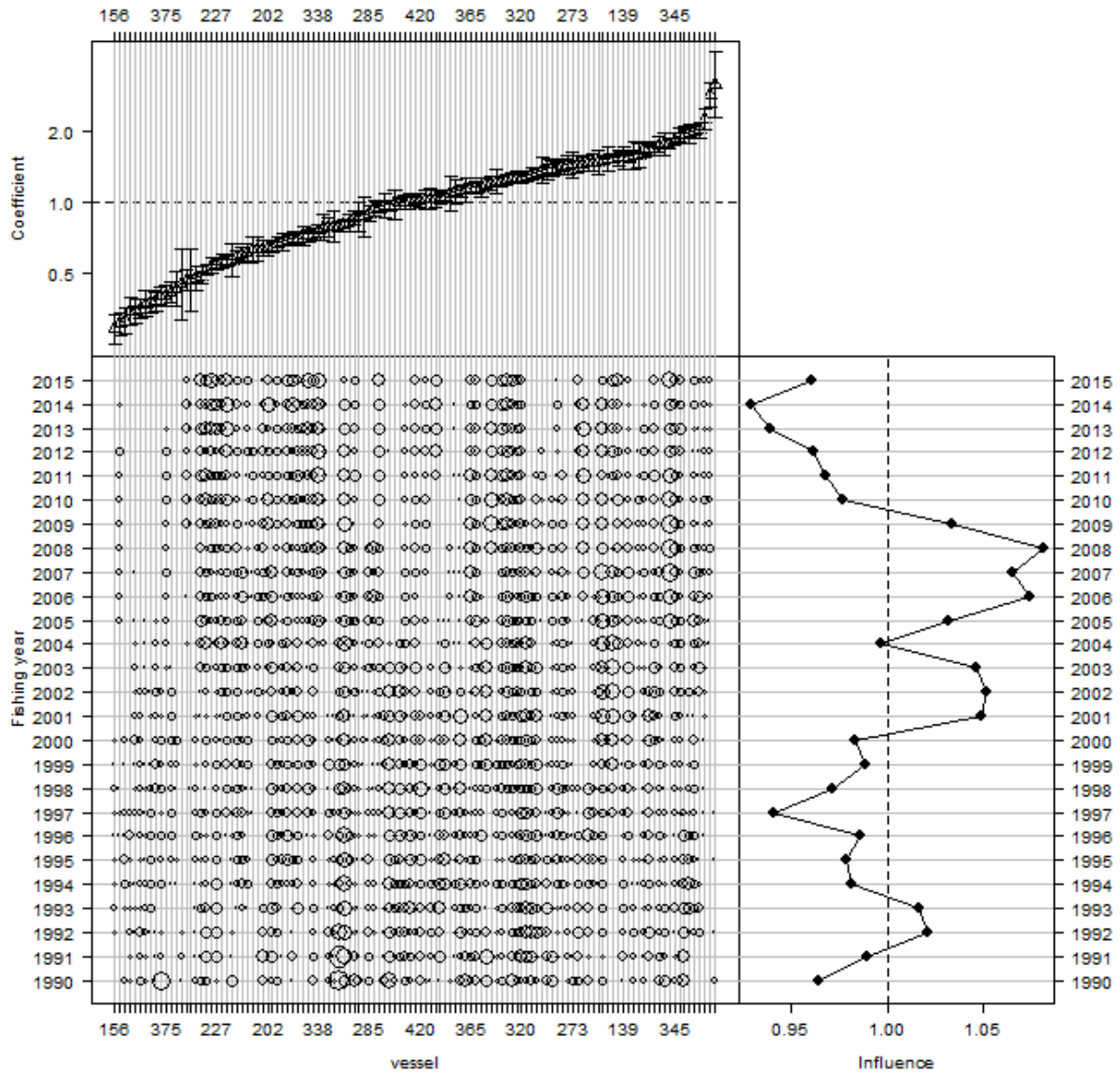

Figure M.6: Effect of vessel fished in the lognormal model for the rig SPO 3_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

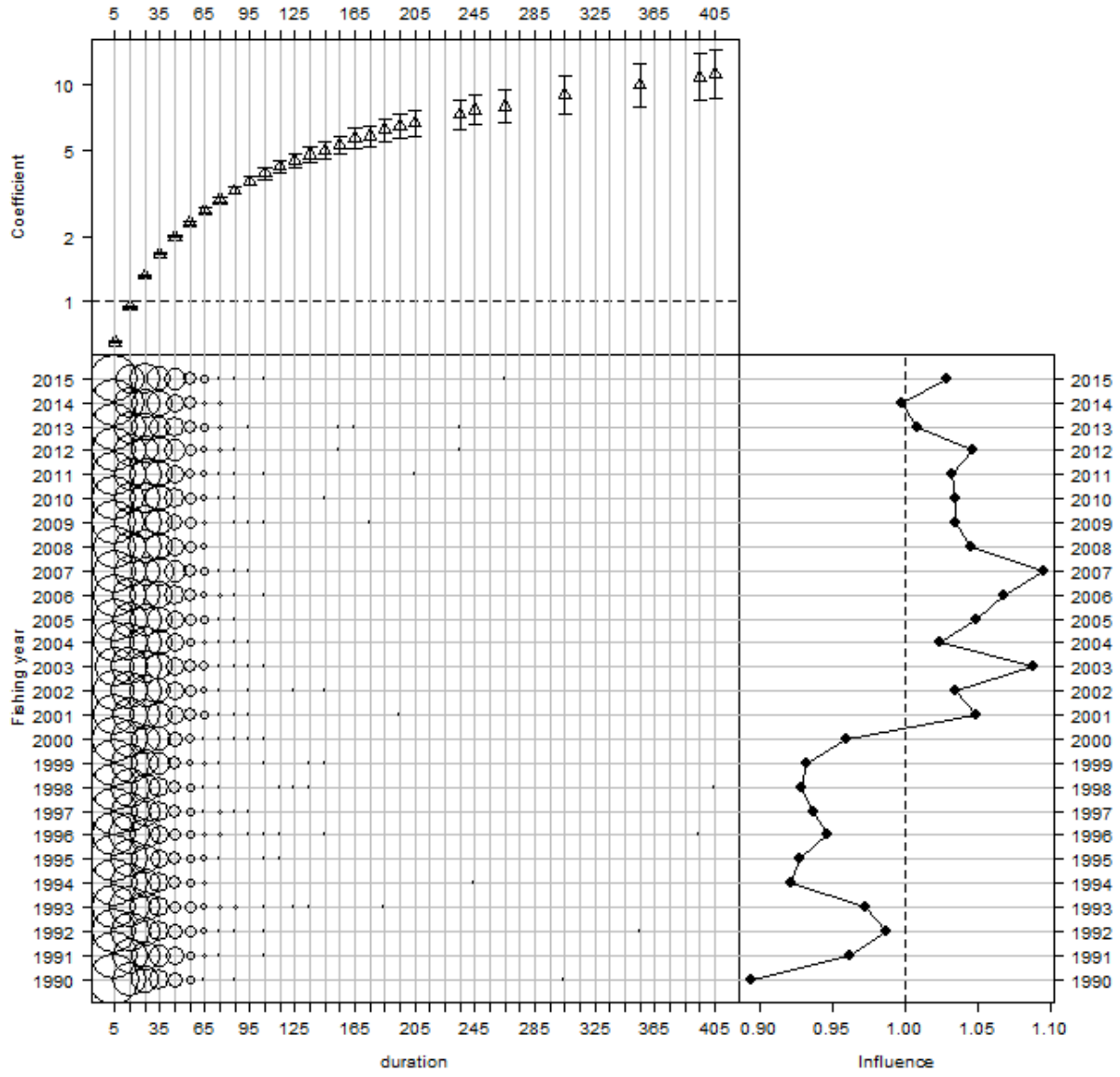

Figure M.7: Effect of hours fished in the lognormal model for the rig SPO 3_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

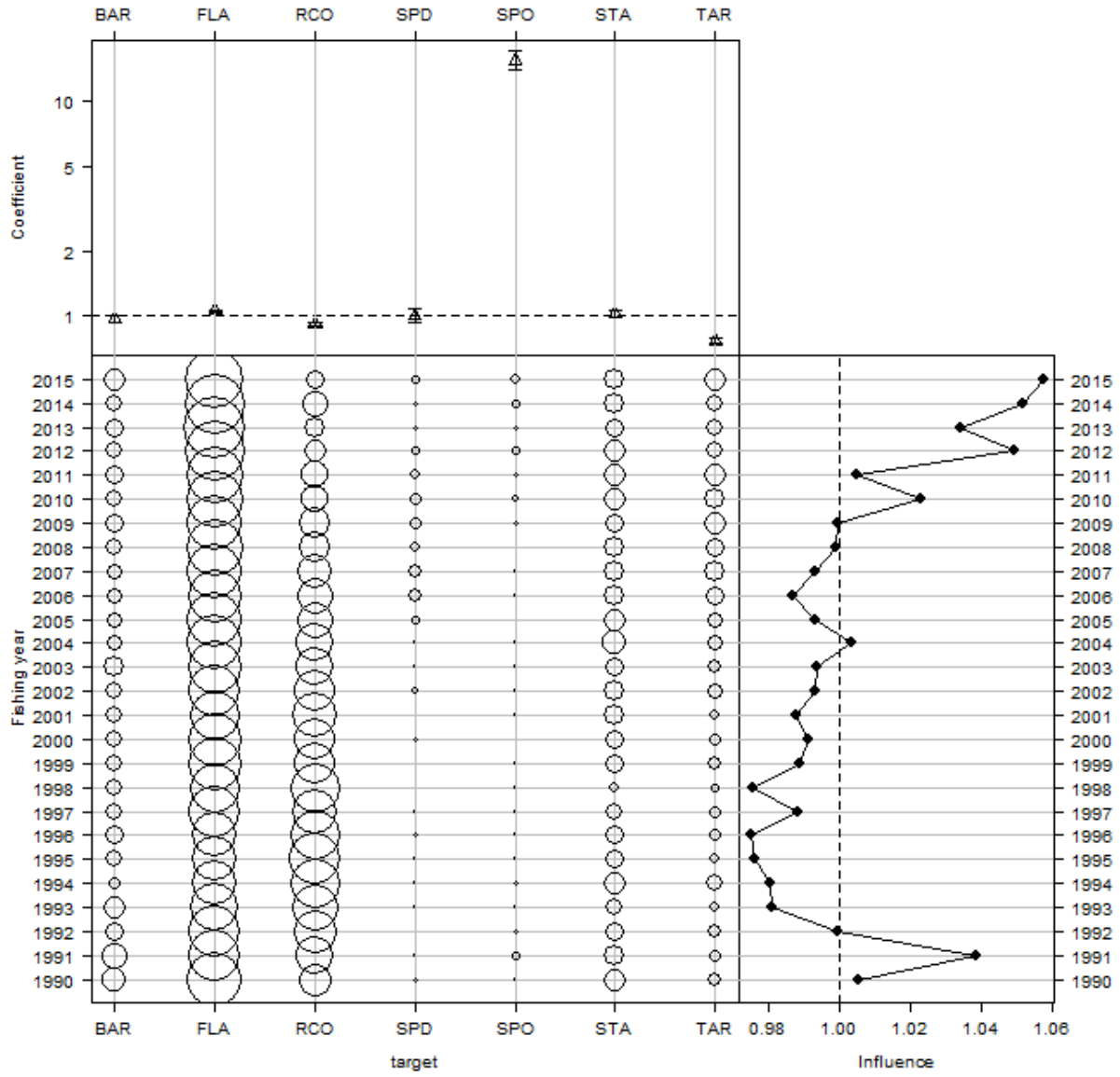

Figure M.8: Effect of target species in the lognormal model for the rig SPO 3_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

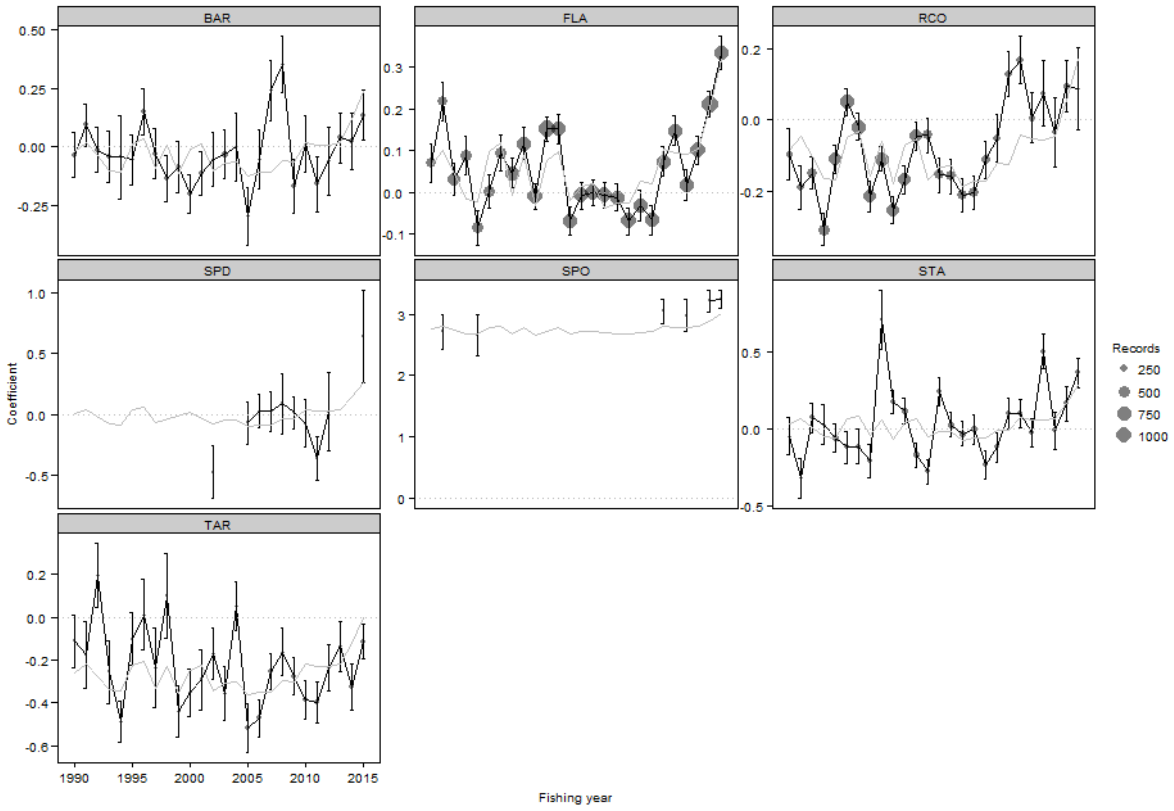

Figure M.9: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 3_BT lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

M.11 Presence/absence (binomial) catch model selection table

Three explanatory variables (vessel, number tows and month) entered the model after fishing year (Table M.3), with the variables statistical area, target species and number tows non-significant. A plot of the model is provided in Figure M.10 and the CPUE indices are listed in Table M.4.

Table M.3: Order of acceptance of variables into the binomial model of presence/absence of rig catches in the SPO 3_BT fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 8 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	26	-68 903	137 859	6.22	*
vessel	144	-60 007	120 303	25.74	*
poly(log(tows), 3)	147	-56 758	113 810	32.13	*
month	158	-53 895	108 107	**37.46**	*
area	169	-53 495	107 328	38.18	
target	175	-53 368	107 086	38.41	
poly(log(hours), 3)	178	-53 264	106 885	38.60	

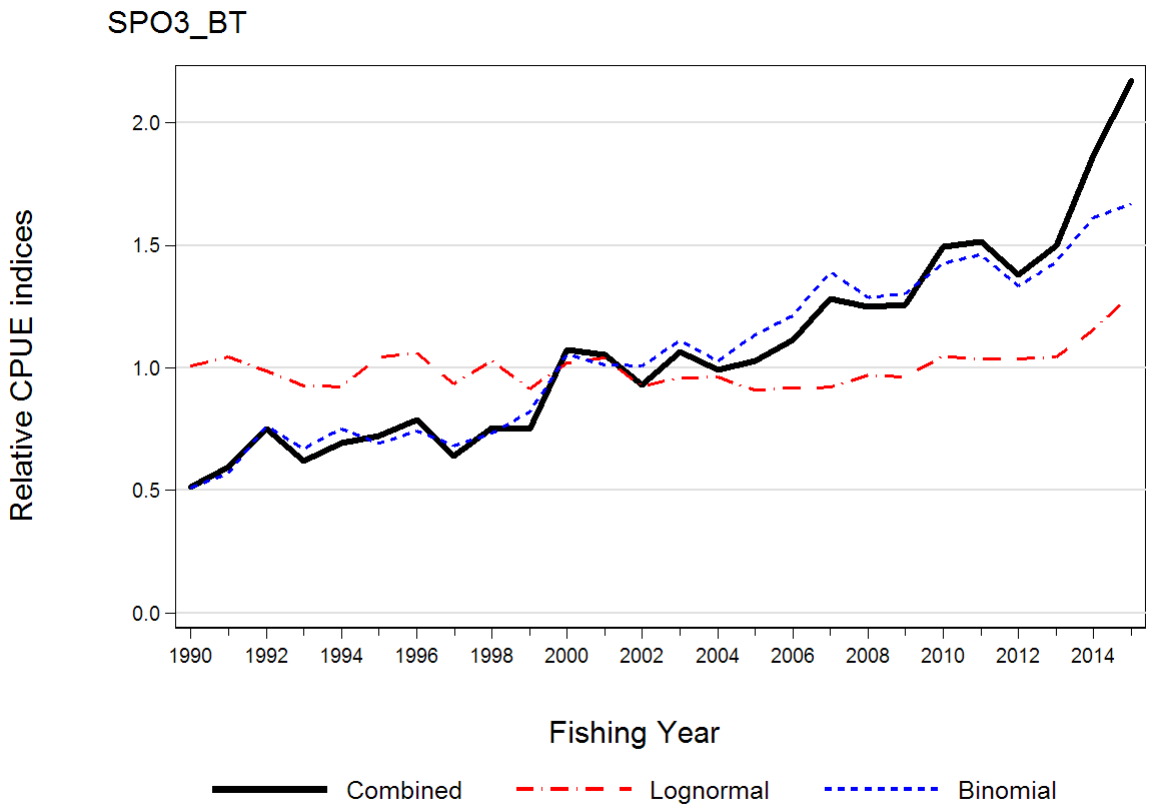

Figure M.10: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 3_BT fishery definition, the binomial standardised model using the logistic distribution, and the combined model using the delta-lognormal procedure (Eq. I.4).

M.12 CPUE indices

Table M.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE), as well as binomial and combined series for the core data set by fishing year for the SPO 3_BT analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels					
year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	0.435	0.440	0.961	1.006	0.0464	0.511	0.514
1991	0.574	0.639	1.070	1.045	0.0414	0.570	0.596
1992	0.628	0.684	1.046	0.988	0.0357	0.762	0.753
1993	0.684	0.734	0.946	0.928	0.0358	0.671	0.622
1994	0.769	0.805	0.912	0.924	0.0329	0.753	0.695
1995	0.691	0.757	1.033	1.041	0.0330	0.692	0.720
1996	0.894	0.985	1.022	1.062	0.0323	0.742	0.788
1997	0.615	0.645	0.809	0.936	0.0315	0.683	0.639
1998	0.803	0.815	0.915	1.032	0.0303	0.733	0.756
1999	0.599	0.585	0.849	0.915	0.0292	0.820	0.750
2000	0.800	0.758	0.928	1.019	0.0287	1.054	1.075
2001	1.048	1.015	0.988	1.040	0.0306	1.014	1.054
2002	0.875	0.830	0.822	0.925	0.0324	1.008	0.933
2003	0.813	0.816	0.859	0.959	0.0307	1.112	1.066
2004	0.881	0.889	0.877	0.963	0.0316	1.027	0.990
2005	0.923	0.855	0.879	0.908	0.0302	1.134	1.030
2006	1.038	0.985	0.973	0.920	0.0313	1.213	1.116
2007	1.365	1.320	0.974	0.920	0.0314	1.391	1.280
2008	1.271	1.249	1.077	0.970	0.0356	1.288	1.249
2009	1.328	1.254	1.086	0.964	0.0346	1.303	1.256
2010	1.630	1.526	1.137	1.048	0.0343	1.428	1.496
2011	1.632	1.426	1.086	1.036	0.0352	1.461	1.514
2012	1.779	1.756	1.106	1.035	0.0363	1.333	1.380
2013	1.850	1.872	1.121	1.046	0.0344	1.432	1.497
2014	2.203	2.146	1.290	1.156	0.0329	1.613	1.864
2015	2.963	3.104	1.486	1.300	0.0377	1.669	2.170

Appendix N. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 7_BT

N.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 7 by the SINSWG (MPI 2016) with a research rating of '1' (High Quality).

N.2 Fishery definition

SPO 7_BT: The fishery is defined from bottom trawl fishing events that fished in Statistical Areas 016–018, 032–040 and declared target species FLA, RCO, SPO, BAR, TAR, GUR, TRE, SNA or WAR.

N.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 5 trips in 10 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 97 vessels, which took 80% of the catch (Figure N.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure N.1).

N.4 Data summary

Table N.1: Summaries by fishing year for core vessels, trips, number of events that have been 'rolled up' into trips, number of events per trip, total tows, total hours towed, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of 5 trips per year in 10 years) in the SPO 7_BT fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Events	Events per trip	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch[1]	% catch: 0 estimated catch trips[1]
1990	51	1 139	2 628	2.31	7 821	22 012	44.40	59.4	59.4	27.2
1991	60	1 239	3 140	2.53	9 102	24 813	43.99	53.3	53.3	33.4
1992	67	1 609	3 882	2.41	11 607	34 280	41.05	52.2	61.4	36.2
1993	76	2 149	5 158	2.40	16 331	47 864	69.41	56.4	65.8	37.7
1994	76	1 803	4 317	2.39	13 191	35 148	60.73	55.7	63.8	33.5
1995	77	2 046	5 086	2.49	14 846	40 459	85.66	60.2	60.9	34.6
1996	81	2 093	5 274	2.52	15 446	43 783	88.42	57.4	58.5	37.5
1997	81	2 289	6 316	2.76	18 403	53 766	89.32	57.6	58.4	35.9
1998	80	2 019	5 475	2.71	14 789	42 944	67.95	55.7	59.4	26.8
1999	80	2 149	5 872	2.73	16 715	49 660	117.77	63.9	57.0	27.4
2000	73	1 677	4 843	2.89	13 895	41 500	112.73	71.9	54.6	25.0
2001	73	1 661	5 273	3.17	14 712	49 420	126.43	72.0	56.7	35.6
2002	69	1 493	4 960	3.32	13 427	44 192	109.75	69.3	53.9	26.4
2003	65	1 474	4 892	3.32	13 475	46 492	92.01	70.0	55.6	27.6
2004	67	1 574	5 632	3.58	14 903	51 612	89.99	76.3	58.7	35.1
2005	65	1 532	5 678	3.71	15 028	51 570	84.77	70.6	59.0	32.2
2006	67	1 511	5 484	3.63	14 234	49 850	90.16	71.9	52.2	29.2
2007	66	1 741	6 152	3.53	16 405	57 521	99.53	67.9	53.0	25.3
2008	61	1 307	12 426	9.51	12 538	46 850	104.87	73.8	15.7	2.1
2009	56	1 286	12 139	9.44	12 214	46 337	104.07	71.0	17.2	3.2
2010	55	1 370	13 277	9.69	13 292	46 367	109.58	75.6	16.6	3.0
2011	53	1 089	10 965	10.07	10 965	38 653	102.69	77.4	13.6	1.8
2012	51	1 166	11 418	9.79	11 418	41 784	105.52	77.4	19.3	7.4
2013	50	1 174	11 726	9.99	11 726	42 069	129.84	82.8	14.0	2.6
2014	46	1 032	10 479	10.15	10 479	39 300	131.56	85.0	11.1	2.1
2015	40	875	9 058	10.35	9 058	34 011	127.76	86.9	14.5	1.9

[1] See note following Figure N.2.

N.5 Core vessel selection

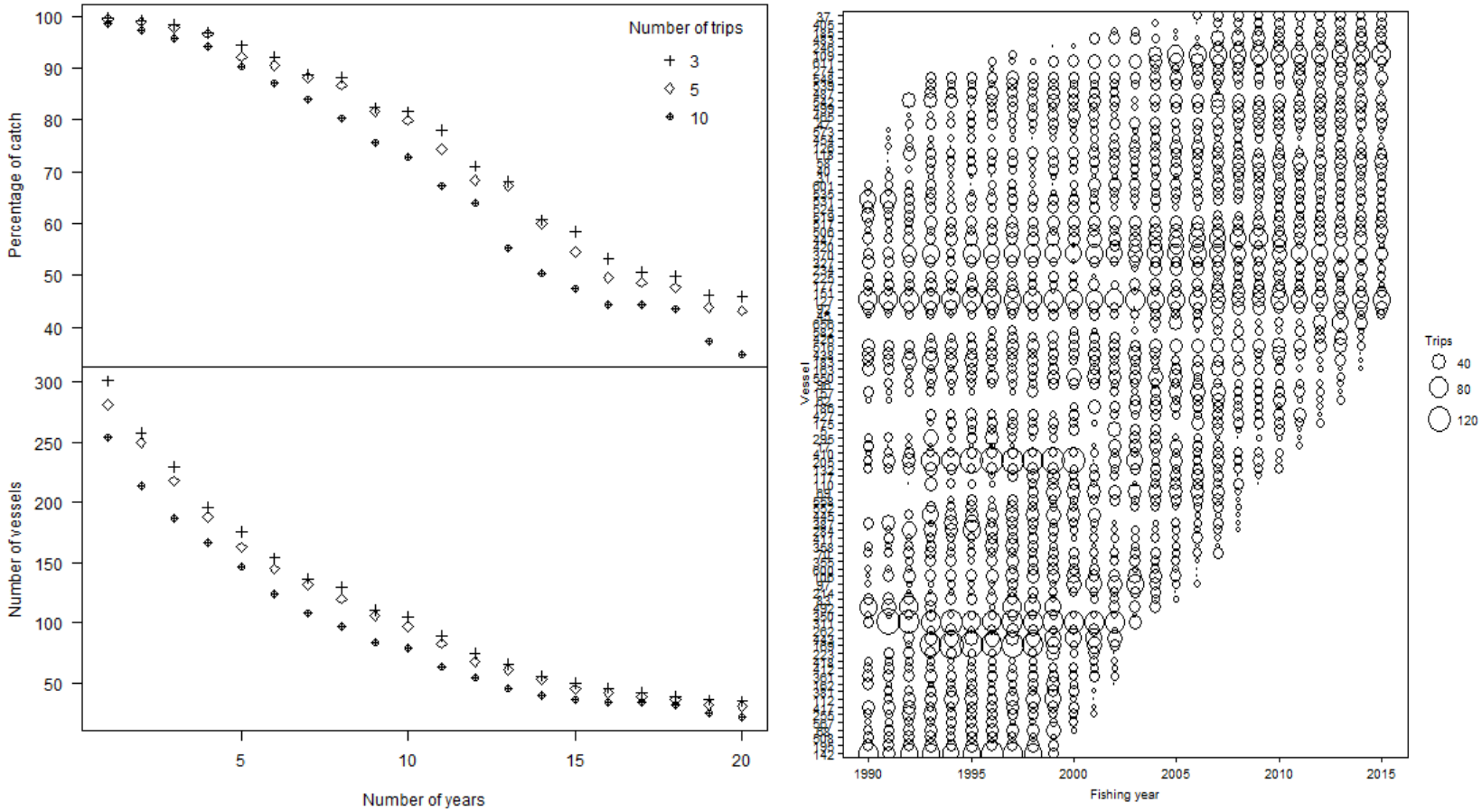

Figure N.1: **[left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 7_BT data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least 5 trips in 10 or more fishing years) by fishing year.**

N.6 Exploratory data plots for core vessel data set

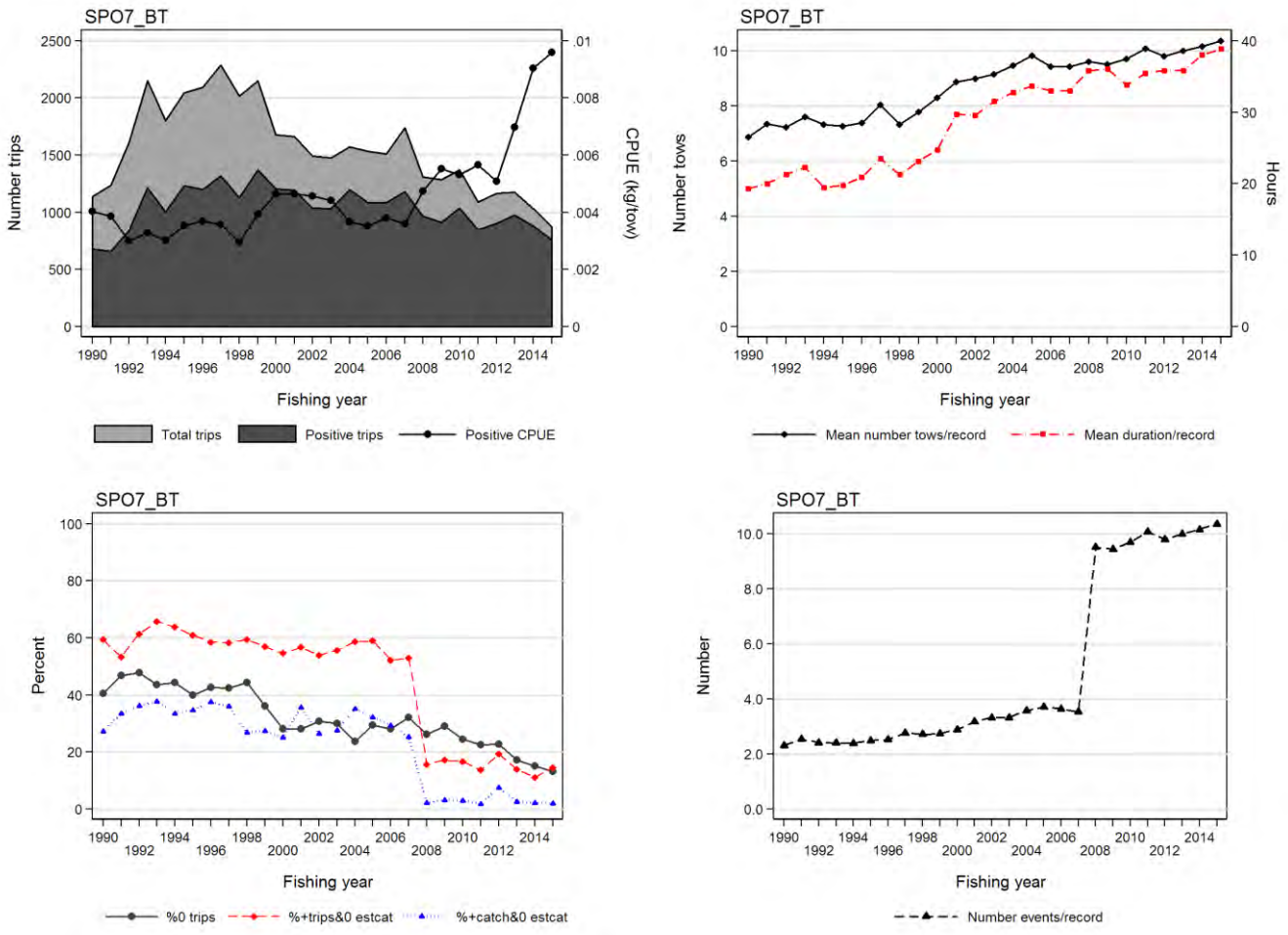

Figure N.2: Core vessel summary plots by fishing year for model SPO 7_BT: [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$**; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record [=*trip*].**

Note: the large decrease in the proportion of trips that did not report SPO from 2007–08 [lower left panel] and the corresponding increase in the number of events per trip [lower right panel] is due to the change to the TCER reporting form whereby the top eight species per tow were reported instead of the top five species per day of fishing. Because each record in this data set was [*trip*] and the estimated catch field was not used, it was not necessary to restrict the post 2007–08 data to the top five species per fishing day within a trip.

N.7 Selection of positive catch distribution

SPO 7_BT is an existing analysis (see Table 12). The positive catch distribution was forced to lognormal for consistency with previous analyses.

N.8 Positive catch model selection table

Three explanatory variables (vessel, number tows and month) entered the model after fishing year (Table N.2), with the variables target species, statistical area and hours fished non-significant. A plot of the model is provided in Figure N.3 and the CPUE indices are listed in Table N.4.

Table N.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 7_BT fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 10 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	26	-49 425	98 904	4.10	*
vessel	122	-44 271	88 789	35.39	*
poly(log(tows), 3)	125	-42 661	85 575	42.96	*
month	136	-42 150	84 575	**45.17**	*
target	144	-41 921	84 132	46.14	
area	155	-41 743	83 797	46.88	
poly(log(hours), 3)	158	-41 700	83 718	47.06	

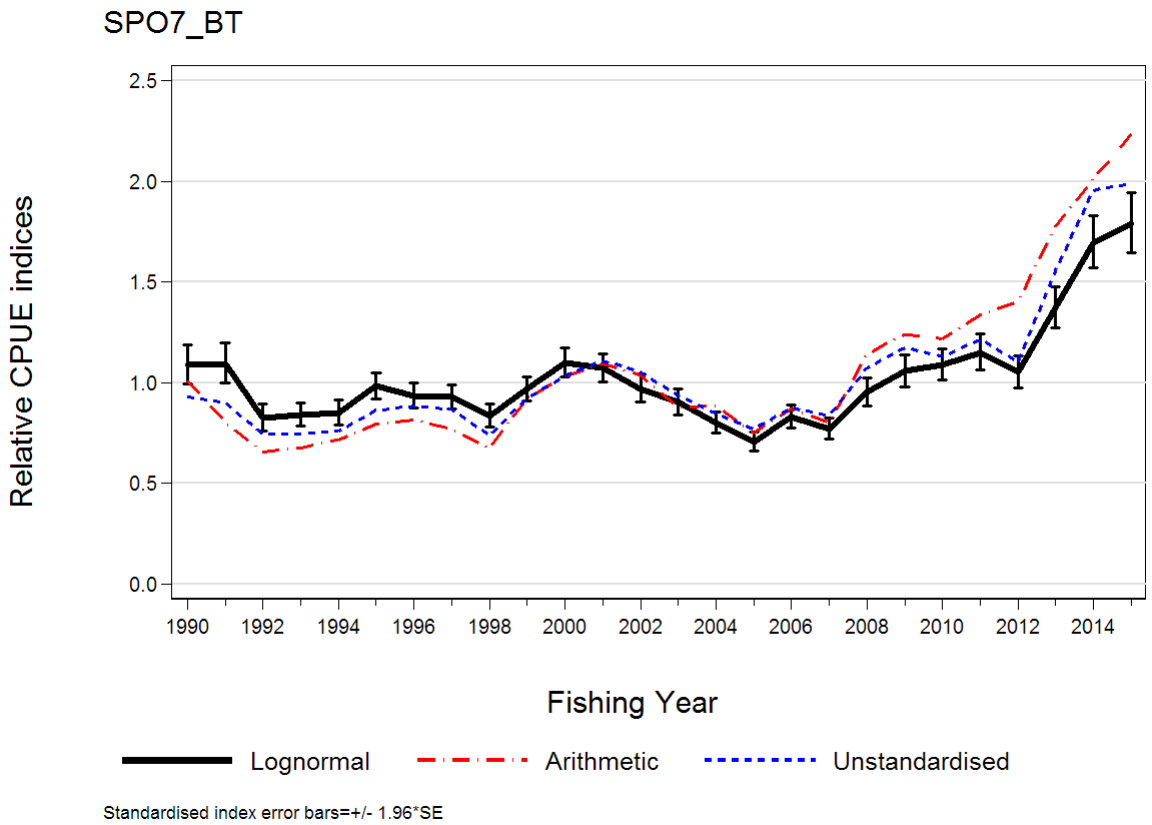

Figure N.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 7_BT fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

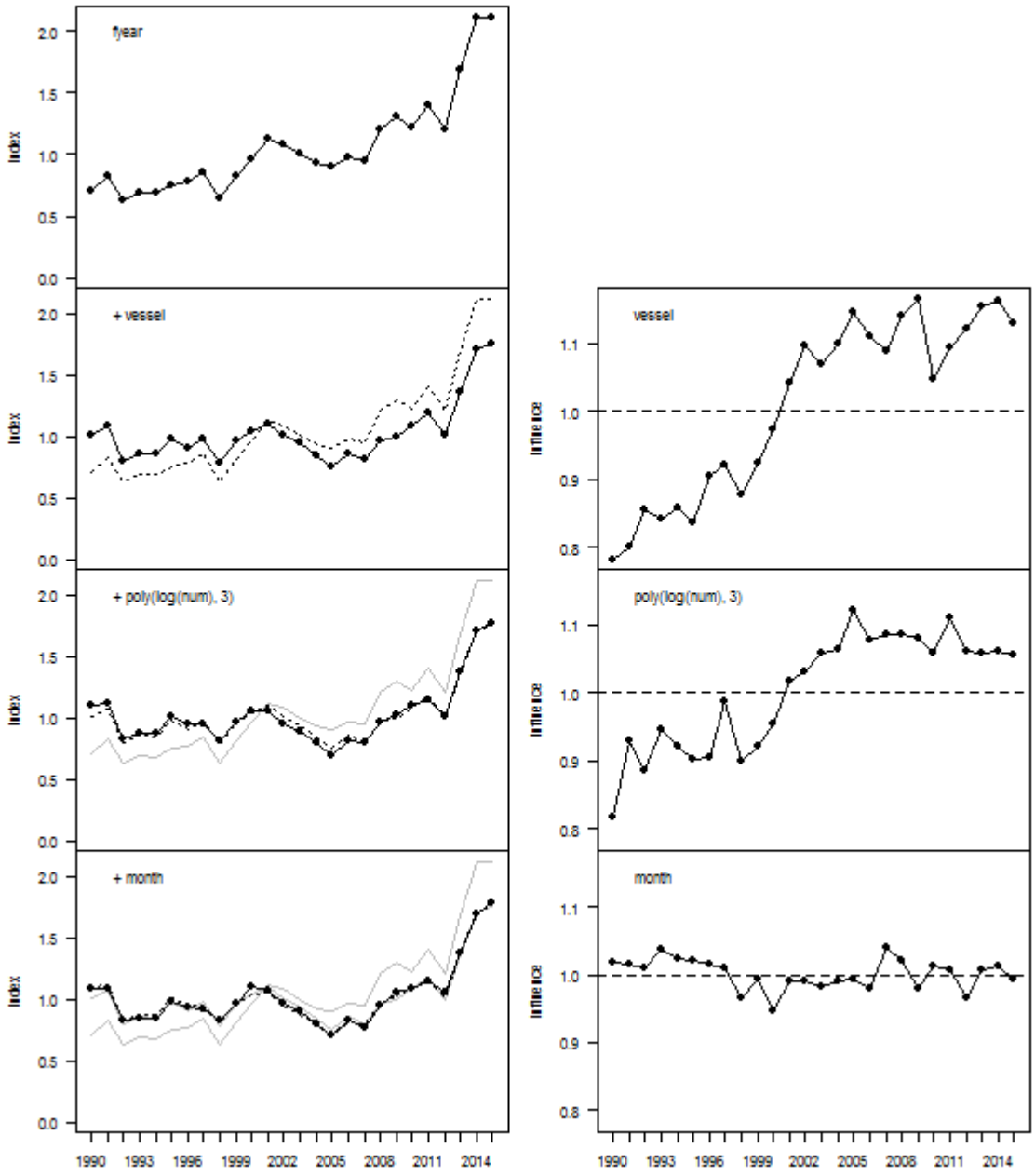

Figure N.4: [left column]: annual indices from the lognormal model of SPO 7_BT at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

N.9 Residual and diagnostic plots

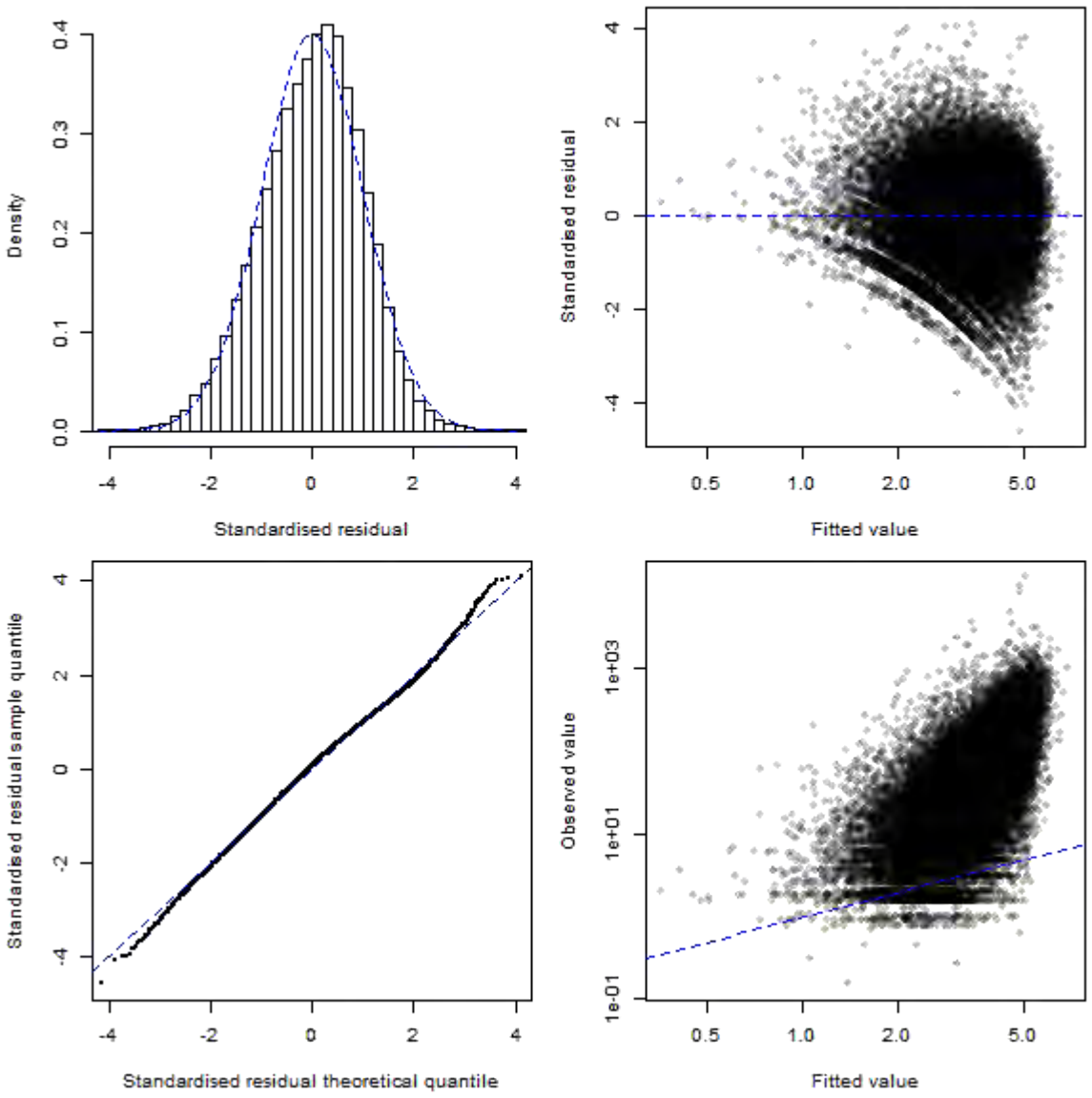

Figure N.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 7_BT fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

N.10 Model coefficients

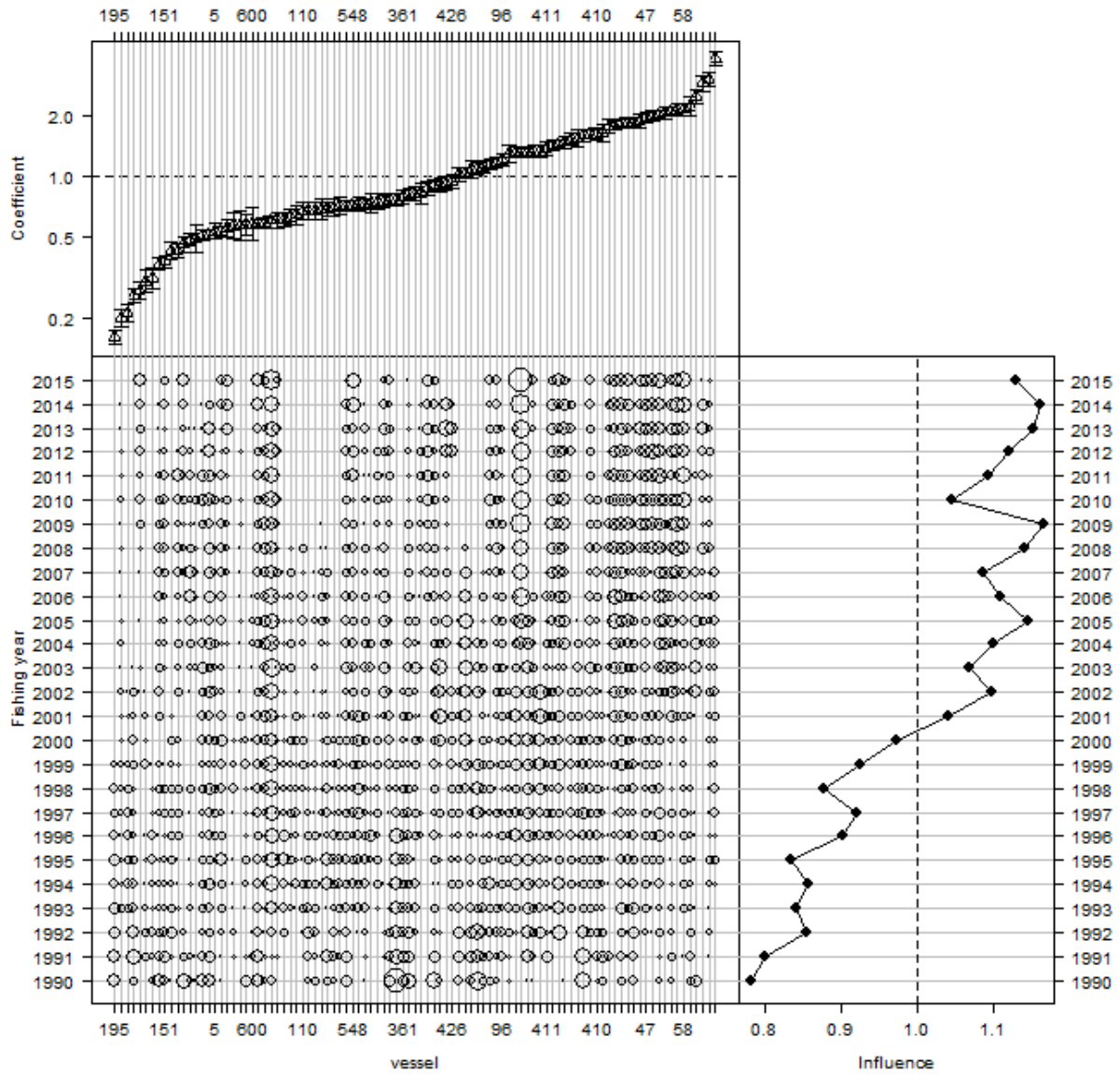

Figure N.6: Effect of vessel fished in the lognormal model for the rig SPO 7_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

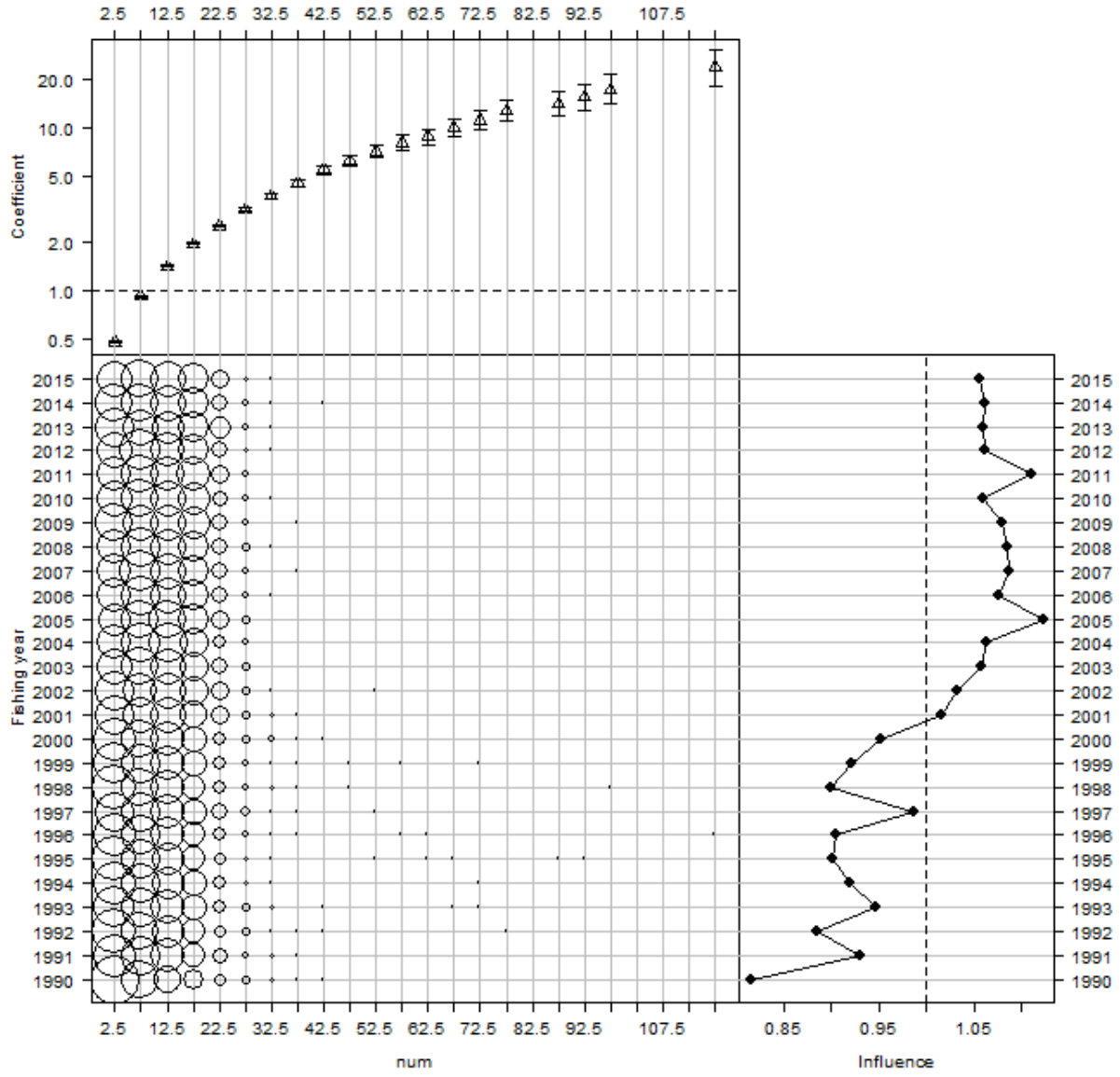

Figure N.7: Effect of number tows in the lognormal model for the rig SPO 7_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

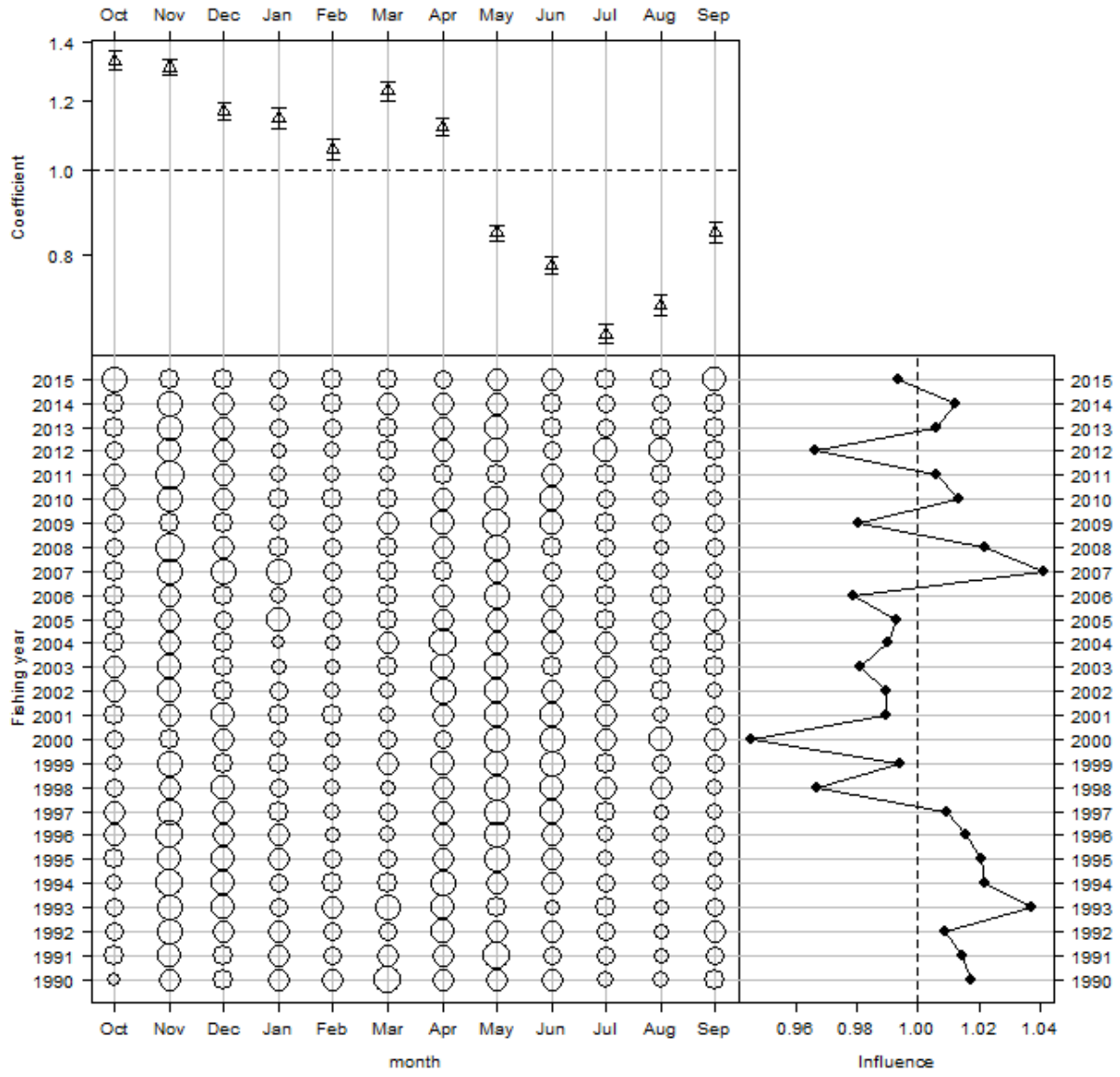

Figure N.8: Effect of month in the lognormal model for the rig SPO 7_BT fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

N.11 Presence/absence (binomial) catch model selection table

Three explanatory variables (vessel, hours fished and month) entered the model after fishing year (Table N.3), with the variables target species, statistical area and number tows non-significant. A plot of the model is provided in Figure N.9 and the CPUE indices are listed in Table N.4.

Table N.3: Order of acceptance of variables into the binomial model of presence/absence of rig catches in the SPO 7_BT fishery model for core vessels (based on the vessel selection criteria of at least 5 trips in 10 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	26	-24 995	50 042	5.57	*
vessel	122	-19 798	39 840	35.72	*
poly(log(hours), 3)	125	-18 892	38 034	40.23	*
month	136	-18 323	36 918	**42.96**	*
target	144	-18 201	36 691	43.53	
area	155	-18 101	36 512	44.00	
poly(log(tows), 3)	158	-18 067	36 451	44.16	

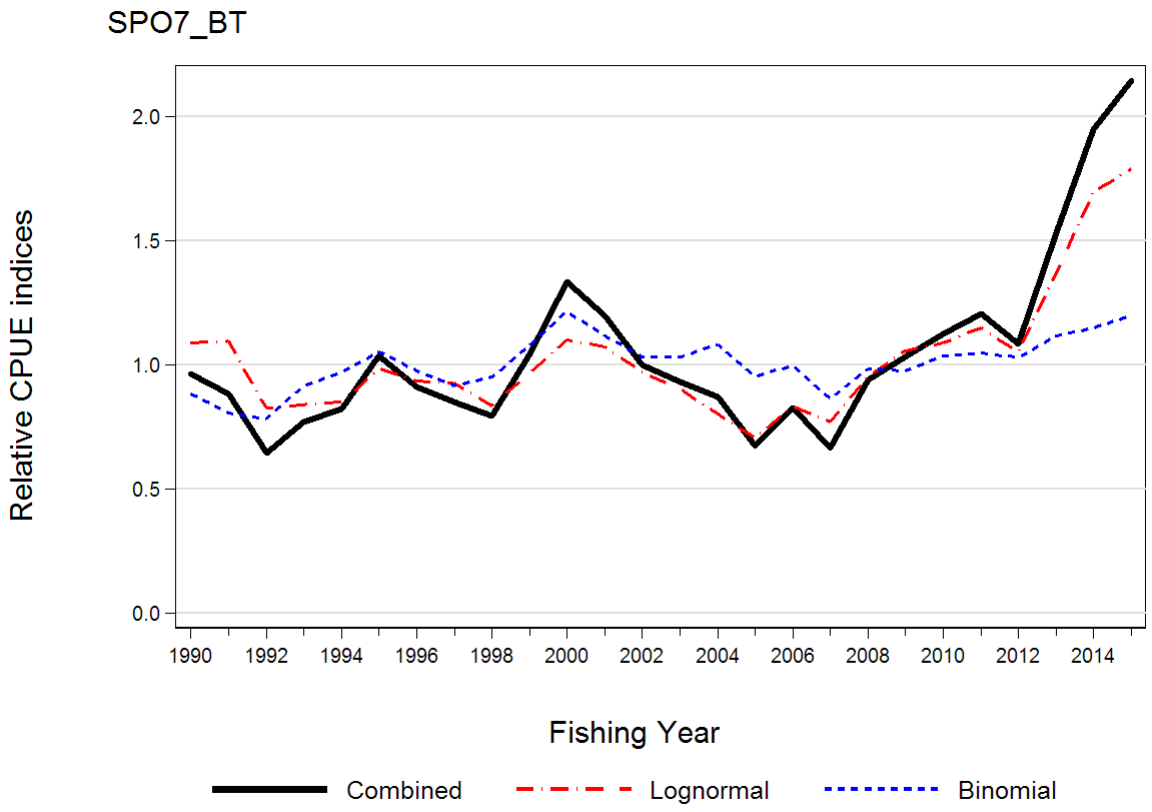

Figure N.9: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 7_BT fishery definition, the binomial standardised model using the logistic distribution, and the combined model using the delta-lognormal procedure (Eq. I.4).

N.12 CPUE indices

Table N.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE), as well as binomial and combined series for the core data set by fishing year for the SPO 7_BT analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels					
year	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	0.900	1.012	0.929	1.089	0.0454	0.884	0.963
1991	0.752	0.802	0.903	1.095	0.0453	0.806	0.883
1992	0.716	0.656	0.743	0.825	0.0404	0.780	0.643
1993	0.671	0.677	0.745	0.840	0.0338	0.915	0.768
1994	0.724	0.717	0.760	0.850	0.0367	0.969	0.824
1995	0.843	0.795	0.864	0.984	0.0336	1.054	1.037
1996	0.787	0.818	0.885	0.934	0.0338	0.975	0.911
1997	0.765	0.771	0.868	0.927	0.0322	0.916	0.849
1998	0.663	0.675	0.737	0.835	0.0347	0.949	0.793
1999	0.898	0.923	0.922	0.967	0.0316	1.078	1.043
2000	1.029	1.031	1.036	1.100	0.0336	1.214	1.335
2001	1.053	1.095	1.110	1.072	0.0337	1.118	1.198
2002	0.993	1.037	1.054	0.971	0.0360	1.031	1.001
2003	0.907	0.877	0.934	0.904	0.0363	1.031	0.932
2004	0.893	0.885	0.848	0.803	0.0335	1.082	0.869
2005	0.783	0.750	0.770	0.706	0.0354	0.952	0.672
2006	0.884	0.872	0.875	0.831	0.0353	0.997	0.828
2007	0.813	0.802	0.838	0.771	0.0340	0.863	0.665
2008	1.236	1.143	1.073	0.952	0.0373	0.984	0.937
2009	1.292	1.241	1.175	1.058	0.0384	0.974	1.031
2010	1.281	1.218	1.129	1.087	0.0362	1.036	1.126
2011	1.407	1.336	1.216	1.149	0.0399	1.047	1.203
2012	1.395	1.404	1.102	1.053	0.0387	1.029	1.084
2013	1.671	1.778	1.559	1.371	0.0377	1.116	1.531
2014	1.920	2.013	1.956	1.696	0.0394	1.149	1.949
2015	2.229	2.237	1.991	1.789	0.0423	1.198	2.143

Appendix O. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1E_SN(007)

O.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 1E by the NINSWG (MPI 2016) with a research rating of '2' (Medium or Mixed Quality: series only indexes a small proportion of SPO 1E). A binomial model was not run because nearly every record successfully captured rig (Table O.1).

O.2 Fishery definition

SPO 1E_SN(007): The fishery is defined from setnet fishing events that fished in Statistical Area 007 and declared target species SPO, SCH, SPD and NSD.

O.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in four years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 32 vessels, which took 77% of the catch (Figure O.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure O.1).

O.4 Data summary

Table O.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of five trips per year in four years) in the SPO 1E_SN(007) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	8	77	78	85	1.09	95.80	719	4.41	93.5	93.6	0	0
1991	11	259	267	280	1.05	334.35	2 899	32.40	97.7	97.8	0	0
1992	12	346	377	417	1.11	570.50	4 380	58.64	98.3	98.1	0	0
1993	14	448	498	550	1.10	806.21	6 384	76.46	98.4	98.4	0	0
1994	15	316	337	347	1.03	526.90	4 061	43.39	97.2	96.7	0	0
1995	14	255	277	297	1.07	435.10	2 805	56.00	98.4	98.6	0	0
1996	14	302	358	381	1.06	660.40	5 319	65.52	95.0	95.8	0	0
1997	11	284	325	337	1.04	528.01	3 490	56.09	98.2	98.2	0	0
1998	12	280	309	324	1.05	521.64	3 096	52.20	98.9	98.7	0	0
1999	15	351	368	392	1.07	678.10	3 900	65.08	94.3	94.6	0	0
2000	16	425	433	442	1.02	799.50	4 910	73.96	96.9	97.0	0	0
2001	11	363	376	396	1.05	684.80	4 310	68.96	99.2	99.2	0	0
2002	13	384	397	440	1.11	838.30	4 665	99.62	98.7	98.7	0	0
2003	19	487	510	543	1.06	1 113.30	6 265	84.69	97.1	97.3	0	0
2004	16	395	407	476	1.17	889.23	5 243	64.68	98.5	98.5	0	0
2005	13	327	331	346	1.05	760.95	3 446	59.82	100.0	100.0	0	0
2006	12	223	227	239	1.05	442.98	2 548	49.42	98.7	98.7	0	0
2007	10	160	160	170	1.06	316.72	1 659	35.34	98.8	98.8	0	0
2008	11	160	167	180	1.08	328.18	1 759	32.57	99.4	99.4	0	0
2009	11	185	197	206	1.05	347.31	2 163	46.47	98.9	99.0	0	0
2010	9	210	225	253	1.12	434.92	3 002	38.54	99.5	99.6	0	0
2011	11	180	188	216	1.15	342.35	2 311	28.55	98.3	98.4	0	0
2012	7	203	211	225	1.07	396.44	2 610	43.39	100.0	100.0	0	0
2013	7	210	212	224	1.06	422.61	3 039	35.04	100.0	100.0	0	0
2014	6	213	214	220	1.03	433.05	3 183	42.61	99.1	99.1	0	0
2015	7	182	182	191	1.05	316.52	2 443	37.50	97.8	97.8	0	0

O.5 Core vessel selection

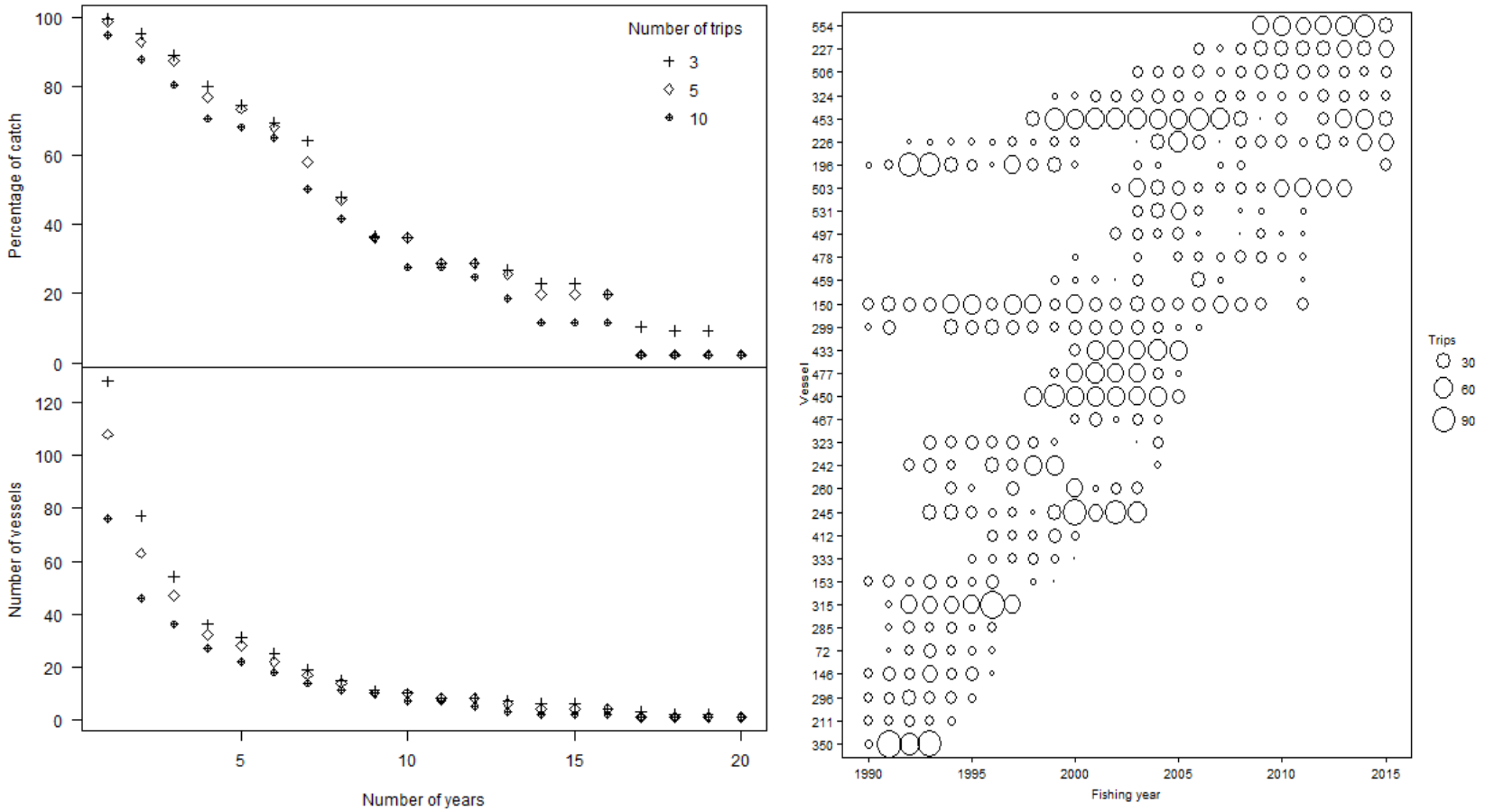

Figure O.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1E_SN(007) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in four or more fishing years) by fishing year.

O.6 Exploratory data plots for core vessel data set

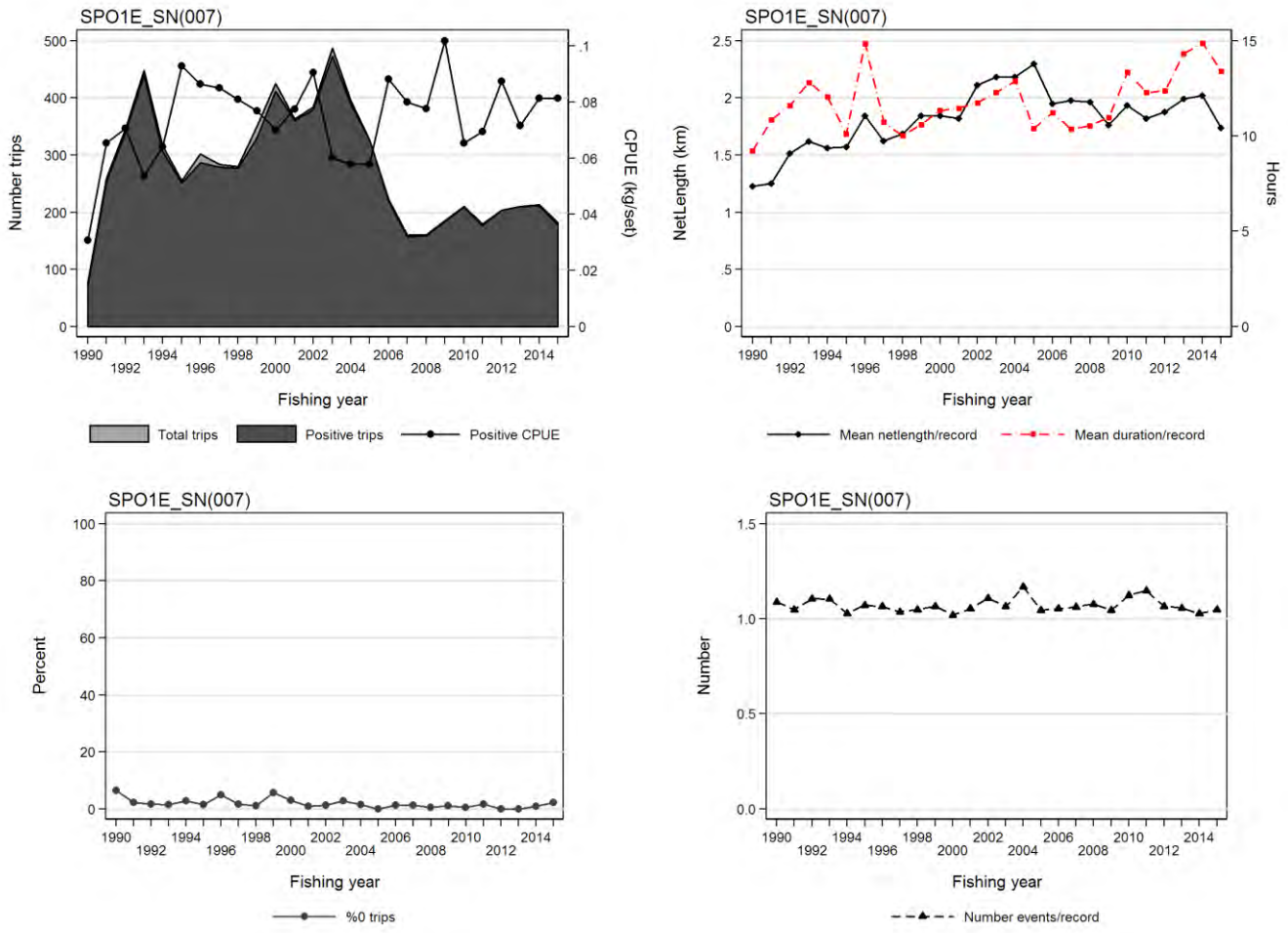

Figure O.2: Core vessel summary plots by fishing year for model SPO 1E_SN(007): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: percentage of trips with no catch of rig; [lower right panel]: mean number of events per stratum record.

O.7 Selection of positive catch distribution

SPO 1E_SN(007) is an existing analysis (see Table 13). The positive catch distribution was forced to log-logistic for consistency with previous analyses.

O.8 Positive catch model selection table

Three explanatory variables (vessel, month and net length) entered the model after fishing year (Table O.2), with the variable duration non-significant. The model discarded the target species variable. 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 SPO 1E_SN(007) fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	-46 521	93 096	4.03	*
vessel	199	-45 002	90 402	36.04	*
month	210	-44 639	89 697	41.96	*
poly(log(netlength), 3)	213	-44 503	89 432	**44.02**	*
poly(log(duration), 3)	216	-44 481	89 395	44.35	
target	–	–	–	–	

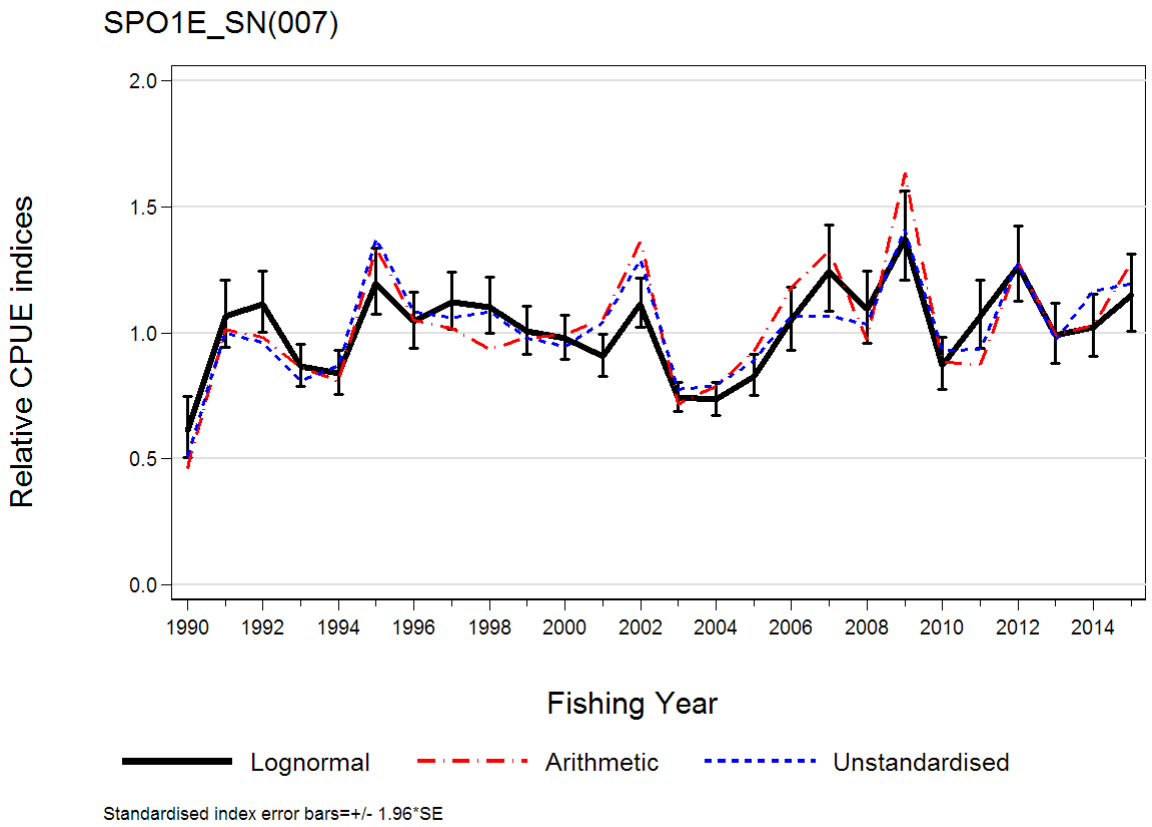

Figure O.3: Relative CPUE indices for rig using the log-logistic non-zero model based on the SPO 1E_SN(007) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

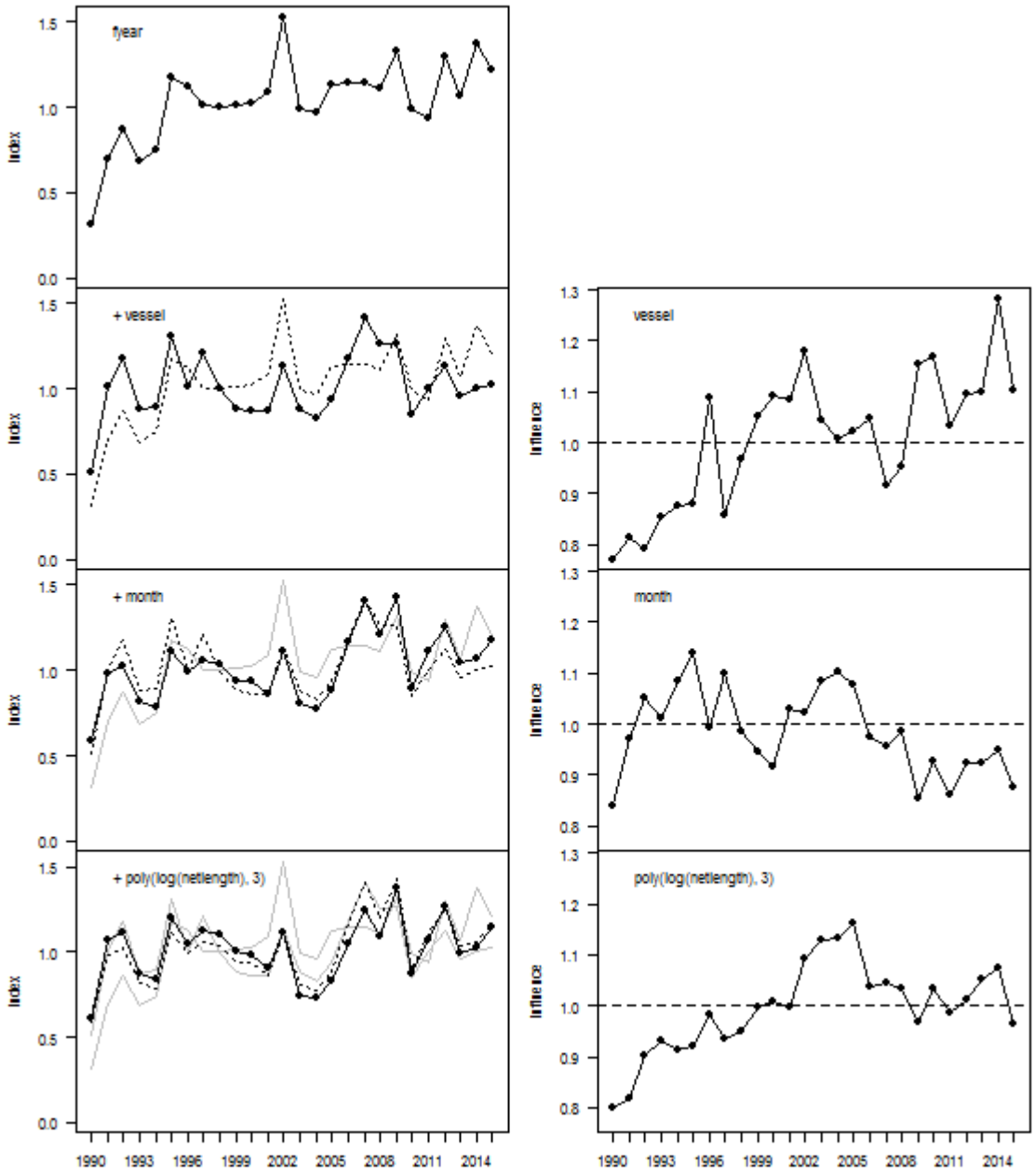

Figure O.4: [left column]: annual indices from the log-logistic model of SPO 1E_SN(007) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

O.9 Residual and diagnostic plots

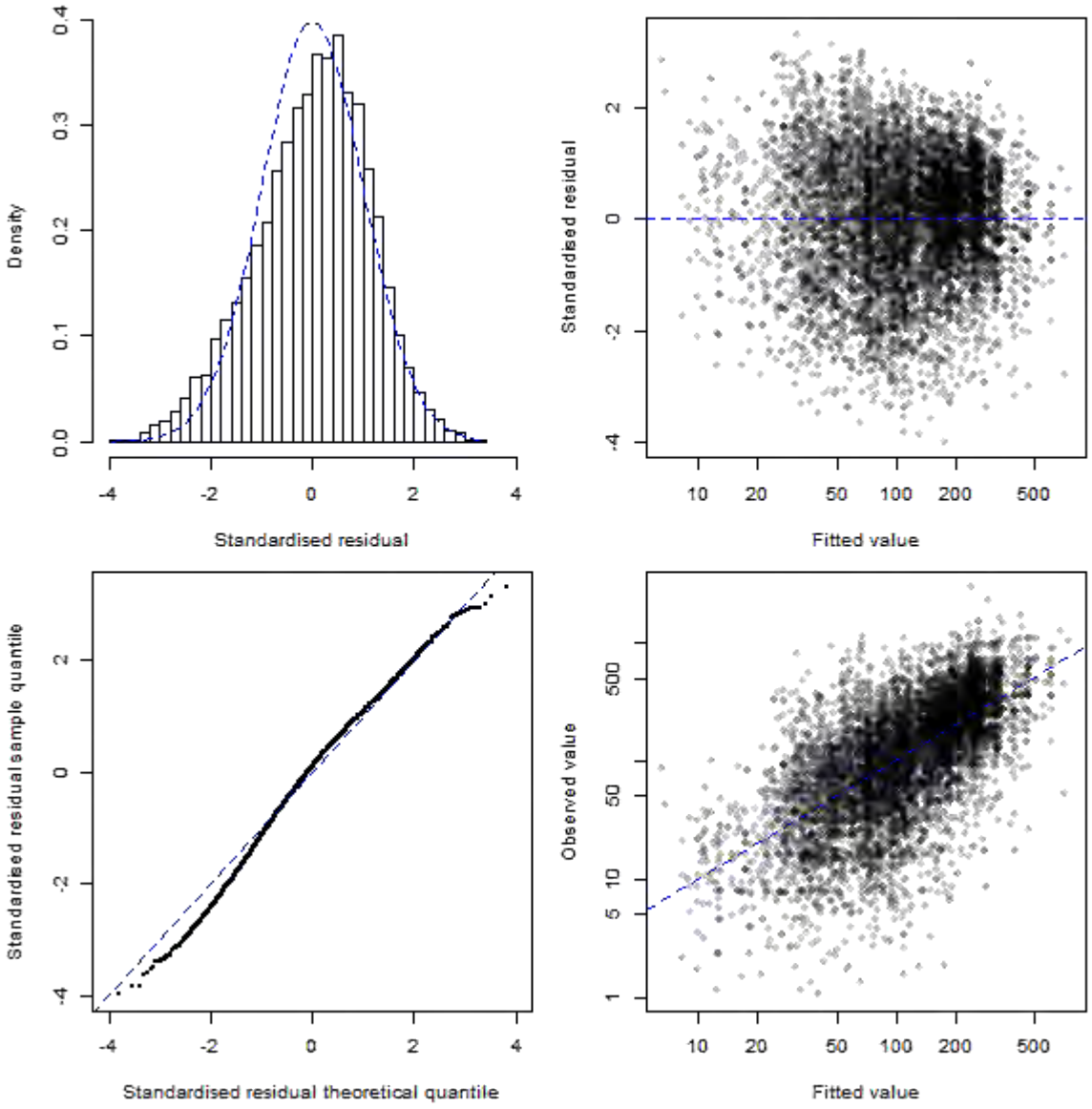

Figure O.5: Plots of the fit of the log-logistic standardised CPUE model of successful catches of rig in the SPO 1E_SN(007) fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

O.10 Model coefficients

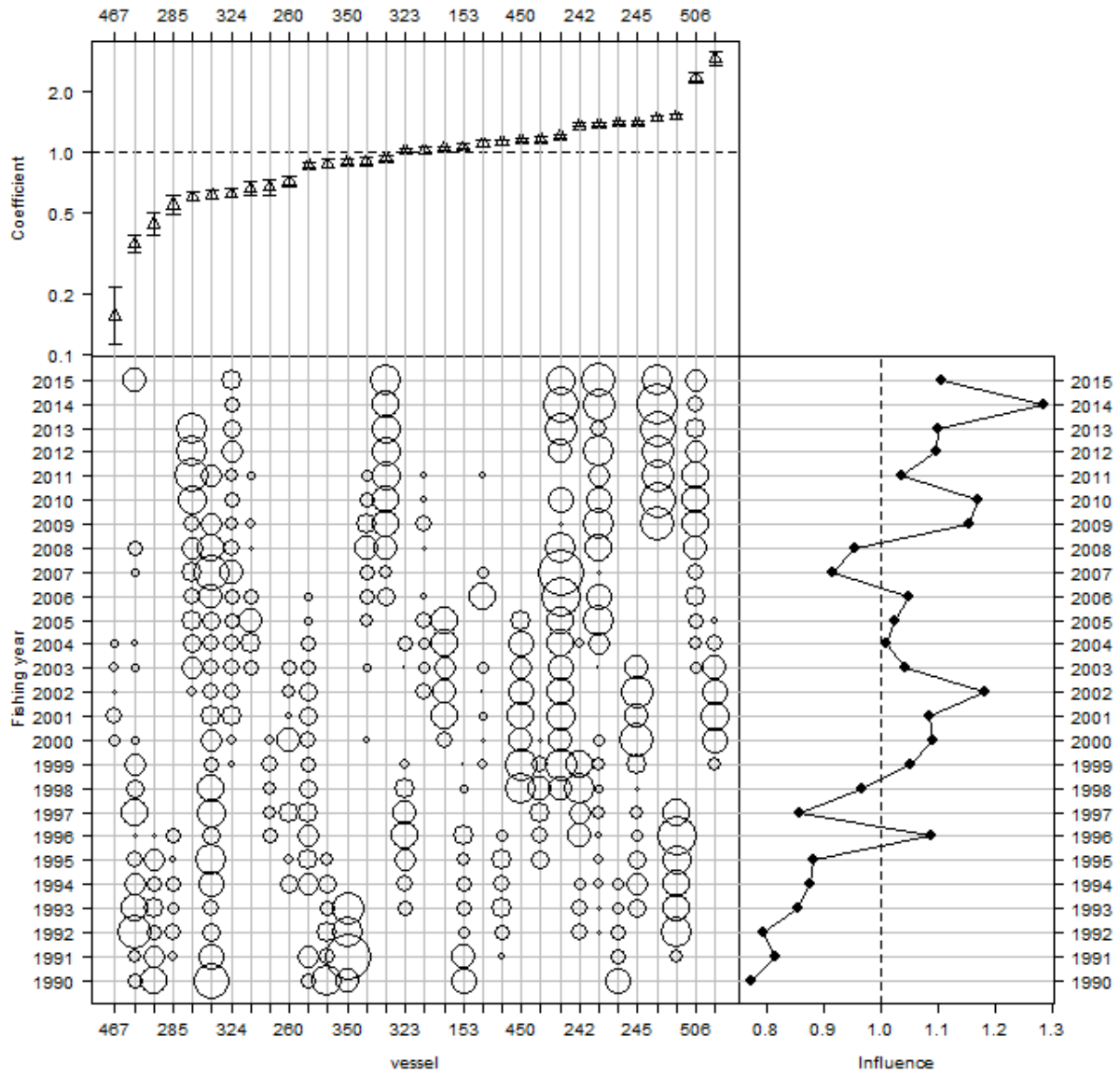

Figure O.6: Effect of vessel fished in the log-logistic model for the rig SPO 1E_SN(007) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

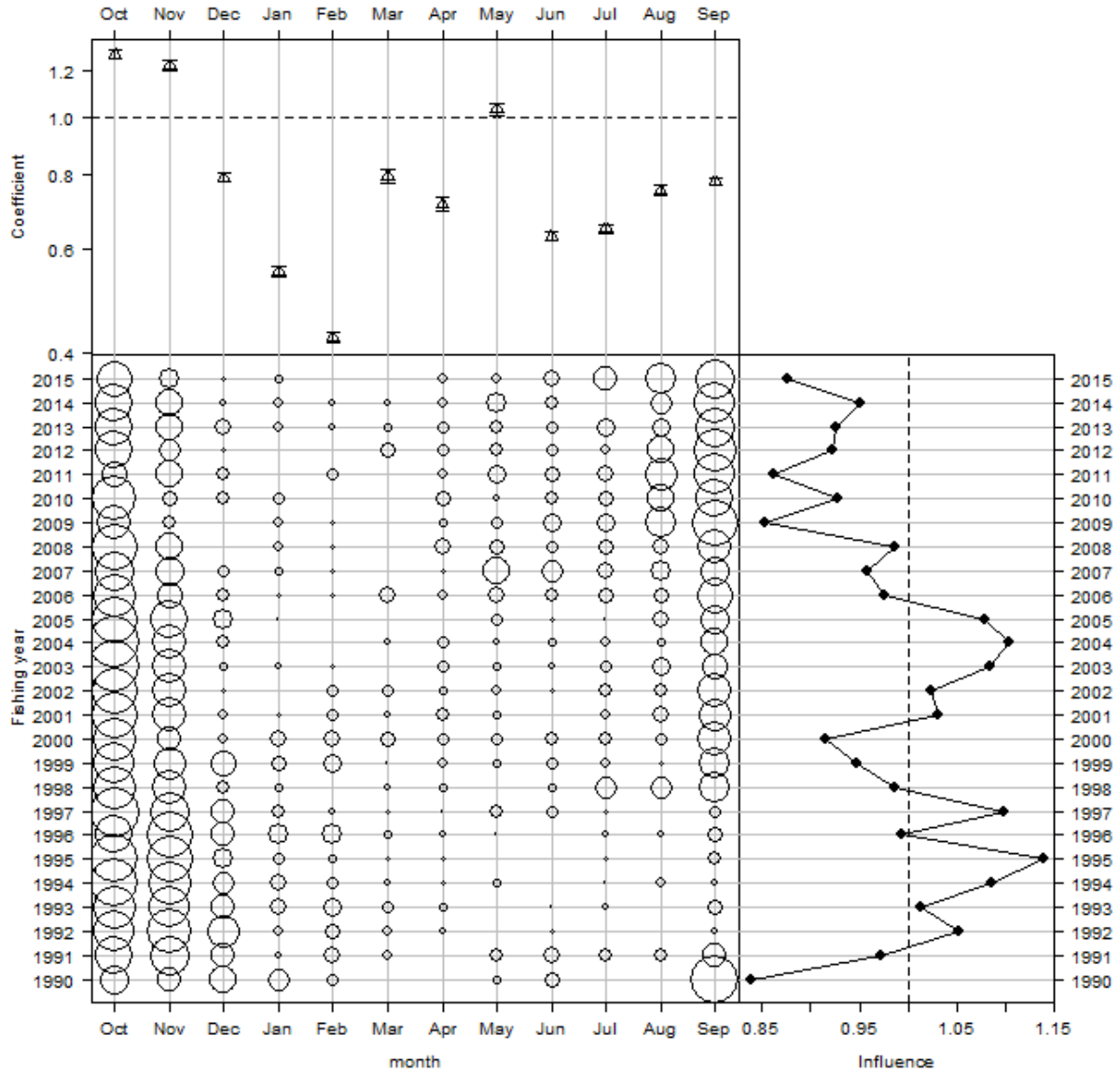

Figure O.7: Effect of month in the log-logistic model for the rig SPO 1E_SN(007) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

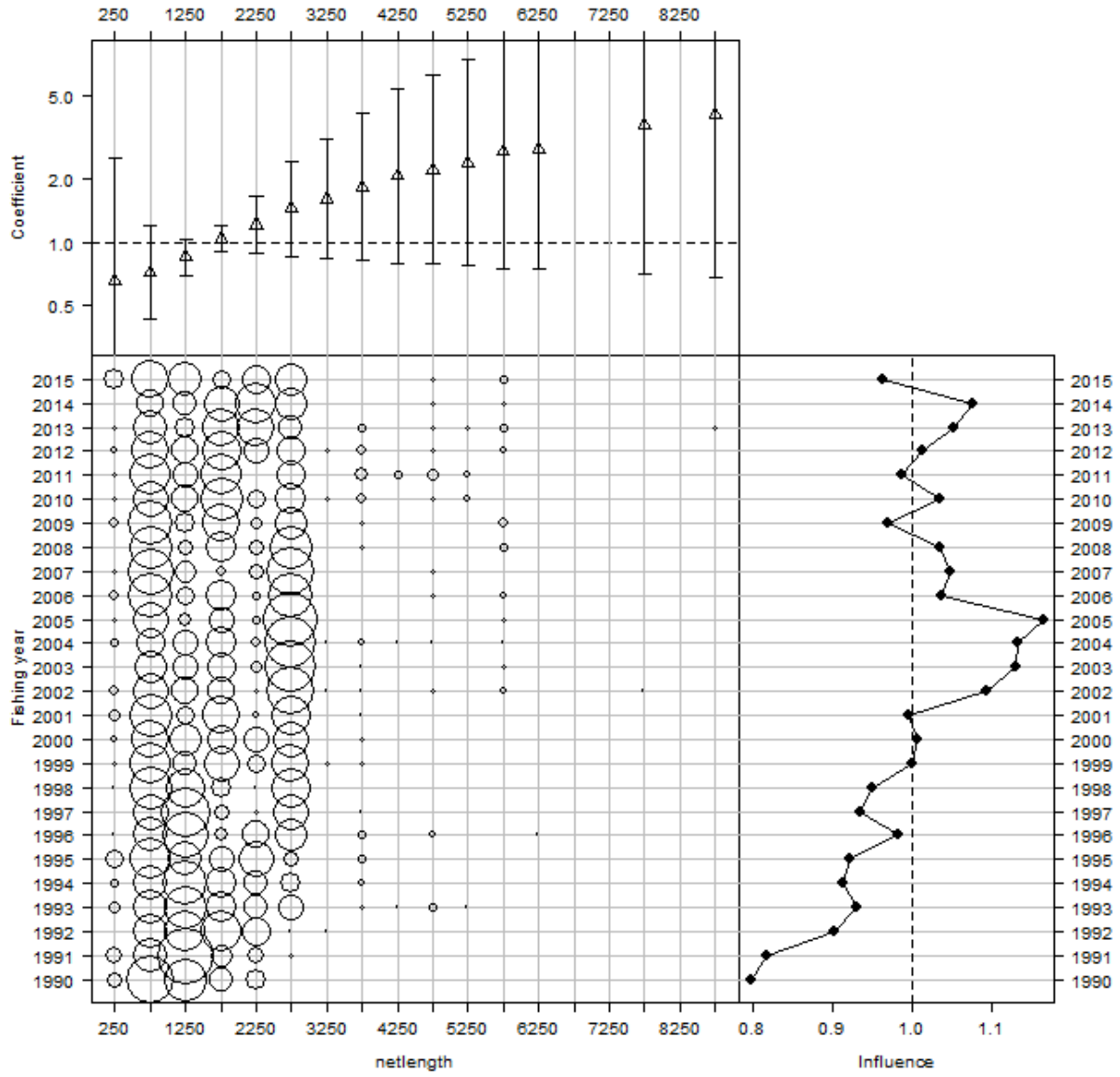

Figure O.8: Effect of length of net set in the log-logistic model for the rig SPO 1E_SN(007) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

O.11 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 SPO 1E_SN(007) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.018	0.463	0.511	0.614	0.1005
1991	1.234	1.013	1.000	1.067	0.0635
1992	1.296	0.984	0.962	1.116	0.0555
1993	1.036	0.865	0.811	0.869	0.0490
1994	0.908	0.806	0.869	0.840	0.0524
1995	1.203	1.338	1.374	1.198	0.0559
1996	1.230	1.049	1.083	1.045	0.0538
1997	0.986	1.019	1.058	1.123	0.0518
1998	0.975	0.935	1.085	1.103	0.0510
1999	0.903	0.982	0.980	1.006	0.0482
2000	0.914	0.992	0.946	0.980	0.0453
2001	0.965	1.054	1.041	0.907	0.0466
2002	1.338	1.361	1.290	1.115	0.0452
2003	0.705	0.717	0.777	0.743	0.0406
2004	0.693	0.789	0.789	0.735	0.0451
2005	0.835	0.926	0.891	0.828	0.0498
2006	1.054	1.177	1.067	1.049	0.0615
2007	1.146	1.324	1.066	1.245	0.0697
2008	0.912	0.972	1.033	1.093	0.0663
2009	1.498	1.635	1.410	1.374	0.0660
2010	0.848	0.885	0.932	0.871	0.0605
2011	0.771	0.874	0.933	1.065	0.0651
2012	1.166	1.275	1.278	1.265	0.0601
2013	0.836	0.992	0.970	0.992	0.0609
2014	0.929	1.030	1.168	1.022	0.0612
2015	1.078	1.277	1.193	1.149	0.0686

Appendix P. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1E_SN(COAST)

P.1 Introduction

This CPUE analysis was not accepted in 2016 for monitoring SPO 1E by the NINSWG (MPI 2016), giving it a research rating of '3' (Low Quality: insufficient data for a reliable analysis). A binomial model was not run because of the high proportion of success captures (Table P.1).

P.2 Fishery definition

SPO 1E_SN(coast): The fishery is defined from setnet fishing events that fished in Statistical Areas 002–006 and 008–010 and declared target species SPO, SCH, SPD and NSD.

P.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least three trips in three years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 40 vessels, which took 73% of the catch (Figure P.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure P.1).

P.4 Data summary

Table P.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of three trips per year in three years) in the SPO 1E_SN(coast) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	%strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	7	106	114	116	1.02	166.65	1 194	11.24	84.9	85.1	0	0
1991	6	259	264	266	1.01	477.55	2 697	16.56	55.2	55.3	0	0
1992	10	209	227	228	1.00	355.87	2 196	25.21	89.5	89.9	0	0
1993	12	329	365	367	1.01	918.10	4 001	47.15	83.9	84.7	0	0
1994	13	229	314	324	1.03	1 260.15	3 680	48.50	90.4	91.7	0	0
1995	9	96	174	179	1.03	530.20	1 763	24.61	94.8	94.8	0	0
1996	12	93	147	148	1.01	251.90	1 850	16.43	89.3	90.5	0	0
1997	13	130	170	173	1.02	251.08	2 280	20.48	91.5	92.9	0	0
1998	12	150	190	199	1.05	341.80	2 876	20.71	87.3	88.4	0	0
1999	7	146	213	216	1.01	383.50	3 313	16.36	93.8	89.2	0	0
2000	13	160	200	201	1.00	363.23	2 846	17.77	96.3	94.5	0	0
2001	13	108	123	125	1.02	158.25	1 601	10.22	96.3	95.9	0	0
2002	10	146	164	170	1.04	316.45	2 157	25.09	74.0	76.8	0	0
2003	12	128	179	186	1.04	286.25	2 424	19.68	96.1	91.1	0	0
2004	10	113	160	162	1.01	172.00	2 041	14.99	96.5	96.3	0	0
2005	10	90	123	126	1.02	170.45	1 744	12.79	94.4	95.1	0	0
2006	15	142	183	183	1.00	289.68	2 612	11.26	73.9	74.3	0	0
2007	11	163	250	262	1.05	476.45	3 271	29.26	94.5	92.8	0	0
2008	10	128	218	233	1.07	404.20	2 904	23.14	98.4	95.9	0	0
2009	9	76	123	127	1.03	222.78	1 847	10.65	94.7	95.1	0	0
2010	8	73	81	81	1.00	112.45	1 174	9.26	89.0	90.1	0	0
2011	7	70	85	86	1.01	74.22	1 353	4.42	94.3	94.1	0	0
2012	8	62	74	77	1.04	75.37	956	6.83	87.1	86.5	0	0
2013	11	116	193	199	1.03	317.26	2 825	25.32	97.4	97.9	0	0
2014	9	92	154	162	1.05	277.09	2 359	14.70	90.2	93.5	0	0
2015	8	65	88	97	1.10	151.80	1 435	9.93	93.9	93.2	0	0

P.5 Core vessel selection

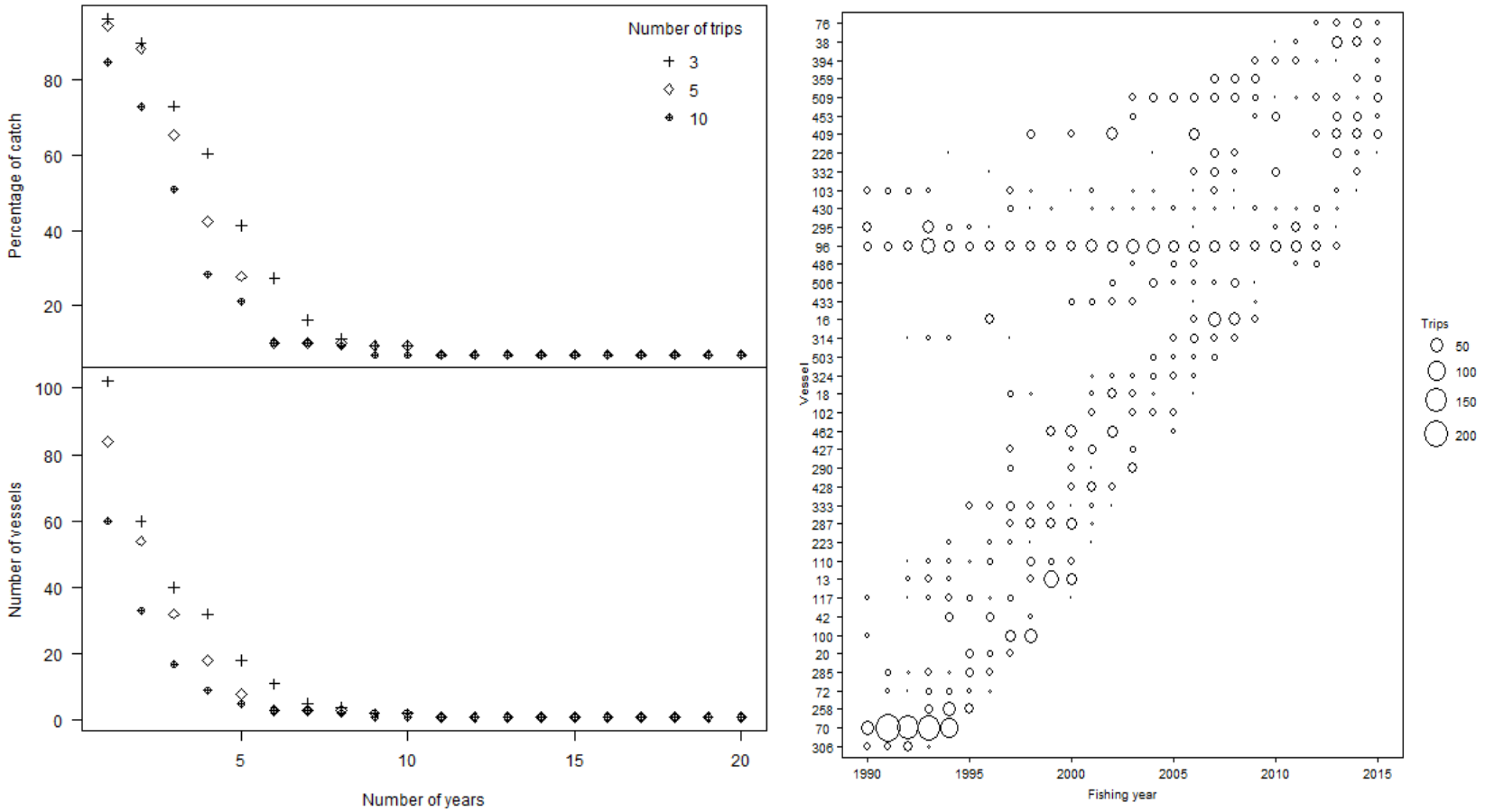

Figure P.1: **[left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1E_SN(coast) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least three trips in three or more fishing years) by fishing year.**

P.6 Exploratory data plots for core vessel data set

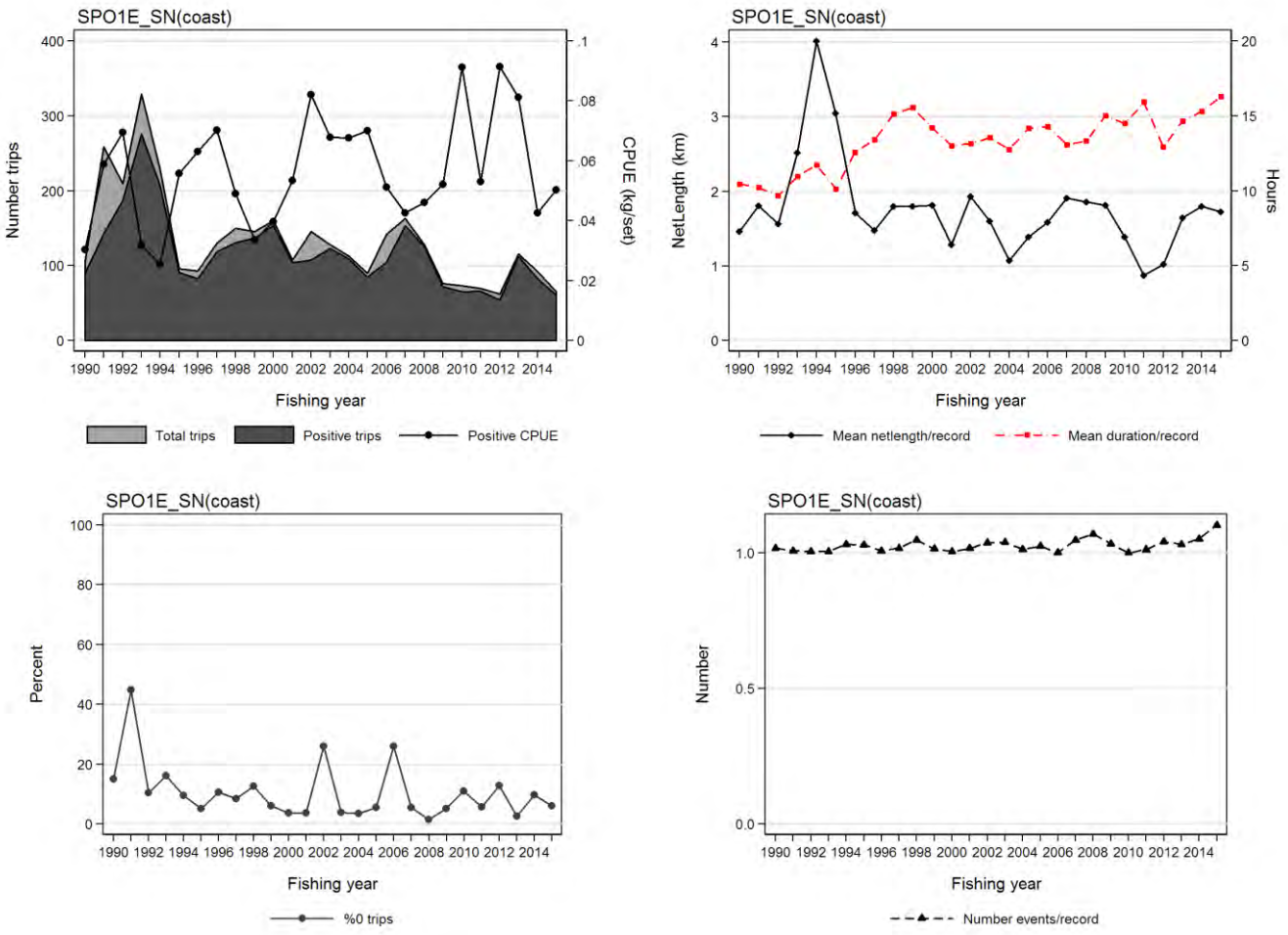

Figure P.2: Core vessel summary plots by fishing year for model SPO 1E_SN(coast): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: percentage of trips with no catch of rig; [lower right panel]: mean number of events per stratum record.

P.7 Selection of positive catch distribution

SPO 1E_SN(coast) is an existing analysis (see Table 13). The positive catch distribution was forced to lognormal for consistency with previous analyses.

P.8 Positive catch model selection table

Two explanatory variables (vessel and net length) entered the model after fishing year (Table P.2), with the variables statistical area, month, duration and target species non-significant. A plot of the model is provided in Figure P.3 and 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 SPO 1E_SN(coast) fishery model for core vessels (based on the vessel selection criteria of at least three trips in three 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	26	-6 239	12 532	4.59	*
vessel	65	-5 867	11 866	21.37	*
poly(log(netlength), 3)	68	-5 837	11 811	**22.61**	*
area	74	-5 818	11 787	23.35	
month	85	-5 796	11 764	24.24	
poly(log(duration), 3)	88	-5 787	11 751	24.61	
target	90	-5 781	11 743	24.85	

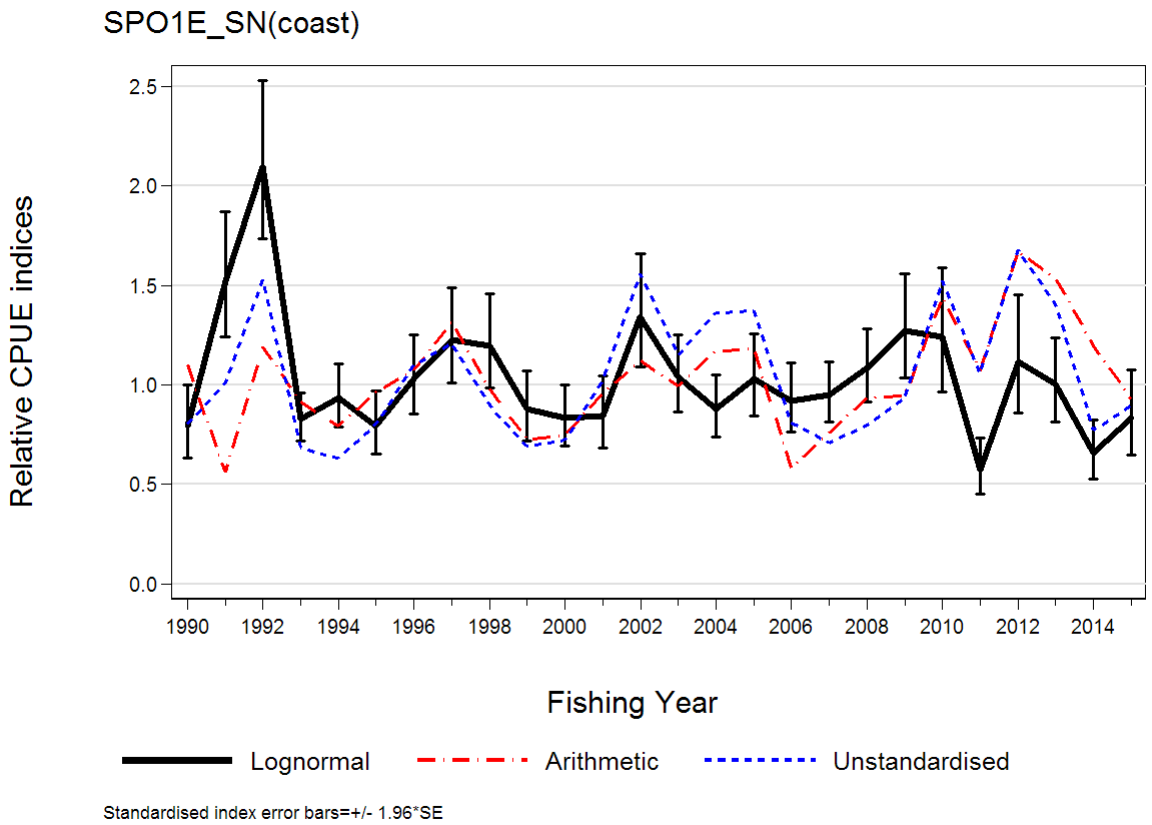

Figure P.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1E_SN(coast) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

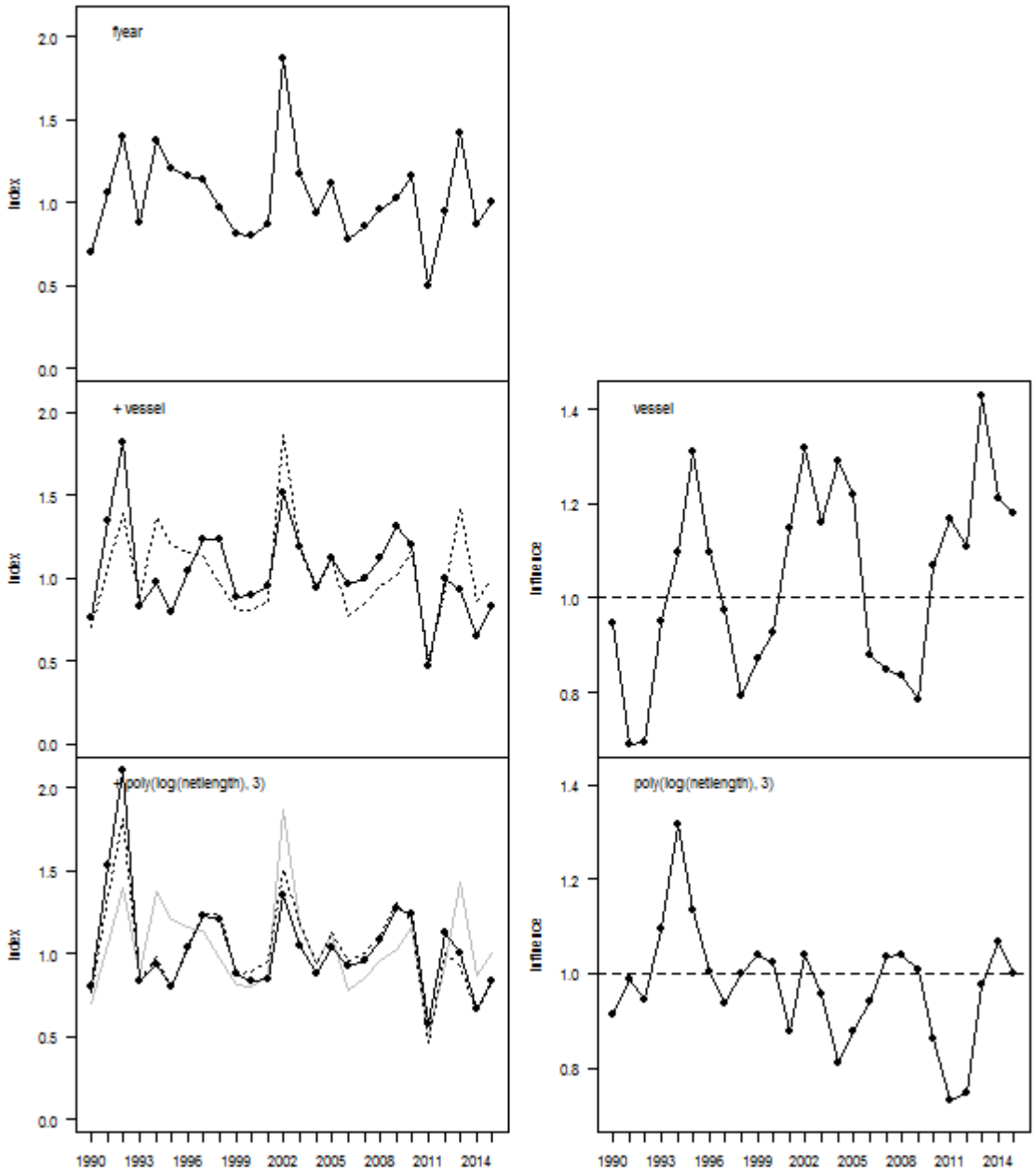

Figure P.4: **[left column]: annual indices from the lognormal model of SPO 1E_SN(coast) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.**

P.9 Residual and diagnostic plots

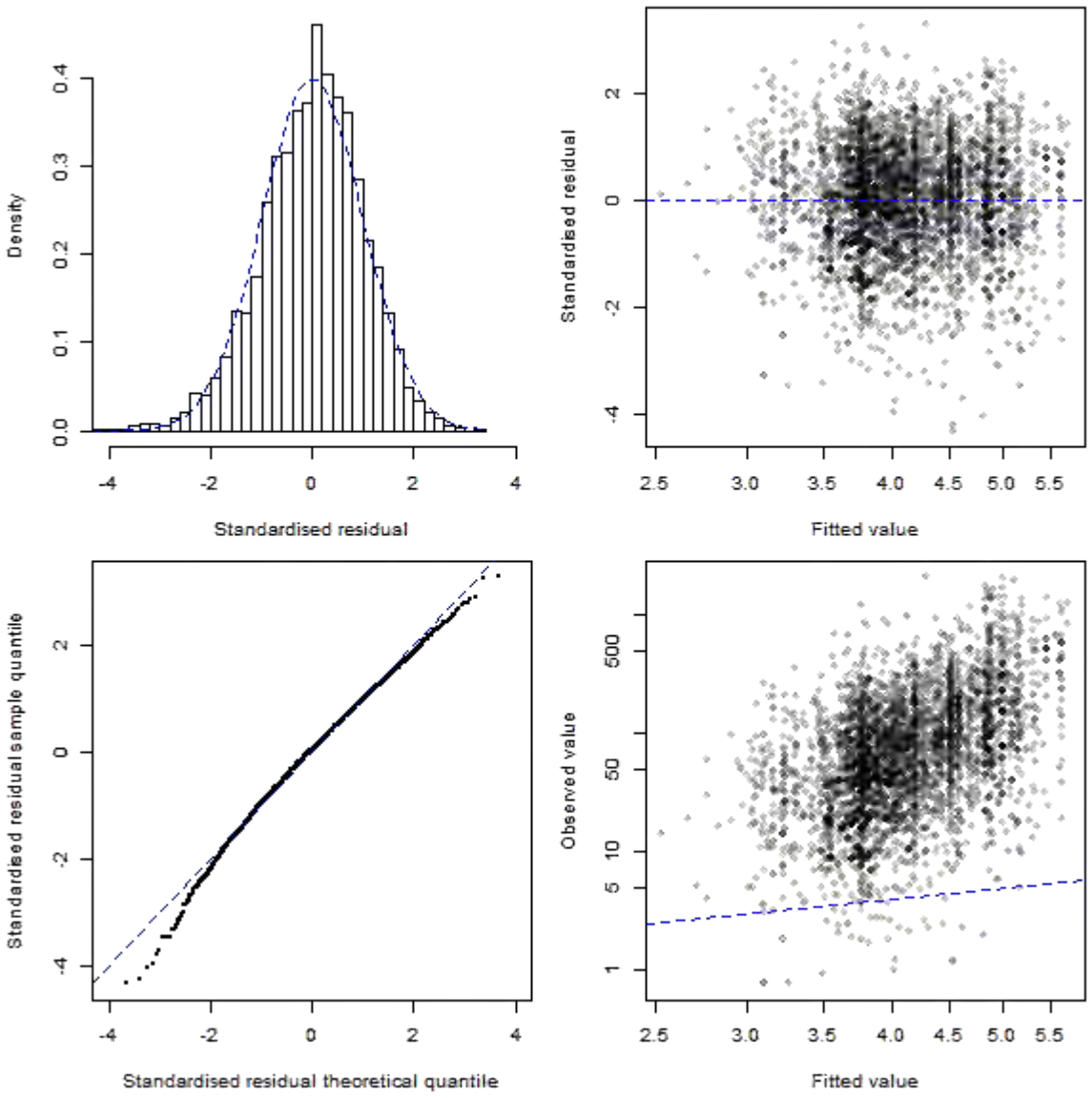

Figure P.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 1E_SN(coast) fishery. [upper left panel]: histogram of the standardised residuals compared to a lognormal distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

P.10 Model coefficients

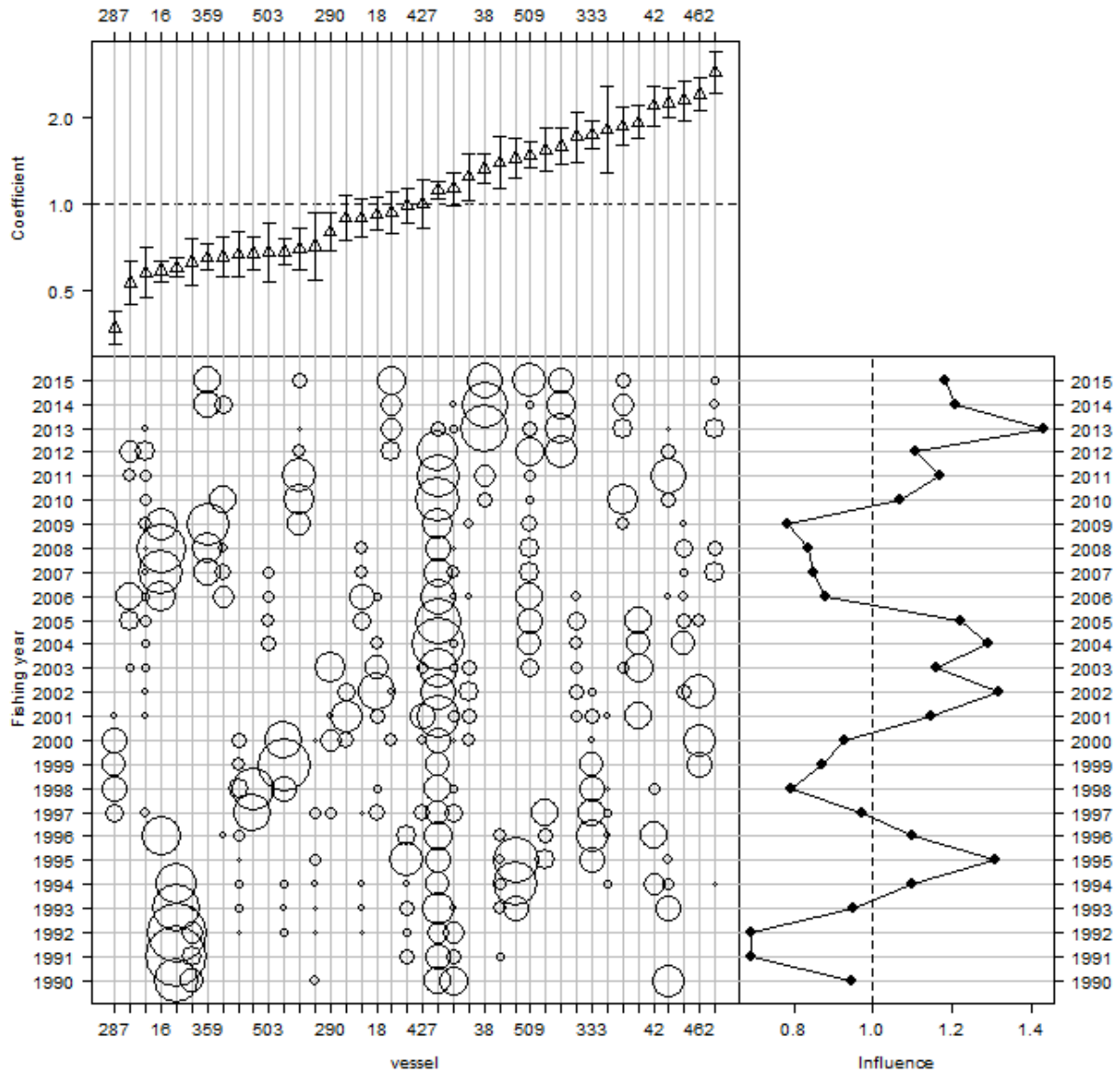

Figure P.6: Effect of vessel fished in the lognormal model for the rig SPO 1E_SN(coast) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

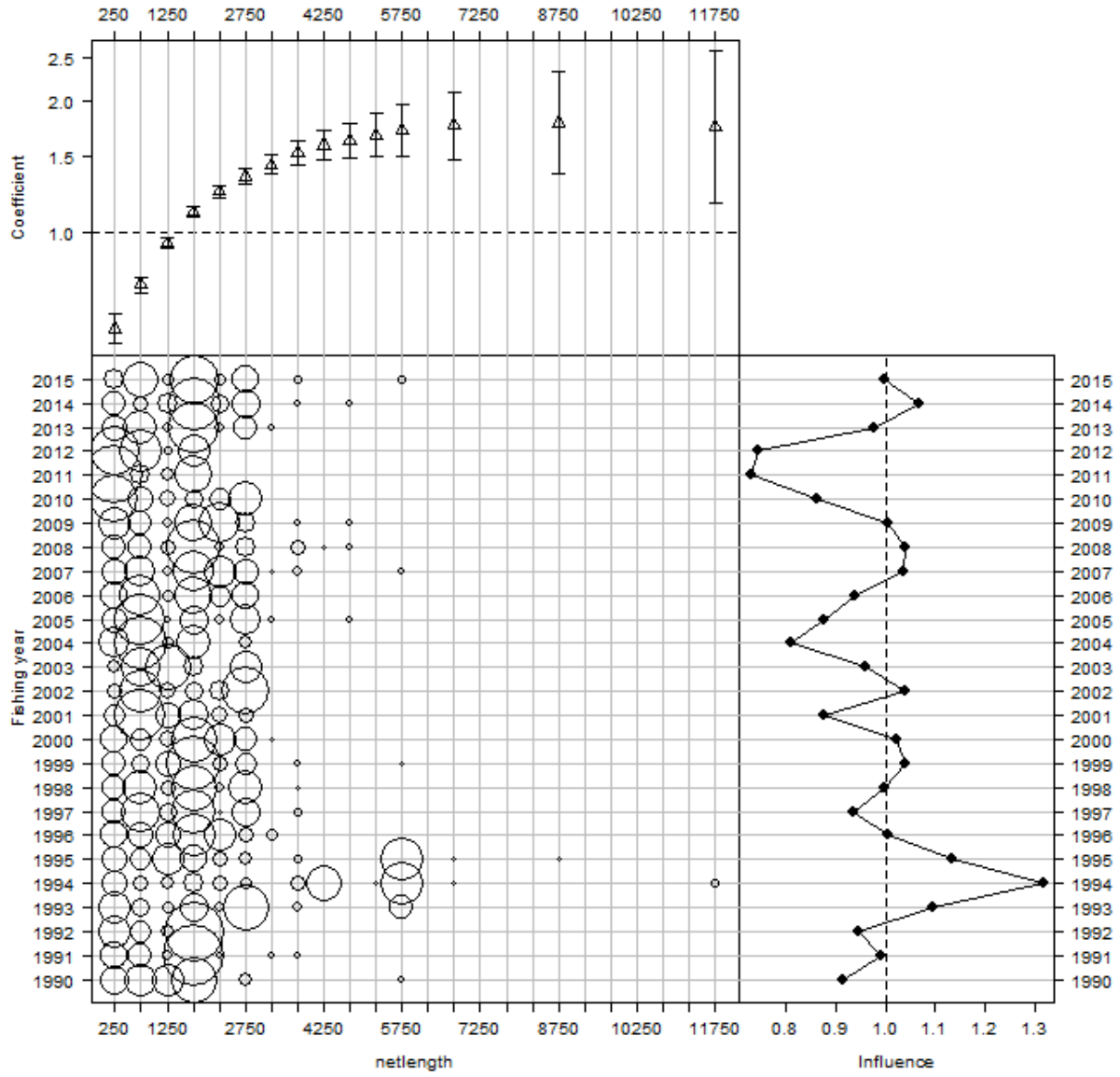

Figure P.7: Effect of length of net set in the lognormal model for the rig SPO 1E_SN(coast) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

P.11 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 SPO 1E_SN(coast) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.066	1.100	0.803	0.796	0.1160
1991	0.489	0.563	1.009	1.525	0.1050
1992	1.514	1.192	1.529	2.096	0.0957
1993	0.860	0.913	0.682	0.830	0.0749
1994	0.939	0.794	0.631	0.934	0.0855
1995	0.804	0.963	0.803	0.797	0.0997
1996	0.892	1.076	1.101	1.033	0.0977
1997	1.251	1.316	1.210	1.228	0.0990
1998	1.086	0.980	0.900	1.198	0.1001
1999	0.726	0.727	0.692	0.878	0.1018
2000	0.902	0.749	0.723	0.834	0.0930
2001	0.892	0.958	1.023	0.844	0.1087
2002	1.136	1.123	1.562	1.345	0.1069
2003	1.109	0.994	1.150	1.042	0.0938
2004	1.326	1.170	1.362	0.879	0.0902
2005	1.258	1.182	1.375	1.029	0.1012
2006	0.683	0.582	0.809	0.921	0.0966
2007	0.734	0.760	0.711	0.953	0.0810
2008	0.848	0.935	0.798	1.084	0.0862
2009	0.917	0.947	0.934	1.270	0.1049
2010	1.374	1.440	1.525	1.240	0.1269
2011	1.065	1.073	1.057	0.575	0.1253
2012	1.518	1.671	1.679	1.119	0.1332
2013	1.469	1.535	1.406	1.005	0.1068
2014	0.858	1.198	0.773	0.658	0.1139
2015	1.201	0.932	0.897	0.835	0.1282

Appendix Q. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1W_SN(043)

Q.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 1W by the NINSWG (MPI 2016) with a research rating of '2' (Medium or Mixed Quality: series only indexes a small proportion of SPO 1W). A binomial model was not run because nearly every record successfully captured rig (Table Q.1).

Q.2 Fishery definition

SPO 1W_SN(043): The fishery is defined from setnet fishing events that fished in Statistical Area 043 and declared target species SPO, SCH, SPD and NSD.

Q.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in four years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 21 vessels, which took 81% of the catch (Figure Q.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure Q.1).

Q.4 Data summary

Table Q.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of five trips per year in four years) in the SPO 1W_SN(043) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	5	52	61	66	1.08	41.15	238	16.46	100.0	100.0	0	0
1991	5	46	52	57	1.10	30.48	180	14.09	100.0	100.0	0	0
1992	5	90	93	107	1.15	72.20	567	23.51	100.0	100.0	0	0
1993	5	51	51	55	1.08	37.85	246	12.42	96.1	96.1	0	0
1994	6	85	90	92	1.02	84.19	611	29.34	100.0	100.0	0	0
1995	7	123	142	150	1.06	119.38	982	27.15	99.2	99.3	0	0
1996	7	152	158	171	1.08	128.70	1 229	24.62	100.0	100.0	0	0
1997	9	202	212	234	1.10	182.85	1 152	32.72	99.5	99.5	0	0
1998	8	126	128	144	1.13	125.33	724	14.56	99.2	99.2	0	0
1999	9	268	268	313	1.17	258.64	1 648	32.19	98.9	98.9	0	0
2000	11	380	380	452	1.19	343.99	2 366	53.98	99.5	99.5	0	0
2001	13	378	383	407	1.06	347.51	2 584	40.64	98.9	99.0	0	0
2002	14	308	317	329	1.04	292.36	2 248	28.68	99.4	99.4	0	0
2003	13	293	317	337	1.06	280.52	2 709	33.44	98.6	96.9	0	0
2004	9	212	217	247	1.14	209.15	2 307	24.37	99.5	99.5	0	0
2005	8	131	139	154	1.11	120.39	1 564	16.99	100.0	100.0	0	0
2006	8	125	129	156	1.21	107.05	1 404	13.99	99.2	99.2	0	0
2007	11	193	196	233	1.19	198.89	2 081	40.72	99.5	99.0	0	0
2008	10	145	149	185	1.24	164.14	1 608	22.30	100.0	100.0	0	0
2009	6	72	78	81	1.04	53.50	785	7.95	98.6	98.7	0	0
2010	4	48	52	56	1.08	33.91	560	5.86	95.8	96.2	0	0
2011	6	118	119	133	1.12	94.26	1 305	13.35	99.2	99.2	0	0
2012	5	91	93	97	1.04	84.20	1 028	17.13	98.9	98.9	0	0
2013	6	123	126	146	1.16	131.45	1 683	20.86	99.2	99.2	0	0
2014	6	103	107	117	1.09	107.50	1 297	15.26	99.0	99.1	0	0
2015	7	163	171	215	1.26	177.35	2 681	25.93	98.8	98.8	0	0

Q.5 Core vessel selection

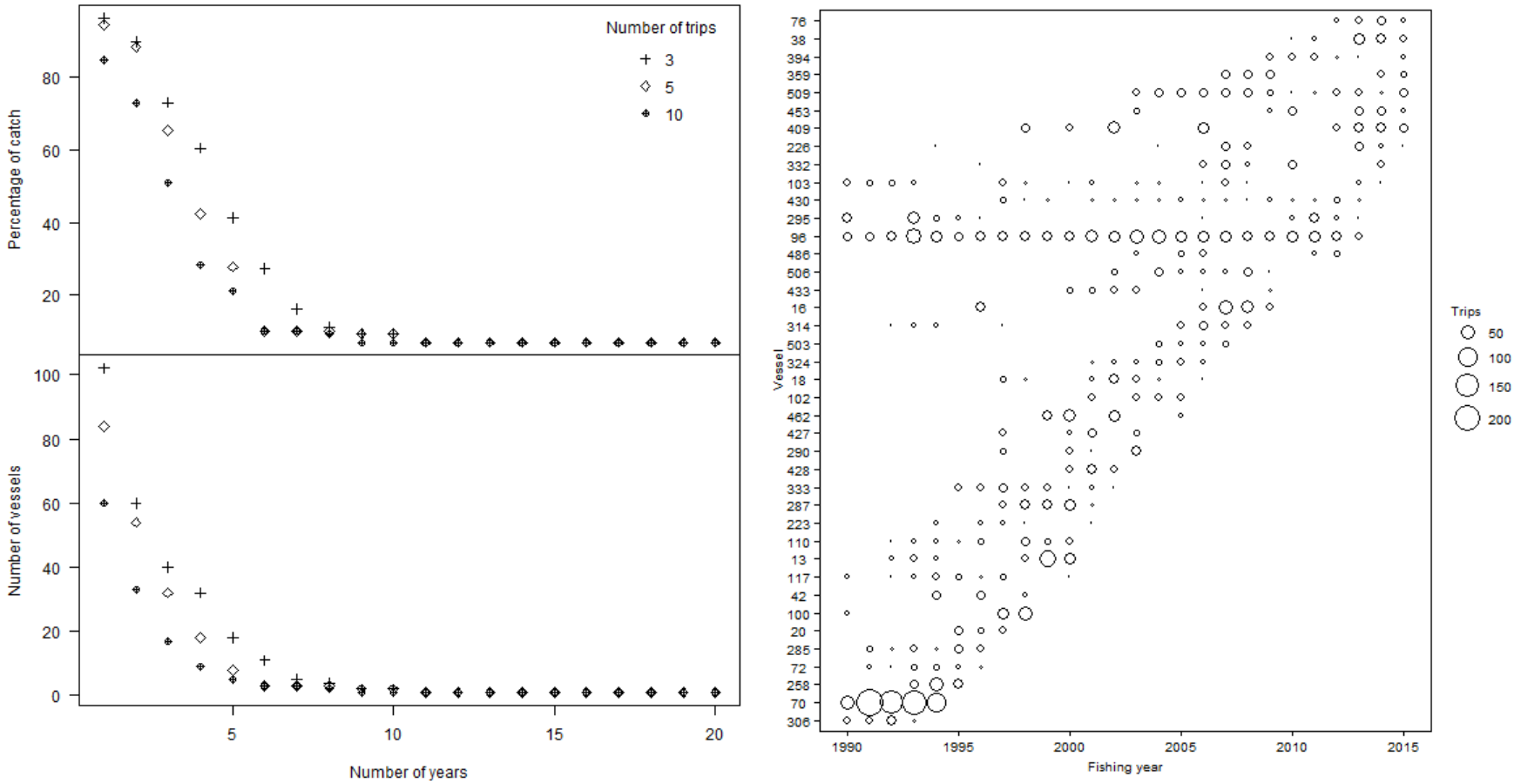

Figure Q.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1W_SN(043) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in four or more fishing years) by fishing year.

Q.6 Exploratory data plots for core vessel data set

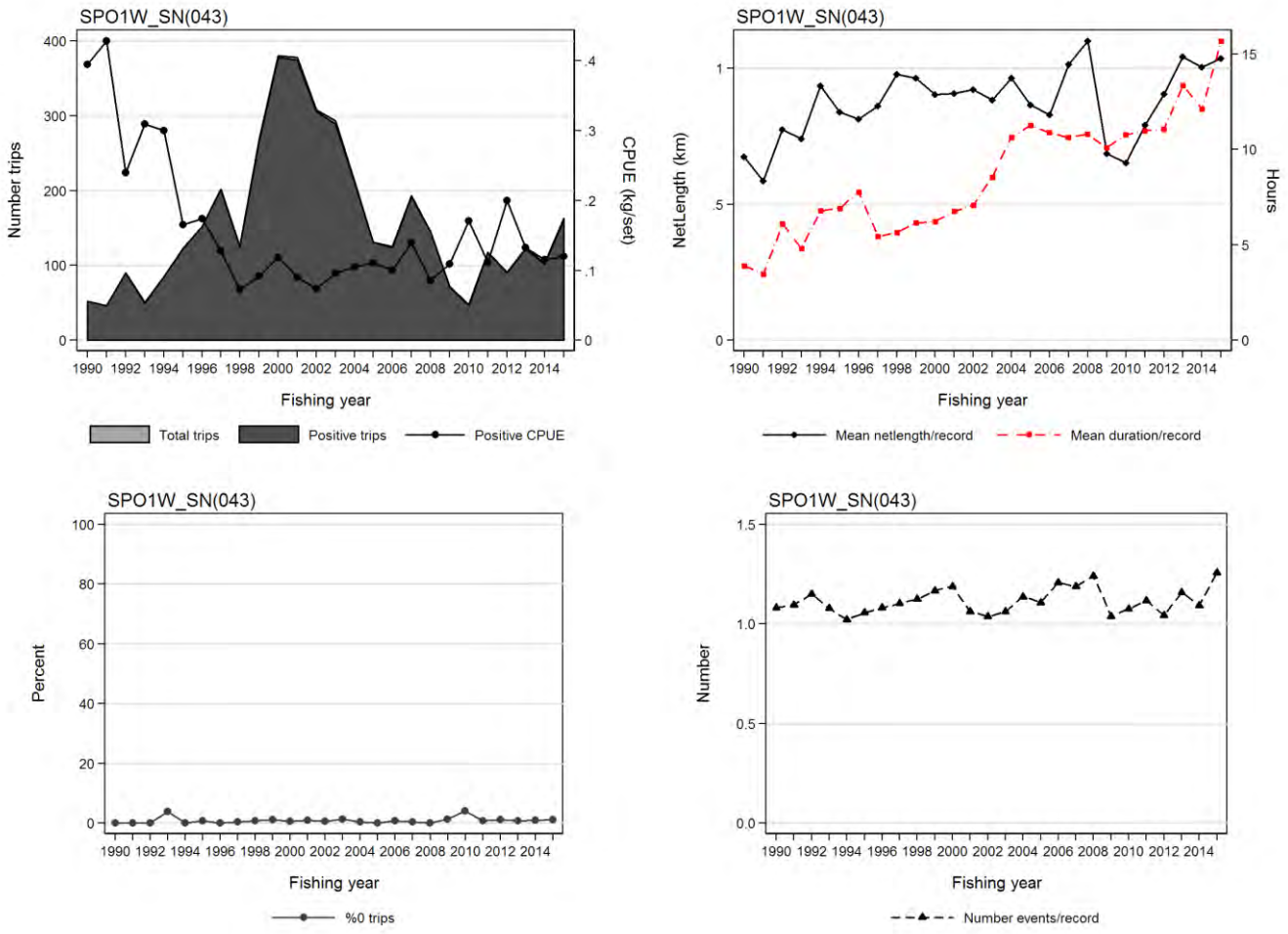

Figure Q.2: Core vessel summary plots by fishing year for model SPO 1W_SN(043): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: percentage of trips with no catch of rig; [lower right panel]: mean number of events per stratum record.

Q.7 Selection of positive catch distribution

SPO 1W_SN(043) is an existing analysis (see Table 13). The positive catch distribution was forced to gamma for consistency with previous analyses.

Q.8 Positive catch model selection table

Four explanatory variables (vessel, month, duration and net length) entered the model after fishing year (Table Q.2). There were no non-significant variables, apart from target species, which the model discarded before the analysis started because all the data were from SPO. A plot of the model is provided in Figure Q.3 and the CPUE indices are listed in Table Q.3.

Table Q.2: Order of acceptance of variables into the gamma model of successful catches in the SPO 1W_SN(043) fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	26	-24 766	49 586	11.67	*
vessel	46	-24 301	48 695	29.27	*
month	57	-24 011	48 138	38.40	*
poly(log(duration), 3)	60	-23 843	47 808	43.15	*
poly(log(netlength), 3)	63	-23 788	47 703	**44.64**	*
target	–	–	–	–	

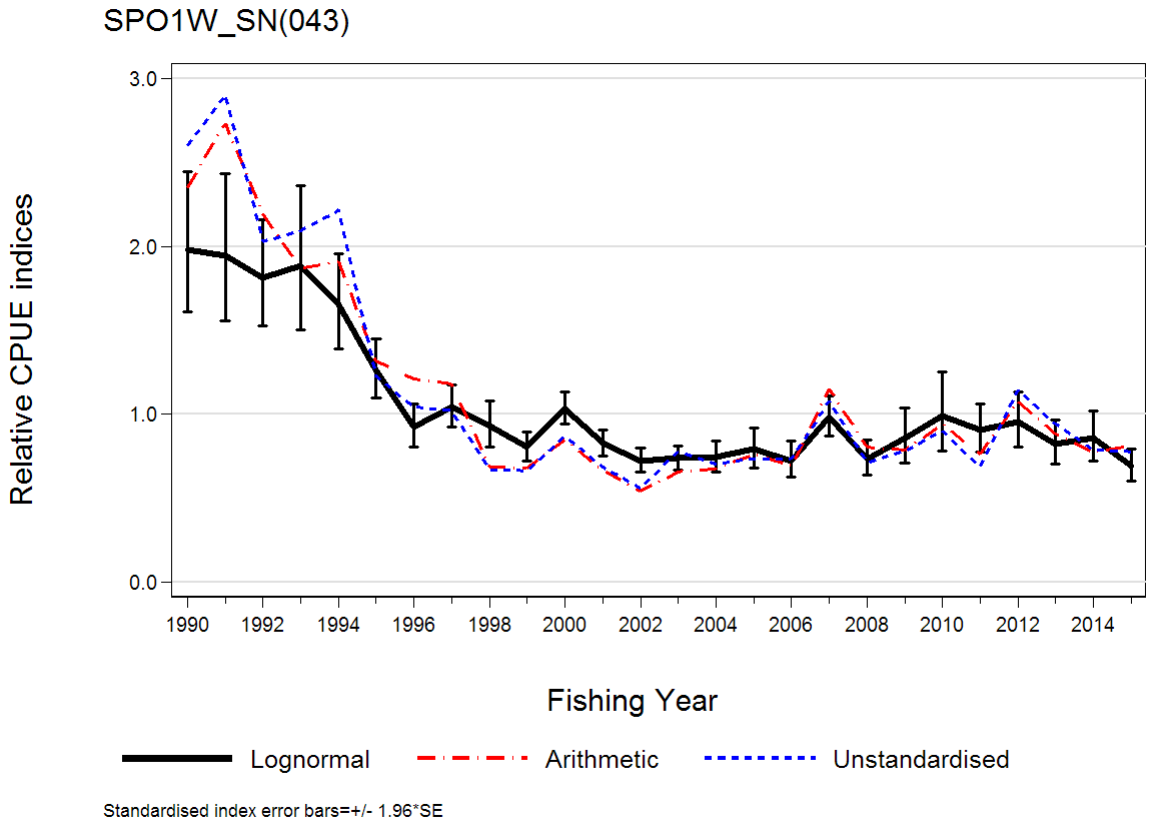

Figure Q.3: Relative CPUE indices for rig using the gamma non-zero model based on the SPO 1W_SN(043) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

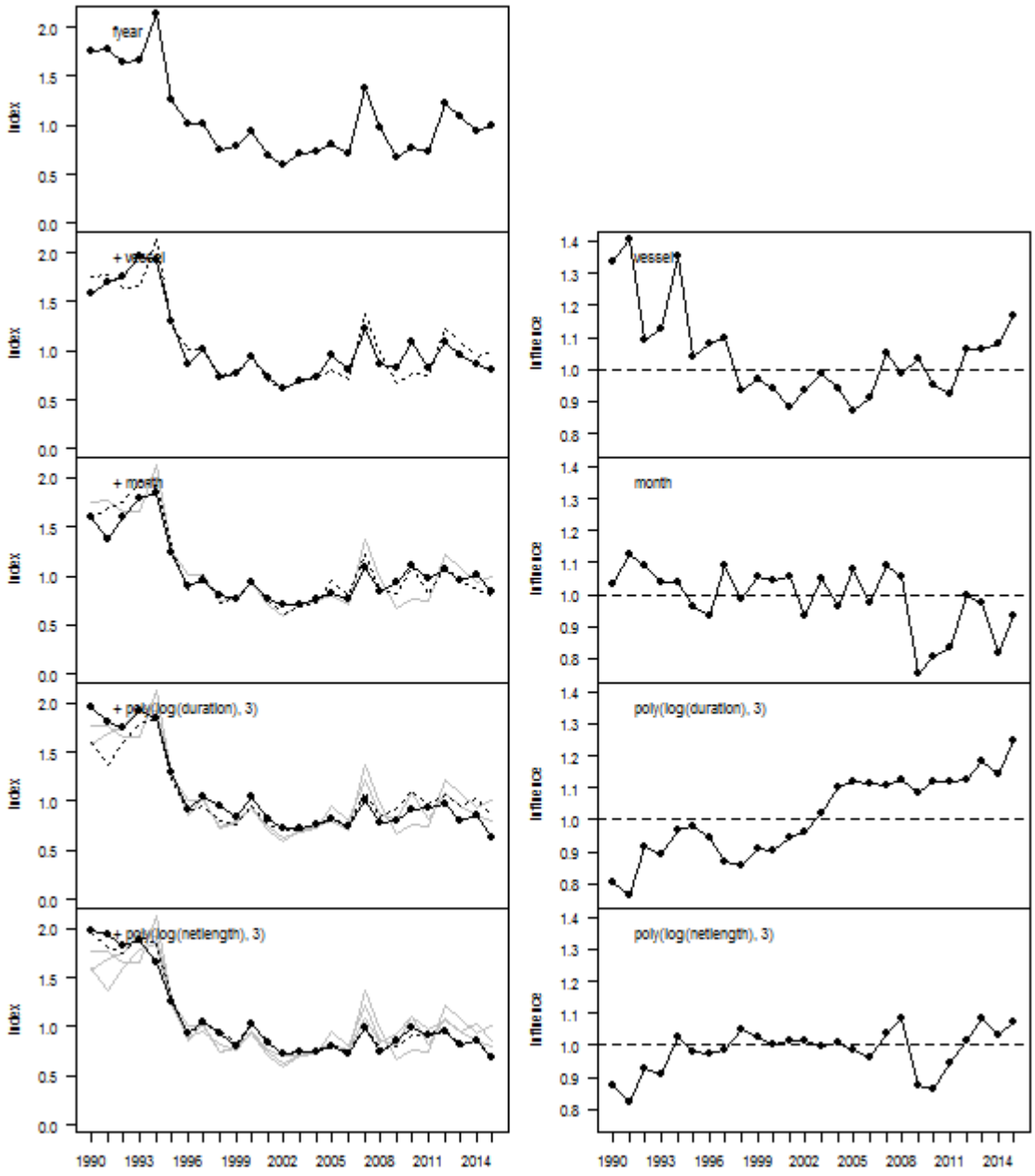

Figure Q.4: [left column]: annual indices from the gamma model of SPO 1W_SN(043) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

Q.9 Residual and diagnostic plots

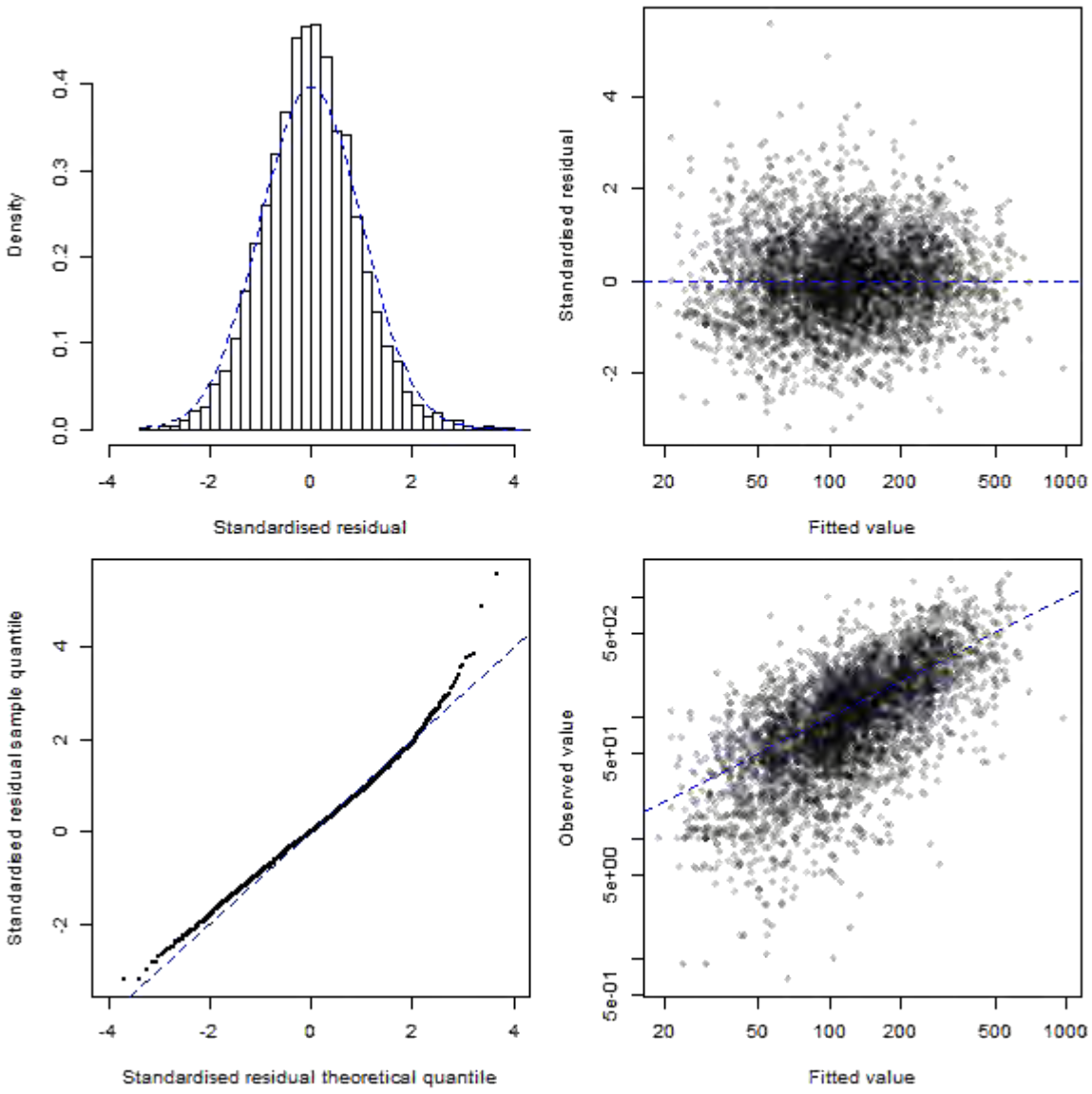

Figure Q.5: Plots of the fit of the gamma standardised CPUE model of successful catches of rig in the SPO 1W_SN(043) fishery. [upper left panel]: histogram of the standardised residuals compared to a gamma distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

Q.10 Model coefficients

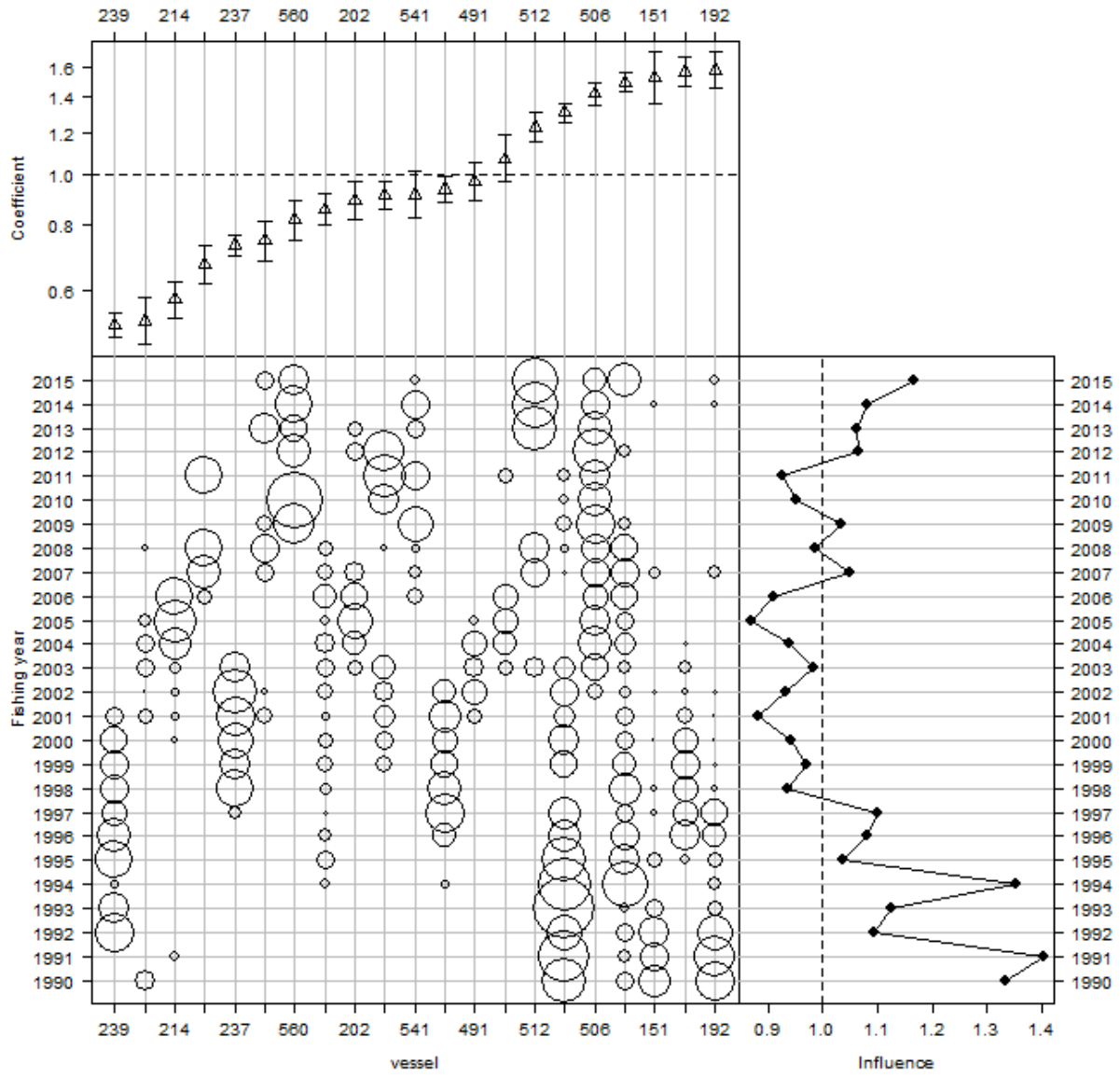

Figure Q.6: Effect of vessel fished in the gamma model for the rig SPO 1W_SN(043) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

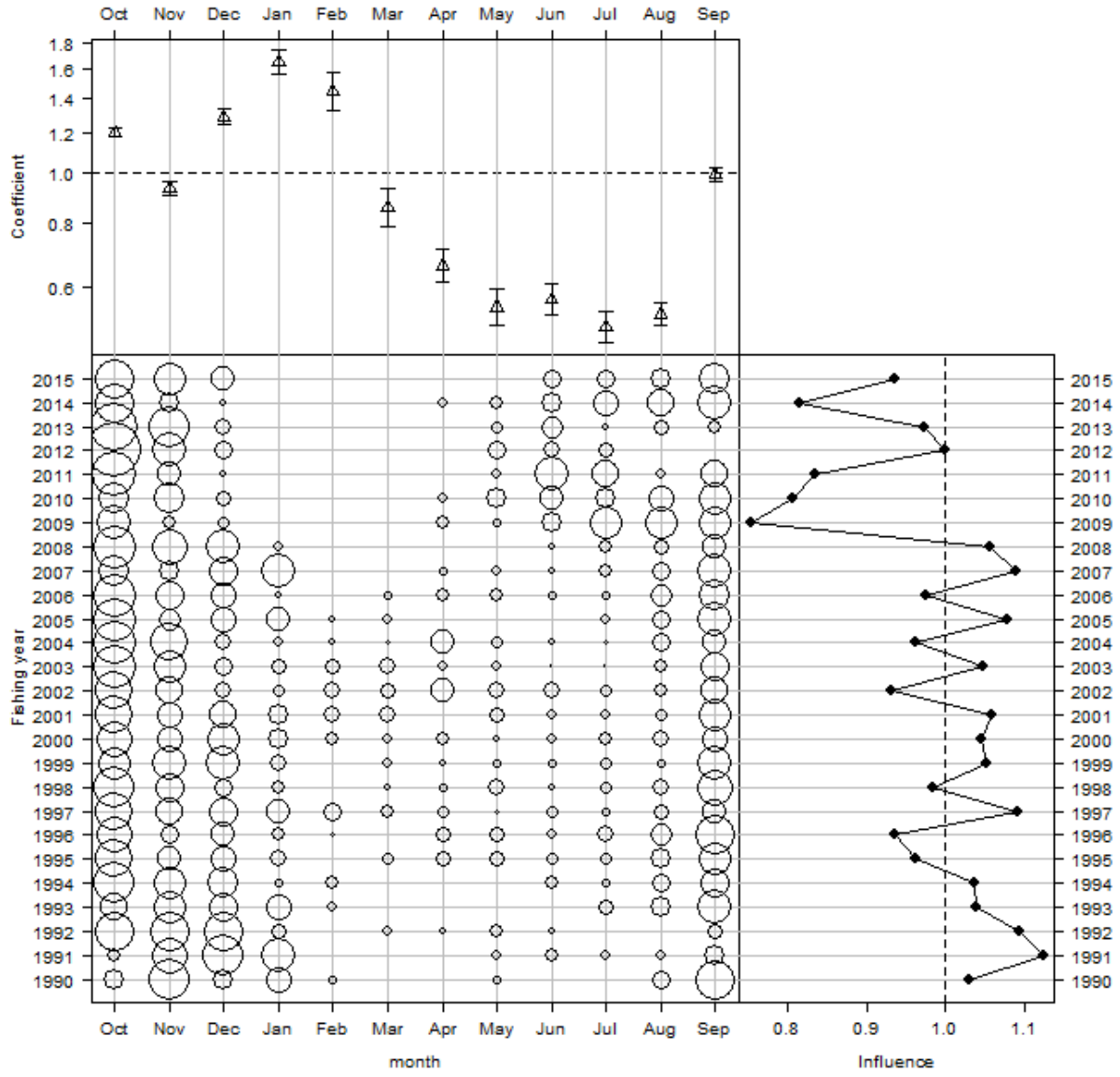

Figure Q.7: Effect of month in the gamma model for the rig SPO 1W_SN(043) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

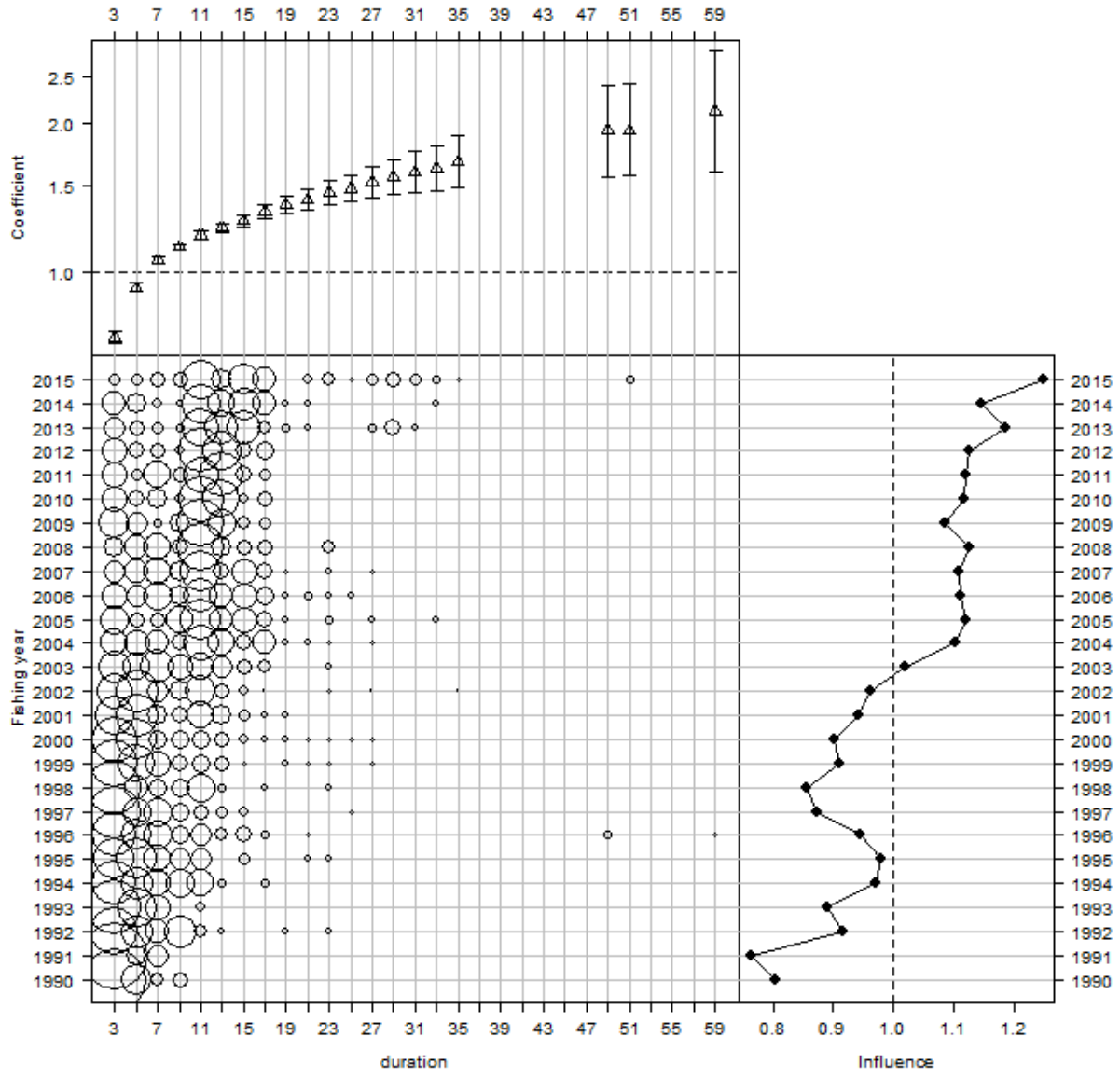

Figure Q.8: Effect of duration (hours set) in the gamma model for the rig SPO 1W_SN(043) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

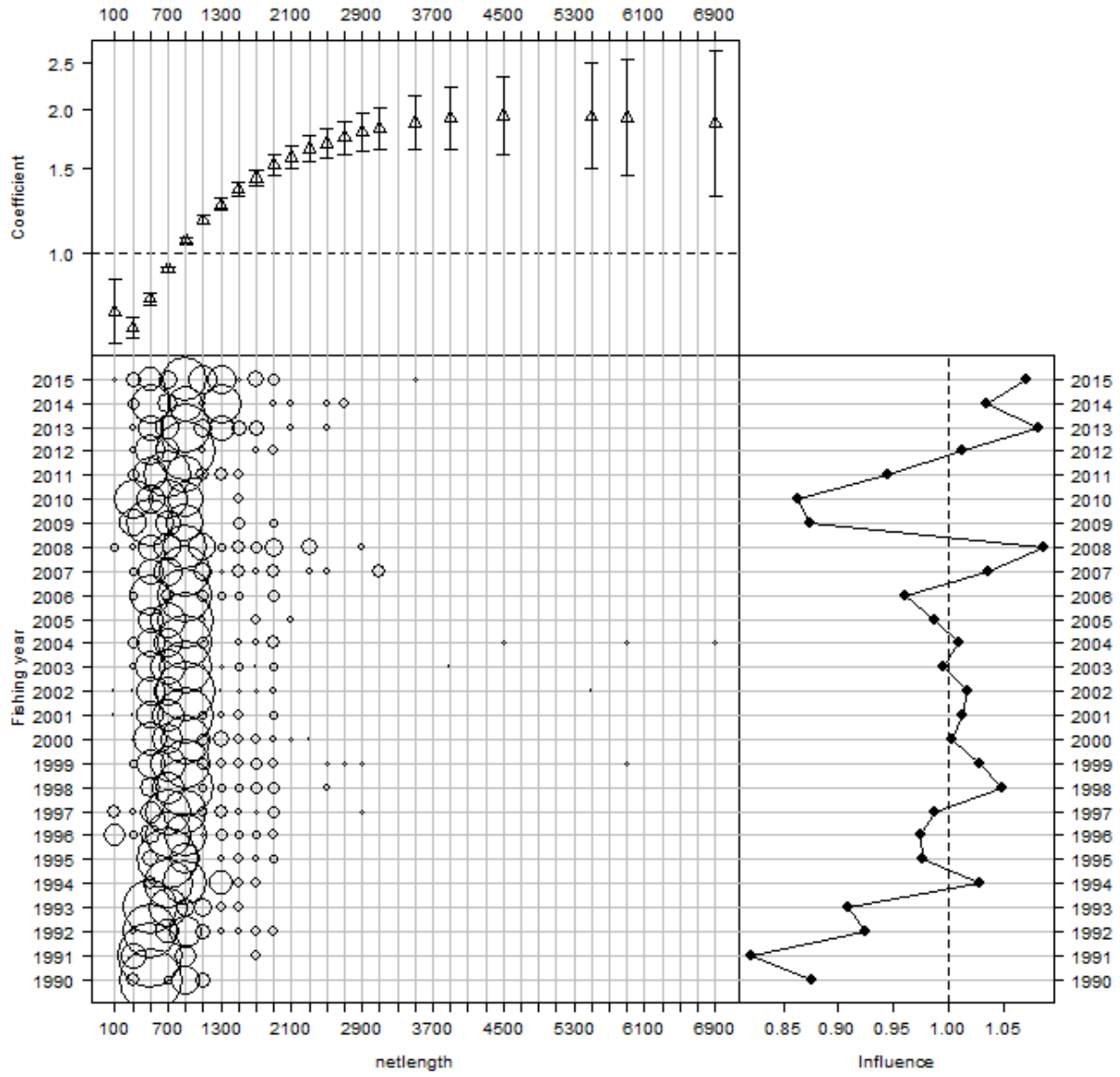

Figure Q.9: Effect of length of net set in the gamma model for the rig SPO 1W_SN(043) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

Q.11 CPUE indices

Table Q.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 SPO 1W_SN(043) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.789	2.351	2.602	1.983	0.1068
1991	1.659	2.735	2.905	1.946	0.1144
1992	1.962	2.197	2.032	1.816	0.0882
1993	1.678	1.870	2.094	1.885	0.1154
1994	1.288	1.910	2.217	1.651	0.0871
1995	1.303	1.319	1.229	1.262	0.0709
1996	1.156	1.210	1.043	0.924	0.0694
1997	1.179	1.181	1.022	1.042	0.0609
1998	0.689	0.687	0.668	0.930	0.0751
1999	0.764	0.680	0.664	0.804	0.0546
2000	0.916	0.848	0.868	1.032	0.0478
2001	0.721	0.666	0.688	0.827	0.0474
2002	0.623	0.543	0.559	0.723	0.0516
2003	0.709	0.658	0.776	0.738	0.0492
2004	0.742	0.676	0.703	0.744	0.0625
2005	0.818	0.762	0.736	0.791	0.0778
2006	0.691	0.694	0.732	0.723	0.0761
2007	1.115	1.152	1.079	0.982	0.0631
2008	0.851	0.802	0.710	0.734	0.0721
2009	0.849	0.785	0.781	0.858	0.0974
2010	1.042	0.942	0.901	0.990	0.1194
2011	0.834	0.762	0.688	0.908	0.0813
2012	1.185	1.077	1.147	0.957	0.0874
2013	1.082	0.884	0.944	0.823	0.0805
2014	0.843	0.775	0.787	0.860	0.0876
2015	0.920	0.812	0.777	0.691	0.0714

Appendix R. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1W_SN(044)

R.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 1W by the NINSWG (MPI 2016) with a research rating of '2' (Medium or Mixed Quality: series only indexes a small proportion of SPO 1W). A binomial model was not run because nearly every record successfully captured rig (Table R.1).

R.2 Fishery definition

SPO 1W_SN(044): The fishery is defined from setnet fishing events that fished in Statistical Area 044 and declared target species SPO, SCH, SPD and NSD.

R.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in four years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 27 vessels, which took 86% of the catch (Figure R.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure R.1).

R.4 Data summary

Table R.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of five trips per year in four years) in the SPO 1W_SN(044) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	4	36	43	49	1.14	33.80	608	11.95	100.0	100.0	0	0
1991	5	17	24	24	1.00	21.70	208	5.19	100.0	91.7	0	0
1992	5	32	43	48	1.12	44.00	433	11.69	100.0	97.7	0	0
1993	6	55	66	77	1.17	65.18	686	17.22	98.2	98.5	0	0
1994	8	73	101	114	1.13	90.21	917	18.55	100.0	98.0	0	0
1995	9	90	135	136	1.01	123.80	1 241	39.87	100.0	100.0	0	0
1996	9	104	140	144	1.03	135.35	1 561	36.66	98.1	98.6	0	0
1997	9	111	147	156	1.06	134.13	1 688	30.21	100.0	99.3	0	0
1998	10	120	155	163	1.05	130.64	1 792	27.56	96.7	96.1	0	0
1999	14	205	241	246	1.02	219.29	2 614	45.44	100.0	99.2	0	0
2000	15	263	358	370	1.03	336.30	3 796	75.30	99.2	98.3	0	0
2001	15	267	412	423	1.03	355.52	5 441	79.21	99.6	99.0	0	0
2002	14	251	307	329	1.07	307.34	4 295	41.53	100.0	100.0	0	0
2003	15	303	399	437	1.10	361.54	5 934	48.69	100.0	99.8	0	0
2004	9	141	182	217	1.19	183.66	2 834	38.65	99.3	99.5	0	0
2005	12	259	308	323	1.05	290.56	4 391	50.86	100.0	100.0	0	0
2006	12	200	244	287	1.18	235.36	4 010	34.96	100.0	100.0	0	0
2007	9	279	296	337	1.14	286.75	4 303	45.43	98.9	99.0	0	0
2008	8	209	218	257	1.18	211.96	3 259	24.53	99.5	99.5	0	0
2009	6	148	160	175	1.09	149.60	2 087	22.28	98.7	98.8	0	0
2010	6	90	104	112	1.08	91.64	1 627	20.16	100.0	100.0	0	0
2011	10	179	191	247	1.29	175.16	2 934	27.87	100.0	100.0	0	0
2012	8	168	180	208	1.16	158.16	2 392	31.30	99.4	99.4	0	0
2013	9	235	265	330	1.25	227.53	4 104	32.87	99.6	99.6	0	0
2014	7	182	195	242	1.24	167.44	2 642	22.65	99.5	99.5	0	0
2015	8	107	117	121	1.03	92.42	1 232	18.42	98.1	98.3	0	0

R.5 Core vessel selection

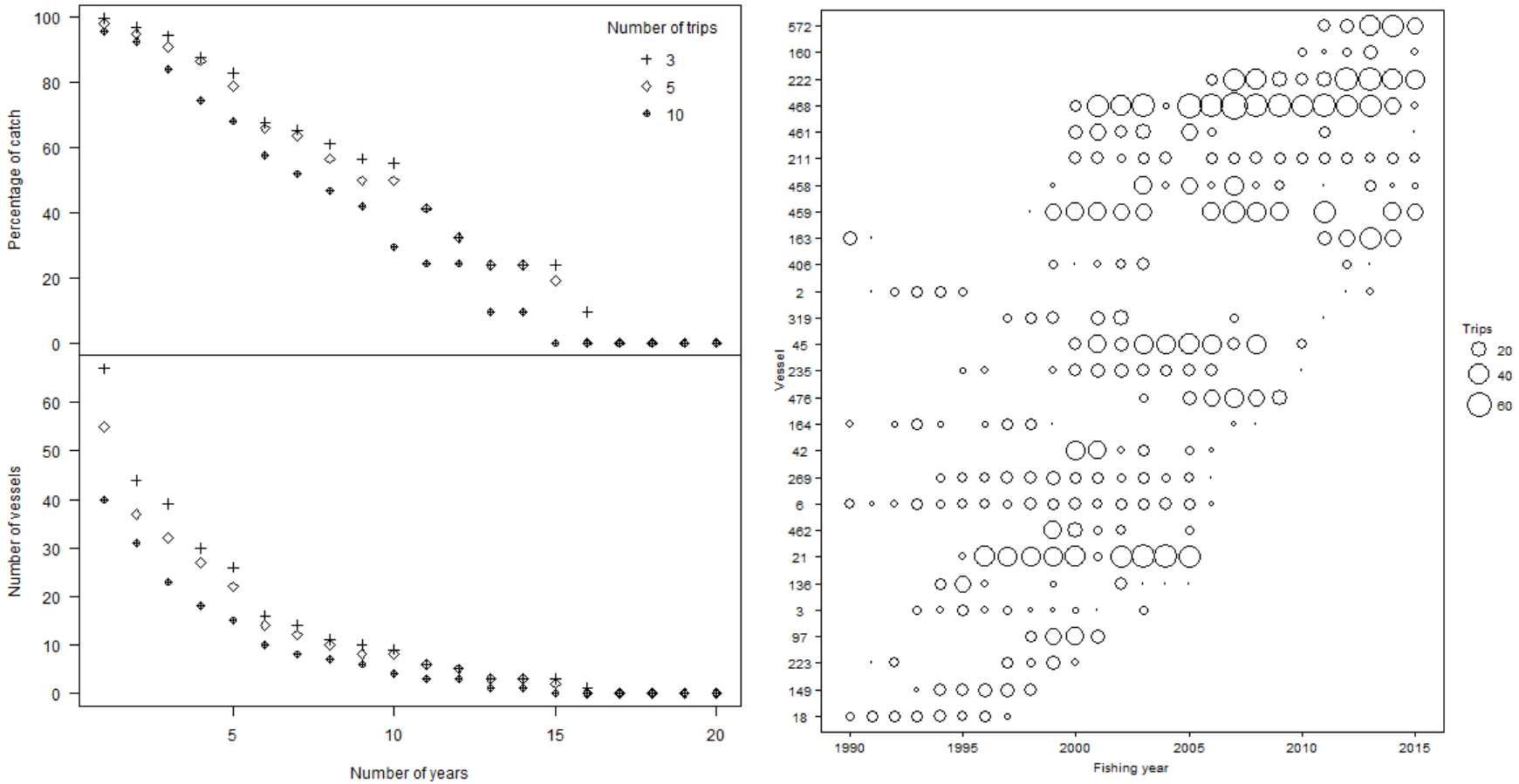

Figure R.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1W_SN(044) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in four or more fishing years) by fishing year.

R.6 Exploratory data plots for core vessel data set

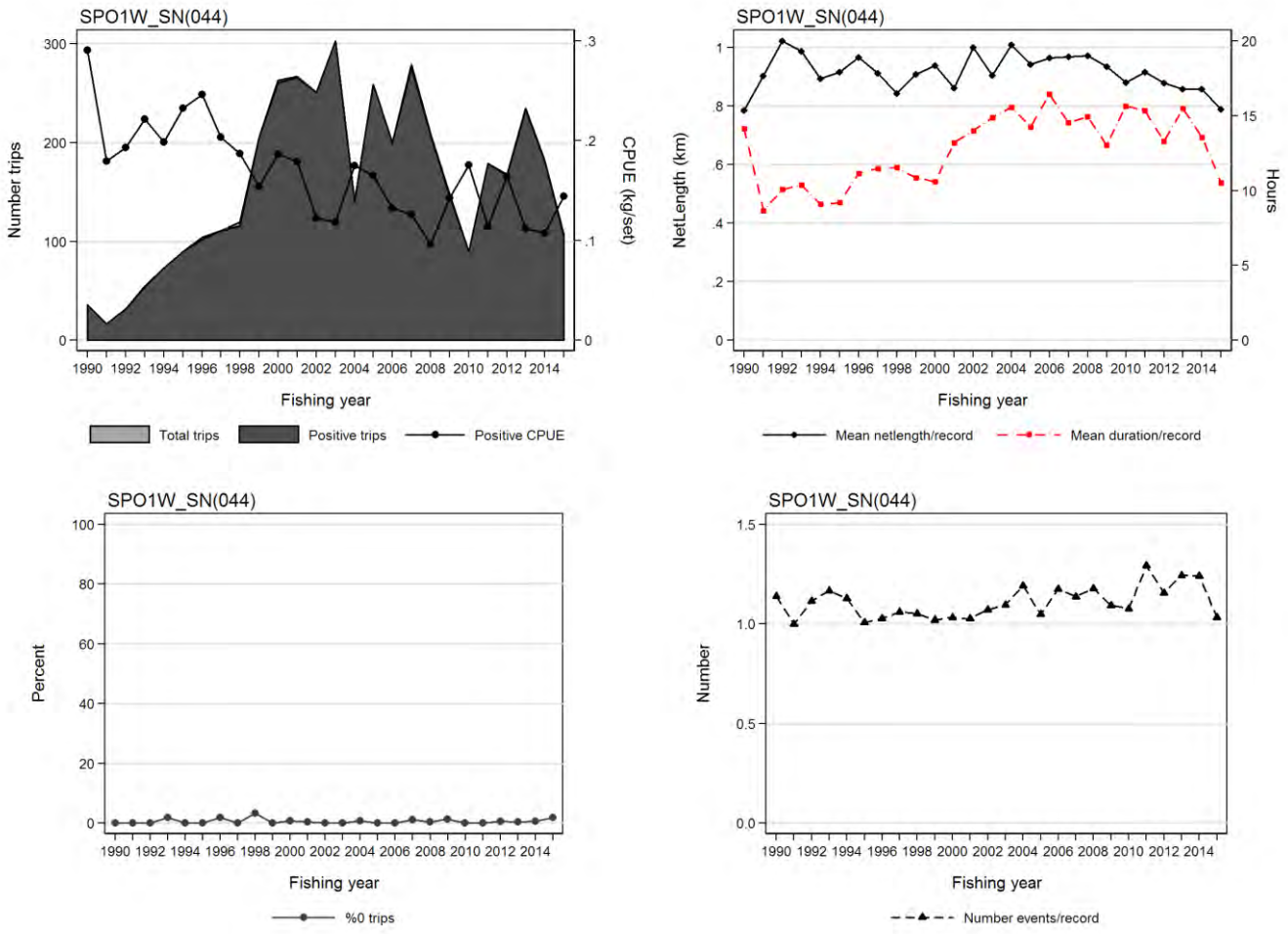

Figure R.2: Core vessel summary plots by fishing year for model SPO 1W_SN(044): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: percentage of trips with no catch of rig; [lower right panel]: mean number of events per stratum record.

R.7 Selection of positive catch distribution

SPO 1W_SN(044) is an existing analysis (see Table 13). The positive catch distribution was forced to gamma for consistency with previous analyses.

R.8 Positive catch model selection table

Three explanatory variables (vessel, month and net length) entered the model after fishing year (Table R.2). Duration was non-significant and target species was discarded by the model before the analysis started because all the data were from SPO. A plot of the model is provided in Figure R.3 and the CPUE indices are listed in Table R.3.

Table R.2: Order of acceptance of variables into the gamma model of successful catches in the SPO 1W_SN(044) fishery model for core vessels (based on the vessel selection criteria of at least five trips in four 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	26	-30 143	60 339	10.38	*
vessel	52	-29 598	59 302	27.95	*
month	63	-29 325	58 779	35.41	*
poly(log(netlength), 3)	66	-29 188	58 509	**38.87**	*
poly(log(duration), 3)	69	-29 169	58 478	39.33	
target	–	–	–	–	

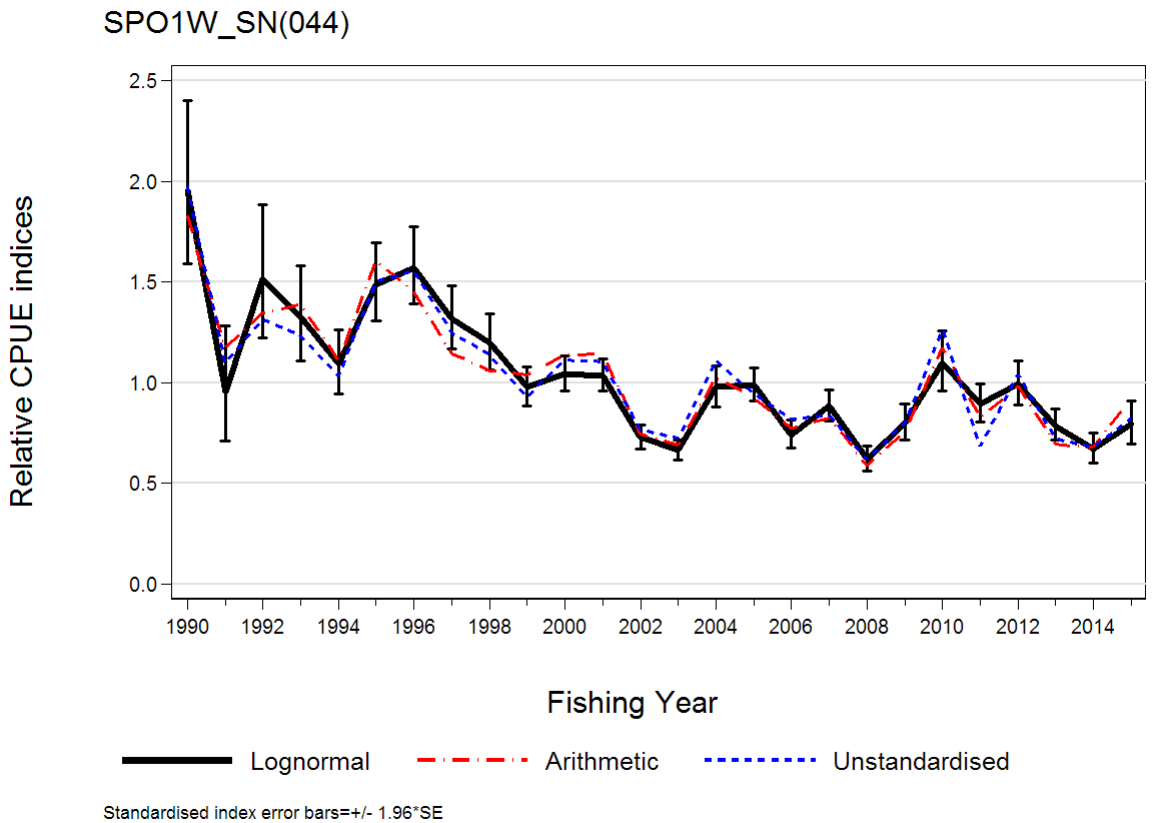

Figure R.3: Relative CPUE indices for rig using the gamma non-zero model based on the SPO 1W_SN(044) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

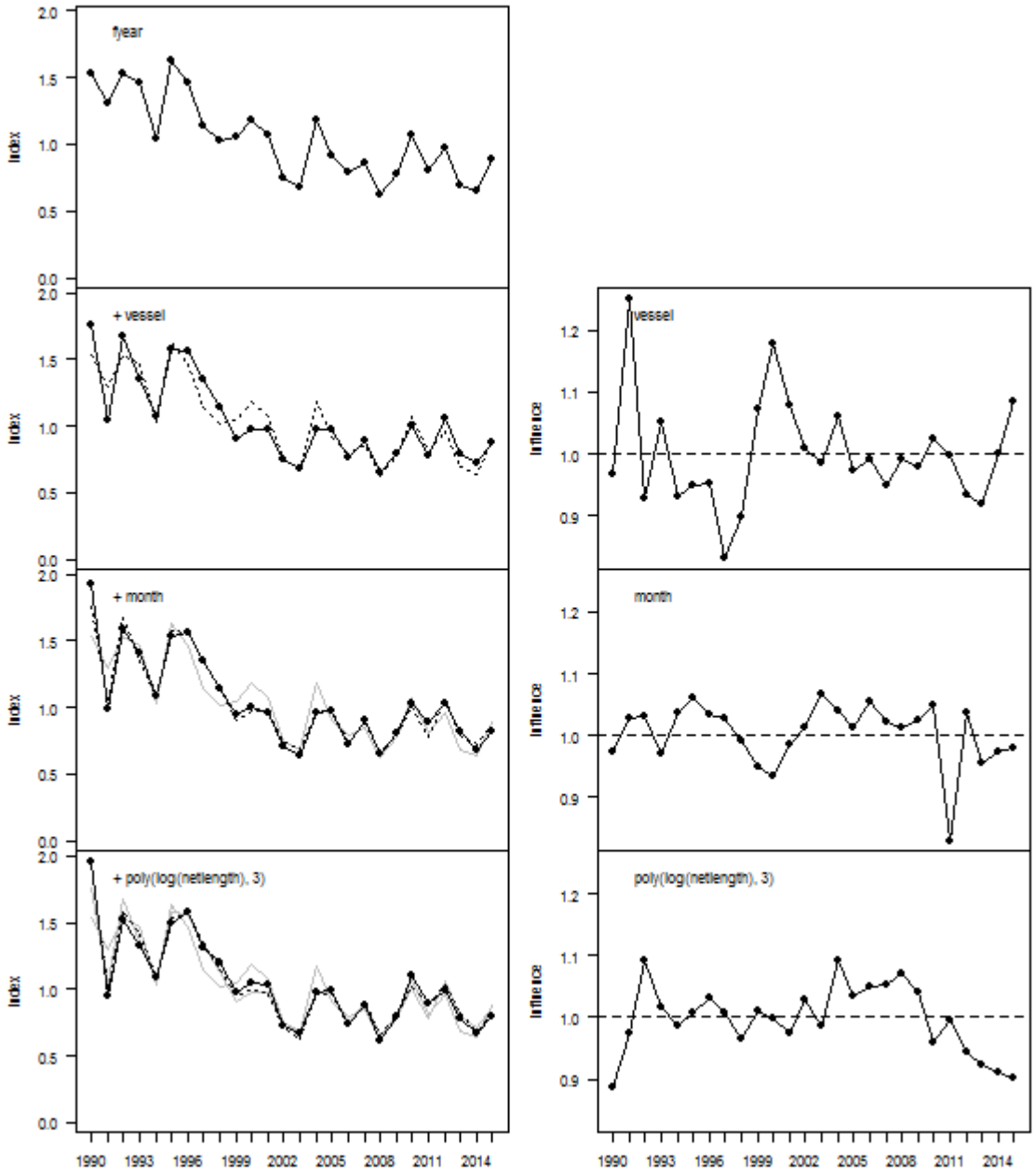

Figure R.4: [left column]: annual indices from the gamma model of SPO 1W_SN(044) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

R.9 Residual and diagnostic plots

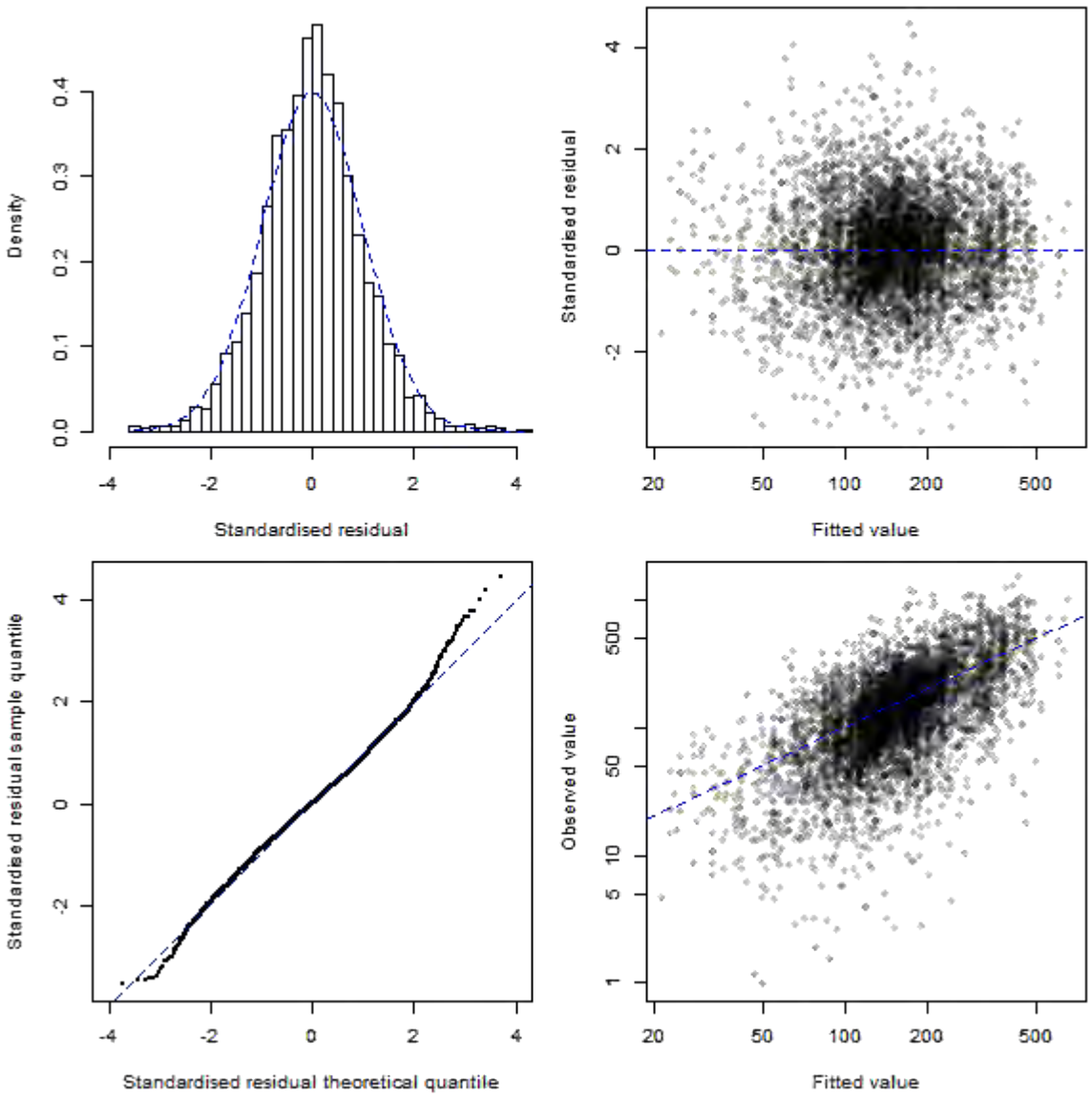

Figure R.5: Plots of the fit of the gamma standardised CPUE model of successful catches of rig in the SPO 1W_SN(044) fishery. [upper left panel]: histogram of the standardised residuals compared to a gamma distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

R.10 Model coefficients

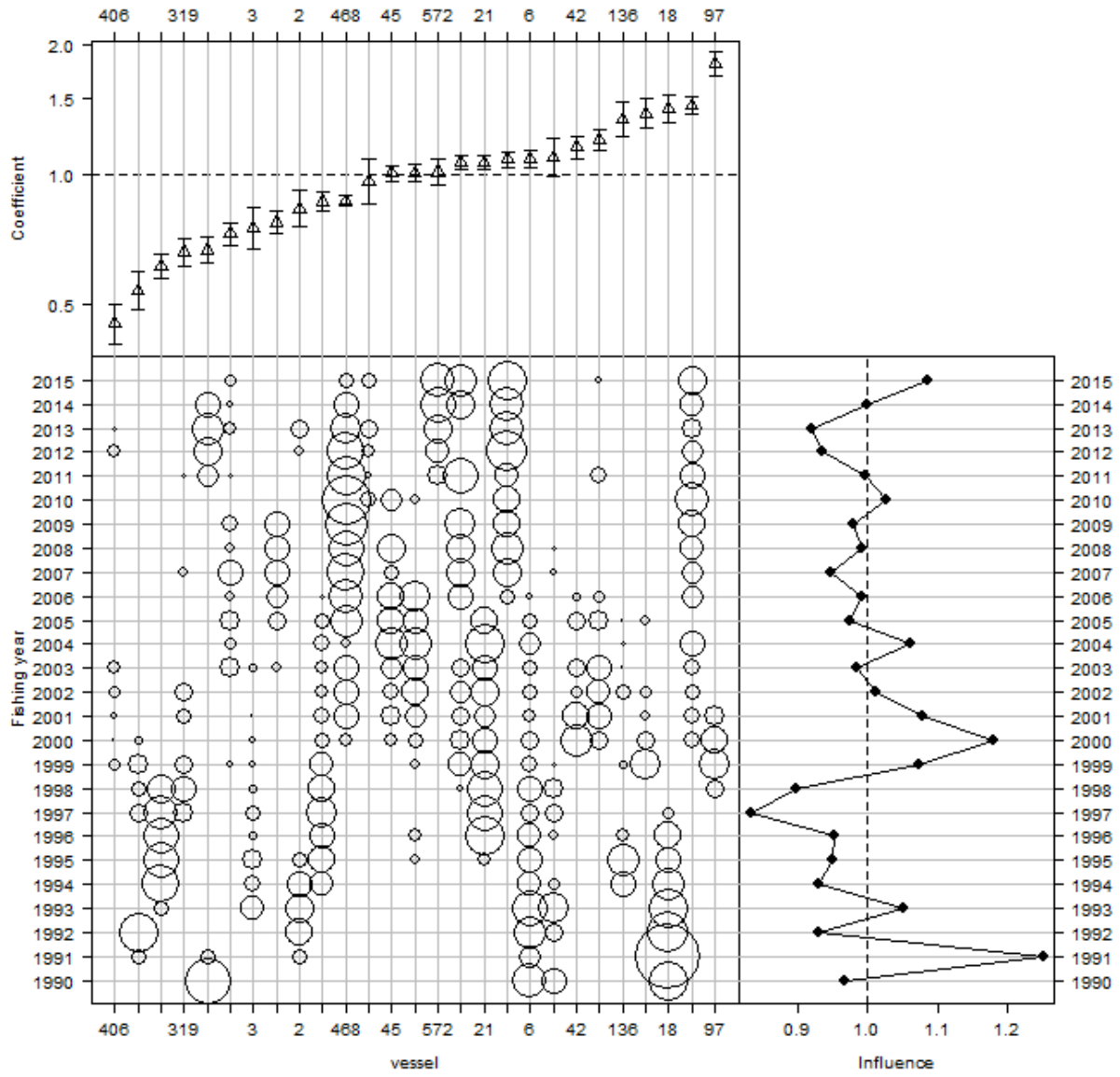

Figure R.6: Effect of vessel fished in the gamma model for the rig SPO 1W_SN(044) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

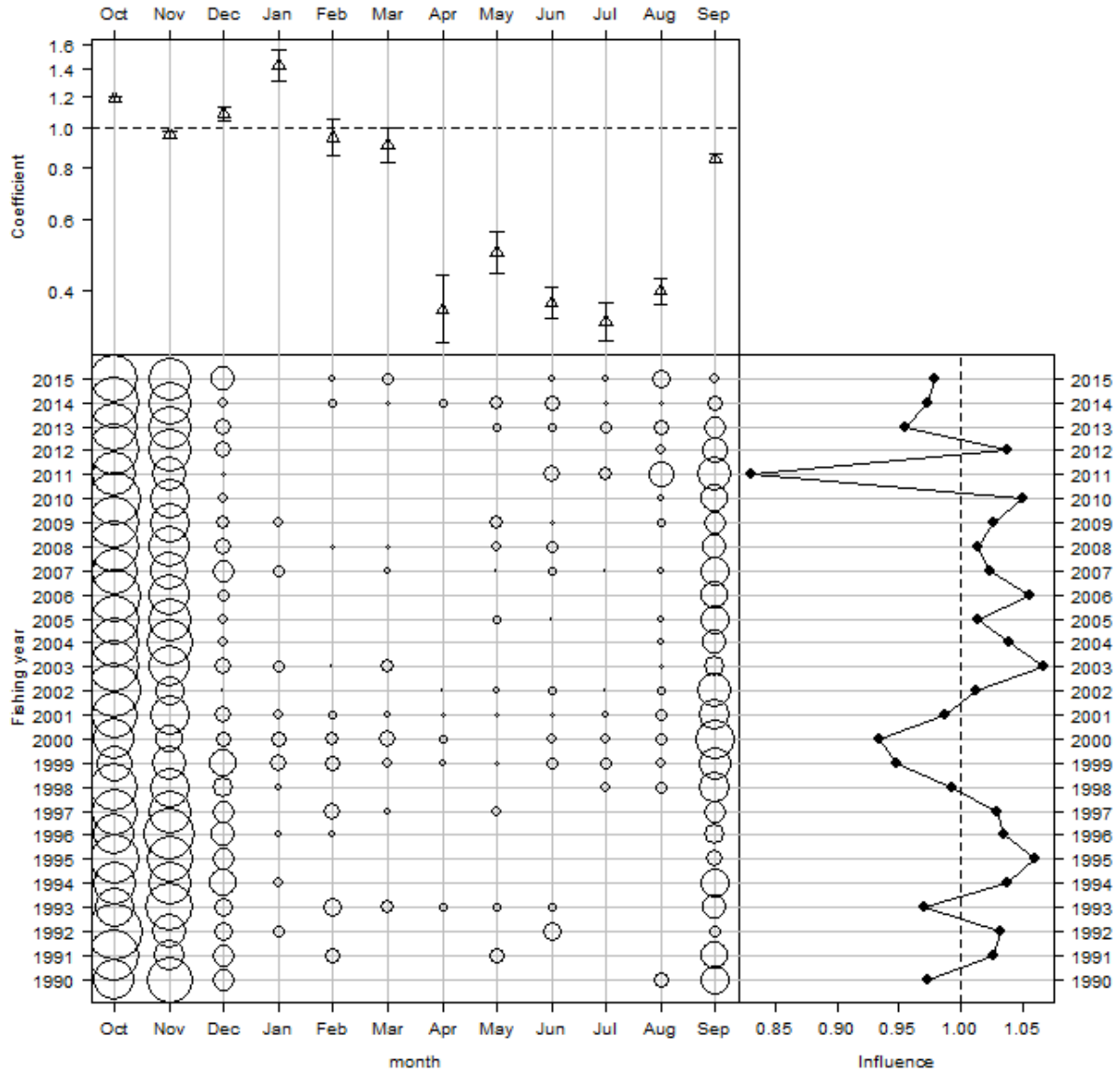

Figure R.7: Effect of month in the gamma model for the rig SPO 1W_SN(044) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

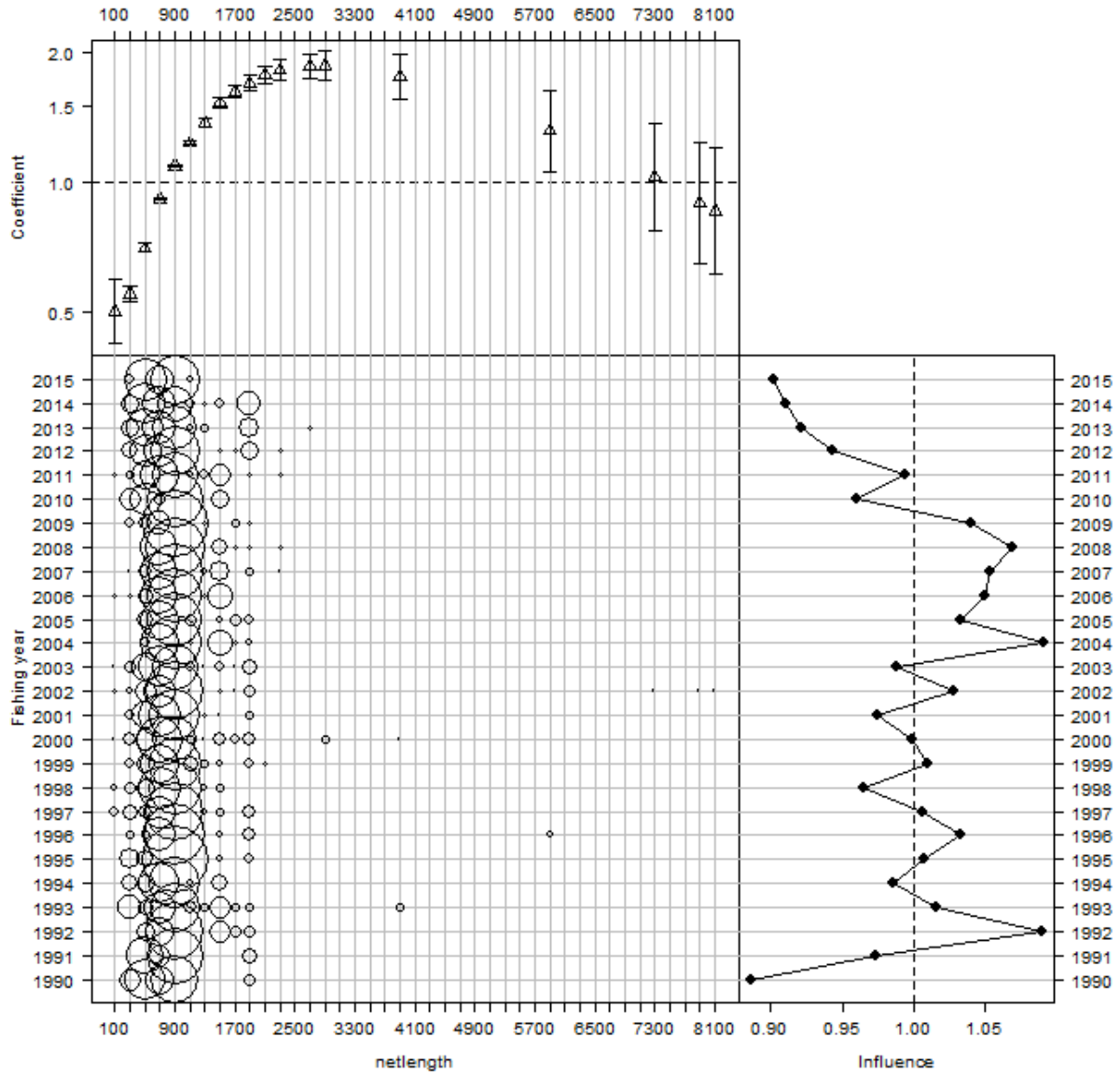

Figure R.8: Effect of length of net set in the gamma model for the rig SPO 1W_SN(044) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

R.11 CPUE indices

Table R.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 SPO 1W_SN(044) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	1.748	1.829	1.975	1.955	0.1055
1991	1.272	1.174	1.096	0.954	0.1505
1992	1.272	1.345	1.316	1.518	0.1098
1993	1.416	1.392	1.235	1.326	0.0903
1994	1.177	1.112	1.034	1.093	0.0743
1995	1.680	1.607	1.502	1.489	0.0657
1996	1.517	1.451	1.557	1.572	0.0617
1997	1.058	1.145	1.248	1.317	0.0609
1998	1.061	1.060	1.140	1.197	0.0596
1999	1.058	1.041	0.929	0.978	0.0509
2000	1.126	1.139	1.112	1.043	0.0426
2001	1.118	1.143	1.105	1.036	0.0387
2002	0.728	0.748	0.764	0.729	0.0422
2003	0.676	0.689	0.726	0.664	0.0386
2004	0.990	1.027	1.111	0.978	0.0533
2005	0.923	0.926	0.945	0.989	0.0425
2006	0.780	0.773	0.819	0.742	0.0474
2007	0.822	0.827	0.841	0.883	0.0452
2008	0.582	0.587	0.619	0.619	0.0507
2009	0.772	0.758	0.798	0.798	0.0576
2010	1.147	1.173	1.265	1.101	0.0691
2011	0.815	0.827	0.684	0.895	0.0535
2012	0.995	0.984	1.042	0.993	0.0562
2013	0.748	0.693	0.720	0.788	0.0498
2014	0.686	0.679	0.681	0.673	0.0555
2015	0.901	0.928	0.825	0.795	0.0678

Appendix S. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 1W_SN(041–047)

S.1 Introduction

This CPUE analysis was not accepted in 2016 for monitoring SPO 1W by the NINSWG (MPI 2016), giving it a research rating of '3' (Low Quality: Maui dolphin regulatory changes appear to have had significant impact). A binomial model was not run because of the high proportion of success captures (Table S.1).

S.2 Fishery definition

SPO 1W_SN(041–047): The fishery is defined from setnet fishing events that fished in Statistical Areas 041, 042, 045, 046 and 047 and declared target species SPO, SCH, SPD and NSD.

S.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least three trips in three years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 47 vessels, which took 88% of the catch (Figure S.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure S.1).

S.4 Data summary

Table S.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of three trips per year in three years) in the SPO 1W_SN(041–047) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	8	263	300	315	1.05	517.15	4 799	31.49	88.6	84.3	0	0
1991	7	197	216	218	1.01	347.35	3 484	27.77	91.4	88.4	0	0
1992	13	403	413	423	1.02	654.46	6 783	49.24	87.3	86.0	0	0
1993	14	380	407	423	1.04	717.90	6 880	79.43	91.6	88.5	0	0
1994	15	404	445	452	1.02	754.22	6 197	83.89	83.9	76.9	0	0
1995	17	370	425	442	1.04	865.15	5 977	91.80	86.8	81.4	0	0
1996	20	428	476	485	1.02	759.43	6 179	94.56	86.9	85.9	0	0
1997	19	505	594	666	1.12	1 221.45	8 232	151.55	89.3	89.4	0	0
1998	18	372	425	451	1.06	789.22	5 408	125.40	86.3	87.8	0	0
1999	16	353	410	416	1.01	745.08	4 808	65.18	94.3	90.2	0	0
2000	15	383	467	473	1.01	903.50	5 598	57.80	87.7	86.9	0	0
2001	16	470	499	507	1.02	755.99	6 681	84.72	92.3	91.6	0	0
2002	16	390	441	481	1.09	797.33	6 155	60.27	85.6	81.0	0	0
2003	16	261	317	344	1.09	635.96	4 456	52.12	87.4	82.7	0	0
2004	13	290	385	396	1.03	795.51	5 106	82.09	92.4	89.4	0	0
2005	14	286	395	398	1.01	896.60	4 784	84.93	95.1	89.1	0	0
2006	14	145	307	310	1.01	851.80	3 845	99.24	91.7	91.5	0	0
2007	16	205	381	387	1.02	913.17	6 040	52.21	94.2	83.5	0	0
2008	14	219	384	396	1.03	934.90	6 232	63.49	95.0	89.3	0	0
2009	12	192	371	399	1.08	948.46	6 176	57.40	92.2	79.8	0	0
2010	12	198	332	355	1.07	796.70	5 554	51.65	90.4	81.3	0	0
2011	11	218	358	365	1.02	800.65	5 880	43.92	94.5	83.0	0	0
2012	12	224	354	366	1.03	768.25	5 803	30.95	95.1	85.6	0	0
2013	8	203	325	345	1.06	792.20	5 637	33.93	90.6	82.8	0	0
2014	8	239	402	417	1.04	1 062.02	7 372	60.32	92.9	84.6	0	0
2015	8	242	408	424	1.04	1 120.30	7 110	54.91	92.6	80.9	0	0

S.5 Core vessel selection

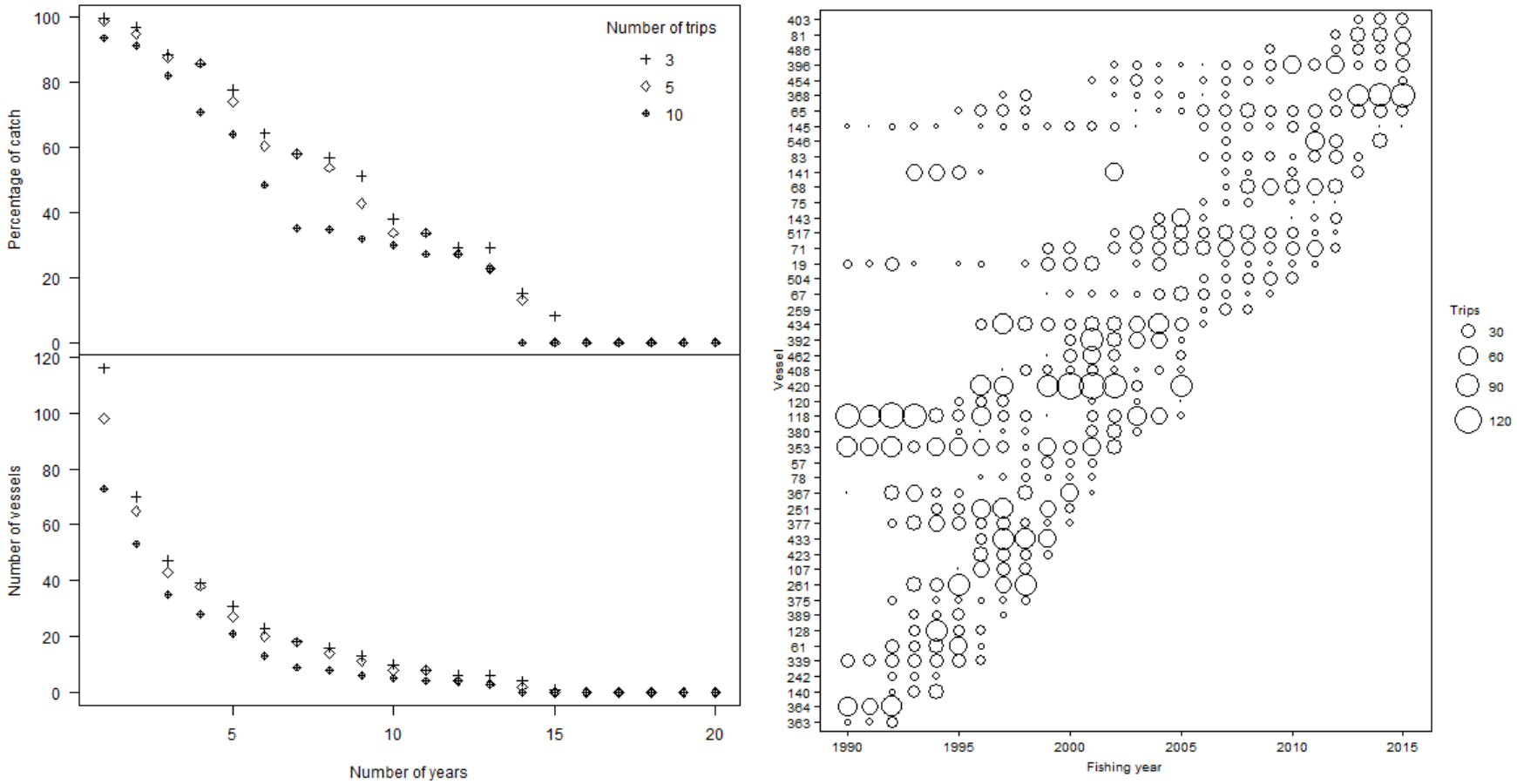

Figure S.1: **[left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 1W_SN(041–047) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least three trips in three or more fishing years) by fishing year.**

S.6 Exploratory data plots for core vessel data set

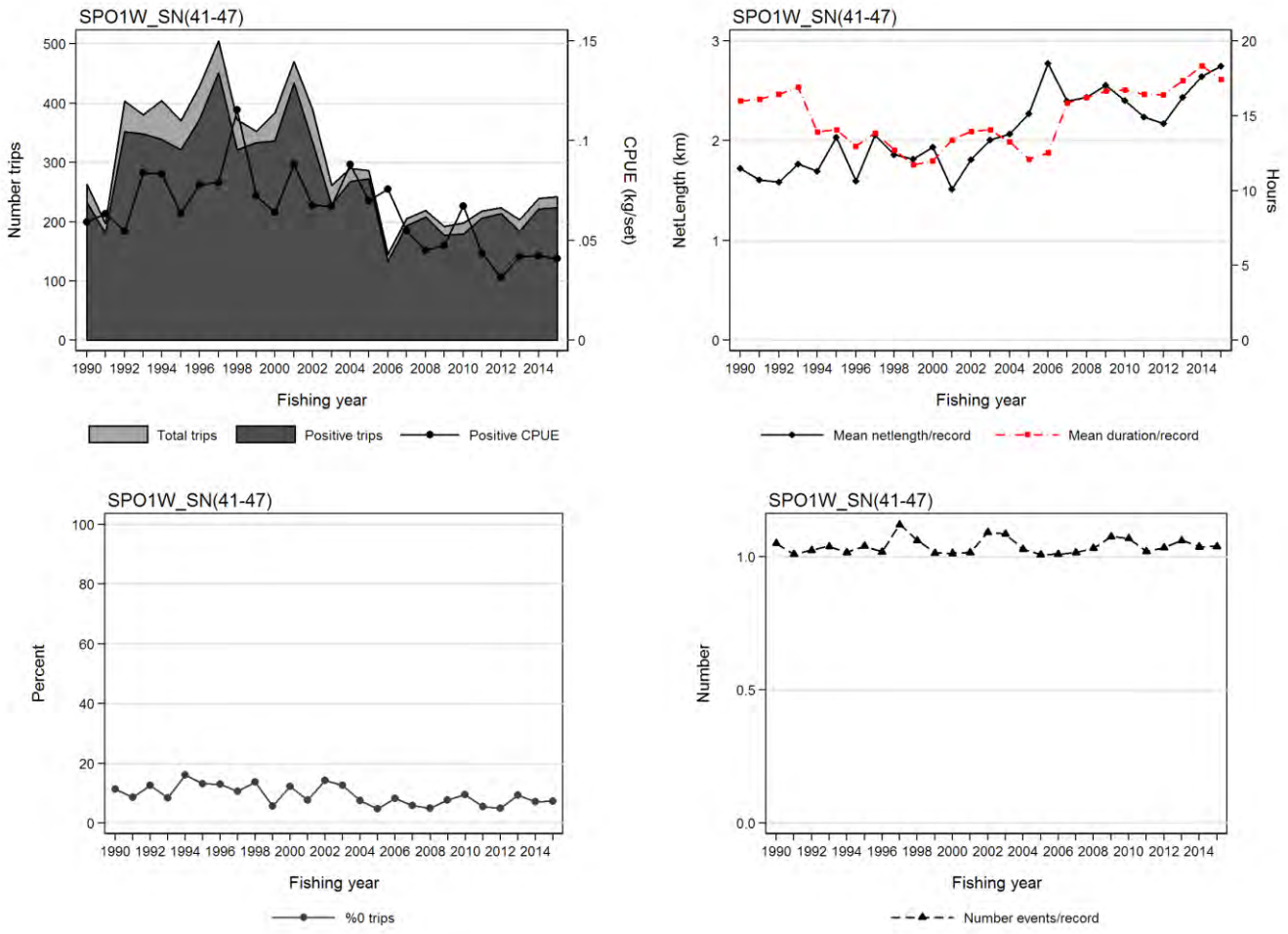

Figure S.2: Core vessel summary plots by fishing year for model SPO 1W_SN(041–047): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: percentage of trips with no catch of rig; [lower right panel]: mean number of events per stratum record.

S.7 Selection of positive catch distribution

SPO 1W_SN(041–047) is an existing analysis (see Table 13). The positive catch distribution was forced to lognormal for consistency with previous analyses.

S.8 Positive catch model selection table

Four explanatory variables (target species, vessel, month and net length) entered the model after fishing year (Table S.2), with the variables statistical area and duration non-significant. A plot of the model is provided in Figure S.3 and the CPUE indices are listed in Table S.3.

Table S.2: Order of acceptance of variables into the lognormal model of successful catches in the SPO 1W_SN(041–047) fishery model for core vessels (based on the vessel selection criteria of at least three trips in three 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	26	-15 181	30 416	3.96	*
target	28	-14 188	28 435	24.07	*
vessel	74	-12 965	26 081	43.33	*
month	85	-12 551	25 275	48.72	*
poly(log(netlength), 3)	88	-12 443	25 065	**50.05**	*
area	92	-12 429	25 044	50.22	
poly(log(duration), 3)	95	-12 415	25 022	50.39	

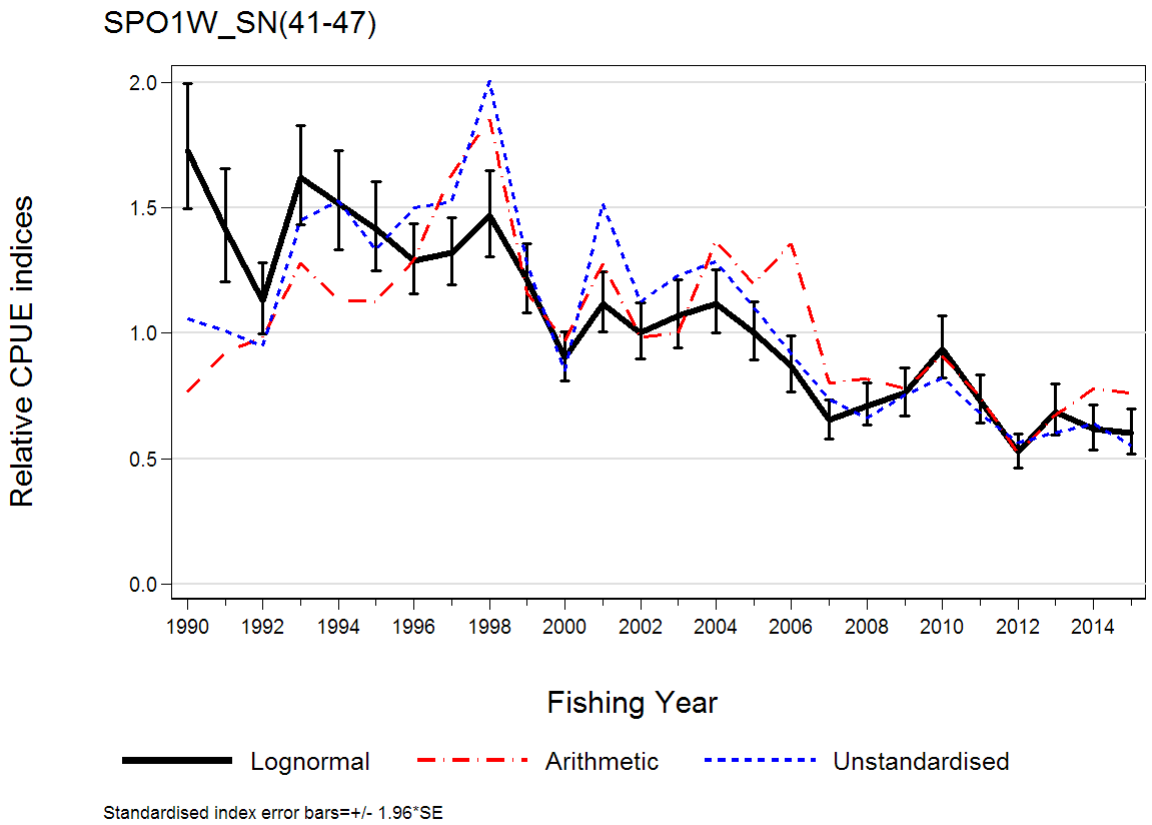

Figure S.3: Relative CPUE indices for rig using the lognormal non-zero model based on the SPO 1W_SN(041–047) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

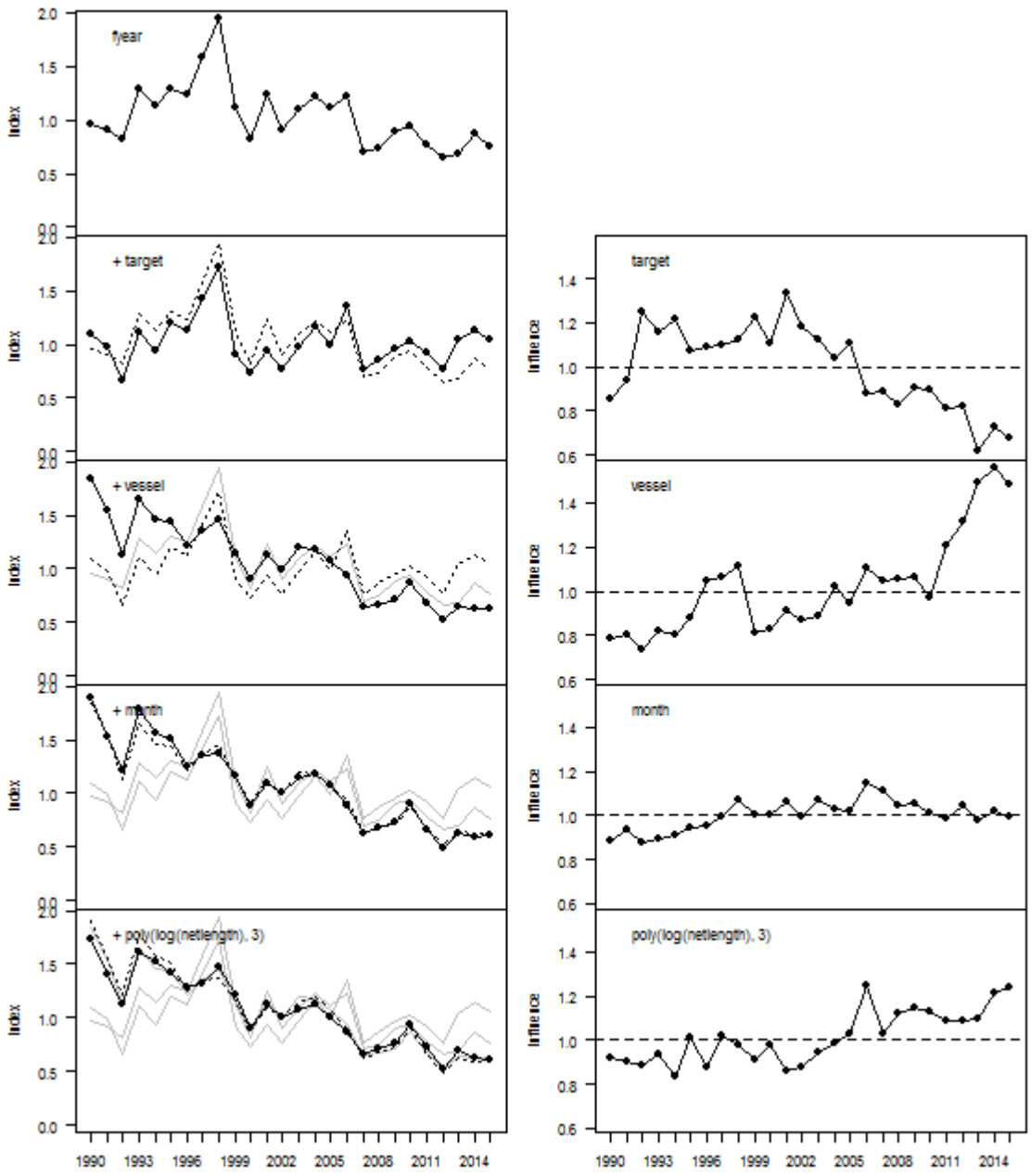

Figure S.4: **[left column]: annual indices from the lognormal model of SPO 1W_SN(041–047) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.**

S.9 Residual and diagnostic plots

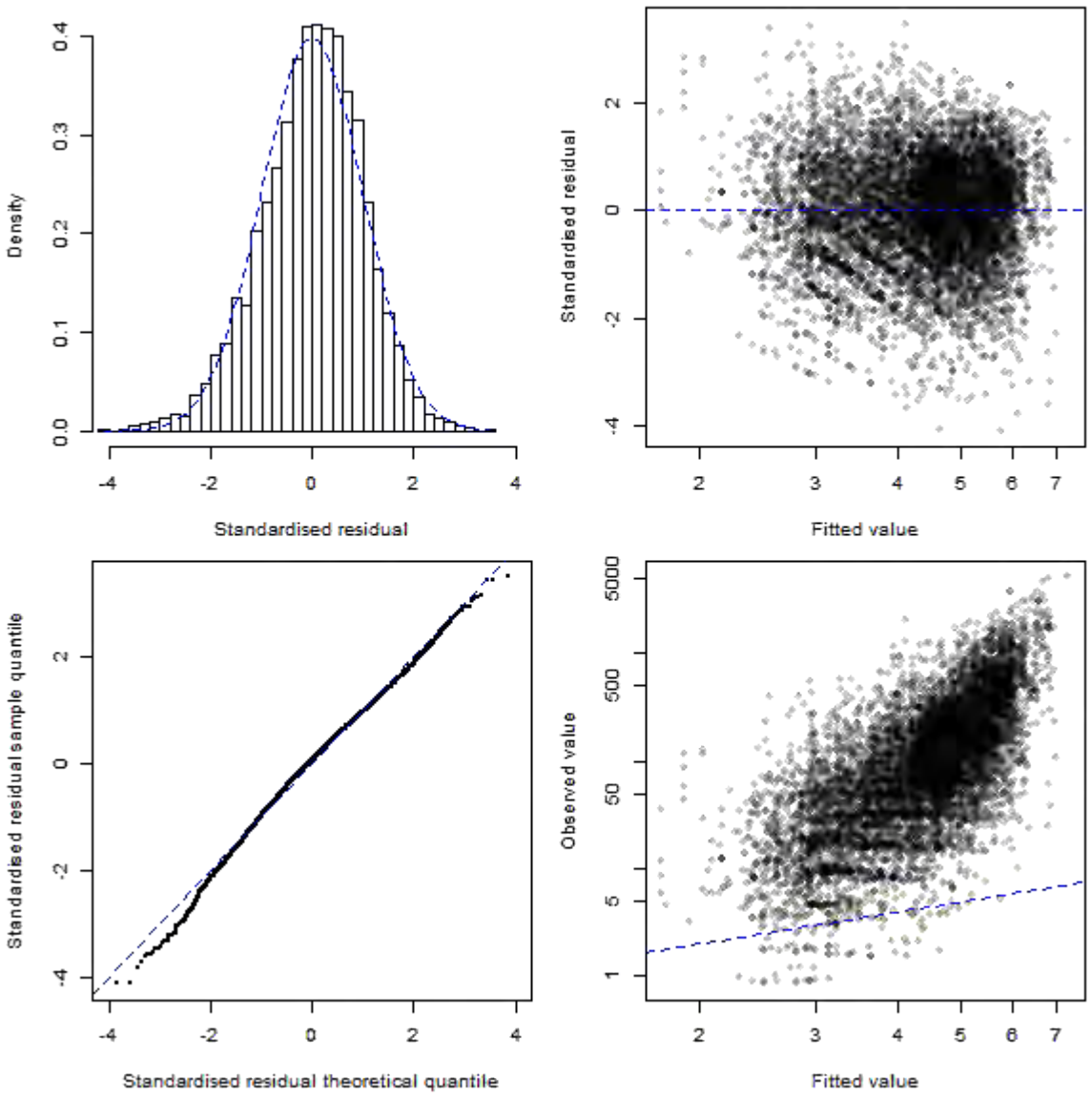

Figure S.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of rig in the SPO 1W_SN(041–047) fishery. [upper left panel]: histogram of the standardised residuals compared to a lognormal distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

S.10 Model coefficients

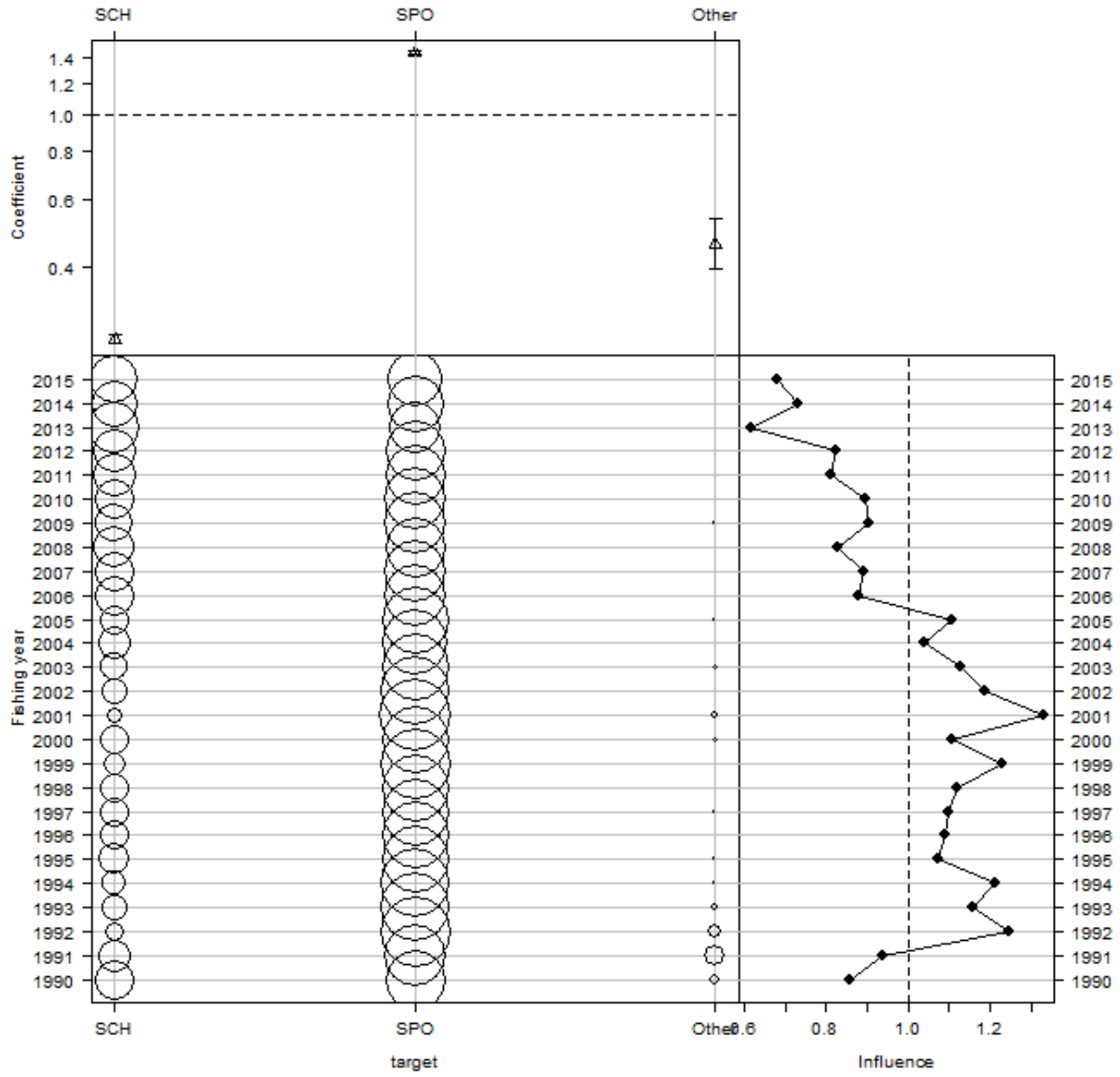

Figure S.6: Effect of target species in the lognormal model for the rig SPO 1W_SN(041–047) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

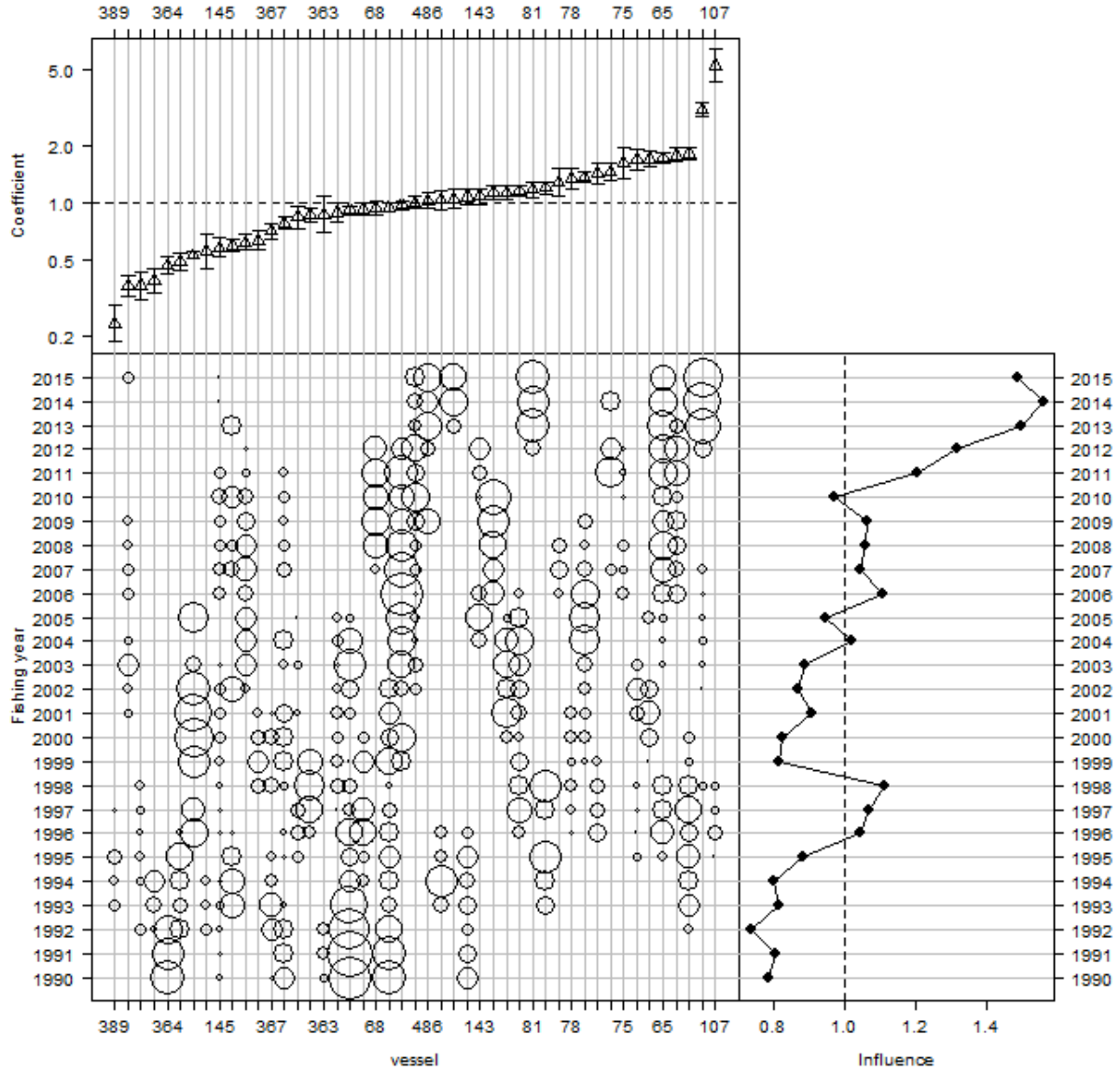

Figure S.7: Effect of vessel fished in the lognormal model for the rig SPO 1W_SN(041–047) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

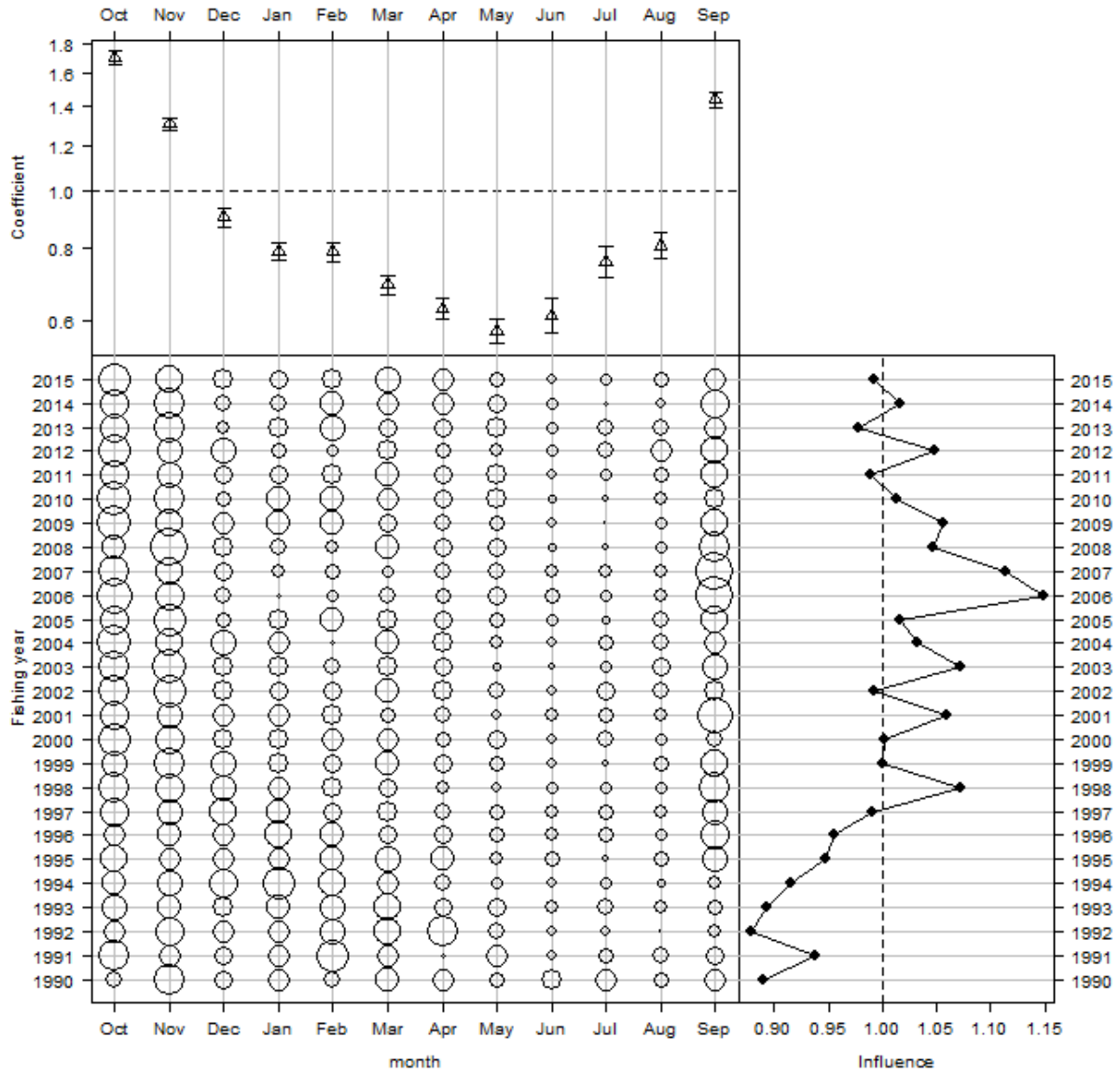

Figure S.8: Effect of month fished in the lognormal model for the rig SPO 1W_SN(041–047) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

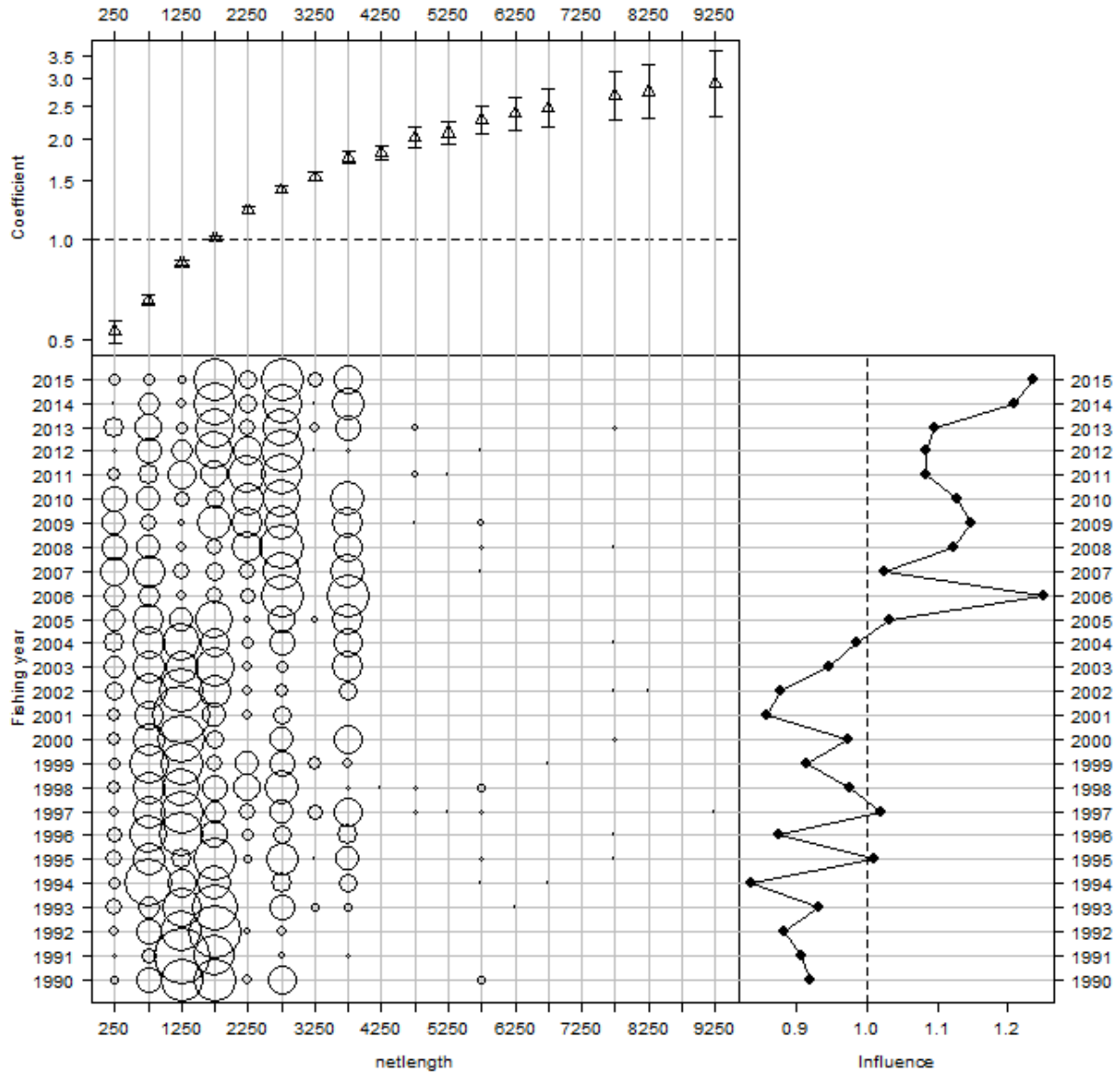

Figure S.9: Effect of length of net set in the lognormal model for the rig SPO 1W_SN(041–047) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

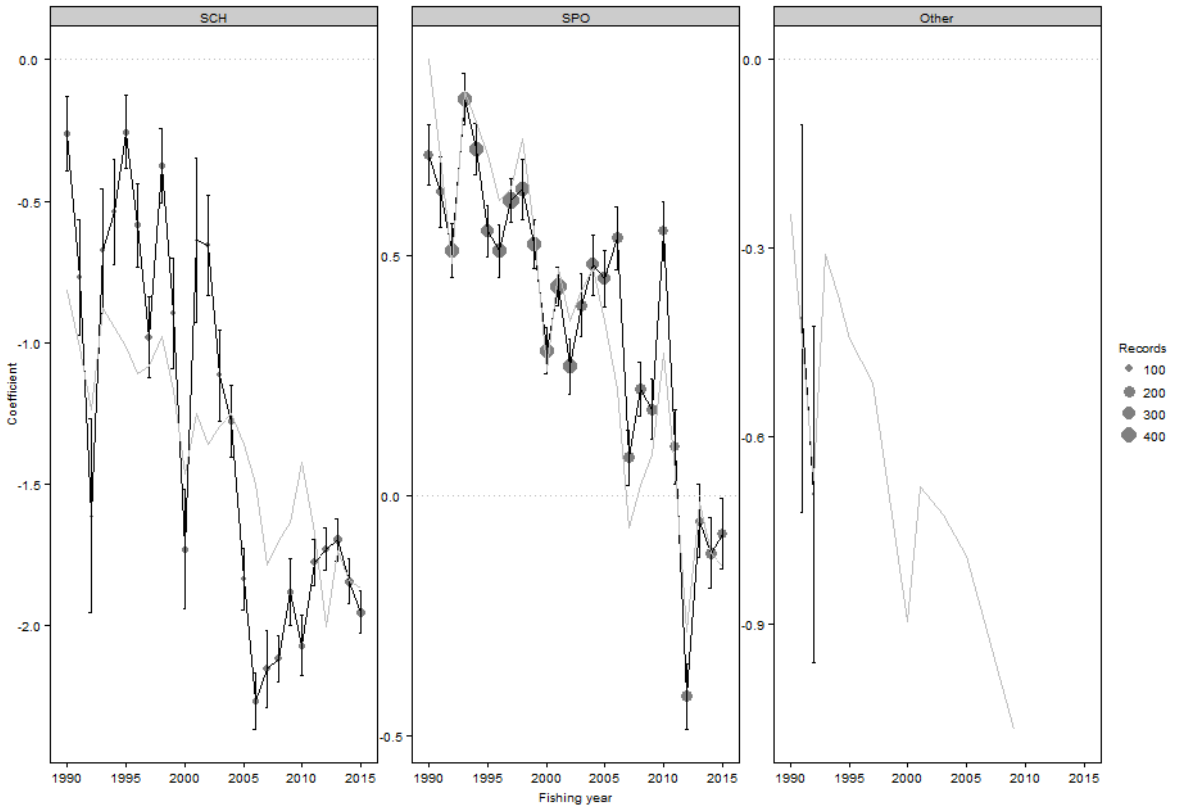

Figure S.10: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 1W_SN(041–047) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

S.11 CPUE indices

Table S.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 SPO 1W_SN(041–047) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.824	0.765	1.059	1.728	0.0733
1991	0.955	0.924	1.008	1.411	0.0811
1992	0.897	0.983	0.949	1.131	0.0638
1993	1.068	1.279	1.451	1.618	0.0620
1994	1.070	1.133	1.527	1.516	0.0664
1995	1.087	1.126	1.332	1.416	0.0636
1996	1.223	1.293	1.499	1.288	0.0553
1997	1.660	1.633	1.525	1.321	0.0514
1998	1.914	1.853	2.006	1.467	0.0595
1999	1.132	1.160	1.276	1.212	0.0579
2000	1.009	0.965	0.847	0.903	0.0544
2001	1.307	1.277	1.518	1.119	0.0548
2002	1.045	0.983	1.124	1.002	0.0572
2003	0.984	1.001	1.231	1.070	0.0645
2004	1.330	1.368	1.286	1.119	0.0577
2005	1.164	1.196	1.105	1.002	0.0587
2006	1.325	1.358	0.918	0.870	0.0648
2007	0.887	0.800	0.736	0.653	0.0607
2008	0.806	0.819	0.660	0.712	0.0601
2009	0.809	0.779	0.753	0.760	0.0647
2010	0.889	0.911	0.824	0.939	0.0669
2011	0.754	0.744	0.680	0.731	0.0664
2012	0.524	0.522	0.563	0.526	0.0656
2013	0.745	0.674	0.604	0.688	0.0756
2014	0.812	0.777	0.640	0.618	0.0733
2015	0.757	0.762	0.552	0.602	0.0749

Appendix T. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 3_SN(SHK)

T.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 3 by the SINSWG (MPI 2016), giving it a research rating of '1' (High Quality). A binomial model was not run because of the high proportion of success captures (Table T.1).

T.2 Fishery definition

SPO 3_SN(SHK): The fishery is defined from setnet fishing events that fished in Statistical Areas 018, 020, 022, 024–032 and declared target species SPO, SCH, SPD and ELE.

T.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least five trips in five years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 64 vessels, which took 84% of the catch (Figure T.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure T.1).

T.4 Data summary

Table T.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of five trips per year in five years) in the SPO 3_SN(SHK) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	27	583	756	867	1.15	1 637.74	12 698	84.83	66.6	62.3	5.9	5.3
1991	26	824	983	1 067	1.09	1 785.73	18 794	77.69	57.7	55.1	3.8	0.6
1992	28	1 041	1 181	1 274	1.08	2 174.92	23 839	98.24	70.7	68.2	7.3	1.8
1993	29	1 419	1 541	1 614	1.05	2 484.79	36 518	88.54	71.3	70.0	11.3	2.9
1994	35	1 916	2 065	2 260	1.09	3 716.39	47 611	152.57	77.6	76.4	16.6	3.9
1995	36	1 530	1 696	1 909	1.13	3 051.76	36 806	186.27	82.6	81.9	13.0	2.5
1996	36	1 354	1 541	1 754	1.14	3 015.67	34 825	186.29	78.3	76.0	13.7	8.1
1997	36	1 163	1 350	1 640	1.21	2 629.55	29 519	195.68	71.5	70.4	14.5	6.7
1998	33	890	1 033	1 097	1.06	1 857.46	16 325	199.18	84.7	82.9	12.2	4.2
1999	30	914	1 094	1 204	1.10	1 988.03	17 626	182.60	84.5	82.3	10.8	5.5
2000	32	900	1 040	1 183	1.14	1 988.95	17 565	201.95	85.3	84.7	7.7	0.7
2001	35	1 145	1 293	1 465	1.13	2 575.99	23 087	264.73	87.4	86.8	4.3	1.2
2002	29	1 002	1 109	1 249	1.13	2 165.15	20 884	236.93	89.4	89.2	9.0	0.9
2003	28	1 090	1 217	1 356	1.11	2 557.20	21 046	233.77	88.2	86.9	6.5	0.7
2004	26	977	1 135	1 262	1.11	2 323.14	18 141	212.90	88.1	87.0	7.7	0.5
2005	27	1 042	1 226	1 321	1.08	2 569.63	17 879	214.18	92.3	90.3	5.4	0.4
2006	25	1 161	1 350	1 487	1.10	2 643.72	21 095	226.89	84.2	84.6	8.5	1.3
2007	26	1 079	1 317	1 690	1.28	2 336.87	26 511	221.57	89.6	89.1	7.8	0.6
2008	25	1 084	1 406	1 880	1.34	2 752.73	31 372	279.16	87.1	87.1	11.3	0.8
2009	26	1 105	1 380	1 710	1.24	2 635.53	29 760	201.55	79.7	79.6	9.3	0.9
2010	23	1 080	1 354	1 836	1.36	2 658.67	35 070	211.47	81.2	80.0	8.8	1.1
2011	25	1 117	1 392	1 944	1.40	2 862.02	35 491	218.73	78.2	77.9	6.5	0.7
2012	23	1 010	1 269	1 848	1.46	2 754.95	32 289	196.64	80.7	80.9	6.0	0.8
2013	24	959	1 256	1 670	1.33	2 769.30	26 261	233.03	81.4	81.0	3.7	0.4
2014	23	997	1 363	1 831	1.34	2 932.79	28 858	226.41	75.2	75.4	4.8	0.8
2015	22	1 010	1 361	1 770	1.30	2 834.81	27 192	253.89	79.1	80.8	3.9	0.3

T.5 Core vessel selection

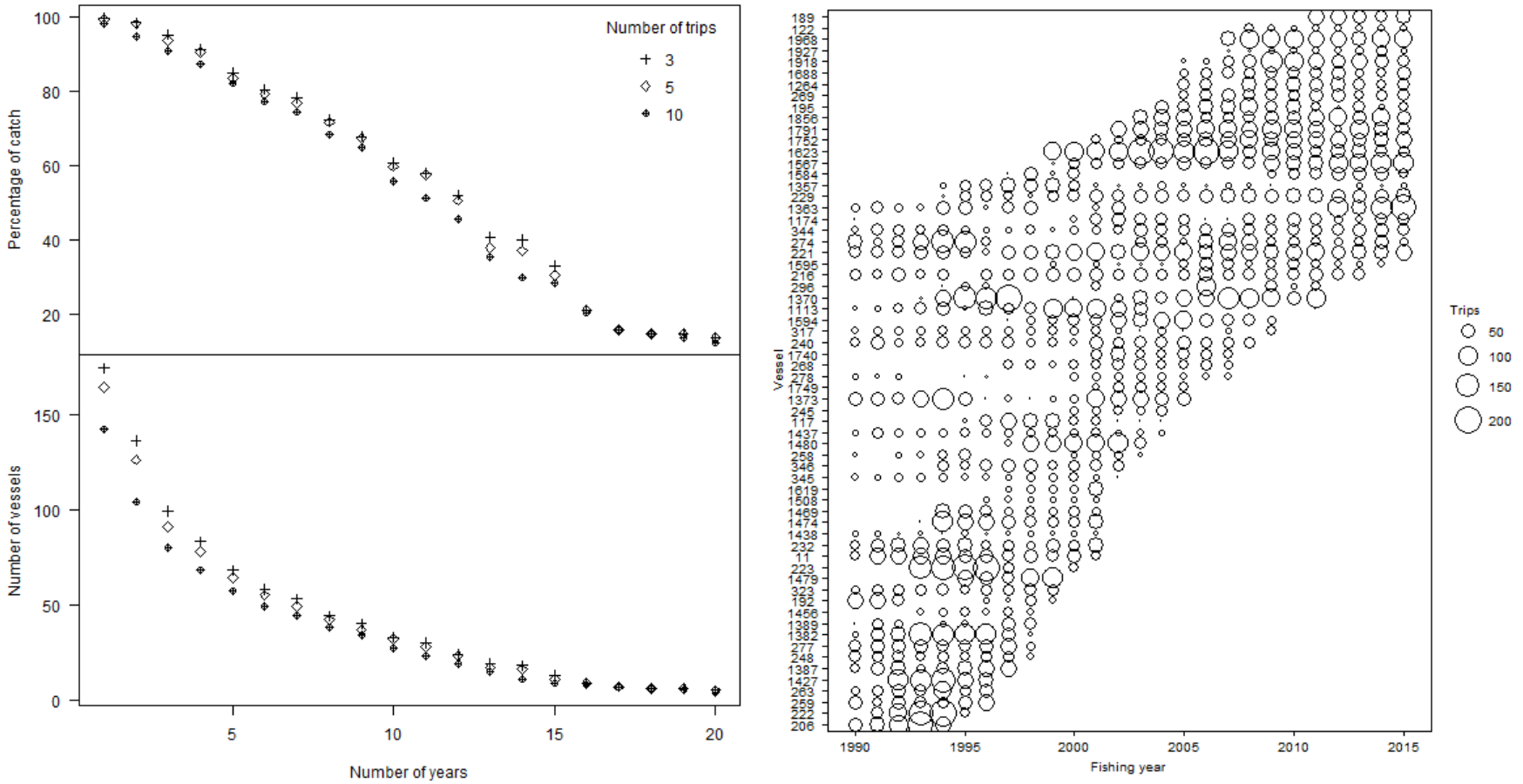

Figure T.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 3_SN(SHK) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least five trips in five or more fishing years) by fishing year.

T.6 Exploratory data plots for core vessel data set

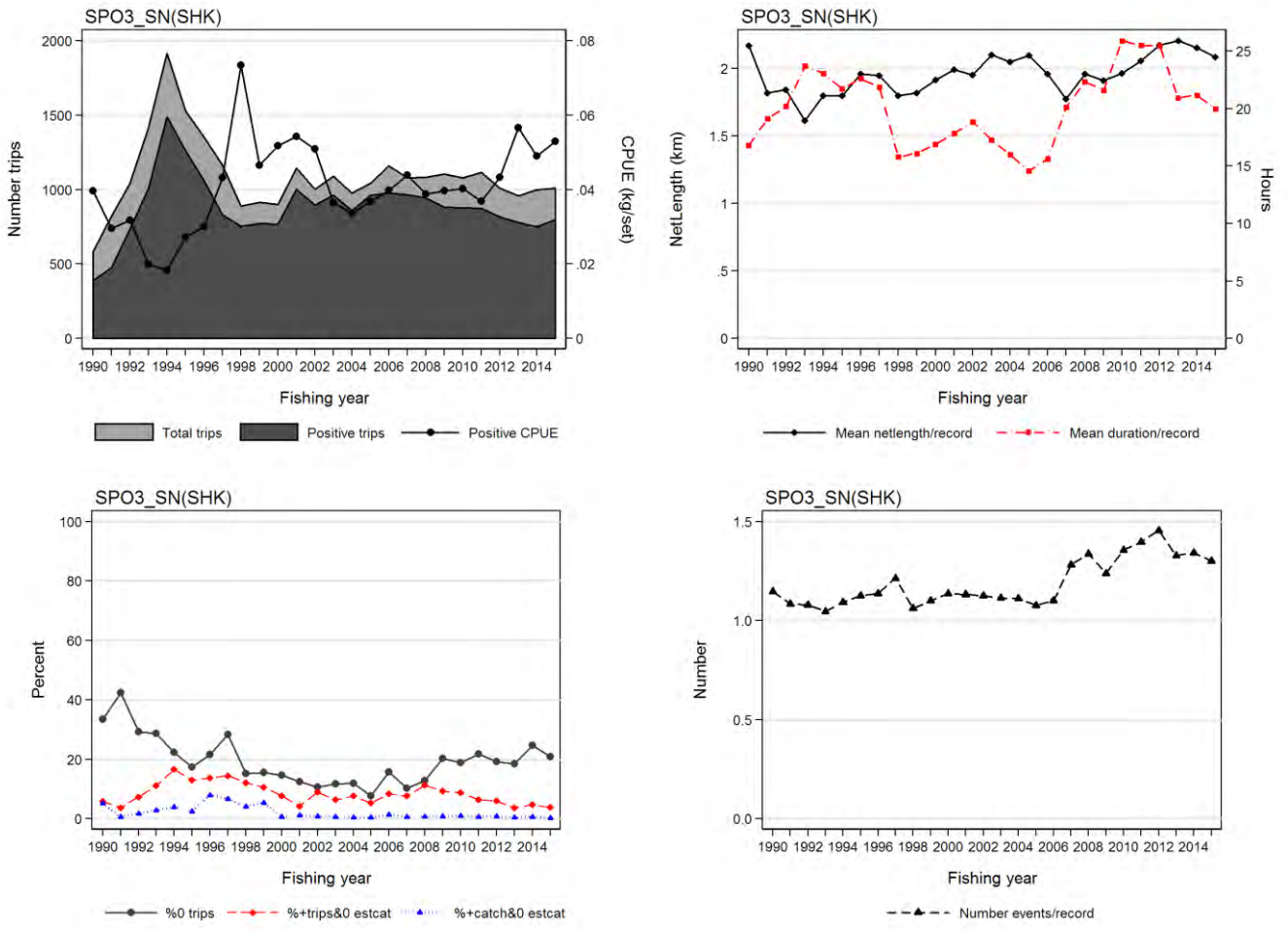

Figure T.2: Core vessel summary plots by fishing year for model SPO 3_SN(SHK): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.

T.7 Selection of positive catch distribution

SPO 3_SN(SHK) is an existing analysis (see Table 13). The positive catch distribution was forced to log-logistic for consistency with previous analyses.

T.8 Positive catch model selection table

Four explanatory variables (vessel, target species, month and net length) entered the model after fishing year (Table T.2), with the variables statistical area and duration non-significant. A plot of the model is provided in Figure T.3 and the CPUE indices are listed in Table T.3.

Table T.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 3_SN(SHK) fishery model for core vessels (based on the vessel selection criteria of at least five trips in five 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	-162 090	324 234	4.96	*
vessel	242	-158 150	316 784	29.13	*
target	245	-156 294	313 079	38.28	*
month	256	-155 096	310 705	43.54	*
poly(log(netlength), 3)	259	-154 842	310 202	**44.60**	*
area	269	-154 679	309 896	45.27	
poly(log(duration), 3)	272	-154 563	309 671	45.74	

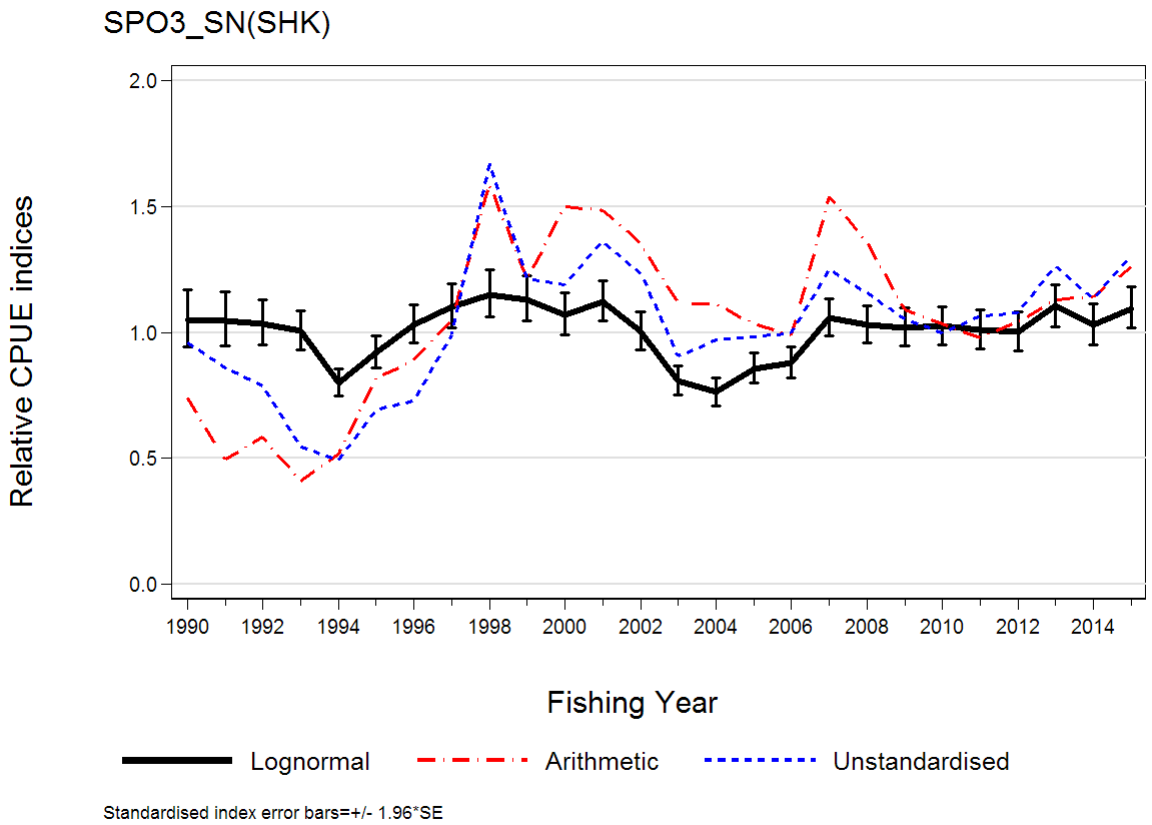

Figure T.3: Relative CPUE indices for rig using the log-logistic non-zero model based on the SPO 3_SN(SHK) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

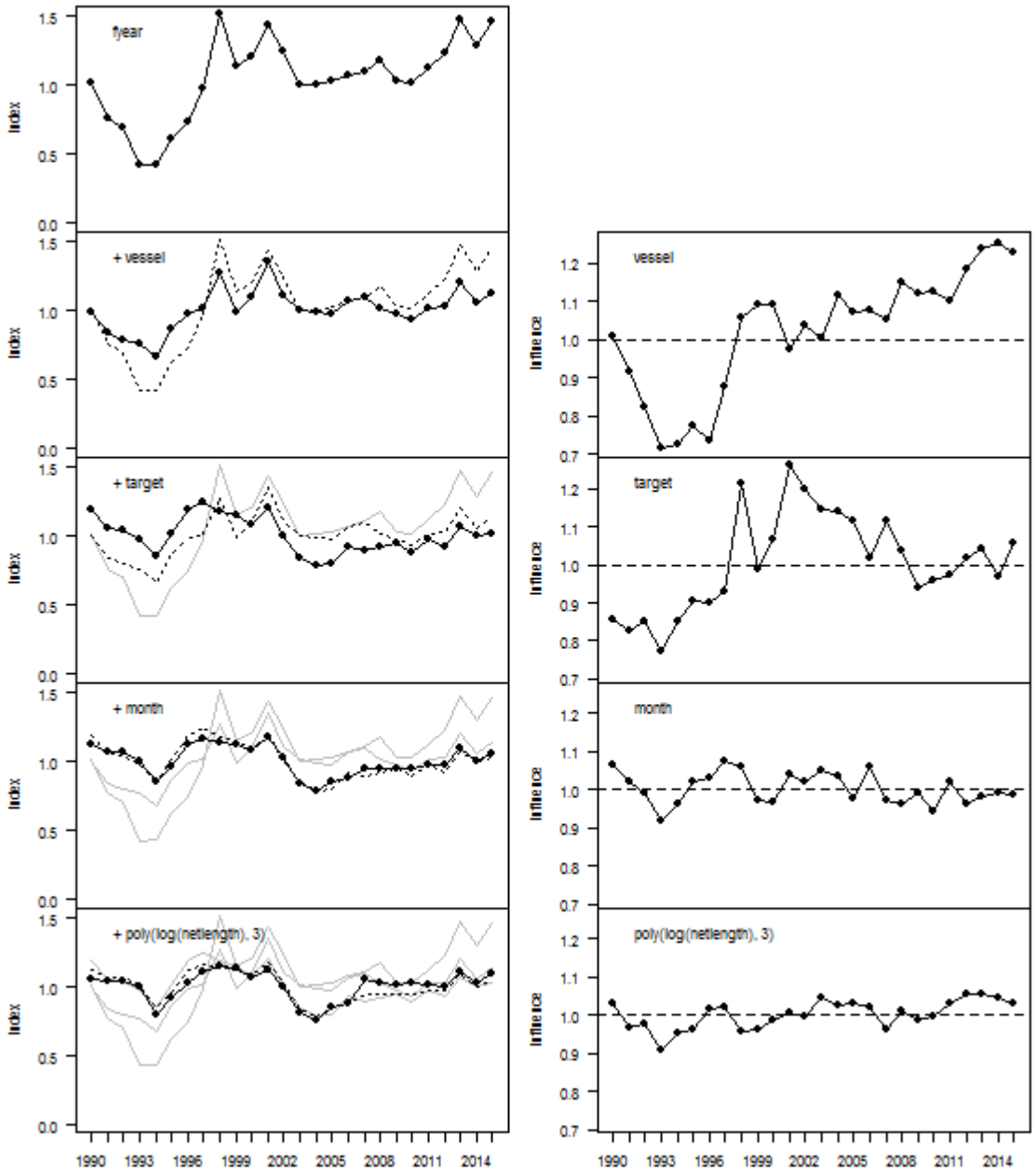

Figure T.4: [left column]: annual indices from the log-logistic model of SPO 3_SN(SHK) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

T.9 Residual and diagnostic plots

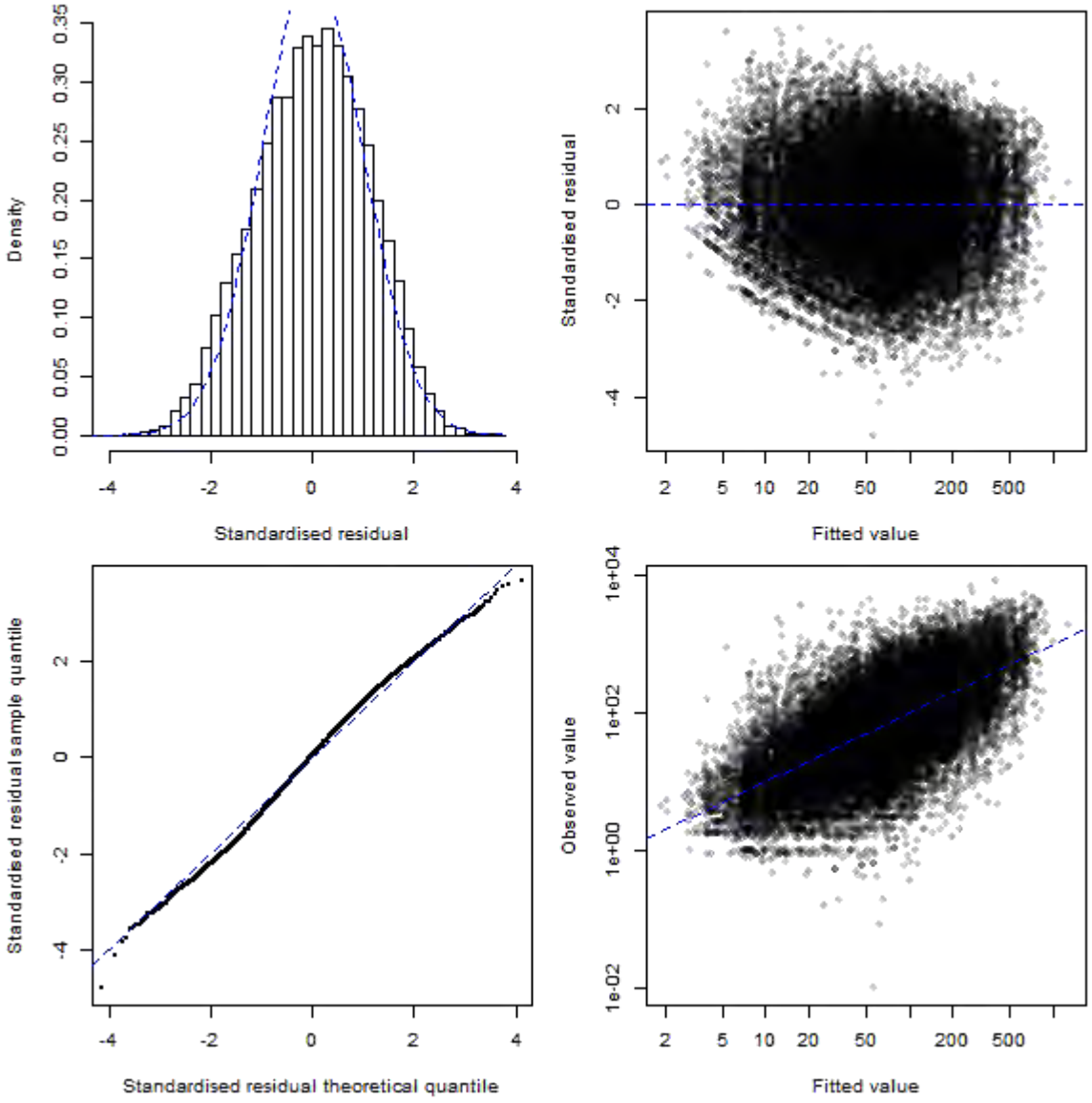

Figure T.5: Plots of the fit of the log-logistic standardised CPUE model of successful catches of rig in the SPO 3_SN(SHK) fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

T.10 Model coefficients

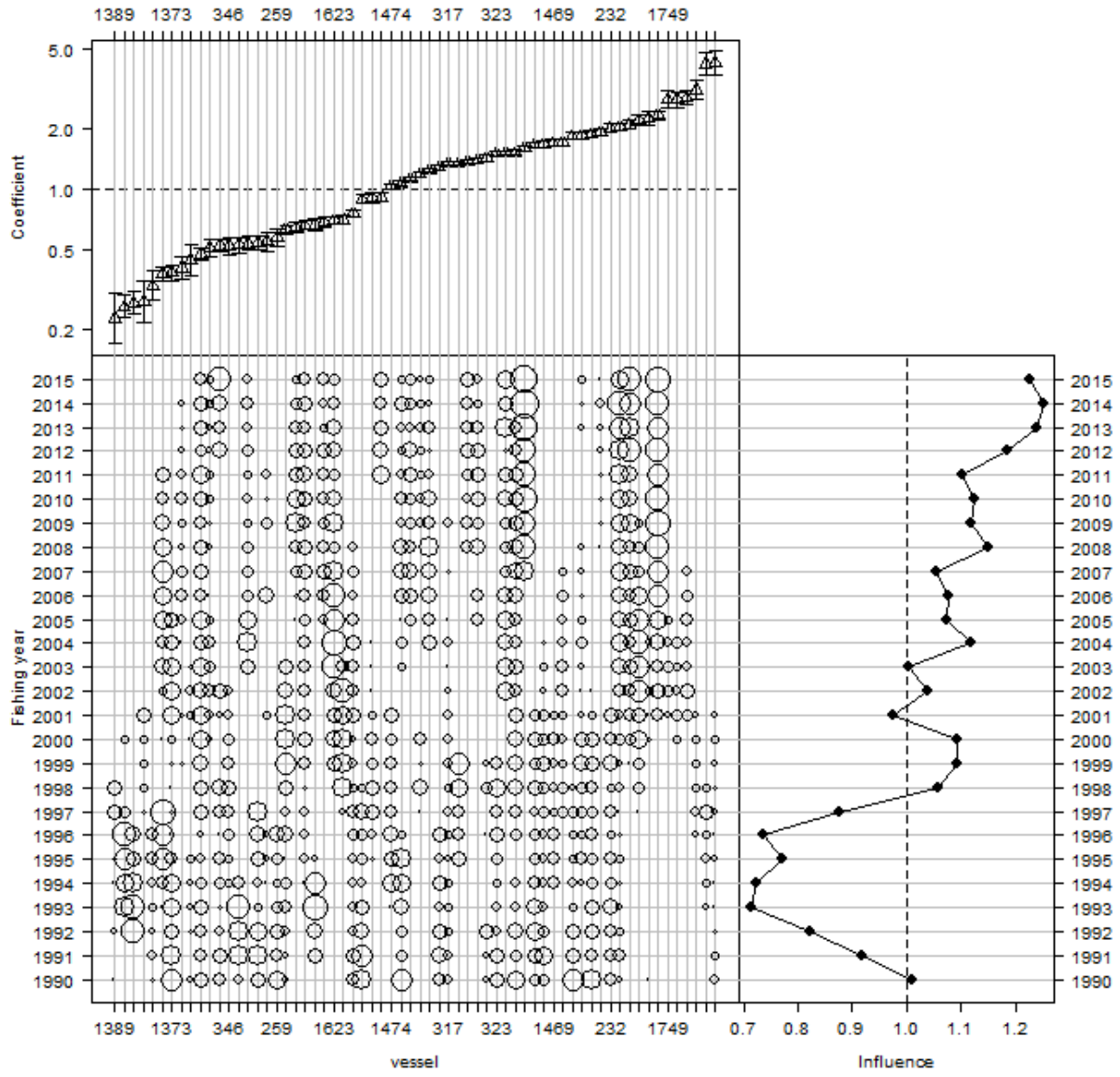

Figure T.6: Effect of vessel in the log-logistic model for the rig SPO 3_SN(SHK) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

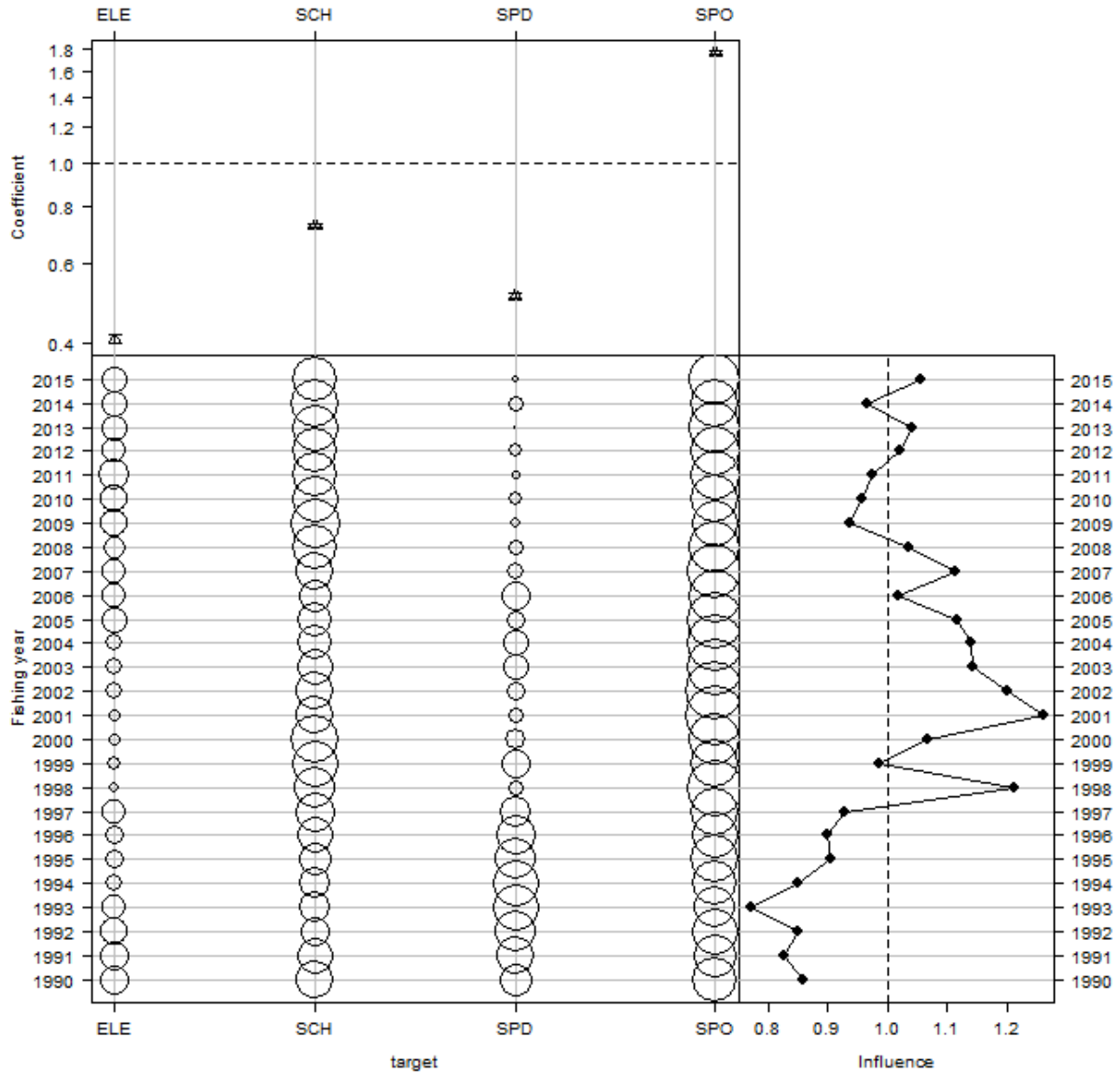

Figure T.7: Effect of target species fished in the log-logistic model for the rig SPO 3_SN(SHK) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

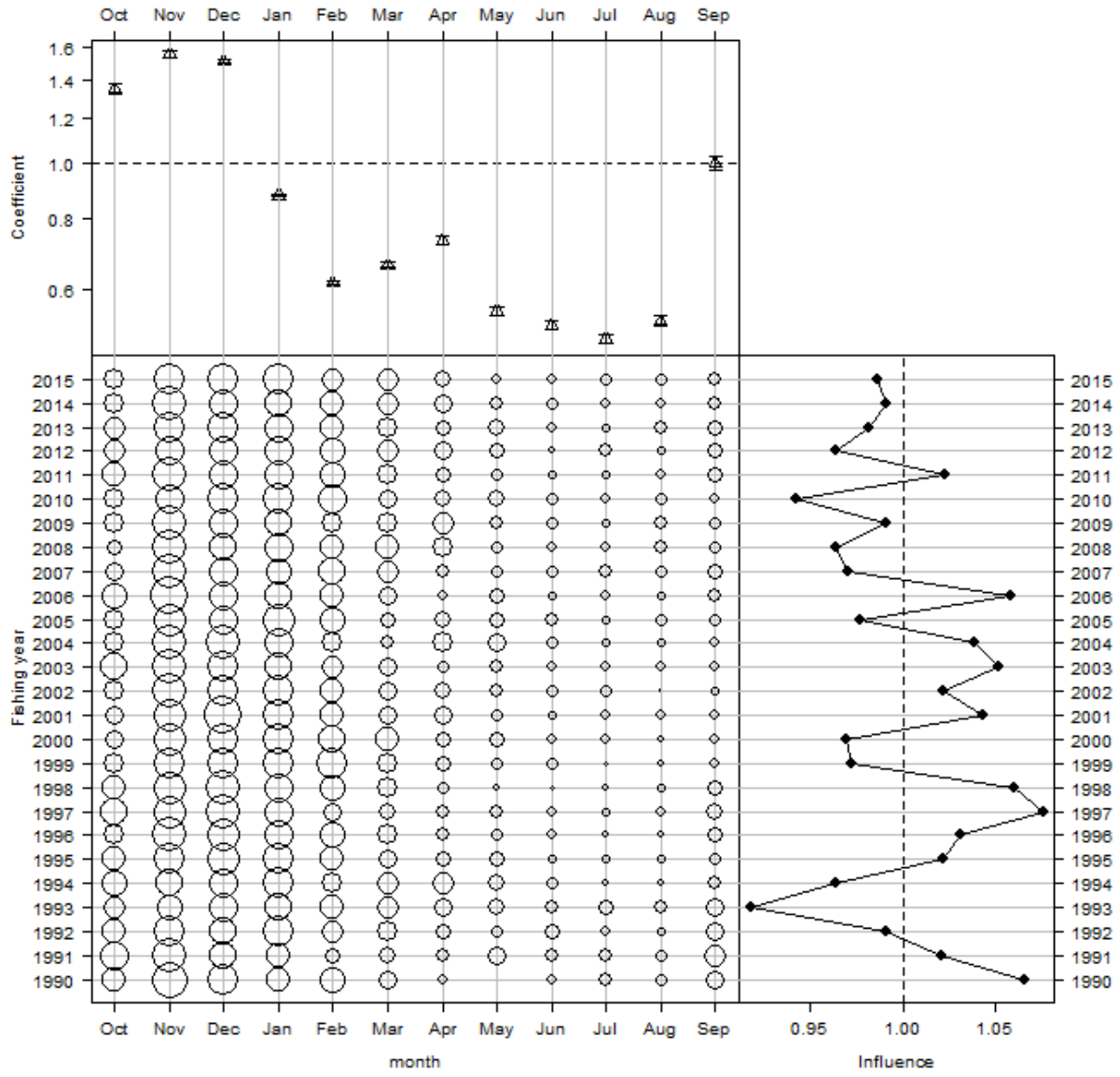

Figure T.8: Effect of month fished in the log-logistic model for the rig SPO 3_SN(SHK) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

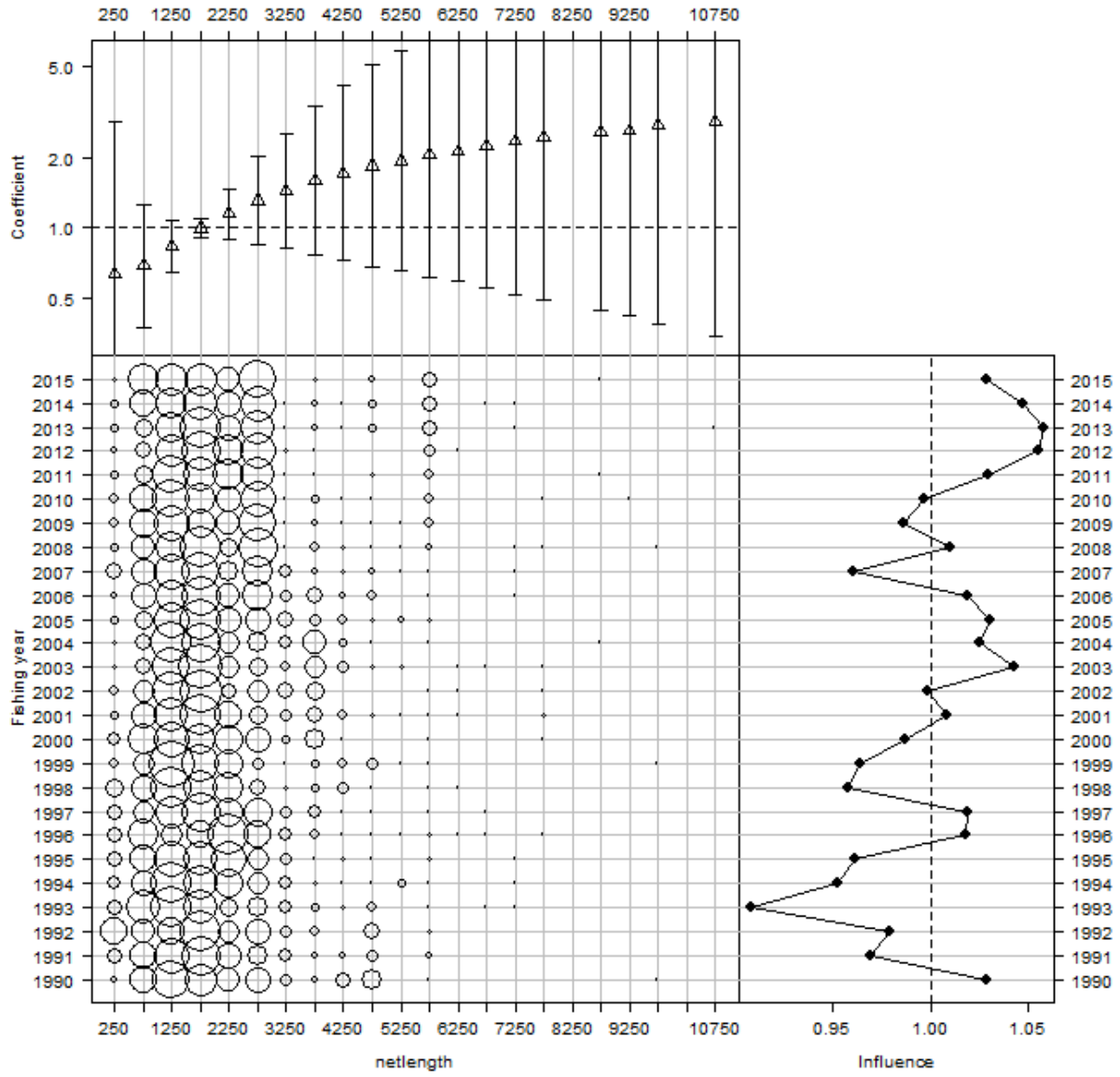

Figure T.9: Effect of length of net set in the log-logistic model for the rig SPO 3_SN(SHK) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

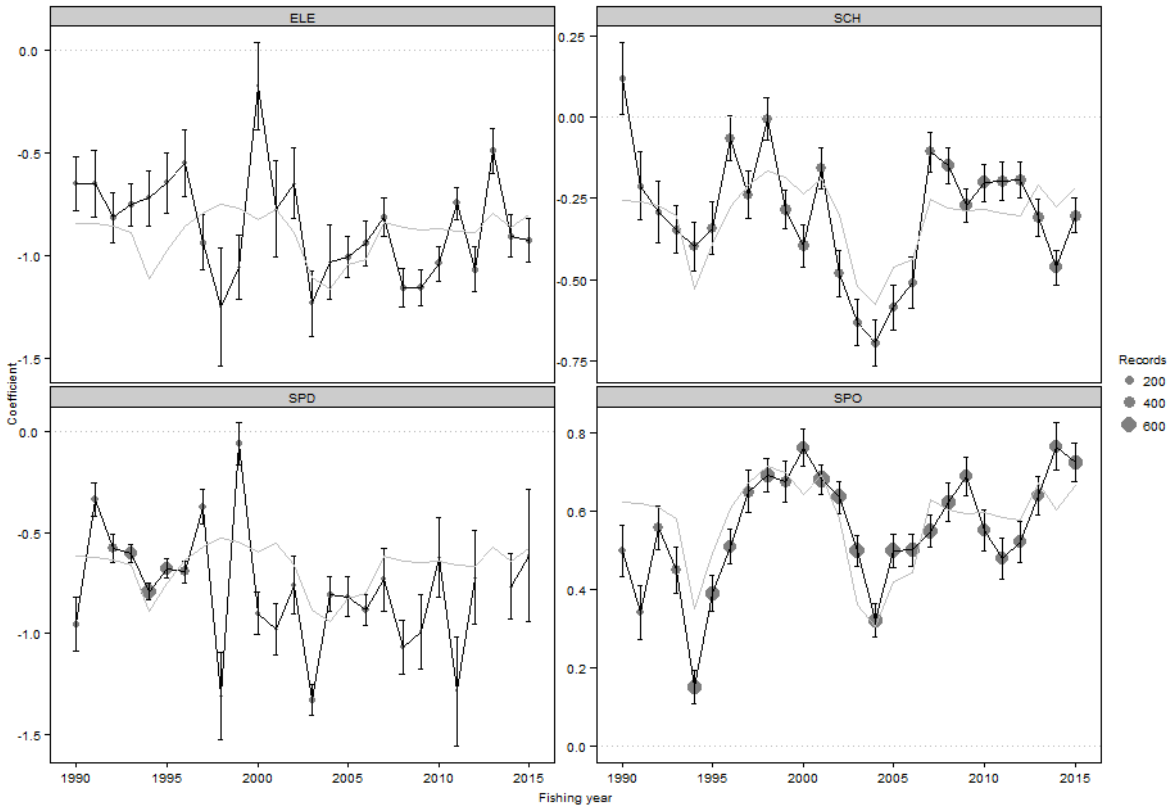

Figure T.10: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 3_SN(SHK) log-logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

T.11 CPUE indices

Table T.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 SPO 3_SN(SHK) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.786	0.738	0.960	1.051	0.0547
1991	0.527	0.496	0.859	1.047	0.0525
1992	0.657	0.583	0.788	1.036	0.0444
1993	0.464	0.410	0.545	1.005	0.0392
1994	0.501	0.517	0.493	0.799	0.0338
1995	0.740	0.818	0.691	0.920	0.0347
1996	0.872	0.889	0.728	1.032	0.0371
1997	1.025	1.050	0.992	1.102	0.0409
1998	1.473	1.589	1.670	1.151	0.0415
1999	1.174	1.212	1.215	1.132	0.0406
2000	1.441	1.501	1.190	1.071	0.0398
2001	1.239	1.486	1.361	1.124	0.0359
2002	1.280	1.356	1.237	1.005	0.0382
2003	0.961	1.116	0.905	0.808	0.0360
2004	1.028	1.112	0.970	0.763	0.0376
2005	1.450	1.035	0.982	0.856	0.0362
2006	1.002	0.989	0.999	0.878	0.0359
2007	2.096	1.542	1.251	1.056	0.0355
2008	1.384	1.357	1.158	1.029	0.0360
2009	1.025	1.091	1.054	1.019	0.0374
2010	0.972	1.033	1.000	1.025	0.0379
2011	0.915	0.980	1.065	1.009	0.0385
2012	1.157	1.041	1.078	1.002	0.0394
2013	1.077	1.131	1.264	1.104	0.0387
2014	1.061	1.141	1.134	1.029	0.0395
2015	1.204	1.262	1.304	1.096	0.0377

Appendix U. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 7_SN(038)

U.1 Introduction

This CPUE analysis was accepted in 2016 for monitoring SPO 7 by the SINSWG (MPI 2016) with a research rating of '1' (High Quality). A binomial model was not run because nearly every record successfully captured rig (Table U.1).

U.2 Fishery definition

SPO 7_SN(038): The fishery is defined from setnet fishing events that fished in Statistical Area 038 and declared target species SPO, SCH or SPD.

U.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least three trips in three years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 17 vessels, which took 96% of the catch (Figure U.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure U.1).

U.4 Data summary

Table U.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips and daily strata with catch for the core vessel data set (based on a minimum of three trips per year in three years) in the SPO 7_SN(038) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	6	59	88	88	1.00	141.33	1 343	61.43	91.5	90.9	0.0	0.0
1991	6	85	114	115	1.01	147.01	1 985	58.92	96.5	93.9	1.2	0.1
1992	7	112	159	159	1.00	254.91	2 432	87.90	93.8	86.2	2.9	1.1
1993	9	133	231	232	1.00	401.54	3 380	96.40	88.0	74.0	0.9	0.1
1994	10	183	341	347	1.02	668.43	4 743	104.84	84.7	66.3	2.6	0.4
1995	9	170	294	295	1.00	495.97	4 114	91.97	93.5	82.7	0.6	0.0
1996	11	99	161	161	1.00	281.31	2 175	68.99	90.9	85.1	2.2	0.6
1997	9	82	141	142	1.01	279.65	2 021	80.45	96.3	95.0	12.7	18.4
1998	7	114	178	179	1.01	477.38	2 572	112.36	95.6	94.9	0.9	1.7
1999	5	65	90	91	1.01	261.20	1 349	50.41	93.9	93.3	0.0	0.0
2000	6	79	167	169	1.01	320.30	2 312	38.97	94.9	92.2	0.0	0.0
2001	6	122	259	259	1.00	383.35	3 544	71.73	97.5	97.3	0.0	0.0
2002	6	98	249	255	1.02	403.14	3 731	59.37	100.0	94.4	0.0	0.0
2003	9	101	268	276	1.03	471.73	3 921	58.68	97.0	95.5	1.0	0.2
2004	8	107	305	305	1.00	526.93	4 196	81.09	99.1	99.3	0.9	0.0
2005	5	94	330	331	1.00	632.50	4 683	85.49	98.9	96.4	0.0	0.0
2006	5	75	268	274	1.02	539.10	3 895	87.14	96.0	95.5	1.4	0.0
2007	5	62	208	247	1.19	495.85	3 436	102.95	93.6	98.1	0.0	0.0
2008	5	59	183	229	1.25	486.47	2 987	89.58	96.6	98.4	0.0	0.0
2009	5	63	170	193	1.14	423.01	2 730	88.65	87.3	91.8	0.0	0.0
2010	5	63	163	180	1.10	399.75	2 593	84.98	88.9	91.4	0.0	0.0
2011	5	60	143	169	1.18	324.20	2 385	93.22	83.3	88.8	0.0	0.0
2012	5	55	136	167	1.23	369.91	2 313	86.65	92.7	95.6	0.0	0.0
2013	4	51	135	168	1.24	371.21	2 507	75.04	98.0	97.0	0.0	0.0
2014	4	47	121	145	1.20	294.64	2 058	73.63	89.4	89.3	0.0	0.0
2015	4	55	150	195	1.30	411.30	2 666	73.61	90.9	94.0	0.0	0.0

U.5 Core vessel selection

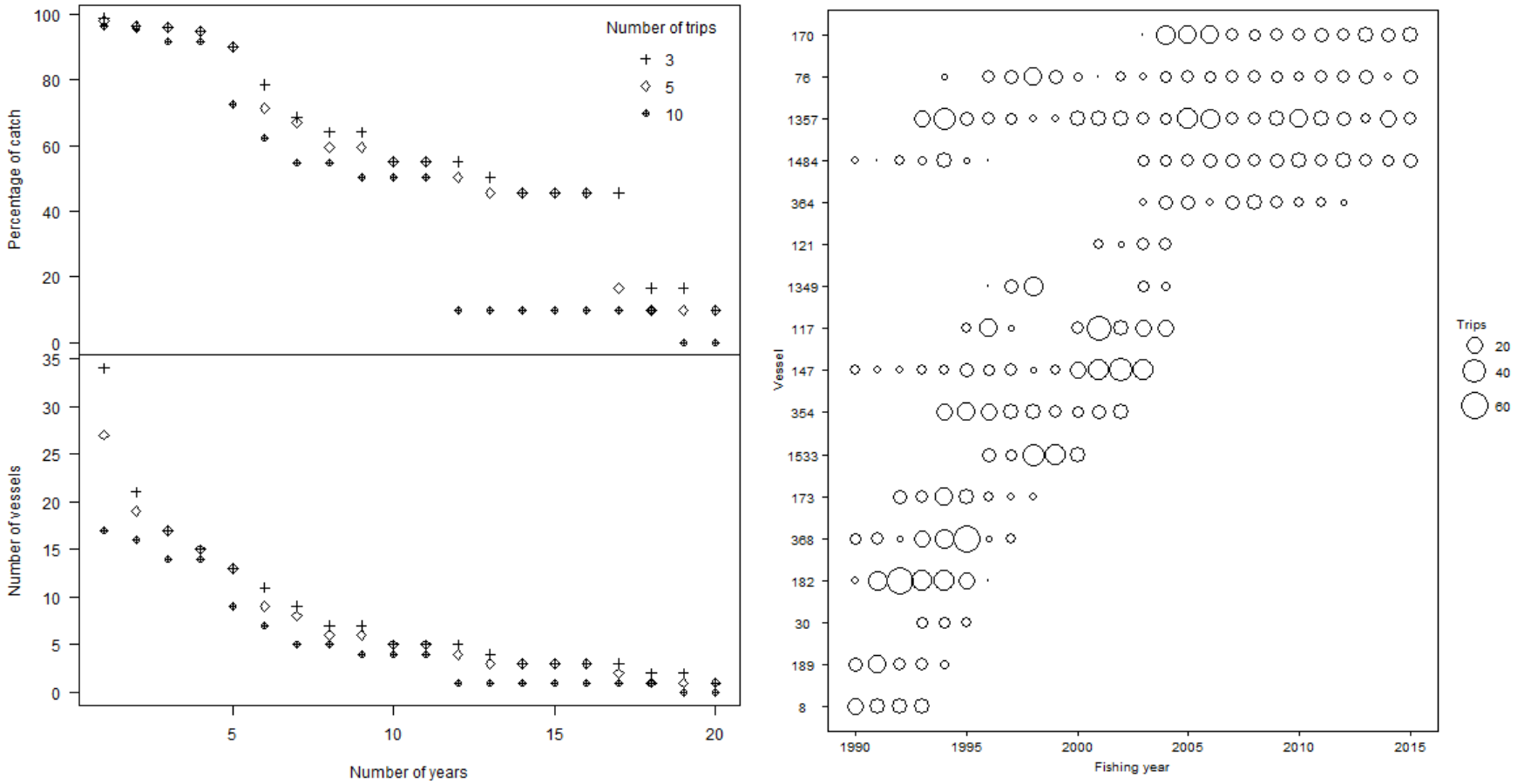

Figure U.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 7_SN(038) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least three trips in three or more fishing years) by fishing year.

U.6 Exploratory data plots for core vessel data set

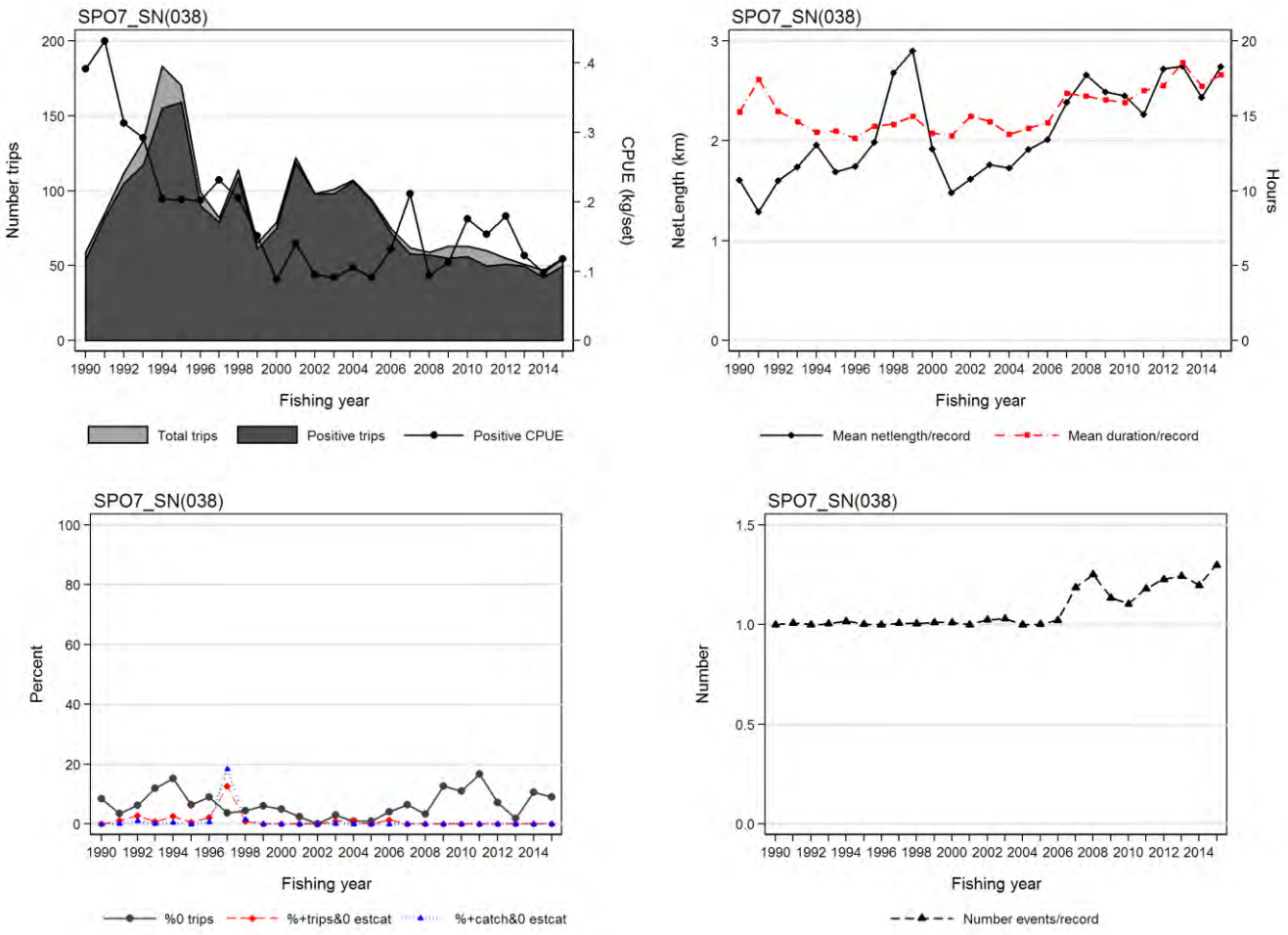

Figure U.2: Core vessel summary plots by fishing year for model SPO 7_SN(038): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.

U.7 Selection of positive catch distribution

SPO 7_SN(038) is an existing analysis (see Table 13). The positive catch distribution was forced to log-logistic for consistency with previous analyses.

U.8 Positive catch model selection table

Four explanatory variables (vessel, month, target species and net length) entered the model after fishing year (Table U.2), with the variable duration non-significant. A plot of the model is provided in Figure U.3 and the CPUE indices are listed in Table U.3.

Table U.2: Order of acceptance of variables into the log-logistic model of successful catches in the SPO 7_SN(038) fishery model for core vessels (based on the vessel selection criteria of at least three trips in three 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	-31 956	63 965	7.48	*
vessel	83	-31 453	63 072	25.77	*
month	94	-31 138	62 464	35.35	*
target	96	-30 964	62 119	40.10	*
poly(log(netlength), 3)	99	-30 879	61 955	**42.29**	*
poly(log(duration), 3)	102	-30 873	61 950	42.44	

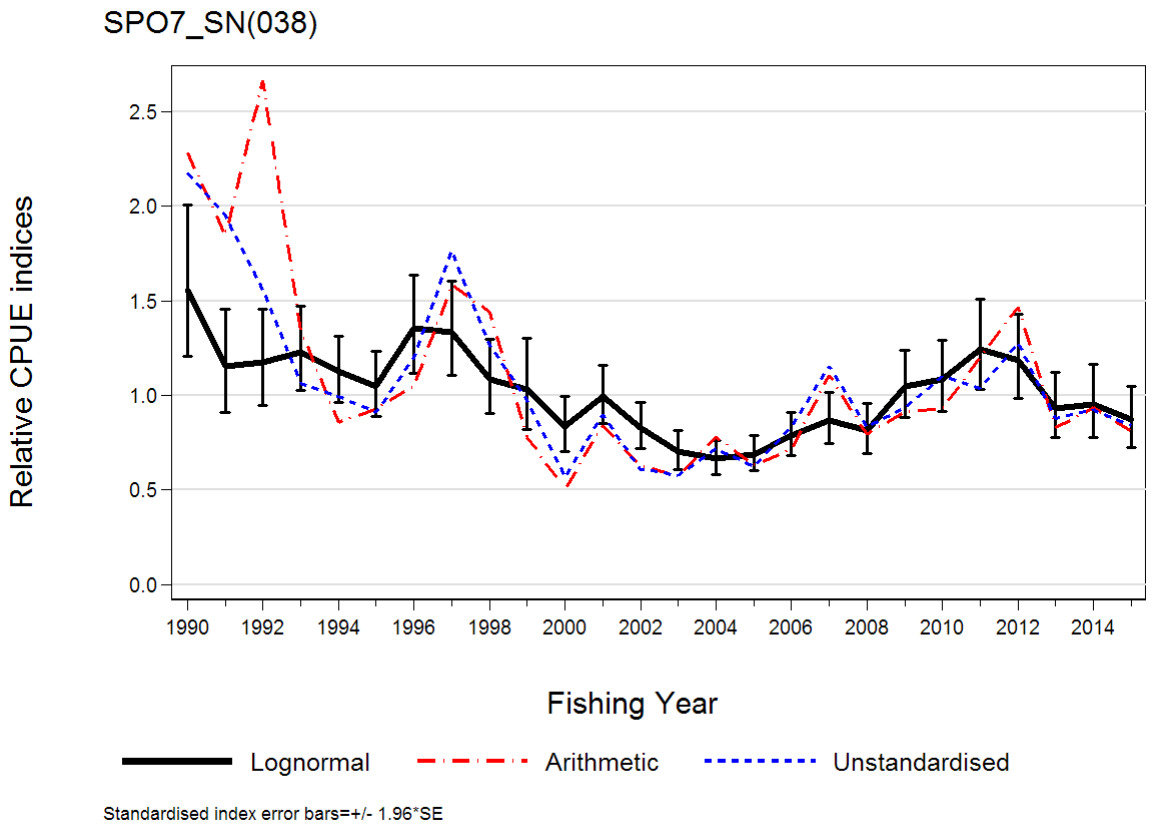

Figure U.3: Relative CPUE indices for rig using the log-logistic non-zero model based on the SPO 7_SN(038) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

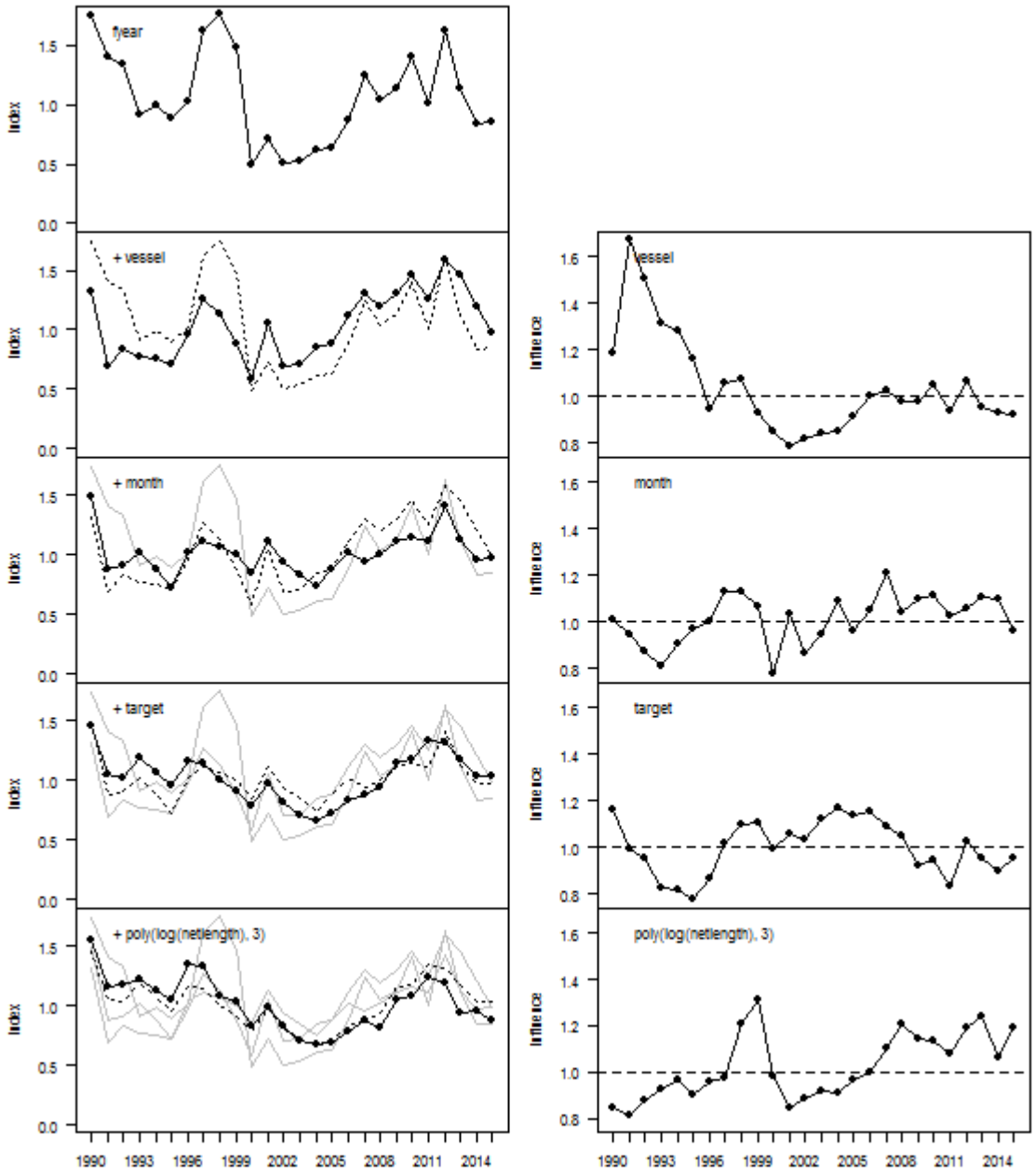

Figure U.4: [left column]: annual indices from the log-logistic model of SPO 7_SN(038) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

U.9 Residual and diagnostic plots

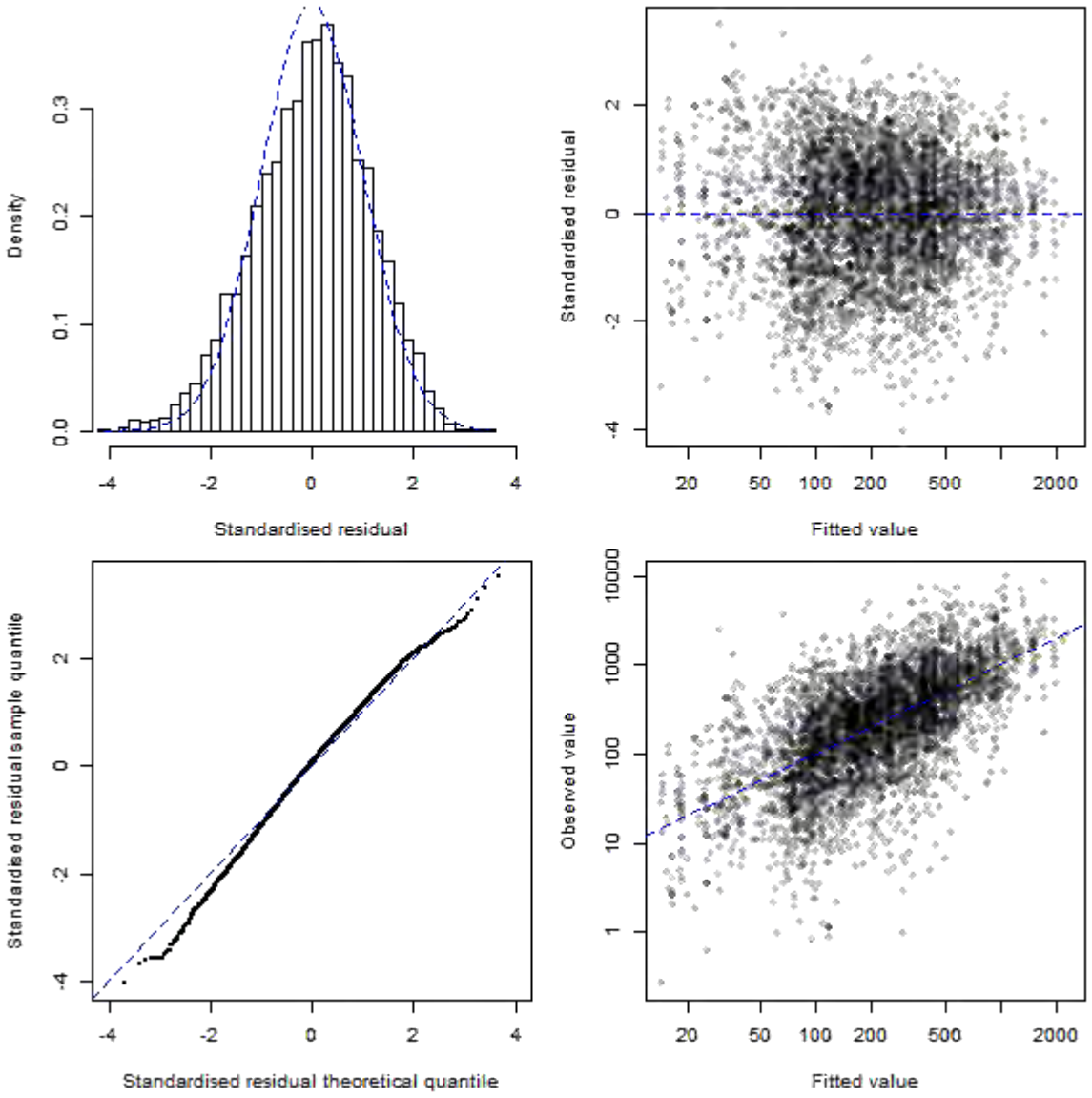

Figure U.5: Plots of the fit of the log-logistic standardised CPUE model of successful catches of rig in the SPO 7_SN(038) fishery. [upper left panel]: histogram of the standardised residuals compared to a log-logistic distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

U.10 Model coefficients

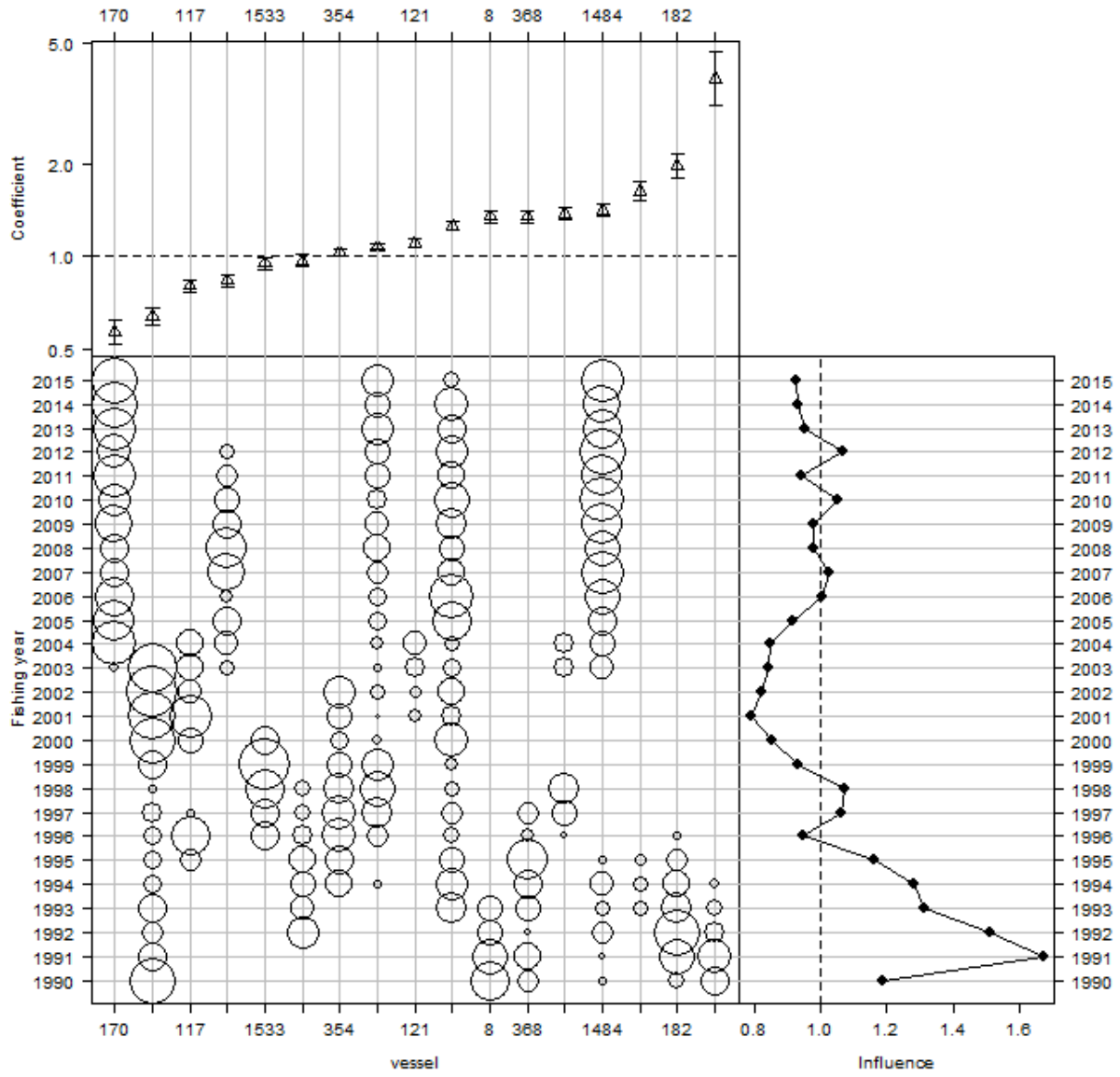

Figure U.6: Effect of vessel fished in the log-logistic model for the rig SPO 7_SN(038) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

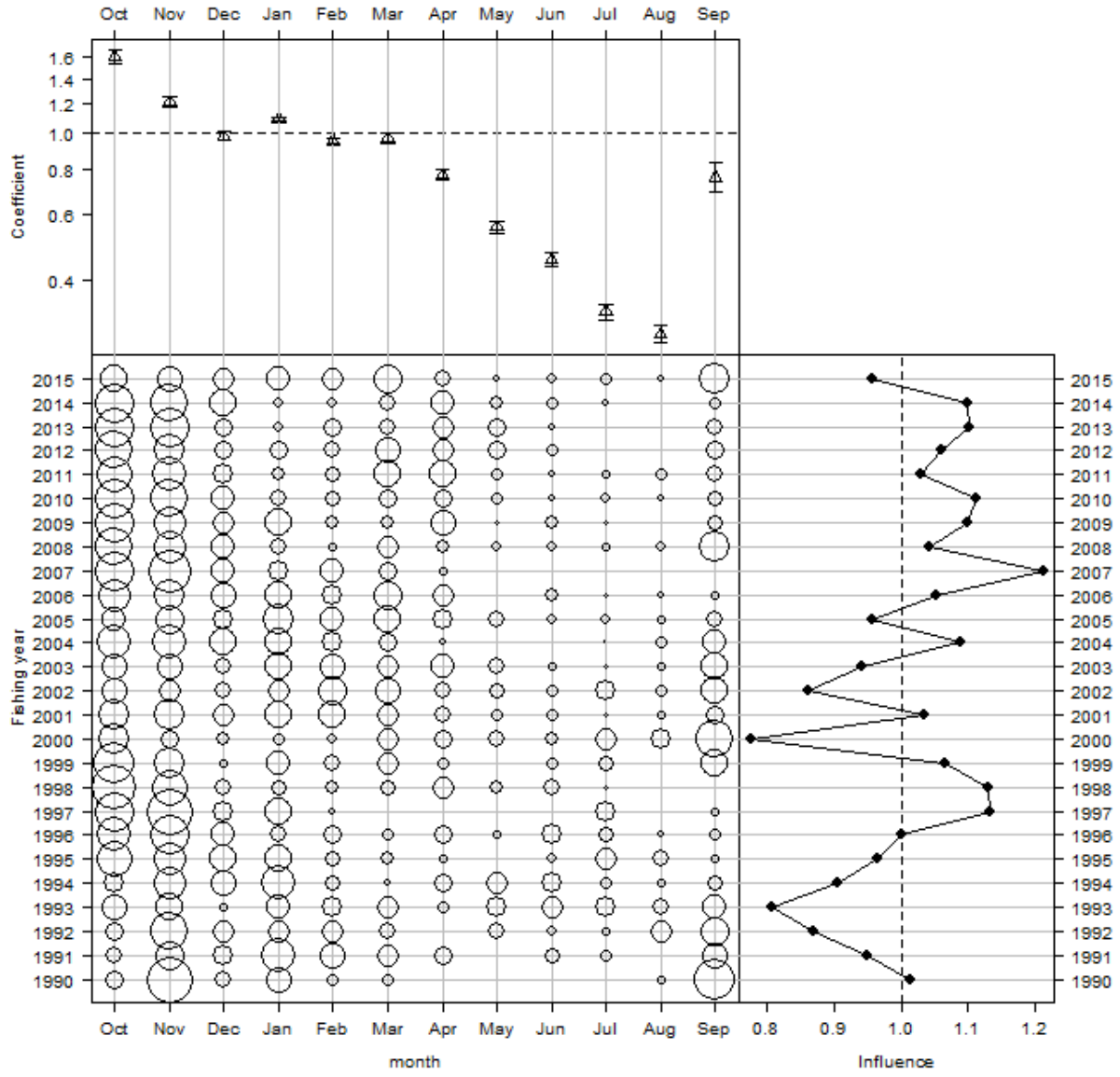

Figure U.7: Effect of month in the log-logistic model for the rig SPO 7_SN(038) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

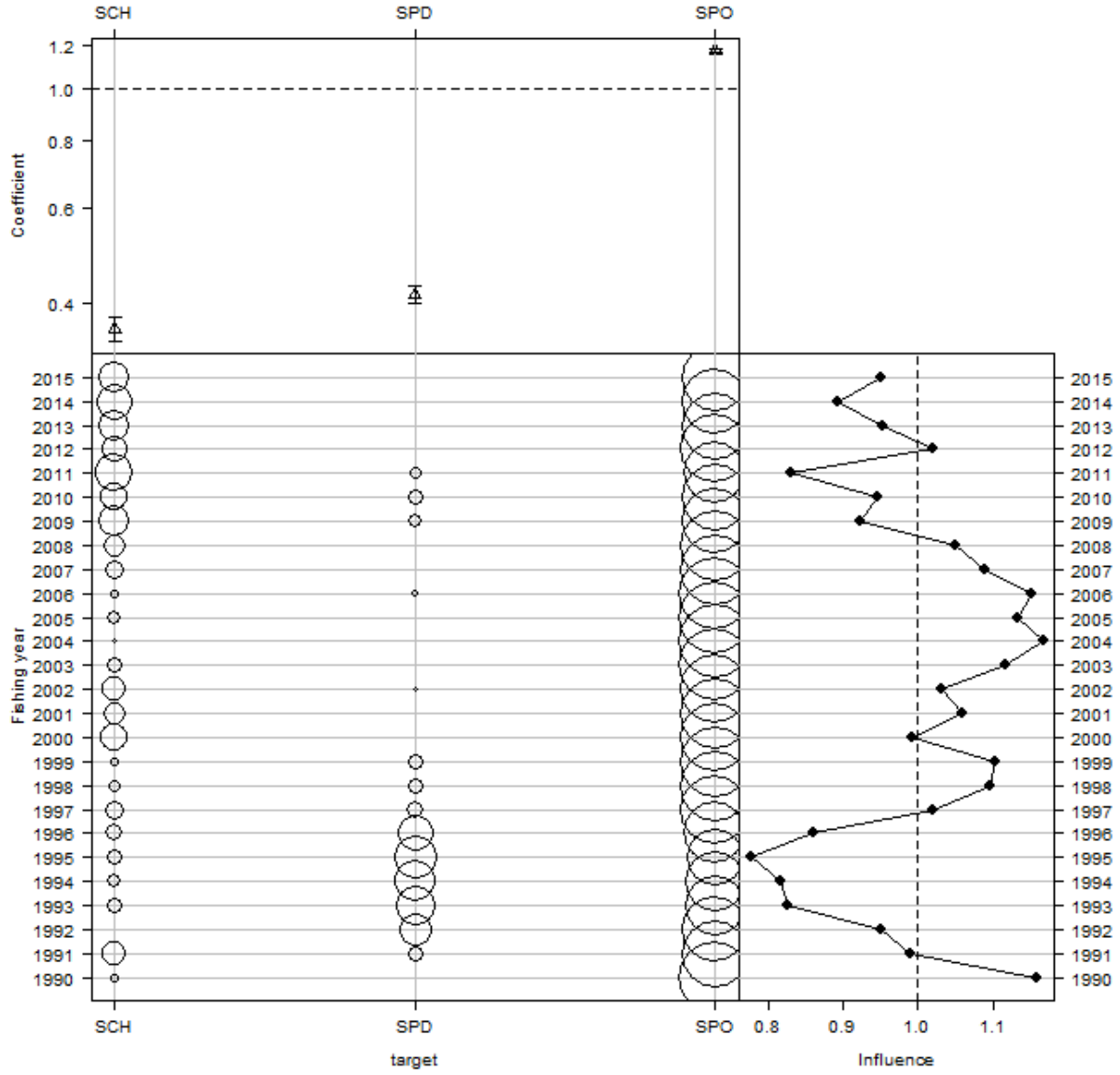

Figure U.8: Effect of target species in the log-logistic model for the rig SPO 7_SN(038) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

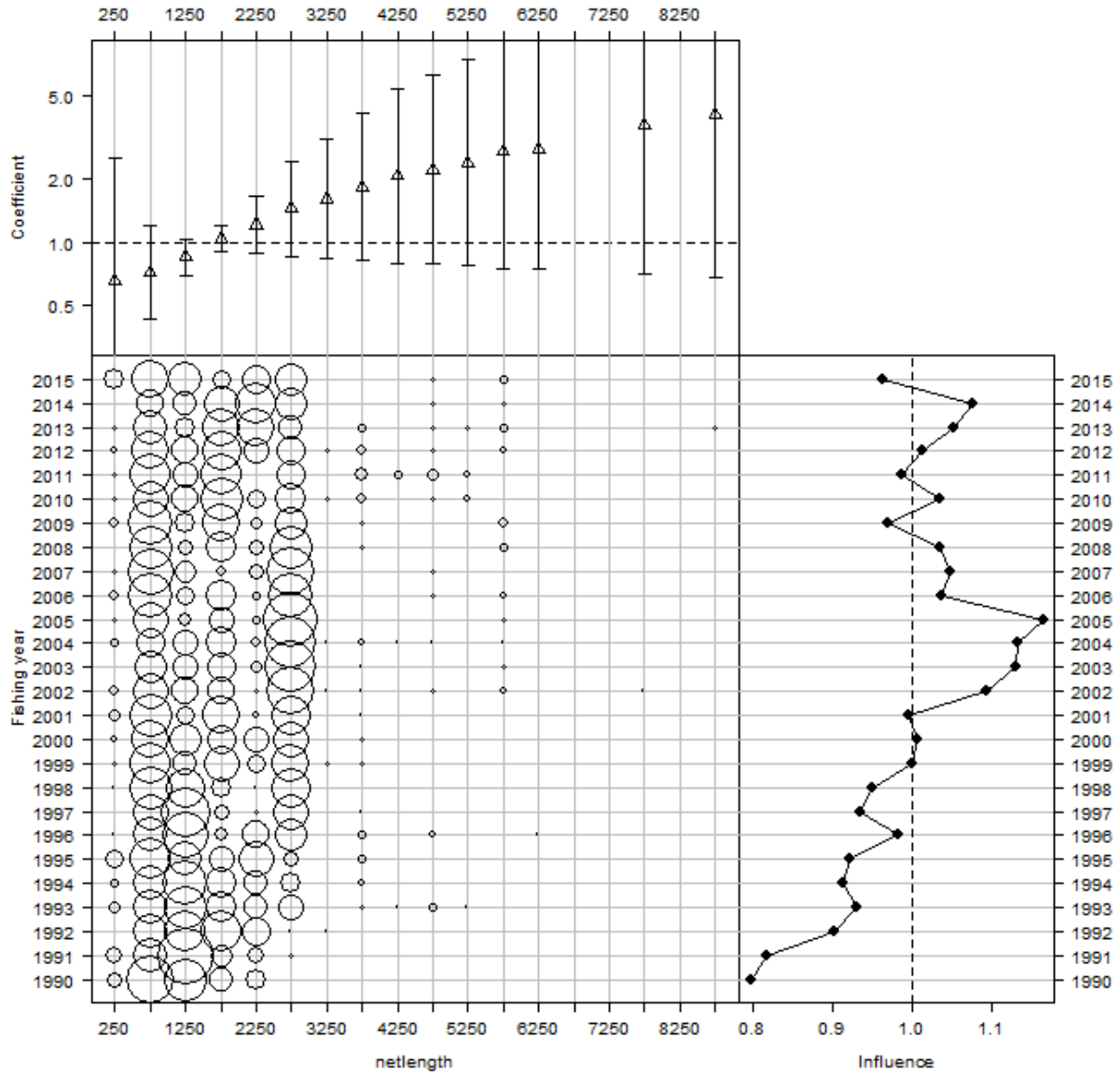

Figure U.9: Effect of length of net set in the log-logistic model for the rig SPO 7_SN(038) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

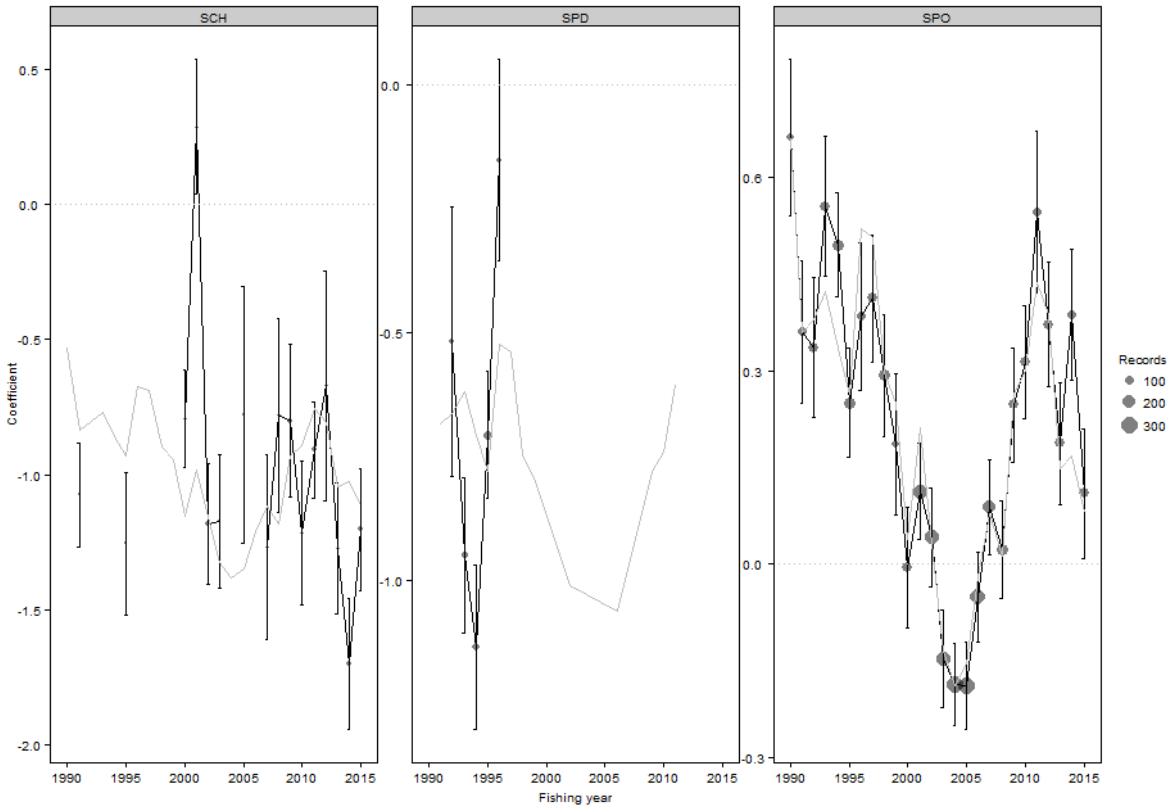

Figure U.10: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 7_SN(038) log-logistic model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

U.11 CPUE indices

Table U.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 SPO 7_SN(038) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	2.134	2.283	2.173	1.556	0.1296
1991	1.595	1.846	1.953	1.152	0.1194
1992	2.510	2.661	1.558	1.176	0.1090
1993	1.313	1.347	1.066	1.229	0.0911
1994	0.878	0.857	0.994	1.125	0.0787
1995	0.935	0.930	0.912	1.048	0.0839
1996	1.117	1.048	1.201	1.353	0.0972
1997	1.556	1.584	1.764	1.333	0.0948
1998	1.423	1.439	1.265	1.083	0.0909
1999	1.000	0.779	0.972	1.033	0.1171
2000	0.556	0.504	0.569	0.835	0.0885
2001	0.839	0.840	0.897	0.993	0.0777
2002	0.626	0.629	0.610	0.832	0.0754
2003	0.568	0.575	0.578	0.704	0.0739
2004	0.756	0.782	0.719	0.667	0.0690
2005	0.624	0.631	0.625	0.689	0.0685
2006	0.715	0.716	0.835	0.789	0.0733
2007	1.093	1.108	1.156	0.870	0.0788
2008	0.795	0.796	0.831	0.815	0.0817
2009	0.912	0.913	0.933	1.048	0.0859
2010	0.927	0.928	1.099	1.087	0.0881
2011	1.184	1.201	1.037	1.245	0.0970
2012	1.497	1.466	1.277	1.185	0.0949
2013	0.798	0.828	0.881	0.932	0.0939
2014	0.933	0.934	0.924	0.951	0.1028
2015	0.811	0.812	0.839	0.873	0.0941

Appendix V. DIAGNOSTICS AND SUPPORTING ANALYSES FOR SPO 7_SN(STB)

V.1 Introduction

This CPUE analysis was not accepted in 2016 for monitoring SPO 7 by the NINSWG (MPI 2016), giving it a research rating of '3' (Low Quality: affected by dolphin management regulations). A binomial model was not run because of the high proportion of success captures (Table S.1).

V.2 Fishery definition

SPO 7_SN(STB): The fishery is defined from setnet fishing events that fished in Statistical Areas 037, 039 or 040 and declared target species SPO, SCH, SPD or NSD.

V.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least three trips in three years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 49 vessels, which took 95% of the catch (Figure V.1). This core vessel definition was used to obtain a good representation of the fishery in the core vessel fleet (Figure V.1).

V.4 Data summary

Table V.1: Summaries by fishing year for core vessels, trips, daily effort strata, number of events that have been 'rolled up' into daily effort strata, number of events per daily effort stratum, total net length set (km), total hours set, landed SPO (t) and proportion of trips with catch for the core vessel data set (based on a minimum of three trips per year in three years) in the SPO 7_SN(STB) fishery. Final two columns apply to trips that declared no estimated catch of rig but reported SPO landings, giving the proportion of these trips relative to trips that reported SPO and the proportion of the reported catch from these trips relative to the total annual SPO reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events	Events per stratum	Sum (net) [km]	Sum (hours)	Catch (t)	% trips with catch	% strata with catch	% trips: 0 estimated catch	% catch: 0 estimated catch trips
1990	12	189	230	233	1.01	538.94	4 290	59.51	95.8	93.5	5.5	2.2
1991	12	266	344	348	1.01	706.97	5 684	76.52	91.4	85.5	4.5	6.8
1992	14	319	388	403	1.04	712.73	6 702	56.20	89.7	87.6	2.5	0.5
1993	18	315	430	443	1.03	918.99	7 713	108.74	95.6	94.9	4.7	0.5
1994	17	411	540	559	1.04	1 301.61	7 977	139.68	96.6	96.3	4.3	2.3
1995	19	376	450	491	1.09	1 159.45	7 058	163.66	97.3	97.3	8.2	4.6
1996	21	296	386	391	1.01	951.74	5 261	148.37	96.6	96.9	11.5	6.9
1997	20	324	427	436	1.02	952.22	5 703	123.33	95.4	93.0	8.4	15.7
1998	17	277	369	375	1.02	754.58	5 075	95.83	97.1	95.7	14.1	7.9
1999	19	337	499	509	1.02	1 092.82	7 031	150.63	99.1	94.2	14.4	11.1
2000	19	331	443	450	1.02	1 044.96	5 711	161.19	98.2	94.4	5.2	1.5
2001	19	318	470	476	1.01	962.84	6 456	163.35	98.7	96.4	1.3	0.1
2002	16	289	480	483	1.01	914.56	6 620	169.66	95.2	93.3	0.4	0.0
2003	16	272	424	428	1.01	804.94	5 658	154.71	89.7	90.3	0.4	0.0
2004	16	300	466	489	1.05	966.48	6 506	184.44	93.3	92.3	0.4	0.1
2005	15	225	392	401	1.02	1 007.40	5 459	149.75	90.7	93.9	1.0	0.0
2006	13	137	281	292	1.04	679.97	3 664	98.55	97.1	95.0	0.0	0.0
2007	16	139	300	337	1.12	744.69	4 715	111.22	92.8	93.3	1.6	0.0
2008	15	175	378	502	1.33	1 032.56	6 271	139.10	88.0	91.3	0.7	0.0
2009	15	210	376	453	1.20	958.15	5 810	149.06	91.0	92.0	2.6	0.1
2010	15	139	317	390	1.23	929.39	5 186	156.90	98.6	98.1	1.5	0.1
2011	13	110	316	388	1.23	963.09	5 020	124.31	91.8	91.5	2.0	0.1
2012	14	108	285	343	1.20	839.28	4 476	120.65	88.9	90.5	2.1	0.5
2013	8	81	233	294	1.26	742.42	4 091	73.28	100.0	95.7	0.0	0.0
2014	10	100	278	370	1.33	885.85	4 972	138.10	99.0	97.1	2.0	0.0
2015	9	94	296	390	1.32	1 035.43	5 295	130.04	97.9	96.6	4.4	0.0

V.5 Core vessel selection

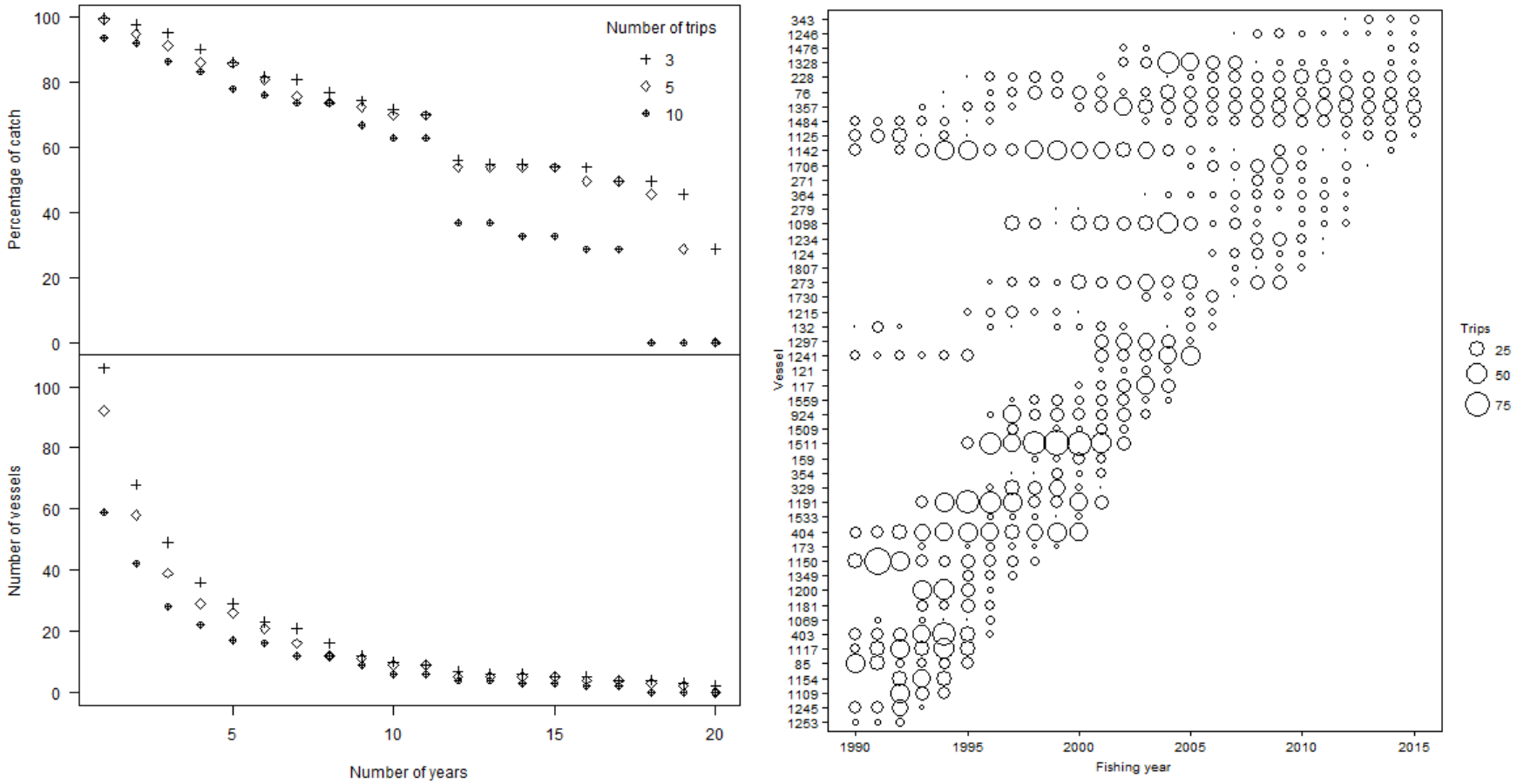

Figure V.1: [left panel] total landed SPO and number of vessels plotted against the number of years used to define core vessels participating in the SPO 7_SN(STB) data set. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend; [right panel]: bubble plot showing the number of strata for selected core vessels (based on at least three trips in three or more fishing years) by fishing year.

V.6 Exploratory data plots for core vessel data set

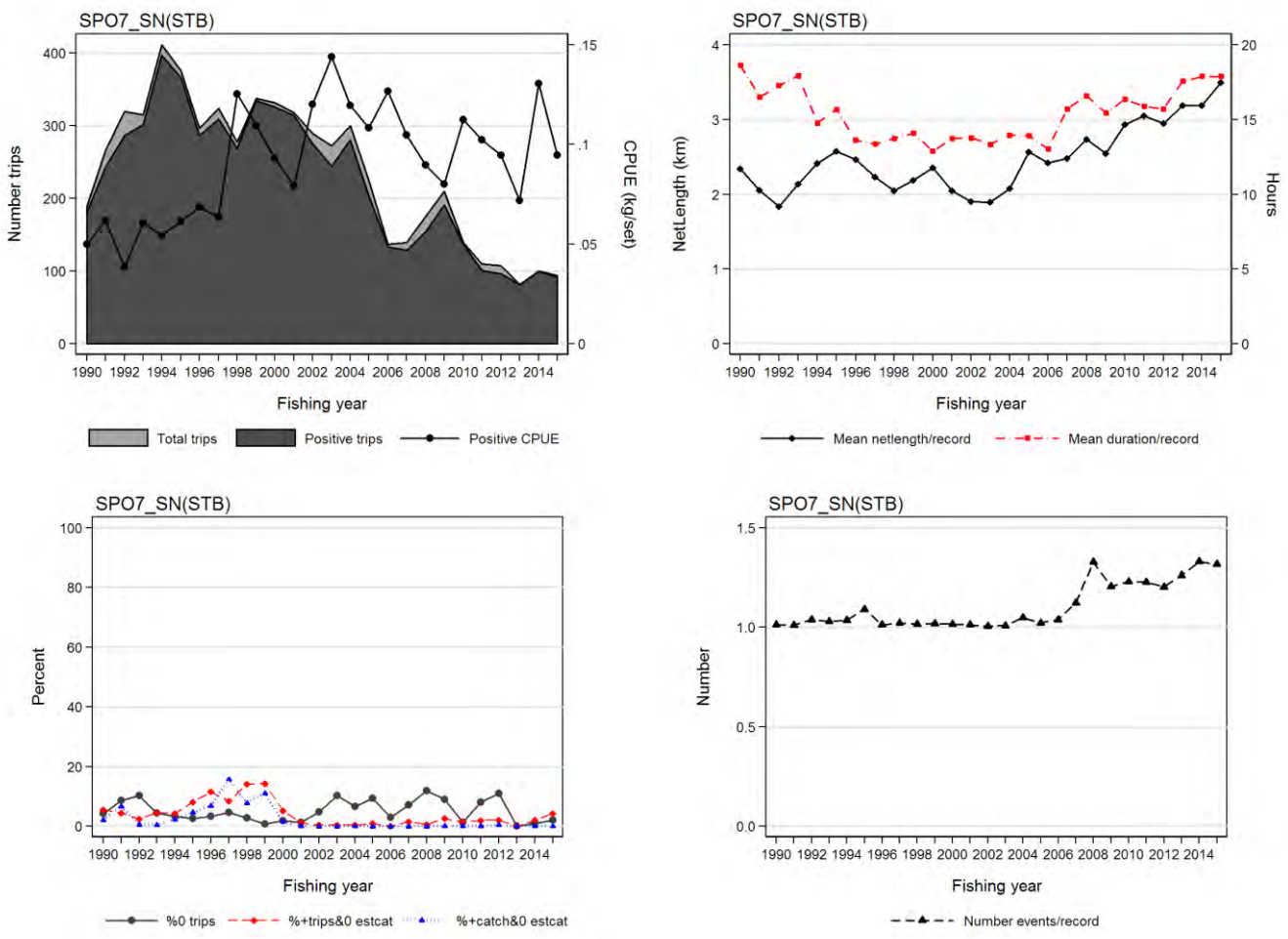

Figure V.2: Core vessel summary plots by fishing year for model SPO 7_SN(STB): [upper left panel]: total trips (light grey) and trips with rig catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips *i* with positive catch: $A_y = \text{median}\left(C_{y,i}/E_{y,i}\right)$; [upper right panel]: mean number of tows and mean number hours per stratum record; [lower left panel]: a) percentage of trips with no catch of rig, b) percentage of trips with no estimated catch but with landed catch, c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per stratum record.

V.7 Selection of positive catch distribution

SPO 7_SN(STB) is a new series, with the most appropriate distribution selected as described in Section I.2.2. This analysis is summarised below in Figure V.3, with the best distribution being Weibull.

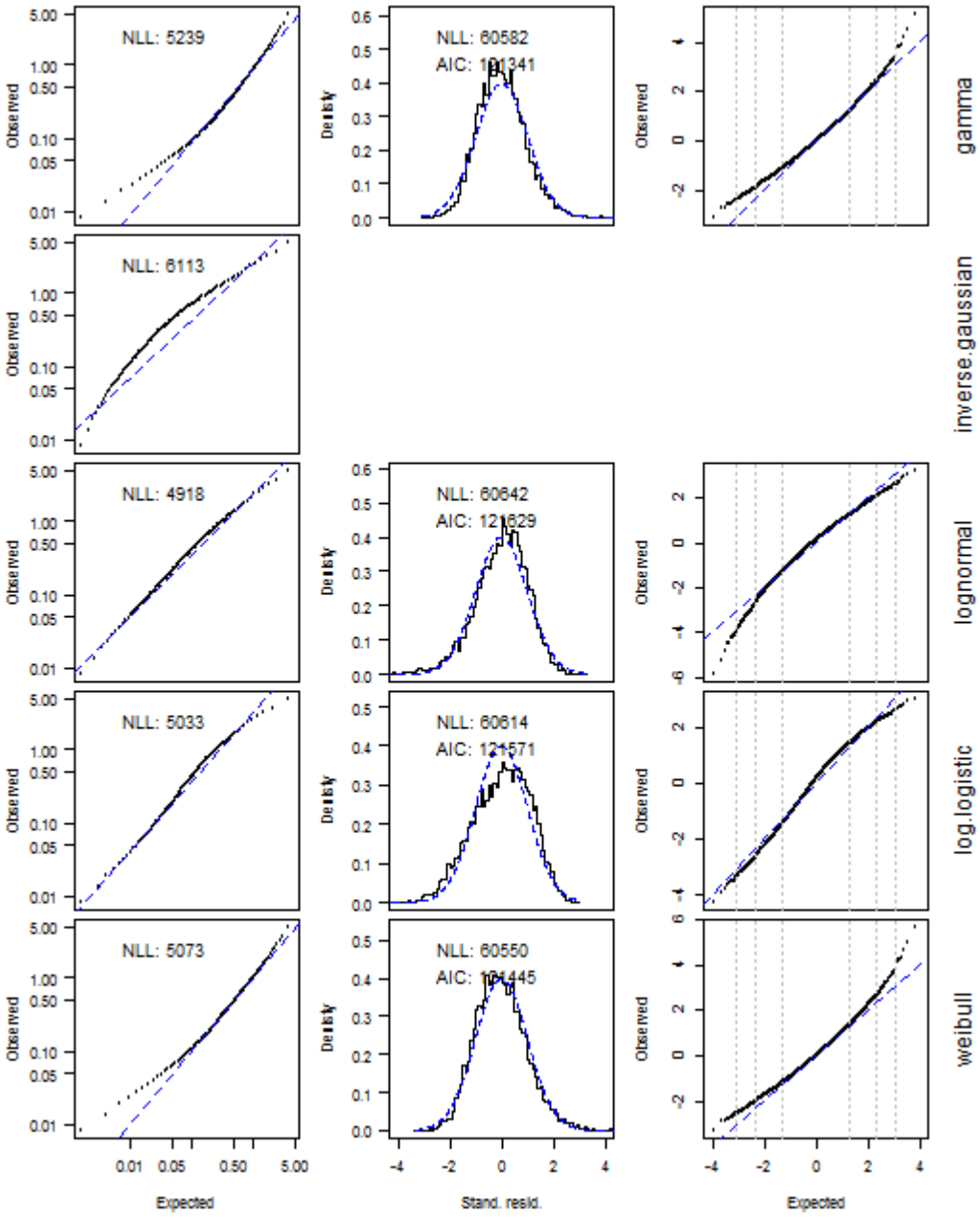

Figure V.3: Diagnostics for alternative distributional assumptions for catch in the SPO 7_SN(STB) analysis. [left column]: quantile-quantile plot of observed catches (centred (by mean) and scaled (by standard deviation in log space) versus maximum likelihood fit of distribution (missing panel indicates the fit failed to converge); [middle column]: standardised residuals from a generalised linear model fitted using the formula catch ~ fyear + month + area + vessel + log(net_length) and the distribution (missing panel indicates the model failed to converge); [right column]: 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.

V.8 Positive catch model selection table

Four explanatory variables (vessel, target species, month and net length) entered the model after fishing year (Table S.2), with the variables duration and statistical area non-significant. A plot of the model is provided in Figure V.3 and the CPUE indices are listed in Table S.3.

Table V.2: Order of acceptance of variables into the Weibull model of successful catches in the SPO 7_SN(STB) fishery model for core vessels (based on the vessel selection criteria of at least three trips in three 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	-62 640	125 334	4.02	*
vessel	158	-61 025	122 367	32.48	*
target	160	-60 605	121 530	38.39	*
month	171	-60 342	121 025	41.82	*
poly(log(netlength), 3)	174	-60 172	120 692	**43.93**	*
poly(log(duration), 3)	177	-60 136	120 626	44.37	
area	179	-60 122	120 601	44.54	

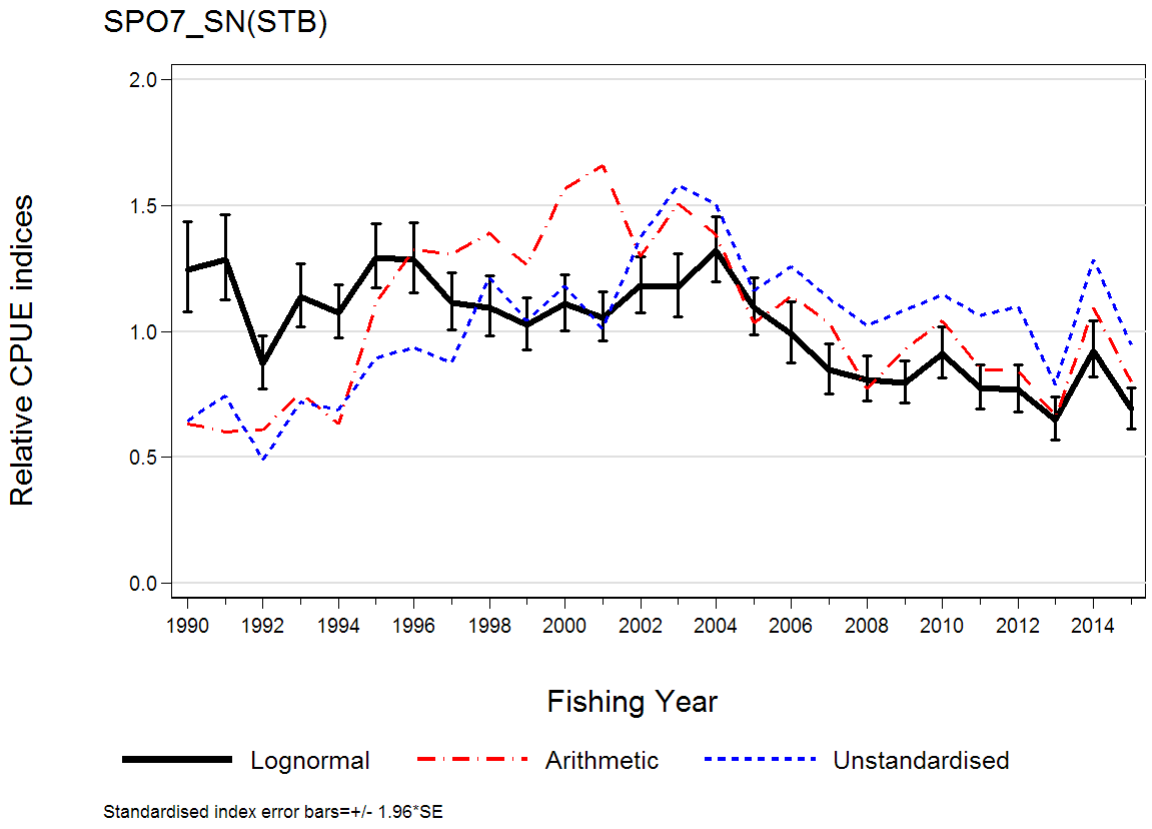

Figure V.4: Relative CPUE indices for rig using the Weibull non-zero model based on the SPO 7_SN(STB) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. I.1) and b) Unstandardised (Eq. I.2).

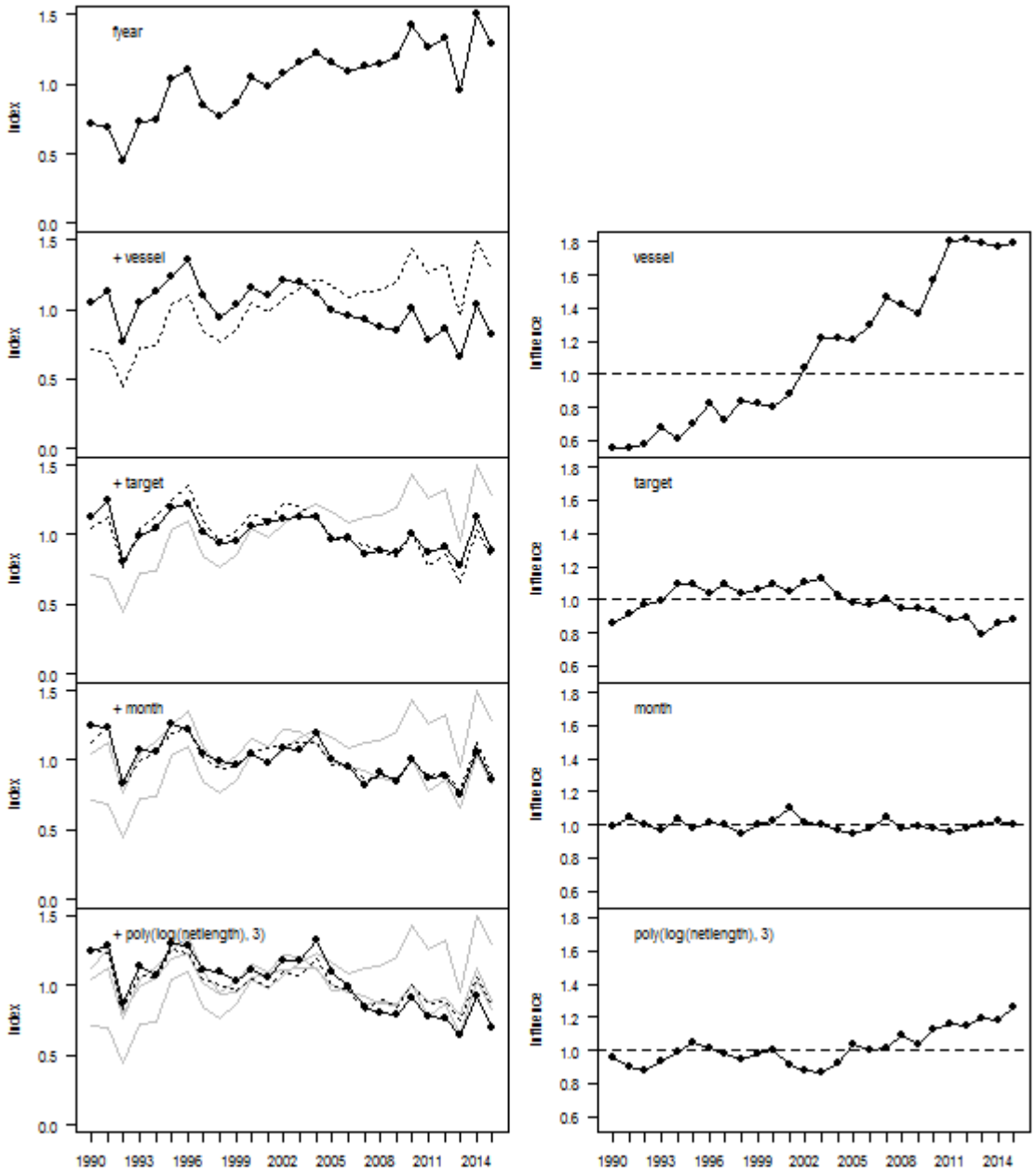

Figure V.5: [left column]: annual indices from the Weibull model of SPO 7_SN(STB) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

V.9 Residual and diagnostic plots

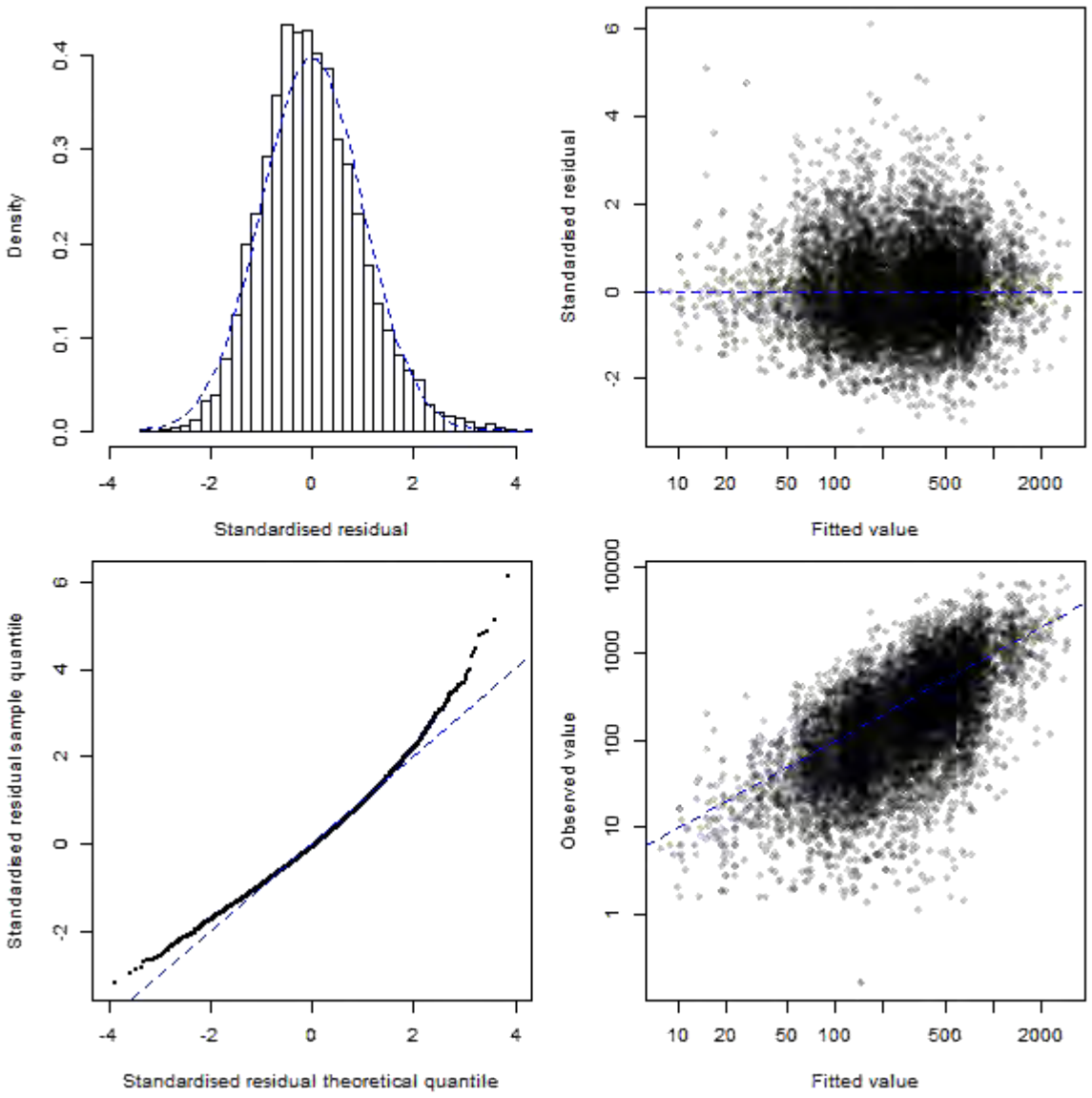

Figure V.6: Plots of the fit of the Weibull standardised CPUE model of successful catches of rig in the SPO 7_SN(STB) fishery. [upper left panel]: histogram of the standardised residuals compared to a Weibull distribution; [upper right panel]: Q-Q plot of the standardised residuals; [lower left panel]: standardised residuals plotted against the predicted model catch per trip; [lower right panel]: observed catch per record plotted against the predicted catch per record.

V.10 Model coefficients

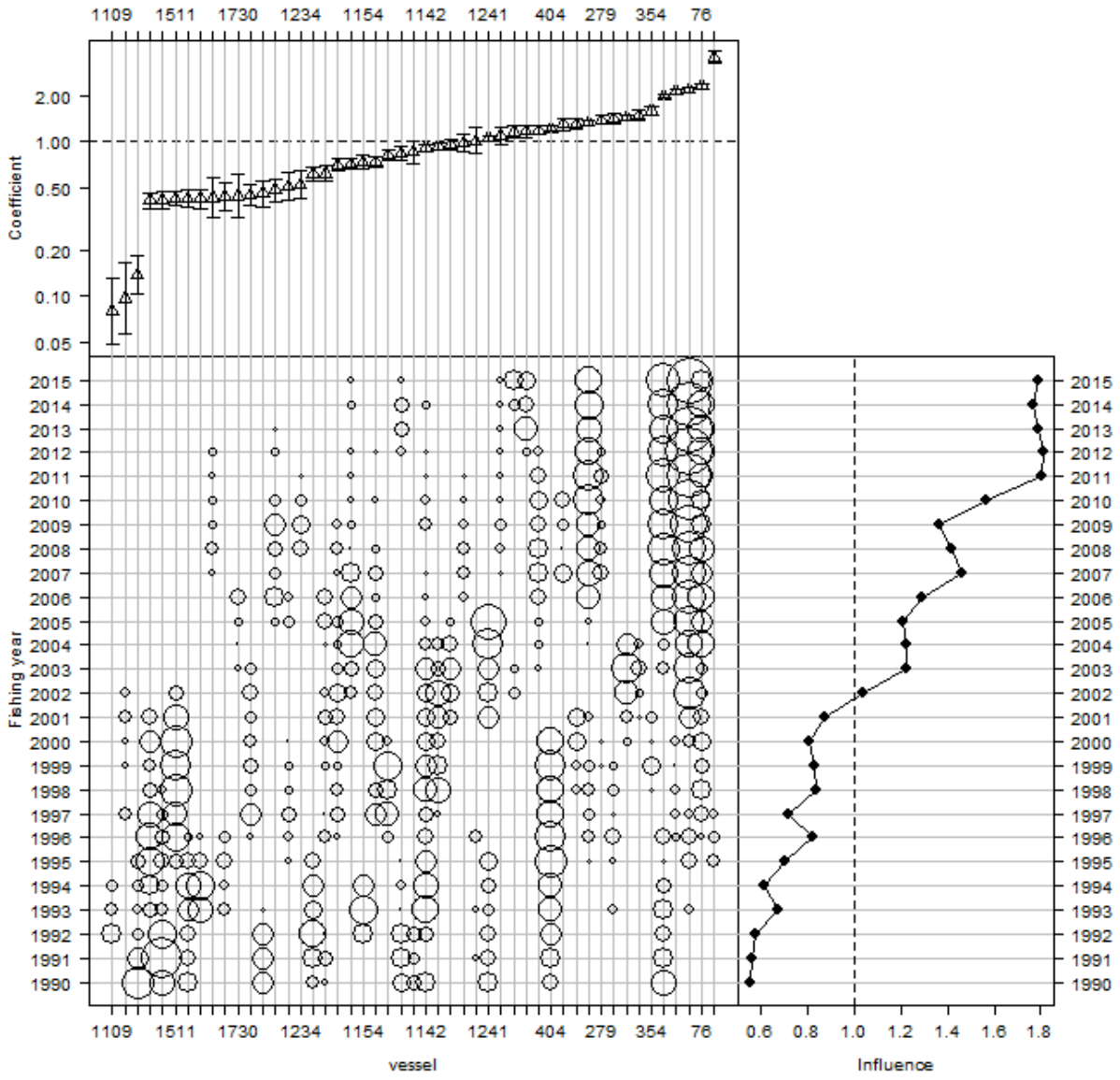

Figure V.7: Effect of vessel in the Weibull model for the rig SPO 7_SN(STB) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

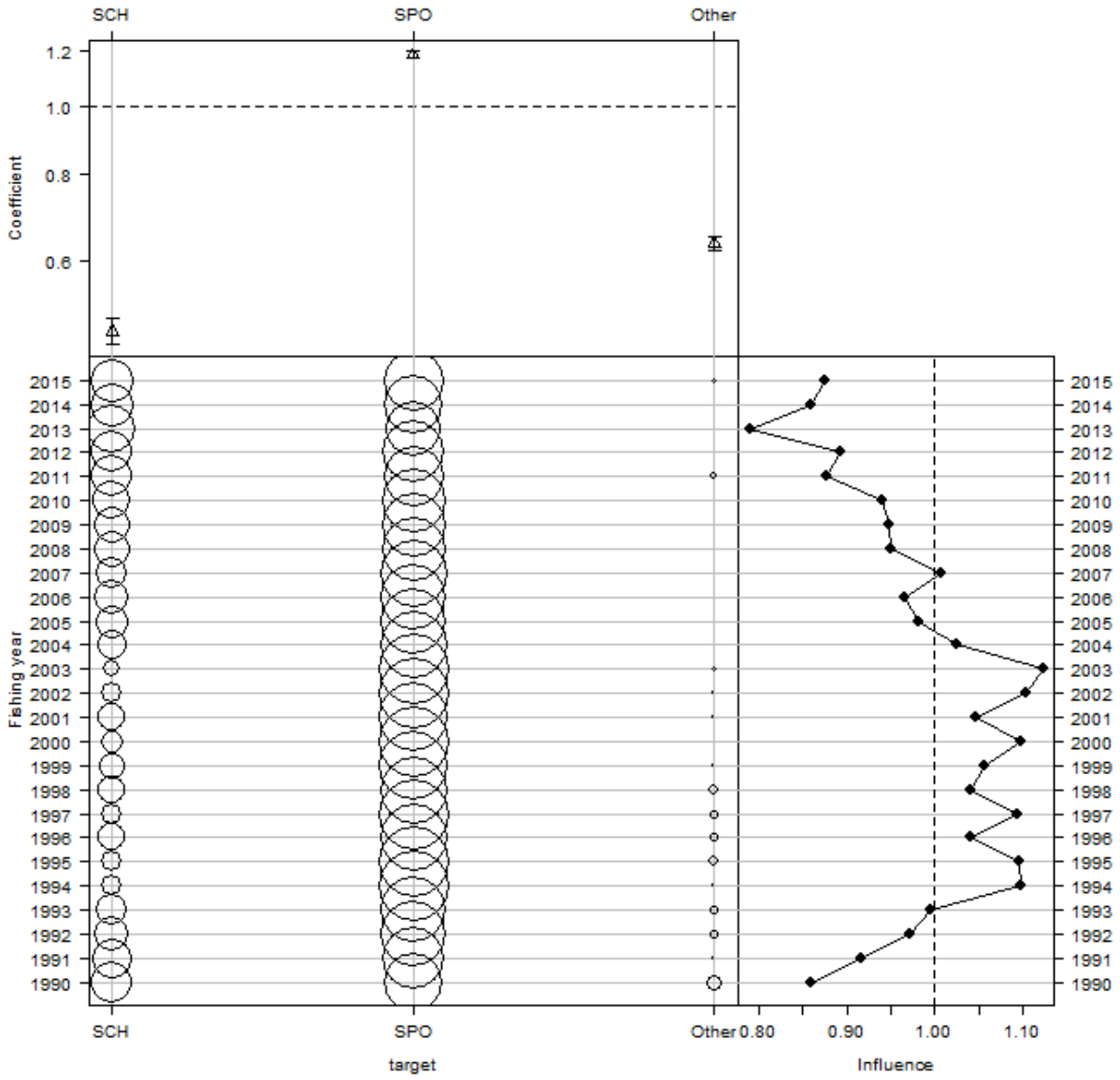

Figure V.8: Effect of target species fished in the Weibull model for the rig SPO 7_SN(STB) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

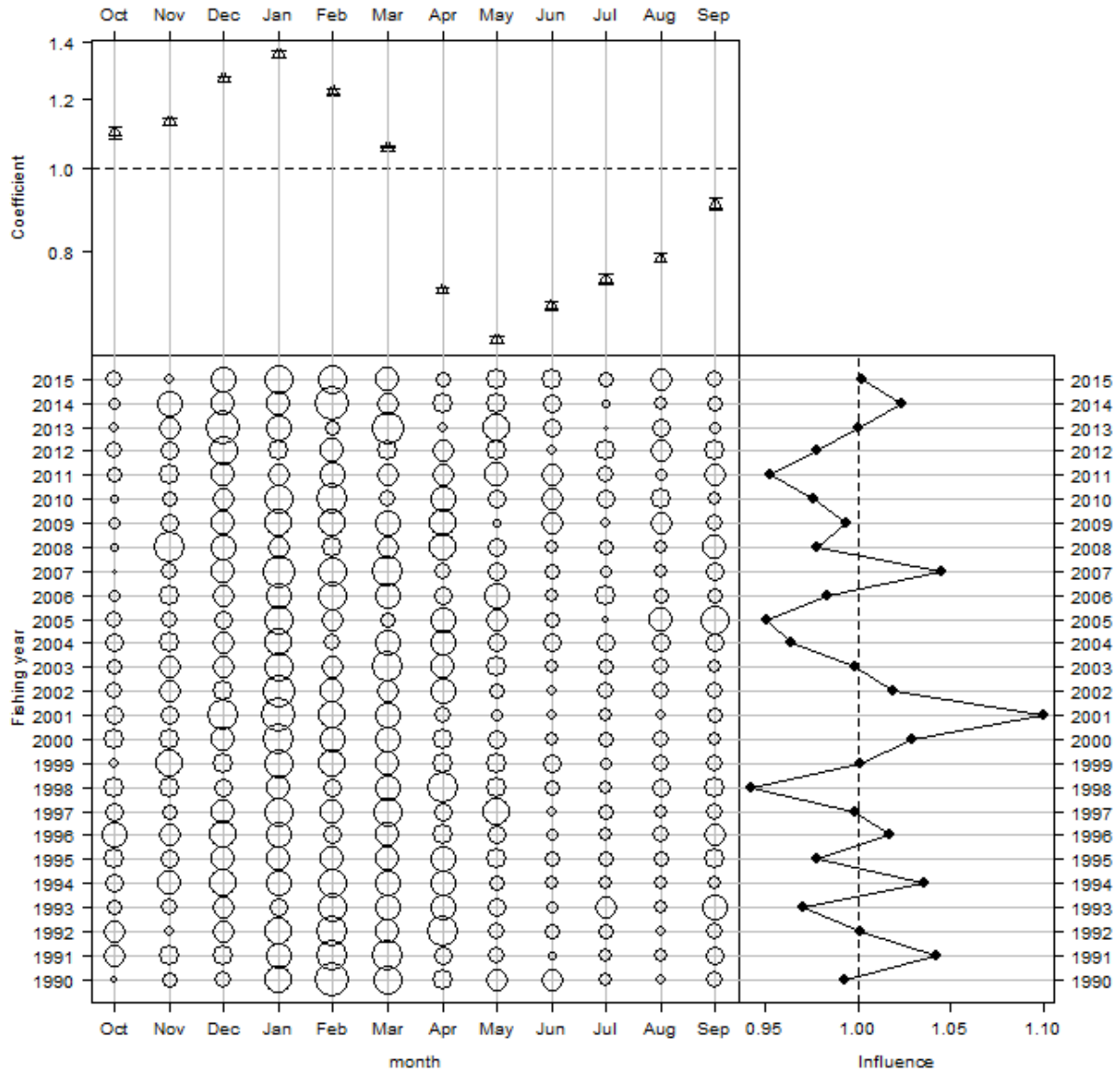

Figure V.9: Effect of month fished in the Weibull model for the rig SPO 7_SN(STB) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

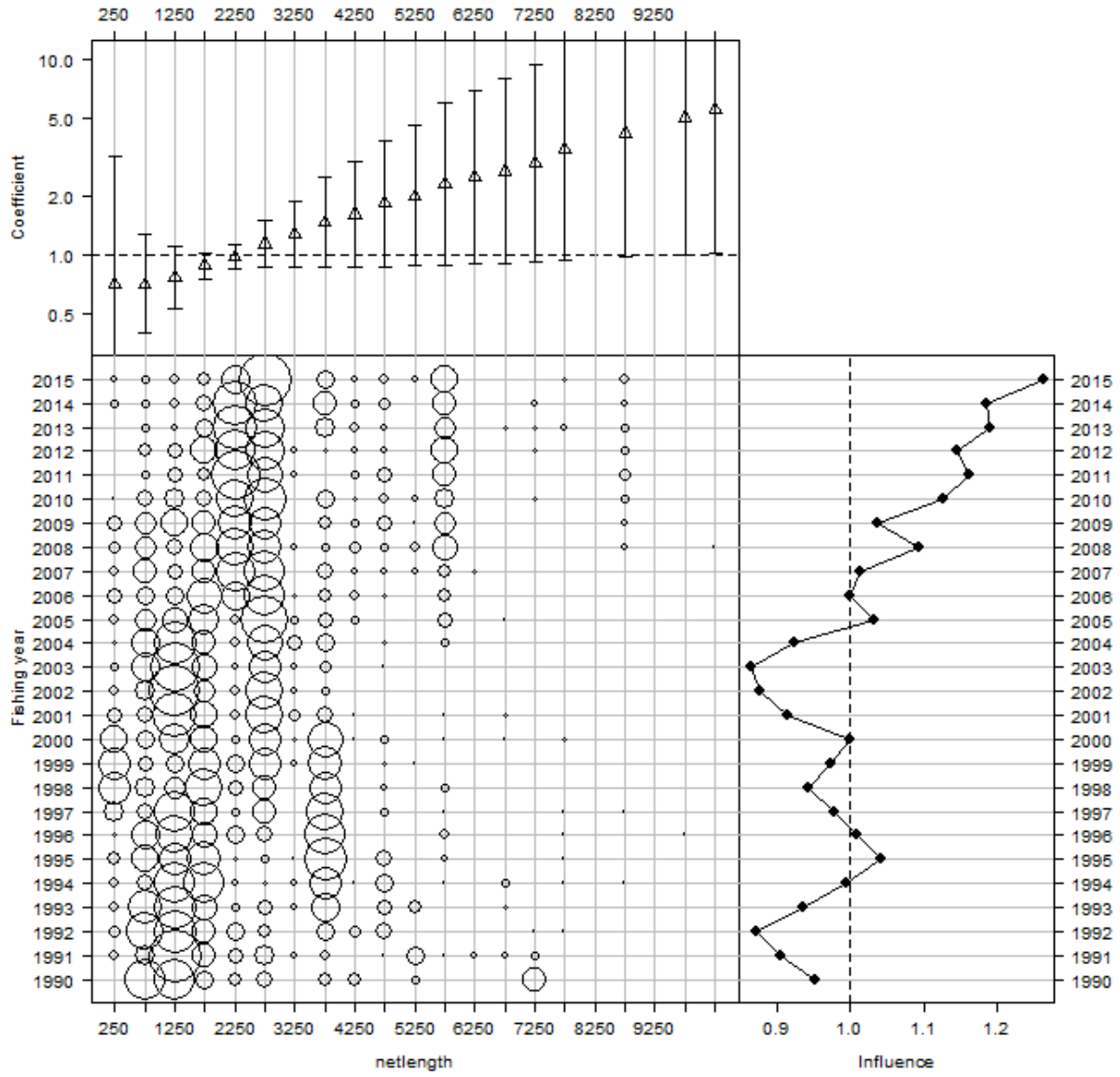

Figure V.10: Effect of length of net set in the Weibull model for the rig SPO 7_SN(STB) fishery. [top panel]: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative); [bottom-left panel]: distribution of variable by fishing year; [bottom-right panel]: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

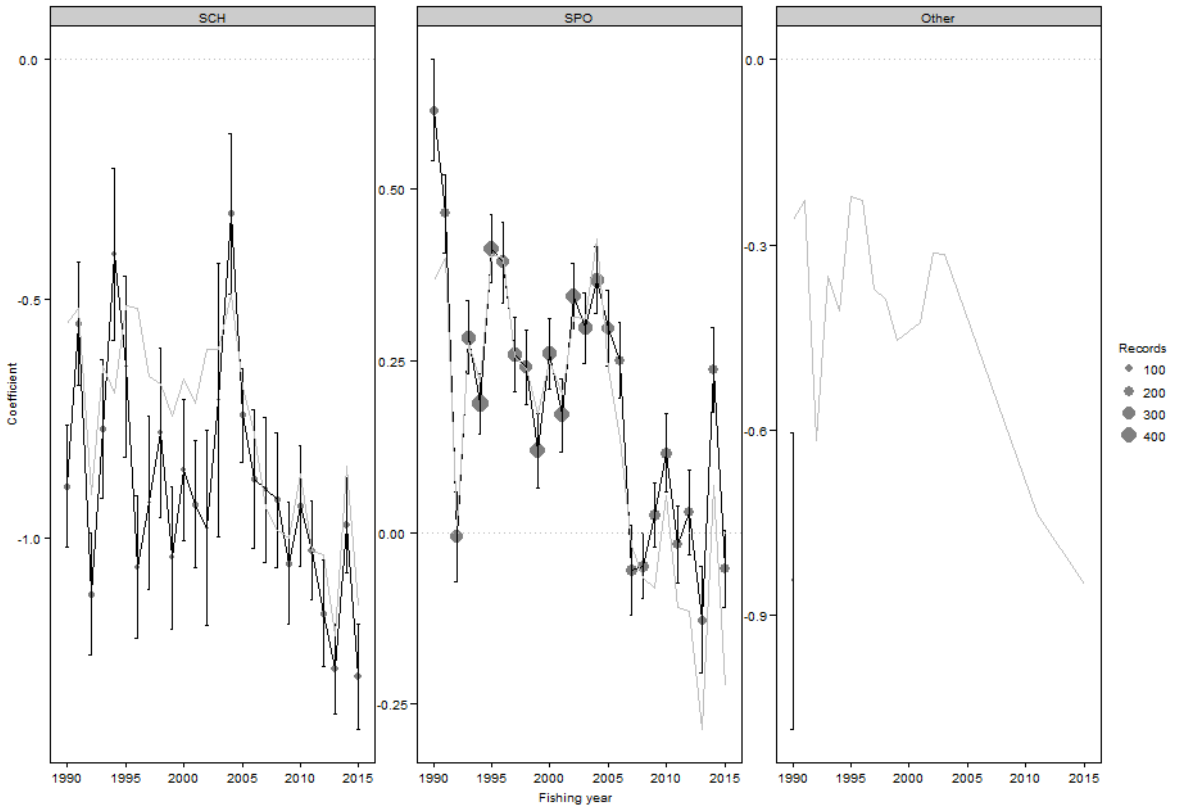

Figure V.11: Residual implied coefficients for target × fishing year interaction (interaction term not offered to the model) in the rig SPO 7_SN(STB) Weibull model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target. These values approximate the coefficients obtained when a target × year interaction term is fitted, particularly for those target × year combinations that have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.

V.11 CPUE indices

Table V.3: Arithmetic indices for the total and core data sets, geometric and Weibull standardised indices and associated standard error (SE) for the core data set by fishing year for the SPO 7_SN(STB) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing	All vessels	Core vessels			
year	Arithmetic	Arithmetic	Geometric	Standardised	SE
1990	0.722	0.634	0.646	1.245	0.0732
1991	0.758	0.601	0.744	1.285	0.0666
1992	0.598	0.609	0.489	0.872	0.0612
1993	0.661	0.759	0.720	1.137	0.0562
1994	0.613	0.632	0.688	1.075	0.0501
1995	1.058	1.114	0.896	1.293	0.0504
1996	1.287	1.326	0.937	1.285	0.0558
1997	1.290	1.307	0.876	1.113	0.0517
1998	1.315	1.391	1.216	1.095	0.0555
1999	1.253	1.263	1.042	1.026	0.0516
2000	1.560	1.569	1.181	1.108	0.0509
2001	1.640	1.659	1.010	1.055	0.0470
2002	1.364	1.298	1.374	1.180	0.0487
2003	1.438	1.507	1.580	1.178	0.0540
2004	1.358	1.386	1.505	1.322	0.0499
2005	1.033	1.033	1.163	1.092	0.0529
2006	1.125	1.142	1.259	0.989	0.0618
2007	1.039	1.034	1.131	0.846	0.0602
2008	0.834	0.771	1.024	0.807	0.0565
2009	0.932	0.927	1.086	0.795	0.0539
2010	1.060	1.044	1.147	0.910	0.0569
2011	0.847	0.850	1.062	0.774	0.0584
2012	0.809	0.846	1.099	0.768	0.0609
2013	0.650	0.660	0.789	0.648	0.0681
2014	1.099	1.093	1.287	0.924	0.0604
2015	0.785	0.799	0.946	0.690	0.0604