ELEPHANTFISH (ELE 5)

REPORT TO THE ADAPTIVE MANAGEMENT PROGRAMME FISHERY ASSESSMENT WORKING GROUP:
REVIEW OF THE ELE 5 ADAPTIVE MANAGEMENT PROGRAMME

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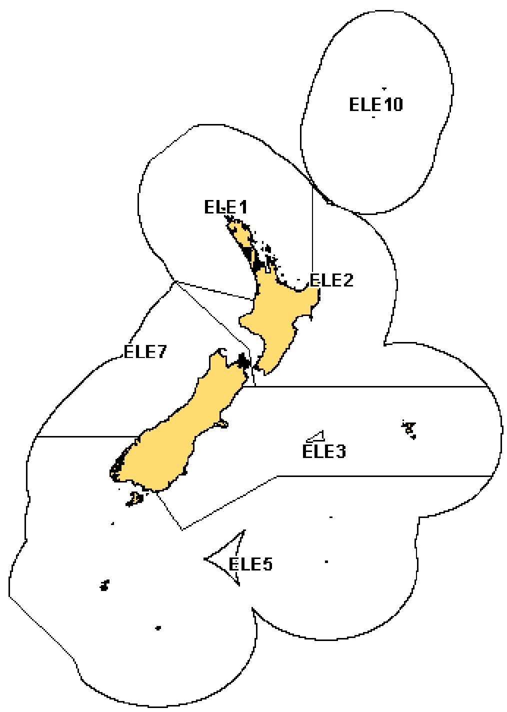

Figure 1. Map of ELE QMAs.

1. DESCRIPTION OF THE PROGRAMME

In 2001, the Southeast Finfish Management Company (SEFMC) proposed an increase to the 71 tonne TACC for elephantfish in QMA 5 (ELE 5) under the conditions of the Adaptive Management Programme (AMP) as specified by the Ministry of Fisheries in the "*Revised Framework for the Adaptive Management Programme*" dated December 2000. The Minister of Fisheries agreed to raise the ELE 5 TACC on 1 October 2001 to 100 t, while also making an allowance of 5 t each for the recreational and customary fisheries, for a total TAC of 110 t. The Southeast Finfish Management Company (SEFMC) proposed another increase to the ELE 5 TACC because of continuing difficulty of staying within the TACC in this by-catch fishery. This second proposal was accepted by the Ministry of Fisheries (MFish) and the

ELE 5 TACC was raised to 120 t, beginning on 1 October 2004. The combined allowance for recreational and customary fisheries was set at 16 t, for a TAC of 136 t.

This paper is a two-year review of the ELE 5 AMP to the AMPWG for the period ending 30 September 2008. Several earlier reviews of the ELE 5 AMP have been presented to the AMPWG: SeaFIC (2003) and Starr et al. (2007). The continuation of ELE 5 in the AMP was justified under the adaptive management provision that the "*stock abundance appears to have increased under current catch levels, i.e. current catch levels appear to be having no effect on stock size*".

2. OBJECTIVE OF THE PROGRAMME

To determine the size, geographical extent and long-term sustainable yield of the ELE 5 Fishstock.

3. INFORMATION ABOUT CURRENT RESEARCH

A preferred method to monitor this Fishstock would be through a trawl survey. The east coast South Island trawl survey is monitored using a winter trawl survey which was suspended in 1996 but resumed in May 2007. There is no on-going survey series on the southern end of the South Island. ELE 5 is monitored using catch and effort data from the bottom trawl fishery presently operating in Statistical Areas 025 and 030. In addition, data from a coastal target setnet fishery for school shark, rig and elephantfish is also monitored for trends. Biological information will be obtained from the shark setnet fishery using voluntary logbooks.

The conditions of the AMP require that the monitoring programme have ("*in order of importance/significance*"): "*1) Expectation that information obtained will provide means to monitor changes in stock status, or 2) Development of quantitative index of abundance to monitor stock status on an on-going basis and expectation that information obtained over 5 years will provide assessment of stock status relative to MSY and estimates of sustainable yield*". Both of these expectations are dependent on the level of contrast that will be generated over the period of observation: small changes in biomass will require very precise measures of biomass level. Measurement tools which may be adequate to detect large biomass changes will usually fail if the biomass changes are within the level of precision of the estimate. Given that CVs in the order of 20% are considered acceptable by the Ministry of Fisheries, then biomass changes greater than this level of uncertainty need to be generated in the appropriate time frame in order to comply with the expectations stated in the AMP "Framework".

4. INFORMATION ABOUT THE STOCK/FISHERY

4.1 TRENDS IN COMMERCIAL CATCH

From the 1950s to the 1980s, total NZ landings of elephantfish at or above 1 000 t were common (Figure 2). Most of these landings were from the area now encompassed by ELE 3, but fisheries for elephantfish also developed in the south and west coasts of the South Island in the late 1950s and early 1960s, with average catches of around 70 t per year (in the 1960s to the early 1980s) in the south and 10 to 30 t per year on the west coast.

Catches in ELE 5 dropped to below 40 t per year by the end of the 1980s after this species was brought into the QMS at a TACC below previous average catch levels but have since recovered to above 100 t per year, with landings exceeding 200 t in 2007–08, the largest annual catch in the time series (Figure 2; Table 1). As in other elephantfish QMAs, landings of elephantfish in QMA 5 have increased markedly since the mid-1990s, and total NZ landings of elephantfish have exceeded 1 000 t per year since 1997–98. The TACC has consistently been exceeded in ELE 5 since 1995–96 (Table 1)

Table 1. Reported landings (t) of elephantfish by Fishstock from 1983–84 to 2007–08 and TACCs (t) from 1986–87 to 2007–08. Data sources: [1983–84 to 1985–86 Fisheries Statistics Unit]; [1986–87 to 2000–01: Quota Management Reports]; [2001–02 to 2007–08: Monthly Harvest Reports]

Fishing		ELE 2		ELE 3		ELE 5		ELE 7		Total NZ
Year	Catch	TACC	Catch	TACC	Catch	TACC	Catch	TACC	Catch[1]	TACC[2]
1983–84	5		605		94		60		765	
1984–85	3		517		134		50		704	
1985–86	4		574		57		46		681	
1986–87	2	20	506	280	48	60	29	90	585	470
1987–88	3	20	500	280	64	60	44	90	612	470
1988–89	1	21	446	415	49	62	35	100	532	618
1989–90	3	21	422	418	32	62	55	101	512	622
1990–91	5	22	434	422	55	71	59	101	553	636
1991–92	11	22	441	422	57	71	78	101	588	636
1992–93	5	22	501	424	39	71	61	102	607	638
1993–94	6	22	475	424	46	71	41	102	567	638
1994–95	5	22	580	424	60	71	39	102	684	638
1995–96	6	22	686	500	72	71	93	102	858	715
1996–97	9	22	730	500	74	71	94	102	907	715
1997–98	11	22	911	500	92	71	64	102	1 079	715
1998–99	9	22	841	500	134	71	117	102	1 102	705
1999–00	6	22	950	500	105	71	87	102	1 148	705
2000–01	7	22	956	825	154	71	90	102	1 208	1 030
2001–02	9	22	852	825	105	100	88	102	1 054	1 059
2002–03	9	22	950	950	106	100	59	102	1 126	1 184
2003–04	10	22	984	950	102	100	42	102	1 138	1 184
2004–05	17	22	972	950	125	120	74	102	1 190	1 204
2005–06	14	22	1 023	950	147	120	76	102	1 260	1 204
2006–07	17	22	960	950	158	120	116	102	1 251	1 204
2007–08	16	22	1 092	950	202	120	125	102	1 436	1 204

[1] includes small amounts of landings from QMA 1 (Auckland)
[2] includes 10 t TACC for QMA 1 (Auckland). Does not include QMA 10 (Kermadecs)

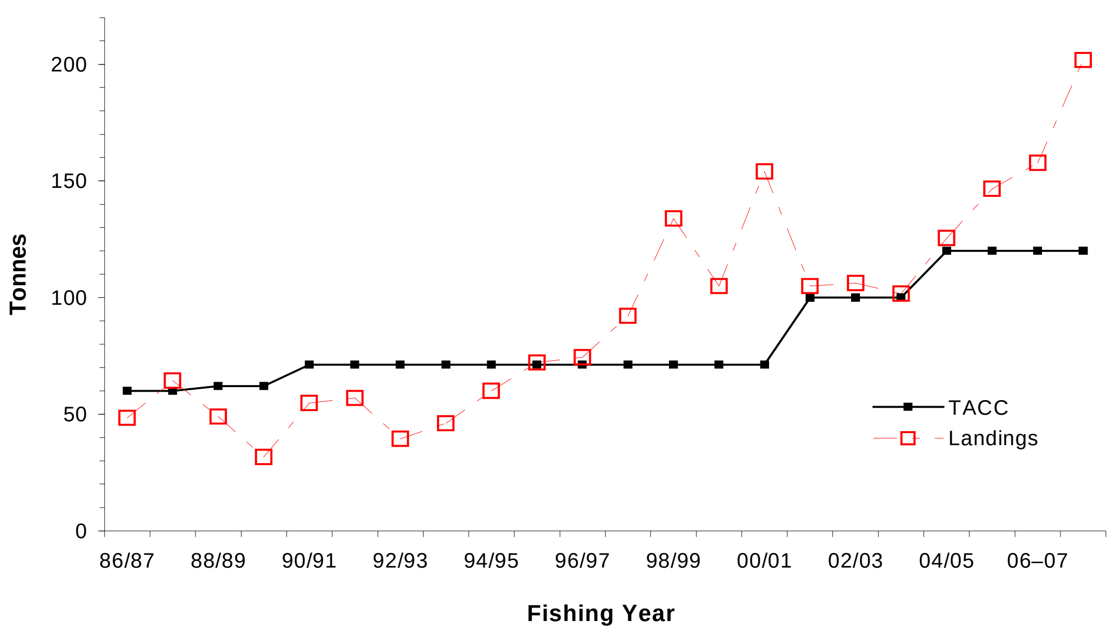

Figure 2. Annual catch and TACC for the ELE 5 fishery by fishing year from 1986–87 to 2007–08 (Table 1).

4.2 Regulations Affecting the Fishery

The data provided by MFish indicate that there have been only minor changes in the elephantfish conversion factors over the period of available data (see Section 4.3.2). However, the control of overcatch in ELE 5 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 MFish "*above ACE price and below landed (port) price*" (Scott Walker, MFish, *pers. comm.*). Deemed values have been 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).

Table 2. Annual and interim deemed values for ELE 5 by fishing year from 2001–02 (source: Ray Voller, MFish, *pers. comm.*). Also shown is the amount by which ACE must be exceeded for deemed value penalties to apply. '–': not applicable

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: $100*\left(\sum \text{landings}_y / \sum \text{ACE}_y\right)$
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	–	120	$0.99	$0.79	suspended

[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

4.3 Analysis of ELE 5 Catch and Effort Data

4.3.1 Methods used for 2009 analysis of MFish catch and effort data

The methods used to prepare the MFish catch/effort data have remained essentially unchanged since 2002, except for some refinements. The current methodology used to prepare these data for both the characterisation and the CPUE analyses has been documented elsewhere (Starr 2007).

However, there are still shortcomings with analysing the catch and effort data using the procedure described by Starr (2007), because of the following issues:

- Trips which land to more than one Fishstock are discarded if they fish in "straddle" statistical areas which are valid for each of the Fishstocks landed. All trips which land multiple Fishstocks and fish in these ambiguous statistical areas have been dropped from the analysis.
- The most detailed level of area attributable for any trip is the statistical area because of a limitation in the design of the CELR system and the requirement to merge the CELR and TCEPR data for this species. Trips with missing statistical areas have used the

predominant (most frequent) statistical area to fill in the missing datum. The few trips which had no statistical area information were dropped.

- Landed greenweight catch is attributed to specific statistical areas, method and target species by assuming that the estimated catches in these categories are distributed correctly. This will lead to some error because small catches from some strata are often not included in the original data. If no estimated catch is available for a trip, the procedure uses the distribution of effort to partition the landed catch for that trip, a procedure which could lead to some bias because it assumes equal catchability in all strata.
- Trips with missing method codes are filled in with the method from the remaining events if only one method is reported for that trip. If a trip with a missing method code reports more than one method, the entire trip is dropped.
- Trips which report no target species codes are dropped but events within a trip which have missing target species codes are filled in with the predominant (most frequent) target species for the trip.
- New forms which have been designed to provide more detailed spatial and other information have been introduced: the NCELR (netting catch-effort landing return) on 1 October 2006 and the TCER (Trawl catch-effort return) on 1 October 2007. These forms have been treated similarly to the TCEPR (trawl catch-effort processing returns) by collapsing the information to a level consistent with the CELR forms. More detailed information will be extracted from these forms as years progress.

Table 3. Comparison of the sum of the landed catch totals (t) (bottom part of the MFish CELR form) with the total catch (t) reported by QMR/MHR for ELE 5 by fishing year. Also shown are the total landings from the analysis dataset and the sum of the estimated catches from the trips included in the analysis dataset. N_y =number trips/year in total dataset; A_y =number trips/year in analysis dataset; $L_{i,y}$ =landed catch from trip stratum *i* in year *y*; $C_{i,y}$ =estimated catch from trip stratum *i* in year *y*.

Fishing Year	$\mathbf{QMR}_y$ [Table 1] (t)	$SL_y = \sum_{i=1}^{N_y} L_{i,y}$ (t)	$\frac{SL_y}{\mathbf{QMR}_y}$ (%)	$AL_y = \sum_{i=1}^{A_y} L_{i,y}$ (t)	$\frac{AL_y}{SL_y}$ (%)	$AC_y = \sum_{i=1}^{A_y} C_{i,y}$ (t)	$\frac{AC_y}{AL_y}$ (%)
89/90	32	20	64	19	94	10	49
90/91	55	47	85	46	99	28	59
91/92	57	57	99	51	90	35	61
92/93	39	42	106	39	94	24	58
93/94	46	39	86	32	81	20	50
94/95	60	57	94	43	76	26	45
95/96	72	71	99	68	96	52	72
96/97	74	71	95	70	99	51	71
97/98	92	95	103	91	96	73	77
98/99	134	132	99	130	98	87	66
99/00	105	97	93	92	95	71	73
00/01	154	146	95	126	86	99	68
01/02	105	104	99	103	99	87	84
02/03	106	104	98	103	99	89	86
03/04	102	93	91	89	97	77	84
04/05	125	120	96	119	99	102	85
05/06	147	145	99	139	96	117	81
06–07	158	155	98	149	96	133	86
07–08	202	189	94	182	96	166	88

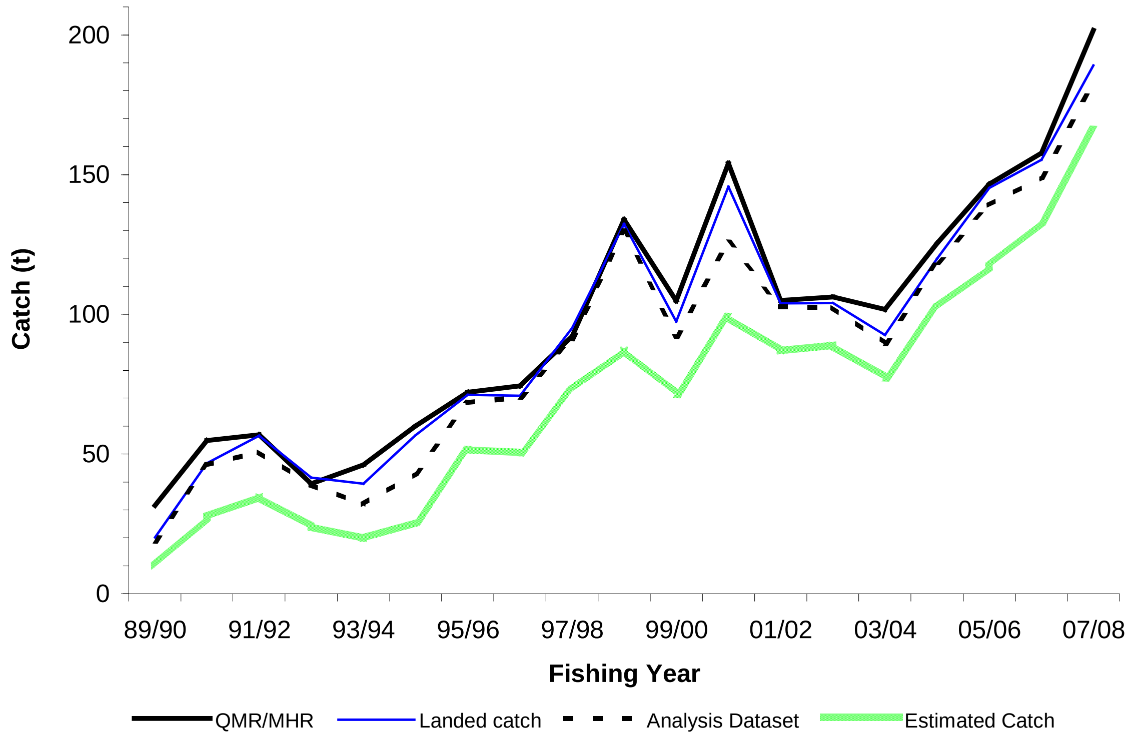

Figure 3. Plot of catch datasets presented in Table 3. The estimated catch total is the sum of the estimated catch in the analysis dataset.

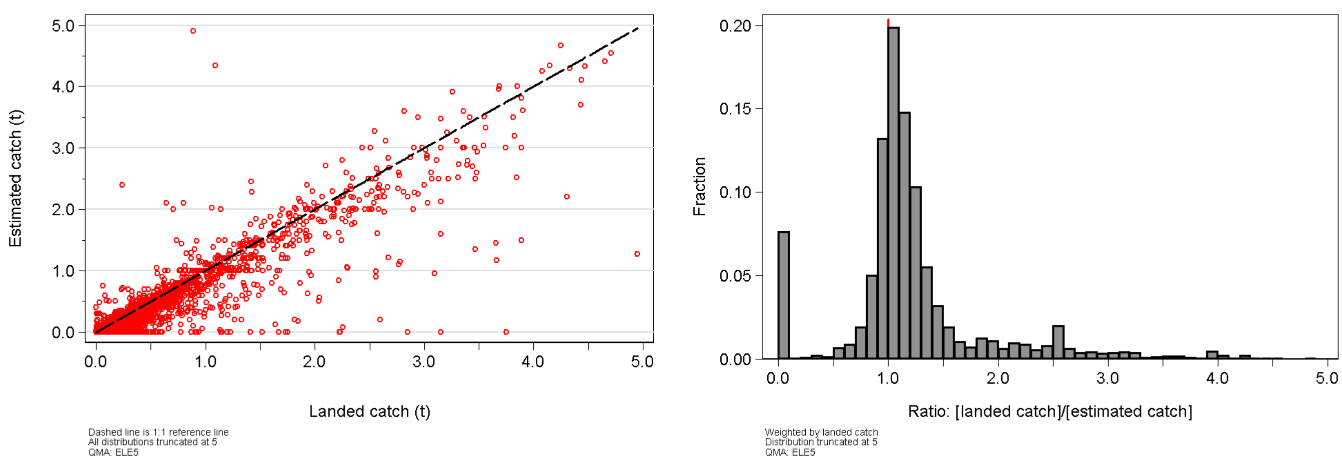

Figure 4. [left panel]: Scatter plot of the sum of landed and estimated elephantfish catch for each trip in the analysis dataset. [right panel]: Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip. Trips where the estimated catch=0 have been assigned a ratio=0.

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

Table 4. Summary statistics pertaining to the reporting of estimated catch from the ELE 5 analysis dataset. A_y, $L_{i,y}$, AL_y, and AC_y are defined in Table 3; $L'_{i,y}$ is defined in Eq.1; ,Z_y: number of trips in year y with no estimated catch; 5%: fifth percentile; 50%: median; 95%: ninety-fifth percentile.

Fishing year	Trips with landed catch but which report no estimated catch			Dataset statistics (excluding 0s) for the ratio of landed/estimated catch by trip			
	$\frac{Z_y}{A_y}$ (%)	$\frac{\sum_{i=1}^{Z_y} L_{i,y}}{\tilde{A}L_y}$ (%)	$\sum_{i=1}^{Z_y} L'_{i,y}$ (t)	$\left(\frac{AL_y}{AC_y}\right)_{5\%}$	$\left(\frac{AL_y}{AC_y}\right)_{50\%}$	$\left(\frac{AL_y}{AC_y}\right)_{\text{Mean}}$	$\left(\frac{AL_y}{AC_y}\right)_{95\%}$
89/90	52	19	6	0.75	1.15	1.73	5.00
90/91	38	9	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	40	9	4	0.83	1.15	1.55	3.29
94/95	35	6	3	0.70	1.21	1.92	3.59
95/96	35	7	5	0.55	1.23	1.60	3.41
96/97	46	11	8	0.83	1.10	1.46	2.71
97/98	34	7	7	0.59	1.13	1.42	2.95
98/99	44	15	20	0.68	1.20	1.59	3.50
99/00	48	8	8	0.70	1.16	1.56	2.78
00/01	42	6	9	0.60	1.16	1.48	3.49
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	1.26	2.48
04/05	39	9	11	0.52	1.07	1.43	2.62
05/06	35	9	13	0.67	1.09	1.40	3.17
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
Total	37	7	139	0.60	1.12	1.48	3.18

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:

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

where $\mathbf{QMR}_y$, $L_{i,y}$ and AL_y are defined in Table 3.

Annual totals from this dataset compared with the annual QMR/MHR totals in Table 1 are presented in Table 3 and Figure 3. Total landings from the bottom part of the CELR form are similar to the landings in the QMR/MHR system, ranging from 85 to 106% of the official QMR/MHR system over the 16 years of available data (excluding the 64% value in 1989–90 which was the first year of the present catch/effort data collection system and is thought to be data deficient). There is a consistent shortfall between the landed and estimated catch by trip for ELE 5 (Table 3; Figure 3), with the sum of the estimated catches ranging from 45 to 88% of the landed catch for the trips included in the analysis dataset (Table 3). As in ELE 3, there is also a trend in this statistic, with the sum of the estimated catches coming closer to the sum of the landed catches in recent years. A comparison scatter plot of the estimated and landed catch by trip shows that fewer trips overestimate the landing total for the trip and that the majority of the trips are close to the 1:1 line ([left panel] Figure 4). The distribution of the ratios of the landed to estimated catch shows that the majority of the ratios are grouped near one, with a possible subsidiary mode near 2.5 ([right panel] Figure 4).

The 5% to 95% percentiles (excluding trips where there is no estimated catch) for the ratio of landed to estimated catch range from 0.60 to 3.18 for the dataset, with the median ratio of the estimated catch at 112% of the landed catch and the mean ratio at 48% higher than the estimated catch (Table 4). Seven percent of trips by landed weight and 37 % by number estimate no elephantfish at all, for total landings of around 139 t over the 19 years of data (Table 4).

4.3.2 Description of ELE 5 landing information

Landing data for elephantfish were provided for all trips which landed ELE 5 at least once, with one record for every reported ELE landing from the trip, regardless of the QMA. Each of these records contained a reported green weight (in kg), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a “destination code” (Table 5), which indicated the category under which the landing occurred. The majority of the landings were made using destination code “L” (landed to a Licensed Fish Receiver; Table 5). However, other codes (e.g., A, O and C; Table 5) also potentially described valid landings and were included in this analysis. A number of other codes (notably R, Q and T; Table 5) were not included because it was felt that these landing were likely 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.

Almost all of the valid landing data were reported using state codes GUR, DRE and HGU, with only a minority of landings were reported using the state codes GRE, MEA, and HGT (Table 6). Unlike for other shark species like rig (SPO) and school shark (SCH), there have been only minor changes in the factors used to convert the dressed weights to landed green weight (Table 7).

Table 5. Destination codes in the unedited landing data received for the ELE 5 analysis. The “how used” column indicates which destination codes were included in the characterisation and CPUE analyses.

Destination code	Number events	Green weight (t)	Description	How used
L	6277	1 796.2	Landed in NZ (to LFR)	Keep
E	49	1.5	Eaten	Keep
F	48	0.4	Section 111 Recreational Catch	Keep
A	4	0.3	Accidental loss	Keep
W	1	0.0	Sold at wharf	Keep
U	1	0.0	Bait used on board	Keep
R	79	13.5	Retained on board	Drop
NULL	8	5.9	Nothing	Drop
T	4	2.2	Transferred to another vessel	Drop
Q	38	1.9	Holding receptacle on land	Drop
D	1	0.0	Discarded (non-ITQ)	Drop

A convention adopted in this analysis was to drop landings for state codes FIN, FLP (flaps), SHF (shark fins) and ROE when there was more 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 all these codes were dropped to avoid potential double counting. This convention resulted in dropping about 1 t of greenweight landings from the combined ELE 3 and ELE 5 landing data set, most of which used the landed state code FIN ("fins") or SHF ("shark fins").

Table 6. Total greenweight reported and number of events by state code in the unedited landing file used to process the ELE 5 characterisation data, arranged in order descending landed weight.

State code	Number Events	Total reported green weight (t)	Description
GUT	3 108	1 109.4	Gutted
DRE	1 474	339.0	Dressed
HGU	1 451	301.1	Headed and gutted
GGO	94	31.8	Gilled and gutted tail-on
GRE	103	9.1	Green (or whole)
NULL	3	2.4	Unknown
HGT	11	1.3	Headed, gutted, and tailed
SKF	4	1.3	Fillets: skin-off
MEA	30	1.0	Fish meal
FIL	26	0.8	Fillets: skin-on
DVC	3	0.8	Dressed-V cut (stargazer)
FIN	35	0.4	Fins
TSK	2	0.0	Fillets: skin-off trimmed
SHF	36	0.0	Shark fins

[1] This category includes 32 t of invalid landed state code GGU and 12 t of invalid landed state code TRU

A calculated greenweight $\left(\varpi_{i,y}\right)$ was inferred from the landings dataset using the following equation:

$$\varpi_{i,y} = U_{i,y}\, W_{i,y} cf_{i,y} \qquad \text{Eq. 2}$$

where

$U_{i,y}$ is the "unit number" of containers associated with the record;

$W_{i,y}$ is the "unit weight" associated with the record;

$cf_{i,y}$ is the conversion factor associated with the record.

A comparative scatter plot of the calculated greenweight relative to the reported greenweight for the three primary state codes reported in Table 6 (GUT, HGU and DRE) shows less scatter around these two quantities in the same record compared to the equivalent plot for ELE 3 (Figure 5 [left panel]). This is likely due to smaller amount of data available for ELE 5. A histogram of the ratio of the calculated greenweight relative to the reported greenweight indicates that the central tendency for this ratio for these two landed state codes is near one (median=1.08 and mean=1.26 when the ratio is truncated at 5.0), but there is some variation. This analysis indicates that it is probably not possible to reconstruct the greenweights using the detailed data provided in the individual records. The best use of the Eq. 2 calculation would be to corroborate the reported greenweight in situations when the reported greenweight appears to be in doubt.

In preparing the data for this report, all large reported landing records (single events with a greenweight landing greater than 1 000 kg for bottom trawl or setnet) were compared with the total calculated greenweight (Eq. 2) and the total estimated elephantfish catch for each trip, as well as calculating the trip CPUE for comparison with the empirical distribution of the trip CPUE (Starr 2007). On this basis, 15 trips representing 557 t of landings (one trip recorded a total of 310 t and another trip had 112 t) were dropped from the analysis. Note that Table 3 indicates that the sum of the landings exceed the QMR/MHR reported landings in both 1999–2000 and 2000–01, and that the landings available to the dataset are within 1–2% of QMR/MHR totals in all but 1989–90.

Table 7. Median conversion factor for the most important state codes reported in Table 6 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited landing file used to process ELE 5 landing data.

Fishing					**Landed State Code**	
year	**GUT**	**DRE**	**HGU**	**GGO**	**GRE**	**OTH**
	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		1	2.85
97/98	1.1	2.3	2.3		1	1.925
98/99	1.1	2.3	2.3		1	5.6
99/00	1.1	2.3	2.3			5.6
00/01	1.1	2.3	2.3		1	2.85
01/02	1.1	2.3	2.3		1	5.6
02/03	1.1	2.3	2.3		1	5.6
03/04	1.1	2.3	2.3		1	3.3
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
	Total landings by state code					
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	40.4		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	0.1
98/99	47.6	60.6	18.5	2.0	2.9	0.7
99/00	51.1	31.4	9.4	5.5		0.0
00/01	84.1	30.2	18.6	12.3	0.0	0.5
01/02	83.6	13.8	0.8	3.6	2.0	0.3
02/03	99.5	3.5	1.1		0.1	0.1
03/04	90.6	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	6.4	0.6		0.2	1.3
Total	1,106.7	339.0	301.1	31.8	9.1	7.9

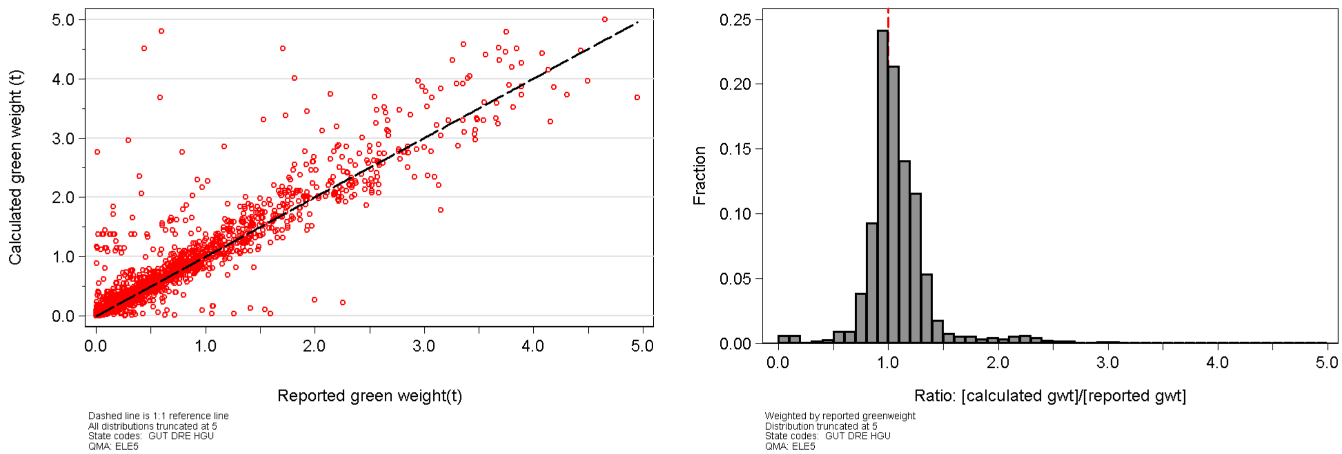

Figure 5. [left panel]: Scatter plot of the calculated greenweight (Eq. 3) compared to the reported greenweight for state codes GUT, DRE and HGU; [right panel]: Distribution (weighted by the reported greenweight catch) of the ratio of calculated greenweight relative to reported greenweight for state codes GUT, DRE and HGU. Records with missing data have been dropped.

Table 8. Distribution of total landings (t) by elephantfish Fishstock and by fishing year for the set of trips that recorded ELE 3 and ELE 5 landings. Landing records with improbable greenweights have been dropped.

Fishing year	ELE1	ELE2	ELE3	ELE5	ELE7	Total
89/90	0.0	0.1	405.6	20.4	4.5	430.5
90/91	0.1		434.7	46.8	11.2	492.8
91/92		0.0	443.6	57.5	19.2	520.3
92/93		0.1	485.1	42.2	10.4	537.7
93/94		0.1	480.7	39.9	2.8	523.6
94/95	0.2	0.6	581.4	56.6	2.6	641.4
95/96	0.4	0.1	694.2	71.3	6.3	772.3
96/97	2.6	1.9	716.7	71.0	5.2	797.4
97/98	0.1	5.0	897.4	95.1	29.3	1 026.9
98/99	0.1	0.6	812.2	132.4	16.0	961.3
99/00	0.1	1.7	959.6	97.4	14.8	1 073.6
00/01		0.7	981.8	145.9	12.4	1 140.9
01/02		2.2	844.5	104.1	11.2	962.0
02/03	0.3	2.4	946.9	104.2	7.9	1 061.6
03/04	0.0	8.7	971.4	92.8	11.5	1 084.3
04/05	0.0	1.6	961.2	120.1	4.4	1 087.3
05/06	0.4	0.5	1 016.4	145.2	3.1	1 165.6
06/07	3.7	0.3	952.3	157.5	6.6	1 120.3
07/08	0.0	2.3	1 094.7	196.5	8.2	1 301.6
Total	8.0	28.8	14 680.2	1 796.9	187.6	16 701.6

Total landings available in the data set are primarily for ELE 3 and ELE 5, with small amounts reported for ELE 2 and ELE 7 (Table 8). Most ELE landings are reported on CELR forms prior to 2007–08, with only minor amounts of landings reported on CLR forms (Catch Landing Returns; Table 9). These latter forms are used by vessels using the TCEPR forms to report their effort. Note the shift to the NCELR forms beginning from 2006–07, accounting from 4 to 17 % of the landings in the final two years. The CELR form virtually disappears in 2007–08, with nearly a complete shift to the TCER and NCELR forms in this QMA (Table 9).

Table 9. Distribution by form type for landed catch by weight for each fishing year in ELE 5. Also provided is the number of days fishing and the associated distribution of days fishing by form type for the effort data using statistical areas consistent with ELE 5. CELR: Catch, effort, landing return; CLR: catch landing return; NCELR: netting catch effort landing return; TCEPR: trawl catch effort processing return; TCER: trawl catch effort return. Forms other than CELR and NCELR report their landings on CLR forms.

Fishing	Landing data			Effort data								
	Distribution (%)[1]			Distribution (%)[2]				Number days fishing				
year	CELR	CLR	NCELR	CELR	TCEPR	TCER	NCELR	CELR	TCEPR	TCER	NCELR	Total
89/90	93	7	0	92	8	0	0	957	83	0	0	1 040
90/91	98	2	0	86	14	0	0	1 052	165	0	0	1 217
91/92	90	10	0	91	9	0	0	1 032	106	0	0	1 138
92/93	86	14	0	92	8	0	0	837	74	0	0	911
93/94	94	6	0	99	1	0	0	1 000	12	0	0	1 012
94/95	96	4	0	99	1	0	0	895	10	0	0	905
95/96	88	12	0	92	8	0	0	1 024	90	0	0	1 114
96/97	99	1	0	99	1	0	0	989	9	0	0	998
97/98	94	6	0	98	2	0	0	933	21	0	0	954
98/99	94	6	0	84	16	0	0	1 126	218	0	0	1 344
99/00	99	1	0	85	15	0	0	1 096	198	0	0	1 294
00/01	97	3	0	84	16	0	0	1 122	217	0	0	1 339
01/02	95	5	0	78	22	0	0	1 133	317	0	0	1 450
02/03	99	1	0	82	18	0	0	1 357	297	0	0	1 654
03/04	100	0	0	92	8	0	0	1 271	115	0	0	1 386
04/05	100	0	0	92	8	0	0	1 384	115	0	0	1 499
05/06	98	2	0	82	18	0	0	1 485	327	0	0	1 812
06/07	94	2	4	75	15	10	0	1 521	308	0	206	2 035
07/08	0	83	17	2	14	13	72	37	318	1 626	287	2 268
Total	85	12	2	80	12	2	6	20 251	3 000	1 626	493	25 370

[1] Percentages of landed greenweight
[2] Percentages of number of days fishing

Table 10. Definitions of statistical area (see Appendix A for the locations of the indicated statistical areas), major method codes and target species codes used in the distribution tables and plots in this report. Number events=number of effort records represented in analysis dataset; number records=number of records in analysis dataset after rolling up to trip/statistical area/method/target species.

Statistical area code	Statistical area definition	Number events	Number records
025	018	5 028	2 586
030	030	9 899	3 652
031-032	031 & 032	286	152
Outside	026–029, 501–504, 601–625	6 881	1 424
Method designation	**Methods included**		
BT	Bottom trawl	17 857	6 184
SN	Setnet	2 447	1 407
OTH	Other methods: midwater trawl: 9 of ELE; dredge: 2 t of ELE	1 790	223
Target species code[1]	**Target species definition**		
FLA	Flatfish (including all related species)	7 245	2 917
STA	Stargazer	5 338	1 928
ELE	Elephantfish	226	168
SPD	Spiny dogfish	212	110
GUR	Red gurnard	317	179
BAR	Barracouta	482	120
RCO	Red cod	66	44
SPO	Rig	30	24
TAR	Tarakihi	48	39
LIN	Ling	746	125
OTH	Other species > 2 t of bottom trawl ELE landings in ranked descending order: arrow squid, blue warehou and blue cod	3 147	530

Target species code[2]	Target species definition	Number events	Number records
SPO	Rig	822	511
SCH	School shark	1 487	770
ELE	Elephantfish	97	87
SPD	Spiny dogfish	33	32
OTH	All other species < 1 t of aggregate setnet landings of ELE	8	7

[1] Bottom trawl method
[2] Setnet method

4.3.3 Description of the ELE 5 fishery

Distributions by statistical area, major fishing method and target species in this section are provided by summarised statistical areas, methods and target species as described in Table 10. ELE 5 shares several statistical areas with other elephantfish Fishstocks, including Areas 026 and 027 with ELE 3 and Area 032 with ELE 7 (Appendix A). The ELE 5 fishery is taken primarily by the bottom trawl method, but there are some landings in the setnet fishery as well (Table 11; Figure 6). Over 87% of the landings have been taken by bottom trawl over the 19 years of available catch history, with the balance taken by the setnet fishery. Other methods account for less than 1% of the total annual ELE 5 catch. On average, 55% of the total ELE 5 landings come from Area 030 (western Foveaux Strait) with most of the remaining landings coming from the adjacent Area 025 (eastern Foveaux Strait; Table 12). Only minor amounts (average near 7%) of ELE 5 come from other statistical areas.

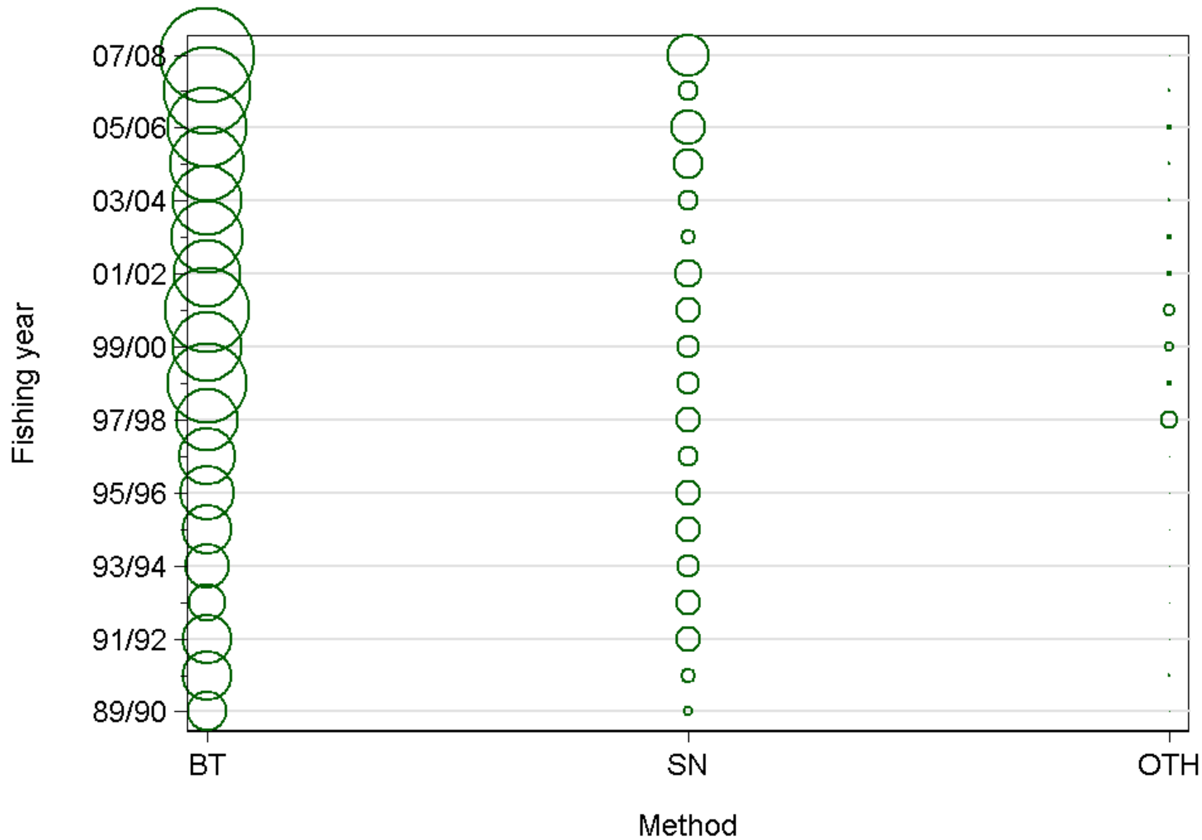

Figure 6. Distribution of catches for the major fishing methods by fishing year from trips which landed ELE 5. Circles are proportional to the catch totals by method and fishing year, with the largest circle representing: 169 t (07/08; BT).

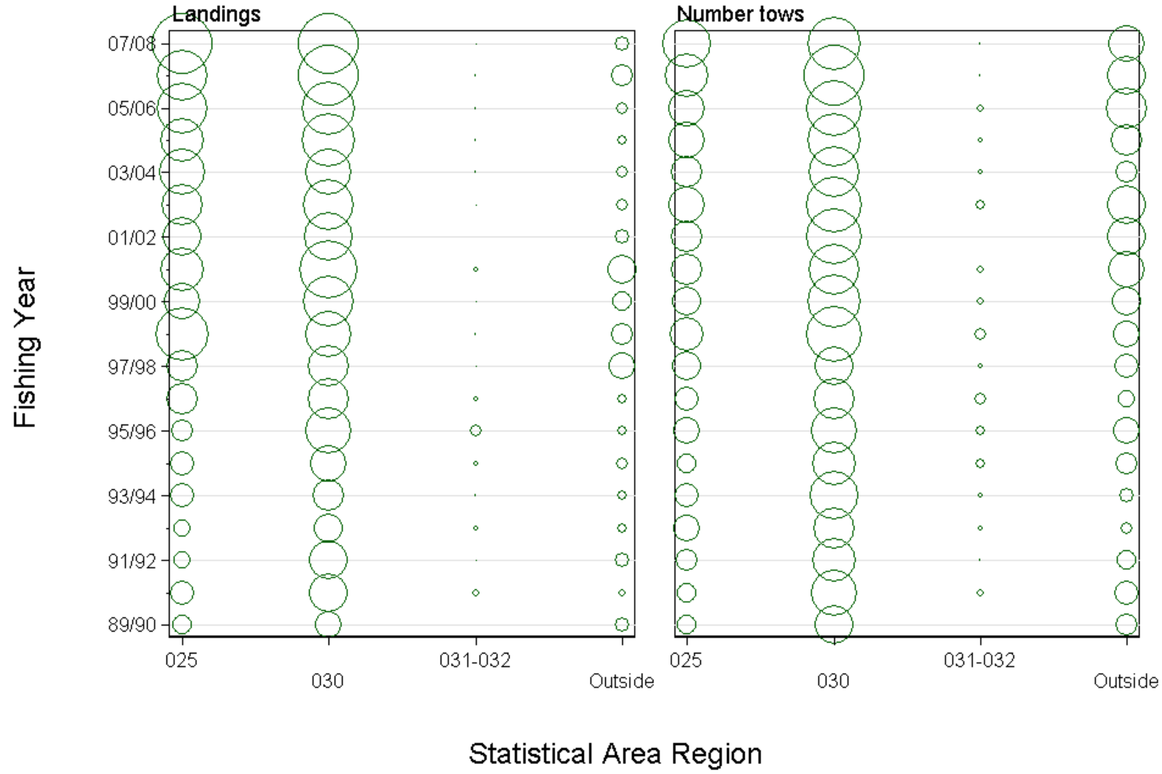

Figure 7. Distribution of landings and number tows for the bottom trawl method by statistical area and fishing year from trips which landed ELE 5. Circles are proportional within each panel: [catches] largest circle=85 t in 07/08 for Area 025; [number tows] largest circle=1 920 tows in 06/07 for Area 030.

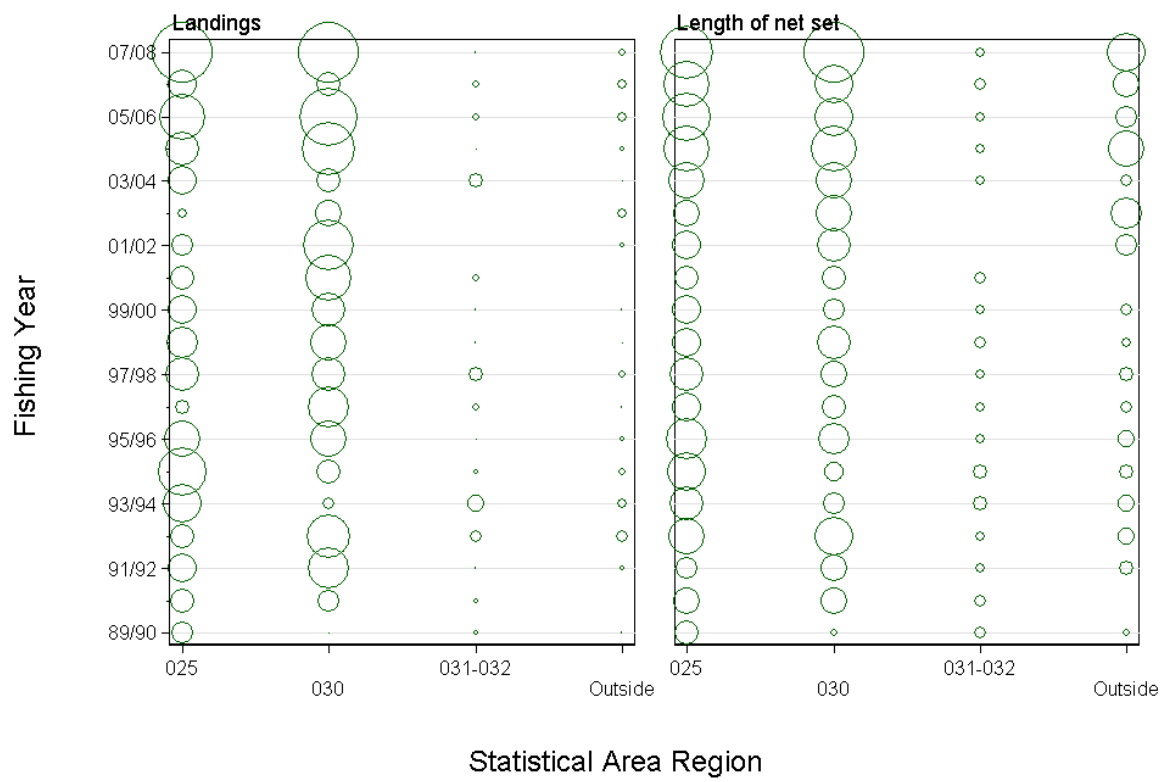

Figure 8. Distribution of landings and length of net set for the setnet method by statistical area and fishing year from trips which landed ELE 5. Circles are proportional within each panel: [catches] largest circle= 16.8 t in 07/08 for Area 025; [length of net] largest circle=329.6 km in 07/08 for 030.

Table 11. Total landings (t) and distribution of landings (%) of elephantfish from trips which landed ELE 5 by statistical area group and important fishing methods (Table 10), summed from 1989–90 to 2007–08. Landings (t) have been scaled to the QMR totals (QMR_y) using Eq. 1.

Statistical Area Region	Method of capture BT	SN	Other	Total	Method of capture BT	SN	Other	Total
	Total landings (t)				Distribution (%)			
025	604	92	9	705	32.4	4.9	0.5	37.8
030	908	123	1	1 032	48.7	6.6	0.0	55.3
031-032	8	5	0	14	0.4	0.3	0.0	0.7
Outside	108	4	4	115	5.8	0.2	0.2	6.2
Total	1 627	224	13	1 865	87.3	12.0	0.7	100.0

The distribution of statistical area of catch for ELE 5 by method of capture is similar to the total fishery, with Area 030 predominating the bottom trawl landings (Figure 7; Table 13). However, Area 025 appears to have increased in relative importance compared to Area 030 and the other more outlying statistical areas in recent years. Setnet landings by area are distributed similarly to the bottom trawl landings, except that Area 025 is relatively more important than Area 030 (Figure 8; Table 13). The distribution of bottom trawl effort by year is similar to the catch distribution, except for a consistent level of effort in the outside statistical areas which only catches small amounts of elephantfish (Figure 7). Similarly, the distribution of setnet effort by statistical area resembles the distribution of catch except for the effort expended in the outside areas which catches relatively small amounts of elephantfish (Figure 8). Setnet landings of elephantfish are too sporadic to conclude much about trends in either effort or catch by statistical area this fishery (Figure 8).

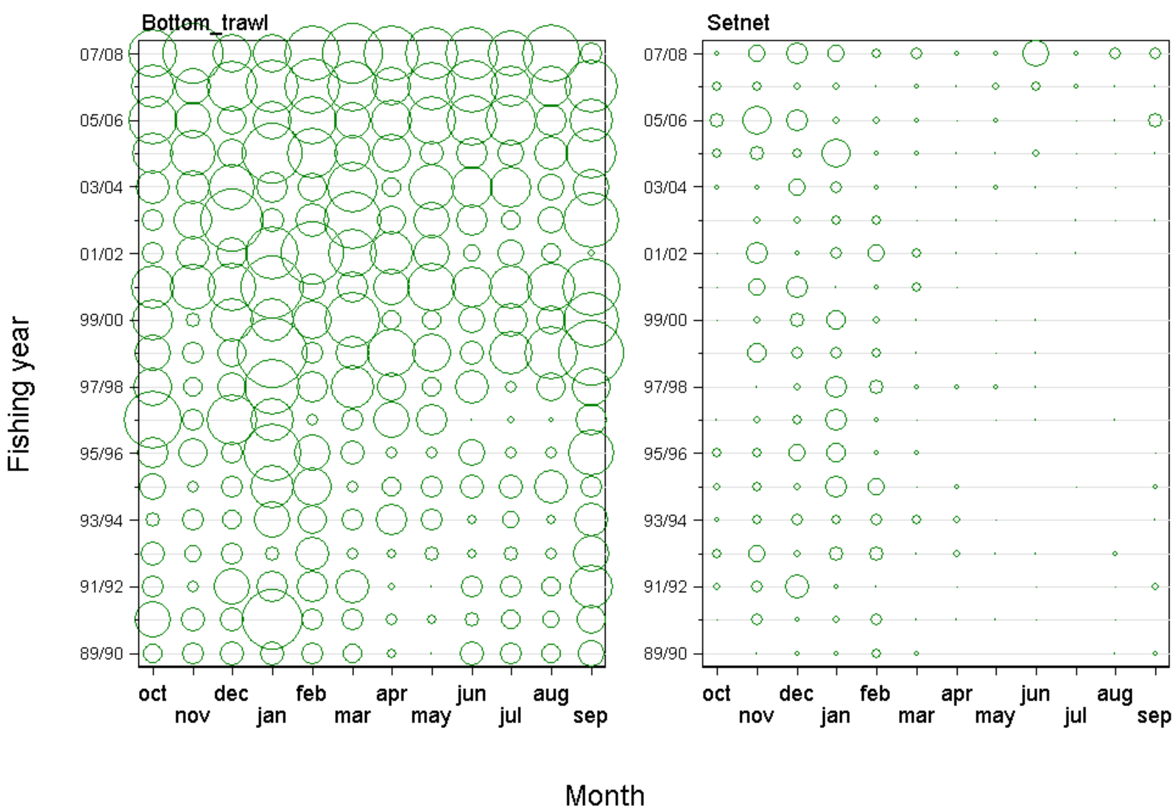

Figure 9. Total landings by month and fishing year for bottom trawl and setnet based on trips which landed ELE 5. Circles sizes are proportional across panels with the largest circle= 27 t for bottom trawl in January 98/99.

The setnet landings from ELE 5 are concentrated in the early part of the fishing year, while the bottom trawl landings are spread out through the fishing year, particularly in recent years (Figure 9; Table 14). Over 80% of the setnet catch is recorded on average in first four months of the fishing year while it takes to the end of June for the trawl fishery to on average accumulate 75% of the catch (Figure 9; Table 14). The seasonal pattern of landings of elephantfish using bottom trawl indicates that the Area 025 fishery lands most of its elephantfish in the autumn and winter months while the Area 030 fishery is more evenly distributed across the months (Figure 10). The broader seasonal distribution of landings in Area 030 possibly reflects the timing of the stargazer fishery which appears to be more important in this area than in Area 025. Seasonal patterns of the setnet fishery by statistical area are identical to the overall pattern, with the fisheries in each area tapering off by end of January (Figure 10).

Table 12. Percent distribution of landings by statistical area group (Table 10) and total annual landings (t) of ELE 5 from 1989–90 to 2007–08 for trips which landed ELE 5. Landings (t) have been scaled to the QMR totals $\left(QMR_y\right)$ using Eq. 1.

Fishing	**Statistical Area Region**					**Statistical Area Region**			
Year	**025**	**030**	**031-032**	**Outside**	**Total**	**025**	**030**	**031-032**	**Outside**
	Total landings (t)					**Distribution (%)**			
89/90	10	17	0	4	32	33.0	53.2	0.5	13.3
90/91	16	36	2	1	55	29.3	66.4	2.8	1.6
91/92	10	42	0	4	57	18.2	74.4	0.1	7.3
92/93	9	27	1	2	39	21.8	69.0	3.0	6.3
93/94	18	24	1	3	46	39.6	52.0	2.9	5.5
94/95	22	34	1	3	60	37.2	56.3	1.3	5.2
95/96	15	51	4	2	72	21.2	71.1	5.1	2.7
96/97	24	47	1	2	74	32.8	63.2	1.3	2.6
97/98	31	44	1	16	92	34.1	47.8	1.0	17.0
98/99	67	56	0	11	134	49.7	41.6	0.2	8.5
99/00	31	62	0	11	105	30.0	59.3	0.0	10.6
00/01	48	86	1	20	154	30.9	55.8	0.6	12.7
01/02	38	62	0	5	105	36.1	59.2	0.0	4.7
02/03	38	64	0	5	106	35.5	60.1	0.0	4.4
03/04	49	49	1	3	102	48.1	47.8	0.9	3.1
04/05	48	75	0	2	125	38.4	59.8	0.1	1.7
05/06	65	76	0	5	147	44.4	52.2	0.2	3.2
06/07	62	85	0	10	158	39.5	53.7	0.2	6.6
07/08	101	95	0	6	202	50.3	46.9	0.0	2.9
total	705	1 032	14	115	1 865	37.8	55.3	0.7	6.2

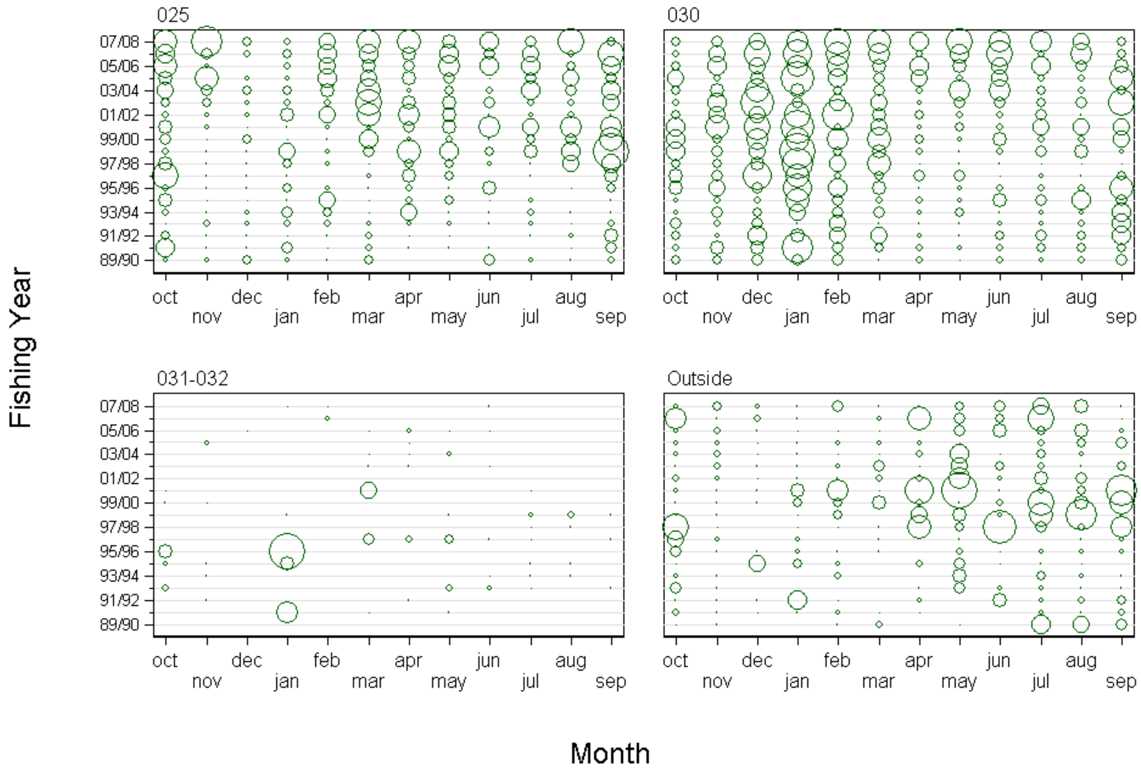

Figure 10. Distribution of landings for the bottom trawl method by grouped statistical area (Table 10) for month and fishing year from trips which landed ELE 5. Circles sizes are proportional within each panel: maximum values: 025 (23 t in 98/99 for Sep); 030 (22 t in 98/99 for Jan); 031–032 (3.1 t in 95/96 for Jan); and Outside (6.3 t in 00/01 for May).

Table 13. Percent distribution of landings by statistical area group (Table 10) from 1989–90 to 2005–06 for the bottom trawl and setnet methods for trips which landed ELE 5. Annual landings by method are available in Table 14 and the rows sum to 100%.

	Statistical Area Region				**Statistical Area Region**			
Year	**025**	**030**	**031-032**	**Outside**	**025**	**030**	**031-032**	**Outside**
	Bottom Trawl (%)				**Setnet (%)**			
89/90	28.5	57.3	0.0	14.2	91.7	0.0	6.5	1.9
90/91	26.8	69.2	2.2	1.8	55.7	41.1	3.2	0.0
91/92	14.9	76.2	0.0	8.9	32.1	66.6	0.4	0.9
92/93	21.8	70.5	1.4	6.3	21.8	65.7	6.3	6.2
93/94	31.9	62.6	0.1	5.4	72.4	7.4	14.3	5.9
94/95	25.8	66.5	1.4	6.3	78.4	19.1	1.2	1.3
95/96	15.7	75.3	6.0	2.9	50.0	48.7	0.0	1.3
96/97	35.5	60.4	1.2	2.9	12.1	85.7	2.1	0.1
97/98	27.5	52.0	0.0	20.5	45.7	44.0	8.3	2.1
98/99	50.6	40.3	0.2	9.0	41.2	58.5	0.3	0.1
99/00	29.5	60.5	0.0	10.1	41.5	58.0	0.2	0.3
00/01	30.9	54.6	0.5	14.0	20.5	77.3	2.2	0.0
01/02	39.0	55.8	0.0	5.2	15.6	83.5	0.0	0.9
02/03	36.7	59.6	0.0	3.7	11.2	77.3	0.0	11.5
03/04	48.2	48.5	0.0	3.3	48.1	39.3	12.5	0.1
04/05	39.8	58.3	0.1	1.9	30.2	69.2	0.0	0.6
05/06	46.2	50.7	0.0	3.1	37.0	60.5	1.2	1.4
06/07	38.8	54.5	0.0	6.6	54.5	37.5	3.6	4.4
07/08	50.1	46.6	0.0	3.3	51.0	48.3	0.0	0.7
Mean	37.1	55.8	0.5	6.6	40.9	55.0	2.4	1.6

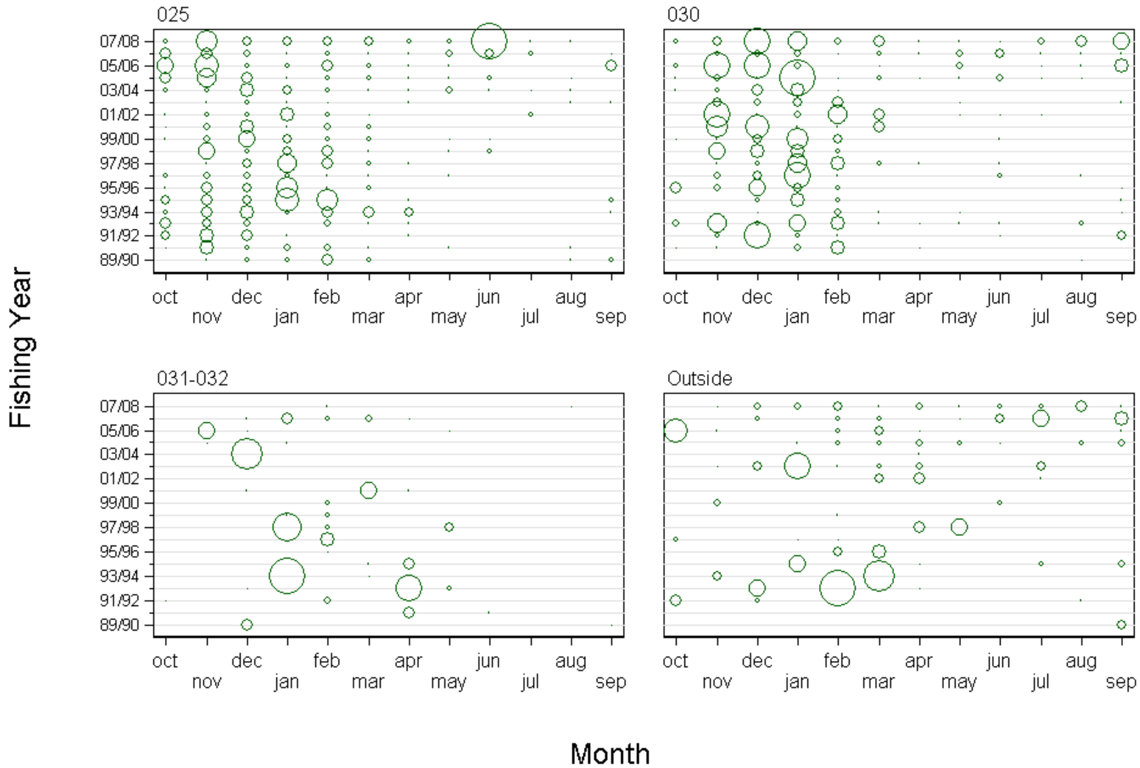

Figure 11. Distribution of landings for the setnet method by grouped statistical area (Table 10) for month and fishing year from trips which landed ELE 5. Circles sizes are proportional within each panel: maximum values: 025 (10 t in 07/08 for Jun); 030 (11 t in 04/05 for Jan); 031–032 (1.3 t in 93/94 for Jan); and Outside (0.6 t in 92/93 for Feb)

Table 14. Percent distribution of landings by month and total annual landings (t) of ELE 5 from 1989–90 to 2007–08 for the setnet and bottom trawl methods for trips which landed ELE 5. Landings (t) have been scaled to the QMR totals $\left(\mathrm{QMR}_y\right)$ using Eq. 1.

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total (t)
	Month												
	Bottom trawl (%)												
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
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	50
91/92	6.1	1.4	14.8	11.3	12.1	13.3	0.8	0.1	5.8	5.4	5.0	23.7	46
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	27
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
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
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	61
96/97	27.0	4.2	21.7	15.4	1.2	3.6	10.3	7.9	0.0	0.6	0.2	7.9	66
97/98	11.5	3.0	5.7	23.3	7.6	13.2	6.5	2.6	8.3	1.2	6.5	10.6	75
98/99	5.6	2.1	3.6	21.8	2.0	5.2	10.3	6.3	2.5	8.3	12.9	19.4	123
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
00/01	7.7	8.1	9.2	16.1	2.8	4.2	5.3	8.9	6.5	7.7	9.6	13.9	138
01/02	3.2	6.7	5.8	17.8	23.5	14.4	11.6	8.5	1.5	4.6	2.1	0.2	90
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
03/04	7.2	6.9	13.0	5.6	5.2	15.3	2.0	12.8	9.8	10.0	4.3	8.0	94
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
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
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
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	169
Mean	8.3	6.2	8.6	14.2	9.4	9.6	6.4	6.8	6.5	5.9	6.3	11.7	1 627

Fishing Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep (Month)	Total (t)
	Setnet (%)												
89/90	0.0	4.5	17.5	8.3	46.2	12.1	0.0	0.0	0.0	0.0	1.3	10.0	2
90/91	0.2	34.1	3.9	18.9	37.3	1.3	3.3	0.7	0.1	0.0	0.3	0.0	5
91/92	7.3	15.7	65.4	2.9	1.1	0.0	0.1	0.0	0.1	0.0	0.1	7.3	11
92/93	11.4	29.3	5.2	21.9	22.1	1.1	6.6	0.4	0.3	0.0	1.8	0.0	13
93/94	2.2	13.2	19.8	16.9	20.8	16.8	9.8	0.1	0.0	0.0	0.0	0.4	9
94/95	5.2	9.0	6.0	48.6	27.1	0.0	2.0	0.0	0.0	0.1	0.0	2.0	13
95/96	12.5	11.9	29.5	40.5	3.6	1.9	0.0	0.0	0.0	0.0	0.0	0.1	12
96/97	1.8	8.5	12.6	71.0	3.2	0.2	0.0	0.2	1.4	0.0	1.1	0.0	8
97/98	0.0	0.4	8.2	56.3	26.7	4.0	1.8	2.3	0.2	0.0	0.0	0.0	11
98/99	0.0	45.9	16.9	22.0	13.3	0.3	0.0	0.1	1.5	0.0	0.0	0.0	10
99/00	0.2	5.4	32.5	51.7	8.6	1.2	0.0	0.0	0.4	0.0	0.0	0.0	9
00/01	0.1	32.5	51.4	0.7	2.9	12.5	0.0	0.0	0.0	0.0	0.0	0.0	13
01/02	0.1	46.5	2.3	12.9	26.2	10.2	0.6	0.0	0.0	1.1	0.0	0.0	14
02/03	0.0	20.5	20.7	29.8	22.9	0.2	1.3	0.2	0.0	1.3	0.4	2.6	4
03/04	2.9	5.6	50.4	29.2	2.6	1.4	0.7	6.0	0.9	0.0	0.3	0.0	7
04/05	5.8	17.2	6.7	62.6	1.1	1.7	0.3	0.6	3.6	0.1	0.1	0.2	17
05/06	11.3	43.4	25.3	2.7	3.7	0.9	0.1	1.3	0.0	0.0	0.3	10.9	25
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
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
Mean	4.6	21.4	21.2	25.6	11.0	3.8	1.3	1.0	5.6	0.4	1.0	3.0	224

A relatively narrow range of target fisheries take elephantfish in ELE 5, with the top five species targeted accounting for nearly 90% of the landed catch (Table 15). The elephantfish trawl catch is primarily taken by fisheries targeting flatfish, stargazer, and elephantfish (Table 15; Figure 12). Target species declared in the setnet fishery are primarily rig and school shark, with a small amount of targeting on elephantfish (Figure 12). The relative importance of the different target fisheries has been reasonably stable over the 19 years of data, with the exception of an increase in elephantfish targeting in the bottom trawl fishery in the most recent four years (Table 16). This increase in targeting of elephantfish since 2002–03 in the bottom trawl fishery is probably due to a combination of the increased apparent abundance of this species, the increase in the ELE 5 TACC in 2004–05 and the change in the deemed value/ACE regulations that govern New Zealand fisheries (see Table 2).

Table 15. Landings (t) and distribution of landings (%) of elephantfish from trips which landed ELE 5 by target species and important fishing methods (Table 10), summed from 1989–90 to 2007–08. Landings (t) have been scaled to the QMR totals (QMR_y) using Eq. 1.

Statistical Area Region	BT	SN	Other	Total (Method of capture)	BT	SN	Other	Total (Method of capture)
	Total landings (t)				**Distribution (%)**			
FLA	844		2	847	45.3	0.0	0.1	45.4
STA	365	0		365	19.6	0.0	0.0	19.6
ELE	222	34		256	11.9	1.8	0.0	13.7
SPO	11	101		112	0.6	5.4	0.0	6.0
SCH	1	76	0	77	0.0	4.1	0.0	4.1
SPD	57	13		70	3.1	0.7	0.0	3.8
GUR	56		1	56	3.0	0.0	0.0	3.0
BAR	23		0	23	1.3	0.0	0.0	1.3
RCO	14			14	0.8	0.0	0.0	0.8
TAR	9		0	10	0.5	0.0	0.0	0.5
LIN	8		0	8	0.4	0.0	0.0	0.4
OTH	16	0	10	26	0.9	0.0	0.5	1.4
Total	1 627	224	13	1 865	87.3	12.0	0.7	100.0

Table 16. Percent distribution of landings by target species (Table 10) from 1989–90 to 2007–08 for the two primary methods which landed ELE 5. Annual landings by method are available in Table 14.

Fishing												Declared target species
Year	**FLA**	**STA**	**ELE**	**SPO**	**SCH**	**SPD**	**GUR**	**BAR**	**RCO**	**TAR**	**LIN**	**OTH**
	Bottom trawl distribution (%)											
89/90	23.2	38.0	11.6	–	0.7	8.8	5.5	0.7	0.2	5.6	2.2	3.4
90/91	50.1	34.6	9.8	0.3	0.6	0.0	2.2	0.4	0.0	0.8	1.1	0.1
91/92	50.1	39.5	6.8	0.1	0.5	–	1.6	–	0.0	0.2	0.5	0.8
92/93	52.9	44.1	0.4	0.1	0.1	0.0	0.1	0.5	0.1	–	0.0	1.6
93/94	27.9	51.0	4.8	1.9	0.0	–	4.2	0.0	0.2	8.9	–	1.0
94/95	45.0	35.4	5.1	0.8	–	–	2.0	0.0	11.5	0.0	0.0	0.1
95/96	43.4	4.7	21.8	11.9	–	–	4.0	11.8	0.1	–	–	2.2
96/97	80.5	6.2	13.0	–	–	–	0.3	–	–	–	–	0.0
97/98	82.8	10.2	7.0	–	–	–	0.0	–	0.0	–	0.0	–
98/99	79.8	12.0	1.0	–	–	–	1.0	5.9	–	–	–	0.2
99/00	81.7	7.9	1.0	–	–	–	7.7	–	1.4	–	–	0.2
00/01	85.6	11.1	–	–	–	–	1.3	0.7	–	–	0.0	1.3
01/02	59.2	16.4	5.0	–	–	–	3.2	3.0	3.9	0.2	6.4	2.7
02/03	47.7	18.5	27.1	–	–	–	1.2	0.2	1.0	3.2	0.0	1.1
03/04	42.4	32.4	16.1	0.9	–	–	5.5	0.6	1.2	–	0.0	0.8
04/05	23.5	30.5	33.8	1.1	–	1.6	7.4	0.1	1.5	0.3	0.1	0.1
05/06	20.4	31.7	26.5	–	0.0	12.4	5.6	0.0	–	–	0.1	3.2
06/07	29.4	28.4	19.5	0.0	–	12.9	7.4	1.6	–	0.1	0.2	0.5
07/08	43.0	24.2	18.8	0.2	0.0	11.0	0.8	0.9	0.0	0.0	0.1	0.9
Mean	51.9	22.4	13.6	0.7	0.0	3.5	3.4	1.4	0.9	0.6	0.5	1.0
	Setnet distribution (%)											
89/90	–	–	50.4	19.2	30.4	–	–	–	–	–	–	–
90/91	–	–	66.4	14.2	19.4	–	–	–	–	–	–	–
91/92	–	–	72.4	16.5	11.1	–	–	–	–	–	–	0.1
92/93	–	–	46.6	39.1	13.9	0.3	–	–	–	–	–	0.2
93/94	–	–	20.9	20.2	59.0	–	–	–	–	–	–	–
94/95	–	0.0	2.2	20.2	77.6	–	–	–	–	–	–	0.0
95/96	–	–	2.9	35.1	62.0	–	–	–	–	–	–	0.1
96/97	–	–	70.4	19.5	10.1	–	–	–	–	–	–	–
97/98	–	–	–	12.5	87.5	–	–	–	–	–	–	–
98/99	–	–	13.6	43.8	42.7	–	–	–	–	–	–	–
99/00	–	–	42.7	31.5	25.8	–	–	–	–	–	–	–
00/01	–	–	16.2	65.9	12.6	5.3	–	–	–	–	–	–
01/02	–	–	–	61.2	38.8	–	–	–	–	–	–	–
02/03	–	–	3.8	41.7	54.5	–	–	–	–	–	–	–
03/04	–	–	–	59.6	40.4	–	–	–	–	–	–	–
04/05	–	–	–	91.7	8.3	–	–	–	–	–	–	–
05/06	–	–	–	71.2	22.7	6.1	–	–	–	–	–	–
06/07	–	–	–	54.5	43.3	2.2	–	–	–	–	–	–
07/08	–	–	–	41.4	27.7	30.9	–	–	–	–	–	–
Mean	–	0.0	15.2	45.2	33.9	5.6	–	–	–	–	–	0.0

The distribution of target fisheries by statistical area for the bottom trawl fishery shows that the increasing trend in targeting elephantfish is present in both Areas 025 and 030 (Figure 13). The relative importance elephantfish bycatch in the flatfish fishery may also be declining in both areas. The bycatch of elephantfish in the ELE 5 setnet fishery is minor and all direct targeting of elephantfish in this fishery disappeared by the mid-1990s (Table 16; Figure 14). There is some suggestion that setnet targeting for rig is taking an increasing proportion of elephantfish in Areas 025 and 030, indicating a possible shift away from SCH target fishing.

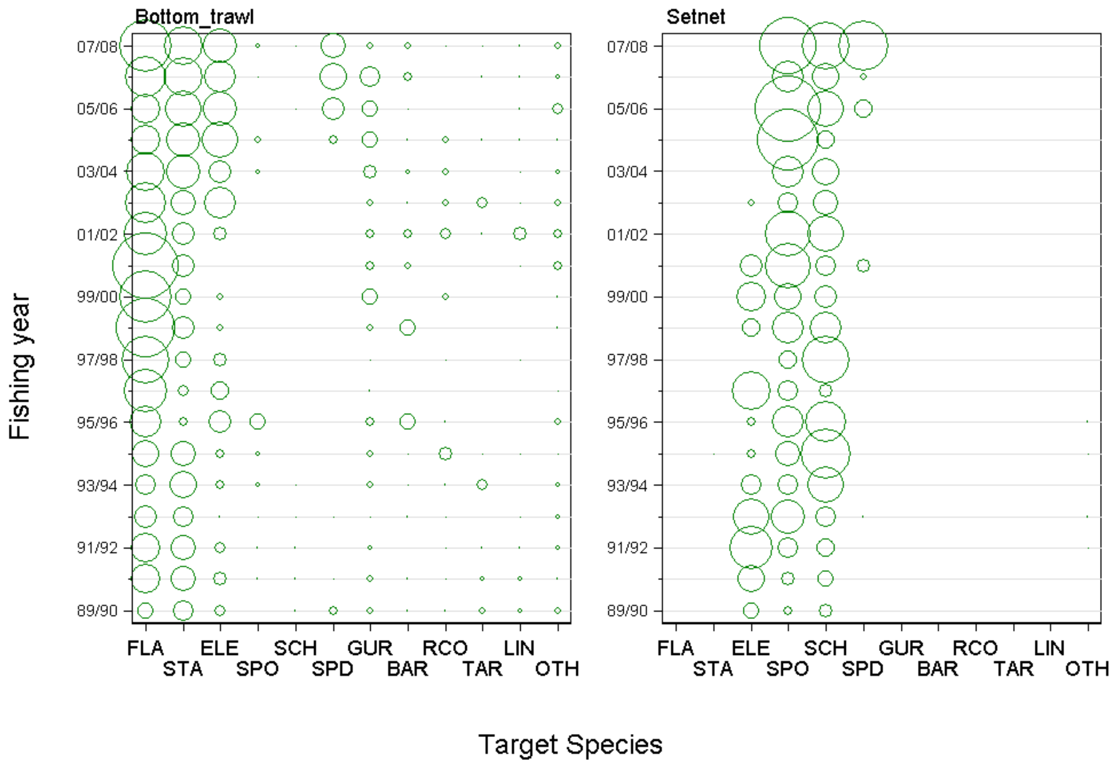

Figure 12. Total landings by target species (Table 10) and fishing year for the bottom trawl and setnet method based on trips which landed ELE 5. Circles sizes are proportional within each panel: maximum values: [bottom trawl]: 118 t in 00/01 targeting FLA; [setnet]: 18 t in 05/06 targeting SPO.

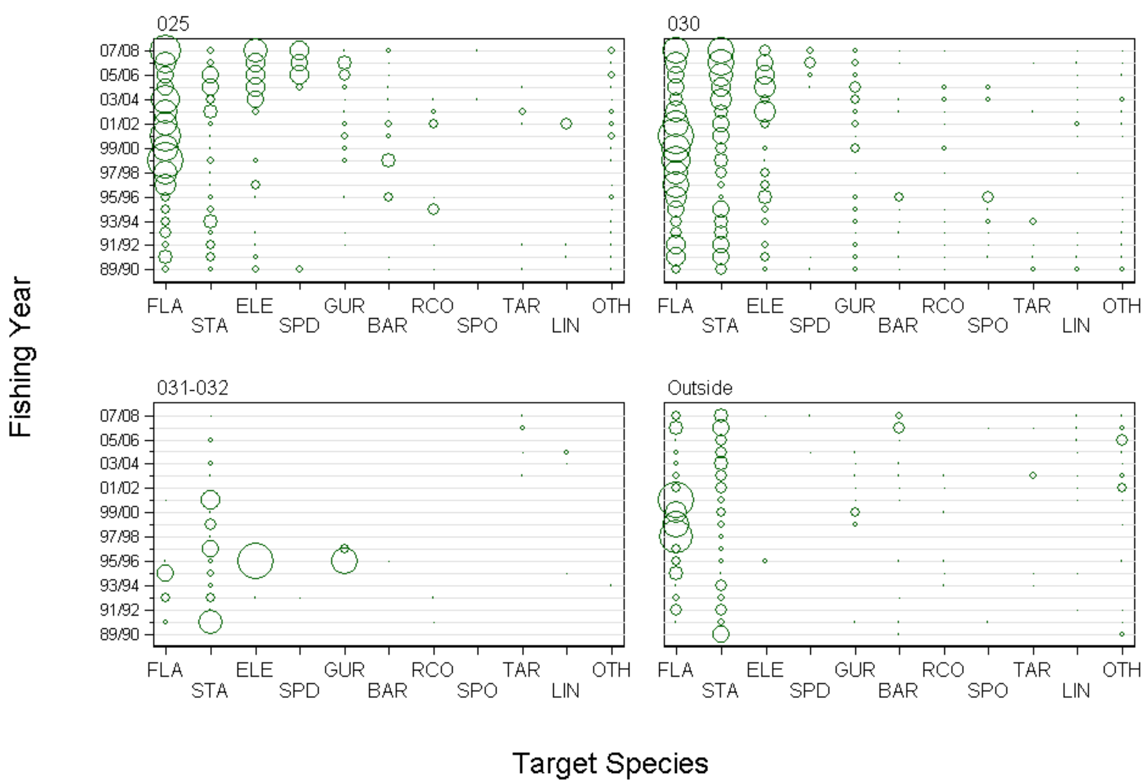

Figure 13. Distribution of landings for the bottom trawl method by grouped statistical area (Table 10) for target species (Table 10) and fishing year from trips which landed ELE 5. Circles sizes are proportional within each panel: maximum values: 025 (50 t in 98/99 for FLA); 030 (62 t in 00/01 for FLA); 031–032 (2.4 t in 95/96 for ELE); and Outside (18 t in 00/01 for FLA).

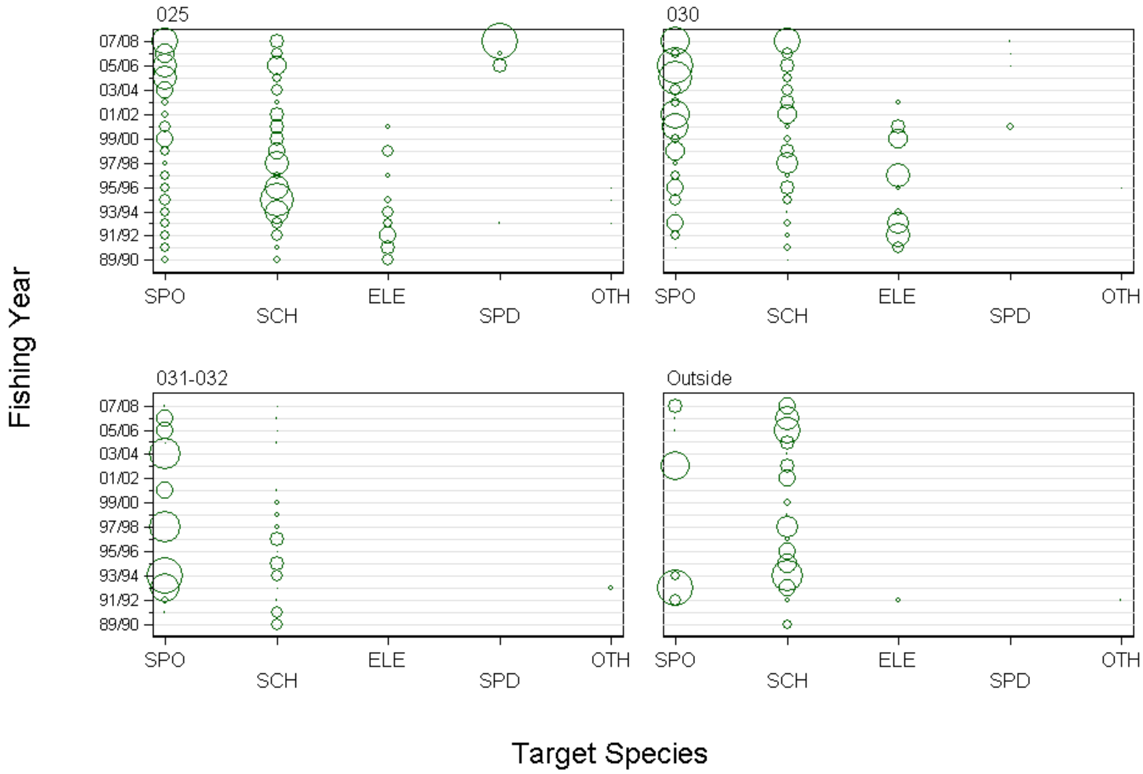

Figure 14. Distribution of landings for the setnet method by grouped statistical area (Table 10) for target species (Table 10) and fishing year from trips which landed ELE 5. Circles sizes are proportional within each panel: maximum values: 025 (10 t in 07/08 for SPD); 030 (13 t in 05/06 for SPO); 031–032 (1.2 t in 93/94 for SPO); and Outside (0.6 t in 92/93 for SPO).

Table 17. Summary statistics of depth distribution for bottom trawl effort reported on TCER or TCEPR forms for tows that targeted or caught elephantfish by target species category (Table 10) in statistical areas consistent with ELE 5. This table uses all tows in the dataset (1989–90 to 2007–08).

		Depth (m)			
Target species category	**Number observations**	**Lower 5% of distribution**	**Mean of distribution**	**Median (50%) of distribution**	**Upper 95% of distribution**
BAR	36	49	74	72	100
ELE	78	14	42	40	76
FLA	1 606	16	47	50	72
GUR	21	24	53	57	80
SPD	47	29	54	56	89
STA	376	31	88	81	150
TAR	28	43	56	56	85
Other	39	14	80	75	420
Total	2 231	17	55	52	118

Depth information is available from TCEPR and TCER forms which report bottom or midwater trawl catches pertaining to elephantfish (either recording an estimated catch or as target species). These reports show that elephantfish are mainly taken between 17 and 118 m of depth, with the median value above 50 m (mean=55 m; Table 17). The distribution of tows which caught or targeted elephantfish are relatively consistent between declared target species, with the distributions showing the most captures in less than 100 m of water (Figure 15).

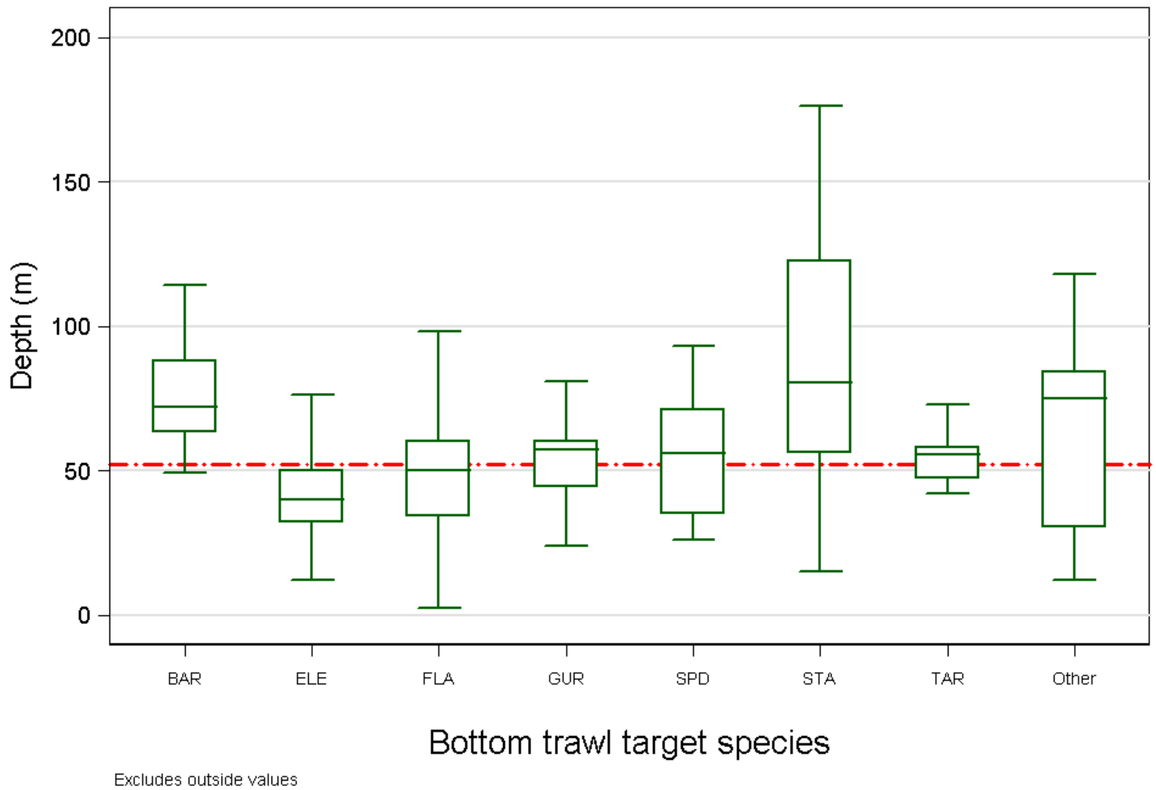

Figure 15. Box plot distributions of depth from bottom trawl effort reported on TCER or TCEPR forms for tows that targeted or caught elephantfish by target species category (Table 10) in statistical areas consistent with ELE 5. This graph is based on all tows in the dataset (1989–90 to 2007–08). Horizontal line indicates the median depth from all tows which caught or targeted elephantfish.

4.4 STANDARDISED CPUE ANALYSIS FOR ELE 5

Several attempts have been made to track the abundance of ELE 5 using standardised CPUE data:

1. bycatch of ELE in the target FLA bottom trawl fishery operating in combined Areas 025 and 030 (SeaFIC 2002);
2. bycatch of ELE in the target FLA bottom trawl fishery: one analysis for the combined Areas 025 and 030 and a second analysis using Area 030 data only (SeaFIC 2003);
3. bycatch of ELE in the mixed target bottom trawl fishery, with separate analyses for each of Area 025 and Area 030, as well as a third analysis based on the shark setnet fishery operating in Areas 025 and 030 data (Starr et al. 2007);

These standardised analyses have been hampered due to a relatively few data and shifts in species preferences. The 2006 Plenary document for ELE 5 concluded: "*Given the current circumstances the Plenary concluded that there is no reliable index of abundance for ELE 5*" (MFish Science 2008). The AMP Plenary in December 2003 rejected the use of a standardised series from Area 025, primarily because of the loss of data during key fishing months in earlier years. The analysis presented in 2007 moved away from the FLA target fishery and included bottom trawl fishing directed towards other species (mostly stargazer and some elephantfish), but confined the analyses to a selected fleet of core vessels. An additional analysis based on the target shark setnet fishery was also explored in 2007. The

AMPWG accepted the two bottom trawl analyses, noting that they showed similar trends, although the series based on data from Area 030 appeared to be more optimistic. The AMPWG also noted that there was reasonable consistency in the common vessel coefficients between the two areas.

The three models introduced in 2007 have been updated in Appendix B. In addition, a model which combines the two areas, much as was done in 2002 and 2003, is presented using data based on linking landings with effort data and which only use selected core vessels. This latter model appears to be slightly more stable than the models based on separate areas.

4.4.1 Methods

The data extract used to conduct this analysis included all landings from individual fishing trips by domestic vessels within either Statistical Area 025 and/or 030 and which used the bottom trawl method or the setnet method and targeted SCH 5, SPO 3 or ELE 5 during the 1989–90 to 2007–08 fishing years (Appendix B). A set of core vessels was selected from the bottom trawl dataset by restricting the extract to vessels that had reported at least a) 3 trips in at least six years (BT(MIX)25 analysis) or b) 5 trips in each of 5 years (BT(MIX)30 analysis) or c) 10 trips in each of 6 years (BT(MIX)All analysis). The core vessels from the shark setnet dataset were required to have made 3 trips in at least three years. Once selected, all data from the selected vessels were used in each analysis, regardless of the number of trips in that year or the target species. Descriptions of the data, and detailed methodologies are reported in Appendix B.

A high proportion of the qualifying trips in the analyses were not used in the lognormal analysis because no elephantfish catch was reported from these trips (about 50-80% of the available records). A declining trend in the proportion of trips which report no elephantfish landings is apparent in the bottom trawl dataset (). A logistic (binomial) model was fit to the presence/absence of elephantfish in the dataset to account for this trend.

4.4.2 Results

A discussion of the detailed results along with appropriate diagnostics are presented in Appendix B for the BT(MIX)All and SN(SHK) analyses. Only a reduced set of results for the BT(MIX)30 and BT(MIX)25 analyses are shown in Appendix B because the analysis which incorporates data from both statistical areas appears to be more stable and is based on a greater amount of data. The BT(MIX)All series ([upper left panel] Figure 16) shows a long trend of increasing catch rates, beginning in the early to mid-1990s. The BT(MIX)30 ([upper right panel] Figure 16) series is also increasing, although possibly at a slower rate. The BT(MIX)25 ([lower left panel] Figure 16) analysis is much more variable and appears to have levelled off or may be declining in the most recent 3–4 years while the SN(SHK) series ([lower right panel] Figure 16) shows no apparent trend. For all models, the standardised series generally track the unstandardised series, with standardisation procedure tending to reduce the overall variability compared to the unstandardised series.

It is plausible that the increasing trend observed in the BT(MIX)All and BT(MIX)30 series reflect an increased level of abundance for elephantfish in QMA 5. The relatively high index levels in these series are corroborated by the increasing catch levels which have been sustained in this fishery over the past decade or longer and which are now at their highest level in the 22 years of the series (Table 1). Plots (Figure 17) which directly compare each of the four reported standardised CPUE series with the total QMR ELE 5 landings show that the CPUE trends for the BT(MIX)All, BT(MIX)30 and the BT(MIX)25 series all appear to have increased at approximately the same rate as the ELE 5 catch but that the CPUE trend for the SN(SHK) series has lagged behind the trend increasing catch. This may be due to management measures designed to reduce interactions with Hector's dolphins or to other factors affecting the setnet fishery.

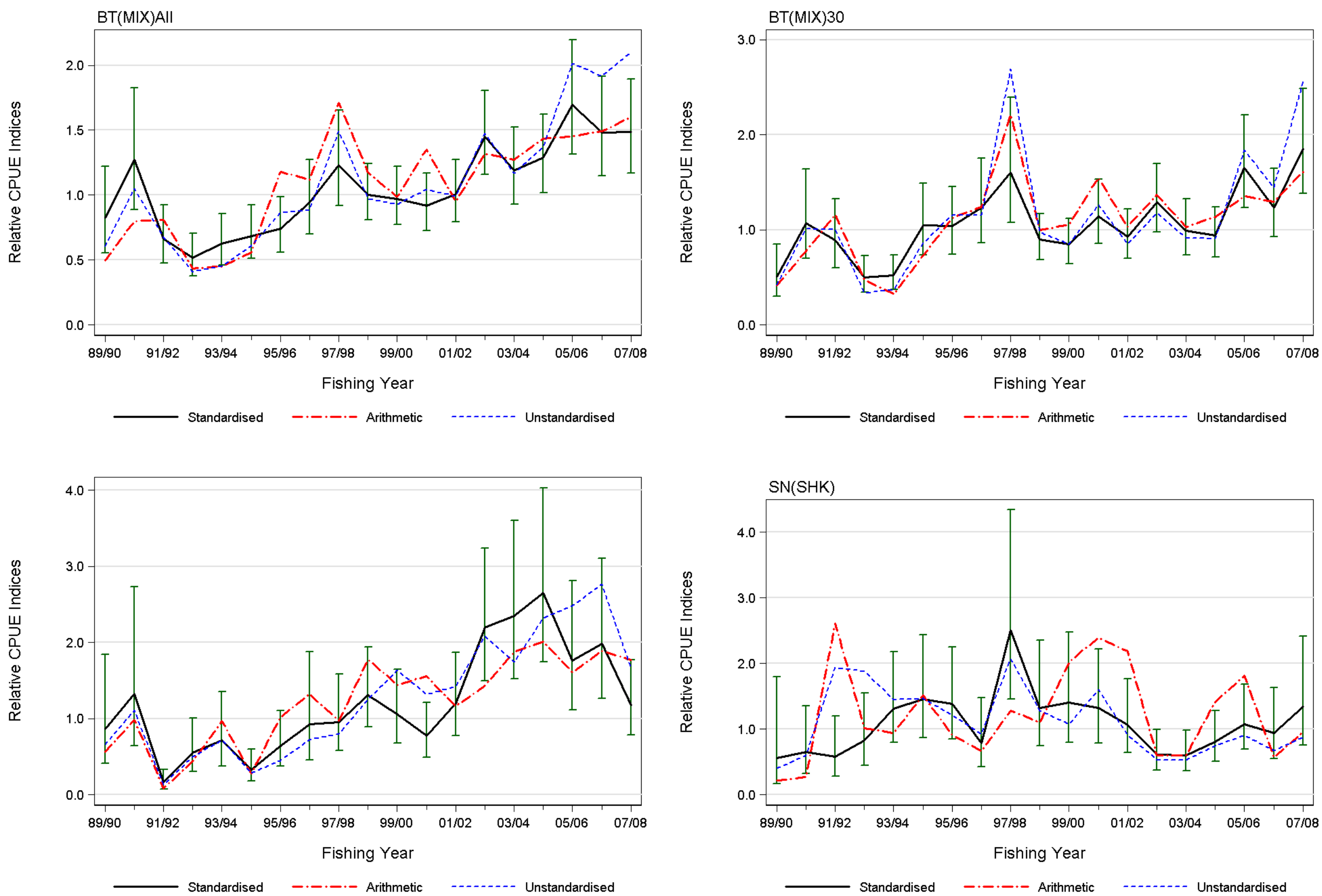

Figure 16. Relative CPUE indices for ELE 5 using the lognormal non-zero model based on the bycatch in four fisheries described in Appendix B: three target flatfish/stargazer/elephantfish bottom trawl fisheries: a) [BT(MIX)All] combined Areas 025 and 030; b) [BT(MIX)30] Area 30 only; c) [BT(MIX)25] Area 025 only; and d) target shark species setnet [SN(SHK)]. Also shown are two unstandardised series from the same data: a) Arithmetic $A_y = \sum_{i=1}^{N_y} C_{i,y} \Big/ \sum_{i=1}^{N_y} E_{i,y}$ and b) Unstandardised $U_y = \exp\left(\dfrac{\sum_{i=1}^{N_y} \ln\left(C_{i,y}/E_{i,y}\right)}{N_y} \right)$ which is the geometric mean of the observations $C_{i,y}$ =landings in year *y*. $E_{i,y}$ =length of net set for [SN(SHK)] in year *y*; =hours towed for [BT (MIX)30]-30 and =number tows for [BT(MIX)25] and [BT(MIX)All]

Direct comparisons of the four lognormal CPUE series (BT(MIX)All, BT(MIX)30, BT(MIX)25, and SN(SHK)) calculated for ELE 5 shows reasonable consistency between all the series ([upper left panel] Figure 18). The BT(MIX)All and BT(MIX)30 are very consistent, with each showing the same peaks and troughs ([upper right panel] Figure 18), although the BT(MIX)30 series appears to be the more variable than the BT(MIX)All series. This is expected, given the strong overlap in data used to generate these respective series, and the greater amount of data available to generate the BT(MIX)All series. When all three bottom trawl series are superimposed, the similarity is immediately apparent, although the BT(MIX)25 series ([lower left panel] Figure 18) is clearly the most variable of the three and should be considered the least reliable of the three bottom trawl series. The series based on the setnet data from the combined areas ([lower right panel] Figure 18) shows relatively little trend over the period, being flatter than any of the bottom trawl series. However, even this series is showing an upturn in the most recent 4–5 years, starting from a lower level. As well, this series is quite unreliable, given the small amount of data it is based upon.

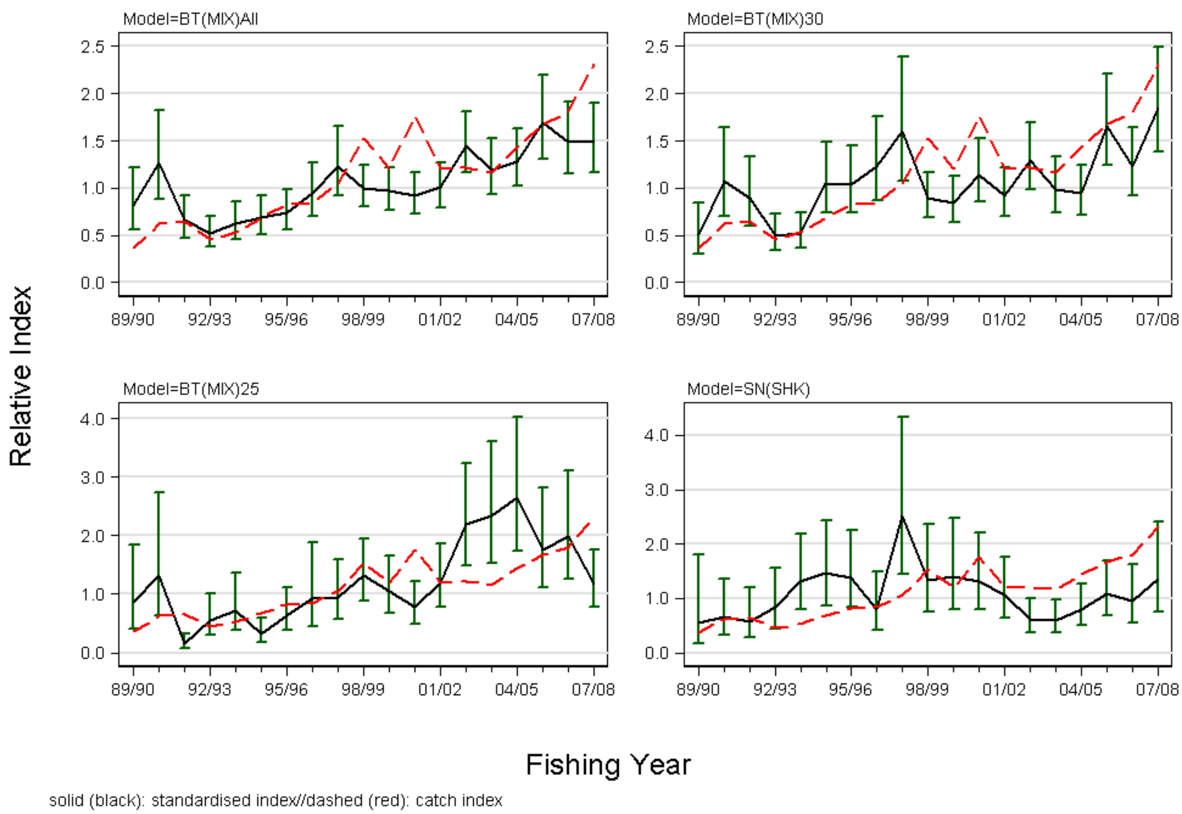

Figure 17. Comparison of the four standardised CPUE indices for ELE 5 against the annual landings in total ELE 5. All series have been standardised to the geometric mean of all years.

The four standardised CPUE series are all consistent with an overall increasing abundance trend for ELE 5. Series which are based on fewer data show more variability and are consequently less conclusive. However, taken as a whole, these four series appear to corroborate an overall increasing trend in abundance for ELE 5.

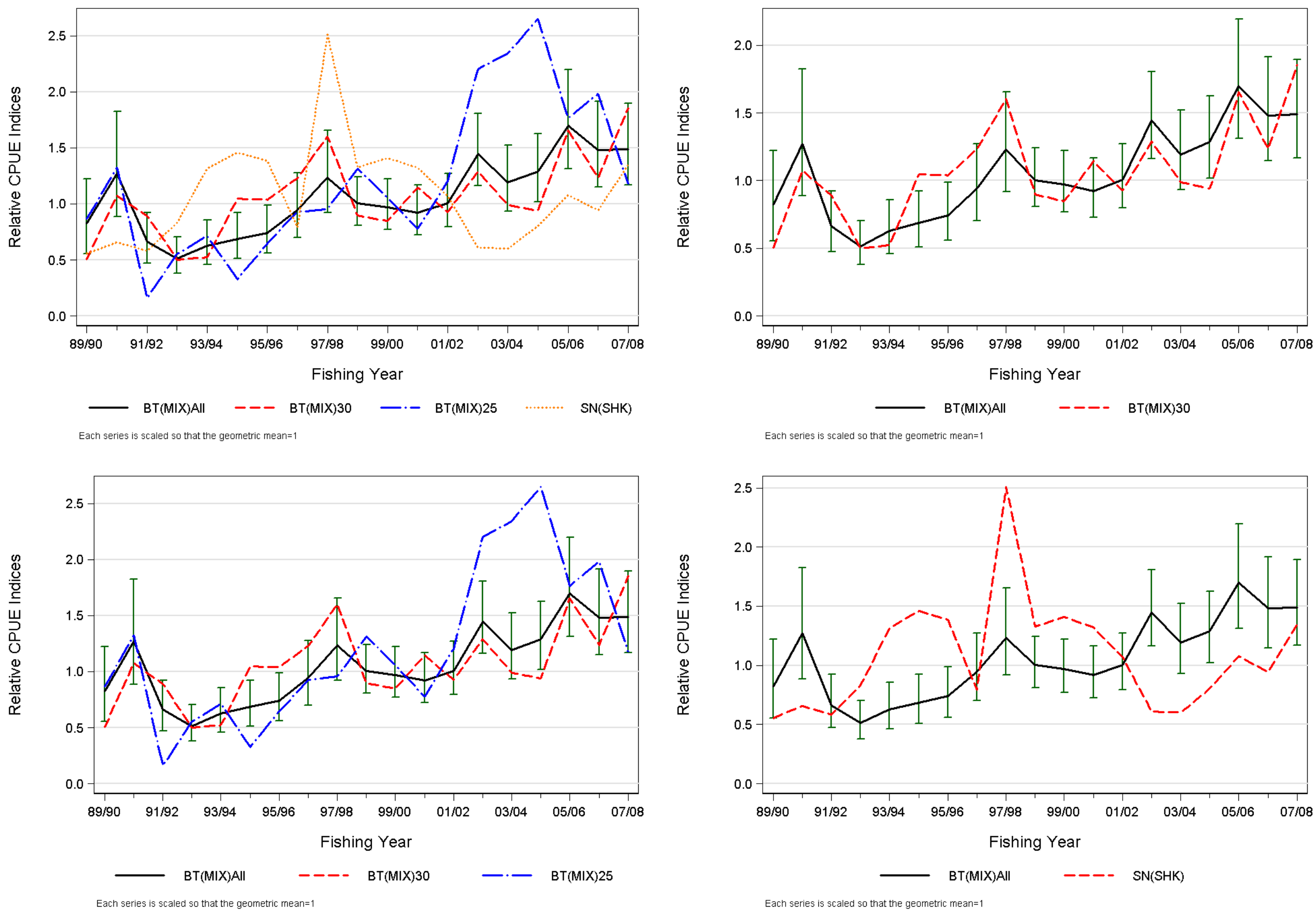

Figure 18. Comparisons of the lognormal indices from four standardised CPUE models (described in the text and the caption for Figure 16), derived from catch/effort data for the by-catch ELE 5. All series have been standardised to a common 1989–90 to 2007–08 geometric mean

5. BIOLOGY

Elephantfish are uncommon off the North Island, occurring south of East Cape on the east coast and south of Kaipara on the west coast. They are most plentiful around the east coast of the South Island (McClatchie & Lester 1994).

Males mature at a length of 50 cm fork length (FL) at an age of 3 years, females at 70 cm FL at 4 to 5 years of age. The maximum age cannot be reliably estimated, but appears to be at least 9 years and may be as high as 15 years. Natural mortality (M) is estimated to be near 0.35, based on unvalidated ageing indicating a maximum age of 13 years. This estimate is based on the method of Hoenig (1983) $\left(M = -\frac{\log_e(p)}{A} \right)$ where *A* is the maximum age at which 1% (*p*) of the population survives in an unexploited stock (McClatchie & Lester 1994).

Mature elephantfish migrate to shallow inshore waters in spring and aggregate for mating. Eggs are laid on sand or mud bottoms, often in very shallow areas. They are laid in pairs in large yellow-brown egg cases. The period of incubation is at least 5–8 months, and juveniles hatch at a length of about 10 cm FL. Females are known to spawn multiple times per season. After egg laying, the adults appear to disperse and are difficult to catch; however, juveniles remain in shallow waters for up to 3 years. During this time juveniles are vulnerable to incidental trawl capture, but are of little commercial value (McClatchie & Lester 1994).

There is only limited information available to support existing stock boundaries. Results from tagging studies conducted during 1966–1969 indicate that elephantfish tagged in the Canterbury Bight remained in ELE 3. Separate spawning grounds which maintain each 'stock' have not been identified. The boundaries used are related to the historical fishing pattern when this was a target fishery.

5.1 TRAWL SURVEY ABUNDANCE INDICES

Four surveys of inshore and middle depths species were conducted on the plateau which extends south and west from the southern end of the South Island in depths ranging from 30 m to 600 m. A total of 20 strata were identified, but there are considerable amounts of foul ground and several of the strata were either dropped or could not be satisfactorily sampled. Three strata were placed in the 30 m to 100 m depth range (where the main catch of elephantfish would be expected) and a total of 15 stations were allocated to these strata.

Table 18. Biomass estimates for elephantfish from the four Southland trawl surveys of inshore and middle depth species carried out between 1993 and 1996. Data from Hurst and Bagley 1997.

Survey designation **Year of survey**	**TAN9301** **1993**	**TAN9402** **1994**	**TAN9502** **1995**	**TAN9604** **1996**
Total tows	113	129	150	124
Total tows in Strata 1-3	22	16	26	20
Tows with ELE	12	13	8	10
Number ELE Captured	75	64	68	49
Number ELE Measured	64	37	68	45
ELE fish weight (kg)	304	198	195	168
ELE biomass (t)	219	177	66	137
CV	33%	47%	49%	46%
% of total survey biomass	0.2%	0.2%	<0.1%	<0.1%

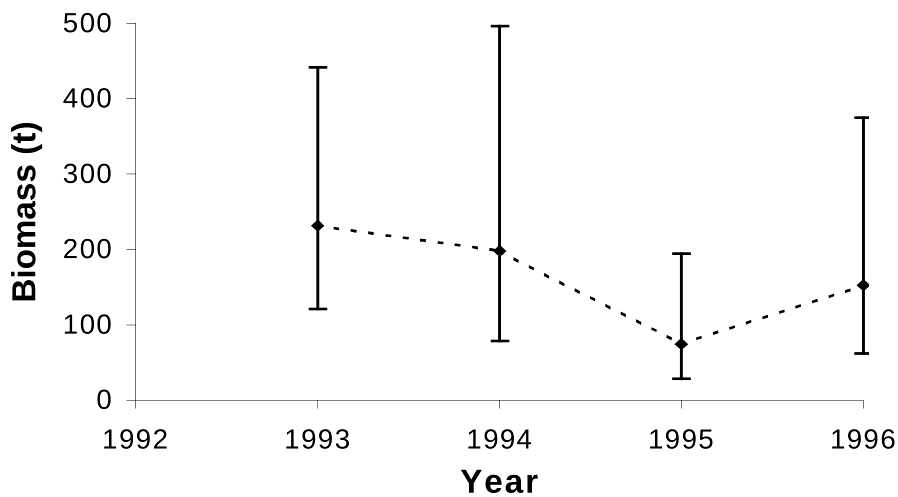

Figure 19. Biomass indices and approximate 95% confidence limits for elephantfish from the four Southland trawl surveys conducted between 1993 and 1996. Data from Hurst and Bagley 1997.

This survey was conducted for four successive years (1993 to 1996) and was primarily targeted at six main commercial species (barracouta, blue warehou, gemfish, ling, school shark, and stargazer). Because it did not cover the shallow depths where significant levels of elephantfish would be expected to reside, it is unlikely that the survey biomass estimates will adequately monitor trends in the relative abundance of the ELE 5 stock. Results for elephantfish from these four surveys are reported here for completeness. Elephantfish were only caught from a few trawl shots and consequently biomass estimates are low with high CVs (Table 18). The estimated biomass levels show no trend (Figure 19).

5.2 INDUSTRY LOGBOOK PROGRAMME

5.2.1 Introduction

The section on the Industry Logbook Programme was not completed for this document. See previous documents for a review of the information available prior to this report (Starr et al. 2007).

6. STATUS OF THE STOCK

The following is taken from the "Status of the Stocks" section for ELE 5 in the current Plenary report (MFish Science 2008):

"*Before the introduction of the QMS, elephantfish in Southland were considered severely overfished, and TACs were initially set at low levels to facilitate stock recovery. The TACC for ELE 5 was increased twice within the AMP - first to 100 t in October 2001 and then to 120 t in October 2004 - as there was a reasonable probability that the stock was above the size that would support the MSY. However, it is not known if recent catch levels and current TACCs are sustainable. The state of the stock in relation to* B_{MSY} *is unknown.*"

We believe that the information presented in this report is consistent with this conclusion and suggest that this Fishstock satisfies the AMP assessment criteria with increasing estimates of abundance in the face of increasing levels of catch. This is a small fishery where most of the available information is derived from fishery dependent data. Therefore, these data and the consequent conclusions are susceptible to being affected by the existing management. The bottom trawl series shows an increasing trend and is based on more data than the target shark setnet series which shows little or no trend (Figure 18). The available information appears to be consistent with anecdotal reports that the abundance of ELE 5 has increased since the mid-1990s and that elephantfish abundance is presently staying high at current catch levels.

7. INFORMATION ABOUT PARTICIPANTS

Name:	South East Finfish Management (SEFM) Limited
Representation:	Stakeholder group which represents finfish quota holders in FMA 3 and FMA 5. Currently this stakeholder company represents 98% of the total ELE 5 quota.
Contact Individual:	Peter Dawson, Chief Executive
Phone:	03-328 9494
Fax:	03-328 9595
Postal Address:	PO Box 43 Lyttleton
Email Address:	pete@fishcon.net
Funding Support:	Voluntary levy from quota owners

8. INFORMATION ABOUT THE ENVIRONMENTAL EFFECTS OF FISHING

8.1 INTRODUCTION

The Fisheries Act 1996 includes obligations to manage any adverse effects of fishing on the aquatic environment. The purpose of the Fisheries Act 1996 (Section 8 (1)), is to "provide for the utilisation of fisheries resources while ensuring sustainability". 'Utilisation' means "conserving, using, enhancing and developing fisheries resources to enable people to provide for their social, economic and cultural well-being." 'Ensuring sustainability' means "maintaining the potential of fisheries resources to meet the reasonably foreseeable needs of future generations and avoiding, remedying, or mitigating any adverse effects of fishing on the aquatic environment."

Section 9 of the Fisheries Act 1996 states that all persons exercising or performing functions, duties or powers in relation to the utilisation of fisheries resources or ensuring sustainability, shall take into account the following environmental principles:

1. associated or dependent species should be maintained above a level that ensures their long-term viability,
2. biological diversity of the aquatic environment should be maintained and
3. habitat of particular significance for fisheries management should be protected.

The ELE 5 TACC was raised to 120 t, under the AMP on 1 October 2004. Elephantfish in ELE 5 are taken mainly by bottom trawl fisheries (85% of landings) targeting flatfish, stargazer, and elephantfish. The remainder of the fishery (15% of landings) is a setnet fishery targeting rig and school shark, with a small amount of elephantfish. About 60% of the total ELE 5 landings come from Area 030 (western Foveaux Strait) with most of the remaining landings coming from the adjacent Area 025 (eastern Foveaux Strait).

8.2 ASSOCIATED OR DEPENDENT SPECIES:

8.2.1 Seabirds

The incidental bycatch of seabird species in fisheries is a global problem. Seabirds and fishermen both target productive areas of the ocean at the same time of year. Seabirds are then attracted to vessels by the discharge of offal and discards and inevitably interactions occur. The assemblage of seabirds attending fishing vessels will differ depending on the number of fishing vessels present in the same fishing grounds, the location, time of day and season. Interaction of different seabird species with fishing gear will be influenced by their feeding method, dive depth abilities and seabird size (Bull 2007). In trawl fisheries, seabirds are attracted to vessels by the discharge of offal and discarded bycatch, or through the availability of catch when the net is brought to the surface. Whilst attempting to feed seabirds can be killed or injured by contacting the trawl warps. Mortalities can also occur when birds dive into the trawl net or become entangled in the meshes when they are trying to seize fish.

Diving seabirds such as shearwaters, penguins, shags and gannets are occasionally caught in setnets. Yellow eyed penguins are known to be caught in near-shore setnets, but there is very little observer information available on the level of interaction (Darby and Dawson 2000).

The extent to which commercial setnet fishing activities interact with protected species is largely unknown due to very low historic achievement of observer coverage. Despite historic intent to collect observer data, this fishery has been difficult to observe because, as with other inshore fisheries, it encompasses smaller vessels carrying out short trips, less predictable operations and there are practical difficulties (Rowe 2008).

Recently the focus of preventing seabird interactions with fishing gear has been on trawling and workshops have been held with fishermen, scientists, government officials, observers and environmentalists. Offal management is a key mitigation measure combined with methods to keep seabirds away from trawl warps. Smaller inshore trawlers that catch 85% of ELE 5 total landings, are not considered to have significant interactions with seabirds due to the low height of the stern causing the warps to enter the water close to the vessel. A meeting between MFish, SeaFIC and Industry was held in Timaru on 10 December 2008 to discuss interactions. Fishermen in FMA 3 reported that captures of birds in the net rarely occur due to net rollers keeping the mesh tight, warp captures of larger seabirds are infrequent but do occasionally occur.

For trawlers over 28m in length, the Minister of Fisheries gazetted mandatory measures on 12 January 2006 to reduce seabird bycatch. Fishing without a warp-strike mitigation device is now prohibited and it must be deployed as soon as practicable after the shooting of the net, and must remain deployed for as long as practicable prior to the net being brought back on board the vessel. The three recognised warp-strike mitigation devices are paired streamer lines, a bird baffler or a warp deflector.

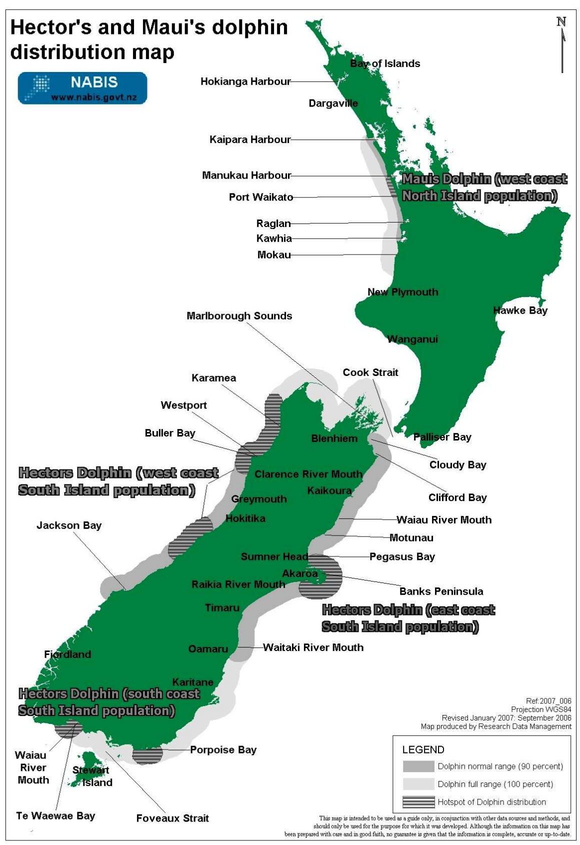

Figure 20. Distribution of Hectors Dolphin (MFish and DoC 2007)

8.2.2 Marine mammals: Hector's dolphins

Hector's dolphin *Cephalorhynchus hectori hectori,* is New Zealand's only endemic cetacean and is one of the world's rarest dolphin species. The total population is estimated by Slooten *et al* (2002) to be 7,270 (C.V. 16.2%, log-normal 95% confidence interval is 5,303-9,966). The Department of Conservation has ranked its status as 'nationally endangered'(Hitchmough *et al* 2007). Analysis of variation among sequences of mitochondrial DNA and microsatellite allele frequencies showed that four genetically isolated populations exist; three in the South Island (off the west, east and south coasts) and a fourth off the west coast of the North Island (Pichler et al 1998).

Te Waewae Bay is considered to be the core area of abundance for Hector's dolphins on the south coast of the South Island (Figure 1). The most recent published and peer reviewed population estimate for Te Waewae Bay (from a boat-based transect survey undertaken in 1998-99) is 89 (CV=32%, log-normal 95% CI=36-218 individuals) (Dawson et al. 2004). This population estimate does not include the group of dolphins resident in Porpoise Bay. Further work is planned to identify whether the Porpoise Bay dolphins (around 50 animals) should be linked with the Te Waewae Bay population or the east coast South Island population. The most recent survey used a vessel based mark-recapture method (MFish and DoC 2007) during 2004 and 2005. The aims of the study were to provide an abundance estimate and document the distribution of the Hector's dolphin population that used the bay. The study estimated that the population that used Te Waewae Bay in the Autumn of 2004 was 259 (CV = 0.171; 95% CI = 185-361) and in the summer period, 403 (CV = 0.121; 95% CI = 280-488). 282 hours were spent on the water over 38 days of study with a total of 2,462 km travelled. Dolphin distribution was concentrated along the inshore coastal section of the bay (less than 5.6km from shore) and dolphins were sighted less at the western and eastern extremes of the bay. 16.1% of the sighted dolphins in the Autumn period were sighted further than 5.6 km from shore and in summer 2.1% were sighted further than 5.6 km from shore, showing some indication of seasonal inshore-offshore movement.

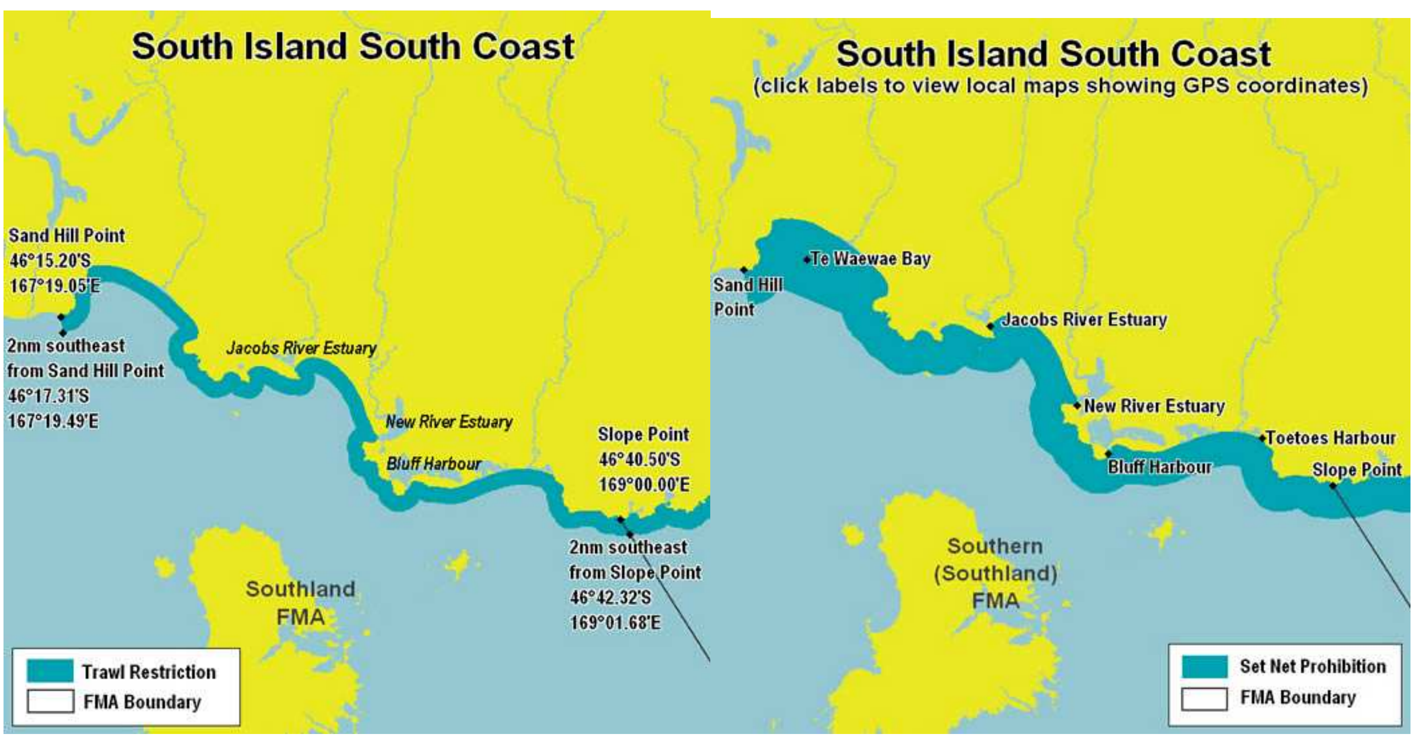

Figure 21. Restrictions implemented on 1 October 2008: [left] trawl; [right]: setnet

Page 9 of the Hectors and Maui Dolphin Threat Management Plan (MFish and DoC 2007) states that *"The nature and extent of threats is still highly uncertain, largely due to gaps in available information."* Summer is when dolphins tend to be closer inshore, and is therefore the time when Hector's dolphins are at most risk of net entanglement. Hector's dolphins are threatened by even low levels of mortality due to slow reproduction rates resulting in low potential for population growth. Incidental mortality of Hectors dolphin from trawling appears to be a rare occurrence probably because of the noise and slow speed of trawling activity alerting Hector's dolphins of the danger and allowing them time to swim out of harms way. Between 1970 and 1998, five hector dolphins were caught by inshore trawlers on the east coast of the South Island (DoC 2008). No trawl mortalities have been observed or reported in FMA 3 or FMA 5 since this incident in 1998.

New prohibitions and other restrictions on set netting, drift netting and trawling came into force from 1 October 2008 to protect threatened Hector's and Maui's dolphins. On the South Island south coast from Slope Point in the Catlins to Sand Hill Point east of Fiordland; trawl gear was restricted offshore to two nautical miles unless a low headline height trawl net is used which has a net opening with a vertical height of no more than 1 metre (Figure 2).

Set netting is prohibited offshore to four nautical miles and for the whole of Te Waewae Bay (Figure 3). Under the interim relief decision, the following exceptions to the set net prohibition are permitted during the period 1 October to 24 December in the waters lying between 1nm and 4 nm from the mean high-water mark that extends from Slope Point to Old Man Rock (i.e. excluding Te Waewae Bay), provided that such commercial fishers use set nets to target only rig, school shark and elephant fish; and set and haul their nets during the period commencing half an hour before sunrise and ending half an hour after sundown.

8.2.3 Marine mammals: Hector's dolphins

New Zealand fur seals (*Arctocephalus forsteri*) are protected under the Marine Mammals Protection Act 1978, and are listed by DoC as 'not threatened'(Hitchmough et al 2007). The population is estimated to be between 50,000 to 100,000 (Suisted and Neale 2004). No census of fur seals has occurred in New Zealand in the last 30 years. Lalas and Bradshaw (2001) note that in recent years the population in New Zealand has increased and the breeding distribution has expanded northwards. The last comprehensive survey of the population was conducted in 1973 by Wilson (1981), who generated a single population estimate for the entire New Zealand region of 39,000 animals (range 30,000 – 50,000). Rookeries (breeding colonies) and haul-outs (non breeding colonies) are re-establishing around the South Island.

Unrepresentative and low observer coverage has limited estimation of marine mammal captures across the fleet in most fisheries. However it is considered that fur seal interactions with trawlers are relatively rare. Fur seal interactions with setnets can occur, 4 juvenile fur seals have been observed caught in the last 5 years (Rowe 2008).

8.3 OBSERVER COVERAGE

Observer coverage in inshore fisheries has been low in relation to number of fishing days as well as other measures of effort. Small vessels have more changeable fishing schedules than larger vessels, due to greater operational sensitivity to weather. In addition, smaller vessels may not have space for an observer. The cost to quota holders of $8025 plus GST per observer day is also prohibitive. As a result of low levels of observer coverage in inshore fisheries, our understanding of the nature and extent of protected species captures and interactions in inshore fisheries is poor. The current lack of information has made it difficult to assess the frequency and representativeness of detected capture events. The paucity of coverage also makes it difficult to assess impacts of incidental mortalities on protected species populations (MFish 2007).

The Department of Conservation Services Programme has requested observer days in inshore trawl for a number of years now but has yet to deliver the requested number of days - coverage has been around 1% of total vessel days in the fishery. For example in 2007/08 a total of 250 observer days were levied but only 81 days were achieved and none of them were in ELE 5. In 2009/10 a total of 300 DoC CSP observer days in inshore trawl are planned and it is noted that

"*while 300 inshore trawl days will not provide sufficient data for estimating total incidental catch of protected species nationwide by this method, greater knowledge will be gained about how these fisheries interact with protected species*." (DoC 2008).

In 2007/08 a total of 161 setnet hauls were observed in FMA 5 (25% of effort) with no marine mammals interactions but 1 Yellow eyed penguin was caught (Rowe 2009). The focus for DoC CSP inshore trawl coverage in 2009/10 will be outside the days planned by MFish to monitor Hector's dolphin interactions. CSP coverage will, instead, investigate all protected species interactions with a particular emphasis on seabird interactions. Coverage will be focused in FMA 3 to monitor for albatross warp strikes. Coverage will be undertaken throughout the year, except during months when Ministry of Fisheries Hector's dolphin monitoring is underway.

In addition under the MFish New Initiative, the Ministry received an additional $1m for observer coverage in 2008/09, $2m in 2009/10 and $3m for 2010/11. These funds were used in 2008/09 for observing protected species interactions, primarily dolphins. Over 50 students provided the monitoring for January and February 2009 on 962 days. No dolphins were caught. MFish observers will additionally conduct a further 1,100 observer days in inshore setnet and trawl fisheries from 1 July 2009 to estimate the nature and extent of incidental captures of protected species in the New Zealand fisheries, in particular data on seabird warp strike incidents.

8.4 BIOLOGICAL DIVERSITY

The potential environmental effects of fishing on the biological diversity of the area have not been well documented. Nor have any habitats of particular significance for fisheries management been identified that may be affected by the fishery. The bottom trawl fishery operates on relatively flat grounds. "Rough" grounds are avoided because of the potential loss or damage to fishing gear. Trawling impacts on the benthos as the ground chain, bobbins and trawl doors contact the sea floor during fishing. Rock hopper gear, which allows the net to bounce over rocks, has extended fishing into sandy/mud areas that have small amounts of foul ground. There is little information on the range and location of broad bottom habitat types or the vulnerability of each habitat (MFish 2006)[1]. It should be noted, however, that the area in which the south coast trawl fisheries operates has a long history of trawling activity and it is unlikely that the higher ELE 5 TACC has resulted in the trawling of new areas that were previously unfished. Setnet fisheries have minimal impacts on benthic associated or dependent species (for example sponges or bryozoans).

[1] http://fpcs.fish.govt.nz/FishPlanComplex.aspx?ID=9

8.5 CONCLUSIONS

Lack of information and data due to low observer coverage and lack of fine scale catch reporting has made it difficult to objectively evaluate the environmental effects of fishing under the ELE 5 AMP. The rates of non-fish bycatch are not monitored adequately. However the adverse effects of fishing on the aquatic environment are considered to be relatively small for ELE 5. The following measures have been undertaken by industry to mitigate the interaction between Hector's dolphin and commercial fishing on the south coast of the South Island. The South East Finfish Management Company Limited reviewed and updated the voluntary Code of Practice (COP) for Commercial Set Net Fishers in 2003. The COP includes a range of voluntary measures to reduce the level of dolphin and penguin bycatch. These voluntary measures include that nets shall not be deployed when Hector's dolphin or yellow-eyed penguins are active around the vessel and turning fish finders on during setting and hauling. Seabird and fur seal interactions cannot be quantified but are considered to be low. Fishermen have a voluntary Code of Practice with a number of measures to avoid interactions with penguins and Hectors dolphin. Hectors dolphin are also protected by the new closed zones. Interactions with trawlers are considered to be rare.

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Appendix A. MAP OF MFISH STATISTICAL AND MANAGEMENT AREAS

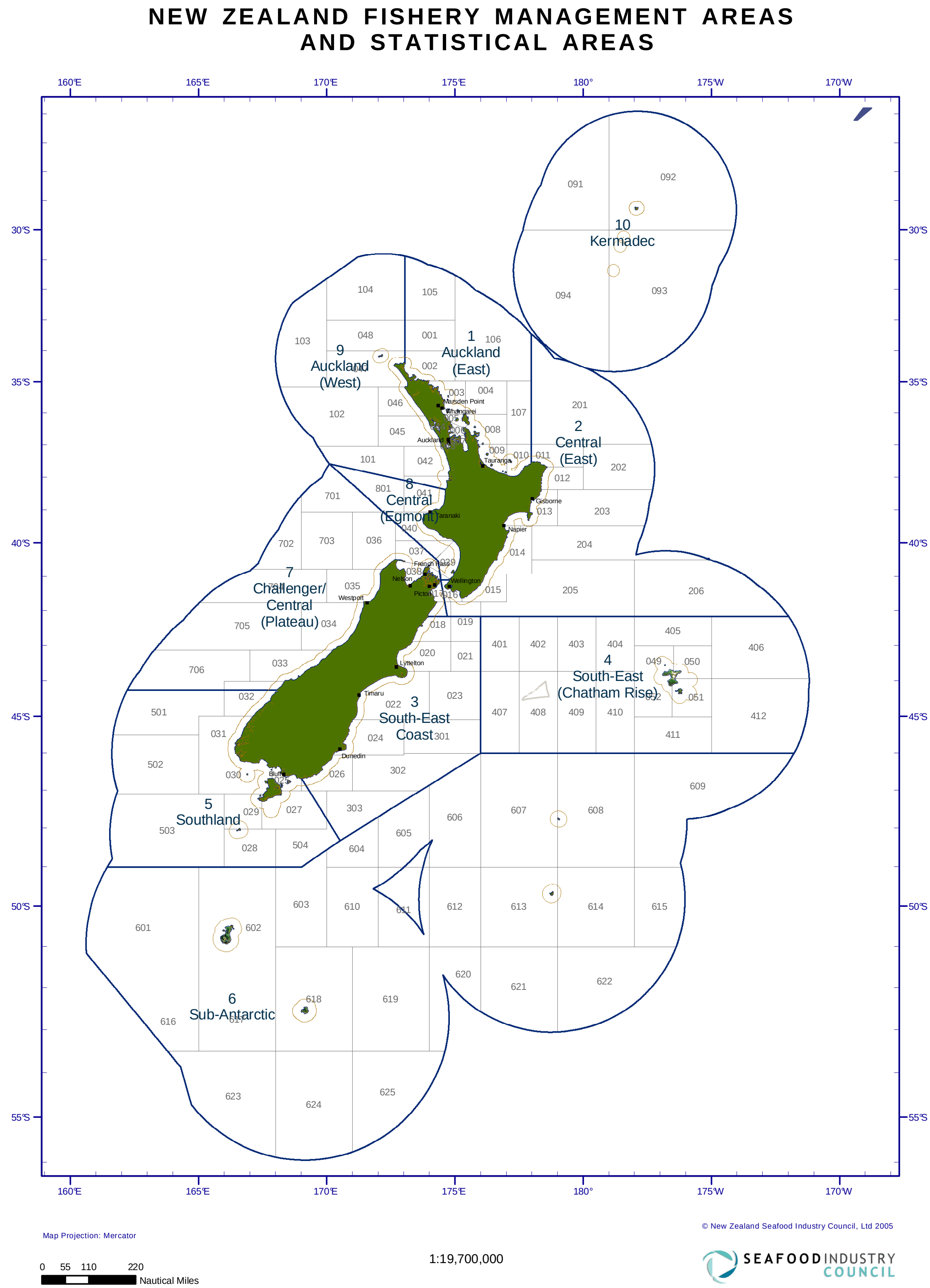

Figure A.1. Map of MFish statistical areas and Quota Management Area (QMA) boundaries, showing locations where QMA boundaries are not contiguous with the statistical area boundaries.

Appendix B. ELE 5 CPUE ANALYSIS

B.1 GENERAL OVERVIEW

A characterisation of the ELE 5 fishery first prepared in 2002 (SeaFIC 2002) demonstrated the importance of the bycatch of elephant fish in the target FLA 3 (flatfish and related species) bottom trawl fishery in statistical areas 025 and 030. That fishery was recognised as the potentially most useful fishery to monitor the abundance of ELE 5, but a characterisation of catch and effort in Areas 025 and 030 for the entire time series showed that a representative fishery no longer existed during the peak months in Area 025 (SeaFIC 2003). At meeting of the AMPWG in September of that year it was suggested that an attempt be made to monitor abundance of elephantfish in area 030 only. In 2007, bottom trawl fisheries in areas 025 and 030 were monitored separately and the fishery definitions expanded to include all months of the year and all target species. This was also done this year but not reported in detail. The main analysis includes all statistical areas valid for ELE 5 and is nevertheless dominated by catches from area 030. The amount of data for a separate area 025 analysis remains inadequate, but the annual indices are not contradictory to those for area 030 only.

The fishing year was redefined in previous analyses of ELE 5 bottom trawl due to large catches that historically took place in area 025 between August and October. Rather than split these catches into two different fishing years, the boundary of the fishing year was moved forward a month to maintain the continuity of catches from September to October. That fishing year (1 Nov – 31 Oct) definition has been maintained in the current analysis.

A series estimated from the shark set net fishery in areas 025 and 030 is also presented for comparison. It uses the conventional fishing year definition and includes only data from the peak months of October through March.

B.2 DATA PREPARATION

Candidate trips were identified by searching for all landings of ELE 5, and any effort records in statistical areas that are valid for ELE 5 that targeted ELE. Once a list of trips that satisfied these criteria was identified, all effort and landing records associated with these trips were extracted.

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

Effort and estimated catch data were summarised by fishing trip, for every unique combination of fishing method, statistical area, and target species, referred to as a "trip strata". This reduced both CELR and TCEPR format records to lower resolution "amalgamated" data, giving fewer records per trip but retaining the original method, area, and target species recorded by the skipper.

The landed catches of ELE 5 for each trip were allocated to the "trip strata" (defined as statistical area, target species and method) in proportion to the appropriate estimated catches by species. In the case where there were no estimated catches, the allocation was made proportionate to the number of sets (or tows). The main assumption made in this allocation procedure is that the reporting of elephantfish is consistent across statistical areas and target species within a trip. In contrast, if estimated catches were used directly, the assumption must be made that reporting rates are constant across the entire fleet and all statistical areas for all years, as well as making the assumption that the ratio of estimated catch to landed greenweight catch is also consistent across the entire fleet for all years.

The data available for each trip included estimated and landed catch of elephantfish, the number of sets (or tows), total duration of fishing, fishing year, statistical area, target species, month of landing, and a unique vessel identifier. Data might not represent an entire fishing trip; just those portions of it that qualified, but the amount of landed catch assigned to the part of the trip that was kept would be proportional to the total landed catch for the trip using the estimated catches to apportion the landings to each trip stratum. Trips were not dropped because they targeted more than one species or fished in more that one statistical area. Trips landing more than one Fishstock of any species from one of the straddling statistical areas were entirely dropped

B.2.1 DATA SELECTION AND METHODS

Those groups of events that satisfied the criteria of target species, method and statistical areas defining the defined fisheries were selected from available fishing trips. Any effort strata that were matched to a landing of ELE 5 were termed "successful", and included any relevant but unsuccessful effort, so that the analysis of catch rates in successful strata also incorporates much of the relevant zero catch information.

Strata which did not include any landed ELE 5 were assigned a value of zero so that the effort data associated with them could be included in the analysis that considered total effort (as differentiated from successful effort only).

Unstandardised and standardised CPUE analyses were performed on each dataset. Two standardised models were applied to each bycatch dataset. One model was a lognormal linear model fit to successful catches of ELE 5, excluding zero catches. A binomial model which predicted success or failure of ELE 5 catch was fit to the total dataset, including records that reported a zero catch of elephantfish. These two models were combined into a single set of indices using the method of Vignaux (1994).

Catch rates were standardised against variation in the explanatory variables using a stepwise multiple regression procedure, selecting until the improvement in model R^2 was less than 0.01. The year effects were extracted as canonical coefficients (Francis 1999) so that confidence bounds could be calculated for each year.

The dependent variable for the lognormal model was the log of landed weight of ELE 5 per record (where a record is a trip/statistical area/target species stratum). The range of explanatory variables offered to the models are given in Table B.1 and Table B.2. 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. The logs of length of net, number of tows and total duration were included as measures of effort to explain catch per trip-stratum.

The dependent variable for the binomial model was a binary variable set to '1' for records which had associated ELE 5 catch and set to '0' for records with no catch. This model was offered the same explanatory variables as the lognormal model.

The two models were combined into a single index using a form of the following equation (Vignaux 1994):

$$C_i = \frac{L_i}{\left(1 - P_0\left[1 - \frac{1}{B_i}\right]\right)} \qquad \text{Eq. 3}$$

where C_{hi} = combined index for year *i*
L_{ie} = lognormal index for year *i*
B_I = binomial index for year *i*
P_0 = proportion zero for base year *0*

It is relatively straightforward to calculate standard errors for the indices L_{ie} and B_I. However, this is not the case for the combined index C_{hi} because the standard errors of the two sets of indices are likely be correlated because they come from the same dataset. Francis (2001) suggests that a bootstrap procedure is the appropriate way to estimate the variability of the combined index. This was not done for this study, as the effect of combining the models is often not great, and, where error bars are shown around combined indices, they are based on the standard errors from the lognormal model.

B.2.2 Fishery definitions for CPUE analysis

The fishery identified as the most appropriate in which to monitor elephantfish is the bycatch of the mixed species bottom trawl fishery operating in ELE 5, dominated by catches from statistical areas 025 and 030 and by tows targeted at flatfish and stargazer. An independent fishery based on the bycatch of elephantfish in the shark setnet fishery is investigated for corroboration or and contrast.

BT (MIX) – Mixed target bottom trawl; The Fishery is defined from all bottom trawl fishing events regardless of target species, that fished in any area valid for ELE 5. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates.

SN (SHK) – Shark setnet; The Fishery is defined from set net fishing events which fished in statistical areas 025 or 030 during the peak months October to March, and targeted elephantfish, rig, spiny dogfish or school shark. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates.

B.3 Unstandardised CPUE

B.3.1 BT (MIX) Mixed target bottom trawl

The effort expended in the mixed species bottom trawl fishery in ELE 5 peaked in the early 1990s and has declined since then to a level now that is about 60 % of the peak level. Reported catch of elephantfish falls into two differing periods; an earlier period of lower encounter rates and catch rates, and a later period after 1999–00, of a greater number of trips landing elephantfish, with higher and more stable catch rates in those trips. The annual catch per tow for trips that landed elephantfish was at its lowest in 1994–95 at less than 20 kg per tow, then increased rapidly to a peak of about 65 kg / tow by 1998–99, and has fluctuated around 45 kg per tow since then (Figure B.1).

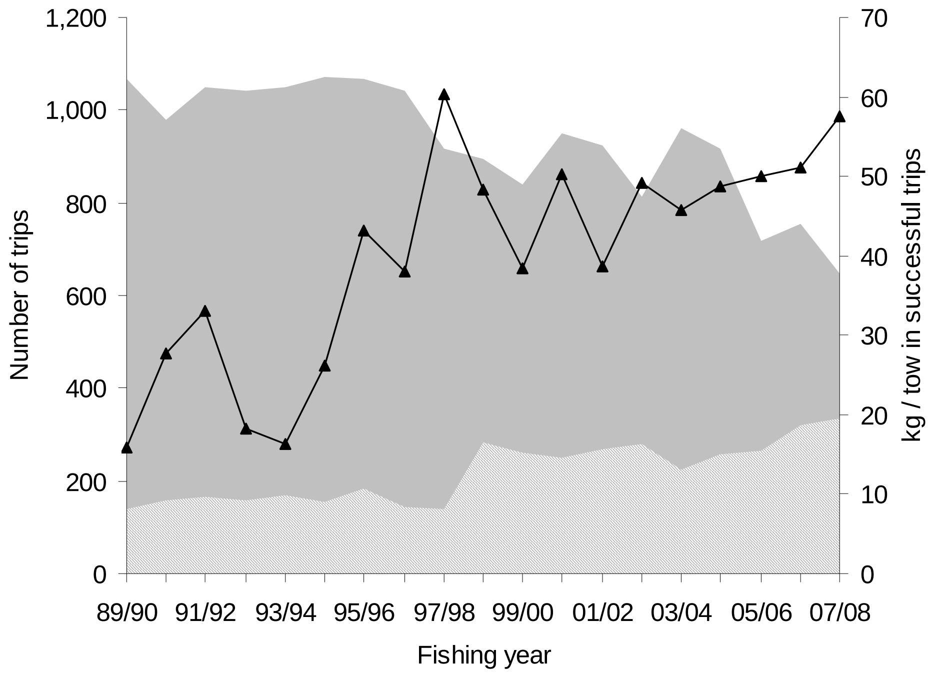

Figure B.1: Number of trips that targeted flatfish by bottom trawl in BT (MIX),(dark area), the number in trips that landed ELE 5 (light area) and the simple catch rate (kg/tow) of ELE 5 in successful trips, by fishing year.

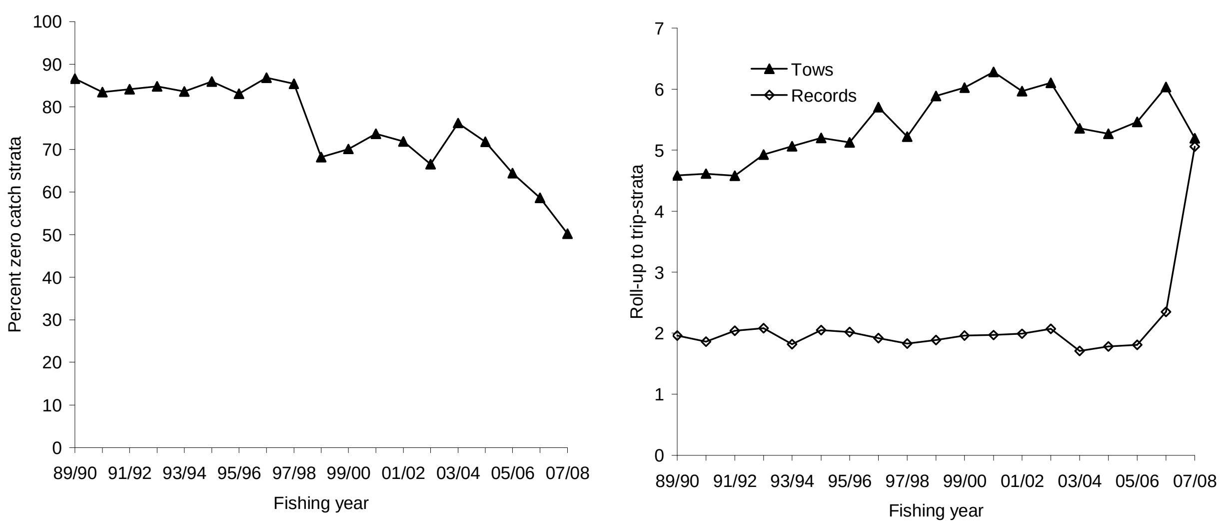

Figure B.2: The proportion of zero catch trip-strata in all qualifying BT (MIX) trips (before selection of core vessels) [left], and the effect of data roll-up indicated by the ratio of original records per trip-stratum, and number of tows per trip-stratum by fishing year [right].

The proportion of trips that have reported zero catches of elephantfish declined from greater than 80% at the beginning of the series to around 50% in 2007–08 (Figure B.2). The roll-up of data shows a trend of increasing tows per trip-stratum but a flat trend of original records per trip-stratum. This indicates that the trend is inherent in the data as reported and not the result of subsequent amalgamation procedures (Figure B.2).

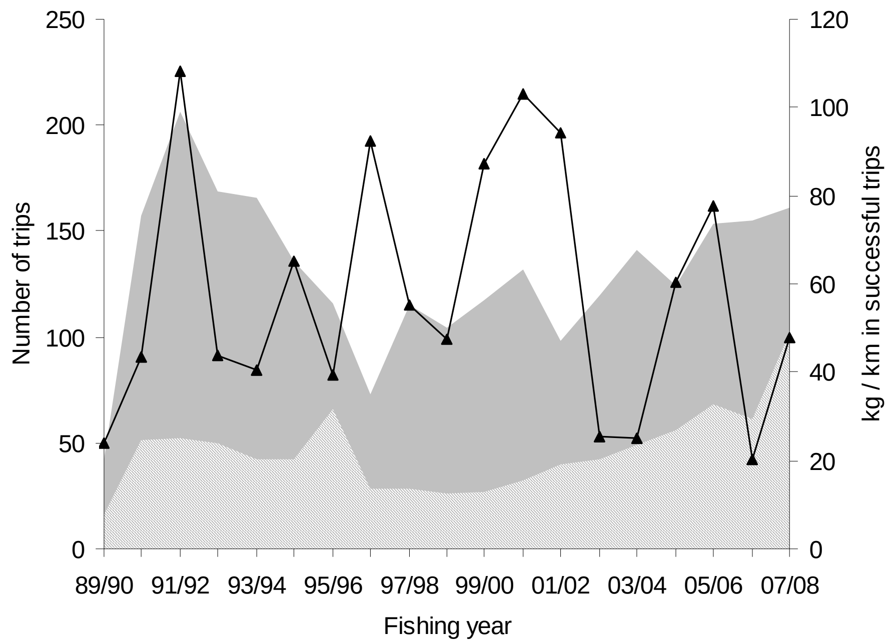

Figure B.3: Number of trips that targeted sharks by set net; SN (SHK) (dark area), the number in trips that landed ELE 5 (light area) and the simple catch rate (kg/set) of ELE 5 in successful trips, by fishing year.

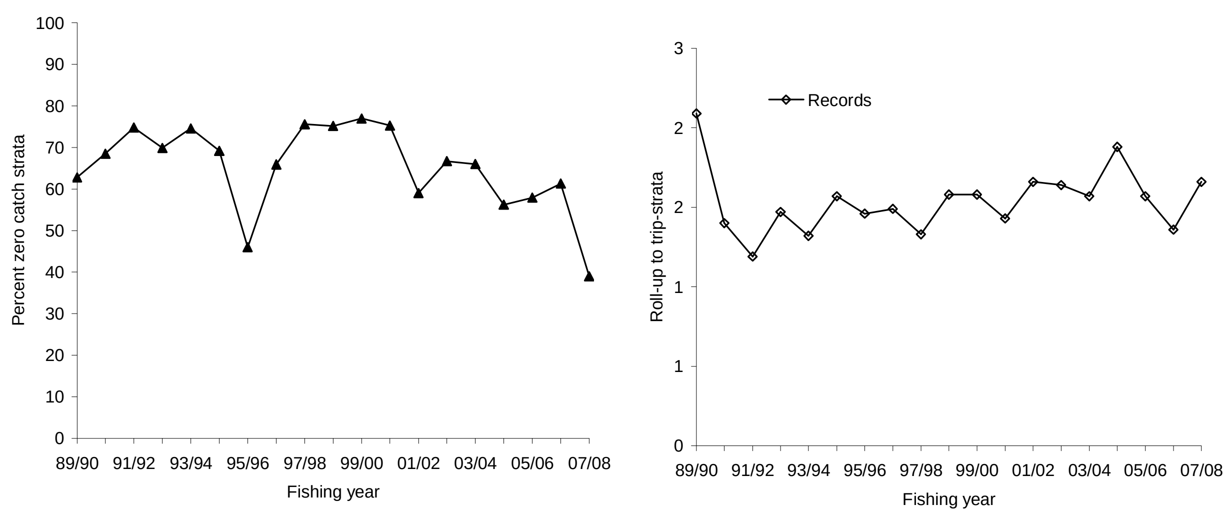

Figure B.4: The proportion of zero catch trip-strata in all qualifying SN (SHK) trips (before selection of core vessels) [left], and the effect of data roll-up indicated by the ratio of original records per trip-stratum, and number of tows per trip-stratum by fishing year [right]..

B.3.2 SN (SHK) SHARK SET NET

Shark set net effort was greatest in areas 025 and 030 during the early 1990s, it declined by more than half into the mid 1990s and has since increased again almost to original levels

(Figure B.3). The bycatch rate of elephantfish in this fishery has fluctuated widely (between 20 and 110 kg per km of net) from year to year, (Figure B.3).The proportion of zero catches had been relatively stable over most the series at around 80%, but in the last five years has declined to sit presently around 40% (Figure B.4). There is no trend in the roll-up of data that might confound the binomial standardisation (Figure B.4).

B.4 STANDARDISED CPUE ANALYSIS

B.4.1 CORE FLEET DEFINITIONS

The data sets used for the standardised CPUE analysis were further restricted to those vessels that participated with some consistency in the defined fishery. The core fleet for the bottom trawl fisheries was selected from a fishery based on bottom trawl in both statistical areas, and the same vessels used for each of the separate analyses. Core vessels were selected by specifying two variables; the number of trips that determined a qualifying year, and the number of qualifying years that each vessel participated in the fishery.

The effect of these two variables on the amount of landed elephantfish retained in the dataset and on the number of core vessels is depicted for each of the defined fisheries in Figure C.1 and Figure C.2. The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of rig. The selection process usually reduced the number of vessels in the dataset by about 70% while reducing the amount of landed rig by about 20%.

The distribution and number of trips in each fishing year for the selected core vessels in each fishery are provided in Figure C.1 and Figure C.2. Data sets for the final core vessels are summarised in Table C.1 to Table C.2.

B.4.2 MODEL SELECTION

The BT (MIX) lognormal model (Table B.1) explained 20% of the variance in log catch, largely by standardising for sporadic targeting of elephantfish in the mid 1990s and increased targeting in recent years. The greater shifts in targeting in this fishery have been between flatfish and stargazer, and a recently developed spiny dogfish fishery, but have been reasonably neutral with respect to expected catches of elephantfish. Overall, the influence of changes in target behaviour on observed CPUE were positive. Vessel ID, month and log number of tows also entered the model but effected little additional change in the annual indices **(**Figure B.5). Changes to the core fleet and seasonal shifts in the fishery both raised observed catch rates overall. For most of the time series there is an upward influence on unstandardised CPUE from an increase in tows per trip-stratum but that was reversed in 2007–08. More detailed demonstrations of the effect of these significant variables are presented in Figure C.5 to Figure C.8. Only year (forced) and vessel ID entered the binomial model explaining 31% of the variance in success rate.

The SN (SHK) lognormal model (Table B.2) explained 27% of the variance in log catch, largely by standardising for a decline in targeting of elephantfish since the early 1990s. Log of net length entered the model standardising for an increasing trend in the length of net set per trip stratum over time **(**Figure B.6). Changes to the core fleet have coincided with declining catch rates so that recent entrants have performed poorly with respect to elephantfish, and the vessel effect may be confounded with the year effect. More detailed demonstration of the effect of these significant variables is presented in Figure C.9, Figure C.10, and Figure C.11

Area was not accepted into this model and it has been suggested previously that vessel serves as a proxy for area in this fishery. An alternative model which forced area to enter the model and dropped vessel was more optimistic in its trajectory of annual indices (Figure C.12) and the influence plot for area showed a reasonably consistent distribution of catch among areas over time and a flat trend to the influence of any shifts among area for most of the series. .

Similar variables entered the binomial model except that no additional measure of effort was accepted. The binomial model explained 17% of the variance in success rate.

Diagnostic residual plots are presented for the two lognormal models are found in Figure C.3 and Figure C.4, each showing a good fit of the data to the lognormal assumption and little in the way of unexplained patterns in the residuals.

Table B.1: Order of acceptance of variables into the lognormal model of successful catches of ELE 5 and the logistic model of catches (successful or unsuccessful) for core vessels based on the vessel selection criteria of at least 10 trips in 6 or more fishing years) in the BT (MIX) fishery, 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 (fyear) was forced as the first variable.

Variable	DF	Deviance	AIC	R^2	Final	Influence magnitude	Influence trend
Lognormal Model							
none	0	14 528	15 146	0.0000		-	-
fyear	19	13 811	15 001	0.0494	*	-	-
target	24	12 969	14 786	0.1073	*	0.061	0.005
vessel	46	12 300	14 641	0.1534	*	0.075	0.013
month	57	11 743	14 498	0.1917	*	0.057	0.012
poly(log(num) 3)	60	11 584	14 455	**0.2027**	*	0.024	-0.002
area	62	11 475	14 426	0.2101		-	-
Binomial model							
none	0	15 757	15 759	0.0000			
fyear	19	15 240	15 278	0.0328	*		
vessel	53	10 839	10 945	**0.3121**	*		
target	58	10 681	10 797	0.3221			
area	60	10 549	10 669	0.3305			
month	71	10 387	10 529	0.3408			
poly(log(duration) 3)	74	10 351	10 499	0.3431			

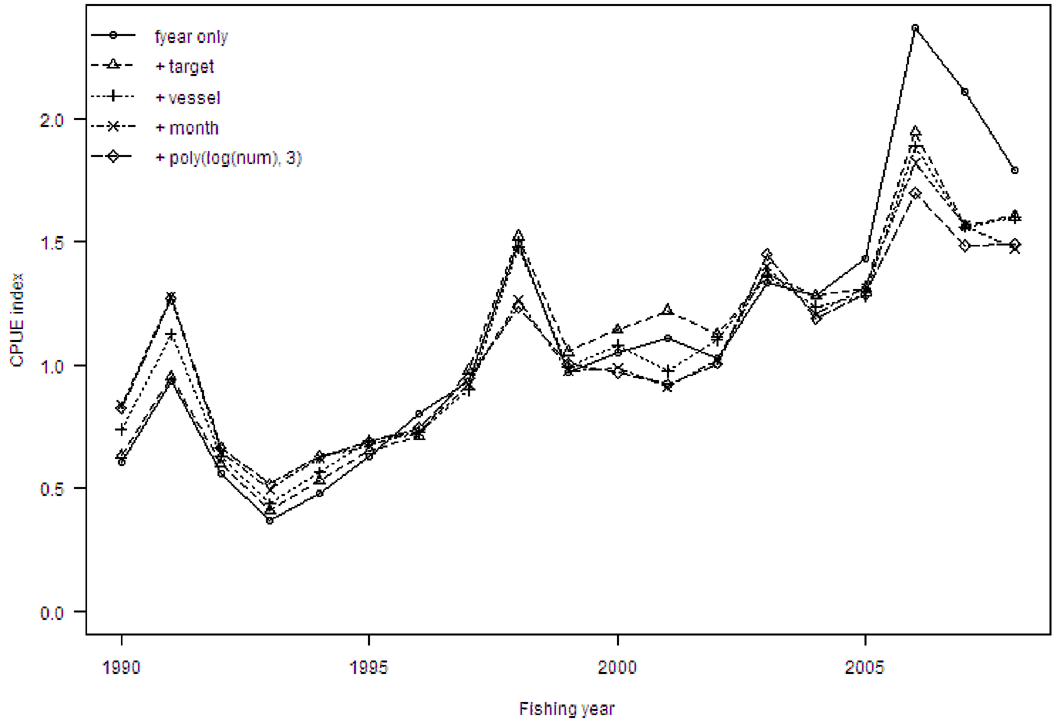

Figure B.5: Annual indices from the lognormal model of BT (MIX) at each step in the variable selection process.

Table B.2: Order of acceptance of variables into the lognormal model of successful catches of ELE 5 and the logistic model of catches (successful or unsuccessful) for core vessels based on the vessel selection criteria of at least 3 trips in 3 or more fishing years) in the SN (SHK) fishery, with the amount of explained deviance (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	Deviance	AIC	R^2	Final	Influence magnitude	Influence trend
Lognormal Model							
none	0	2 046	2 825	0.0000		-	-
fyear	19	1 976	2 836	0.0341	*	-	-
target	22	1 796	2 772	0.1223	*	0.216	0.031
poly(log(netlength) 3)	25	1 576	2 683	0.2297	*	0.213	0.001
vessel	42	1 490	2 676	0.2719	*	0.183	-0.037
area	43	1 470	2 668	0.2816		-	-
Binomial model							
none	0	2 804	2 806	0.0000			
fyear	19	2 681	2 719	0.0440	*		
vessel	36	2 406	2 478	0.1418	*		
target	39	2 317	2 395	0.1738	*		
area	40	2 306	2 386	0.1778			
month	45	2 289	2 379	0.1839			
poly(log(netlength) 3)	48	2 281	2 377	0.1866			

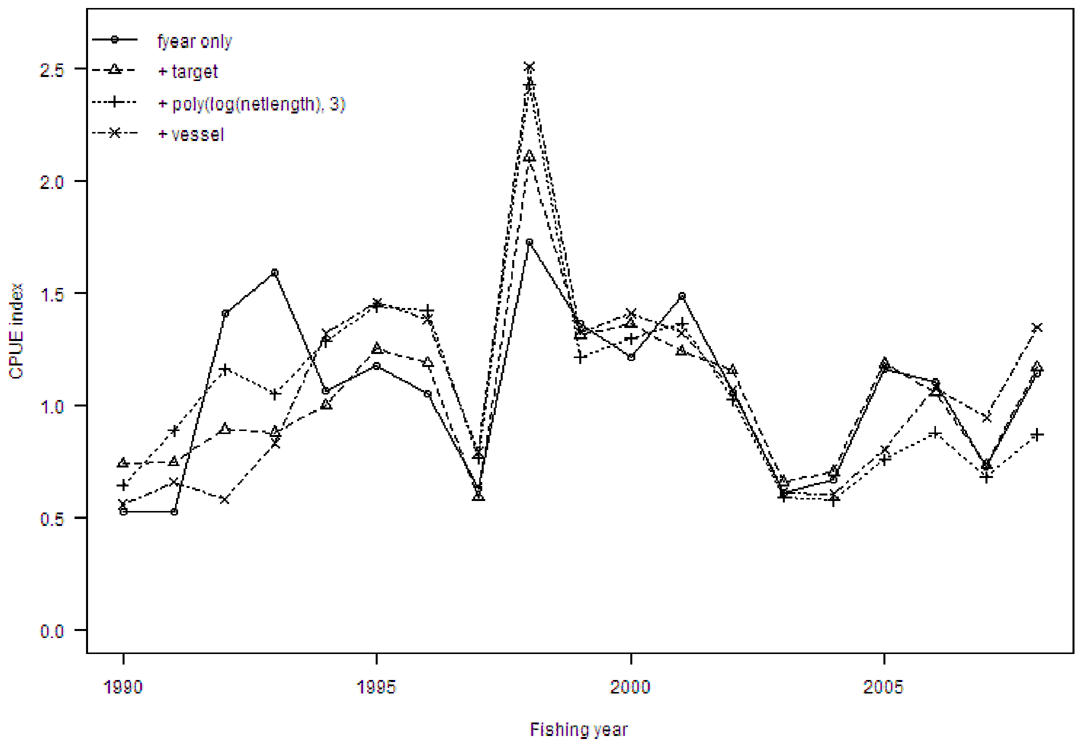

Figure B.6: Annual indices from the lognormal model of SN (SHK) at each step in the variable selection process.

B.4.3 TRENDS IN MODEL YEAR EFFECTS

B.4.3.1 BT (MIX) Mixed target bottom trawl fishery

The standardised indices for the BT (MIX) lognormal model increase steadily from their lowest point in 1992–93 to levels that currently are around three times the 1992–93 level. The effect of standardisation is to smooth the series considerably, removing entirely the peaks seen in the unstandardised series in the late 1990s and early 2000s and dropping the points since then with the overall effect of lowering the observed increase (Figure B.7). Previous series were not based on exactly the same fishery definition (previously Area 030 only) but are compared here because Area 030 makes up the largest part of the dataset used for ELE 5 BT.

The binomial model indices resemble the lognormal closely and also suggest an increase of a similar magnitude. Because of the high number of zero catches in this fishery and the strong declining trend in the proportion of zero catches, this series has lot of influence, and, when combined with the lognormal indices, it emphasises the apparent recovery in the most recent few years (Figure B.8).

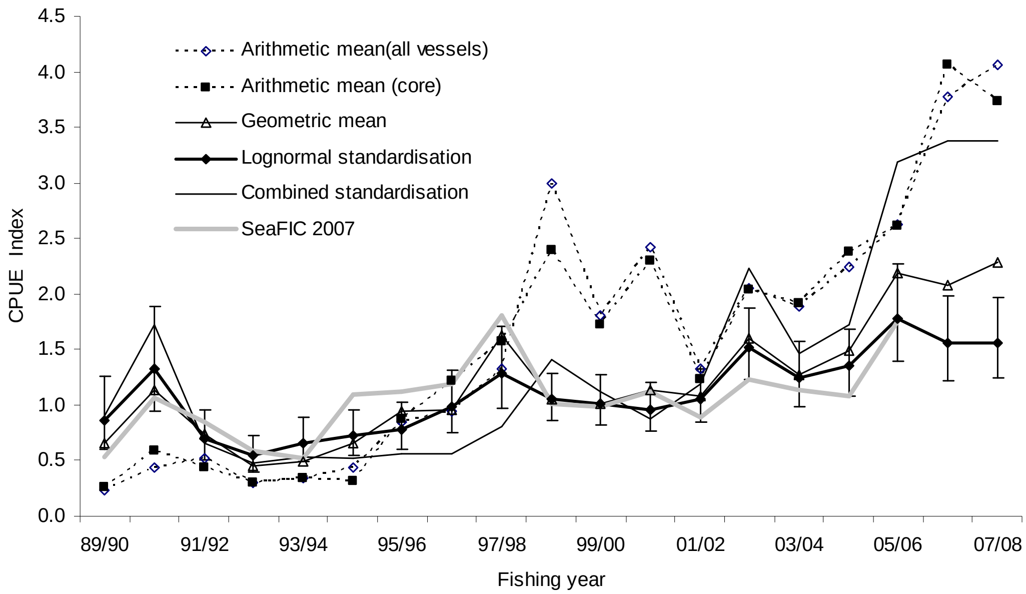

Figure B.7: The effect of standardisation on the raw CPUE of ELE 5 in successful trips by core vessels in the BT (MIX) fishery. Broken line is the raw CPUE (kg / tow), the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2007 for this fishery. All series are relative to the geometric mean over the years in common.

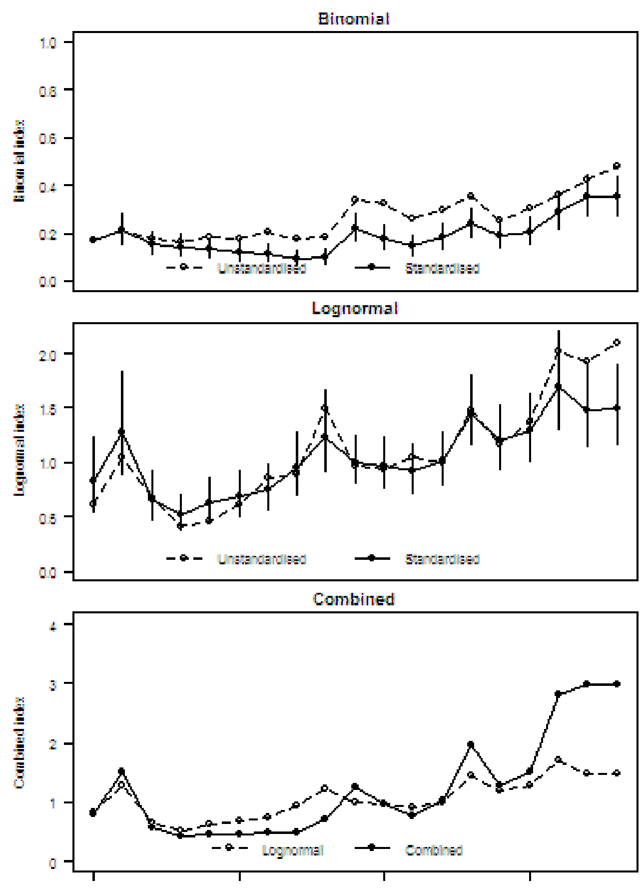

Figure B.8: The effect of standardisation on the raw CPUE of ELE 5 by core vessels in the BT (MIX) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch., broken line is the raw CPUE (kg / km), the solid line is the standardised CPUE canonical indices with ± 2 * SE error bars. Bottom: The effect on the lognormal index of combining it with the Binomial index.

B.4.4 BT (MIX) AREA 25

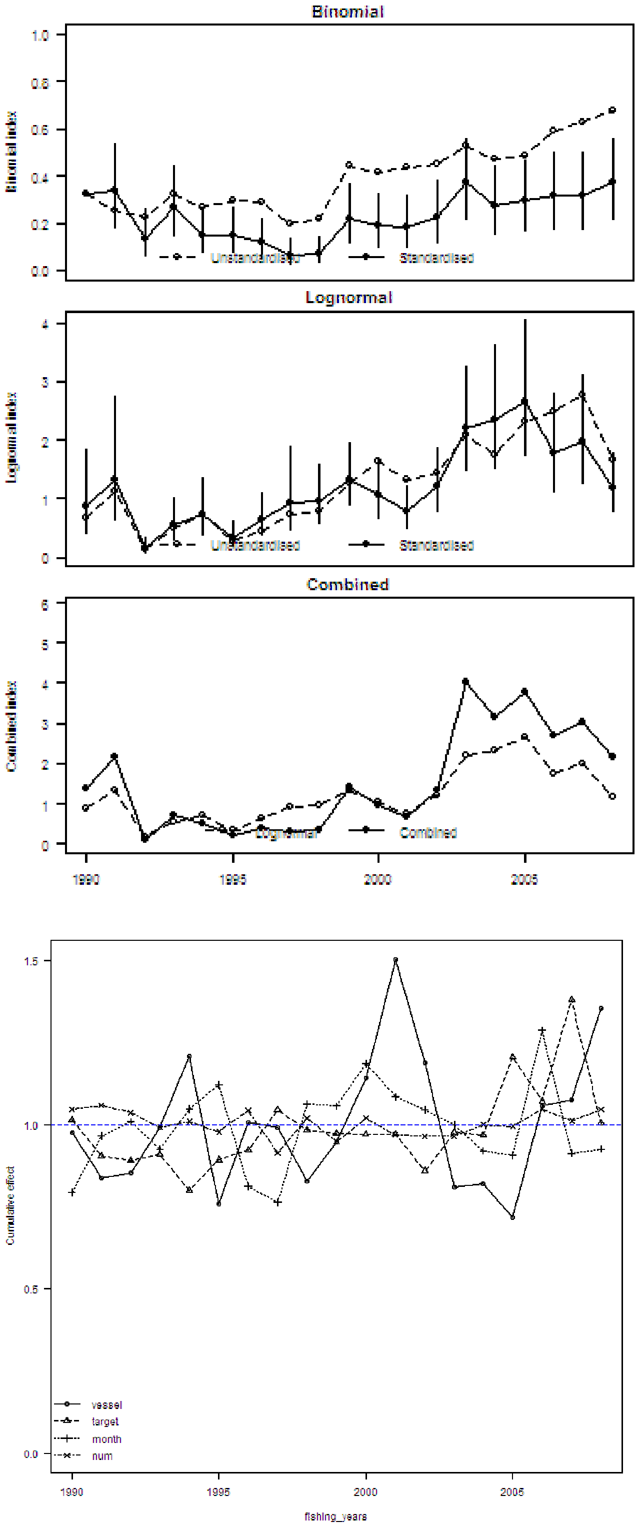

Figure B.9. [upper panel]: Comparison of indices for the bottom trawl mixed species fishery in area 025 only [lower panel]: Influence by significant explanatory variable on the estimated catch rates in the lognormal model of BT (MIX) 25.

BT (MIX) AREA 30

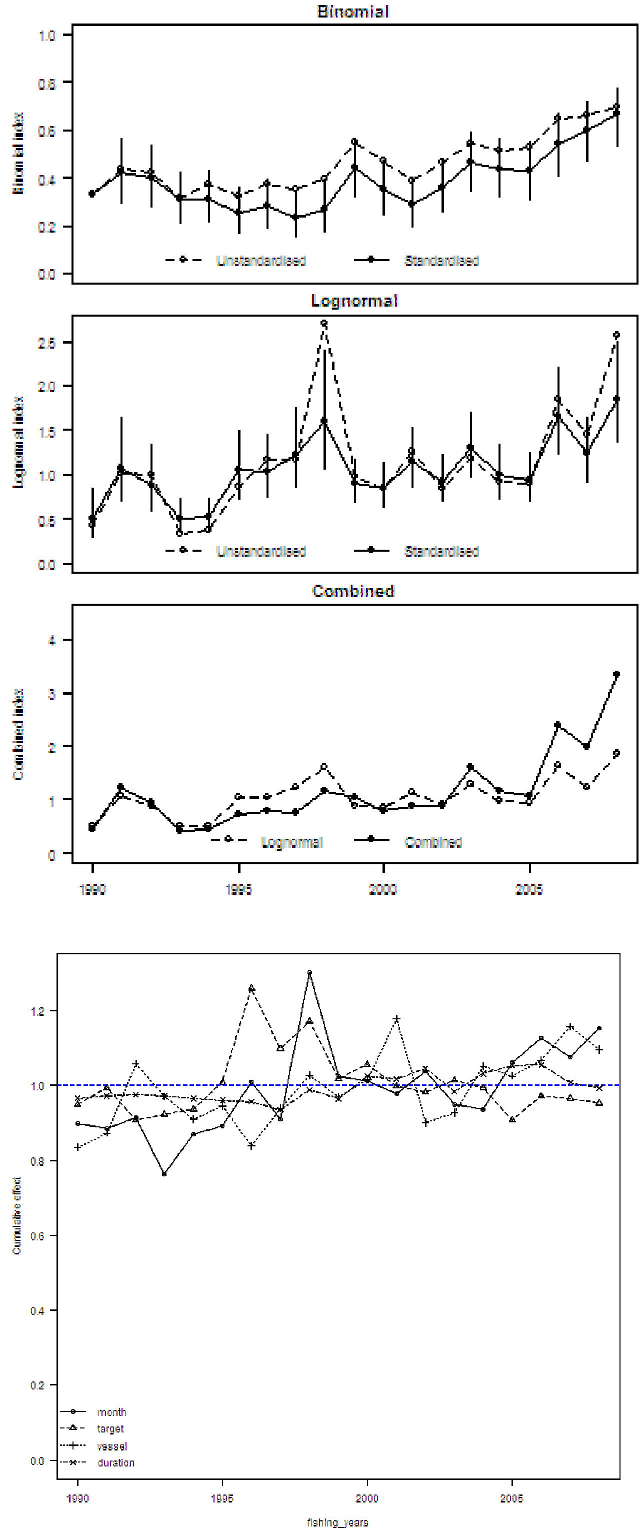

Figure B.10: [upper panel]: Comparison of indices for the bottom trawl mixed species fishery in area 030 only [lower panel]: Influence by significant explanatory variable on the estimated catch rates in the lognormal model of BT (MIX) 30

B.4.4.1 Trends for BT (MIX) Area 025 and BT (MIX) Area 025 models

Standardised CPUE analyses were done for Areas 025 and 030 separately, but are not reported in detail. This was done to provide continuity with the analyses performed in 2007 as well as serving as sensitivities for the main BT(MIX) model. Final indices for lognormal, binomial and combined Area 025 models are shown in Figure B.9 [upper panel] and for Area 030 in Figure B.10 [upper panel]. Influence plots for the Area 025 lognormal model explanatory variables are found in Figure B.9 [lower panel] and similar plot for the Area 030 lognormal model are found in Figure B.10 [lower panel]. The lognormal model for Area 030 is very similar to that for BT (MIX) and the lognormal model for Area 025 is also similar, except that it declines in recent years. The Area 025 model is characterised by wide error bars, caused by the scarcity of data in this model. The binomial models fitted to the same in Areas 025 and 030 series resemble the lognormal models, suggesting an increasing probability of capture of elephantfish in recent years.

B.4.5 SN (SHK) SHARK SET NET FISHERY

The standardised lognormal indices for SN (SHK) are flat overall with wide error bars. The effect of standardisation was considerable in some years without appreciably smoothing the interannual variation noticeably and lifting the points in the last three years (Figure B.11). There is good agreement with a previous series from a similar model. The binomial series has a strong signal of a peak in availability in 1995-96, and when combined with the lognormal series it results in a pronounced peak in that year. It also serves to raise the points in the most recent years (Figure B.12).

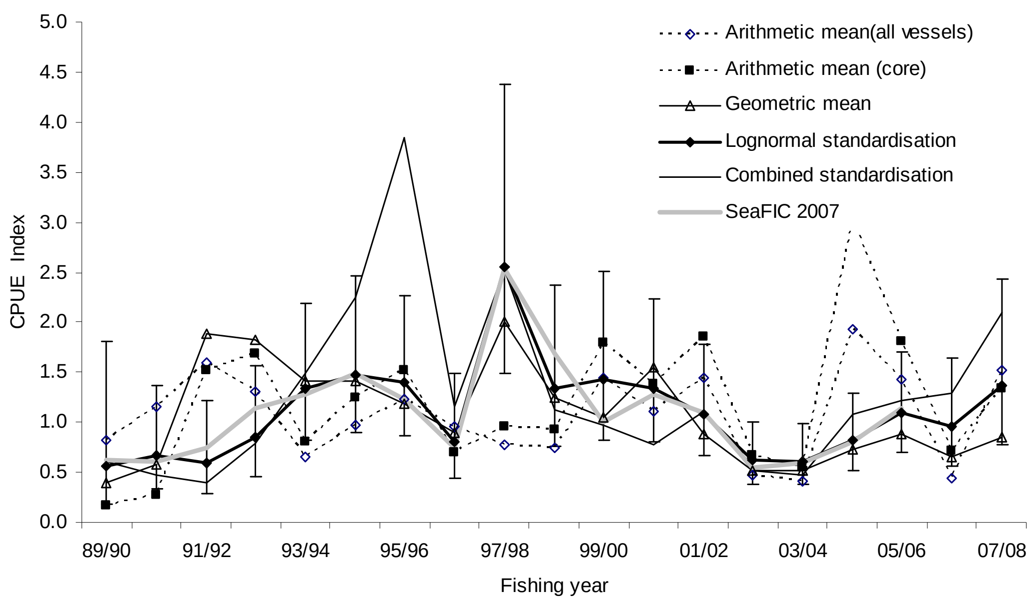

Figure B.11: The effect of standardisation on the raw CPUE of ELE 5 in successful trips by core vessels in the SN (SHK) fishery. Broken line is the raw CPUE (kg / km), the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with ± 2 * SE error bars. Grey line is the previous lognormal series presented in 2007 for this fishery. All series are relative to the geometric mean over the years in common.

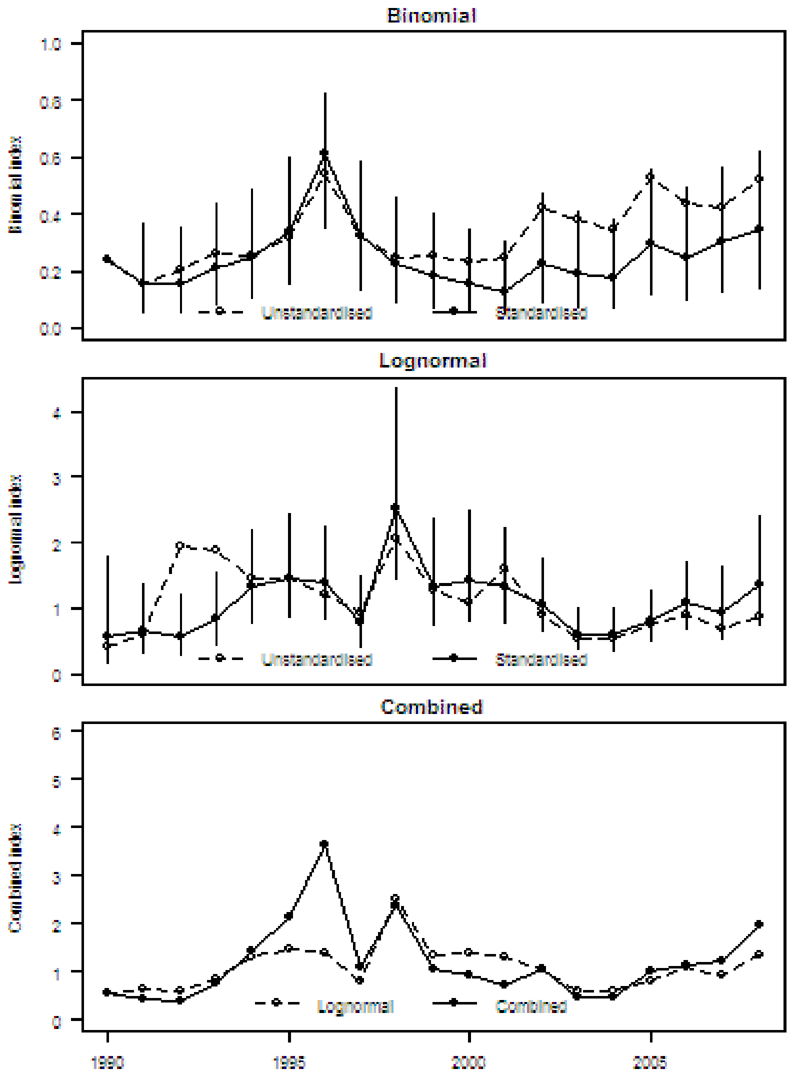

Figure B.12: The effect of standardisation on the raw CPUE of ELE 5 by core vessels in the SN(SHK) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch., broken line is the raw CPUE (kg / km), the solid line is the standardised CPUE canonical indices with $\pm 2 * SE$ error bars. Bottom: The effect on the Lognormal index of combining it with the Binomial index.

Appendix C. DETAILED DIAGNOSTICS FOR ELE 5 CPUE STANDARDISATIONS

C.1 CORE VESSEL SELECTION

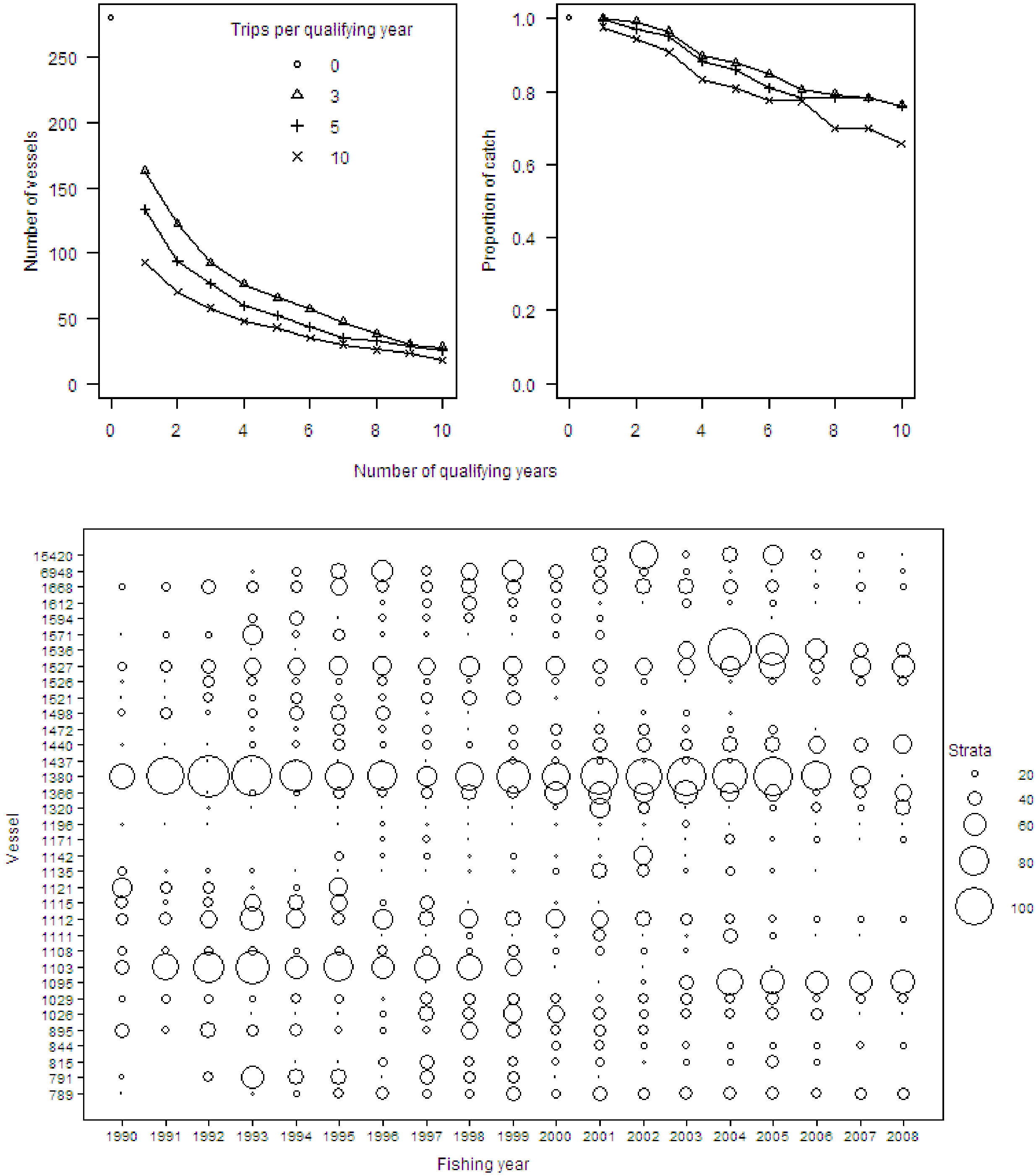

Figure C.1: The total landed ELE 5 [top left] and the number of vessels [top right] retained in the BT (MIX) dataset depending on the minimum number of qualifying years used to define core vessels. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. The participation of selected core vessels (based on at least 10 trips in 6 or more fishing years)); number of records for each vessel in each fishing year [bottom].

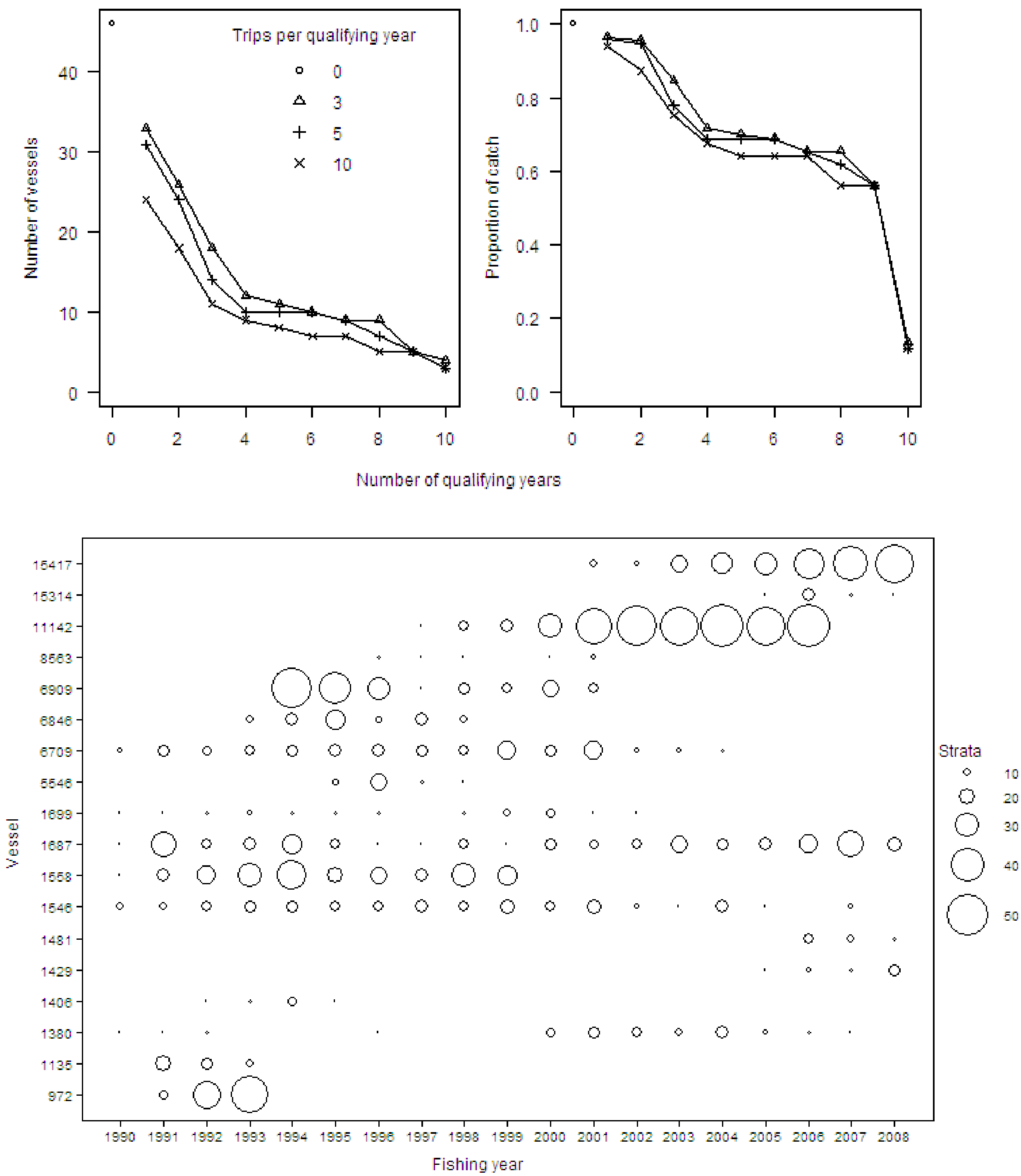

Figure C.2: The total landed ELE 5 [top left] and the number of vessels [top right] retained in the SN (SHK) dataset depending on the minimum number of qualifying years used to define core vessels. The number of qualifying years (minimum number of trips per year) for each series is indicated in the legend. The participation of selected core vessels (based on at least 3 trips in 3 or more fishing years)); number of records for each vessel in each fishing year [bottom].

C.2 DATA SUMMARIES

Table C.1: Number of trips, proportion of records in those trips that did not land ELE 5, number of core vessels, and number of tows, landed ELE 5 (t), and simple catch rate for core vessels (based on a minimum of 10 trips per year in at least 6 years in the combined fishery) for BT (MIX) , by fishing year.

Fishing year	Trips	% zero strata	Vessels	Number of tows	Catch (t)	CPUE kg / tow
89/90	454	83	19	2 087	9	4
90/91	438	79	17	1 916	17	9
91/92	597	82	21	2 626	19	7
92/93	739	84	26	3 766	15	4
93/94	711	82	27	3 716	17	4
94/95	771	83	28	4 472	22	5
95/96	688	80	30	4 380	44	10
96/97	767	83	31	4 961	44	9
97/98	752	82	29	4 424	63	14
98/99	796	66	27	5 233	87	17
99/00	712	68	29	4 871	70	14
00/01	835	74	31	5 905	88	15
01/02	765	71	28	4 876	57	12
02/03	691	65	27	4 544	79	17
03/04	804	75	25	4 536	72	16
04/05	768	70	24	4 426	89	20
05/06	532	64	23	3 236	81	25
06/07	472	58	20	3 134	88	28
07/08	421	52	18	2 586	83	32

Table C.2: Number of trips, proportion of records in those trips that did not land ELE 5, number of core vessels, and number of tows, landed ELE 5 (t), and simple catch rate for core vessels (based on a minimum of 3 trips per year in at least 3 years) in the SN (SHK) fishery, by fishing year.

Fishing year	Trips	% zero strata	Vessels	Length of net (m)	Catch (t)	CPUE kg / km
89/90	25	76	6	73 900	0	3
90/91	103	84	8	320 430	1	2
91/92	124	79	9	306 500	6	20
92/93	147	74	9	406 020	7	16
93/94	166	75	8	483 060	4	9
94/95	132	68	9	433 830	9	20
95/96	116	46	10	371 920	7	19
96/97	71	68	9	209 250	2	8
97/98	115	76	10	317 070	5	14
98/99	103	75	7	324 150	5	14
99/00	117	77	8	343 830	8	23
00/01	132	75	9	352 550	10	28
01/02	95	58	7	304 350	13	44
02/03	103	62	6	392 700	4	9
03/04	125	66	6	425 500	5	12
04/05	99	47	7	441 720	16	35
05/06	144	56	7	536 811	19	36
06/07	98	58	7	309 406	3	11
07/08	80	48	5	358 620	8	23

C.3 RESIDUAL PLOTS

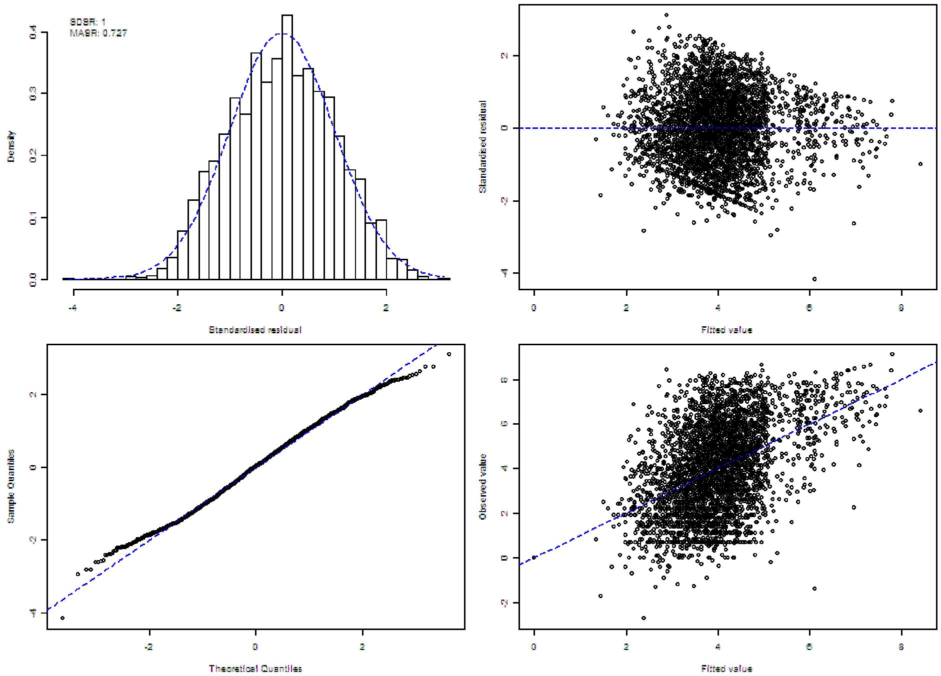

Figure C.3: Plots of the fit of the standardised CPUE model to successful catches of ELE 5 in the BT (MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

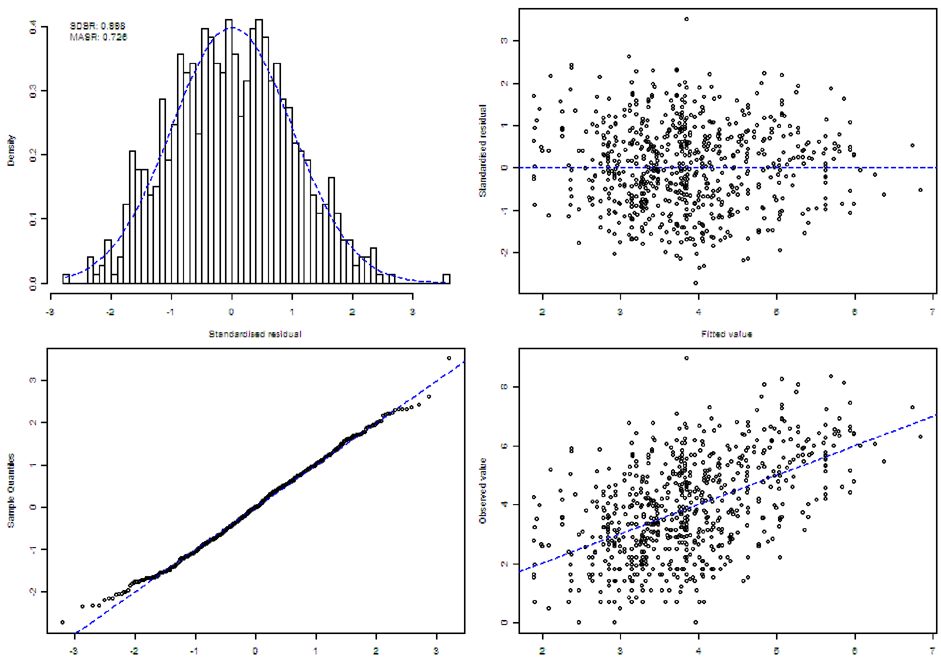

Figure C.4: Plots of the fit of the standardised CPUE model to successful catches of ELE 5 in the SN (SHK) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Q-Q plot of the standardised residuals; [Lower left] Standardised residuals plotted against the predicted model catch per trip; [Lower right] Observed catch per record plotted against the predicted catch per record.

C.4 MODEL COEFFICIENTS

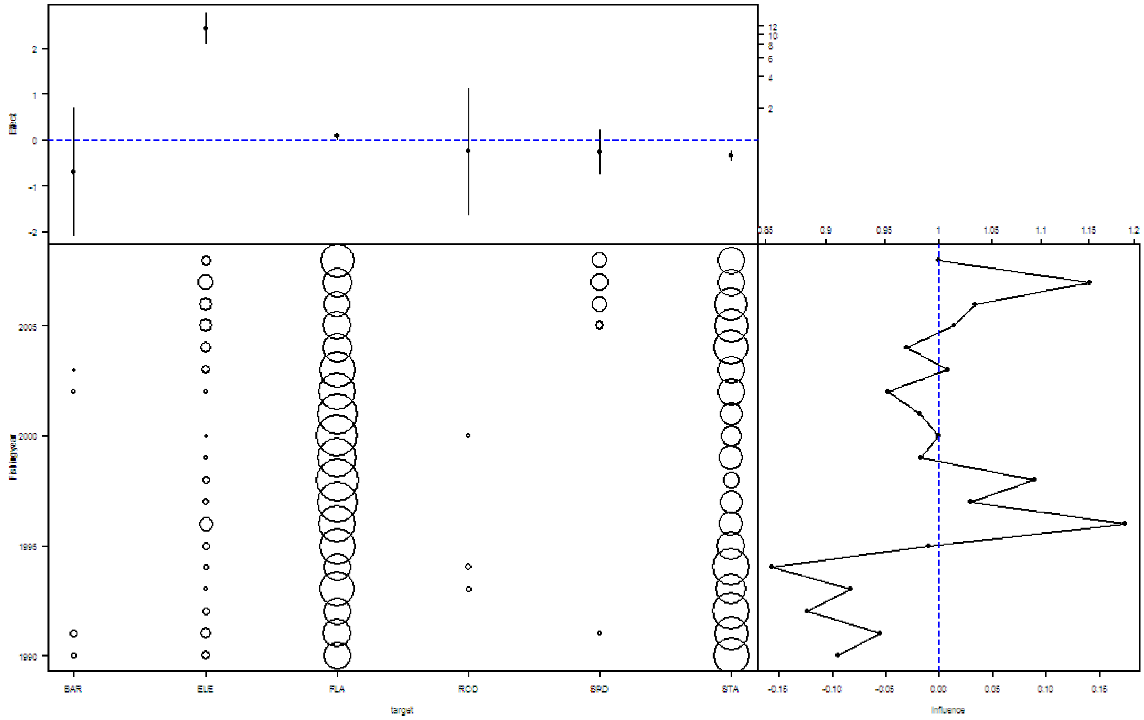

Figure C.5: Effect of target in the lognormal model for the ELE5 BT(MIX) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

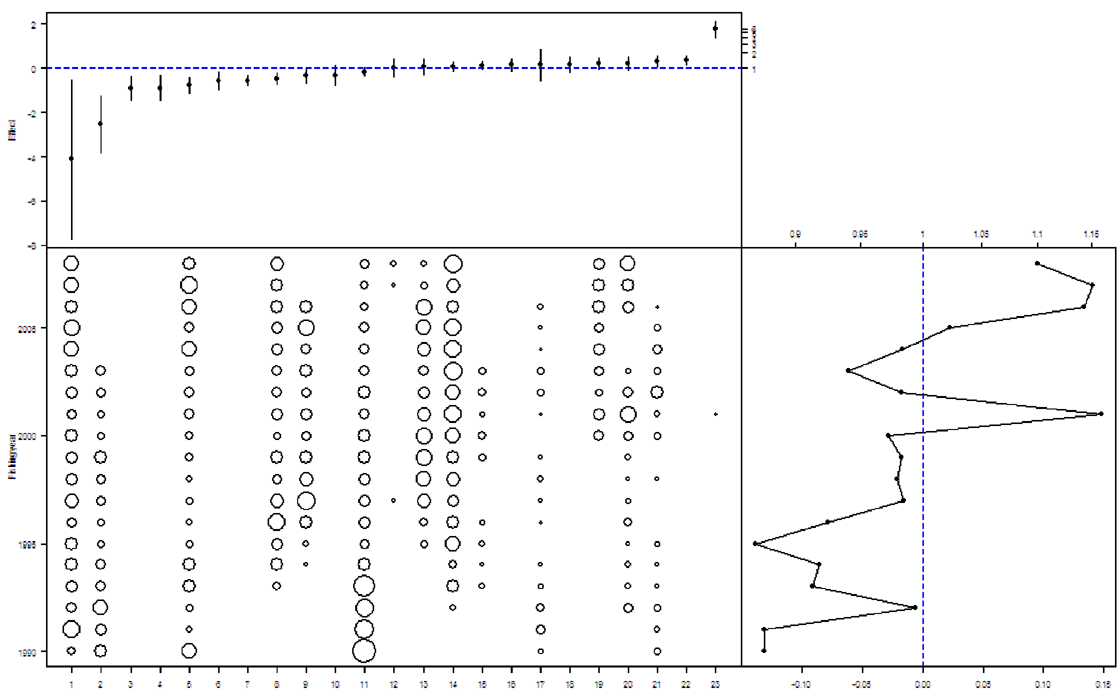

Figure C.6: Effect of vessel in the lognormal model for the ELE5 BT(MIX) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing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

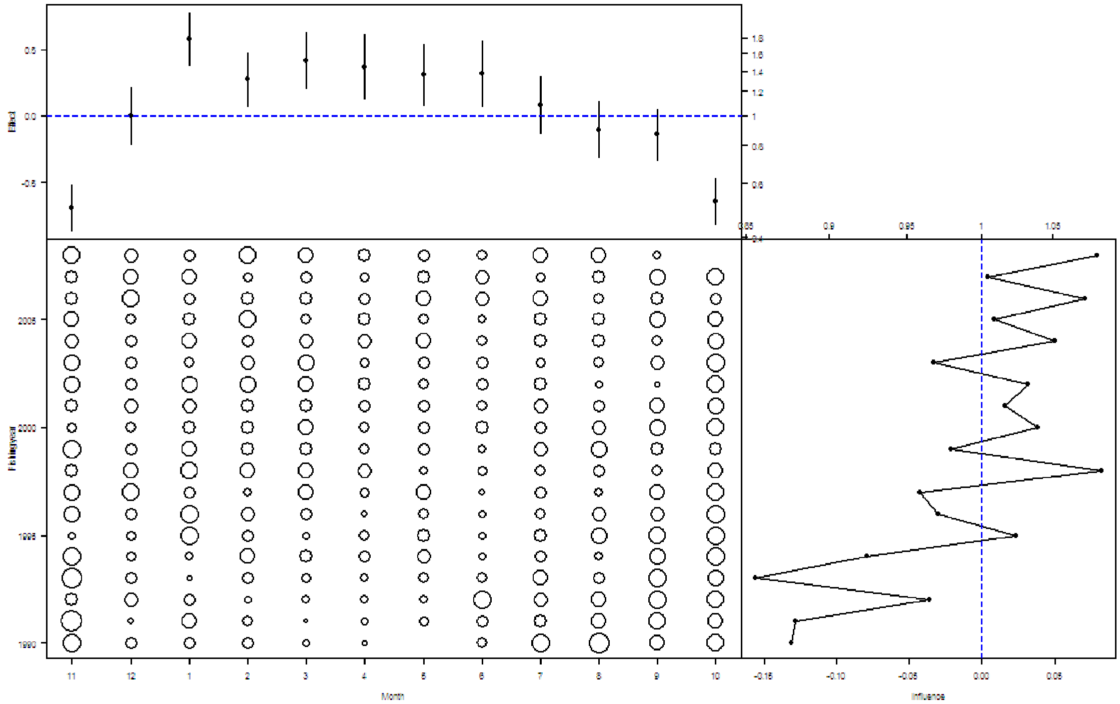

Figure C.7: Effect of month in the lognormal model for the ELE5 BT(MIX) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year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

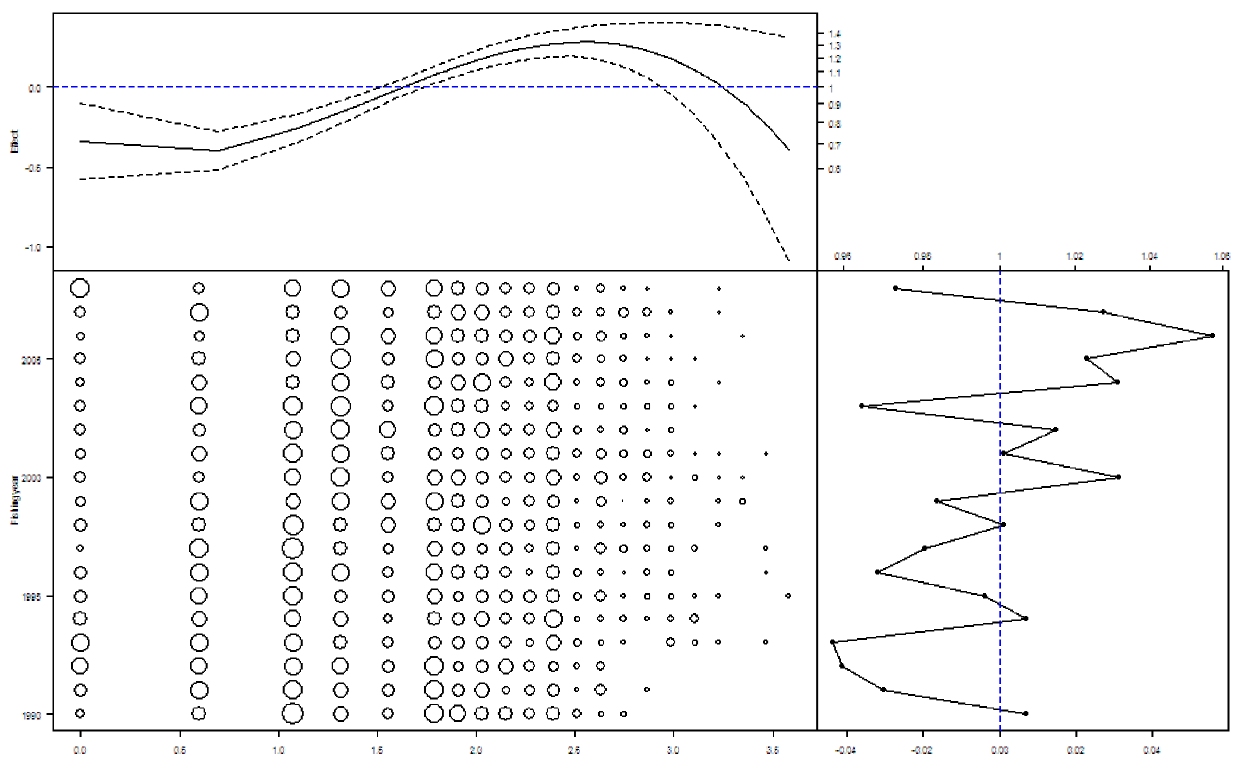

Figure C.8: Effect of log(number tows) in the lognormal model for the ELE5 BT(MIX) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by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

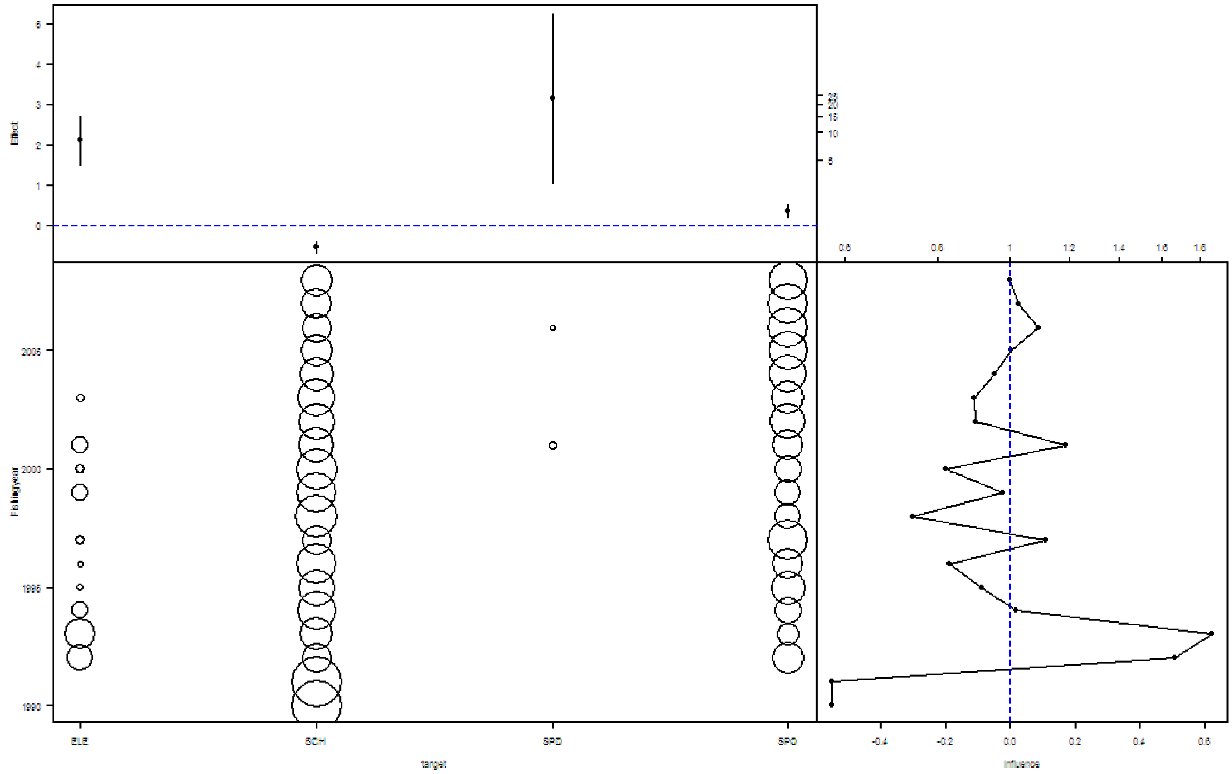

Figure C.9: Effect of target in the lognormal model for the ELE5 SN(SHK) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

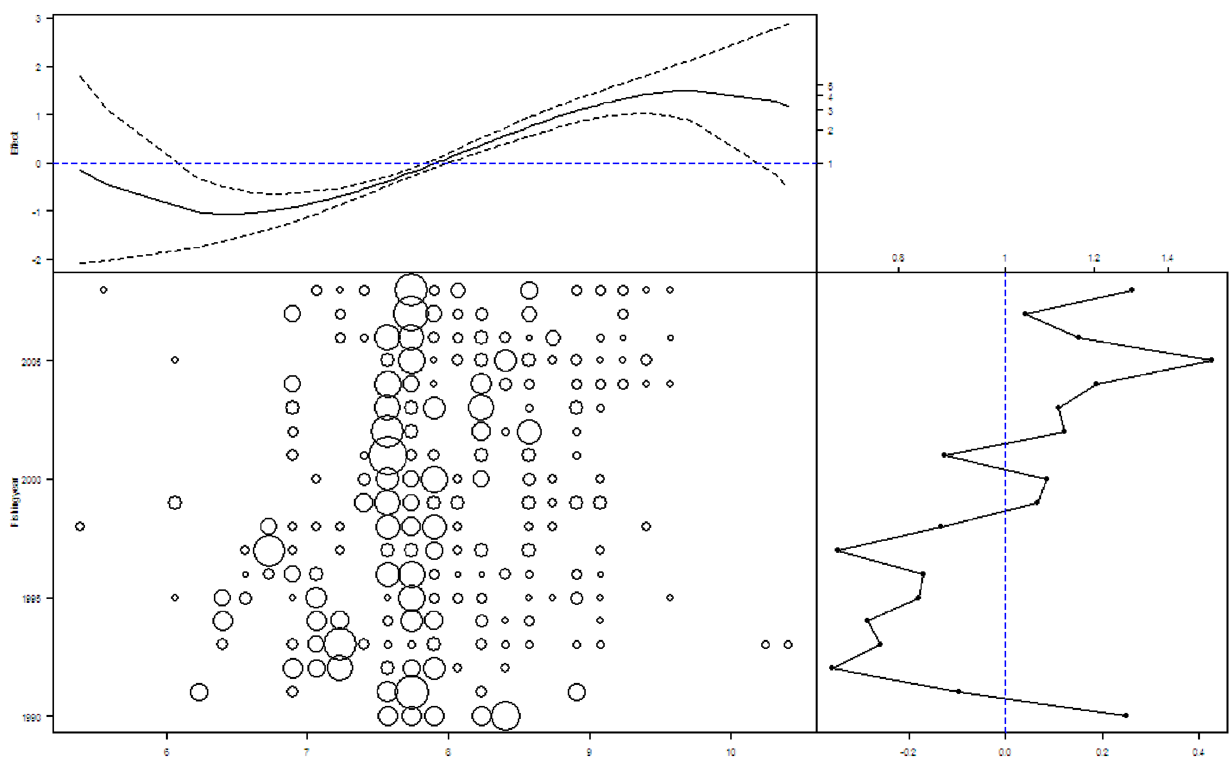

Figure C.10: Effect of log(netlength) in the lognormal model for the ELE5 SN(SHK) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

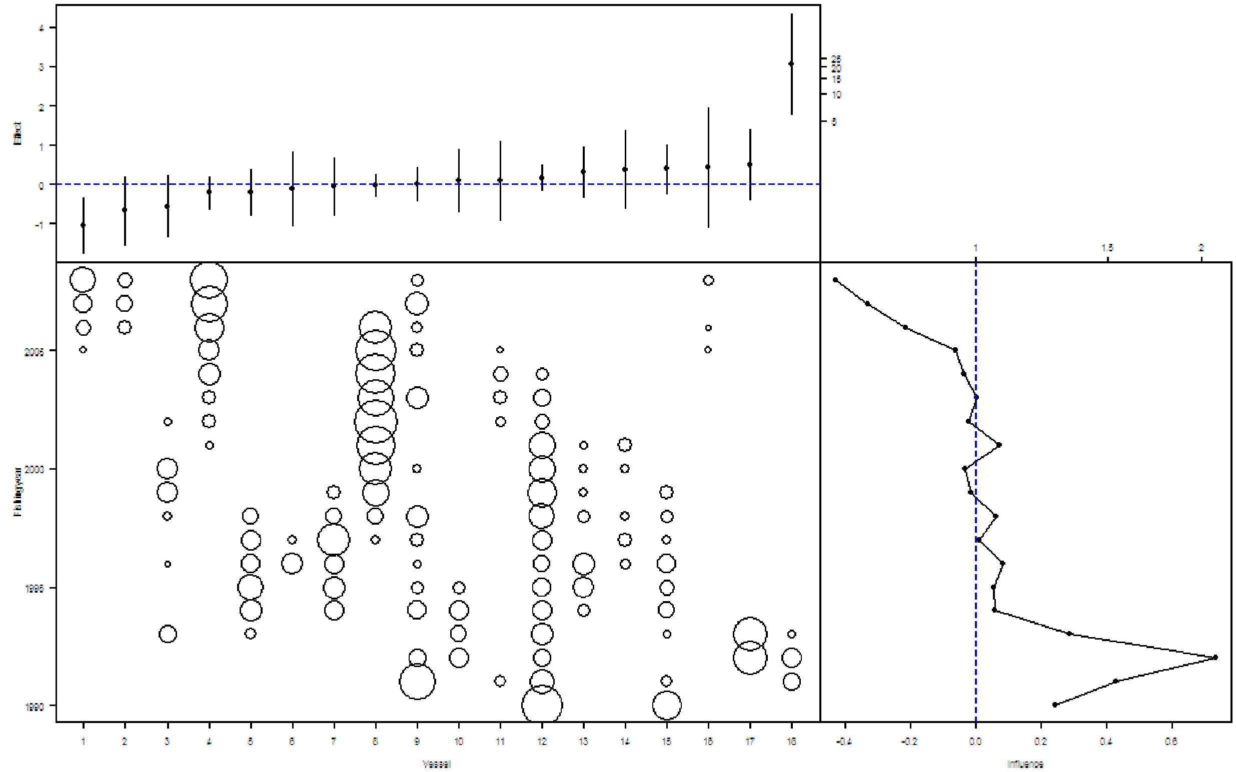

Figure C.11: Effect of vessel in the lognormal model for the ELE5 SN(SHK) fishery.Top: effect by level of variable (left-axis: log space, additive; right-axis: natural space, multiplicative). Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year (bottom-axis: log space additive; top-axis: natural space multiplicative).

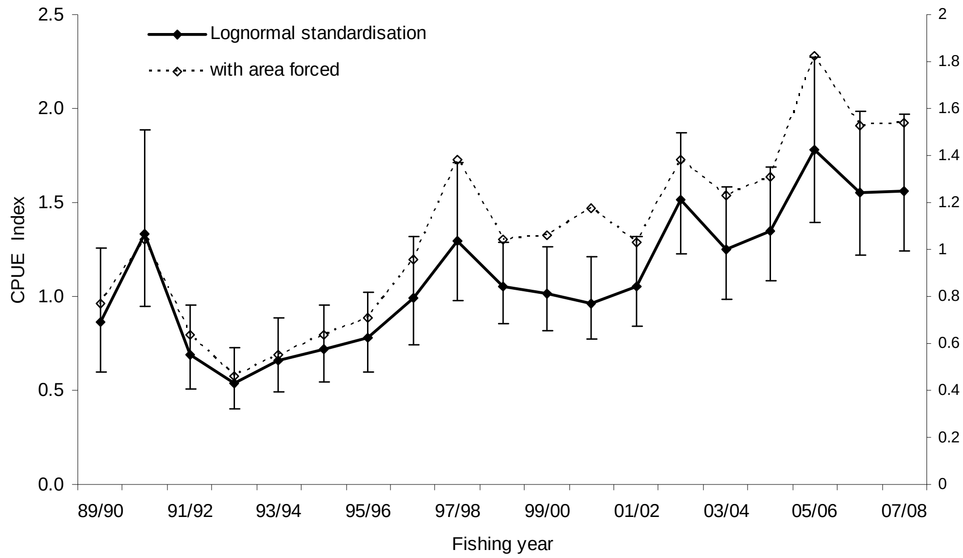

Figure C.12: Effect of forcing area into an alternative lognormal model of the BT (MIX) fishery by not offering vessel.

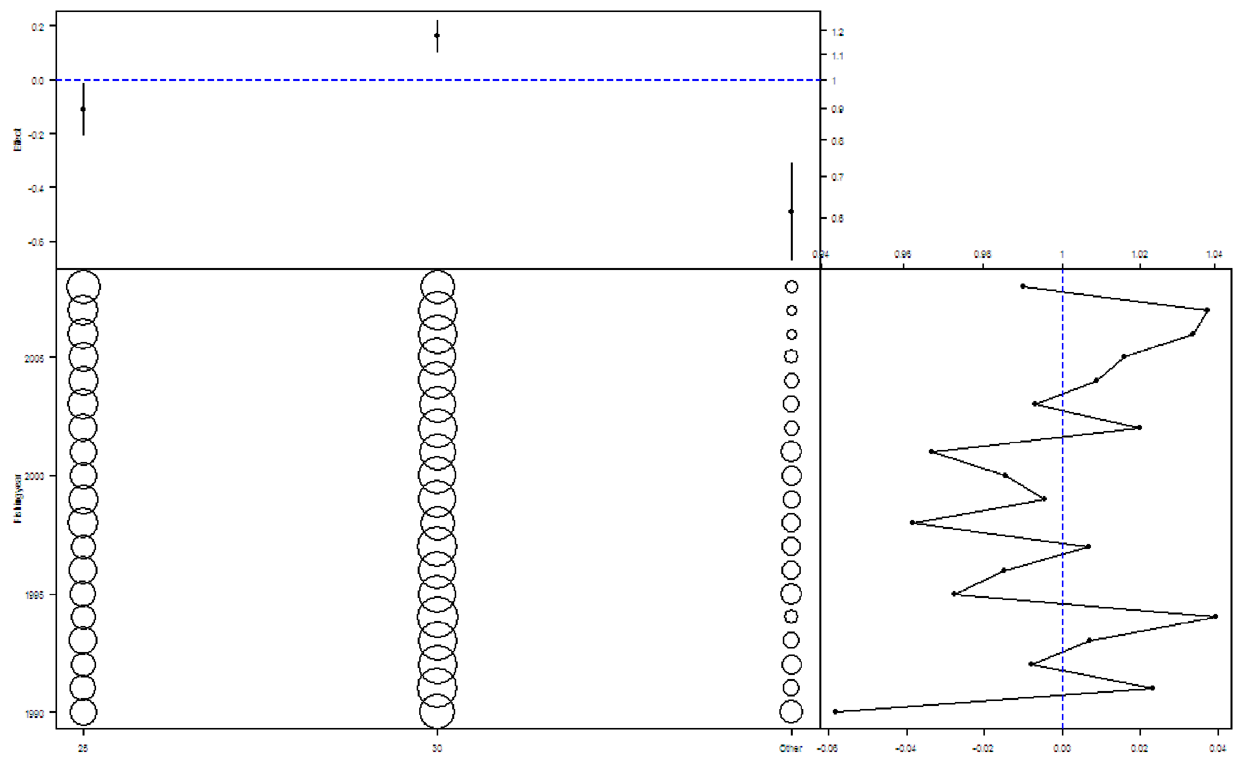

Figure C.13: Effect of area when forced into an alternative lognormal model of the ELE5 BT(MIX) fishery.

C.5 CPUE INDICES

Table C.3: Relative year effects and 95% confidence intervals (in parentheses) for the models fitted to the ELE 5 BT(MIX) model

Fishing year	Arithmetic mean (all vessels)	Arithmetic mean (core vessels)	Geometric mean	Lognormal standardisation	Binomial standardisation	Combined standardisation
1990	0.201	0.222	0.605	0.824 (0.556-1.222)	0.169	0.797 (0.537-1.183)
1991	0.384	0.512	1.051	1.271 (0.885-1.825)	0.209 (0.151-0.282)	1.518 (1.057-2.179)
1992	0.445	0.376	0.675	0.661 (0.473-0.924)	0.152 (0.110-0.206)	0.573 (0.410-0.800)
1993	0.264	0.257	0.411	0.516 (0.378-0.703)	0.144 (0.105-0.194)	0.423 (0.310-0.577)
1994	0.293	0.296	0.453	0.628 (0.460-0.858)	0.132 (0.096-0.179)	0.474 (0.347-0.648)
1995	0.379	0.275	0.609	0.687 (0.510-0.924)	0.117 (0.085-0.158)	0.458 (0.341-0.617)
1996	0.730	0.764	0.864	0.744 (0.561-0.987)	0.115 (0.084-0.155)	0.488 (0.368-0.647)
1997	0.819	1.057	0.887	0.945 (0.701-1.274)	0.092 (0.067-0.126)	0.497 (0.369-0.670)
1998	1.151	1.359	1.495	1.233 (0.919-1.656)	0.100 (0.073-0.137)	0.705 (0.525-0.946)
1999	2.593	2.074	0.973	1.003 (0.810-1.243)	0.217 (0.165-0.279)	1.241 (1.001-1.537)
2000	1.561	1.495	0.929	0.970 (0.770-1.221)	0.177 (0.133-0.232)	0.982 (0.780-1.237)
2001	2.099	1.986	1.044	0.920 (0.726-1.166)	0.146 (0.109-0.193)	0.765 (0.604-0.970)
2002	1.151	1.067	0.991	1.006 (0.796-1.272)	0.181 (0.136-0.237)	1.041 (0.823-1.316)
2003	1.774	1.762	1.476	1.448 (1.161-1.805)	0.237 (0.181-0.304)	1.957 (1.569-2.440)
2004	1.635	1.657	1.168	1.191 (0.931-1.523)	0.190 (0.142-0.249)	1.289 (1.008-1.649)
2005	1.948	2.058	1.372	1.287 (1.019-1.625)	0.206 (0.156-0.268)	1.515 (1.200-1.913)
2006	2.272	2.264	2.015	1.698 (1.313-2.195)	0.289 (0.220-0.371)	2.803 (2.168-3.625)
2007	3.269	3.520	1.916	1.483 (1.149-1.914)	0.351 (0.271-0.440)	2.969 (2.300-3.832)
2008	3.522	3.239	2.101	1.489 (1.169-1.896)	0.350 (0.272-0.437)	2.975 (2.336-3.788)

Table C.4: Relative year effects and 95% confidence intervals (in parentheses) for the models fitted to the ELE 5 SN(SHK) fishery.

Fishing year	Arithmetic mean (all vessels)	Arithmetic mean (core vessels)	Geometric mean	Lognormal standardisation	Binomial standardisation	Combined standardisation
1990	0.833	0.167	0.402	0.556 (0.172-1.795)	0.240	0.575 (0.178-1.856)
1991	1.186	0.269	0.601	0.657 (0.318-1.355)	0.157 (0.057-0.363)	0.443 (0.215-0.914)
1992	1.624	1.527	1.941	0.582 (0.282-1.201)	0.152 (0.056-0.351)	0.380 (0.184-0.784)
1993	1.342	1.697	1.881	0.832 (0.446-1.553)	0.210 (0.083-0.436)	0.751 (0.402-1.402)
1994	0.660	0.804	1.451	1.317 (0.797-2.177)	0.249 (0.104-0.486)	1.410 (0.853-2.330)
1995	0.992	1.244	1.465	1.459 (0.873-2.438)	0.340 (0.153-0.596)	2.136 (1.278-3.571)
1996	1.250	1.524	1.216	1.384 (0.852-2.249)	0.613 (0.354-0.821)	3.653 (2.249-5.936)
1997	0.978	0.700	0.925	0.791 (0.422-1.482)	0.322 (0.137-0.587)	1.095 (0.584-2.053)
1998	0.784	0.955	2.070	2.511 (1.452-4.343)	0.222 (0.089-0.454)	2.401 (1.388-4.153)
1999	0.754	0.928	1.285	1.326 (0.747-2.355)	0.186 (0.072-0.402)	1.061 (0.598-1.884)
2000	1.472	1.794	1.076	1.409 (0.800-2.482)	0.151 (0.057-0.344)	0.918 (0.521-1.617)
2001	1.139	1.388	1.603	1.323 (0.790-2.215)	0.129 (0.048-0.301)	0.735 (0.439-1.230)
2002	1.479	1.858	0.913	1.070 (0.647-1.768)	0.228 (0.090-0.467)	1.048 (0.634-1.732)
2003	0.475	0.668	0.533	0.610 (0.376-0.991)	0.186 (0.071-0.405)	0.490 (0.302-0.795)
2004	0.416	0.552	0.532	0.602 (0.368-0.984)	0.174 (0.067-0.382)	0.451 (0.276-0.738)
2005	1.976	3.018	0.748	0.803 (0.505-1.277)	0.295 (0.123-0.557)	1.021 (0.642-1.624)
2006	1.456	1.819	0.904	1.079 (0.691-1.684)	0.249 (0.101-0.493)	1.155 (0.740-1.803)
2007	0.449	0.722	0.676	0.944 (0.546-1.634)	0.301 (0.125-0.565)	1.225 (0.708-2.119)
2008	1.552	1.342	0.874	1.348 (0.752-2.414)	0.343 (0.143-0.619)	1.989 (1.110-3.563)