



ELE 5 Fishery Characterisation and CPUE Report

New Zealand Fisheries Assessment Report 2017/50

P.J. Starr
T.H. Kendrick

ISSN 1179-5352 (online)
ISBN 978-1-77665-672-1 (online)

September 2017



Requests for further copies should be directed to:

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

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

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

© Crown Copyright - Ministry for Primary Industries

TABLE OF CONTENTS

EXECUTIVE SUMMARY	1
1. INTRODUCTION	2
2. INFORMATION ABOUT THE STOCK/FISHERY	3
3. STANDARDISED CPUE ANALYSIS.....	28
4. ACKNOWLEDGEMENTS.....	30
5. REFERENCES	30
APPENDIX A. GLOSSARY OF ABBREVIATIONS, CODES, AND DEFINITIONS OF TERMS.....	32
APPENDIX B. MAP OF MPI STATISTICAL AND MANAGEMENT AREAS.....	34
APPENDIX C. DATA SUMMARIES BY ELE 5 STATISTICAL AREA GROUP FOR BOTTOM TRAWL AND SETNET.....	35
APPENDIX D. ELE 5 CPUE ANALYSIS	44
APPENDIX E. DIAGNOSTICS AND SUPPORTING ANALYSES FOR ELE 5 BOTTOM TRAWL CPUE	47

EXECUTIVE SUMMARY

Starr, P.J.; Kendrick, T.H. (2017). ELE 5 Fishery Characterisation and CPUE Report.

New Zealand Fisheries Assessment Report 2017/50. 63 p.

The fisheries taking elephantfish (*Callorhynchus milii*) in ELE 5, located at the southern end of the New Zealand South Island and operating from 1989–90 to 2015–16, are described using compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI). This species is mostly captured by bottom trawl, accounting for 87% of the accumulated landings over the 27 year period. The balance of the elephantfish catch is taken by setnet. Elephantfish are primarily taken as a bycatch of the shallow flatfish bottom trawl fishery (44%) or the deeper stargazer fishery (26%). Fourteen percent of the bottom trawl landings in ELE 5 were targeted at elephantfish, with no apparent recent trend in this statistic. Elephantfish are a bycatch species in the target rig setnet fishery (40%) and the target school shark setnet fishery (35%). Seventeen percent of the setnet landings were targeted at elephantfish. Setnet catches in ELE 5 are low and highly variable, so it is not possible to be confident of any apparent trends. Detailed characteristics of the landing data associated with ELE 5, as well as the spatial, temporal, target species and depth distributions relative to the catch of elephantfish in the bottom trawl fishery are presented.

Fine scale positional information from catch and effort records are available from 2007–08 for the bottom trawl fishery and from 2006–07 for the setnet fishery. These dates coincide with the introduction of new event based catch reporting forms (TCER for bottom trawl and NCELR for setnet) by MPI. Previously, all of the ELE 5 catch was reported on the daily summary forms (CELR) which do not require fine scale positional information. These positional data show that bottom trawl catches of elephantfish extend on both the east and west ends of Foveaux Strait and down along the west side of Stewart Island. Interpretation of the setnet positional data is hampered by the “three vessel rule” for confidentiality, which precludes plotting about 60% of the positional grids. However, the distribution of setnet landings is very similar to the bottom trawl distribution. Setnet landings of elephantfish tend to be concentrated in the spring and summer while the bottom trawl landings of elephantfish occur all year. Reported depth information from bottom trawl landings shows that elephantfish are taken in shallow (less than 20 m) up to about 150 m, depending on the species being targeted. The preferred depth distribution for ELE target fishing lies between 13 and 80 m. There are no depth reports from the setnet fishery as these data are not required on the form.

Commercial Catch Per Unit Effort (CPUE) analyses have been used to monitor ELE 5 since 2012 (MPI 2016). Only one analysis is available from the bottom trawl fishery, given the relatively small amount of data and the homogeneity of the fishery. The setnet fishery is much too small to generate a reliable series. This analysis was updated in 2014 and this paper represents a further update, extending the series to 2015–16. The resulting analysis indicates that there has been a decline in the ELE 5 elephantfish population relative to the peak CPUE observed around 2010–11. However, current levels of CPUE remain well above the long-term average levels.

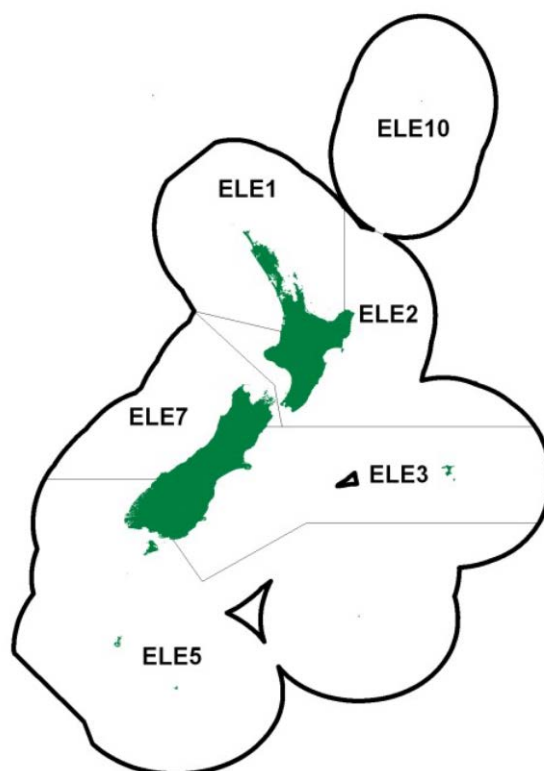


Figure 1: Map of ELE QMAs.

1. INTRODUCTION

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

Overall Objective:

1. To characterise the elephantfish (*Callorhynchus milii*) fishery in ELE 5 and to update the existing CPUE analysis.

Specific Objectives:

1. To characterise the ELE 5 fishery.
2. To analyse existing commercial catch and effort data to the end of 2015/16 fishing year to update the existing ELE 5 bottom trawl CPUE abundance series.

This project extends the following previous projects:

Reference	Last fishing year in analysis
Starr et al. (2009)	2007–08
Starr & Kendrick (2013)	2010–11
Langley (2014)	2012–13

This report summarises fishery and landings characterisations for ELE 5, as well as presenting a CPUE standardisation derived from bottom trawl data originating from ELE 5.

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

2. INFORMATION ABOUT THE STOCK/FISHERY

2.1 Catches

The TACC for ELE 5 increased progressively from 60 to 170 t after 1986–87, the year ELE 5 was introduced into the QMS, to 2012–13, which was the year of the most recent TACC increase (Figure 2; Table 1). The initial TACC increases were likely to have been due to the quota appeal system, but the successive increases from the early 2000s were in response to evidence of increases in the abundance of elephantfish at the south end of the South Island. Catches have exceeded the TACC in nearly every year from 1995–96, except for 2012–13 and 2015–16 (Table 1; Figure 2).

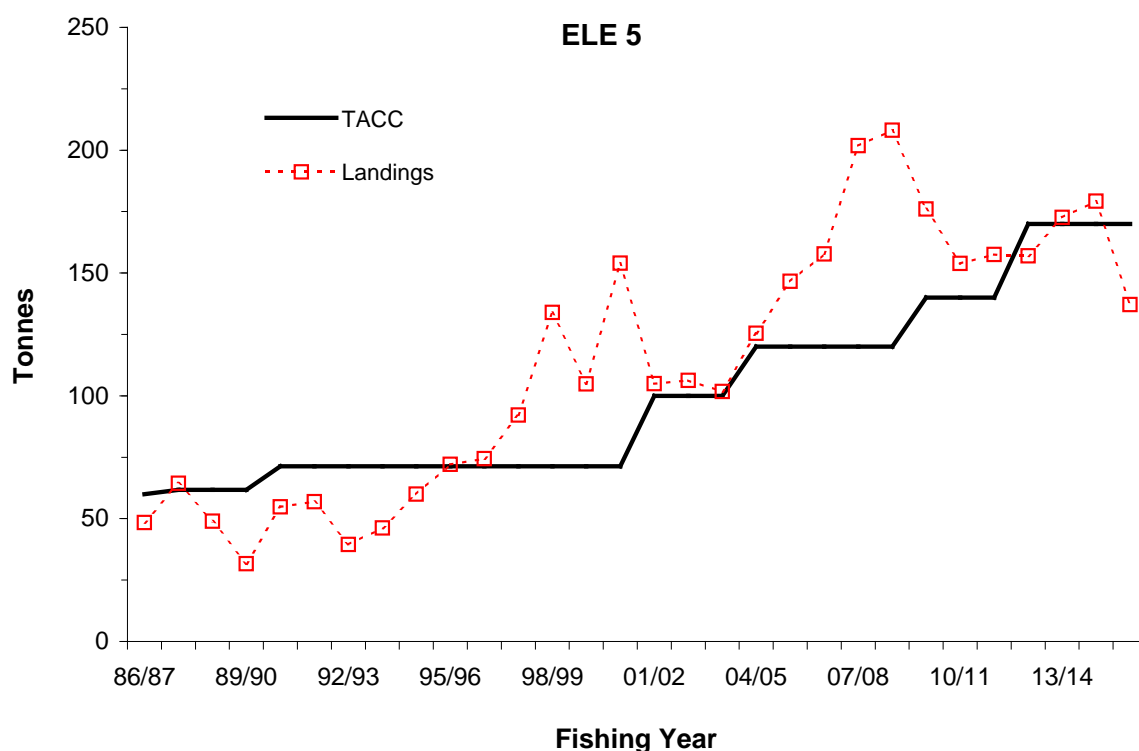


Figure 2: Plot of ELE 5 landings and TACCs from 1986–87 to 2015–16. Landings and TACCs are reported in Table 1.

Table 1: Reported landings (t) and TACC (t) of elephantfish in ELE 5 from 1986–87 to 2015–16 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2015–16]).

Fishing Year	Landings	TACC	Fishing Year	Landings	TACC
1986–87	48	60	2001–02	105	100
1987–88	64	62	2002–03	106	100
1988–89	49	62	2003–04	102	100
1989–90	32	62	2004–05	125	120
1990–91	55	71	2005–06	147	120
1991–92	57	71	2006–07	158	120
1992–93	39	71	2007–08	202	120
1993–94	46	71	2008–09	208	120
1994–95	60	71	2009–10	176	140
1995–96	72	71	2010–11	154	140
1996–97	74	71	2011–12	158	140
1997–98	92	71	2012–13	157	170
1998–99	134	71	2013–14	173	170
1999–00	105	71	2014–15	179	170
2000–01	154	71	2015–16	137	170

2.2 Regulations Affecting the Fishery

2.2.1 Deemed values

There have been no changes in the ELE 5 conversion factors over the period of available data (see Section 2.3.2). However, the control of overcatch in ELE 5 (and ELE 3) has been a vexing issue since the mid-1990s (Raj & Voller 1999). Deemed values, the penalty applied to landing quota species when the fisher has insufficient ACE (Annual Catch Entitlement) to balance the landings, have been used as the main deterrent to control overcatch. However, if these penalties are set too high, there is the potential for dumping at sea and consequent loss of catch information. Deemed values are generally set by Ministry for Primary Industries “*above ACE price and below landed (port) price*” (Scott Walker, Ministry for Primary Industries, *pers. comm.*). Deemed values were reduced for ELE 5 from 2005–06 as well as suspending the excess penalty schedule to encourage accurate reporting of the catch of elephantfish on the east and south coasts of the South Island (Table 2). The ELE 5 TACC was reviewed for 2009–10 and 2012–13 based on the performance of the fishery, taking into account a change in reporting requirements. The TACC was subsequently increased in both years. The deemed value regime was also reviewed in 2009–10 and a modified excess penalty schedule was reinstated. The deemed value was increased for the 2011–12 fishing year in response to changes in the port price and has remained at that level since then (Table 2).

Table 2: Annual and interim deemed values for ELE 5 by fishing year from 2001–02 (source: Ray Voller, Ministry of Fisheries, *pers. comm.*; Mark Geytenbeek, MPI, *pers. comm.*; Matthew Baird, MPI, *pers. comm.*). Also shown is the amount by which ACE must be exceeded for deemed value penalties to apply.

Fishing Year	MHR landings (t)	TACC (t)	Annual Deemed Value ¹ (\$/kg)	Interim Deemed Value ² (\$/kg)	Excess of ACE for deemed value penalties ³ to apply: $100 * (\sum \text{landings}_y / \sum \text{ACE}_y)$
2001–02	105	100	\$1.57	\$0.79	120%
2002–03	106	100	\$1.57	\$0.79	120%
2003–04	102	100	\$1.57	\$0.79	120%
2004–05	125	120	\$1.57	\$0.79	120%
2005–06	147	120	\$0.99	\$0.79	suspended
2006–07	158	120	\$0.99	\$0.79	suspended
2007–08	202	120	\$0.99	\$0.79	suspended
2008–09	208	120	\$0.99	\$0.79	suspended
2009–10	176	140	\$1.30	\$1.10	130%
2010–11	154	140	\$1.30	\$1.10	130%
2011–12	158	140	\$1.65	\$1.40	120%
2012–13	157	170	\$1.65	\$1.40	120%
2013–14	173	170	\$1.65	\$1.50	120%
2014–15	179	170	\$1.65	\$1.50	120%
2015–16	137	170	\$1.65	\$1.50	120%

¹ applied at end of year to landings not covered by ACE but less than lower limit shown in final column

² applied when landing in excess of ACE but refunded if ACE is subsequently provided

³ penalties usually increase about 20% for every 20% landings exceed ACE after the initial threshold

2.2.2 Closures for the protection of Hector’s dolphins

2.2.2.1 Regulatory closures

From 1 October 2008, year-round closure regulations to protect Maui and Hector’s dolphin were implemented for all of New Zealand by the Minister of Fisheries. These closures extend on the east and south coasts of the South Island from Cape Jackson in the Marlborough Sounds to Sandhill Point on the most western side of Te Wae Wae Bay. These closures include the Hector’s dolphin preferred areas in FMA 3 and FMA 5, and ban all commercial and recreational setnets within four nautical miles from shore, apart from permitting setnets to be used:

- beyond one nautical mile offshore around the Kaikoura Canyon

- in most harbours, estuaries, river mouths, lagoons and inlets except for the Avon-Heathcote Estuary, Lyttleton Harbour, Akaroa Harbour, Timaru Harbour and Te Wae Wae Bay;
- for flounder fishing between 1 April and 30 September in designated flounder areas around Banks Peninsula and Queen Charlotte Sound using defined nets.

Using the same FMA 3 and FMA 5 boundaries as for setnets, trawling is prohibited inside of two nautical miles from shore, unless flatfish nets with defined low headline heights are used.

2.2.2.2 Voluntary closures

Voluntary measures for the protection of Hector's dolphins were implemented through the adoption of a Code of Practice (CoP) developed by the SEFMC from the 1999–00 fishing year. The practices in this CoP which may affect CPUE include a voluntary setnet closure extending seaward for four nautical miles beginning from the southern end of the Banks Peninsula Marine Mammal Sanctuary to the mouth of the Waitaki River for the period 1 October to 31 January. The same boundaries enclose a voluntary one nautical mile seaward closure for the entire fishing year from 1 October to 30 September for the setnet method only. Porpoise Bay (Catlins) was added as a year-round setnet voluntary closure in 2004.

From 2001, the CoP requested that trawlers use their best endeavours to limit the use of bottom trawling whilst in waters inside the 30 metre depth contour and to not use bottom trawl within this depth contour at any time during the hours of darkness. Trawlers were also asked not to deploy high opening trawl gear inside the 50 metre depth contour.

2.3 Analysis of ELE 5 catch and effort data

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

Three data extracts were obtained from the Ministry for Primary Industries (MPI) Warehouse database (Ministry of Fisheries 2010). One extract consisted of the complete data set (all fishing event information along with all elephantfish landing information) from every trip which recorded landing elephantfish in ELE 5, starting from 1 October 1989 and extending to 30 September 2016. Two further extracts were obtained: one consisting of all trips which fished in one of the valid statistical areas for ELE 5 (025 to 032, 501 to 504, 601 to 625) using the method BT (bottom trawl), and which targeted FLA (also: BFL, BLF, BRI, ESO, FLO, GFL, LSO, SFL, SFI, SOL, TUR, WIT, YBF, BOT, GBL, MAN, SLS, SDF), ELE, STA, SPD (also: NSD, OSD), GUR, RCO, BAR, TAR, LEA, SPO and LIN. The final extract requested data pertaining to trips using the SN (setnet) method, fished in one of the ELE 5 statistical areas, and targeted SPO, SCH, ELE, and SPD (also: NSD, OSD). Once these trips were identified, all fishing event data and elephantfish landing data from the entire trip, regardless of method of capture, were obtained. These data extracts (MPI replog 10956) were received 15 February 2017. The first data extract was used to characterise and understand the fisheries taking elephantfish. These characterisations are reported in Sections 2.3.2 and 2.3.3, plus detailed summary tables with greater spatial resolution in Appendix C. The BT extract was used to calculate a standardised CPUE series (Section 3 and Appendix D), while the SN extract was requested for completeness but is not reported. This is because a CPUE series based on the ELE 5 SN was rejected by the AMPWG in 2009 due to the effect of regulations imposed on this fishery for the protection of Hector's dolphins (see Section 2.2.2 and page 271, MPI 2016).

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 E of Starr & Kendrick (2016) – only one landing of 2.3 t from 1994–95 was removed from the ELE 5 landing dataset due to lack of internal corroboration in the trip. The procedures used to prepare the effort data are documented in Starr (2007).

The original level of time stratification for a trip is either by tow, or day of fishing, depending on the type of form used to report the trip information. 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 elephantfish by trip were allocated to the “trip strata” in proportion to the estimated elephantfish catches in each “trip stratum”. In situations when trips recorded landings of elephantfish without any associated estimates of catch in any of the “trip strata” (operators were only required to report the top five (CELR forms) or the top eight (TCER and NCELR forms) species in any fishing event), the elephantfish landings were allocated proportionally to effort (tows for trawl data and length of net set for setnet data) in each “trip stratum”. Trips which fished within an ambiguous statistical area and landed to multiple ELE QMAs were dropped entirely from the characterisation data set. This “Fishstock” expansion is done to maintain the integrity of the data to characterise a specific QMA. Because of the isolation of the ELE 5 QMA, this procedure only resulted in the loss of about 5% of the landings in the data set.

Table 3: Comparison of the total ELE 5 QMR/MHR catch (t) with the sum of the landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data (‘Analysis’ data set) and the sum of the estimated catches from the Analysis data set. Data source: MPI relog 10956: 1989–90 to 2015–16.

Fishing Year	QMR/MHR (t)	Total landed catch (t)	% landed/ QMR/MHR	Total Analysis catch (t)	% Analysis /Landed	Total Estimated Catch (t)	% Estimated /Analysis
89/90	32	20	64	19	93	10	52
90/91	55	47	85	46	98	28	60
91/92	57	57	99	51	90	35	69
92/93	39	42	106	39	94	24	62
93/94	46	39	86	32	81	20	62
94/95	60	57	94	43	76	26	59
95/96	72	71	99	68	96	52	75
96/97	74	70	95	70	99	51	72
97/98	92	95	103	91	96	72	80
98/99	134	130	97	128	98	87	68
99/00	105	97	93	92	95	71	77
00/01	154	147	96	127	86	99	78
01/02	105	104	99	103	99	87	85
02/03	106	104	98	103	99	89	87
03/04	102	94	92	91	97	78	86
04/05	125	120	95	119	99	102	86
05/06	147	145	99	139	96	117	85
06/07	158	155	98	149	96	133	89
07/08	202	189	94	182	96	166	91
08/09	208	202	97	193	96	172	89
09/10	176	176	100	171	97	160	93
10/11	154	160	104	145	91	128	88
11/12	158	155	98	147	95	130	88
12/13	157	157	100	152	97	138	91
13/14	173	168	97	165	98	154	94
14/15	179	166	92	156	94	147	94
15/16	137	130	95	121	93	111	91
Total	3 206	3 095	97	2 941	95	2 485	85

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

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

where 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 .

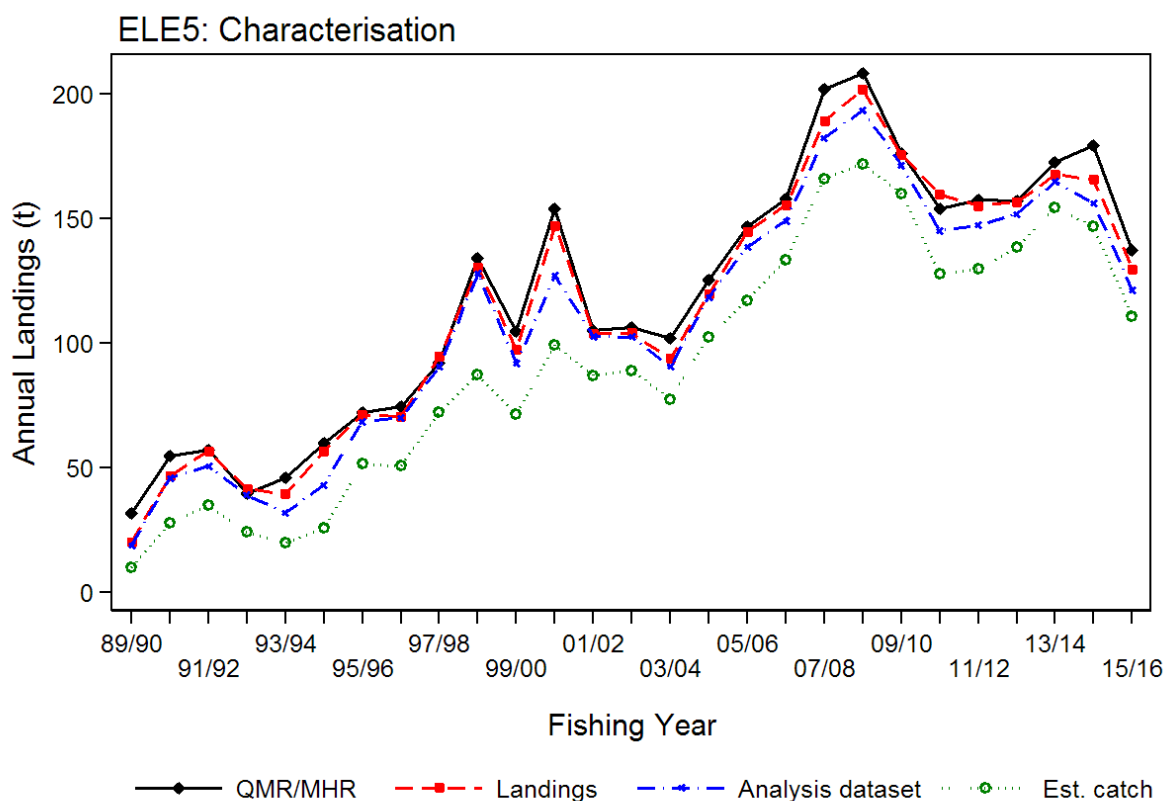


Figure 3: Plot of the ELE 5 catch dataset for totals presented in Table 3.

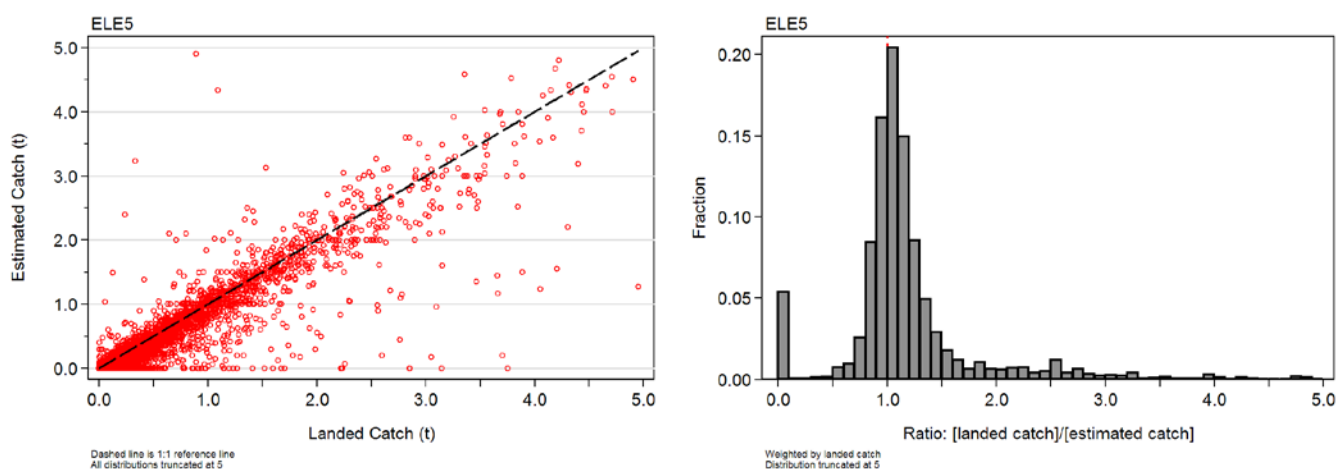


Figure 4: [left panel]: Scatter plot of the sum of landed and estimated elephantfish catch for each trip in the ELE 5 analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

Table 4: Summary statistics pertaining to the reporting of estimated catch from the ELE 5 analysis dataset.

Fishing year	Trips with landed catch but which report no estimated catch			Statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
	Trips: % relative to total trips	Landings: % relative to total landings	Landings (t)	5% quantile	Median	Mean	95% quantile
89/90	51	19	6	0.75	1.15	1.73	5.00
90/91	38	8	5	0.71	1.15	1.53	3.32
91/92	40	6	4	0.40	1.22	1.59	3.50
92/93	45	9	4	0.67	1.38	1.97	4.40
93/94	39	9	4	0.83	1.15	1.55	3.29
94/95	35	6	3	0.70	1.21	1.93	3.59
95/96	35	7	5	0.55	1.23	1.60	3.41
96/97	45	10	8	0.83	1.10	1.46	2.71
97/98	34	7	6	0.65	1.13	1.42	2.95
98/99	43	14	18	0.68	1.20	1.59	3.50
99/00	48	8	8	0.70	1.16	1.53	2.77
00/01	42	7	11	0.60	1.16	1.48	3.42
01/02	43	7	7	0.63	1.09	1.37	2.59
02/03	39	7	7	0.64	1.10	1.26	2.15
03/04	37	4	4	0.42	1.07	1.29	3.20
04/05	39	9	11	0.52	1.07	1.32	2.54
05/06	35	9	13	0.67	1.08	1.35	2.85
06/07	33	6	10	0.55	1.03	1.27	2.64
07/08	14	2	3	0.48	1.07	1.45	2.60
08/09	15	1	2	0.58	1.11	1.53	2.75
09/10	16	2	3	0.65	1.06	1.28	2.60
10/11	16	2	4	0.63	1.10	1.62	3.33
11/12	15	3	5	0.61	1.04	1.54	3.05
12/13	18	3	5	0.57	1.02	1.35	2.53
13/14	14	2	3	0.61	1.07	1.43	3.27
14/15	17	4	6	0.63	1.08	1.57	3.13
15/16	18	4	5	0.62	1.04	1.34	2.59
Total	29	5	171	0.60	1.09	1.46	3.03

The annual totals at different stages of the data preparation procedure are presented in Table 3 and Figure 3. Total landings in the data set are similar to the landings in the QMR/MHR system, except for a 36% shortfall in landings in the first year of data (1989–90: see Table 3). Landings by year in the subsequent fishing years vary from –15% to +6% relative to the QMR/MHR annual totals (Table 3). The shortfall between landed and estimated catch by trip varies from –48% to –6% by fishing year and has averaged at -9% over the most recent 10 years (Table 3). A scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip (Figure 4 [left panel]). The distribution of the ratios of the landed relative to estimated catch shows a skewed distribution with a long tail of ratios greater than 1.0, a mode and median slightly above 1.0 and a mean near 1.5 (Figure 4 [right panel]).

For the ELE 5 dataset across all years, 29% of all trips which landed elephantfish estimated no catch of elephantfish but reported ELE in the landings (Table 4). 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 5% of the total ELE 5 landings over the period, for a total of 171 tonnes (Table 4). 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 reduced the proportion of trips which estimated nil elephantfish while landing this species, and has reduced the proportion of

ELE landings in this category which now account for 2 to 4% of the ELE 5 landings since the introduction of the new forms (Table 4).

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

- discard trips that used more than one method in the trip (except for rock lobster potting, cod potting and fyke nets where just these methods were dropped) or used more than one form type;
- sum effort for each day of fishing in the trip;
- sum estimated catch for each day of fishing in the trip and only use the estimated catch from the top five species sorted by weight in descending order;
- calculate the modal statistical area and target species for each day of fishing, each weighted by the number of fishing events: these are the values assigned to the effort and catch for that day of fishing;
- create a list of “most relevant” target species by summing the landings in the ELE 5 characterisation data set across all years to identify the main target fisheries which capture elephantfish. A second list of target species, consisting of species which were thought to be very unlikely to interact with elephantfish (e.g., orange roughy, hake, arrow squid), was matched with the first list with the intent of dropping all matches. Thirteen of the 35 target species in the initial list fell into this category (Table 5). After this step, the target species list was re-ranked, resulting in 22 species which accounted for 99.6% of the total ELE 5 landings (Table 5). Finally, a further seven species, each with less than 1 t of accumulated catches over 27 years, were dropped, leaving 15 species in the “most relevant” target species list and accounting for 99.5% of the merged landed catches in the ELE 5 characterisation data set (Table 5). This list was used to screen daily effort, discarding entire trips which reported target species that were not in this list because it was felt that the effort from the discarded species was not relevant to elephantfish CPUE analysis. The decision to discard the entire trip rather than just the effort with the non-relevant target species because analysis showed that there was potential for bias when linking elephantfish landings by trip with the remaining partial trip – it is safer to drop the entire trip;
- distribute landings proportionately to each day of the trip based on the elephantfish estimated catch or to the daily effort for trips with no estimated elephantfish 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 reported more than one statistical area or target species in a day of fishing. The CPUE data set was prepared using the “Fishstock” expansion procedure, whereby trips which fished in shared statistical areas and which landed to more than one ELE QMA were dropped. Because of the relative isolation of ELE 5, this procedure only resulted in the loss of just over 5% of the landings, which was thought to be acceptable. Because the remaining data were unequivocally from ELE 5, no further filtering of the data were required.

Table 5: Table of target species fisheries which take ELE 5, summed over the period 1989–90 to 2015–16. The “original rank” column shows the relative rank of all 35 target species in this table. The “final rank” column shows the rank of the remaining 22 target species after 13 species (coloured orange), deemed unlikely to capture ELE 5, were dropped. The “revised cum. %” column calculates the contribution of the 22 remaining target species relative to the total catch in the data set, including catch from the 13 dropped target species. A further seven target species (coloured light blue) were dropped from the “most relevant” list because there was less than 1 t of accumulated landings over the 27 years of data.

Final rank	Original rank	Target species	Common Name	Total ELE 5 landings (t)	Revised cum. %	Original cum. %
1	1	FLA	Flatfish	1127.14	43.96	43.96
2	2	STA	Giant Stargazer	662.54	69.80	69.80
3	3	ELE	Elephantfish	370.12	84.23	84.23
4	4	SPD	Spiny Dogfish	123.72	89.06	89.06
5	5	GUR	Gurnard	89.78	92.56	92.56
6	6	BAR	Barracouta	46.94	94.39	94.39
7	7	SPO	Rig	42.70	96.05	96.05
8	8	LEA	Leatherjacket	21.45	96.89	96.89
9	9	TAR	Tarakihi	19.54	97.65	97.65
10	10	WAR	Blue Warehou	18.26	98.36	98.36
11	11	RCO	Red Cod	15.56	98.97	98.97
12	12	LIN	Ling	8.76	99.31	99.31
13	14	BCO	Blue Cod	2.86	99.42	99.70
14	15	HPB	Hapuku & Bass	1.63	99.49	99.76
15	16	SSK	Smooth Skate	1.25	99.54	99.81
16	18	SWA	Silver Warehou	0.80	99.57	99.89
17	20	SCH	School Shark	0.60	99.59	99.93
18	21	SNA	Snapper	0.59	99.61	99.96
19	24	SPE	Sea Perch	0.21	99.62	99.99
20	26	SKA	Skate	0.05	99.62	100
21	27	GSH	Ghost Shark	0.04	99.63	100
22	29	DIS	Discfish	0.01	99.63	100
–	13	SQU	Arrow Squid	6.98	–	99.58
–	17	HOK	Hoki	1.16	–	99.85
–	19	JMA	Jack Mackerel	0.67	–	99.91
–	22	SCI	Scampi	0.34	–	99.97
–	23	LDO	Lookdown Dory	0.33	–	99.98
–	25	WWA	White Warehou	0.11	–	100
–	28	OEO	Oreos	0.01	–	100
–	30	HAK	Hake	0.00	–	100
–	31	SBW	Southern Blue Whiting	0.00	–	100
–	33	STR	Stingray	0.00	–	100
–	35	BGZ	Banded Giant Stargazer	0.00	–	100
–	34	ORH	Orange Roughy	0.00	–	100
–	32	BNS	Bluenose	0.00	–	100

2.3.2 Description of landing information for ELE 5

2.3.2.1 Destination codes in the ELE landing data

Landing data for elephantfish were provided for every trip which landed ELE 5 at least once, with one record for every reported ELE landing from the trip. Each of these records contained a reported green weight (in kilograms), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a “destination code” (Table 6), 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 6). However, other codes (e.g., A, C or W; Table 6) 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 6) 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 which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set.

Table 6: Destination codes in the unedited landing data received for ELE 5. The “how used” column indicates which destination codes were included in the characterisation analysis. These data summaries have been restricted to ELE 5 over the period 1989–90 to 2015–16.

Destination code	Number events	Green weight (t)	Description	How used
L	10 323	3 120.0	Landed in NZ (to LFR)	keep
J	70	5.3	Returned to sea [Section 72(5)(2)]	keep
E	103	2.3	Eaten	keep
F	172	1.5	Section 111 Recreational Catch	keep
A	15	0.6	Accidental loss	keep
W	1	0.0	Sold at wharf	keep
U	1	0.0	Bait used on board	keep
R	118	34.4	Retained on board	drop
[NULL]	9	5.9	Missing	drop
T	4	2.2	Transferred to another vessel	drop
Q	35	1.9	Holding receptacle on land	drop
D	1	0.0	Discarded (non-ITQ)	drop

2.3.2.2 State codes in the ELE landing data

Seventy-six percent of the valid landing data for ELE 5 were reported using state code GUT, with most of the remaining landings using state code DRE (13%) or HGU (10%) (Table 7). The remaining 2% of landings was spread out among GGO, GRE, or MEA codes. There have been no changes in conversion factors for the three primary state codes (GUT, DRE and HGU) used for processing ELE 5 (Table 8).

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 greenweight, but these were all dropped to avoid potential double counting.

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

State Code	Number Events	Total reported green weight (t)	Description
GUT	7 100	2 389.6	Gutted
DRE	1 707	408.2	Dressed
HGU	1 512	312.4	Headed and gutted
GGO	94	31.8	Gilled and gutted tail-on
GRE	263	20.3	Green (or whole)
MEA	66	3.3	Fish meal
Other	108	8.5	Other ¹

¹ includes (in descending order): Fish meal, missing, Fillets: skin-off, Headed, gutted, and tailed, Surimi, Fillets: skin-on, Dressed-V cut (stargazer), Fins, Fillets: skin-off trimmed.

Table 8: Median conversion factor for the five most important state codes reported (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process ELE 5 landing data. ‘–’: no observations; ‘unk’: conversion factor not reported in the database.

Fishing Year	Landed State Code					
	GUT	DRE	HGU	GGO	GRE	Other
	Median Conversion Factor					
89/90	1.1	–	2.3	–	1	2.3
90/91	1.1	2.3	2.3	–	1	2.575
91/92	1.1	2.3	2.3	–	1	–
92/93	1.1	2.3	2.3	–	1	–
93/94	1.1	2.3	2.3	–	1	2.85
94/95	1.1	2.3	2.3	–	1	2.85
95/96	1.1	2.3	2.3	–	1	2.85
96/97	1.1	2.3	2.3	unk	1	2.85
97/98	1.1	2.3	2.3	unk	1	2.85
98/99	1.1	2.3	2.3	unk	1	5.6
99/00	1.1	2.3	2.3	unk	–	5.6
00/01	1.1	2.3	2.3	unk	1	2.85
01/02	1.1	2.3	2.3	unk	1	5.6
02/03	1.1	2.3	2.3	–	1	5.6
03/04	1.1	2.3	2.3	–	1	5.6
04/05	1.1	2.3	2.3	–	1	5.6
05/06	1.1	2.3	2.3	–	1	5.6
06/07	1.1	2.3	2.3	–	1	5.6
07/08	1.1	2.3	2.3	–	1	5.6
08/09	1.1	2.3	2.3	–	1	3.55
09/10	1.1	2.3	2.3	–	1	5.6
10/11	1.1	2.3	2.3	–	1	4.575
11/12	1.1	2.3	–	–	1	3.55
12/13	1.1	2.3	2.3	–	1	5.6
13/14	1.1	2.3	2.3	–	1	5.6
14/15	1.1	2.3	2.3	–	1	2.85
15/16	1.1	2.3	2.3	–	1	2.85
	Total Landings (t)					
89/90	0.2	–	19.3	–	0.2	0.8
90/91	0.1	13.9	32.5	–	0.1	0.2
91/92	1.5	9.6	46.4	–	0.0	–
92/93	3.6	16.6	21.7	–	0.2	–
93/94	2.6	15.3	21.8	–	0.3	0.0
94/95	5.3	10.3	38.1	–	0.6	0.0
95/96	6.2	32.5	32.1	–	0.0	0.5
96/97	17.1	25.0	23.4	2.9	0.0	2.4
97/98	23.3	52.9	12.7	5.6	0.3	0.2
98/99	47.6	60.6	18.5	2.0	2.9	0.7
99/00	51.1	31.4	9.4	5.5	–	0.1
00/01	85.7	30.2	18.6	12.3	0.0	0.6
01/02	83.6	13.8	0.8	3.6	2.0	0.3
02/03	99.5	3.5	1.1	–	0.1	0.0
03/04	91.7	1.9	0.1	–	0.1	0.1
04/05	113.3	5.5	0.4	–	0.7	0.0
05/06	139.1	2.9	1.1	–	0.9	0.8
06/07	149.9	6.7	0.3	–	0.6	0.0
07/08	188.0	6.0	0.6	–	0.2	1.3
08/09	196.3	2.7	1.5	–	2.2	1.2
09/10	171.5	3.3	0.2	–	1.9	0.1
10/11	158.4	2.3	2.0	–	0.2	0.0
11/12	142.9	13.4	–	–	0.2	0.1
12/13	147.1	7.7	1.6	–	0.3	0.3
13/14	160.8	7.3	1.1	–	0.1	0.0
14/15	154.8	13.6	0.1	–	5.1	0.9
15/16	120.5	7.5	0.6	–	0.5	1.1
Total	2 361.7	396.6	305.9	31.8	19.6	11.7

Table 9: Distribution by form type for landed catch by weight for each fishing year in the ELE 5 landings dataset. Also provided are the number of days fishing and the associated distribution of days fishing by form type for the effort data in the ELE 5 dataset. See Appendix A for definitions of abbreviations used in this table.

	Landings (%) ¹			Days Fishing (%) ²				Days Fishing				Total
	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	CELR	TCEPR	TCER	NCELR	
89/90	93	7	–	90	10	–	–	437	47	–	–	484
90/91	98	2	–	87	13	–	–	573	85	–	–	658
91/92	90	10	–	85	15	–	–	529	90	–	–	619
92/93	86	14	–	92	8	–	–	540	49	–	–	589
93/94	94	6	–	100	0	–	–	600	2	–	–	602
94/95	96	4	–	99	1	–	–	539	4	–	–	543
95/96	88	12	–	88	12	–	–	586	80	–	–	666
96/97	99	1	–	99	1	–	–	466	7	–	–	473
97/98	94	6	–	94	6	–	–	478	28	–	–	506
98/99	94	6	–	85	15	–	–	808	148	–	–	956
99/00	99	1	–	84	16	–	–	719	135	–	–	854
00/01	97	3	–	82	18	–	–	715	161	–	–	876
01/02	95	5	–	71	29	–	–	757	312	–	–	1 069
02/03	99	1	–	78	22	–	–	881	246	–	–	1 127
03/04	100	0	–	89	11	–	–	715	84	–	–	799
04/05	100	0	–	90	10	–	–	853	91	–	–	944
05/06	98	2	–	69	31	–	–	873	385	–	–	1 258
06/07	94	2	4	62	27	–	11	951	412	–	162	1 525
07/08	0	83	17	0.4	21	60	18	6	345	966	292	1 609
08/09	0	95	5	1	11	76	13	9	146	1 000	169	1 324
09/10	0	86	14	–	15	69	15	–	212	949	212	1 373
10/11	0	86	14	–	21	66	13	–	264	826	158	1 248
11/12	0	87	13	–	22	68	10	–	307	952	135	1 394
12/13	0	83	17	0.2	25	64	11	3	437	1 118	193	1 751
13/14	0	83	17	0.2	17	67	15	4	287	1 144	260	1 695
14/15	0	87	13	0.1	23	59	18	2	380	978	293	1 653
15/16	0	93	7	0.1	26	63	11	2	405	975	170	1 552
Average or Total	49	44	7	43	18	32	7	12 046	5 149	8 908	2 044	28 147

¹ Percentages of landed greenweight

² Percentages of number of days fishing

2.3.2.3 Form types used in the ELE landing and effort data

Most (over 90%) of the ELE 5 landings were reported on CELR forms up to 2006–07, with only minor amounts on the CLR form (Table 9). However, reporting on the CELR form disappeared after the TCER form was introduced in 2007–08. The NCELR form, used exclusively to report setnet effort and landings from 2006–07, also contributed to the displacement of the CELR form. The CLR form is used to report landings forms other than the CELR and NCELR forms, particularly the TCER and TCEPR trawl effort forms. There was a corresponding drop in the usage of the CELR form in the effort data, beginning from 2006–07 (calculated as days fishing, Table 9) and an increase in the use of other form types in the effort data set after that year.

2.3.3 Description of the ELE 5 fishery

2.3.3.1 Introduction

As discussed in Section 2.3.1, landings were matched with effort for every trip while maintaining the integrity of the QMA-specific information. This procedure worked well for ELE 5, with only 5% of the catch lost because trips were dropped which fished in shared statistical areas and reported landings from more than one QMA. This amount of lost landings was considered acceptable for the purposes of characterising the fishery and for CPUE analysis.

The characterisation information in this section is presented in three statistical area groupings, with eastern Foveaux Strait represented by Statistical Areas 025 and 026, western Foveaux Strait by Statistical Areas 030 to 032 (although the majority of the catch occurs in 030) and Stewart Island, represented by Statistical Areas, 027–029 (see Appendix B for the locations of these Areas):

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

Elephantfish in ELE 5 are primarily (87%) taken by the bottom trawl method, with the remaining catch taken by the setnet method (Figure 5; Table 10). Other capture methods in ELE 5 are negligible, accounting for less than 1% of the landings over the 27 years (Table 11). Most of the setnet landings come from the eastern and western parts of Foveaux Strait (Figure 6).

2.3.3.3 Fine scale distribution of landings for setnet

Fine scale landings and effort data are available from 1 Oct 2006 onwards for the setnet fleet and from 1 Oct 2007 for the bottom trawl fleet. A plot (Figure 7) of bottom trawl landings aggregated by $0.1 \times 0.1^\circ$ cell, summed over ten years, shows that elephantfish are taken in both the eastern and western sections of Foveaux Strait and along the south-eastern shore of the South Island all the way to the Catlins. There seems to be little capture of elephantfish by bottom trawl to the west, off the coast of Fiordland. A similar plot of elephantfish setnet landings in ELE 5 is compromised by the MPI “3-vessel” rule, with only a scattering of the $0.1 \times 0.1^\circ$ grids meeting the criterion (Figure 8). The actual distribution of grids is similar to that seen in Figure 7, concentrated in the eastern and western parts of Foveaux Strait and extending along the southeast shore to the Catlins, although small amounts of elephantfish setnet catch are also taken along the western coast of Fiordland. Neither the bottom trawl nor the setnet fisheries show year-to-year patterns of change in fishing locations (plots available but not shown).

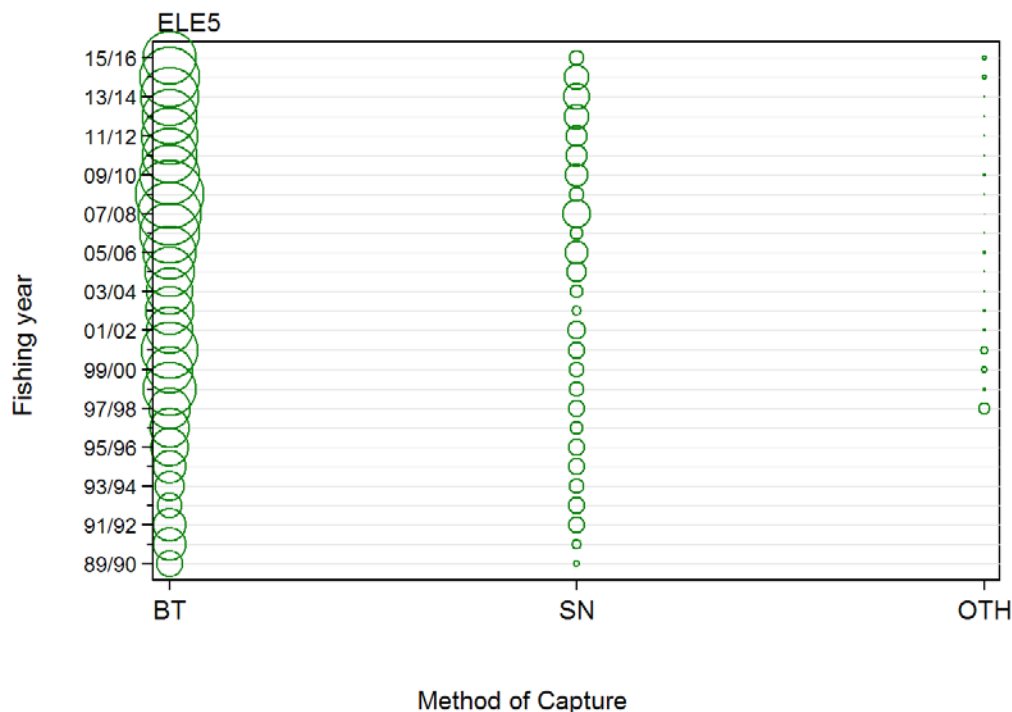


Figure 5: Distribution of landings for the two major fishing methods by fishing year from trips which landed ELE 5. Circles are proportional to the catch totals by method and fishing year, with the largest circle representing 198 t (in 2008–09 for BT).

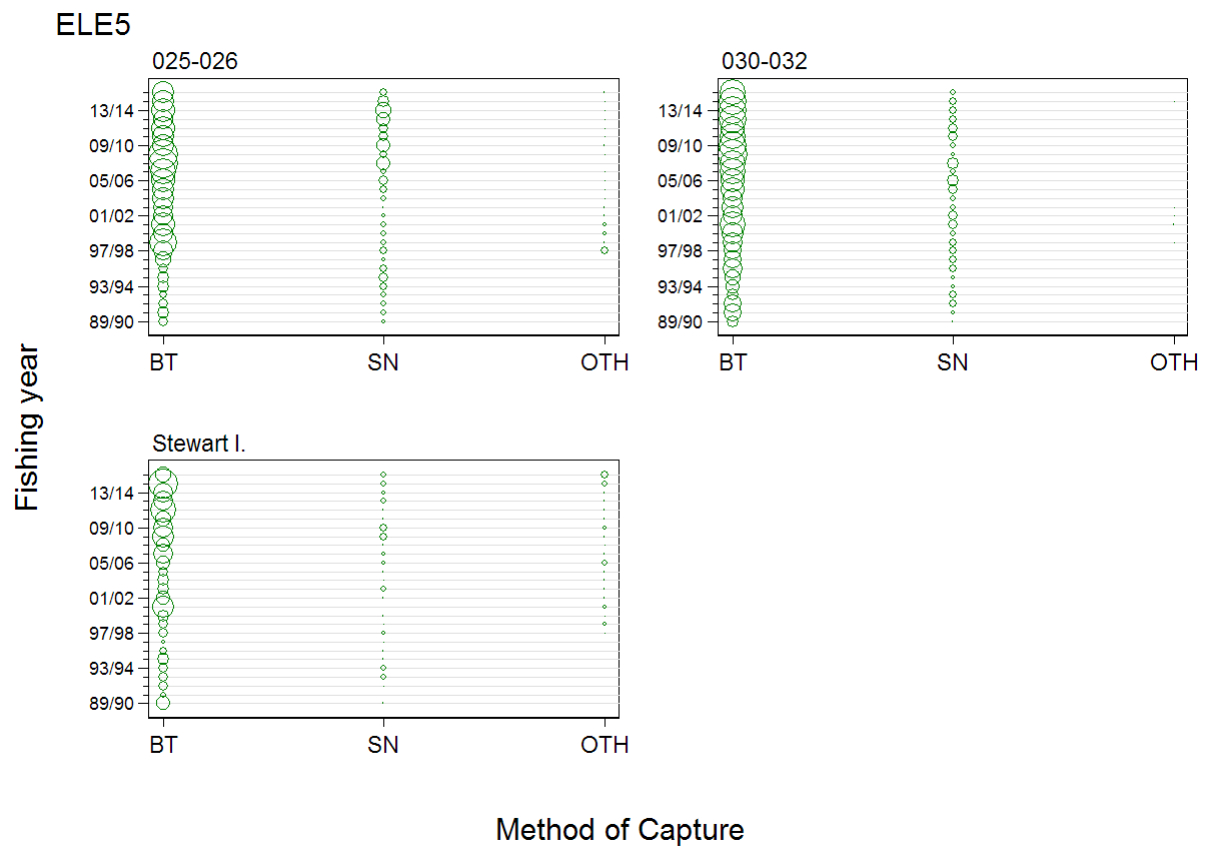


Figure 6: Distribution of elephantfish landings for the major fishing methods by fishing year by ELE 5 statistical area grouping from 1989–90 to 2015–16. Circles are proportional to the catch totals by method and fishing year within each sub-graph: [025-026]: largest circle= 86 t in 07/08 for BT; [030-032]: largest circle= 107 t in 08/09 for BT; [Stewart I.]: largest circle= 18 t in 14/15 for BT.

Table 10: Total landings (t) by fishing year for elephantfish for the two important fishing methods in ELE 5 from trips which landed elephantfish, for the period from 1989–90 to 2015–16 in the three statistical area groupings and all of ELE 5. ‘–’: no observations.

Fishing Year	Group [025-026] (t)			Group [030-032] (t)			Group [Stewart I] (t)			ELE 5 (t)		
	BT	SN	OTH	BT	SN	OTH	BT	SN	OTH	BT	SN	OTH
89/90	8.5	2.1	–	16.8	0.1	–	4.0	0.0	–	29.4	2.3	–
90/91	13.4	2.7	–	35.6	2.2	–	0.8	–	–	49.9	4.9	–
91/92	9.2	3.6	–	35.0	7.4	–	1.7	0.0	–	45.9	11.0	–
92/93	6.0	2.7	–	19.4	9.0	–	1.6	0.8	–	26.9	12.5	–
93/94	11.9	6.4	–	23.4	1.9	–	2.0	0.5	–	37.3	8.9	–
94/95	12.3	10.1	–	31.9	2.6	–	2.8	0.2	–	47.1	12.9	–
95/96	10.2	5.8	–	49.3	5.6	–	1.1	0.1	–	60.6	11.5	–
96/97	25.2	1.0	–	40.7	7.1	–	0.3	0.0	–	66.2	8.1	–
97/98	34.7	5.1	5.7	39.1	5.8	–	1.6	0.2	0.0	75.4	11.1	5.7
98/99	70.7	4.3	0.1	50.3	6.1	0.1	2.0	0.0	0.3	123.0	10.4	0.5
99/00	34.5	3.8	1.6	56.9	5.3	–	2.7	0.0	0.0	94.1	9.2	1.6
00/01	54.7	2.6	2.2	75.3	9.9	0.7	8.5	–	0.3	138.5	12.4	3.1
01/02	35.6	2.2	0.5	50.5	11.7	0.0	4.2	0.1	0.1	90.3	14.0	0.6
02/03	38.0	0.5	0.4	60.4	3.4	0.0	2.9	0.5	0.1	101.3	4.4	0.5
03/04	46.7	3.5	0.0	45.2	3.7	–	2.5	0.0	0.1	94.4	7.2	0.1
04/05	43.2	5.3	0.0	63.1	12.0	–	1.8	0.1	0.0	108.1	17.3	0.0
05/06	56.2	9.1	0.0	61.5	15.3	–	3.6	0.3	0.6	121.3	24.7	0.6
06/07	61.4	4.0	0.0	82.0	3.0	–	6.9	0.3	0.0	150.4	7.3	0.0
07/08	86.2	16.9	–	78.7	16.0	–	3.9	0.2	0.0	168.8	33.1	0.0
08/09	81.4	7.1	0.0	106.9	2.4	–	9.4	0.9	0.0	197.6	10.5	0.0
09/10	49.3	18.8	0.1	94.1	5.1	–	7.3	1.0	0.4	150.7	24.9	0.5
10/11	49.0	10.2	0.0	79.1	10.9	–	4.6	0.1	0.0	132.6	21.3	0.0
11/12	52.4	11.0	0.0	71.3	10.4	–	12.3	0.1	0.0	136.0	21.5	0.0
12/13	34.9	20.3	0.0	86.4	6.5	–	8.3	0.5	0.1	129.6	27.4	0.1
13/14	50.3	23.8	0.0	84.5	6.2	–	7.3	0.3	0.0	142.2	30.3	0.1
14/15	45.1	14.9	0.0	90.5	9.3	0.0	17.7	0.8	0.8	153.3	25.1	0.8
15/16	43.4	6.2	0.2	76.8	3.3	–	5.1	0.9	1.3	125.4	10.4	1.4
Average	1064.4	204.0	10.9	1604.8	182.4	0.7	126.9	8.2	4.0	2796.1	394.6	15.7

Table 11: Distribution of landings (%) by fishing year for elephantfish for the two important fishing methods in ELE 5 from trips which landed elephantfish, for the period from 1989–90 to 2015–16 in the three statistical area groups and all of ELE 5. ‘–’: no observations.

Fishing Year	Group [025-026] (%)			Group [030-032] (%)			Group [Stewart I] (%)			ELE 5 (%)		
	BT	SN	OTH	BT	SN	OTH	BT	SN	OTH	BT	SN	OTH
89/90	80.5	19.5	–	99.1	0.9	–	99.0	1.0	–	92.9	7.1	–
90/91	83.1	16.9	–	94.3	5.7	–	100.0	–	–	91.1	8.9	–
91/92	71.7	28.3	–	82.5	17.5	–	99.2	0.8	–	80.6	19.4	–
92/93	68.6	31.4	–	68.2	31.8	–	67.0	33.0	–	68.2	31.8	–
93/94	65.0	35.0	–	92.4	7.6	–	79.0	21.0	–	80.8	19.2	–
94/95	54.8	45.2	–	92.4	7.6	–	94.3	5.7	–	78.4	21.6	–
95/96	63.9	36.1	–	89.8	10.2	–	88.4	11.6	–	84.0	16.0	–
96/97	96.1	3.9	–	85.2	14.8	–	97.1	2.9	–	89.1	10.9	–
97/98	76.4	11.1	12.5	87.1	12.9	–	87.5	12.5	0.0	81.8	12.0	6.2
98/99	94.1	5.7	0.2	89.1	10.8	0.1	86.6	0.2	13.2	91.9	7.8	0.4
99/00	86.5	9.6	3.9	91.4	8.6	–	98.6	1.0	0.4	89.7	8.8	1.5
00/01	92.0	4.3	3.7	87.7	11.5	0.8	96.9	–	3.1	89.9	8.1	2.0
01/02	93.0	5.7	1.4	81.2	18.8	0.0	95.3	2.9	1.9	86.1	13.3	0.6
02/03	97.7	1.3	1.0	94.6	5.4	0.0	83.7	14.7	1.6	95.4	4.2	0.4
03/04	93.1	6.9	0.0	92.4	7.6	–	97.0	0.2	2.8	92.8	7.1	0.1
04/05	89.1	10.9	0.0	84.0	16.0	–	93.6	5.1	1.3	86.1	13.8	0.0
05/06	86.0	13.9	0.1	80.0	20.0	–	80.0	7.6	12.4	82.7	16.9	0.4
06/07	93.9	6.1	0.0	96.5	3.5	–	95.2	4.2	0.6	95.4	4.6	0.0
07/08	83.6	16.4	–	83.1	16.9	–	95.6	4.0	0.4	83.6	16.4	0.0
08/09	91.9	8.0	0.0	97.8	2.2	–	90.7	9.1	0.2	94.9	5.0	0.0
09/10	72.2	27.6	0.2	94.9	5.1	–	84.2	11.6	4.1	85.6	14.2	0.3
10/11	82.8	17.2	0.0	87.8	12.2	–	96.5	2.7	0.8	86.2	13.8	0.0
11/12	82.6	17.4	0.0	87.3	12.7	–	99.1	0.7	0.2	86.3	13.6	0.0
12/13	63.2	36.8	0.0	93.0	7.0	–	93.3	5.9	0.8	82.5	17.4	0.0
13/14	67.8	32.1	0.0	93.2	6.8	–	95.7	3.8	0.5	82.4	17.6	0.0
14/15	75.1	24.8	0.1	90.6	9.4	0.0	91.7	4.3	4.0	85.5	14.0	0.5
15/16	87.2	12.5	0.3	95.9	4.1	–	70.8	11.9	17.4	91.4	7.6	1.0
Average	83.3	15.8	0.9	89.7	10.3	0.0	91.1	6.0	2.9	87.2	12.3	0.5

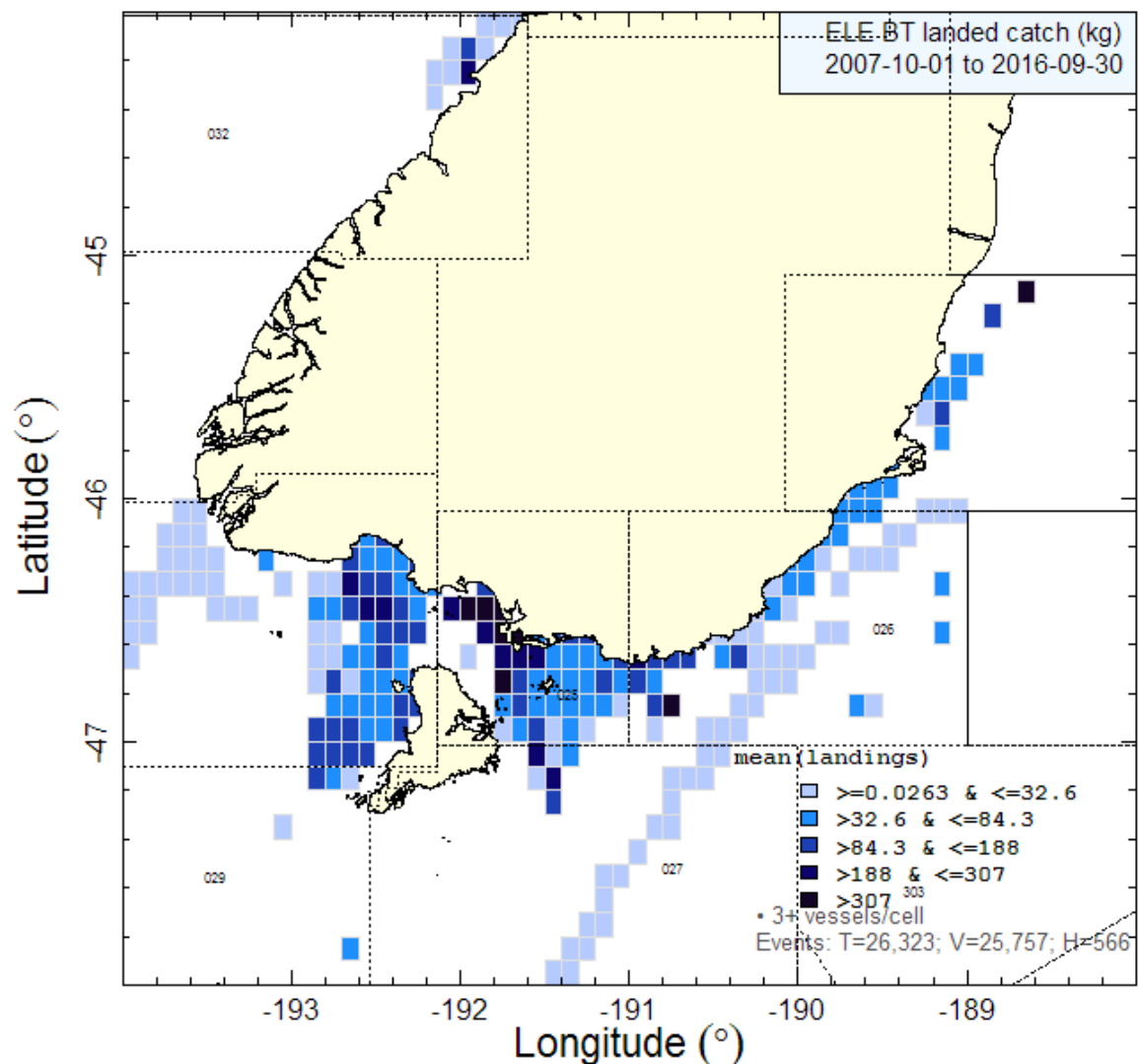


Figure 7: Spatial distribution of elephantfish bottom trawl landings (t) in the southern part of the South Island, arranged in $0.1^{\circ} \times 0.1^{\circ}$ grids, summed from 2007–08 to 2015–16. Legend colours divide the distribution of total landings into 25%, 50%, 75%, 90% and 95% quantiles. Only grids which have at least three reporting vessels are plotted. Note that this requirement has dropped 566 of 26 323 events. Boundaries are shown for the general statistical areas plotted in Appendix B.

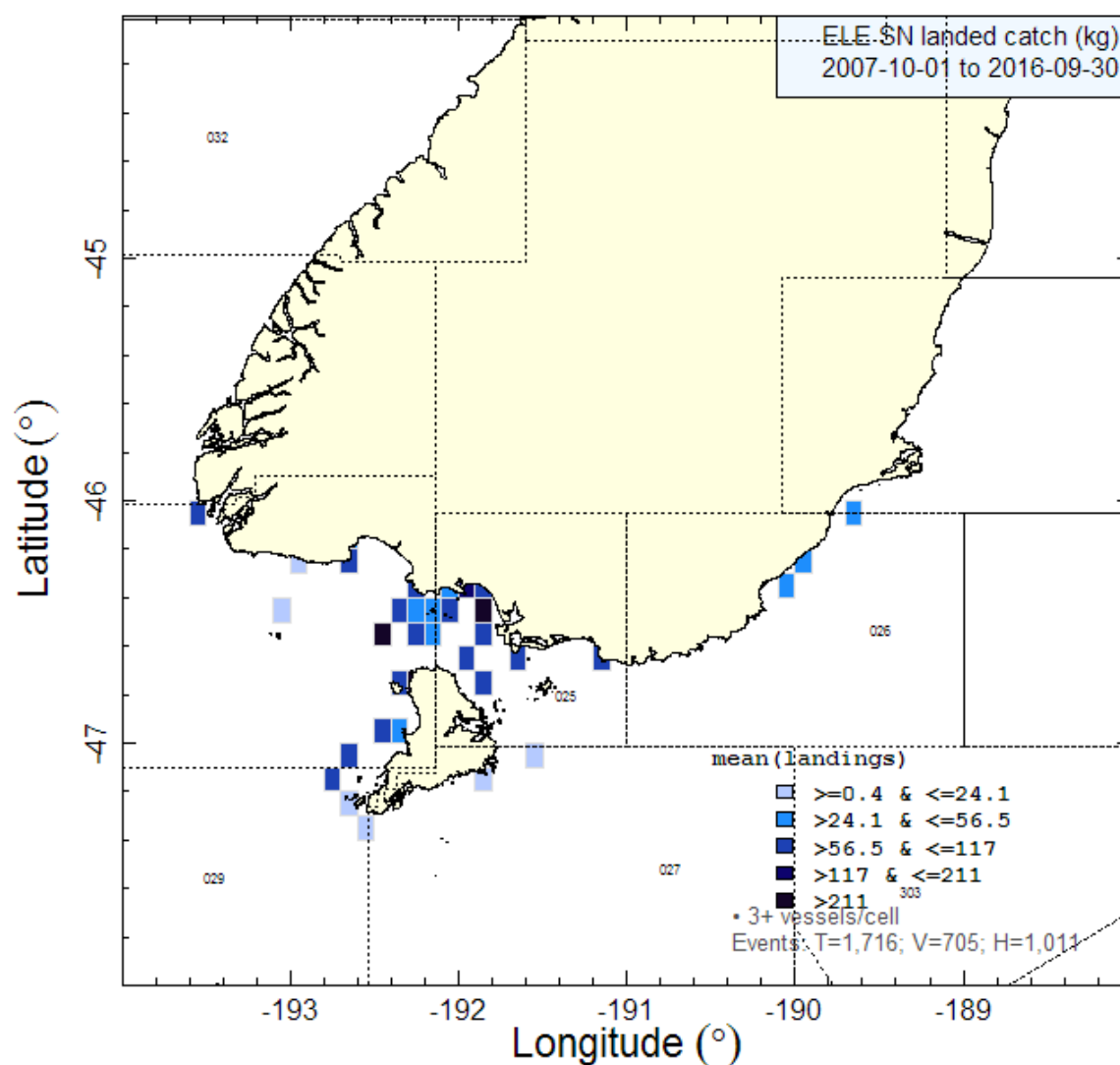


Figure 8: Spatial distribution of elephantfish setnet landings(t) in the southern part of the South Island, arranged in $0.1^{\circ} \times 0.1^{\circ}$ grids, summed from 2006–07 to 2015–16. Legend colours divide the distribution of total landings into 25%, 50%, 75%, 90% and 95% quantiles. Only grids which have at least three reporting vessels are plotted. Note that this requirement has resulted in dropping 1011 of 1716 events. Boundaries are shown for the general statistical areas plotted in Appendix B.

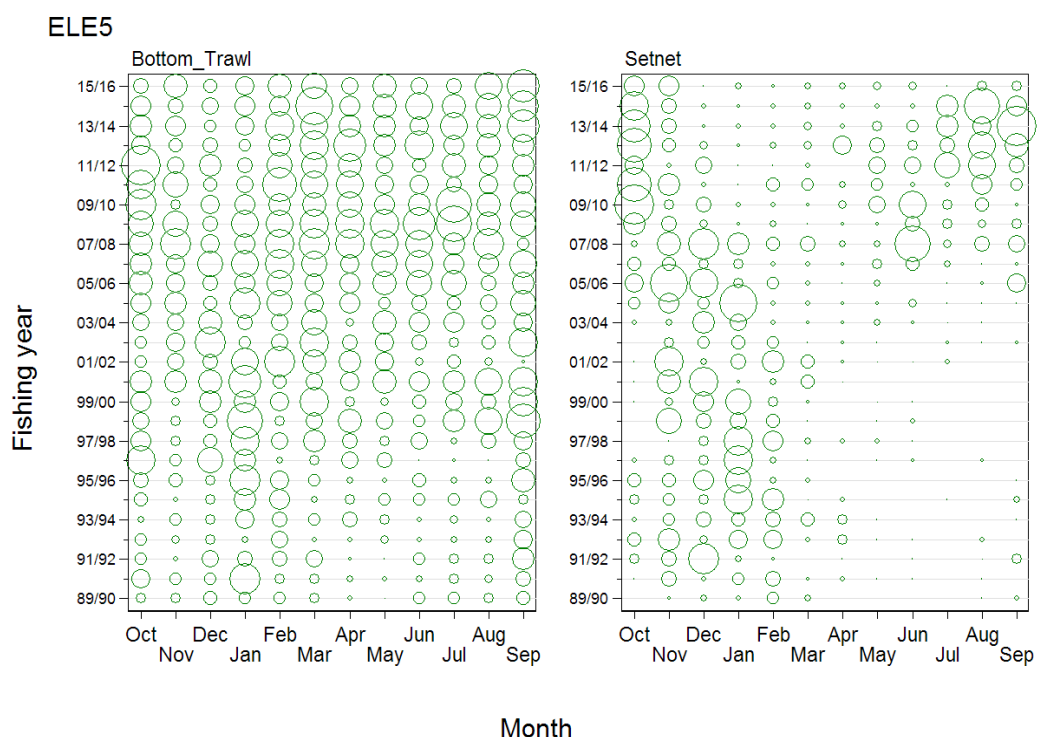


Figure 9: Distribution of landings for the two major fishing methods by month and fishing year from trips which landed ELE 5. Circles are proportional to the catch totals by month and fishing year within each sub-graph: [Bottom_Trawl]: largest circle= 32 t in 11/12 for Oct; [Setnet]: largest circle= 11 t in 13/14 for Sep.

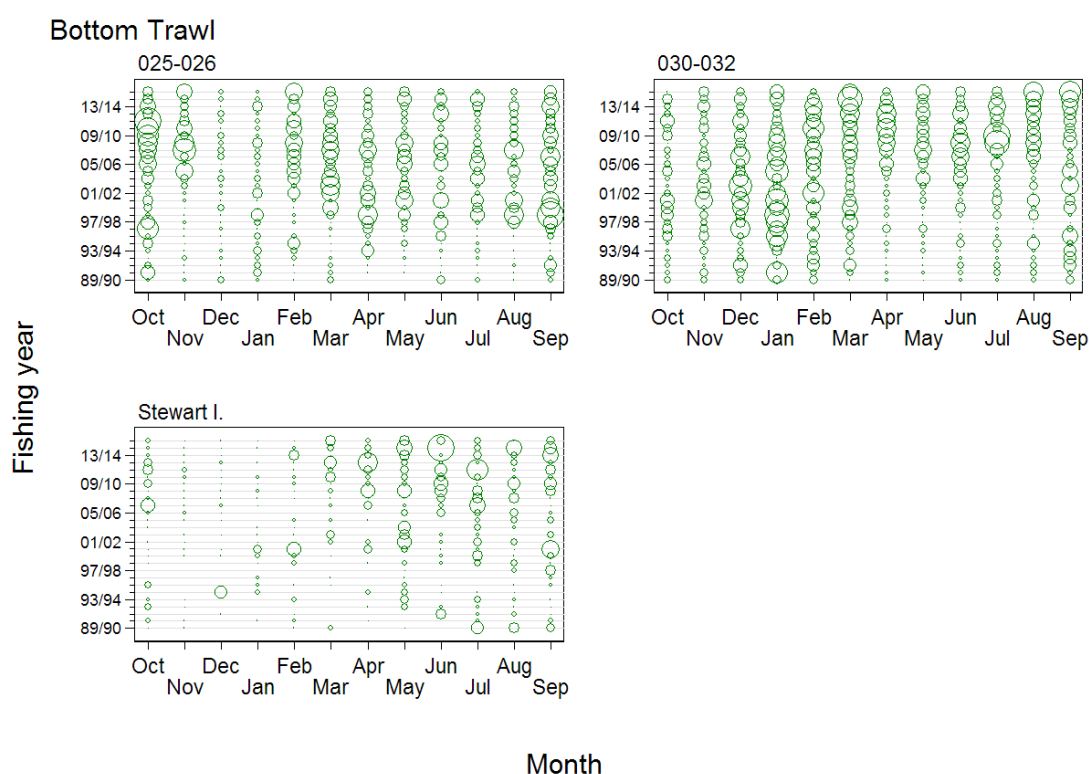


Figure 10: Distribution of elephantfish landings for bottom trawl by month and fishing year by ELE 5 statistical area grouping from 1989–90 to 2015–16. Circles are proportional to the catch totals by month and fishing year within each sub-graph: [025-026]: largest circle= 24 t in 11/12 for Oct; [030-032]: largest circle= 27 t in 09/10 for Jun; [Stewart I.]: largest circle= 8.2 t in 14/15 for Jun. These plot data are tabulated in Table C.1A-C.

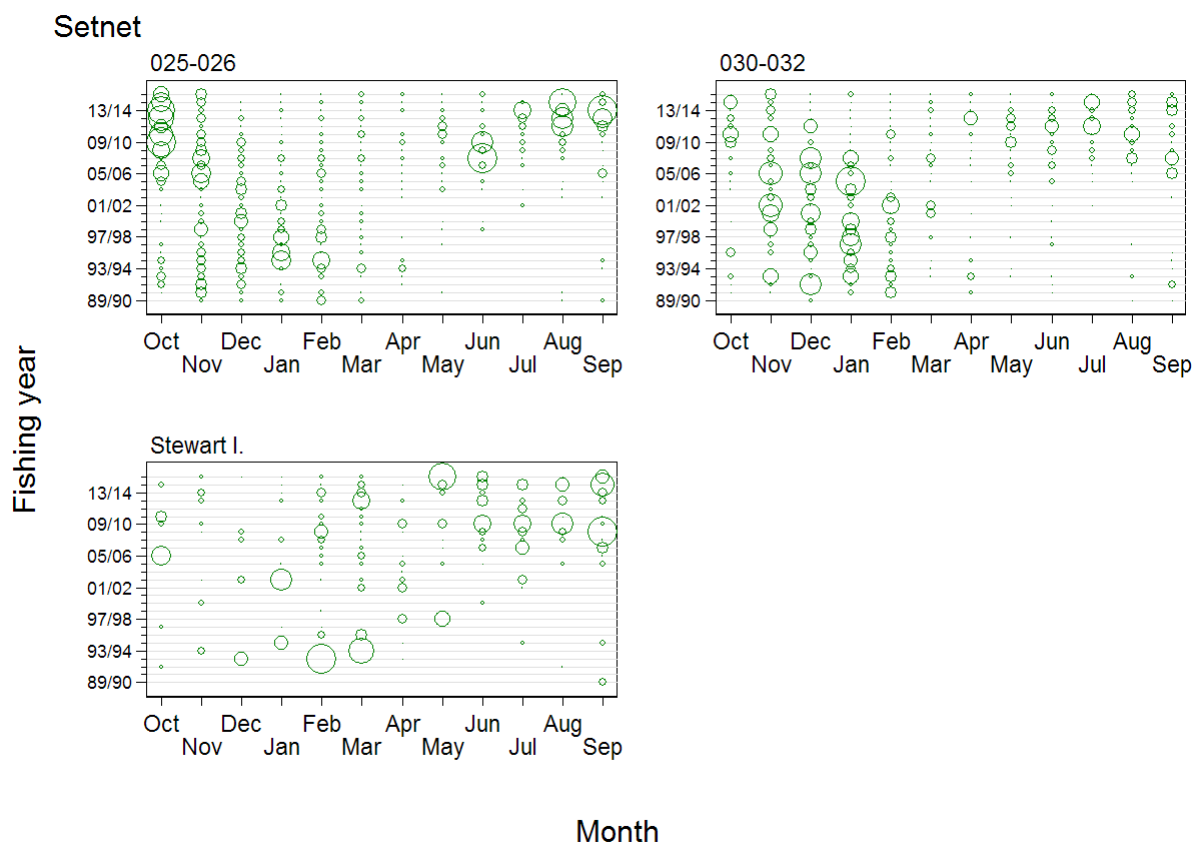


Figure 11: Distribution of elephantfish landings for setnet by month and fishing year by ELE 5 statistical area grouping from 1989–90 to 2015–16. Circles are proportional to the catch totals by month and fishing year within each sub-graph: [025-026]: largest circle= 10 t in 07/08 for Jun; [030-032]: largest circle= 11 t in 04/05 for Jan; [Stewart I.]: largest circle= 0.65 t in 92/93 for Feb. These plot data are tabulated in Table C.2A-C.

2.3.3.4 Seasonal distribution of landings

Landings of ELE 5 in the bottom trawl fishery do not show strong seasonality, with fairly uniform landings across all months of the fishing year, particularly from the late 1990s and early 2000s (left panel, Figure 9; Table 12). There is a suggestion of seasonality in the ELE 5 setnet landings, with the landings confined to the spring and summer months up to the mid-2000s (right panel, Figure 9; Table 13). However, after the mid-2000s, setnet landings of ELE 5 extend right across the year, particularly towards the end of the fishing year. Bottom trawl landings by statistical area region show similar seasonal distribution patterns on both sides of Foveaux Strait, with each region encompassing the full year from the early 2000s (Figure 10). The seasonal distribution of setnet landings by statistical area grouping is also very similar on both sides of Foveaux Strait, with each side mirroring the overall seasonal pattern (Figure 11).

2.3.3.5 Distribution of landings by declared target species

Most of the landings from the ELE 5 bottom trawl fishery taking elephantfish were targeted at FLA or one of the species making up this complex (left panel, Figure 12). Elephantfish were also taken when targeting STA with bottom trawl. There is elephantfish catch by bottom trawl when targeted at ELE as well (Table 14). The remaining target species, which are relatively minor in terms of accumulated catch, include SPD, GUR and BAR. The dominant target species in the ELE 5 setnet fisheries are the

inshore shark species: SPO and SCH (right panel, Figure 12, Table 14). Elephantfish are only occasionally targeted by setnet in ELE 5 (right panel, Figure 12).

The spatial pattern of targeting in the ELE 5 bottom trawl catch is similar on both sides of Foveaux Strait (Figure 13), with FLA dominating, followed by STA. STA seems to be somewhat more important in the western Foveaux Strait statistical areas compared to the eastern areas (Figure 13). Unsurprisingly, STA is the most important bottom trawl target species in the outlying southern statistical areas around Stewart Island. However, ELE 5 catches in these areas are an order of magnitude lower than in the main Foveaux Strait statistical areas. There seems to be little difference in the setnet target species preferences among the eastern and western Foveaux Strait regions (Figure 14).

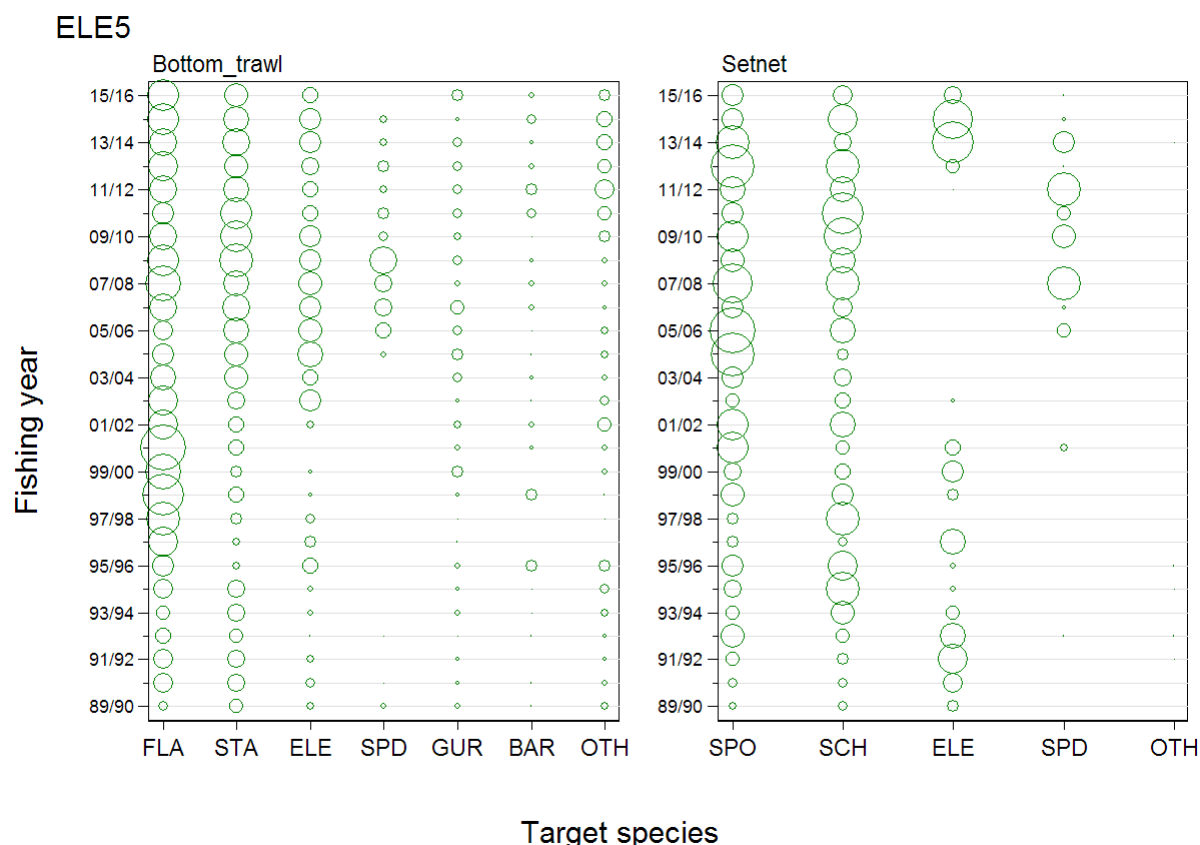


Figure 12: Distribution of landings for the two major fishing methods by target species and fishing year from trips which landed ELE 5. Circles are proportional to the catch totals by target species and fishing year within each sub-graph: [Bottom_trawl]: largest circle= 119 t in 00/01 for FLA; [Setnet]: largest circle= 17 t in 05/06 for SPO.

Table 12: Distribution of bottom trawl landings (%) for elephantfish by month and fishing year from trips which landed ELE 5, from 1989–90 to 2015–16. The final column shows the total ELE 5 BT landings by fishing year.

Fishing year	Distribution (%)												Total (t)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	6.8	8.3	12.1	11.2	9.6	7.7	2.2	0.0	11.0	9.5	7.5	14.1	29.37
90/91	15.3	6.5	6.5	41.1	5.0	4.8	1.6	1.0	2.1	3.8	3.2	9.1	49.87
91/92	6.1	1.4	14.8	11.3	12.1	13.3	0.8	0.1	5.8	5.5	5.0	23.7	45.86
92/93	11.1	5.1	9.5	3.7	24.0	2.6	1.7	4.8	2.1	3.9	3.0	28.3	26.92
93/94	3.2	7.1	5.2	18.9	12.6	7.5	13.8	6.7	1.2	4.3	1.4	18.0	37.28
94/95	8.5	1.5	5.5	22.7	17.9	1.7	4.6	5.7	7.0	6.3	13.5	5.1	47.05
95/96	9.2	7.4	3.9	31.6	11.8	5.5	1.5	1.1	6.6	1.3	1.3	18.8	60.61
96/97	27.1	4.2	21.7	15.3	1.2	3.6	10.3	7.9	0.0	0.6	0.2	7.9	66.23
97/98	11.6	2.9	5.6	23.2	7.6	13.3	6.6	2.7	8.4	1.0	6.5	10.6	75.39
98/99	5.5	2.1	3.6	22.1	2.0	5.3	10.4	5.0	2.6	8.5	13.1	19.7	123.00
99/00	9.8	1.4	11.7	10.8	8.6	18.9	2.1	1.9	4.5	6.9	4.8	18.7	94.09
00/01	7.6	8.0	9.1	15.9	2.8	4.1	5.2	8.8	6.4	7.6	10.9	13.7	138.47
01/02	3.1	6.7	5.8	17.8	23.6	14.5	11.6	8.5	1.5	4.6	2.1	0.2	90.35
02/03	2.8	8.1	20.9	3.2	6.0	18.2	4.6	7.5	5.5	2.3	3.7	17.1	101.32
03/04	7.1	6.8	12.8	5.6	6.4	15.1	2.0	12.6	9.7	9.8	4.3	7.9	94.43
04/05	8.4	10.3	4.0	18.8	13.0	7.1	7.9	3.2	5.0	3.6	5.5	13.2	108.11
05/06	10.3	6.0	4.0	7.2	10.9	6.1	7.8	10.5	11.6	11.9	4.5	9.1	121.25
06/07	6.6	4.7	9.7	10.4	11.6	9.9	5.2	8.9	10.8	6.0	5.9	10.2	150.39
07/08	7.3	11.7	4.6	5.1	10.3	12.0	10.4	9.5	9.3	6.7	11.4	1.6	168.78
08/09	7.0	7.5	2.6	8.4	7.7	9.6	8.9	9.2	11.8	13.5	6.5	7.4	197.63
09/10	14.0	1.7	4.8	6.4	6.9	7.9	9.1	6.0	6.6	18.8	8.1	9.8	150.68
10/11	13.9	9.9	2.8	4.6	18.4	11.7	12.0	5.3	6.2	3.8	5.5	5.9	132.63
11/12	23.9	4.7	7.5	3.7	10.0	10.0	9.4	4.9	3.3	8.8	5.6	8.0	136.04
12/13	5.6	3.4	3.7	2.6	8.3	13.7	16.8	7.6	13.5	7.0	9.3	8.4	129.57
13/14	8.0	6.3	2.0	4.9	13.0	11.2	7.3	7.4	5.0	10.8	8.6	15.4	142.19
14/15	5.5	3.6	3.9	6.1	6.2	19.7	6.0	8.4	10.6	8.4	9.0	12.5	153.29
15/16	3.6	10.3	3.1	6.0	9.3	11.6	5.0	10.1	5.3	4.2	13.2	18.3	125.36
Average	9.0	6.1	6.6	10.6	9.6	10.6	7.6	7.0	7.1	7.5	7.1	11.2	2796.14 ¹

¹ total landings for all years

Table 13: Distribution of setnet landings (%) for elephantfish by month and fishing year from trips which landed ELE 5, from 1989–90 to 2015–16. The final column shows the total ELE 5 SN landings by fishing year.

Fishing year	Distribution (%)												Total (t)
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	–	4.5	17.5	8.3	46.2	12.1	–	–	–	–	1.3	10.0	2.25
90/91	0.2	34.1	3.9	18.9	37.3	1.3	3.3	0.7	0.1	–	0.3	–	4.90
91/92	7.3	15.7	65.4	2.9	1.1	–	0.1	–	0.1	–	0.1	7.3	11.05
92/93	11.4	29.3	5.2	21.9	22.1	1.1	6.6	0.4	0.3	–	1.8	–	12.52
93/94	2.2	13.2	19.8	16.9	20.8	16.8	9.8	0.1	–	–	–	0.4	8.85
94/95	5.2	9.0	6.0	48.6	27.1	0.0	2.0	–	–	0.1	–	2.0	12.93
95/96	12.5	11.9	29.5	40.5	3.6	1.9	–	–	–	–	–	0.1	11.51
96/97	1.9	8.8	9.3	73.6	3.3	0.2	–	0.2	1.4	–	1.2	–	8.13
97/98	–	0.4	8.2	56.3	26.7	4.0	1.8	2.3	0.2	–	–	–	11.06
98/99	–	45.9	16.9	22.0	13.3	0.3	–	0.1	1.5	–	–	–	10.39
99/00	0.2	5.4	32.5	51.7	8.6	1.2	–	0.0	0.4	–	–	–	9.18
00/01	0.1	32.5	51.4	0.7	2.9	12.5	0.0	–	–	–	–	–	12.43
01/02	0.1	46.6	2.1	12.9	26.3	10.2	0.6	0.0	0.0	1.1	–	–	14.01
02/03	–	20.5	20.7	29.8	22.9	0.2	1.3	0.2	–	1.3	0.4	2.6	4.44
03/04	2.9	5.6	50.4	29.2	2.6	1.4	0.7	6.0	0.9	0.0	0.3	–	7.21
04/05	5.9	17.3	6.8	63.1	1.1	1.0	0.3	0.6	3.6	0.1	0.1	0.2	17.35
05/06	11.5	43.0	25.2	2.8	3.8	0.9	0.1	1.4	–	0.0	0.3	11.1	24.75
06/07	17.1	18.5	11.8	11.1	2.4	3.3	0.9	9.5	19.2	3.9	0.4	1.8	7.26
07/08	1.1	12.1	20.3	11.8	3.7	5.7	0.9	0.8	30.2	1.4	4.9	7.0	33.07
08/09	33.4	16.6	5.1	0.9	3.9	0.3	0.7	0.5	17.0	8.7	5.0	7.9	10.48
09/10	45.2	3.6	6.4	0.8	0.8	0.2	2.1	8.6	23.2	3.3	5.4	0.2	24.92
10/11	41.3	17.7	0.8	0.2	6.2	4.7	1.3	5.1	1.2	1.2	15.8	4.7	21.25
11/12	11.5	1.1	10.0	0.1	0.2	0.9	–	9.6	11.0	21.4	25.1	9.1	21.49
12/13	30.9	5.7	1.6	0.3	1.5	2.2	9.6	5.8	2.5	6.1	19.1	14.6	27.35
13/14	26.4	5.7	0.2	0.5	0.6	1.5	0.6	2.2	3.3	12.7	8.8	37.4	30.32
14/15	24.9	6.6	0.5	0.2	0.6	1.6	0.6	0.8	0.8	13.6	37.8	12.1	25.10
15/16	29.3	32.6	0.1	3.3	0.8	4.1	3.7	6.0	6.1	0.3	7.2	6.5	10.35
Average	15.8	15.9	13.2	14.8	7.0	2.9	1.8	2.7	6.4	4.2	7.8	7.5	394.56 ¹

¹ total landings for all years

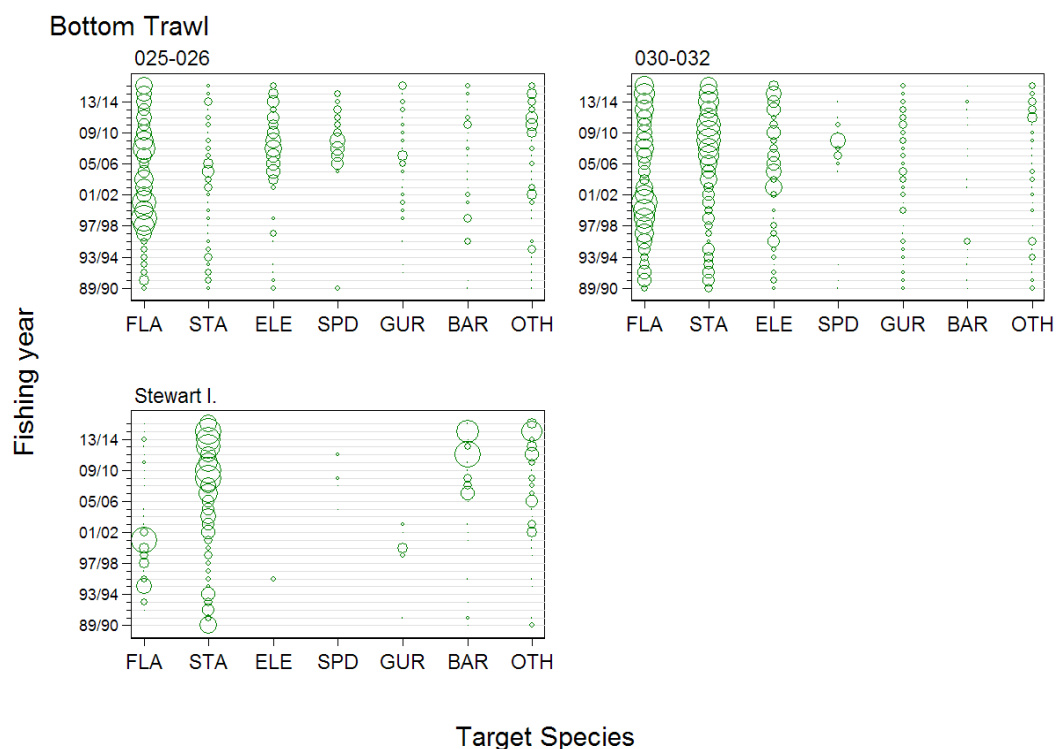


Figure 13: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for bottom trawl in the three statistical area groupings based on trips which caught ELE 5. Circle sizes are proportional within each panel: [025-026]: largest circle= 60 t in 98/99 for FLA; [030-032]: largest circle= 61 t in 00/01 for FLA; [Stewart I.]: largest circle= 7.9 t in 08/09 for STA. These plot data are tabulated in Table C.3A-C.

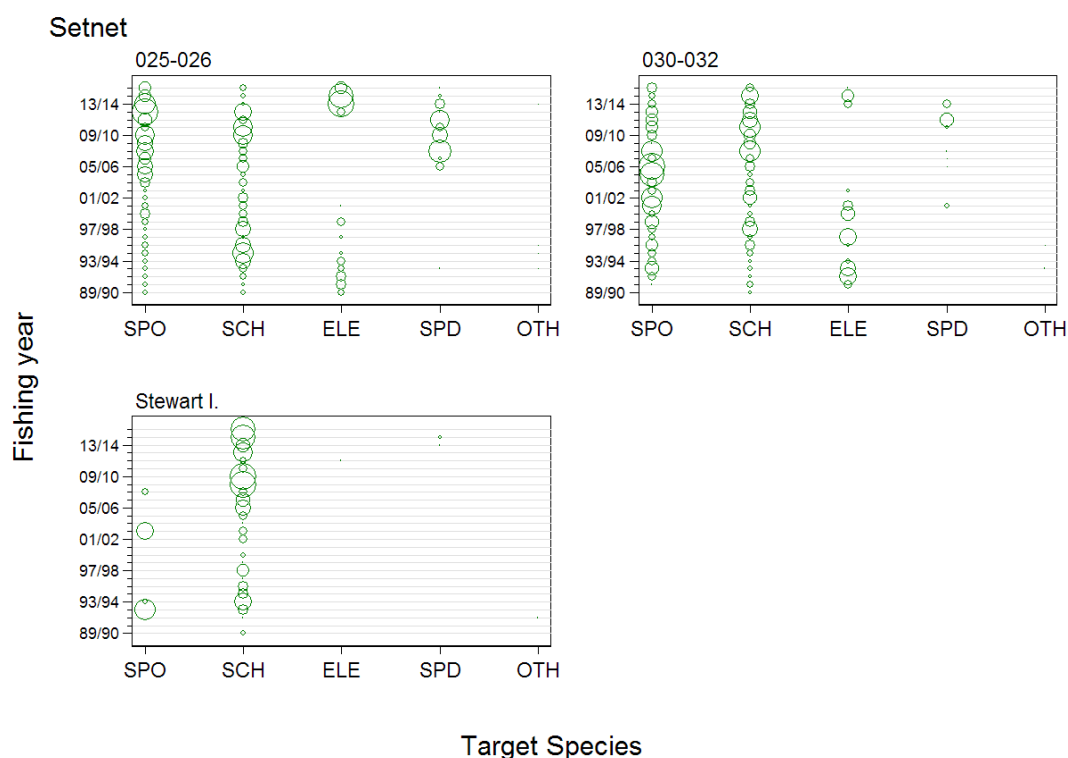


Figure 14: Distribution of landings by target species (ranked in terms of descending order of total landings) and fishing year for setnet in the three statistical area groupings based on trips which caught ELE 5. Circle sizes are proportional within each panel: [025-026]: largest circle= 13 t in 12/13 for SPO; [030-032]: largest circle= 13 t in 05/06 for SPO; [Stewart I.]: largest circle= 1.0 t in 09/10 for SCH. These plot data are tabulated in Table C.3A-C

Table 14: Distribution (%) for bottom trawl and setnet elephantfish landings by target species and fishing year from trips which landed ELE 5, from 1989–90 to 2015–16.

Fishing Year	Bottom Trawl							Setnet				
	FLA	STA	ELE	SPD	GUR	BAR	OTH	SPO	SCH	ELE	SPD	OTH
89/90	23.2	38.0	11.6	8.8	5.5	0.7	12.1	19.2	30.4	50.4	–	–
90/91	50.1	34.6	9.8	0.0	2.2	0.4	2.9	14.2	19.4	66.4	–	–
91/92	50.1	39.5	6.8	–	1.6	–	2.0	16.5	11.1	72.4	–	0.1
92/93	52.9	44.1	0.4	0.0	0.1	0.5	2.0	39.1	13.9	46.6	0.3	0.2
93/94	27.9	51.0	4.8	–	4.2	0.0	12.0	20.2	59.0	20.9	–	–
94/95	45.0	35.4	5.1	–	2.0	0.0	12.4	20.2	77.6	2.2	–	0.0
95/96	43.4	4.7	21.8	–	4.0	11.8	14.3	35.1	62.0	2.9	–	0.1
96/97	80.5	6.2	13.0	–	0.3	–	–	16.6	10.5	72.9	–	–
97/98	82.6	10.2	7.1	–	0.0	–	0.0	12.5	87.5	–	–	–
98/99	81.0	10.8	1.0	–	1.0	6.0	0.2	43.8	42.7	13.6	–	–
99/00	81.7	7.9	1.0	–	7.7	–	1.6	31.5	25.8	42.7	–	–
00/01	85.8	11.0	–	–	1.2	0.7	1.3	65.9	12.6	16.2	5.3	–
01/02	59.2	16.4	5.0	–	3.2	3.0	13.3	61.1	38.9	–	–	–
02/03	47.7	18.5	27.1	–	1.2	0.2	5.4	41.7	54.5	3.8	–	–
03/04	43.2	32.0	15.9	–	5.5	0.6	2.8	59.6	40.4	–	–	–
04/05	23.5	30.5	33.8	1.6	7.4	0.1	3.2	92.4	7.6	–	–	–
05/06	20.4	31.7	26.5	12.4	5.6	0.0	3.3	70.7	23.1	–	6.2	–
06/07	29.4	28.4	19.5	12.9	7.4	1.6	0.8	54.5	43.3	–	2.2	–
07/08	43.0	24.2	18.8	11.0	0.8	0.9	1.3	41.4	27.7	–	30.9	–
08/09	27.8	31.8	13.5	22.3	3.0	0.6	1.0	45.7	54.3	–	–	–
09/10	29.4	38.4	19.6	4.1	2.4	0.0	6.1	32.9	46.6	–	20.5	–
10/11	22.4	41.6	12.2	5.2	4.9	4.3	9.5	20.4	71.3	–	8.3	–
11/12	31.2	26.8	10.4	3.0	3.7	6.7	18.3	27.7	27.5	0.0	44.8	–
12/13	37.4	25.4	15.6	6.1	5.1	1.1	9.3	57.7	36.2	5.9	0.2	–
13/14	32.3	33.5	18.0	2.5	3.7	0.9	9.1	30.7	8.4	48.7	12.2	0.0
14/15	38.5	24.8	19.5	2.1	0.9	4.0	10.3	16.1	28.6	54.6	0.8	–
15/16	49.2	24.4	11.4	–	6.5	1.7	6.8	40.4	33.1	25.9	0.6	–
Average	44.1	25.9	14.2	4.8	3.5	1.8	5.6	39.8	34.8	16.9	8.4	0.0

2.3.3.6 Preferred bottom trawl fishing depths for elephantfish

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 which report bottom trawl catches pertaining to elephantfish (either recording an estimated catch of elephantfish or declaring elephantfish 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). Eighty-three percent of the depth observations reported in Table 15 originate from the TCER forms, accumulated over nine years. The remaining 17% of the trawl returns are on the older TCEPR forms. This predominance of TCER reports reflects the inshore nature of the elephantfish bottom trawl fisheries.

Reported depth observations, summarised over both form types, show that target elephantfish bottom trawl fishing tends to be shallow for all target species, ranging from a minimum 5% quantile of 8 m for SPO to a maximum upper 95% quantile of 102 m for STA (Table 15). The distribution of tows which caught or targeted elephantfish is similar for most of the target species, with the depth range for STA being slightly deeper than the other target species (Figure 15).

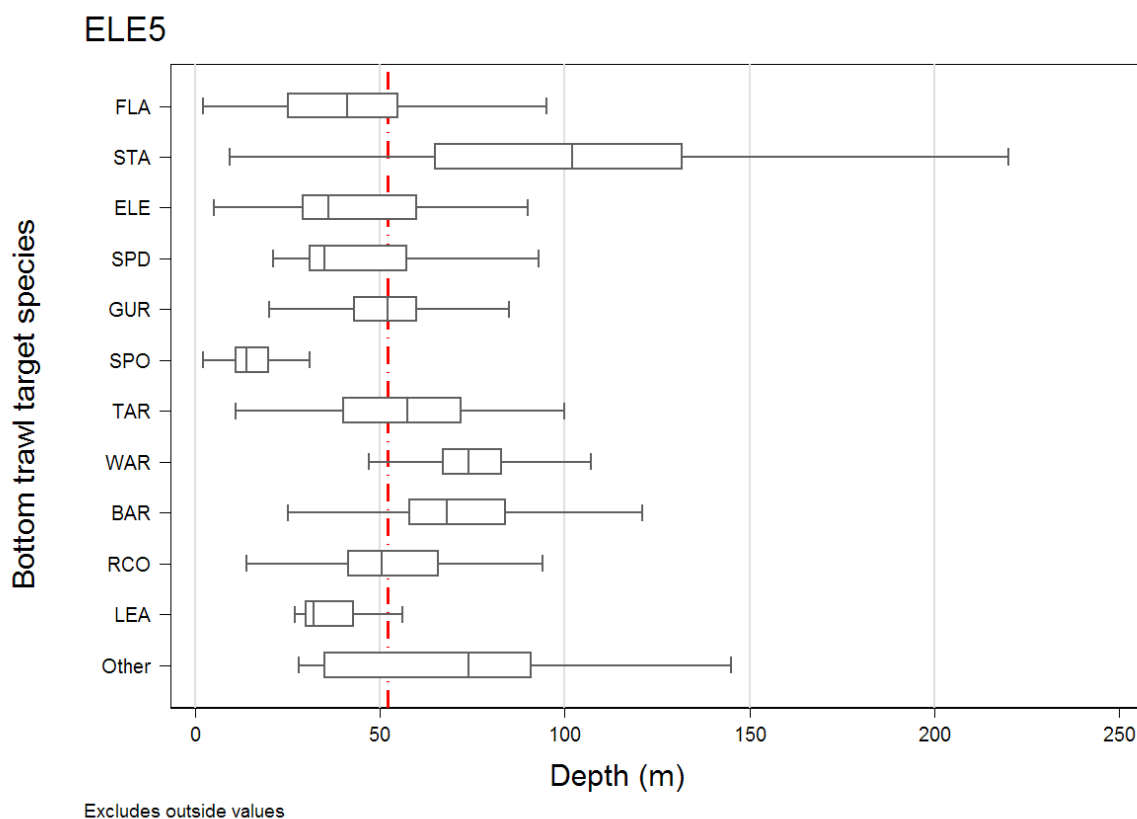


Figure 15: Box plot distributions for ELE 5 of bottom depth from combined TCER and TCEPR form types for effort that targeted or caught elephantfish by target species category for the period 2007–08 to 2015–16. Vertical line in each sub graph indicates the median depth from all tows which caught or targeted elephantfish.

Table 15: Summary statistics for ELE 5 from distributions from all records (combined TCER and TCEPR formtypes) using the bottom trawl method for effort that targeted or caught elephantfish by target species category. Data are summarised by QMA from 2007–08 to 2015–16.

Target species category	Number observations	Depth (m)			
		Lower 5% of distribution	Mean of distribution	Median (50%) of distribution	Upper 95% of distribution
FLA	4 560	10	41	41	75
STA	3 495	31	98	102	151
ELE	530	13	42	36	79
SPD	400	27	44	35	80
GUR	375	34	55	52	80
SPO	203	8	17	14	36
TAR	118	18	57	58	86
WAR	111	52	75	74	96
BAR	73	39	72	68	113
RCO	38	15	52	50	81
LEA	25	27	37	32	63
Other	37	29	89	74	460
Total	9 965	12	62	52	141

3. STANDARDISED CPUE ANALYSIS

The following quote, taken from a recent MPI Plenary Report (MPI 2016), summarises the SINSWG interpretation of the ELE 5 CPUE series:

Two standardised CPUE series for ELE 5 were prepared for 2012 with each series based on the bycatch of elephant fish in the bottom trawl fisheries defined by target species combinations (Starr & Kendrick 2013). One of these series [ELE 5(MIX)] is analogous to the MIX series developed for ELE 3, with the series defined by six target species in all valid ELE 5 statistical areas. The second ELE 5 analysis [ELE 5(MIX)-trip] was a trip- based analysis using the same target species selection method as described for ELE 3(MIX)-trip. The two sets of indices were very similar.

In 2014, the ELE 5(MIX) CPUE model was updated to include data from 2011–12 to 2012–13 (Langley 2014). The two most recent indices were lower than the peak CPUE from 2008–09 to 2010–11, although CPUE has been maintained at a relatively high level compared to the 1990s–early 2000s. There are relatively broad confidence intervals associated with the individual CPUE indices and there is no strong trend in the CPUE indices during 2005–06 to 2012–13.

This report has updated the ELE5-BT(MIX) model, given the similarity (noted above) of this series with the alternative ELE5-BT(MIX)-trip model. This is the same decision made by Langley (2014) when he updated the ELE5-BT(MIX) series. The primary innovation introduced in this update is to calculate the binomial series from the ELE5-BT(MIX) data set and to calculate a combined series using the delta-lognormal method (Eq. D.4). The addition of the binomial and combined series is consistent with current practice in both the NINSWG and SINSWG, which have accepted that there is a trade-off between the determination of the presence/absence of a species in the data and the positive catch series. Furthermore, there is a strong decreasing trend in the proportion of zero catch of elephantfish in ELE 5 (see lower left panel, Figure E.2) which should be included in the CPUE series.

The ELE 5 CPUE series defined for this report was:

- a) **ELE5-BT(MIX): South coast mixed target species bottom trawl** – ELE 5 bottom single trawl in all ELE 5 statistical areas, target species ELE, FLA, STA, BAR, RCO, or SPD;

Data were prepared in the manner described in Section 2.3.1 and detailed results, including all diagnostics, are presented for the above CPUE series in Appendix E.

There is agreement between the positive catch (lognormal) ELE5-BT(MIX) series estimated from the current dataset, the update analysis provided by Langley (2014) and the equivalent series accepted by the 2012 SINSWG review (Starr & Kendrick 2013) (Figure 16). For reasons that are unclear, the current series appears to be smoother, showing less year-to-year variation than either the 2012 or the 2014 analyses. This smoothing effect seems unlikely to be due to a change in data processing, because Langley (2014) used the same daily-effort stratification as done for this update while the 2012 analysis was based on the trip-stratum method of Starr (2007). Furthermore, while Langley (2014) used a statistical area definition to select his ELE 5 dataset, Starr & Kendrick (2013) used the same “Fishstock” expansion procedure as was done for the present analysis.

As noted above, there is a strong declining trend in the proportion of zeros, which translates into an increasing trend in the binomial series that resembles the trend in the positive catch series (Figure 17). When these two series are combined using the delta-lognormal method (Eq. D.4), the resulting series is similar to the positive series but is elevated to a higher level from the mid-2000s (Figure 17).

The Plenary accepted this revised index which combined the binomial and lognormal series using the delta-lognormal method (MPI 2017). This was done because the Inshore WGs have adopted the standard of combining positive catch and fishing success models when there is a trend in the proportion zero catch. As well, simulation work has indicated that calculating a combined index may reduce bias when reporting small catch amounts (Langley 2015). Recent indices estimated by this updated series are lower than the peak observed at the end of the 2010 decade, but these indices remain above the long-term average CPUE (Figure 17), and are close to the target (Mean CPUE for the period 2005–06 to 2015–16)

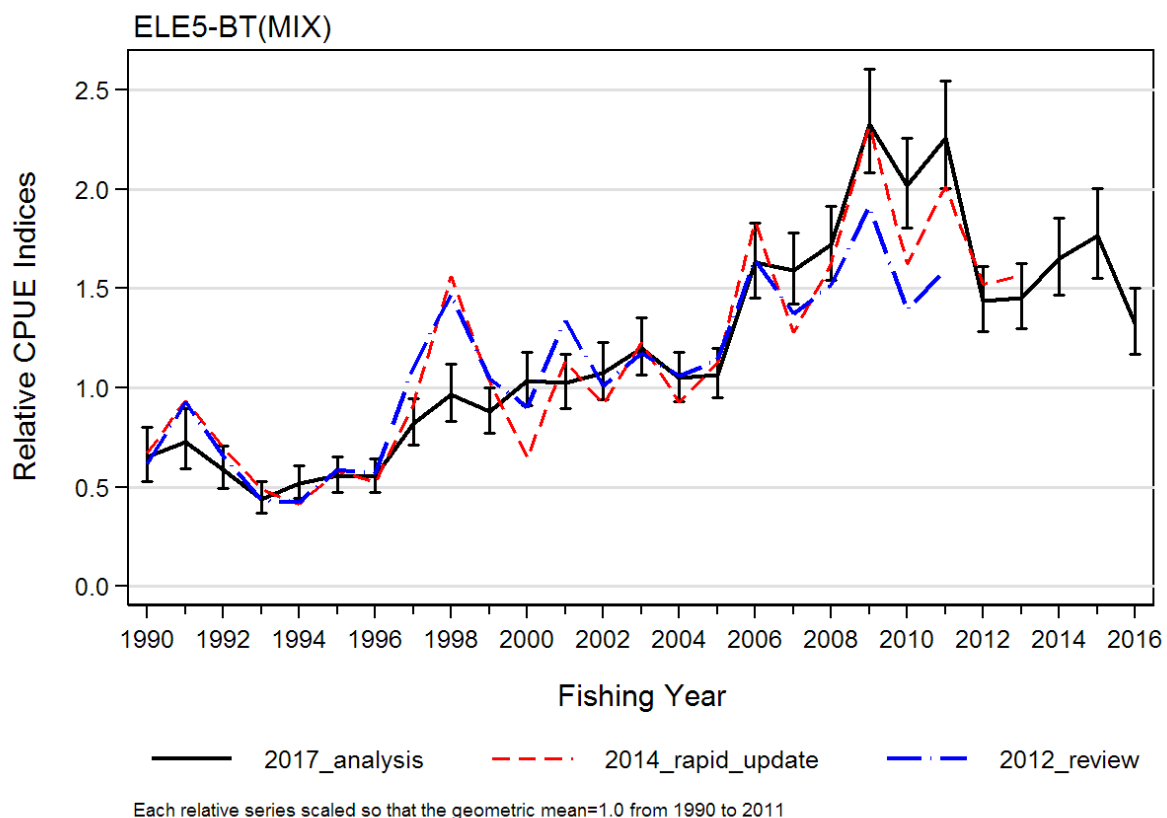


Figure 16: Comparison of the standardised lognormal CPUE analysis prepared for this report with the equivalent ELE5-BT(MIX) mixed series prepared by Langley(2014) and the 2012 SINSWG review (Starr & Kendrick 2013). Each series is based on an assumed lognormal distribution and error bars show plus or minus two Standard Errors.

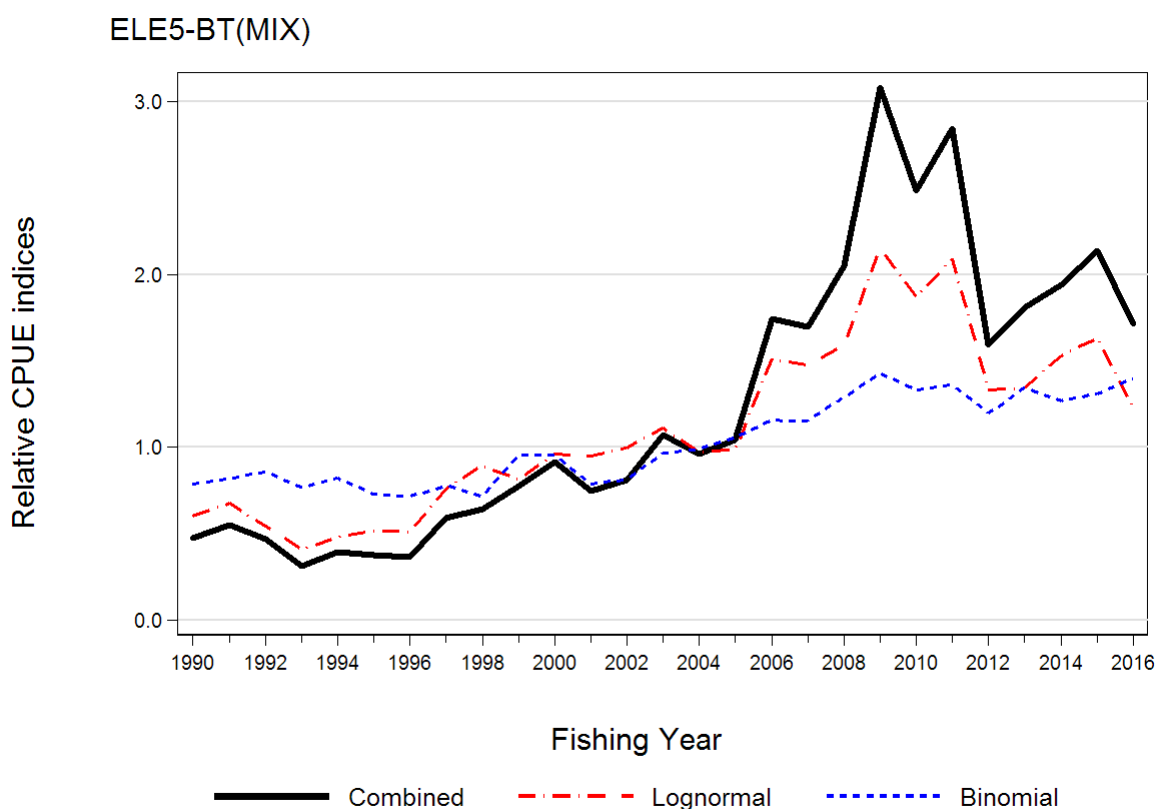


Figure 17: Plots of three ELE5-BT(MIX) CPUE series: a) positive catch (lognormal); b) presence/absence (binomial) and c) combined series using the delta-lognormal method.

4. ACKNOWLEDGEMENTS

This work was funded by the South Island Inshore Fisheries Group. We thank the MPI Information & Data Management team for providing the catch/effort data in a timely manner. Mark Geytenbeek and Matthew Baird of MPI provided updated information for Table 2. Members of the Southern Inshore Working Group provided input and advice to the analyses contained in this report.

5. REFERENCES

- Bentley, N.; Kendrick, T.H.; Starr, P.J.; Breen, P.A. (2012). Influence plots and metrics: tools for better understanding fisheries catch-per-unit-effort standardisations. *ICES Journal of Marine Science* 69(1):84–88, doi:10.1093/icesjms/fsr174
- Francis, R.I.C.C. (1999). The impact of correlations in standardised CPUE indices. New Zealand Fisheries Assessment Research Document 99/42. 30 p. (Unpublished report held in NIWA library, Wellington.)
- Francis, R.I.C.C. (2001). Orange roughy CPUE on the South and East Chatham Rise. *New Zealand Fisheries Assessment Report* 2001/26. 30 p.
- Langley, A.D. (2014). Updated CPUE analyses for selected South Island inshore finfish stocks. *New Zealand Fisheries Assessment Report* 2014/40. 116 p.
- Langley, A.D. (2015). Fishery characterisation and Catch-Per-Unit-Effort indices for John dory in JDO 1. *New Zealand Fisheries Assessment Report* 2015/47. 76 p.

- Ministry for Primary Industries (2016). Fisheries Assessment Plenary, May 2016: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1556 p. (Elephantfish found on page 263 of Volume 1: <http://cs.fish.govt.nz/forums/thread/12485.aspx>)
- Ministry for Primary Industries (2017). Fisheries Assessment Plenary, May 2017: stock assessments and stock status. Compiled by the Fisheries Science Group, Ministry for Primary Industries, Wellington, New Zealand. 1596 p. (Elephantfish found on page 268 of Volume 1: http://fs.fish.govt.nz/Doc/24474/May_Plenary_2017_Volume_1_FINAL.pdf.ashx)
- Ministry of Fisheries. (2010). WAREHOU Database Documentation Catch Effort Base Views and Fields. Version 9. 80 p. (Unpublished report held by the Ministry of Fisheries, Wellington. Obtainable from <mailto:RDM.Shared@mpi.govt.nz>)
- Quinn, T.R.; Deriso, R.B. (1999). Quantitative Fish Dynamics. Oxford University Press. 542 p.
- Raj, L.; Voller, R. (1999). Characterisation of the south-east elephantfish fishery–1998. 55 p. (Unpublished report held by Ministry for Primary Industries, Dunedin, New Zealand)
- Sarr, P.J. (2007). Procedure for merging MFish landing and effort data, version 2.0. Report to the Adaptive Management Programme Fishery Assessment Working Group: AMP WG/07/04. 17 p. (Unpublished document held by the Ministry for Primary Industries, Wellington, N.Z: <http://cs.fish.govt.nz/forums/194/PostAttachment.aspx>)
- Sarr, P.J.; Kendrick, T.H. (2013). ELE 3 & 5 Fishery Characterisation and CPUE. *New Zealand Fisheries Assessment Report 2013/38*. 95 p.
- Sarr, P.J.; Kendrick, T.H. (2016). SCH 1, 2, 3, 4, 5, 7 and 8 Fishery Characterisation and CPUE Report. *New Zealand Fisheries Assessment Report 2016/64*. 251 p.
- Sarr, P.J.; Kendrick, T.H.; Lydon, G.J.; Bentley, N.B. (2009). Report to the Adaptive Management Programme Fishery Assessment Working Group: Review of the ELE 5 Adaptive Management Programme. AMP WG 2009/06. 88 p. (Unpublished document held by the Ministry for Primary Industries, Wellington, N.Z: <http://cs.fish.govt.nz/forums/2086/PostAttachment.aspx>)
- Vignaux, M. (1994). Catch per unit effort (CPUE) analysis of west coast South Island and Cook Strait spawning hoki fisheries, 1987–93. New Zealand Fisheries Assessment Research Document 94/11. 29 p. (Unpublished report held in NIWA library, Wellington, New Zealand.)

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

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

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

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

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

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

Appendix B. MAP OF MPI STATISTICAL AND MANAGEMENT AREAS

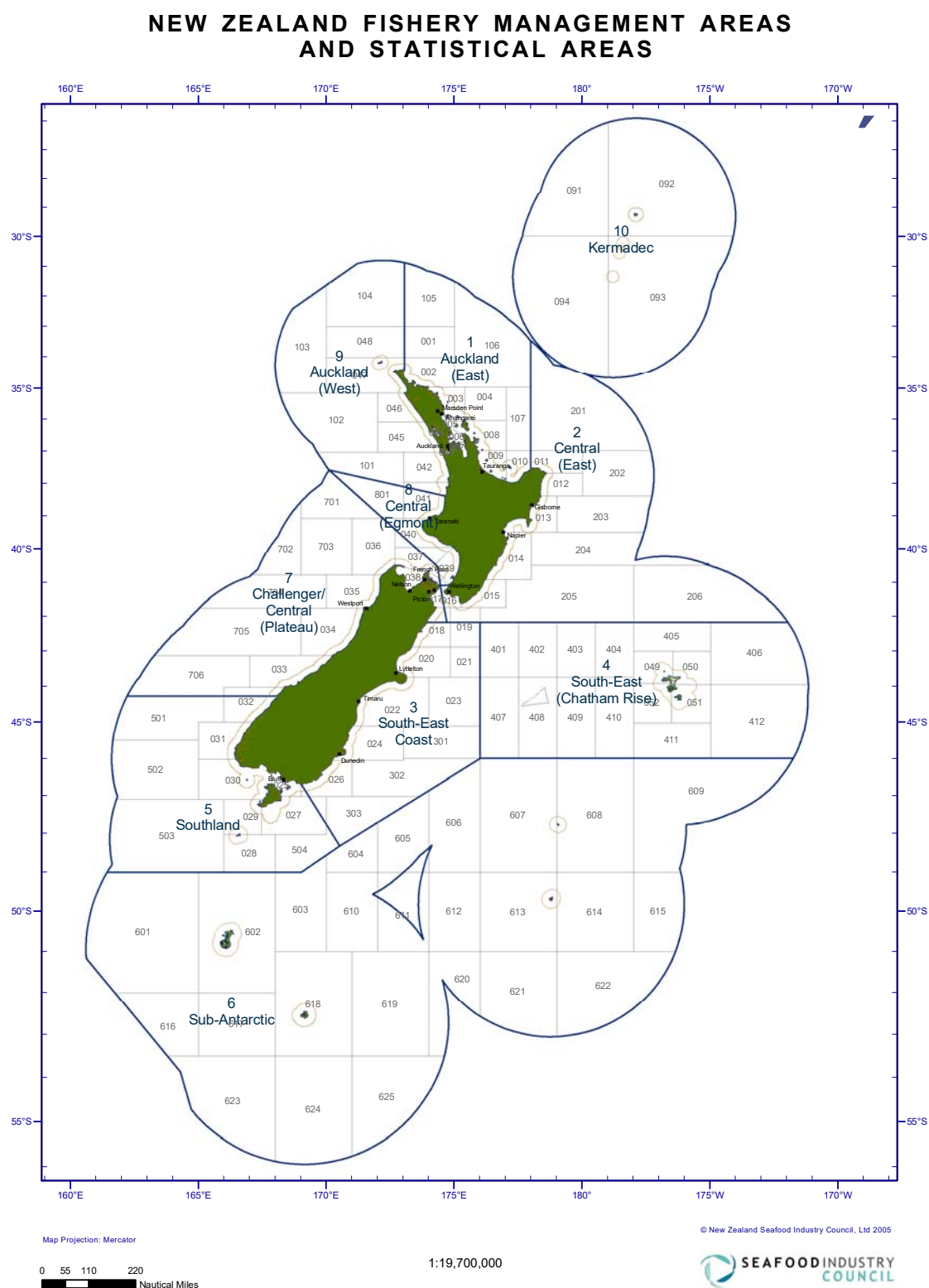


Figure B.1: Map of Ministry for Primary Industries statistical areas and Fishery Management Area (FMA) boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries.

Appendix C. DATA SUMMARIES BY ELE 5 STATISTICAL AREA GROUP FOR BOTTOM TRAWL AND SETNET

Table C.1A: Distribution of ELE 5 landings (%) by fishing year and by month for bottom trawl in statistical area group [025–026] based on trips which landed elephantfish. The final column gives the annual total bottom trawl landings (t) for [025–026]. These values are plotted in Figure 10.

Fishing Year	Month												Total (t)
	Oct [025-026] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	3.9	4.3	16.0	3.3	1.9	23.2	–	–	29.8	7.6	0.4	9.7	8.5
90/91	46.1	0.9	0.6	20.9	0.0	5.7	1.1	0.6	1.3	0.1	0.6	22.3	13.4
91/92	16.8	1.3	0.8	18.5	0.6	7.2	1.3	0.0	0.0	0.8	3.4	49.3	9.2
92/93	0.1	11.5	4.1	15.6	16.6	8.9	6.6	7.3	1.4	8.7	0.2	19.0	6.0
93/94	6.8	1.4	3.0	20.4	16.9	0.0	39.5	1.8	2.0	6.9	0.3	0.9	11.9
94/95	27.3	0.1	0.1	2.0	45.1	0.1	8.4	11.9	0.0	4.2	–	0.8	12.3
95/96	9.2	1.9	0.5	18.0	6.7	0.8	8.0	1.0	32.2	0.7	1.1	20.0	10.2
96/97	56.6	0.8	0.9	0.8	–	1.5	16.6	8.4	–	0.2	0.1	14.1	25.2
97/98	20.1	0.7	0.3	4.9	1.2	0.1	14.3	5.5	18.0	2.2	13.3	19.4	34.7
98/99	1.0	0.3	0.1	6.4	0.6	3.5	16.9	8.0	2.5	9.9	17.2	33.6	70.7
99/00	8.7	0.0	5.9	0.0	0.2	22.4	2.0	3.5	0.2	12.1	10.8	34.0	34.5
00/01	6.6	0.9	0.1	0.4	0.8	0.5	11.0	17.9	14.5	10.3	18.3	18.9	54.7
01/02	2.7	1.8	0.8	11.7	12.6	27.0	24.5	12.5	0.6	1.8	3.4	0.6	35.6
02/03	5.5	3.8	1.6	1.8	2.6	35.2	11.0	11.3	8.2	2.2	2.1	14.6	38.0
03/04	11.2	5.4	3.9	3.1	10.2	24.2	1.6	4.1	1.8	15.1	6.4	13.0	46.7
04/05	9.8	22.8	1.0	0.8	15.5	11.0	8.8	5.7	0.0	6.4	10.9	7.3	43.2
05/06	18.9	0.8	0.0	1.5	9.3	6.3	4.5	15.3	13.3	13.5	3.3	13.2	56.2
06/07	10.8	3.6	2.2	3.4	11.4	11.3	9.4	11.2	5.1	7.8	2.0	21.8	61.4
07/08	12.5	20.1	2.4	1.2	6.9	11.7	12.5	5.2	8.6	2.9	14.4	1.7	86.2
08/09	16.8	14.7	1.4	5.3	12.5	10.7	4.7	13.6	8.4	3.1	2.7	6.2	81.4
09/10	32.8	4.5	3.2	1.1	4.5	13.2	10.0	5.7	1.0	2.4	5.9	15.7	49.3
10/11	30.9	17.5	0.4	1.7	16.1	8.8	4.8	1.6	2.9	3.4	4.5	7.3	49.0
11/12	45.8	6.2	1.6	1.7	11.8	11.9	2.4	2.9	2.2	2.3	4.9	6.3	52.4
12/13	11.9	7.6	5.5	1.3	1.5	8.6	11.8	4.5	22.0	4.8	8.2	12.3	34.9
13/14	18.1	4.9	0.2	8.5	9.6	9.2	5.4	5.7	4.4	6.7	7.0	20.2	50.3
14/15	8.4	6.0	1.5	2.4	9.7	13.5	5.6	14.3	10.7	14.6	2.1	11.3	45.1
15/16	9.4	19.5	2.0	1.0	22.0	8.6	5.7	9.0	4.8	2.4	3.4	12.3	43.4
Average	16.2	7.5	1.7	3.8	8.6	11.1	9.0	8.2	6.7	6.2	7.0	14.1	1064.4 ¹

¹ total landings for all years

Table C.1B: Distribution of ELE 5 landings (%) by fishing year and by month for bottom trawl in statistical area group [030–032] based on trips which landed elephantfish. The final column gives the annual total bottom trawl landings (t) for [030–032]. These values are plotted in Figure 10.

Fishing Year	Month												Total (t)
	Oct [030–032] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	9.9	12.1	12.9	17.9	15.5	0.3	3.9	0.1	4.0	2.6	5.7	15.2	16.8
90/91	3.3	8.8	9.0	49.6	6.6	4.5	1.8	1.2	2.5	5.1	4.2	3.5	35.6
91/92	3.6	1.6	19.1	10.0	15.7	15.5	0.7	0.1	4.3	6.5	4.8	18.1	35.0
92/93	12.2	3.6	12.0	0.4	28.3	0.9	0.2	1.0	1.9	2.3	4.0	33.4	19.4
93/94	1.3	10.6	6.7	19.8	10.2	11.9	1.9	5.9	0.9	1.3	1.4	28.0	23.4
94/95	2.0	2.2	3.2	31.5	9.0	2.5	2.8	1.9	10.2	7.6	19.8	7.2	31.9
95/96	8.2	8.7	4.6	34.9	13.1	6.5	0.2	0.7	1.5	1.4	1.3	18.7	49.3
96/97	9.1	6.3	34.8	24.1	1.9	4.8	6.6	7.6	0.1	0.8	0.2	3.8	40.7
97/98	4.4	5.0	10.6	40.4	13.6	25.6	0.0	0.2	0.1	0.0	0.0	0.0	39.1
98/99	11.9	4.8	8.7	45.1	3.3	8.1	1.7	0.4	2.4	5.7	7.0	1.0	50.3
99/00	10.9	2.2	15.6	17.2	13.3	17.7	2.2	1.1	7.0	2.1	1.4	9.3	56.9
00/01	9.2	14.0	16.6	27.8	1.6	7.2	0.6	2.4	1.3	6.3	6.7	6.4	75.3
01/02	3.6	10.7	9.8	23.7	33.2	6.3	3.0	2.3	2.1	5.2	0.1	0.0	50.5
02/03	1.2	11.0	34.1	4.1	8.4	7.2	0.9	3.5	3.7	2.2	4.9	18.7	60.4
03/04	3.0	8.6	22.7	8.3	2.9	6.5	2.5	18.2	18.3	3.8	2.2	3.1	45.2
04/05	7.7	1.9	6.1	31.6	11.5	4.5	7.4	1.6	8.5	1.3	1.3	16.6	63.1
05/06	2.8	10.8	7.9	13.0	13.1	6.3	11.1	5.8	9.0	10.4	4.2	5.7	61.5
06/07	1.3	5.9	16.0	16.6	12.8	9.6	1.4	7.8	15.6	1.3	9.4	2.3	82.0
07/08	1.9	3.0	7.1	9.7	14.5	12.9	8.6	14.7	9.6	9.4	7.1	1.7	78.7
08/09	0.0	2.7	3.7	11.4	4.8	9.3	10.9	4.8	13.5	21.4	9.8	7.8	106.9
09/10	4.4	0.3	5.9	9.7	8.5	5.8	9.0	6.2	7.9	28.8	8.0	5.3	94.1
10/11	4.1	5.6	4.4	6.4	20.7	12.9	16.7	7.2	7.2	3.4	6.2	5.0	79.1
11/12	9.9	4.1	13.1	5.9	10.4	10.0	15.1	6.0	2.2	7.7	7.0	8.7	71.3
12/13	2.6	2.1	3.2	3.4	11.7	15.0	15.9	9.1	11.3	8.4	10.1	7.3	86.4
13/14	2.5	7.7	3.2	3.2	14.5	13.4	8.4	7.6	5.7	13.3	9.7	10.7	84.5
14/15	5.1	3.1	5.8	9.1	5.6	26.1	6.8	4.1	3.6	6.2	10.9	13.6	90.5
15/16	0.2	5.8	3.9	9.3	2.7	12.5	4.5	9.9	5.0	4.9	19.5	21.8	76.8
Average	4.5	5.6	10.1	15.8	10.7	10.7	6.6	5.6	6.7	7.8	7.0	9.0	1604.8 ¹

¹ total landings for all years

Table C.1C: Distribution of ELE 5 landings (%) by fishing year and by month for bottom trawl in statistical area group [Stewart I.] based on trips which landed elephantfish. The final column gives the annual total bottom trawl landings (t) for [Stewart I.]. These values are plotted in Figure 10.

Fishing Year	Month												Total (t)
	Oct [Stewart I.] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	0.1	1.0	–	–	0.9	6.1	–	0.0	–	43.1	30.4	18.5	4.0
90/91	27.9	2.4	–	2.2	17.8	–	0.0	–	–	11.2	–	38.6	0.8
91/92	–	–	1.9	–	0.1	–	–	–	70.1	9.7	17.7	0.4	1.7
92/93	40.0	0.3	–	–	–	–	1.2	42.8	7.4	6.6	1.9	0.0	1.6
93/94	4.4	0.4	–	–	15.8	–	–	45.2	–	24.4	7.7	2.0	2.0
94/95	–	–	54.9	12.3	–	–	9.4	21.4	0.2	1.6	0.2	–	2.8
95/96	51.6	–	–	8.3	2.1	0.8	–	22.2	0.0	–	3.0	11.9	1.1
96/97	–	–	–	27.1	–	15.8	–	16.1	–	–	–	41.0	0.3
97/98	–	–	–	–	–	–	–	0.4	–	–	18.2	81.5	1.6
98/99	0.2	–	–	0.1	20.5	–	3.4	11.2	9.0	30.4	23.5	1.7	2.0
99/00	0.3	1.4	1.8	12.9	14.4	0.0	–	–	6.7	40.7	1.2	20.7	2.7
00/01	0.1	0.1	0.1	10.1	26.2	–	8.8	7.3	0.1	2.1	0.1	45.1	8.5
01/02	0.5	0.1	–	0.0	–	5.9	5.7	49.0	2.5	21.7	14.7	–	4.2
02/03	–	2.2	0.3	1.4	0.9	24.9	–	41.8	7.2	5.3	–	15.9	2.9
03/04	3.1	–	–	1.6	0.0	–	–	70.4	–	20.9	4.0	–	2.5
04/05	2.3	2.4	0.0	–	6.4	6.9	4.2	–	–	16.2	24.8	36.8	1.8
05/06	4.4	5.5	0.2	–	–	–	–	14.4	28.8	15.0	29.3	2.3	3.6
06/07	31.1	0.6	1.6	0.1	–	1.3	12.1	2.5	5.8	45.0	–	0.0	6.9
07/08	2.8	1.7	1.7	0.5	0.1	1.2	0.1	2.0	21.0	38.2	30.5	0.3	3.9
08/09	0.1	0.4	0.8	1.1	0.0	4.2	22.3	21.5	20.8	13.8	2.2	12.8	9.4
09/10	10.3	0.7	0.0	0.0	1.7	0.1	3.3	5.0	28.4	0.4	22.9	27.2	7.3
10/11	1.3	4.3	0.2	4.3	2.5	23.7	7.1	12.2	23.2	14.2	2.0	5.1	4.6
11/12	11.6	1.9	0.0	–	0.4	1.9	6.8	7.6	14.1	43.1	0.8	11.9	12.3
12/13	10.0	0.4	1.2	0.2	0.6	22.1	47.5	5.4	1.7	1.3	5.5	4.1	8.3
13/14	1.2	0.5	0.1	–	19.1	0.0	8.3	15.7	1.7	10.6	6.2	36.7	7.3
14/15	0.5	0.1	0.0	0.3	0.6	2.8	3.2	15.1	46.5	4.0	17.2	9.6	17.7
15/16	5.7	0.2	0.2	0.1	0.0	23.5	7.1	23.2	14.1	9.6	0.3	15.9	5.1
Average	6.0	0.9	1.6	1.8	4.4	5.3	8.8	14.5	16.0	16.4	9.4	14.8	126.9 ¹

¹ total landings for all years

Table C.2A: Distribution of ELE 5 landings (%) by fishing year and by month for setnet in statistical area group [025–026] based on trips which landed elephantfish. The final column gives the annual total setnet landings (t) for [025–026]. These values are plotted in Figure 11.

Fishing Year	Month												Total (t)
	Oct [025-026] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	–	4.9	12.0	9.1	50.4	13.2	–	–	–	–	1.5	8.9	2.1
90/91	0.3	58.3	6.9	18.5	11.9	2.3	–	1.2	–	–	0.5	–	2.7
91/92	22.0	41.7	34.0	1.9	–	–	0.4	–	–	–	–	–	3.6
92/93	36.9	31.0	14.5	–	12.7	2.5	2.4	–	–	–	–	–	2.7
93/94	3.1	17.5	27.4	3.5	19.7	14.7	13.5	–	–	–	–	0.6	6.4
94/95	6.6	11.5	5.9	40.5	32.6	–	1.0	–	–	–	–	2.0	10.1
95/96	0.2	16.0	13.3	66.8	1.7	2.0	–	–	–	–	–	–	5.8
96/97	13.9	30.1	28.6	19.4	4.4	1.9	–	1.7	–	–	–	–	1.0
97/98	–	0.5	15.4	50.9	26.6	5.1	1.4	–	–	–	–	–	5.1
98/99	–	52.2	3.2	14.5	25.4	0.7	–	0.3	3.5	–	–	–	4.3
99/00	0.4	11.8	59.0	21.1	4.6	2.8	–	0.1	0.2	–	–	–	3.8
00/01	0.3	15.1	66.4	1.1	11.6	5.5	–	–	–	–	–	–	2.6
01/02	0.8	8.5	11.5	66.4	5.9	0.2	–	–	–	6.8	–	–	2.2
02/03	–	6.6	55.5	9.3	1.1	–	6.0	–	–	–	3.7	17.7	0.5
03/04	4.5	4.4	50.0	16.8	5.2	2.9	1.3	12.4	1.9	0.1	0.6	–	3.5
04/05	18.8	49.3	21.7	0.8	3.4	2.7	0.3	0.8	2.0	–	0.1	0.0	5.3
05/06	26.9	44.7	2.6	2.5	10.2	1.8	0.2	0.3	–	–	–	10.9	9.1
06/07	31.3	27.5	8.5	2.0	3.1	0.5	0.4	9.1	14.2	3.3	–	0.3	4.0
07/08	1.0	20.0	4.0	4.6	3.6	4.4	1.2	1.1	58.9	0.5	0.7	–	16.9
08/09	49.2	19.4	7.0	0.2	2.8	0.2	0.9	–	9.4	6.7	4.1	0.1	7.1
09/10	49.3	4.7	6.5	0.9	0.9	0.2	2.5	0.8	28.7	2.4	2.8	0.2	18.8
10/11	56.4	10.6	1.6	0.0	1.5	7.6	1.4	10.2	1.0	1.5	3.2	5.0	10.2
11/12	18.9	2.2	0.3	0.0	0.1	0.8	–	8.1	3.1	5.4	46.7	14.5	11.0
12/13	37.4	5.6	2.1	0.2	1.5	1.5	–	1.9	–	6.0	24.4	19.4	20.3
13/14	33.3	1.1	0.1	0.4	0.2	0.3	0.6	0.4	0.9	14.5	8.3	39.8	23.8
14/15	26.6	7.4	0.6	0.3	0.7	1.2	0.5	0.6	0.6	1.1	55.0	5.5	14.9
15/16	48.6	26.0	–	0.3	0.7	5.6	4.2	0.5	6.1	–	1.5	6.5	6.2
Average	25.0	14.6	8.6	8.2	6.1	2.4	1.3	1.9	8.9	3.4	10.7	9.0	204.0 ¹

¹ total landings for all years

Table C.2B: Distribution of ELE 5 landings (%) by fishing year and by month for setnet in statistical area group [030–032] based on trips which landed elephantfish. The final column gives the annual total setnet landings (t) for [030–032]. These values are plotted in Figure 11.

Fishing Year	Month												Total (t)
	Oct [030–032] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	–	–	100.0	–	–	–	–	–	–	–	0.0	0.0	0.1
90/91	0.0	3.6	–	19.5	69.3	–	7.4	–	0.3	–	–	–	2.2
91/92	0.0	3.0	80.9	3.4	1.7	–	–	–	0.1	–	–	10.9	7.4
92/93	4.6	31.3	1.3	30.4	19.7	0.8	8.4	0.5	0.4	–	2.5	–	9.0
93/94	–	–	0.0	66.0	29.9	3.6	–	0.5	–	–	–	0.0	1.9
94/95	–	–	6.6	78.5	7.7	0.1	5.9	–	–	–	–	1.2	2.6
95/96	25.4	8.1	46.9	14.5	5.0	–	–	–	–	–	–	0.1	5.6
96/97	–	5.8	6.6	81.5	3.2	–	–	–	1.6	–	1.3	–	7.1
97/98	–	0.3	2.3	63.3	27.9	3.1	1.0	1.7	0.4	–	–	–	5.8
98/99	–	41.5	26.5	27.2	4.7	–	–	–	–	–	–	–	6.1
99/00	0.0	0.6	13.8	73.8	11.5	–	–	–	0.3	–	–	–	5.3
00/01	–	37.0	47.5	0.5	0.6	14.3	0.1	–	–	–	–	–	9.9
01/02	–	54.2	0.4	3.2	30.3	11.8	–	0.0	0.0	0.1	–	–	11.7
02/03	–	25.6	17.3	26.6	29.4	–	–	0.3	–	–	–	0.8	3.4
03/04	1.3	6.8	50.9	40.8	0.2	–	–	–	–	–	–	–	3.7
04/05	0.2	3.4	0.2	91.0	0.0	0.1	0.1	0.5	4.3	0.1	0.0	–	12.0
05/06	0.8	42.9	39.1	3.0	–	0.1	–	2.0	–	0.1	0.6	11.4	15.3
06/07	–	8.5	17.3	24.4	1.6	6.9	1.7	11.1	26.1	0.6	1.0	0.9	3.0
07/08	1.2	3.9	37.6	19.5	3.5	7.2	0.5	0.6	0.0	2.4	9.2	14.5	16.0
08/09	–	14.8	–	3.5	2.8	0.7	0.3	2.4	44.6	15.1	7.8	8.3	2.4
09/10	38.4	–	7.3	0.4	0.4	0.2	0.1	38.0	2.8	2.7	9.3	0.3	5.1
10/11	26.9	24.5	–	0.4	10.3	2.0	1.2	0.4	1.5	0.8	27.7	4.4	10.9
11/12	3.6	–	20.5	0.1	0.3	1.0	–	11.4	19.5	37.9	2.3	3.5	10.4
12/13	13.4	5.9	0.2	0.3	1.6	1.2	40.0	18.5	9.1	6.6	3.2	–	6.5
13/14	1.3	22.4	0.6	0.9	1.1	5.4	0.4	9.0	12.3	6.5	11.1	28.9	6.2
14/15	24.2	5.8	0.5	0.1	0.4	1.8	0.8	0.4	0.1	33.9	12.4	19.7	9.3
15/16	0.3	53.3	0.4	9.8	0.8	2.0	3.7	0.8	4.2	0.8	20.0	3.7	3.3
Average	5.9	17.9	18.9	22.6	7.6	3.0	2.3	3.3	3.5	4.9	4.7	5.4	182.4 ¹

¹ total landings for all years

Table C.2C: Distribution of ELE 5 landings (%) by fishing year and by month for setnet in statistical area group [Stewart I.] based on trips which landed elephantfish. The final column gives the annual total setnet landings (t) for [Stewart I.]. These values are plotted in Figure 11.

Fishing Year	Month												Total (t)
	Oct [Stewart I.] (%)	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
89/90	—	—	—	—	—	—	—	—	—	—	—	100.0	0.04
90/91	—	—	—	—	—	—	—	—	—	—	—	—	0.00
91/92	58.3	—	—	—	—	—	—	—	—	—	41.7	—	0.01
92/93	—	—	17.1	—	82.9	—	0.0	—	—	—	—	—	0.78
93/94	—	9.1	—	—	—	90.9	—	—	—	—	—	—	0.52
94/95	—	—	—	73.5	—	—	0.0	—	—	7.3	—	19.1	0.17
95/96	—	—	—	—	27.9	72.1	—	—	—	—	—	—	0.15
96/97	100.0	—	—	0.0	0.0	—	—	—	—	—	—	—	0.01
97/98	—	—	—	—	—	—	30.7	69.3	—	—	—	—	0.23
98/99	—	—	—	—	100.0	—	—	—	—	—	—	—	0.01
99/00	—	66.5	—	—	—	—	—	—	33.5	—	—	—	0.03
00/01	—	—	—	—	—	—	—	—	—	—	—	—	0.00
01/02	—	—	—	—	—	33.1	63.7	—	—	3.2	—	—	0.13
02/03	—	0.0	9.8	71.7	0.4	1.6	5.1	—	—	11.4	—	—	0.51
03/04	—	—	—	—	—	—	100.0	—	—	—	—	—	0.01
04/05	—	—	—	1.6	9.7	12.1	23.2	12.6	0.0	—	9.7	31.2	0.10
05/06	78.9	—	—	—	4.1	16.5	0.0	—	—	—	—	0.5	0.34
06/07	—	—	—	—	3.1	4.5	—	0.0	17.5	45.1	—	29.7	0.30
07/08	—	—	18.3	16.2	33.8	2.7	—	0.0	7.4	5.4	14.5	1.6	0.16
08/09	—	0.0	3.5	—	15.4	0.1	0.0	—	4.1	7.2	4.6	65.1	0.94
09/10	2.9	1.4	—	—	0.7	0.7	5.6	6.7	23.4	22.5	34.4	1.6	1.01
10/11	72.4	—	—	—	17.1	5.9	—	—	—	—	0.0	4.6	0.13
11/12	—	—	—	—	—	17.6	—	—	—	82.4	—	—	0.09
12/13	—	5.5	—	2.0	2.4	44.6	1.6	—	19.5	3.7	12.0	8.7	0.52
13/14	—	18.4	—	0.0	25.9	20.3	—	6.8	8.4	—	—	20.3	0.29
14/15	2.8	—	—	0.1	0.4	5.7	0.0	7.5	10.8	11.9	14.6	46.4	0.83
15/16	—	0.8	0.0	0.0	1.5	1.6	—	66.0	12.8	—	0.0	17.2	0.86
Average	5.3	2.1	3.0	6.5	13.0	13.5	3.3	10.9	8.3	8.6	7.5	18.0	8.2 ¹

¹ total landings for all years

Table C.3A: Distribution of ELE 5 landings (%) by fishing year and by target species for bottom trawl and setnet in statistical area group [025–026] based on trips which landed elephantfish. The bottom trawl values are plotted in Figure 13 and the setnet values are plotted in Figure 14.

Fishing Year	[025–026] (%)											
	Bottom Trawl							Setnet				
	FLA	STA	ELE	SPD	GUR	BAR	OTH	SPO	SCH	ELE	SPD	OTH
89/90	31.5	7.2	23.5	29.0	–	2.2	6.6	20.9	24.0	55.0	–	–
90/91	63.9	24.9	8.6	–	–	0.2	2.3	24.8	7.7	67.5	–	–
91/92	45.0	47.3	2.6	–	0.0	–	5.1	18.1	27.4	54.4	–	–
92/93	85.6	9.8	1.4	–	0.0	–	3.1	21.4	44.3	33.1	1.2	0.0
93/94	33.0	63.8	–	–	–	–	3.2	9.1	70.5	20.4	–	–
94/95	34.4	21.3	–	–	–	–	44.3	10.0	87.2	2.8	–	0.0
95/96	35.1	10.5	4.1	–	0.9	35.8	13.6	16.2	83.7	–	–	0.2
96/97	82.5	1.1	16.4	–	–	–	–	55.9	30.2	13.9	–	–
97/98	99.5	0.5	–	–	–	–	–	3.5	96.5	–	–	–
98/99	85.2	1.2	1.6	–	1.3	10.4	0.4	16.3	50.8	32.9	–	–
99/00	93.0	3.2	–	–	2.8	–	1.0	56.0	44.0	–	–	–
00/01	91.6	0.3	–	–	3.2	1.8	3.2	41.6	54.1	4.3	–	–
01/02	60.5	2.5	–	–	2.9	7.5	26.7	20.3	79.7	–	–	–
02/03	62.9	19.9	6.4	–	0.6	0.1	10.1	57.5	42.5	–	–	–
03/04	68.4	7.3	22.2	–	0.0	1.1	1.1	60.4	39.6	–	–	–
04/05	28.6	29.1	35.1	3.6	2.6	0.2	0.9	89.2	10.8	–	–	–
05/06	17.5	17.2	27.3	24.8	9.3	0.0	3.9	49.1	34.0	–	17.0	–
06/07	34.7	3.6	25.1	20.6	14.9	0.2	0.9	66.4	29.9	–	3.7	–
07/08	47.2	2.5	28.6	18.5	0.2	0.8	2.2	31.3	8.6	–	60.2	–
08/09	37.3	3.3	28.3	28.1	2.0	0.6	0.5	67.1	32.9	–	–	–
09/10	42.1	0.8	25.4	11.6	2.8	0.0	17.2	33.3	39.6	–	27.1	–
10/11	28.7	5.6	19.3	9.4	1.6	11.4	24.1	15.4	68.5	–	16.0	–
11/12	37.3	5.1	22.8	6.7	0.3	3.5	24.3	31.1	10.6	–	58.2	–
12/13	40.2	1.2	14.0	22.5	7.3	1.2	13.5	64.7	27.1	7.9	0.3	–
13/14	39.7	11.9	24.0	6.3	4.9	0.5	12.8	34.0	1.4	55.0	9.6	0.0
14/15	46.8	1.8	22.5	7.1	0.8	1.4	19.5	20.3	4.2	74.3	1.3	–
15/16	64.4	1.4	7.9	–	13.3	4.7	8.4	39.0	17.2	42.8	1.0	–
Average	52.5	7.3	16.9	9.2	3.3	2.6	8.2	35.4	32.6	18.4	13.6	0.0

Table C.3B: Distribution of ELE 5 landings (%) by fishing year and by target species for bottom trawl and setnet in statistical area group [030–032] based on trips which landed elephantfish. The bottom trawl values are plotted in Figure 13 and the setnet values are plotted in Figure 14.

Fishing Year	[030–032] (%)											
	Bottom Trawl							Setnet				
	FLA	STA	ELE	SPD	GUR	BAR	OTH	SPO	SCH	ELE	SPD	OTH
89/90	24.4	40.5	8.3	0.6	9.7	0.2	16.4	–	100.0	–	–	–
90/91	46.1	37.2	10.4	0.0	3.0	0.2	3.1	0.9	34.1	64.9	–	–
91/92	53.9	34.6	8.2	–	2.1	–	1.3	15.7	3.0	81.3	–	–
92/93	43.9	53.4	0.1	0.0	0.2	0.7	1.8	40.6	4.4	54.7	–	0.3
93/94	27.6	40.4	7.7	–	6.7	0.0	17.6	60.0	11.8	28.2	–	–
94/95	44.6	43.6	7.5	–	3.0	0.0	1.2	61.1	38.9	–	–	–
95/96	44.9	3.1	25.5	–	4.8	7.1	14.7	55.5	38.7	5.9	–	0.0
96/97	79.8	8.7	11.0	–	0.5	–	–	11.0	7.5	81.5	–	–
97/98	67.7	18.6	13.7	–	0.1	–	0.0	20.9	79.1	–	–	–
98/99	76.4	23.3	0.3	–	–	–	–	63.1	36.9	–	–	–
99/00	76.4	10.6	1.7	–	9.2	–	2.0	14.2	12.4	73.5	–	–
00/01	81.2	18.8	–	–	0.0	–	0.0	72.2	1.9	19.3	6.6	–
01/02	61.2	23.5	9.0	–	3.6	–	2.6	69.3	30.7	–	–	–
02/03	40.4	15.7	41.4	–	1.3	0.3	1.0	33.5	61.6	4.9	–	–
03/04	19.5	53.9	10.3	–	11.4	0.2	4.8	59.0	41.0	–	–	–
04/05	20.6	29.6	33.9	0.3	10.9	–	4.7	94.6	5.4	–	–	–
05/06	24.2	43.8	27.3	1.8	2.7	–	0.2	85.0	15.0	–	0.0	–
06/07	27.8	44.1	17.0	8.2	2.5	0.0	0.4	44.1	55.5	–	0.4	–
07/08	40.4	45.6	9.0	3.3	1.6	0.0	0.1	52.1	47.7	–	0.2	–
08/09	23.0	49.0	3.4	19.7	4.1	–	0.8	0.8	99.2	–	–	–
09/10	24.9	53.4	18.0	0.5	2.3	–	0.8	37.6	62.4	–	–	–
10/11	19.6	61.3	8.5	2.9	7.2	0.1	0.4	25.2	73.6	–	1.2	–
11/12	32.1	43.6	3.0	0.5	6.8	0.1	14.0	24.2	44.9	–	30.9	–
12/13	39.9	29.9	17.7	–	4.7	0.5	7.3	40.5	59.5	–	–	–
13/14	30.2	41.5	16.0	0.6	3.3	1.2	7.2	19.8	31.0	26.6	22.6	–
14/15	41.9	32.7	21.7	–	1.1	–	2.6	10.8	61.2	28.0	–	–
15/16	43.9	34.2	14.2	–	3.0	0.0	4.6	53.7	45.6	0.7	–	–
Average	41.0	35.7	13.6	2.2	3.8	0.3	3.5	45.9	35.0	16.1	3.0	0.0

Table C.3C: Distribution of ELE 5 landings (%) by fishing year and by target species for bottom trawl and setnet in statistical area group [Stewart I.] based on trips which landed elephantfish. The bottom trawl values are plotted in Figure 13 and the setnet values are plotted in Figure 14.

Fishing Year	[Stewart I.] (%)											
	Bottom Trawl							Setnet				
	FLA	STA	ELE	SPD	GUR	BAR	OTH	SPO	SCH	ELE	SPD	OTH
89/90	–	93.9	–	–	–	0.0	6.1	–	100.0	–	–	–
90/91	–	78.1	–	–	3.7	10.6	7.7	–	–	–	–	–
91/92	0.0	100.0	–	–	–	–	–	–	58.3	–	–	41.7
92/93	39.4	60.6	–	–	–	0.0	–	82.9	17.1	–	–	–
93/94	–	100.0	–	–	–	–	–	9.1	90.9	–	–	–
94/95	95.7	4.2	–	–	–	–	0.1	–	100.0	–	–	–
95/96	52.4	22.5	22.1	–	–	1.0	2.0	–	100.0	–	–	–
96/97	15.8	84.2	–	–	–	–	–	–	100.0	–	–	–
97/98	81.5	18.5	–	–	–	–	–	–	100.0	–	–	–
98/99	45.5	35.8	–	–	18.7	–	0.0	–	100.0	–	–	–
99/00	50.1	10.4	–	–	39.0	–	0.5	–	100.0	–	–	–
00/01	89.2	10.7	–	–	–	0.0	0.1	–	–	–	–	–
01/02	24.2	49.2	–	–	0.2	0.1	26.3	–	100.0	–	–	–
02/03	0.9	57.4	–	–	5.7	1.0	35.0	81.5	18.5	–	–	–
03/04	0.4	99.4	–	–	–	–	0.2	–	100.0	–	–	–
04/05	0.9	95.2	–	0.3	–	–	3.6	–	100.0	–	–	–
05/06	–	53.5	–	–	–	0.2	46.3	–	100.0	–	–	–
06/07	–	63.3	–	–	–	32.2	4.4	–	100.0	–	–	–
07/08	0.1	72.2	–	0.0	–	21.6	6.1	34.5	65.5	–	–	–
08/09	0.1	84.4	–	1.1	–	7.7	6.7	–	100.0	–	–	–
09/10	0.0	99.3	–	–	–	0.3	0.3	–	100.0	–	–	–
10/11	3.2	85.8	–	–	–	1.7	9.3	–	100.0	–	–	–
11/12	0.0	22.0	–	1.5	–	58.6	17.9	–	93.9	6.1	–	–
12/13	0.8	79.6	–	–	–	6.7	12.9	–	100.0	–	–	–
13/14	5.2	89.9	–	–	–	0.0	4.9	–	98.4	–	1.6	–
14/15	0.0	43.2	–	–	–	31.1	25.8	–	98.8	–	1.2	–
15/16	0.1	72.6	–	–	–	1.2	26.2	–	100.0	–	–	–
Average	13.2	59.3	0.2	0.2	1.3	13.7	12.1	14.3	85.4	0.1	0.2	0.1

Appendix D. ELE 5 CPUE ANALYSIS

D.1 General overview

This Appendix describes a repeat of an ELE 5 CPUE analysis that was initially presented in Starr et al. (2009) and then updated by Starr & Kendrick (2013) and Langley (2014). This Appendix and Appendix E support the analyses presented in Section 3 of the main report. This Appendix contains the definition for the modelled fishery, equations used, and procedures followed. Appendix E provides detailed tables and figures with statistics and diagnostics, and a final table giving the estimated indices with the standard error.

D.2 Methods

D.2.1 Data Preparation

The identification of candidate trips for these analyses and the methods used to prepare them are described in Section 2.3.1 in the main report. Landings were allocated to effort at the “daily effort stratum” resolution procedure described on page 9. As described in Section 2.3.1, the CPUE data set was prepared using the “Fishstock” expansion procedure, whereby trips which fished in shared statistical areas and which landed to more than one ELE QMA were dropped. Because of the relative isolation of ELE 5, this procedure only resulted in the loss of just over 5% of the landings, which was thought to be acceptable. Because the remaining data were unequivocally from ELE 5, no further filtering of the data were required.

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 elephantfish were termed “successful”, and may include relevant but unsuccessful effort given that a “daily-effort stratum” represents amalgamated catch and effort. Consequently, the analysis of catch rates in successful strata also incorporates some zero catch information.

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

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

D.2.2 Analytical methods for standardisation

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

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

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

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

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

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

A standardised abundance index (Eq. D.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:

$$\text{Eq. D.3} \quad \ln(I_i) = B + Y_{y_i} + \alpha_{a_i} + \beta_{b_i} + \dots + f(\chi_i) + f(\delta_i) + \dots + \varepsilon_i$$

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 $f(\chi_i)$ and $f(\delta_i)$ 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. Net length ($\ln(L)_i$) and fishing duration ($\ln(D)_i$) were offered to the setnet models as continuous third order polynomial variables. Number of sets ($\ln(S)_i$) and fishing duration ($\ln(H)_i$) were offered to the bottom longline models as continuous third order polynomial variables.

It was decided to force the lognormal distribution for analysing the positive catch part of this CPUE analysis. This was done for consistency with past analyses, which selected the lognormal as the “best” distribution when analysed by Starr & Kendrick (2013).

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. D.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 elephantfish as the dependent variable (where 1 is substituted for $\ln(I_i)$ in Eq. D.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. D.3. Such a model provides an alternative series of standardised coefficients of relative annual changes that is analogous to the equivalent series estimated from the positive catch regression.

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

Eq. D.4

$${}^cY_y = \frac{{}^LY_y}{\left(1 - P_0 \left[1 - \frac{1}{{}^BY_y}\right]\right)}$$

where cY_y = combined index for year y
 LY_y = lognormal index for year i
 BY_y = binomial index for year i
 P_0 = proportion zero for base year 0

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

Appendix E. DIAGNOSTICS AND SUPPORTING ANALYSES FOR ELE 5 BOTTOM TRAWL CPUE

E.1 Introduction

This CPUE analysis was accepted for monitoring ELE 5 by the Southern Inshore Fishery Assessment Working Group (MPI 2016). The Plenary agreed, when this analysis was reviewed in 2017, to add a binomial presence/absence series because of a declining trend in the proportion of days with zero catch and accepted a revised index which combined the binomial and lognormal series using the delta-lognormal method (Eq. D.4) (MPI 2017).

E.2 Fishery definition

ELE5-BT(MIX): The fishery is defined from bottom trawl fishing events which fished in Statistical Areas 025, 026, 027, 028, 030, 031, and 032 declaring target species ELE, FLA, STA, BAR, SPD, and RCO.

E.3 Core vessel selection

The criteria used to define the core fleet were those vessels that had fished for at least 10 trips in each of at least 6 years using trips with at least 1 kg of catch. These criteria resulted in a core fleet size of 50 vessels which took 89% of the catch (Figure E.1).

E.4 Data summary

Table E.1: Summaries by fishing year for core vessels, trips, daily effort strata, events that have been “rolled up” into daily effort strata, events per daily-effort stratum, tows, hours fished, landed ELE (t), and proportion of trips with catch for the core vessel data set (based on a minimum of 10 trips per year in 6 years) in the ELE5-BT(MIX) fishery. Final two columns apply to trips which declared no estimated catch of elephantfish but reported ELE landings, giving the proportion of these trips relative to trips which reported ELE and the proportion of the reported catch from these trips relative to the total annual ELE reported catch.

Fishing year	Vessels	Trips	Daily effort strata	Events per stratum	Sum (tows)	Sum (hours)	Catch (t)	% trips with catch	% trips: 0 estimated catch	% trips: 0 estimated catch	% trips: 0 estimated trips
1990	23	556	969	977	1.01	3 021	6 793	11.11	27.9	44.5	13.8
1991	20	516	944	949	1.01	2 788	6 772	18.95	29.1	56.7	13.5
1992	26	714	1 160	1 293	1.11	3 662	8 505	21.75	30.5	60.1	12.7
1993	31	863	1 472	1 672	1.14	4 886	11 603	21.13	24.0	60.4	12.2
1994	30	875	1 488	1 507	1.01	5 071	11 482	20.00	32.3	64.0	16.9
1995	33	961	1 655	1 706	1.03	5 794	12 697	26.84	31.7	62.3	13.4
1996	37	910	1 774	1 842	1.04	6 742	14 869	37.62	36.6	54.1	16.2
1997	37	1 065	1 903	1 965	1.03	7 477	15 135	69.28	37.1	58.2	18.3
1998	34	996	1 758	1 833	1.04	6 726	14 054	76.02	36.0	56.3	11.2
1999	31	935	1 826	1 897	1.04	6 752	15 133	94.27	43.3	57.3	15.3
2000	30	889	1 866	1 890	1.01	6 670	15 939	84.69	47.4	52.5	10.9
2001	33	991	2 104	2 126	1.01	7 842	18 678	119.33	43.4	48.6	8.9
2002	32	941	1 923	2 007	1.04	6 889	16 038	96.15	40.7	50.4	7.5
2003	31	950	2 047	2 138	1.04	7 891	17 095	126.19	50.0	41.5	8.5
2004	31	1 059	2 140	2 169	1.01	7 605	17 613	145.96	43.5	43.2	4.2
2005	30	1 084	2 123	2 136	1.01	7 445	17 984	140.76	45.2	47.1	9.1
2006	32	936	1 921	1 937	1.01	7 202	17 703	163.82	54.7	39.8	7.4
2007	29	855	2 033	2 045	1.01	7 501	19 603	191.95	59.4	40.9	6.7
2008	28	835	1 920	6 363	3.31	6 479	16 705	199.06	66.4	39.4	5.5
2009	28	767	1 745	5 509	3.16	5 695	15 212	216.97	73.4	37.1	4.8
2010	26	777	1 874	6 130	3.27	6 231	16 815	166.00	70.8	33.8	4.6
2011	28	665	1 535	4 971	3.24	5 009	13 806	143.49	73.5	34.8	7.4
2012	27	746	1 875	5 989	3.19	6 047	17 424	120.55	68.4	38.4	7.2
2013	26	661	1 745	5 634	3.23	5 683	16 356	125.84	79.4	40.4	7.9
2014	25	649	1 615	5 108	3.16	5 156	15 177	133.40	74.0	38.1	6.5
2015	19	524	1 319	4 119	3.12	4 184	12 516	136.75	79.8	34.7	4.5
2016	20	572	1 370	4 214	3.08	4 402	12 936	106.76	73.4	42.6	9.4

E.5 Core vessel selection

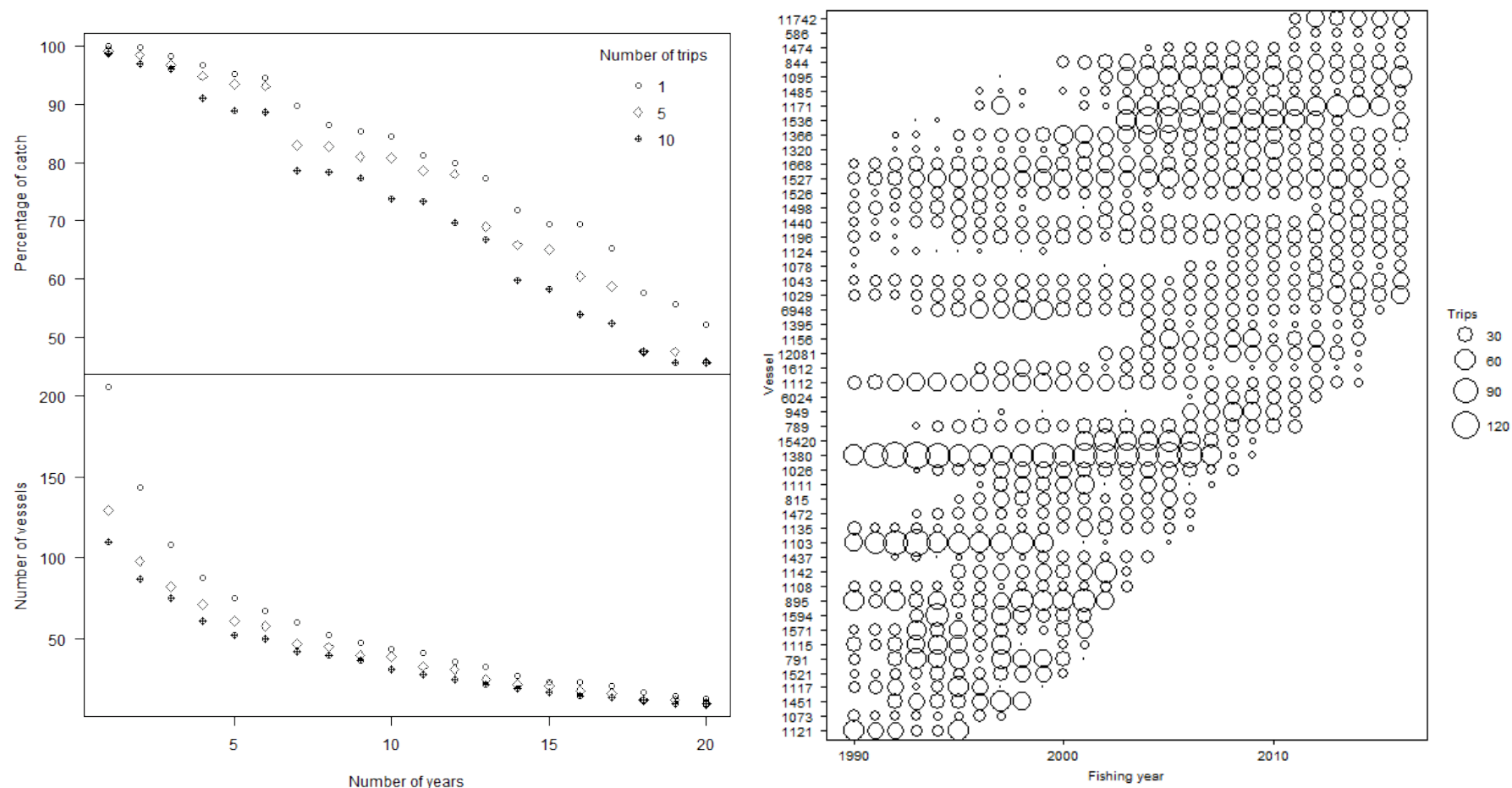


Figure E.1: [left panel] total landed ELE and number of vessels plotted against the number of years used to define core vessels participating in the ELE5-BT(MIX) dataset. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. [right panel]: bubble plot showing the number of daily-effort strata for selected core vessels (based on at least 10 trips in 6 or more fishing years) by fishing year.

E.6 Exploratory data plots for core vessel data set

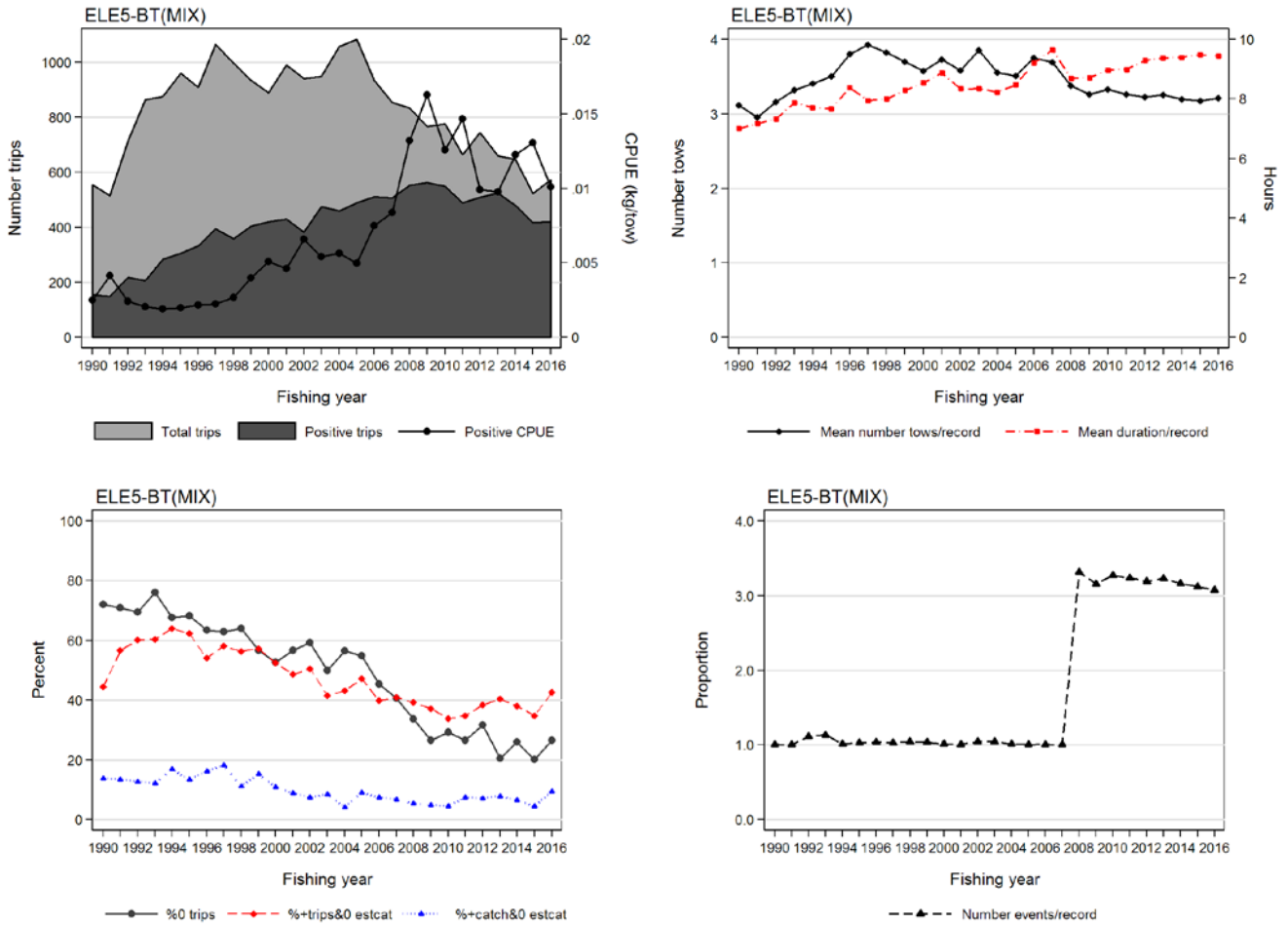


Figure E.2: Core vessel summary plots by fishing year for model ELE5-BT(MIX): [upper left panel]: total trips (light grey) and trips with elephantfish catch (dark grey) overlaid with median annual arithmetic CPUE (kg/tow) for all trips i with positive catch: $A_y = \text{median}(C_{y,i}/E_{y,i})$; [upper right panel]: mean number of tows and mean duration per daily-effort stratum record; [lower left panel]: a) percentage of trips with no catch of elephantfish, b) percentage of trips with no estimated catch but with landed catch; c) percentage of catch with no estimated catch relative to total landed catch; [lower right panel]: mean number of events per daily-effort stratum record.

E.7 Positive catch model selection table

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

Table E.2: Order of acceptance of variables into the lognormal model of successful catches in the ELE5-BT(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 6 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	28	-106 054	212 165	6.16	*
vessel	77	-104 865	209 884	16.40	*
target species	82	-104 442	209 048	19.76	*
month	93	-104 106	208 397	22.34	*
poly(log(tows), 3)	96	-104 009	208 210	23.06	
poly(log(duration), 3)	99	-103 995	208 189	23.16	
area	104	-103 983	208 175	23.25	

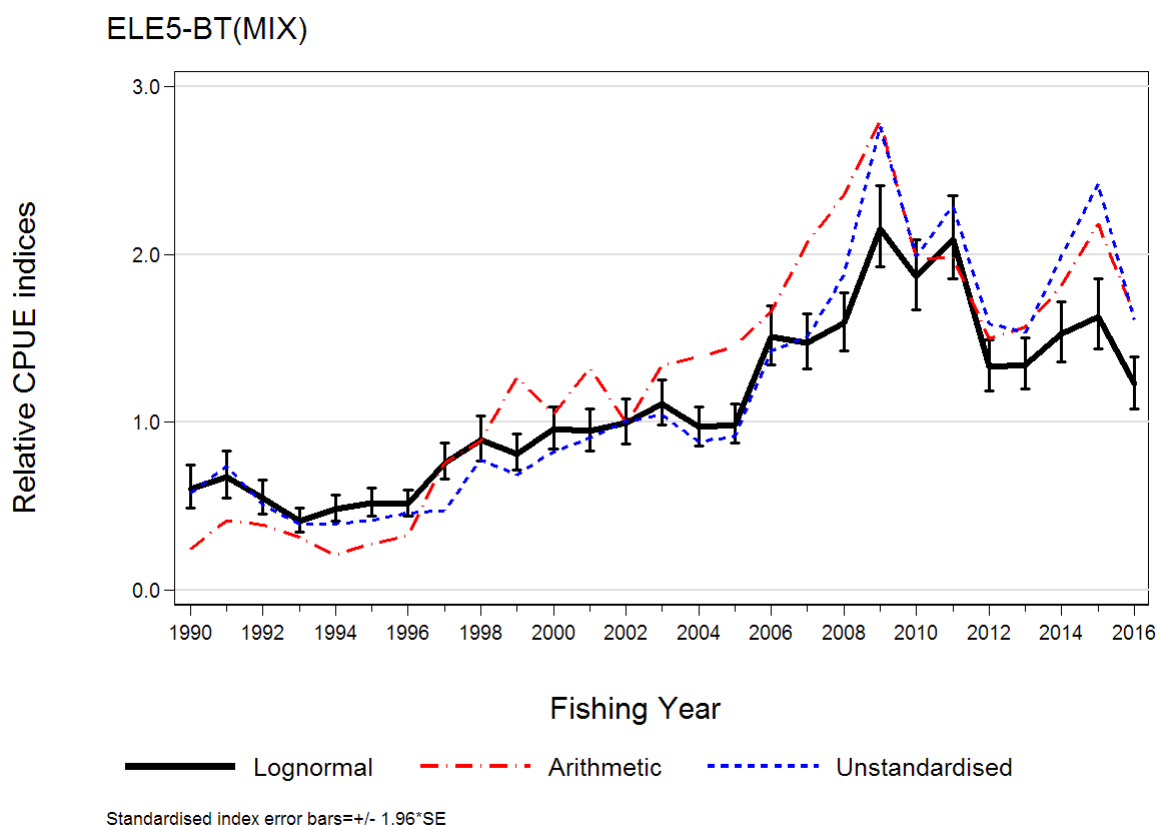


Figure E.3: Relative CPUE indices for elephantfish using the lognormal non-zero model based on the ELE5-BT(MIX) fishery definition. Also shown are two unstandardised series from the same data: a) Arithmetic (Eq. D.1) and b) Unstandardised (Eq. D.2).

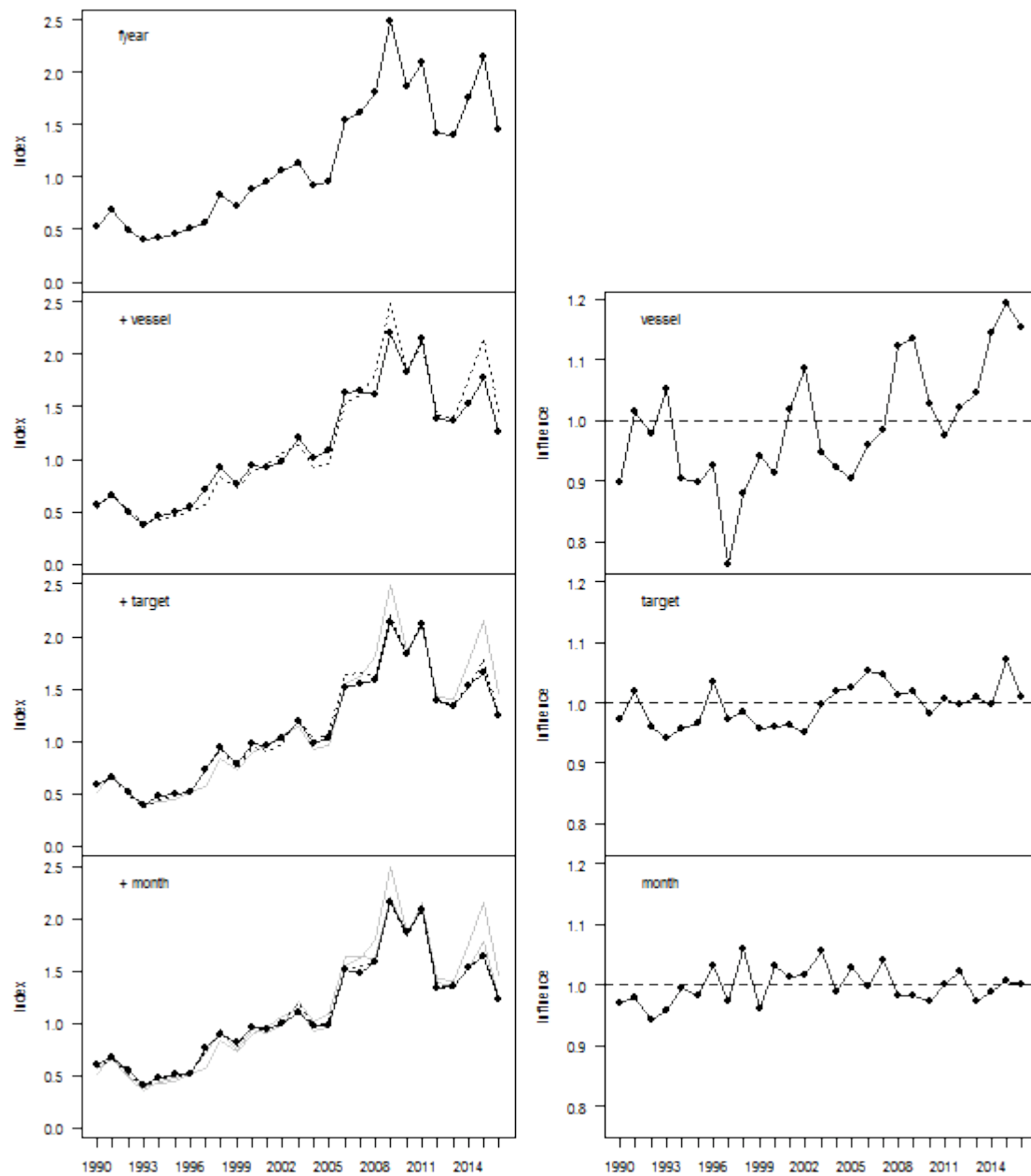


Figure E.4: [left column]: annual indices from the lognormal model of ELE5-BT(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

E.8 Residual and diagnostic plots

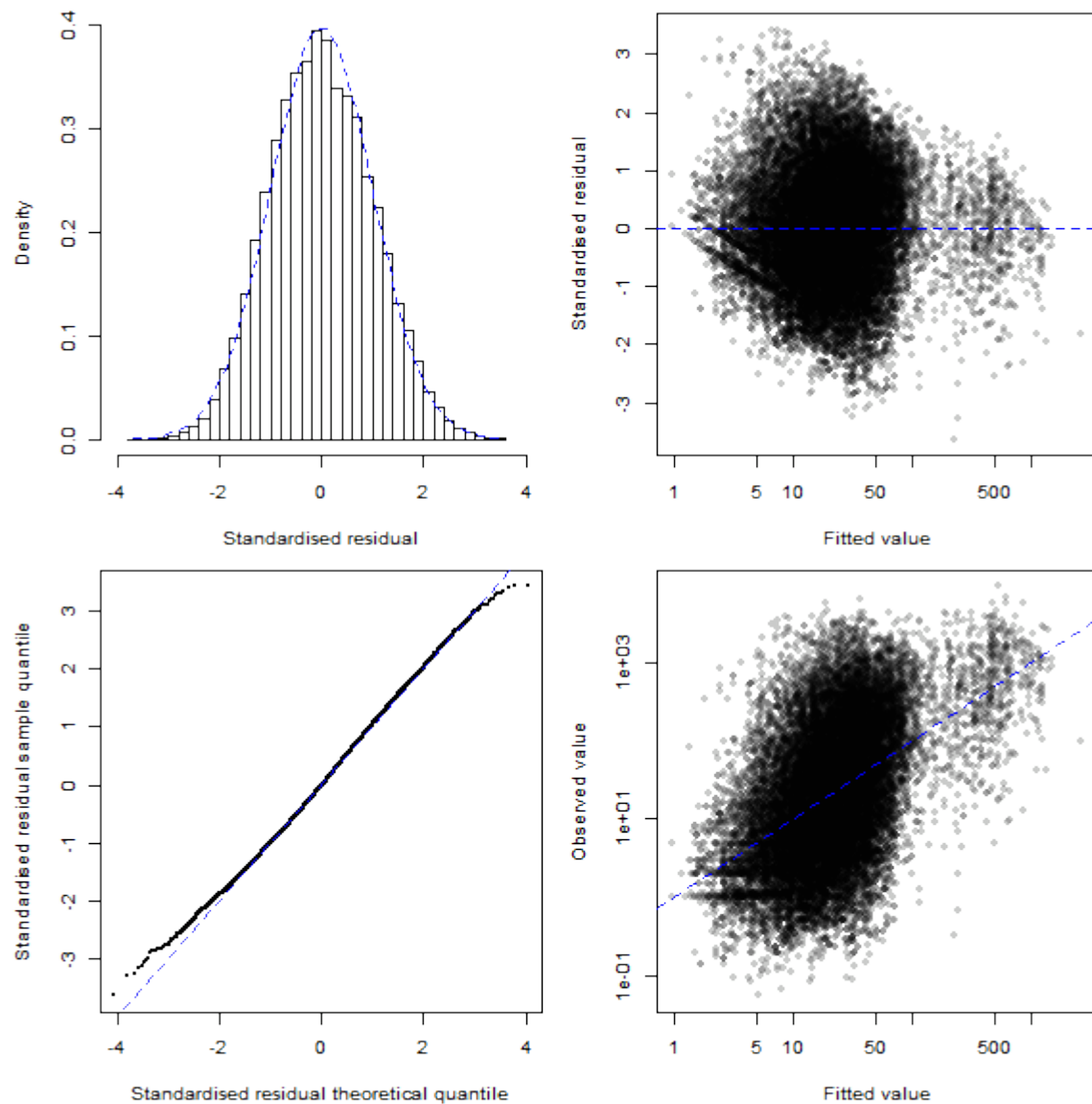


Figure E.5: Plots of the fit of the lognormal standardised CPUE model of successful catches of elephantfish in the ELE5-BT(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution; [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

E.9 Model coefficients

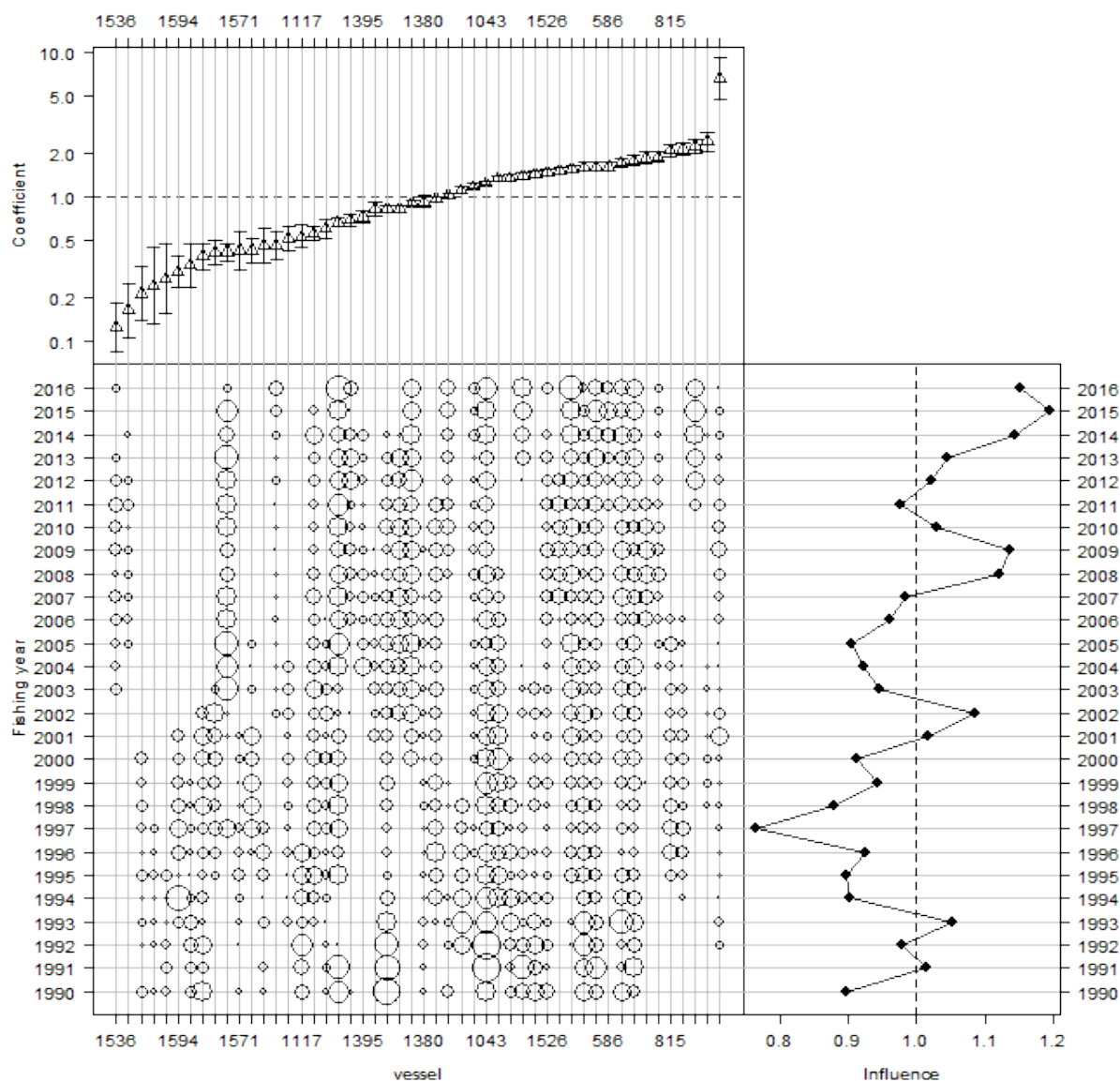


Figure E.6: Effect of vessel in the lognormal model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

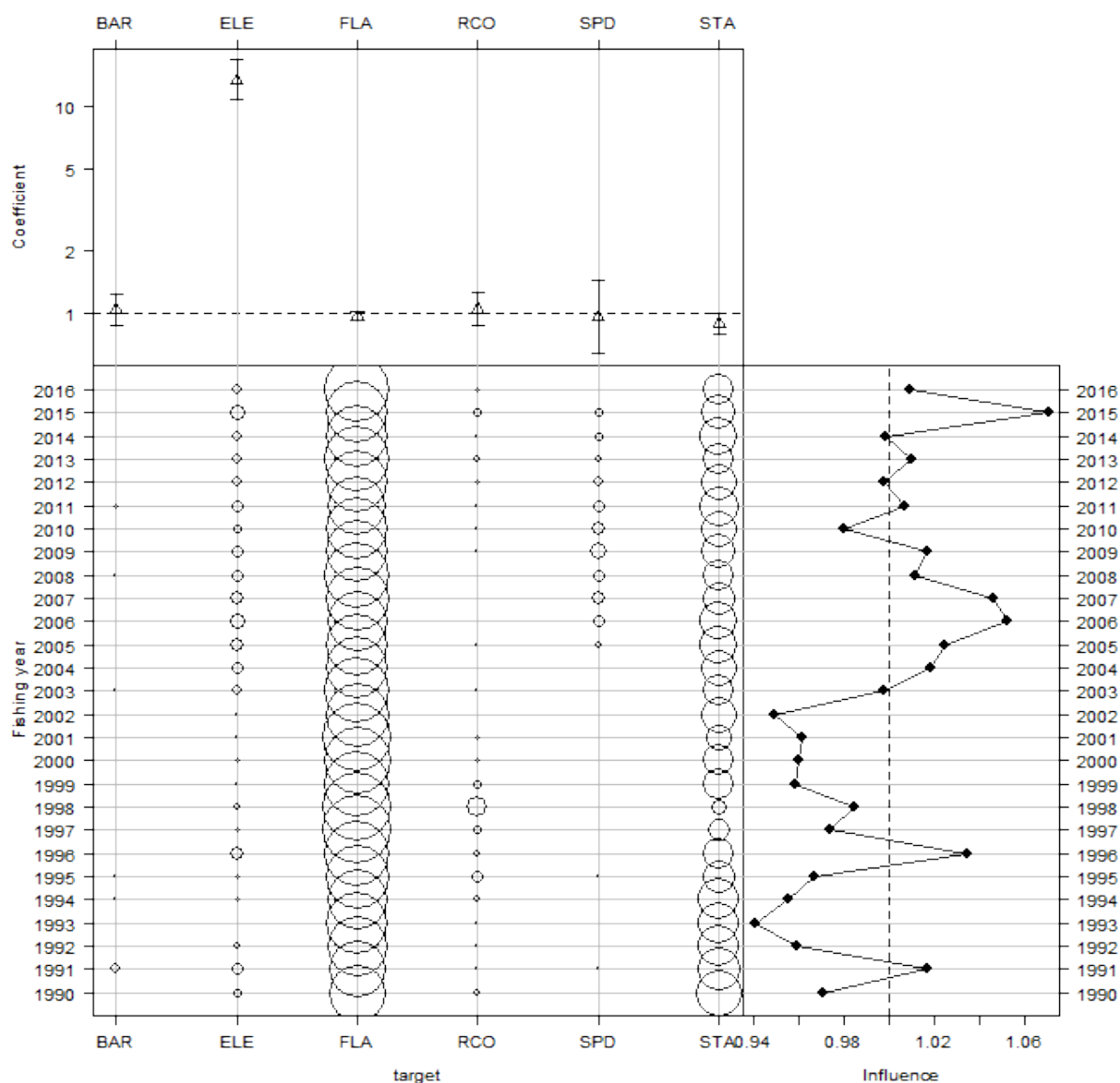


Figure E.7: Effect of target species in the lognormal model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

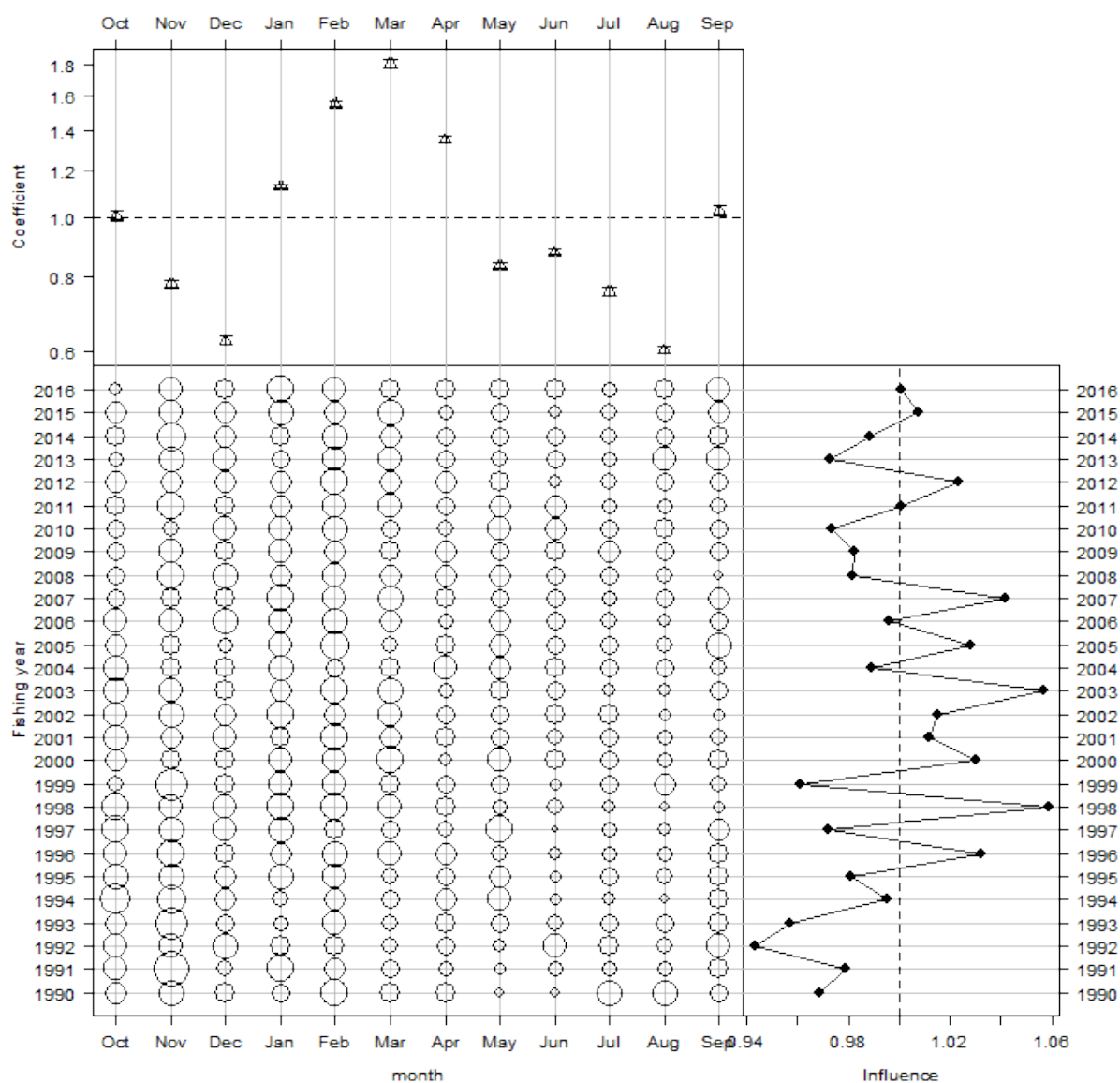


Figure E.8: Effect of month in the lognormal model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

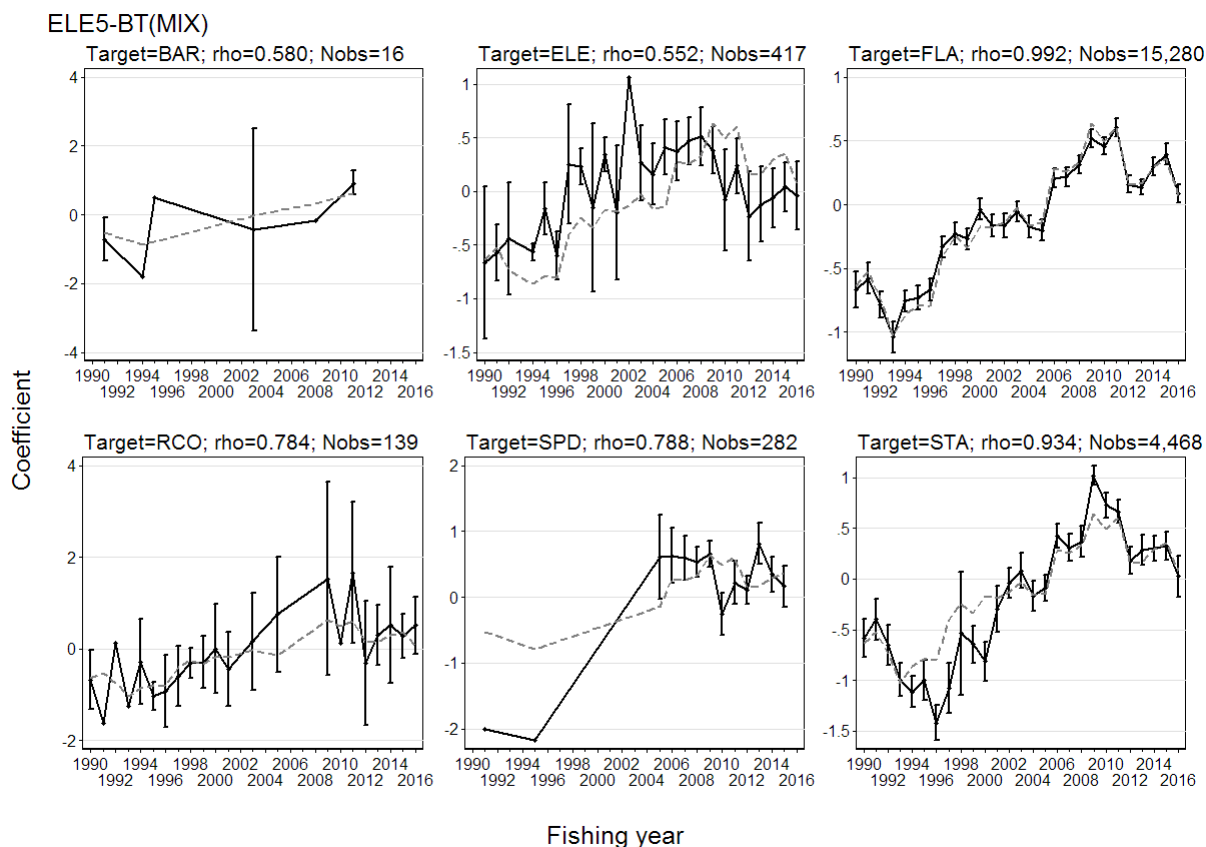


Figure E.9: Residual implied coefficients for target species \times fishing year interaction (interaction term not offered to the model) in the elephantfish ELE5-BT(MIX) lognormal model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target \times year interaction term is fitted, particularly for those target \times year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (ρ) between the category year index and the overall model index, and the number of records supporting the category.

E.10 Logistic (binomial) model selection table

Three explanatory variables entered the model after fishing year (Table E.3), with duration fished and number tows non-significant. The model discarded area as an explanatory variable. A plot of the binomial model and the combined delta-lognormal model is provided in Figure E.10 and the CPUE indices are listed in Table E.4.

Table E.3: Order of acceptance of variables into the binomial (logistic) model of the presence/absence of elephantfish catches in the ELE5-BT(MIX) fishery model for core vessels (based on the vessel selection criteria of at least 10 trips in 6 or more fishing years), with the amount of explained deviance and R^2 for each variable. Variables accepted into the model are marked with an *, and the final R^2 of the selected model is in bold. Fishing year was forced as the first variable.

Variable	DF	Neg. Log likelihood	AIC	R^2	Model use
fishing year	27	-30 452	60 958	6.64	*
vessel	76	-28 567	57 285	16.65	*
month	87	-28 073	56 320	19.14	*
target species	92	-27 768	55 721	20.65	*
poly(log(duration), 3)	95	-27 678	55 545	21.10	
poly(log(tows), 3)	98	-27 662	55 520	21.17	
area	—	—	—	—	—

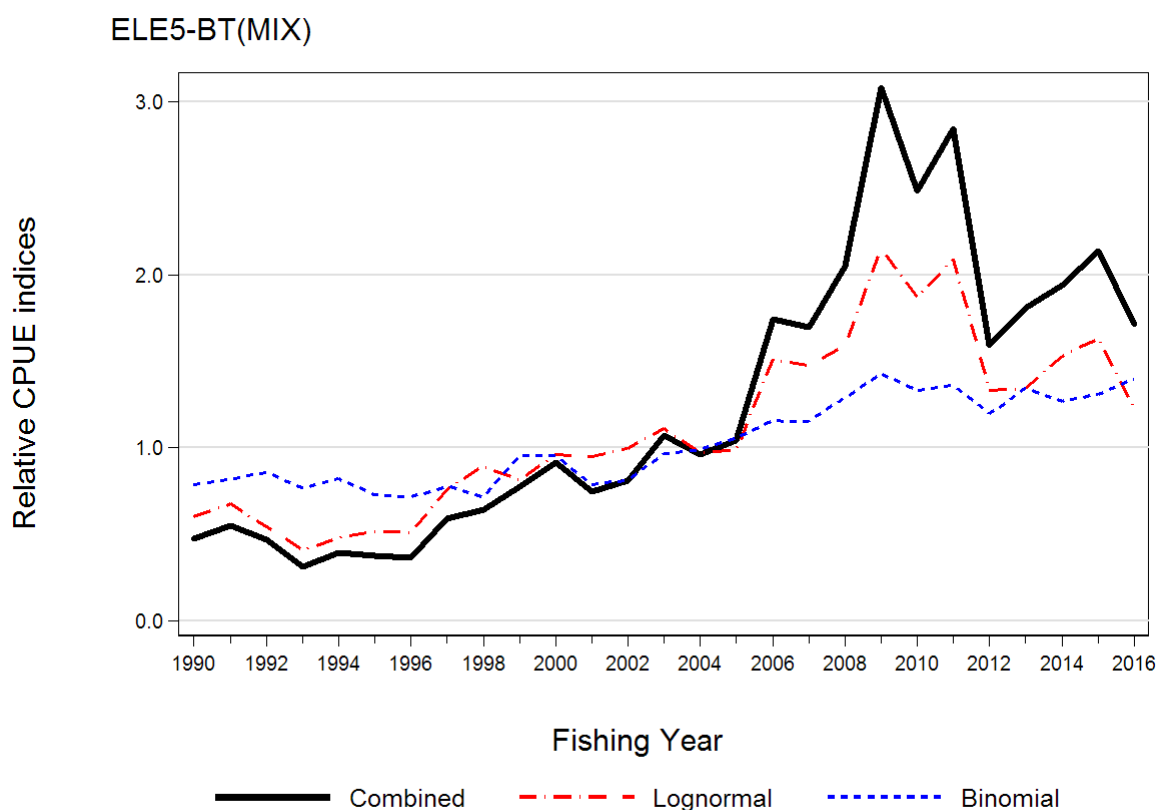


Figure E.10: Relative CPUE indices for elephantfish using the lognormal non-zero model based on the ELE5-BT(MIX) fishery definition, the binomial standardised model using the logistic distribution and a regression based on presence/absence of ELE, and the combined model using the delta-lognormal procedure (Eq. D.4).

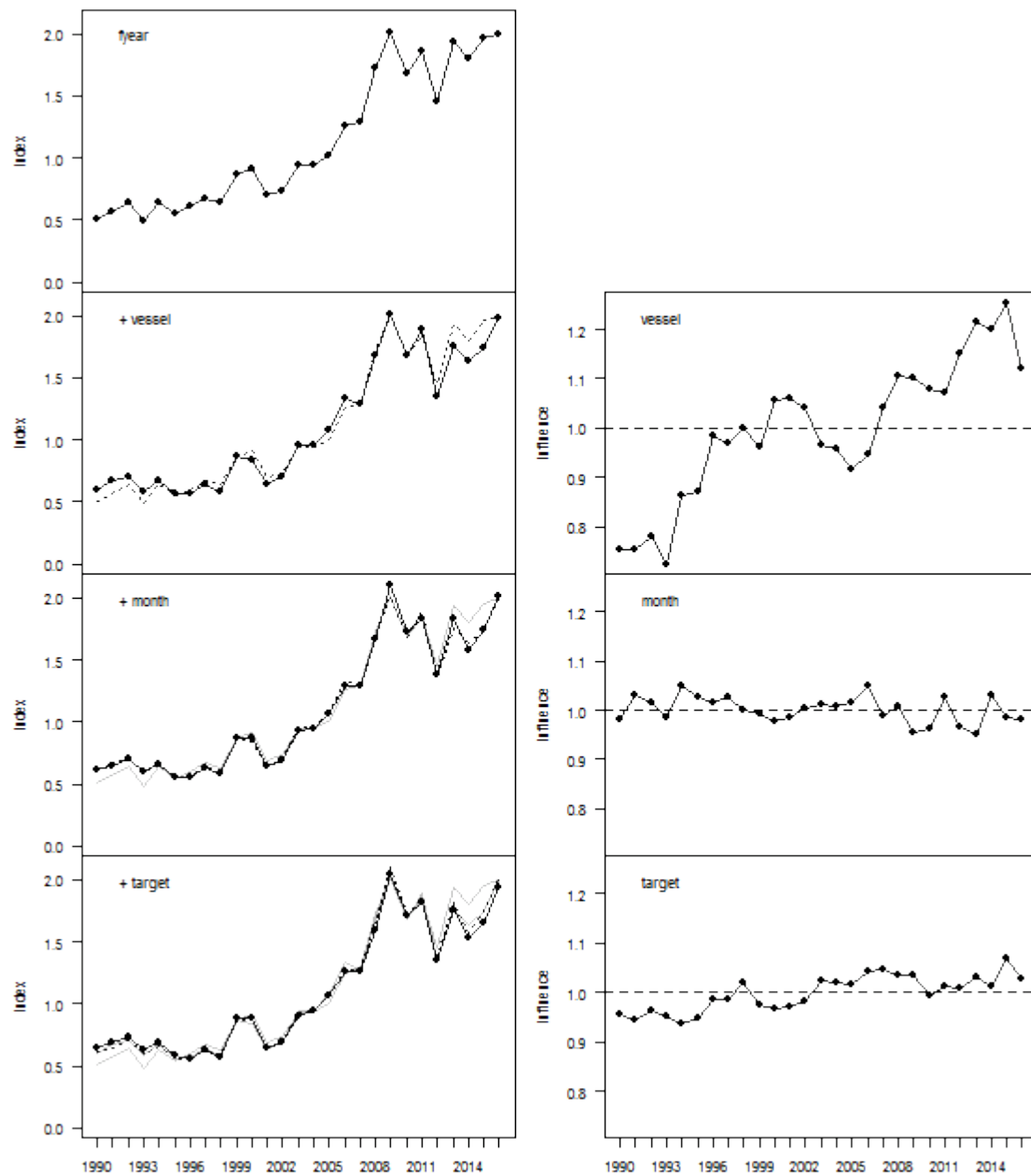


Figure E.11: [left column]: annual indices from the binomial model of ELE5-BT(MIX) at each step in the variable selection process; [right column]: aggregate influence associated with each step in the variable selection procedure.

E.11 Model coefficients

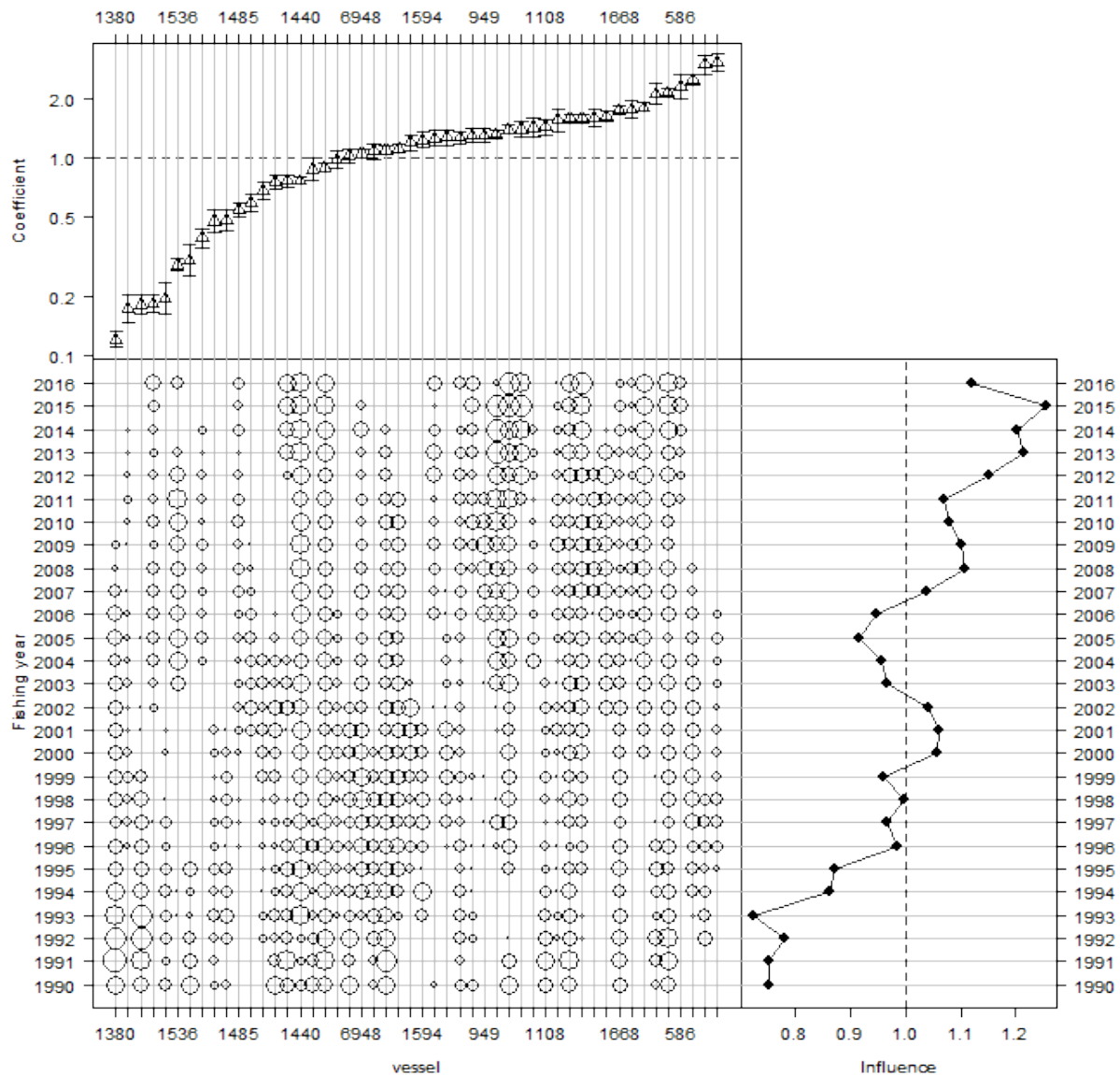


Figure E.12: Effect of vessel in the binomial model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

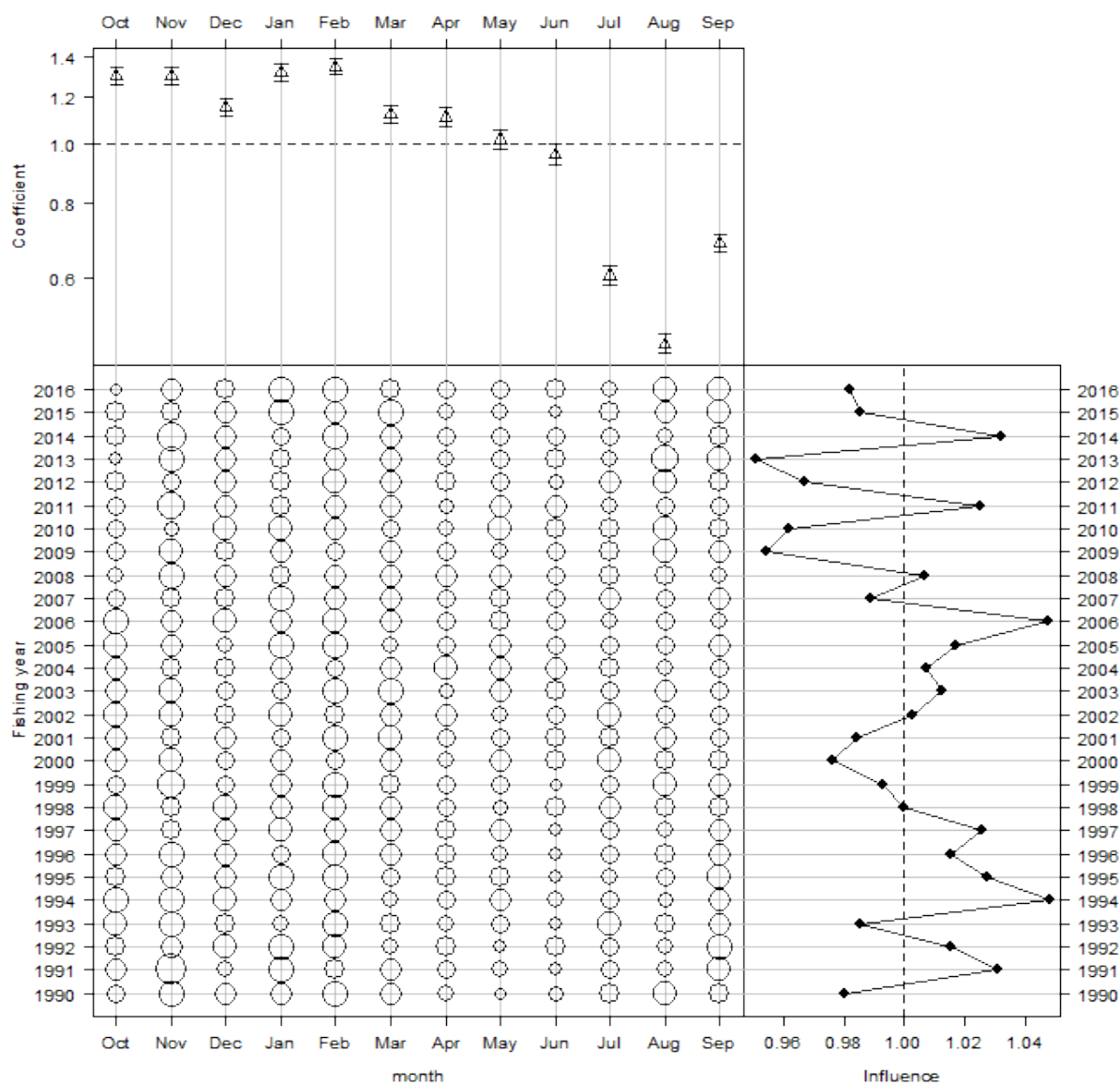


Figure E.13: Effect of month in the binomial model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

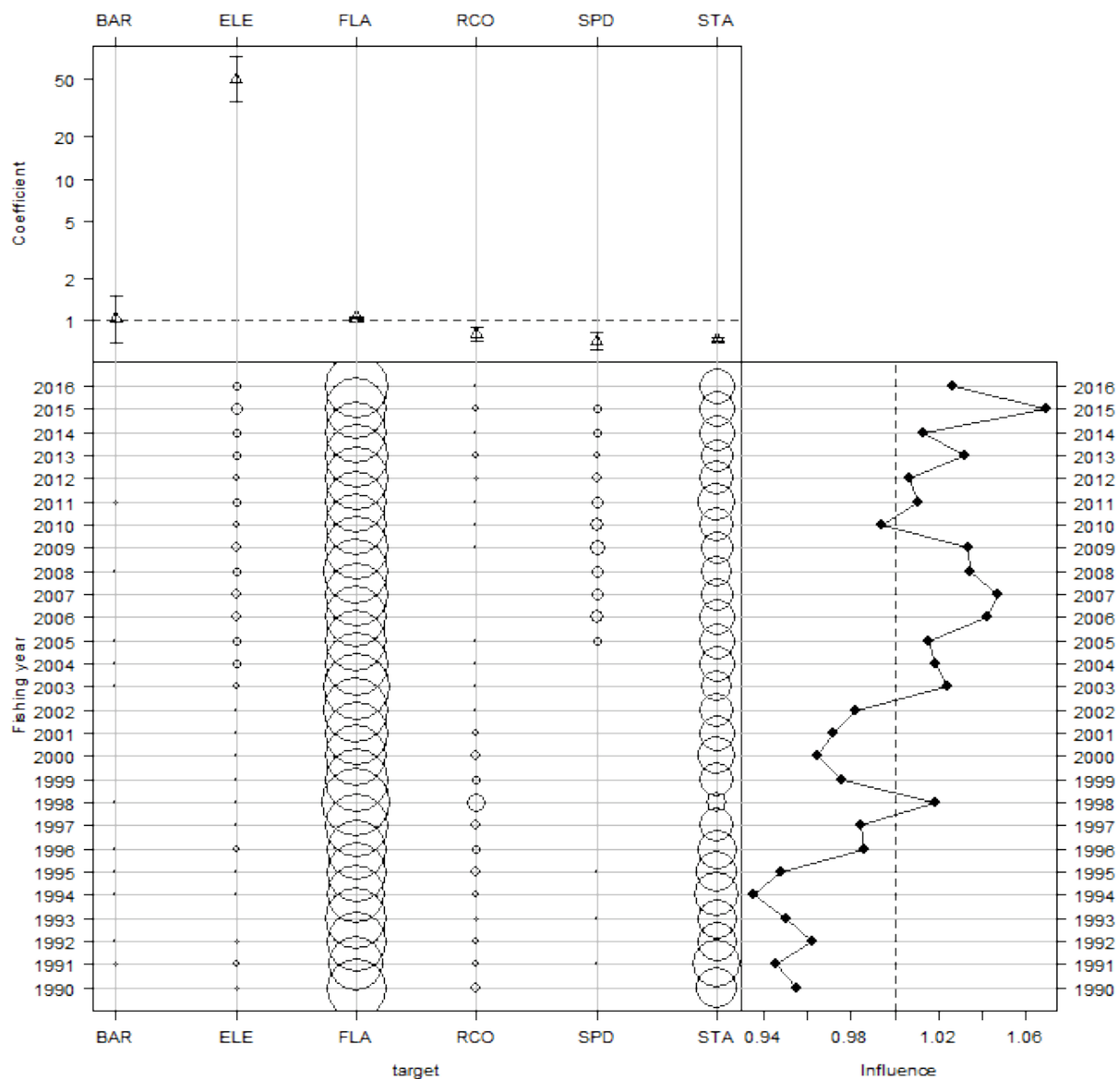


Figure E.14: Effect of target species in the binomial model for the elephantfish ELE5-BT(MIX) fishery. Top: effect by level of variable (left-axis: log space additive; right-axis: natural space multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

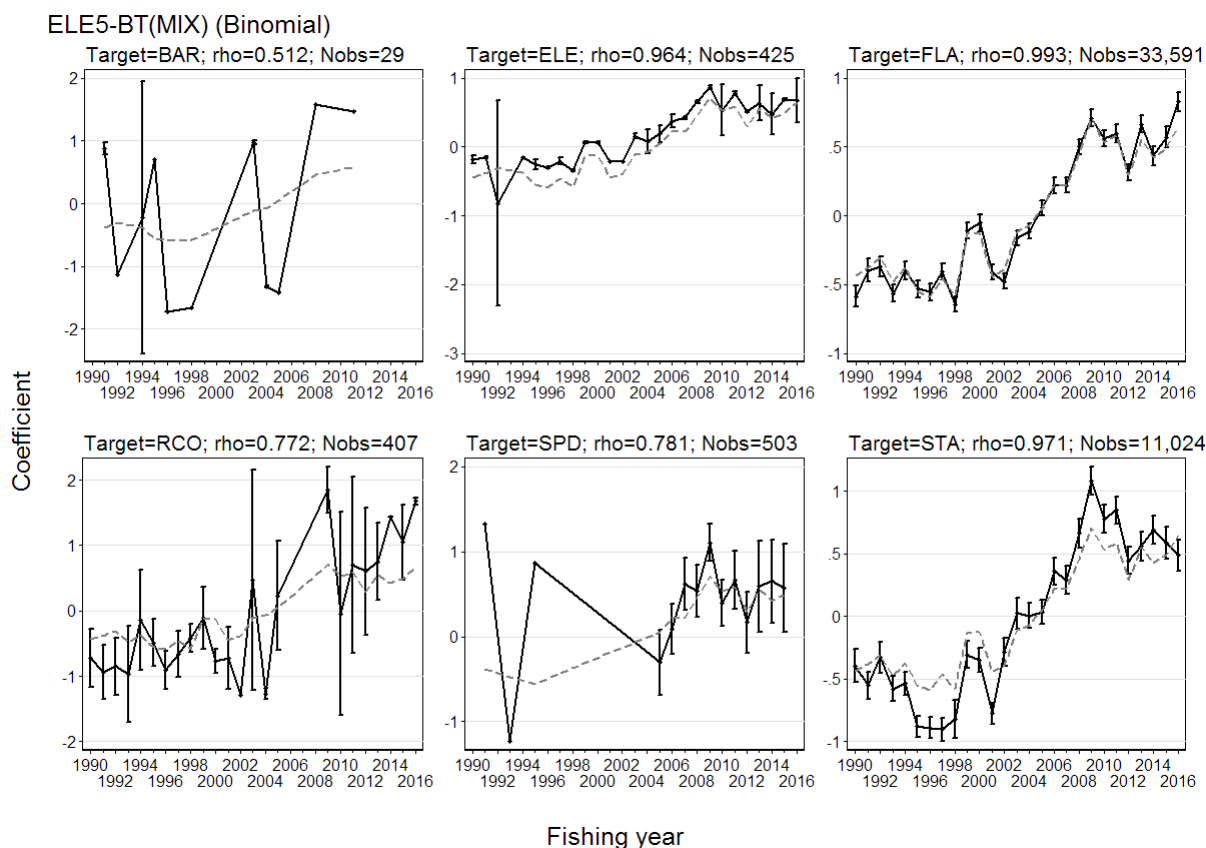


Figure E.15: Residual implied coefficients for target species \times fishing year interaction (interaction term not offered to the model) in the elephantfish ELE5-BT(MIX) binomial model. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals in each fishing year and target species. These values approximate the coefficients obtained when a target \times year interaction term is fitted, particularly for those target \times year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals. The information at the top of each panel identifies the plotted category, provides the correlation coefficient (ρ) between the category year index and the overall model index, and the number of records supporting the category.

E.12 CPUE indices

Table E.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error (SE) for the core data set by fishing year for the elephantfish ELE5-BT(MIX) analysis. All series (except SE) standardised to geometric mean=1.0.

Fishing year	All vessels				Core vessels		
	Arithmetic	Arithmetic	Geometric	Standardised	SE	Binomial	Combined
1990	0.199	0.247	0.578	0.604	0.1064	0.789	0.477
1991	0.452	0.414	0.738	0.675	0.1043	0.819	0.553
1992	0.504	0.387	0.508	0.546	0.0921	0.858	0.468
1993	0.365	0.314	0.395	0.409	0.0896	0.768	0.314
1994	0.234	0.209	0.393	0.480	0.0821	0.821	0.394
1995	0.392	0.274	0.417	0.517	0.0812	0.730	0.378
1996	0.366	0.327	0.460	0.511	0.0767	0.714	0.365
1997	0.653	0.758	0.473	0.760	0.0714	0.778	0.591
1998	0.796	0.887	0.777	0.894	0.0759	0.717	0.641
1999	1.335	1.266	0.687	0.814	0.0669	0.955	0.777
2000	1.021	1.050	0.826	0.959	0.0652	0.957	0.917
2001	1.410	1.323	0.906	0.948	0.0674	0.786	0.745
2002	1.060	0.993	1.006	0.997	0.0680	0.815	0.813
2003	1.289	1.339	1.043	1.110	0.0615	0.965	1.071
2004	1.316	1.391	0.885	0.970	0.0604	0.989	0.959
2005	1.382	1.454	0.916	0.987	0.0595	1.058	1.044
2006	1.506	1.658	1.426	1.509	0.0593	1.156	1.744
2007	1.883	2.069	1.508	1.473	0.0574	1.153	1.699
2008	2.342	2.357	1.878	1.590	0.0557	1.291	2.053
2009	2.782	2.795	2.765	2.155	0.0568	1.429	3.079
2010	2.082	1.974	1.986	1.868	0.0566	1.330	2.486
2011	2.010	1.984	2.291	2.090	0.0607	1.362	2.845
2012	1.425	1.498	1.586	1.330	0.0583	1.196	1.591
2013	1.437	1.567	1.536	1.344	0.0571	1.344	1.806
2014	1.596	1.816	1.993	1.529	0.0598	1.270	1.941
2015	1.959	2.184	2.424	1.632	0.0653	1.310	2.138
2016	1.459	1.644	1.613	1.227	0.0639	1.397	1.714