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# ELE 3&5 Fishery Characterisation and CPUE

New Zealand Fisheries Assessment Report 2013/38

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# EXECUTIVE SUMMARY

**Starr, P.J.; Kendrick, T.H. (2013). ELE 3 & 5 Fishery Characterisation and CPUE.**

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The fisheries taking elephantfish (*Callorhinchus milii*) from 1989–90 to 2010–11 on the east and south coasts of the New Zealand South Island are described, based on compulsory reported commercial catch and effort data held by the Ministry for Primary Industries (MPI, formerly the Ministry of Fisheries). A number of bottom trawl fisheries take elephantfish on the east coast of the South Island (ELE 3), including (in order of total catch over 22 fishing years) the target red cod fishery, the target elephantfish fishery, and the target flatfish fishery. In Foveaux Strait (ELE 5) the primary bottom trawl fisheries taking elephantfish are the target flatfish and stargazer fisheries. A target bottom trawl fishery for elephantfish is of minor importance in ELE 5. Setnet fisheries targeted at rig and elephantfish take elephantfish in ELE 3, while setnet fisheries take relatively few elephantfish in ELE 5. Detailed characteristics of the landing data, as well as the spatial, temporal, target species and depth distributions relative to the catch of elephantfish in these fisheries are presented for ELE 3 and ELE 5. Annual performance of the ELE 3 and ELE 5 catches and regulatory information are also presented.

Commercial Catch Per Unit Effort (CPUE) analyses, based on the compulsory reported commercial catch and effort data from the major bottom trawl fisheries, are used to estimate changes in abundance for this species in these two QMAs. These estimated abundance trends inform MPI on the need for potential management action in ELE 3 or ELE 5.

Research trawl information for elephantfish off the east coast of the South Island is presented for 14 surveys, covering the period 1992 to 2009. Two trawl surveys series were implemented in this period: one in the winter months of May and June and the other in the summer (December/January). The first six surveys (1992–1996) took place in the winter. This survey was replaced by a summer survey that was repeated five times between 1996–97 and 2000–01, but which was discontinued because of concerns that it was too variable to provide reliable time series of biomass estimates. The winter survey was reinstated in 2007 and was repeated twice in 2008 and 2009. A fourth winter survey was conducted in May–June 2012, after the data for this report were compiled.

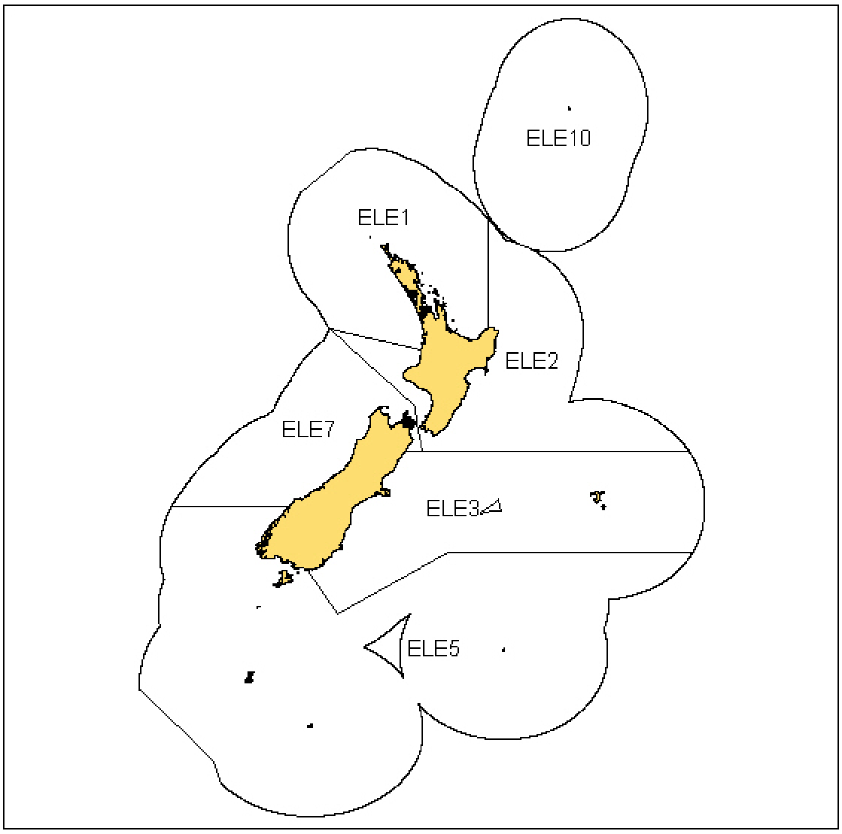


**Figure 1: Map of the New Zealand EEZ showing the elephantfish Quota Management Areas (QMAs).**

## 1. INTRODUCTION

ELE 3 and ELE 5 were brought into the Quota Management System (QMS) at its inception in 1986, with ELE 3 contributing between 75 and 86% of the total NZ-EEZ landings of elephantfish between 1989–90 and 2010–11 and ELE 5 contributing between 6 and 15% in the same period. In terms of total landings, these two QMAs are the largest and second largest of the five ELE FMAs. Together, these two QMAs also account for a large fraction of the aerial extent of the New Zealand EEZ, with ELE 3 occupying most of the east coast of the South Island (apart from Cloudy Bay and the eastern entrance to Cook Strait) and the Chatham Islands, while ELE 5 includes Foveaux Strait, Stewart Island and Fiordland on the south and western parts of the South Island (Figure 1).

The TACC for ELE 3 was increased 15% in 1995–96 under the conditions of the Adaptive Management Programme (AMP). ELE 5 was brought into the AMP in 2001–02 with an increase of 40% to 100 t. There have been three additional increases to the ELE 3 TACC: by 65% in 2000–01 to 825 t, by another 15% in 2002–03 to 950 t and by 5% in 2009–10 to 1 000 t. Similarly there have been two further increases in the ELE 5 TACC: by 20% in 2004–05 to 120 t and by 17% in 2009–10 to 140 t. The text table below summarises these changes to the TACCs for these two Fishstocks.

| Fishstock | Year TACC changed | TACC prior to change | AMP or new TACC | % increase |
|---|---|---|---|---|
| ELE 3 | 1995–96 | 424 | 500 | 18.0% |
| ELE 3 | 2000–01 | 500 | 825 | 65.0% |
| ELE 3 | 2002–03 | 825 | 950 | 15.2% |
| ELE 3 | 2009–10 | 950 | 1 000 | 5.3% |
| ELE 5 | 2001–02 | 71 | 100 | 40.3% |
| ELE 5 | 2004–05 | 100 | 120 | 20.0% |
| ELE 5 | 2009–10 | 120 | 140 | 16.7% |

The ELE 3 and ELE 5 AMP programmes are no longer active, having been discontinued by the Ministry of Fisheries in 2009–10. Both TACCs were increased in 2009–10 and have since remained unchanged. The Southeast Finfish Management Company has retained its previous commitment to monitor this Fishstock using periodic CPUE standardisations.

This report summarises fishery and landings characterisations for ELE 3 and ELE 5, as well as presenting CPUE standardisations derived from trawl data originating from ELE 3 and ELE 5 which are used to estimate changes in relative abundance in these QMAs. Abbreviations and definitions of terms used in this report are presented in Appendix A.

## 2. INFORMATION ABOUT THE STOCK/FISHERY

### 2.1 Biology (from Ministry of Fisheries 2011)

Elephantfish (*Callorhinchus milii*) are relatively rare in the North Island, mainly occurring south of East Cape on the east coast of the North Island and south of Kaipara River on the west coast. They are most plentiful around the east coast of the South Island. Males mature at a length of 50 cm fork length (FL), corresponding to an age of 3 years and females mature 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. The estimated *M* value of 0.35 is based on unvalidated ageing work indicating a maximum age of 13 years.

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, adults are thought 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.

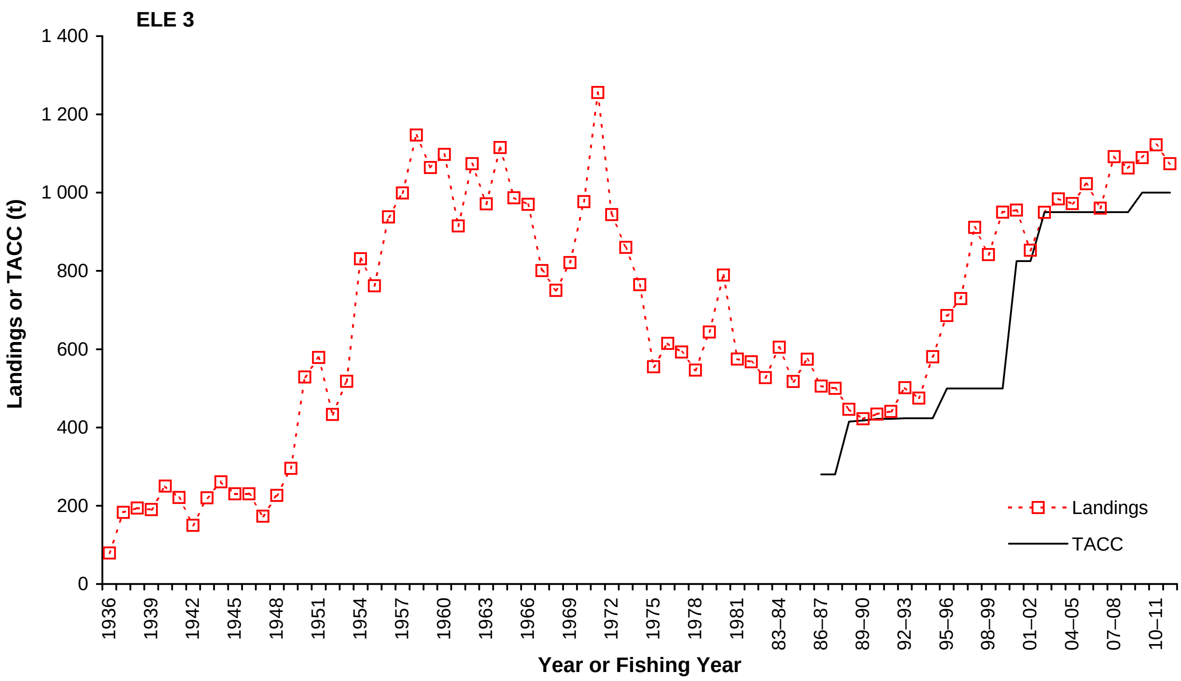


**Figure 2: Annual catch for the ELE 3 fishery for the period 1936 to 1983 by calendar year and then by fishing year from 1983–84 to 2010–11. TACCs are presented from 1986–87 to 2011–12. Historical catches from 1936 to 1982 from Colman et al. (1985). Recent data sources in Table 1.**

## 2.2 Catches

### 2.2.1 Commercial catches

From the 1950s to the 1980s, total NZ landings of elephantfish at or above 1 000 t per year 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. When elephantfish were brought into the QMS in 1986–87, the TACCs were set to levels below historical catch because of a general feeling that elasmobranch fishing mortalities were too high (K. Sullivan, *pers comm.*). As a result, landings in both ELE 3 and ELE 5 dropped to levels below previous average catch levels by the end of the 1980s and into the early part of the 1990s (Table 1).

ELE 3 landings have met or exceeded the TACC since this Fishstock entered the QMS in 1986–87, in spite of five increases in TACC over that period (Figure 3; Table 1). The same observation can be made for ELE 5 after 1995–96 (Figure 3; Table 1). In general, landings of elephantfish in all NZ QMAs have increased markedly since the mid-1990s, and total NZ landings of elephantfish have exceeded 1 000 t per year since 1997–98.

**Table 1: Total landings (t) and TACCs (t) for elephantfish in ELE 2, ELE 3, ELE 5 and ELE 7 from 1986–87 to 2011–12. Landings and TACCs from 1986–87 to 2000–01 are from Quota Management Returns (QMR). Landings from 2001–02 to 2011–12 are from Monthly Harvest Returns (MHR). '–': TACC not set.**

| 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 |
| 2008–09 | 21 | 22 | 1 063 | 950 | 208 | 120 | 91 | 102 | 1 384 | 1 204 |
| 2009–10 | 21 | 22 | 1 089 | 1 000 | 176 | 140 | 86 | 102 | 1 372 | 1 274 |
| 2010–11 | 14 | 22 | 1 122 | 1 000 | 154 | 140 | 93 | 102 | 1 383 | 1 274 |
| 2011–12 | 16 | 22 | 1 074 | 1 000 | 157 | 140 | 130 | 102 | 1 377 | 1 274 |

[1] includes small (<10 t in 22 years) amounts of landings from QMA 1 (Auckland)
[2] includes 10 t TACC for QMA 1 (Auckland). Does not include QMA 10 (Kermadecs)

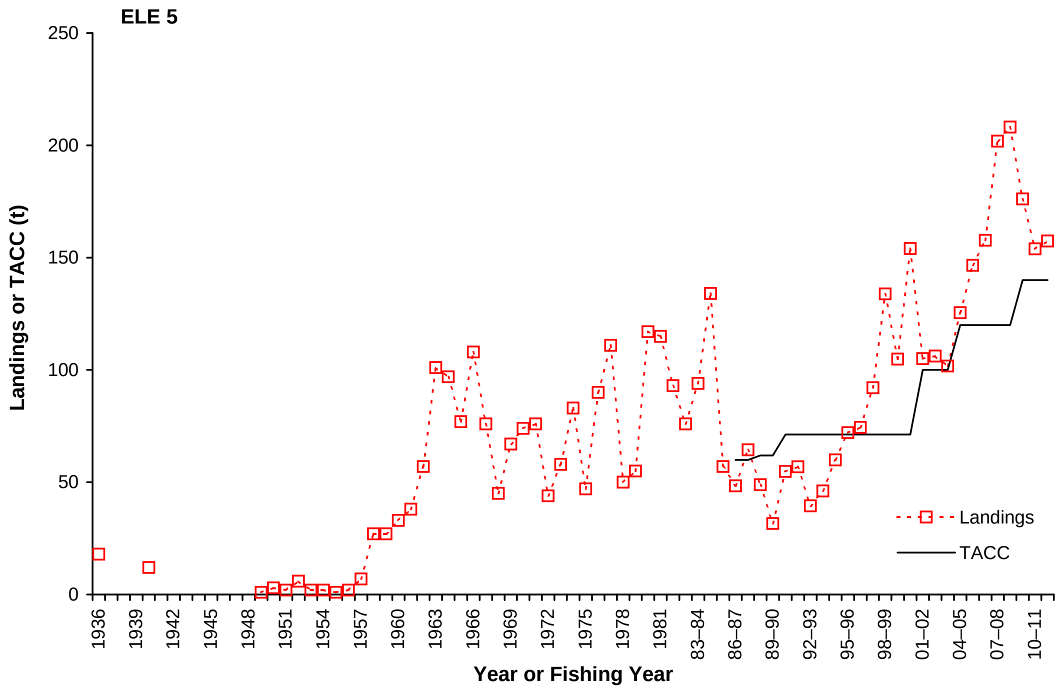


**Figure 3: Annual catch for the ELE 5 fishery for the period 1936 to 1983 by calendar year, and then by fishing year from 1983–84 to 2010–11. TACCs are presented from 1986–87 to 2011–12. Historical catches from 1936 to 1982 from Colman et al. (1985). Recent data sources in Table 1.**

**Table 2: Estimated catch of ELE 3 by recreational fisheries based on diary surveys conducted in the indicated years. Data for the South Regional Survey (1991–92) from Tierney et al. (1997); 1996 survey results from Bradford (1998); 2000 and 2001 survey results from Boyd & Reilly (2005).**

| QMA/FMA | Number | c.v. (%) | Point est. (t) | Range (t) | No. diarists | Mean Weight |
|---|---|---|---|---|---|---|
| South Region Survey (1 Sept 1991 to 30 Nov 1992) | | | | | | |
| ELE 5 | no estimate | – | – | – | – | – |
| ELE 5 | no estimate | – | – | – | – | – |
| 1996 Nationwide survey | | | | | | |
| ELE 5 | no estimate | – | – | – | – | – |
| ELE 5 | no estimate | – | – | – | – | – |
| 2000 Nationwide survey | | | | | | |
| ELE 3 | no estimate | – | – | – | – | – |
| ELE 5 | no estimate | – | – | – | – | – |
| 2001 “Roll-over” nationwide survey | | | | | | |
| ELE 3 | 1 000 | 49 | 0.0 | – | 3 | no estimate |
| ELE 5 | no estimate | – | – | – | – | – |

## 2.2.2 Recreational catches

Recreational catches in New Zealand are poorly known, an observation which applies to all inshore finfish FMAs, including ELE 3 and ELE 5. A series of regional and national surveys, which combined phone interviews with randomly selected diarists, have been conducted since the early 1990s (Tierney et al. 1997, Bradford 1998, Boyd & Reilly 2005; see Table 2), but the results from these surveys are not considered to be reliable by many of the Fishery Assessment Working Groups. In particular, the Recreational Technical Working Group (RTWG) concluded that the framework used for the telephone interviews for the 1996 and previous surveys contained a methodological error, resulting in biased eligibility figures. Consequently the harvest estimates derived from these surveys are unreliable. This group also indicated concerns with some of the harvest estimates from the 2000–01 survey. The following summarises that group's views on the telephone /diary estimates:

> The RTWG recommends that the harvest estimates from the diary surveys should be used only with the following qualifications: a) they may be very inaccurate; b) the 1996 and earlier surveys contain a methodological error; and, c) the 2000 and 2001 harvest estimates are implausibly high for many important fisheries. (quoted from the chapter on kahawai, Ministry of Fisheries 2011)

There is a single estimate of 1 000 elephantfish taken in 2000–01 by recreational catch for ELE 3, with a very high c.v. (49%) (Table 2). This estimate was not converted to an estimated weight because there were no observations of mean catch weight. The remaining three surveys do not report a recreational catch estimate for ELE 3 and none of the surveys report a catch estimate for ELE 5.

**Table 3: Annual and interim deemed values for ELE 3 and ELE 5 by fishing year from 2001–02 (source: Ray Voller, Ministry of Fisheries, *pers. comm.* and Mark Geytenbeek, MPI, *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: $100*\left(\sum \text{landings}_y / \sum \text{ACE}_y\right)$ |
|---|---|---|---|---|---|
| | | | | | ELE 3 |
| 2001–02 | 852 | 825 | $1.53 | $0.77 | 120% |
| 2002–03 | 950 | 950 | $2.41 | $1.21 | 120% |
| 2003–04 | 984 | 950 | $2.41 | $1.21 | 120% |
| 2004–05 | 972 | 950 | $2.41 | $1.21 | 120% |
| 2005–06 | 1 023 | 950 | $1.41 | $1.21 | suspended |
| 2006–07 | 960 | 950 | $1.41 | $1.21 | suspended |
| 2007–08 | 1 092 | 950 | $1.41 | $1.21 | suspended |
| 2008–09 | 1 063 | 950 | $1.41 | $1.21 | suspended |
| 2009–10 | 1 089 | 1 000 | $1.41 | $1.21 | 130% |
| 2010–11 | 1 122 | 1 000 | $1.41 | $1.21 | 130% |
| 2011–12 | – | 1 000 | $1.65 | $1.40 | 120% |
| | | | | | ELE 5 |
| 2001–02 | 105 | 100 | $1.57 | $0.79 | 120% |
| 2002–03 | 106 | 100 | $1.57 | $0.79 | 120% |
| 2003–04 | 102 | 100 | $1.57 | $0.79 | 120% |
| 2004–05 | 125 | 120 | $1.57 | $0.79 | 120% |
| 2005–06 | 147 | 120 | $0.99 | $0.79 | suspended |
| 2006–07 | 158 | 120 | $0.99 | $0.79 | suspended |
| 2007–08 | 202 | 120 | $0.99 | $0.79 | suspended |
| 2008–09 | 208 | 120 | $0.99 | $0.79 | suspended |
| 2009–10 | 176 | 140 | $1.30 | $1.10 | 130% |
| 2010–11 | 154 | 140 | $1.30 | $1.10 | 130% |
| 2011–12 | – | 140 | $1.65 | $1.40 | 120% |

[1] applied at end of year to landings not covered by ACE but less than lower limit shown in final column
[2] applied when landing in excess of ACE but refunded if ACE is subsequently provided
[3] penalties usually increase about 20% for every 20% landings exceed ACE after the initial threshold

## 2.3 Regulations affecting the fishery

### 2.3.1 Deemed values

There have been only minor changes in the elephantfish conversion factors over the period of available data (see Section 2.4.2). However, the control of overcatch in ELE 3 and ELE 5 have been a vexing issue since the mid-1990s (Raj & Voller 1999). Deemed values, the penalty applied to landing quota species when the fisher has insufficient ACE (Annual Catch Entitlement) to balance the landings, have been used as the main deterrent to control overcatch. However, if these penalties are set too high, there is the potential for dumping at sea and consequent loss of catch information. Deemed values are generally set by Ministry for Primary Industries "*above ACE price and below landed (port) price*" (Scott Walker, Ministry for Primary Industries, *pers. comm.*). Deemed values were reduced for ELE 3 and 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 3). The TACCs for both stocks were reviewed for 2009–10 based on the performance of the fishery since the change in reporting requirements and the TACC was increased. The deemed value regime was also reviewed at this time and a modified excess penalty schedule was reinstated. The deemed value was increased for the 2011–12 fishing year for both stocks in response to changes in the port price (Table 3).

### 2.3.2 Closures for the protection of Hector's dolphins

#### 2.3.2.1 Regulatory closures

The Banks Peninsula Marine Mammal Sanctuary, created in 1988 by legislation, stretches from Sumner Head in the north, around Banks Peninsula to the southern bank of the Rakaia River, including all area to seaward from the shore for four nautical miles. The sanctuary excludes lagoons and Lake Ellesmere. Setnetting is prohibited in the Sanctuary from 1 November to the last day of February in the following year.

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

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

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

#### 2.3.2.2 Voluntary closures

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

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

## 2.4 Analysis of ELE 3 & 5 Catch and Effort Data

### 2.4.1 Methods used for 2012 analysis of MPI catch and effort data

Data extracts were obtained from the Ministry of Fisheries (now Ministry for Primary Industries) Warehou database (Ministry of Fisheries 2010). One extract consisted of the complete data (all fishing event information along with all elephantfish landing information) from every trip which recorded landing elephantfish from ELE 3 and ELE 5, starting from 1 October 1989 and extending to 30 September 2011. Two further extracts were obtained, the first consisting of all trips using the method BT that targeted one of RCO, FLA (also: ESO, SFL, LSO, GFL, FLO, YBF, BFL), ELE, BAR, TAR, GUR, WAR, STA, SQU, SPO, SPD (also: NSD, OSD), or SPE, and that fished at least one event in ELE 3 or ELE 5 (see Appendix A for definitions of abbreviations). A second extract consisted of trips which used the method SN (setnet) and targeted one of ELE, SPO, SCH, SPD (also: NSD, OSD), HPB (also: BAS, HAP), MOK, TAR, WAR, or LIN and fished in a statistical area valid for ELE 3 or ELE 5. Once these trips were identified, all fishing event data (including the estimated catch of elephantfish) and associated elephantfish landing data from the entire trip, regardless of method or location of capture, were obtained. These data extracts (Ministry for Primary Industries replog 8403) were received 13 February 2012. The first data extract was used to characterise and understand the fisheries taking elephantfish. These characterisations are reported in Sections 2.4.2 and 2.4.3. The remaining extracts were used to calculate CPUE standardisations for the BT and SN fisheries (Section 3 and Appendix E).

Data were prepared by linking the effort ("fishing event") section of each trip to the landing section, based on unique trip identification numbers supplied in the database. Effort and landing data were groomed to remove "out-of-range" outliers. The method used to groom the landings data are documented in Appendix C. The remaining procedures used to prepare these data are documented in Starr (2007).

The procedure described by Starr (2007) drops trips which fished in ambiguous "straddling" statistical areas (the statistical area boundaries do not coincide with the QMA boundaries–see Appendix B) and which reported more than one elephantfish QMA in the landing data. This expansion can also be done by statistical area without regard to the QMA of landing, resulting in no landing data being dropped but losing the capacity to link captures and effort to a specific QMA. Appendix D lists the total landings by statistical area that are obtained by these two alternative expansion methods, thus documenting the extent of the loss of catch information incurred when trips which fished in straddling statistical areas and landed to multiple QMAs are dropped. The loss for the ELE 3&5 data set was small in terms of overall catch, with 1.4% of total catch lost when the Fishstock expansion method is compared to the "statistical area" expansion method.

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

The annual totals at different stages of the data preparation procedure are presented in Table 4 and Figure 4. Total landings in the data set are similar to the landings in the QMR/MHR system, except for a 10% shortfall in landings in the first year of data (1989–90), which was affected by the changeover to a new system of data reporting. Landings in the subsequent fishing years have varied from –4% to +1% relative to the QMR/MHR annual totals (Table 4). The shortfall between landed and estimated catch by trip has varied from –45% to -3% by fishing year and may be diminishing in recent years (Table 4). A scatter plot of the estimated and landed catch by trip shows that relatively few trips overestimate the landing total for the trip (Figure 5 [left panel]). The distribution of the ratios of the landed relative to estimated catch shows a skewed distribution with many ratios greater than 1.0 and with a mode slightly above 1.0 (Figure 5 [right panel]).

**Table 4: Comparison of ELE 3 and ELE 5 QMR/MHR catch (t), reported by fishing year, with the sum of the ELE 3 and ELE 5 corrected landed catch totals (bottom part of the MPI CELR form), the total catch after matching effort with landing data ('Analysis' data set) and the sum of the estimated catches from the Analysis data set. Data source: MPI replog 8402.**

| Fishing Year | QMR/MHR (t) | Total landed catch (t)[1] | % landed/ QMR/MHR | Total Analysis catch (t) | % Analysis /Landed | Total Estimated Catch (t) | % Estimated /Analysis |
|---|---|---|---|---|---|---|---|
| | | | | | | | ELE 3 |
| 89/90 | 422 | 377 | 90 | 346 | 92 | 215 | 62 |
| 90/91 | 434 | 425 | 98 | 388 | 91 | 232 | 60 |
| 91/92 | 441 | 437 | 99 | 406 | 93 | 270 | 66 |
| 92/93 | 501 | 496 | 99 | 487 | 98 | 341 | 70 |
| 93/94 | 475 | 478 | 101 | 465 | 97 | 353 | 76 |
| 94/95 | 580 | 582 | 100 | 568 | 97 | 414 | 73 |
| 95/96 | 686 | 692 | 101 | 672 | 97 | 503 | 75 |
| 96/97 | 730 | 710 | 97 | 697 | 98 | 566 | 81 |
| 97/98 | 911 | 896 | 98 | 888 | 99 | 664 | 75 |
| 98/99 | 841 | 806 | 96 | 802 | 100 | 676 | 84 |
| 99/00 | 950 | 957 | 101 | 929 | 97 | 792 | 85 |
| 00/01 | 956 | 969 | 101 | 944 | 97 | 838 | 89 |
| 01/02 | 852 | 844 | 99 | 826 | 98 | 737 | 89 |
| 02/03 | 950 | 946 | 100 | 941 | 99 | 838 | 89 |
| 03/04 | 984 | 971 | 99 | 966 | 99 | 899 | 93 |
| 04/05 | 972 | 959 | 99 | 948 | 99 | 894 | 94 |
| 05/06 | 1 023 | 1 021 | 100 | 1 012 | 99 | 927 | 92 |
| 06/07 | 960 | 951 | 99 | 946 | 99 | 870 | 92 |
| 07/08 | 1 092 | 1 077 | 99 | 1 060 | 98 | 1 015 | 96 |
| 08/09 | 1 063 | 1 051 | 99 | 1 027 | 98 | 1 016 | 99 |
| 09/10 | 1 089 | 1 080 | 99 | 1 068 | 99 | 1 040 | 97 |
| 10/11 | 1 122 | 1 114 | 99 | 1 088 | 98 | 1 027 | 94 |
| Total | 18 035 | 17 840 | 99 | 17 475 | 98 | 15 124 | 87 |
| | | | | | | | ELE 5 |
| 89/90 | 32 | 20 | 64 | 19 | 94 | 10 | 52 |
| 90/91 | 55 | 47 | 85 | 46 | 98 | 28 | 60 |
| 91/92 | 57 | 57 | 99 | 51 | 90 | 35 | 69 |
| 92/93 | 39 | 42 | 106 | 39 | 94 | 24 | 62 |
| 93/94 | 46 | 39 | 86 | 32 | 81 | 20 | 62 |
| 94/95 | 60 | 57 | 94 | 44 | 77 | 26 | 59 |
| 95/96 | 72 | 71 | 99 | 68 | 96 | 52 | 75 |
| 96/97 | 74 | 71 | 95 | 70 | 99 | 51 | 72 |
| 97/98 | 92 | 95 | 103 | 91 | 96 | 73 | 80 |
| 98/99 | 134 | 132 | 99 | 130 | 98 | 87 | 67 |
| 99/00 | 105 | 97 | 93 | 92 | 95 | 71 | 77 |
| 00/01 | 154 | 147 | 96 | 127 | 86 | 99 | 78 |
| 01/02 | 105 | 104 | 99 | 103 | 99 | 87 | 85 |
| 02/03 | 106 | 104 | 98 | 103 | 99 | 89 | 87 |
| 03/04 | 102 | 94 | 92 | 91 | 97 | 78 | 86 |
| 04/05 | 125 | 120 | 95 | 119 | 99 | 102 | 86 |
| 05/06 | 147 | 145 | 99 | 139 | 96 | 117 | 85 |
| 06/07 | 158 | 155 | 98 | 149 | 96 | 133 | 89 |
| 07/08 | 202 | 189 | 94 | 182 | 96 | 166 | 91 |
| 08/09 | 208 | 202 | 97 | 194 | 96 | 172 | 89 |
| 09/10 | 176 | 176 | 100 | 171 | 97 | 160 | 93 |
| 10/11 | 154 | 160 | 104 | 145 | 91 | 128 | 88 |
| Total | 2 403 | 2 323 | 97 | 2 203 | 95 | 1 806 | 82 |

[1] includes all landings in replog 8403 except for 21 trips excluded for being "implausibly large" (see Appendix C)

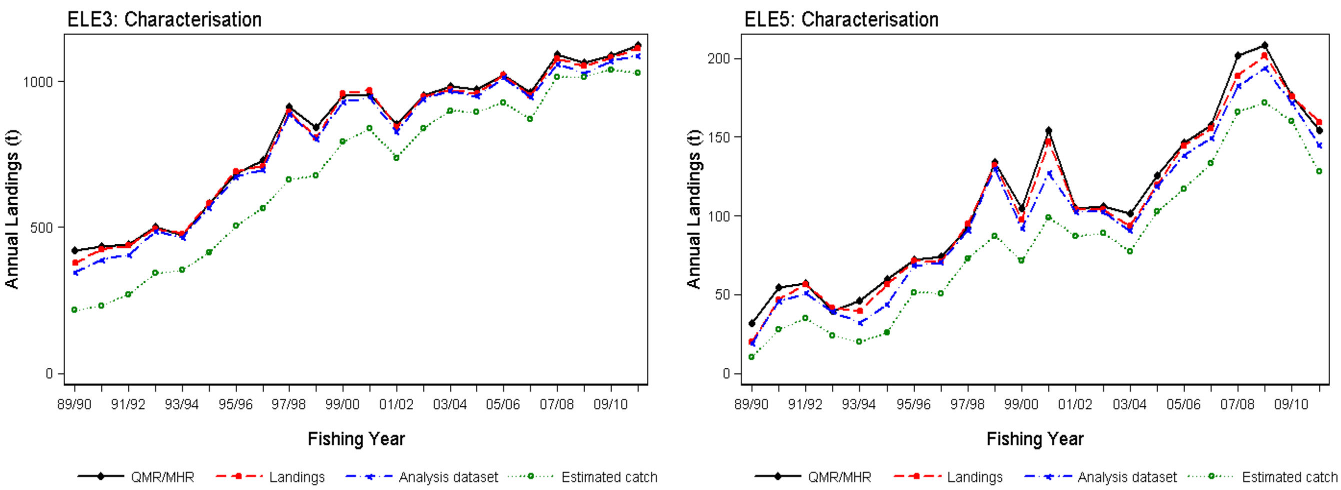


**Figure 4:** **Plot of the ELE 3 (left panel) and ELE 5 (right panel) catch dataset totals presented in Table 4. The estimated catch total is the sum of the estimated catch in the analysis dataset.**

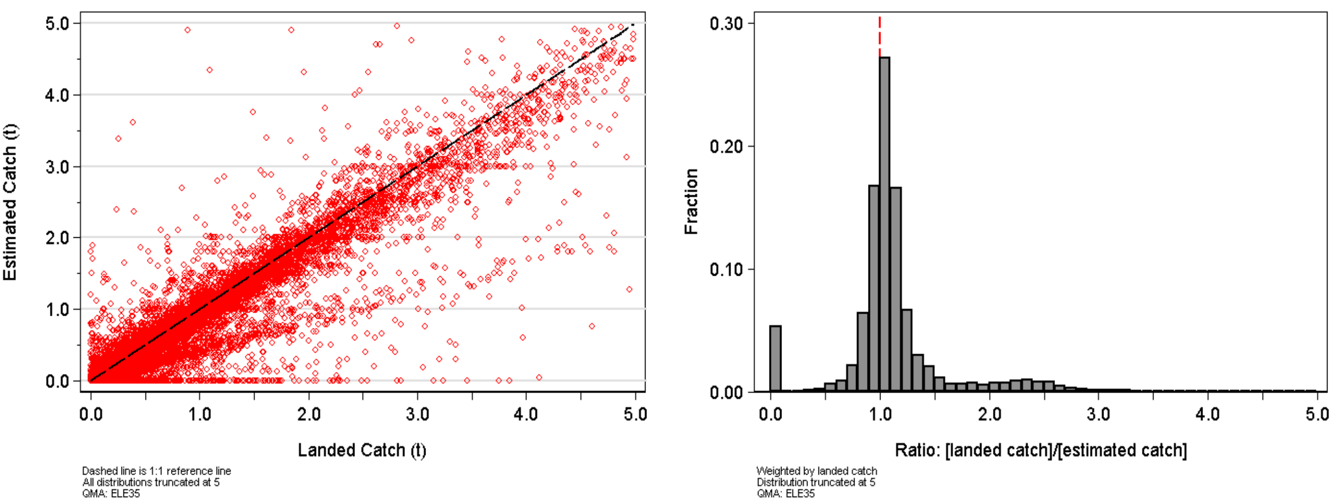


**Figure 5:** **Scatter plot of the sum of landed and estimated elephantfish catch for each trip in the combined ELE 3 and ELE 5 analysis dataset [left panel]. Distribution (weighted by the landed catch) of the ratio of landed to estimated catch per trip [right panel]. Trips where the estimated catch is zero have been assigned a ratio of zero.**

The 5% to 95% quantiles (excluding trips where there was no estimated catch) for the ratio of landed to estimated catch range from 0.55 to 2.67 for the dataset, with the median and mean ratios showing the landed catch 6% and 40% higher respectively than the estimated catch (Table 5). On average, 39% of trips estimated no catch of elephantfish but then reported ELE in the landings (Table 5). These landings represented 5% of the total ELE landings over the period, for a total of 1 043 tonnes over all years (Table 5). The new inshore forms (NCELR and TCER), which record fishing activity at the event level, have reduced the proportion of trips which estimate nil elephantfish while landing this species, with the ELE landings in this category accounting for about 1% of the total ELE 3 plus ELE 5 landings in the most recent four years, down from 4 to 14% of trips prior to the change in formtype (Table 5).

**Table 5: Summary statistics pertaining to the reporting of estimated catch from the combined ELE 3 and ELE 5 analysis dataset.**

| | Trips with landed catch but which report no estimated catch | | | Statistics (excluding zeros) for the ratio of landed/estimated catch by trip | | | |
|---|---|---|---|---|---|---|---|
| Fishing year | Trips: % relative to total trips | Landings: % relative to total landings | Landings (t) | 5% quantile | Median | Mean | 95% quantile |
| 89/90 | 44 | 14 | 50 | 0.57 | 1.17 | 1.63 | 3.50 |
| 90/91 | 47 | 10 | 42 | 0.63 | 1.23 | 1.80 | 3.72 |
| 91/92 | 47 | 11 | 48 | 0.60 | 1.20 | 1.58 | 3.01 |
| 92/93 | 48 | 9 | 45 | 0.59 | 1.13 | 1.63 | 3.28 |
| 93/94 | 53 | 11 | 54 | 0.56 | 1.10 | 1.50 | 3.00 |
| 94/95 | 51 | 8 | 51 | 0.50 | 1.10 | 1.45 | 2.96 |
| 95/96 | 47 | 8 | 62 | 0.53 | 1.13 | 1.44 | 2.89 |
| 96/97 | 50 | 10 | 80 | 0.56 | 1.10 | 1.34 | 2.71 |
| 97/98 | 50 | 9 | 91 | 0.51 | 1.11 | 1.43 | 2.68 |
| 98/99 | 43 | 8 | 79 | 0.47 | 1.05 | 1.29 | 2.53 |
| 99/00 | 44 | 7 | 76 | 0.52 | 1.04 | 1.26 | 2.50 |
| 00/01 | 41 | 5 | 58 | 0.55 | 1.04 | 1.30 | 2.30 |
| 01/02 | 37 | 5 | 46 | 0.55 | 1.04 | 1.25 | 2.25 |
| 02/03 | 39 | 4 | 47 | 0.50 | 1.05 | 1.22 | 2.20 |
| 03/04 | 35 | 3 | 33 | 0.53 | 1.02 | 1.22 | 2.07 |
| 04/05 | 39 | 4 | 42 | 0.58 | 1.03 | 1.21 | 2.03 |
| 05/06 | 37 | 4 | 47 | 0.58 | 1.03 | 1.17 | 1.97 |
| 06/07 | 32 | 4 | 43 | 0.57 | 1.03 | 1.26 | 2.40 |
| 07/08 | 14 | 1 | 12 | 0.55 | 1.03 | 1.26 | 2.28 |
| 08/09 | 14 | 1 | 11 | 0.60 | 1.02 | 1.25 | 2.30 |
| 09/10 | 15 | 1 | 12 | 0.55 | 1.02 | 1.29 | 2.48 |
| 10/11 | 12 | 1 | 15 | 0.60 | 1.05 | 2.09 | 2.75 |
| Total | 39 | 5 | 1 043 | 0.55 | 1.06 | 1.40 | 2.67 |

Catch totals in the fishery characterisation tables have been scaled (Eq. 1) 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 then scaling all the landed catch observations $\left(L'_{i,y}\right)$ by trip-stratum with this ratio:

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

where $\mathbf{QMR}_y$ = QMR/MHR landings in year $y$;

$L_{i,y}$ = landing of ELE 3 or ELE 5 for trip-stratum $i$ in year $y$;

$A_y$ = number of trip-strata records for ELE 3 or ELE 5 in year $y$.

### 2.4.2 Description of the ELE 3 and ELE 5 landing information

Landing data for elephantfish were provided for every trip which landed ELE 3 or ELE 5 at least once, with one record for every reported ELE landing (including landings from all ELE Fishstocks landed by a trip that also landed ELE 3 or ELE 5) from the trip. Each of these records contained a reported green weight (in kilograms), a code indicating the processed state of the landing, along with other auxiliary information such as the conversion factor used, the number of containers involved and the average weight of the containers. Every landing record also contained a "destination code" (Table 6), which indicated the category under which the landing occurred. The majority of the landings were made using destination code "L" (landed to a Licensed Fish Receiver; Table 6). However, other codes (e.g., A, O and C; Table 6) also potentially describe valid landings and were included in this analysis.

A number of other codes (notably R, Q and T; Table 6) were not included because these landings were likely to be reported at a later date under the "L" destination category. Two other codes (D and NULL) represented errors which could not be reconciled without making unwarranted assumptions and these were not included in the landing data set. The quantity of dropped landings, both in terms of total tonnage and as a proportion of the total landings, was very low for ELE 3&5 (Table 6).

**Table 6: Destination codes in the unedited landing data received for the combined ELE 3&5 analysis. The "how used" column indicates which destination codes were included in the characterisation and CPUE analyses. These data summaries have been restricted to ELE 3 or ELE 5 over the period 1989–90 to 2010–11.**

| Destination code | Number of events | Green weight (t) | Description | How used |
|---|---|---|---|---|
| L | 80 613 | 21 104.0 | Landed in NZ (to LFR) | Keep |
| C | 78 | 12.2 | Disposed to Crown | Keep |
| O | 2 | 8.5 | Conveyed outside NZ | Keep |
| E | 113 | 2.2 | Eaten | Keep |
| F | 94 | 0.8 | Section 111 Recreational Catch | Keep |
| A | 29 | 0.7 | Accidental loss | Keep |
| W | 82 | 0.4 | Sold at wharf | Keep |
| U | 52 | 0.1 | Bait used on board | Keep |
| S | 1 | 0.0 | Seized by Crown | Keep |
| | | | | |
| R | 696 | 64.7 | Retained on board | Drop |
| Q | 452 | 22.9 | Holding receptacle on land | Drop |
| NULL | 84 | 14.1 | Nothing | Drop |
| T | 9 | 5.2 | Transferred to another vessel | Drop |
| D | 6 | 0.9 | Discarded (non-ITQ) | Drop |
| B | 5 | 0.0 | Bait stored for later use | Drop |

**Table 7: Total greenweight reported and number of events by state code in the landing file used to process the combined ELE 3 and ELE 5 characterisation and CPUE data, arranged in order of descending landed weight (only for destination codes indicated as "Keep" in Table 6). These data summaries have been restricted to ELE 3 and ELE 5 from 1989–90 to 2010–11.**

| State code | Number of Events | Total reported green weight (t) | Description |
|---|---|---|---|
| GUT | 40 502 | 15 353.1 | Gutted |
| HGU | 17 825 | 2 976.3 | Headed and gutted |
| DRE | 16 868 | 1 805.0 | Dressed |
| GGO | 2 341 | 524.7 | Gilled and gutted tail-on |
| GRE | 943 | 140.3 | Green (or whole) |
| HGT | 251 | 19.5 | Headed, gutted, and tailed |
| Other | 550 | 44.9 | Other[1] |

[1] includes (in descending order of total landings): fish meal, fillets: skin-on, dressed-v cut (stargazer), unknown, surimi, fillets: skin-off, fins, shark fins, tailed (scampi), gilled and gutted tail-off, squid wings, lugs or collars, dressed-straight cut (stargazer), fillets: skin-off trimmed, headed gutted and finned

The majority of the valid landing data for ELE 3 or ELE 5 were reported using state code GUT with the balance of the remaining landings using state codes HGU and DRE (Table 7; Table 8). The few remaining landings were spread among GGO, GRE and HGT codes. There were no changes in the conversion factors used for this species over the period of available data (Table 8). State codes HGU and DRE predominated in elephantfish landings up to the mid-1990s, after which most landings were made in the GUT state code.

Total landings available in the data set are primarily for ELE 3 or ELE 5 (in descending order of importance) (Table 9). Small amounts of ELE 1, ELE 2, and ELE 7 are also taken in this set of trips. Just under seventy percent of the combined ELE 3 and ELE 5 landings have been reported on CELR forms over the 22 years of record, with 27% of the remaining landings reported using CLR forms and 4% on NCELR forms (Table 10). The CLR form is used by vessels using the TCEPR forms to report their effort as well as the new TCER form which was developed specifically for small inshore trawl vessels. The NCELR form is used exclusively to report setnet effort and landings. The use of these new forms, beginning with the 2006–07 fishing year for these Fishstocks, has resulted in a substantial drop in the use of the CELR form, which dropped to less than 10 percent of the combined ELE 3 or ELE 5 landings in 2007–08, while being greater than 80% of landings in the years previous (Table 10). The introduction of these new forms can also be seen in the effort data associated with these trips, with a strong decline in the number of days fishing associated with the CELR form after 2006–07 (Table 10).

**Table 8: Median conversion factor for the five most important state codes reported in Table 7 (in terms of total landed greenweight) and the total reported greenweight by fishing year in the edited file used to process ELE 3&5 landing data. These data summaries have been restricted to ELE 3 and ELE 5 over the period 1989–90 to 2010–11. '–': no observations**

| Fishing | Landed State Code | | | | | |
|---|---|---|---|---|---|---|
| Year | GUT | HGU | DRE | GGO | GRE | OTH |
| | Median Conversion Factor | | | | | |
| 89/90 | 1.1 | 2.3 | – | 1.1 | 1 | 2.3 |
| 90/91 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 2.9 |
| 91/92 | 1.1 | 2.3 | 2.3 | – | 1 | 2.9 |
| 92/93 | 1.1 | 2.3 | 2.3 | – | 1 | 2.9 |
| 93/94 | 1.1 | 2.3 | 2.3 | – | 1 | 2.9 |
| 94/95 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 2.9 |
| 95/96 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 2.9 |
| 96/97 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 2.9 |
| 97/98 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 1.0 |
| 98/99 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 1.0 |
| 99/00 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 3.6 |
| 00/01 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 1.0 |
| 01/02 | 1.1 | 2.3 | 2.3 | 1.1 | 1 | 1.0 |
| 02/03 | 1.1 | 2.3 | 2.3 | – | 1 | 4.3 |
| 03/04 | 1.1 | 2.3 | 2.3 | – | 1 | 4.6 |
| 04/05 | 1.1 | 2.3 | 2.3 | – | 1 | 2.9 |
| 05/06 | 1.1 | 2.3 | 2.3 | – | 1 | 1.0 |
| 06/07 | 1.1 | 2.3 | 2.3 | – | 1 | 5.6 |
| 07/08 | 1.1 | 2.3 | 2.3 | – | 1 | 5.6 |
| 08/09 | 1.1 | 2.3 | 2.3 | – | 1 | 3.6 |
| 09/10 | 1.1 | 2.3 | 2.3 | – | 1 | 5.6 |
| 10/11 | 1.1 | 2.3 | 2.3 | – | 1 | 5.6 |
| | Total Landings (t) | | | | | |
| 89/90 | 1.9 | 381.9 | – | 20.0 | 2.4 | 15.6 |
| 90/91 | 36.8 | 383.8 | 47.2 | 3.7 | 1.2 | 10.1 |
| 91/92 | 103.4 | 303.1 | 86.8 | – | 1.3 | 1.8 |
| 92/93 | 173.8 | 224.5 | 134.5 | – | 4.6 | 1.3 |
| 93/94 | 166.2 | 227.4 | 114.2 | – | 12.8 | 0.1 |
| 94/95 | 240.1 | 259.3 | 128.9 | 0.0 | 11.1 | 0.2 |
| 95/96 | 283.1 | 286.6 | 125.3 | 62.8 | 5.1 | 2.5 |
| 96/97 | 398.5 | 187.7 | 125.8 | 59.1 | 5.8 | 5.7 |
| 97/98 | 386.7 | 281.5 | 232.3 | 83.5 | 6.2 | 2.4 |
| 98/99 | 488.7 | 208.4 | 154.7 | 72.9 | 16.7 | 3.1 |
| 99/00 | 776.7 | 91.2 | 117.3 | 65.0 | 4.8 | 2.1 |
| 00/01 | 864.4 | 68.2 | 91.3 | 86.0 | 4.8 | 4.6 |
| 01/02 | 780.1 | 8.0 | 84.0 | 71.7 | 3.8 | 0.9 |
| 02/03 | 1 002.3 | 7.3 | 35.4 | – | 1.5 | 4.5 |
| 03/04 | 1 033.9 | 2.4 | 25.6 | – | 0.5 | 2.9 |
| 04/05 | 1 046.1 | 2.7 | 29.3 | – | 2.9 | 0.3 |
| 05/06 | 1 132.6 | 5.9 | 16.3 | – | 8.2 | 3.3 |
| 06/07 | 1 056.5 | 7.8 | 43.3 | – | 2.1 | 0.2 |
| 07/08 | 1 250.1 | 8.5 | 21.5 | – | 9.4 | 1.4 |
| 08/09 | 1 205.5 | 6.9 | 38.4 | – | 16.4 | 1.4 |
| 09/10 | 1 241.4 | 4.7 | 10.2 | – | 10.3 | 0.1 |
| 10/11 | 1 254.2 | 9.0 | 15.4 | – | 9.9 | 0.1 |
| Total | 14 923.0 | 2 966.8 | 1 677.9 | 524.7 | 141.9 | 64.3 |

**Table 9.: Distribution of total landings (t) by elephantfish Fishstock and by fishing year for the set of trips that recorded ELE 3 or ELE 5 landings. Landing records with improbable greenweights have been dropped (see Appendix C); '–': no recorded landings**

| Fishing year | ELE1 | ELE2 | ELE3 | ELE5 | ELE7 | Total |
|---|---|---|---|---|---|---|
| 89/90 | 0.0 | 0.1 | 401 | 20 | 4.5 | 426 |
| 90/91 | 0.1 | – | 436 | 47 | 11 | 494 |
| 91/92 | – | 0.0 | 439 | 58 | 19 | 516 |
| 92/93 | – | 0.1 | 497 | 42 | 10 | 549 |
| 93/94 | – | 0.1 | 481 | 40 | 2.8 | 524 |
| 94/95 | 0.2 | 0.6 | 583 | 57 | 2.6 | 643 |
| 95/96 | 0.4 | 0.1 | 694 | 71 | 6.5 | 772 |
| 96/97 | 2.6 | 2.0 | 711 | 71 | 5.2 | 792 |
| 97/98 | 0.1 | 5.2 | 897 | 95 | 29 | 1 027 |
| 98/99 | 0.1 | 0.8 | 812 | 132 | 16 | 961 |
| 99/00 | 0.1 | 1.8 | 959 | 97 | 15 | 1 073 |
| 00/01 | – | 0.8 | 972 | 147 | 13 | 1 132 |
| 01/02 | – | 2.3 | 844 | 104 | 11 | 962 |
| 02/03 | 0.3 | 2.4 | 947 | 104 | 7.9 | 1 062 |
| 03/04 | 0.0 | 8.8 | 971 | 94 | 11 | 1 086 |
| 04/05 | 0.0 | 1.6 | 961 | 120 | 4.6 | 1 087 |
| 05/06 | 0.4 | 0.5 | 1 021 | 145 | 3.1 | 1 170 |
| 06/07 | 3.7 | 0.1 | 952 | 157 | 6.6 | 1 120 |
| 07/08 | 0.0 | 2.3 | 1 095 | 196 | 8.2 | 1 301 |
| 08/09 | 0.0 | 0.2 | 1 065 | 204 | 6.6 | 1 276 |
| 09/10 | 0.0 | 2.7 | 1 090 | 177 | 8.3 | 1 278 |
| 10/11 | 0.5 | 1.3 | 1 126 | 163 | 16 | 1 306 |
| Total | 8.6 | 34 | 17 954 | 2 342 | 219 | 20 558 |

**Table 10: Distribution by form type for landed catch by weight for each fishing year in ELE 3 and 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 3 and ELE 5. Forms other than CELR and NCELR report their landings on CLR forms.**

| Fishing | Landings (%)[1] | | | Days Fishing (%)[2] | | | | Days Fishing | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | CELR | CLR | NCELR | CELR | TCEPR | TCER | NCELR | CELR | TCEPR | TCER | NCELR | Other[3] | Total |
| 89/90 | 81 | 19 | 0 | 84 | 16 | – | – | 4 044 | 745 | – | – | – | 4 789 |
| 90/91 | 85 | 15 | 0 | 89 | 11 | – | – | 4 504 | 540 | – | – | – | 5 044 |
| 91/92 | 90 | 10 | 0 | 88 | 12 | – | – | 4 917 | 648 | – | – | – | 5 565 |
| 92/93 | 82 | 18 | 0 | 90 | 10 | – | – | 4 784 | 558 | – | – | – | 5 342 |
| 93/94 | 88 | 12 | 0 | 93 | 7 | – | – | 5 719 | 418 | – | – | – | 6 137 |
| 94/95 | 92 | 8.1 | 0 | 93 | 7 | – | – | 5 408 | 426 | – | – | – | 5 834 |
| 95/96 | 83 | 17 | 0 | 88 | 12 | – | – | 5 240 | 739 | – | – | – | 5 979 |
| 96/97 | 93 | 7.4 | 0 | 90 | 10 | – | – | 5 245 | 601 | – | – | – | 5 846 |
| 97/98 | 92 | 8.0 | 0 | 90 | 10 | – | – | 5 612 | 613 | – | – | – | 6 225 |
| 98/99 | 93 | 7.0 | 0 | 88 | 12 | – | – | 5 673 | 749 | – | – | – | 6 422 |
| 99/00 | 92 | 7.7 | 0 | 89 | 11 | – | – | 5 340 | 636 | – | – | – | 5 976 |
| 00/01 | 97 | 2.9 | 0 | 91 | 9 | – | – | 5 865 | 562 | – | – | – | 6 427 |
| 01/02 | 93 | 6.8 | 0 | 86 | 14 | – | – | 4 790 | 791 | – | – | – | 5 581 |
| 02/03 | 90 | 10 | 0 | 87 | 13 | – | – | 5 475 | 828 | – | – | – | 6 303 |
| 03/04 | 90 | 10 | 0 | 90 | 10 | – | – | 4 656 | 544 | – | – | – | 5 200 |
| 04/05 | 91 | 9.1 | 0 | 92 | 8 | – | – | 5 084 | 444 | – | – | 10 | 5 538 |
| 05/06 | 93 | 7.4 | 0 | 89 | 11 | – | – | 5 602 | 682 | – | – | – | 6 284 |
| 06/07 | 83 | 5.8 | 11 | 74 | 12 | – | 15 | 4 690 | 736 | – | 945 | – | 6 371 |
| 07/08 | 9.8 | 75 | 15 | 9 | 9 | 62 | 19 | 543 | 571 | 3 768 | 1 173 | 2 | 6 057 |
| 08/09 | 7.3 | 80 | 12 | 9 | 8 | 68 | 16 | 510 | 448 | 4 008 | 944 | 9 | 5 919 |
| 09/10 | 4.6 | 80 | 15 | 5 | 8 | 70 | 17 | 322 | 495 | 4 522 | 1 060 | 17 | 6 416 |
| 10/11 | 7.6 | 78 | 15 | 6 | 10 | 66 | 17 | 370 | 656 | 4 213 | 1 108 | 20 | 6 367 |
| Total | 69 | 27 | 4.2 | 73 | 10 | 13 | 4 | 94 393 | 13 430 | 16 511 | 5 230 | 58 | 129 622 |

[1] Percentages of landed greenweight
[2] Percentages of number of days fishing
[3] includes 12 days for LCER (lining), and 46 days for LTCER (lining trip)

### 2.4.3 Description of the ELE 3 and ELE 5 fisheries

#### 2.4.3.1 Introduction

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 11.

**Table 11: Definitions of Statistical Area Group (Appendix B), major method and target species codes used in the distribution tables and plots in this report. Number of events is number of effort records in analysis dataset; number of records is number of trip-strata in analysis dataset; sum of landings is sum of landings after using "Fishstock expansion" method (Appendix D).**

| Statistical area code | Statistical Area Group definition | Number of events | Number of records | Sum landings (t) |
|---|---|---|---|---|
| 018 | 018, 019 (ELE 3) | 12 799 | 10 435 | 287.2 |
| 020 | 020, 021 (ELE 3) | 28 567 | 16 090 | 2 809.5 |
| 022 | 022, 023 (ELE 3) | 63 534 | 31 492 | 11 875.9 |
| 024 | 024, 301 (ELE 3) | 26 426 | 18 003 | 1 700.0 |
| 026 | 026 ,302, 303 (ELE 3) | 19 970 | 5 558 | 786.7 |
| Chatham Rise | 049–052 (ELE 3) | 2 017 | 289 | 15.8 |
| 025–026 | 025, 026 (ELE 5) | 8 759 | 3 893 | 898.6 |
| 030–032 | 030, 031, 032 (ELE 5) | 15 576 | 4 774 | 1 229.8 |
| Stewart I. | 027, 028, 029 (ELE 5) (remaining areas less than 1.2 t) | 6 986 | 1 258 | 75.1 |
| | | | | |
| Method designation | Methods included | | | |
| BT | Bottom trawl | 154 229 | 68 457 | 16 201.5 |
| SN | Setnet | 24 800 | 20 783 | 3 009.4 |
| DS | Danish seine | 1 536 | 1 148 | 444.0 |
| OTH | Other (Midwater trawl: 10.7 t; cod potting: 10.4 t, dredge: 2.4 t) | 4 069 | 1 404 | 23.6 |
| | | | | |
| Target species code[1] | Target species definition | | | |
| RCO | Red cod | 40 466 | 20 729 | 5 302.7 |
| FLA | Flatfish (including all related species) | 58 284 | 27 361 | 4 025.1 |
| ELE | Elephantfish | 4 693 | 2 216 | 3 198.0 |
| BAR | Barracouta | 14 299 | 4 637 | 1 808.1 |
| STA | Stargazer | 9 237 | 3 009 | 543.4 |
| TAR | Tarakihi | 8 364 | 3 841 | 466.2 |
| GUR | Red gurnard | 2 551 | 1 379 | 347.4 |
| SPD | Spiny dogfish | 1 296 | 526 | 130.3 |
| SPO | Rig | 384 | 222 | 93.5 |
| OTH | Remaining 14 species > 2 t of total bottom trawl landings in ranked descending order: blue warehou, sea perch, arrow squid, school shark, leatherjacket, ling, hapuku & bass, hoki, blue cod, rough skate, gemfish, orange roughy, ghost shark, skate | 14 655 | 4 537 | 286.7 |
| | | | | |
| Target species code[2] | Target species definition | Number events | Number records | Sum landings (t) |
| ELE | Elephantfish | 2 714 | 2 603 | 1 246.5 |
| SPO | Rig | 8 963 | 7 464 | 1 166.5 |
| SCH | School shark | 4 305 | 2 931 | 445.4 |
| SPD | Spiny dogfish | 2 214 | 1 972 | 83.5 |
| HPB | Hapuku & bass | 525 | 476 | 16.1 |
| MOK | Blue moki | 706 | 532 | 15.3 |
| OTH | Remaining 5 species > 1 t of total setnet landings in ranked descending order: tarakihi, blue warehou, ling, red cod, kahawai | 5 373 | 4 805 | 36.1 |

[1] Bottom trawl method
[2] Setnet method

### 2.4.3.2 Distribution of landings and effort by method of capture and statistical area

ELE 3 shares several statistical areas with other elephantfish Fishstocks, including Area 018 with ELE 2 and ELE 7, Area 019 with ELE 2, and Areas 026 and 027 with ELE 5 (Appendix B). 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 B). Eighty-two percent of the total ELE 3 landings and 88% of the ELE 5 landings have been taken by bottom trawl over the 22 years of available catch history, with the most of the balance taken by the setnet fishery. The Danish seine method, which became important on the east coast of the South Island in the mid-2000s, accounts for just over 2 % of the total ELE 3 landings and none in ELE 5 (Table 12; Figure 6).

**Table 12: Total landings (t) and distribution of landings (%) of elephantfish from trips which landed ELE 3&5 by statistical area group and important fishing methods (Table 11), summed from 1989–90 to 2010–11. Landings (t) have been scaled to the QMR totals using Eq. 1. '–': no data in cell. Proportional distribution by statistical area for BT and SN within each QMA can be found in Table 13.**

| Statistical | | | | | Fishing Method | | | | | Fishing Method |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | BT | SN | DS | Other | Total | BT | SN | DS | Other | Total |
| Group | | | | Total landings (t) | | | | Distribution of landings (%) | | |
| 018 | 202 | 92 | 2.4 | 0.2 | 296 | 1.0 | 0.45 | 0.01 | 0.001 | 1.4 |
| 020 | 2 616 | 55 | 223 | 0.3 | 2 895 | 12.8 | 0.3 | 1.1 | 0.001 | 14.2 |
| 022 | 9 834 | 2 192 | 229 | 0.4 | 12 256 | 48.1 | 10.7 | 1.1 | 0.002 | 60.0 |
| 024 | 1 267 | 490 | 0.8 | 6.5 | 1 764 | 6.2 | 2.40 | 0.004 | 0.03 | 8.6 |
| 026 | 791 | 13 | – | 3.1 | 807 | 3.9 | 0.06 | – | 0.02 | 3.9 |
| Chatham Rise | 17 | 0.2 | – | 0.1 | 18 | 0.1 | 0.0 | – | 0.001 | 0.1 |
| | | | | | | | | | | |
| Total ELE 3 | 14 727 | 2 842 | 456 | 11 | 18 035 | 72.1 | 13.9 | 2.2 | 0.1 | 88.2 |
| 025–026 | 839 | 127 | – | 11.6 | 978 | 4.1 | 0.6 | – | 0.1 | 4.8 |
| 030–032 | 1 194 | 147 | – | 0.8 | 1 341 | 5.8 | 0.7 | – | 0.004 | 6.6 |
| Stewart I. | 76 | 5.6 | – | 1.9 | 83 | 0.4 | 0.0 | – | 0.01 | 0.4 |
| | | | | | | | | | | |
| Total ELE 5 | 2 109 | 280 | – | 14 | 2 403 | 10.3 | 1.4 | – | 0.1 | 11.8 |
| Total ELE 3&5 | 16 836 | 3 121 | 456 | 25 | 20 438 | 82.4 | 15.3 | 2.2 | 0.1 | 100 |

The ELE 3 bottom trawl catch is mainly taken in Statistical Areas 020 or 022, with only about 10% of the trawl catches taken south of Canterbury Bight (Figure 7; Table 12). About one-third of the ELE 5 bottom trawl landings are taken in the eastern Foveaux Strait and the remaining two-thirds in the western Foveaux Strait. The distribution of bottom trawl effort in ELE 3&5 by year resembles the catch distribution, although a large number of tows occur in Areas 024 and 026 which are less productive for elephantfish than the statistical areas to the north and in western Foveaux Strait (Figure 7). There does not appear to be any obvious trend in the distribution of bottom trawl catch or effort between statistical areas, indicating that the relative importance of these areas has remained consistent over the period covered by the data (Figure 7; Table 13).

Setnet landings in ELE 3 mainly come from Statistical Areas 022 and 024 (Figure 8; Table 13). The distribution of setnet effort shows that there is a large amount of setnet effort in Area 018 which catches few elephantfish, being mainly directed at tarakihi (Figure 8). Setnet catch and effort in ELE 5 are relatively minor compared to the major fishing areas on the east coast in ELE 3 (Figure 8), indicating that elephantfish is not a major component of the Southland setnet fishery.

**Table 13: Percent distribution of landings by statistical area group (Table 11) and QMA from 1989–90 to 2010–11 for the bottom trawl and setnet methods for trips which landed ELE 3 or ELE 5. Annual landings by method are available in Table 14 and the rows sum to 100% across all nine statistical area groups. '–': no fishing**

| | Statistical Area Group | | | | | | | Statistical Area Group | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing year | 018 | 020 | 022 | 024 | 026 | Chatham Rise | ELE 3 | 025-026 | 030-032 | Stewart I. | ELE 5 |
| Bottom trawl distribution (%) | | | | | | | | | | | |
| 89/90 | 1.0 | 12.3 | 62.5 | 11.7 | 2.4 | 2.4 | 92.3 | 2.2 | 4.4 | 1.0 | 7.7 |
| 90/91 | 0.7 | 9.7 | 66.1 | 9.9 | 1.5 | 0.0 | 88.0 | 3.2 | 8.6 | 0.2 | 12.0 |
| 91/92 | 0.7 | 11.6 | 59.9 | 15.7 | 1.3 | 0.0 | 89.2 | 2.2 | 8.2 | 0.4 | 10.8 |
| 92/93 | 0.7 | 14.9 | 62.9 | 13.3 | 2.2 | 0.0 | 94.1 | 1.3 | 4.2 | 0.3 | 5.9 |
| 93/94 | 0.9 | 19.7 | 60.4 | 8.6 | 1.6 | 0.0 | 91.2 | 2.8 | 5.5 | 0.5 | 8.8 |
| 94/95 | 0.6 | 18.2 | 61.9 | 8.9 | 1.6 | 0.0 | 91.2 | 2.3 | 6.0 | 0.5 | 8.8 |
| 95/96 | 1.9 | 18.1 | 62.9 | 5.7 | 1.6 | 0.2 | 90.5 | 1.6 | 7.7 | 0.2 | 9.5 |
| 96/97 | 1.0 | 16.4 | 59.2 | 9.9 | 3.5 | 0.0 | 90.1 | 3.8 | 6.1 | 0.0 | 9.9 |
| 97/98 | 1.9 | 24.1 | 57.1 | 6.2 | 1.8 | 0.0 | 91.1 | 4.1 | 4.6 | 0.2 | 8.9 |
| 98/99 | 1.2 | 24.2 | 51.9 | 7.3 | 0.8 | 0.0 | 85.4 | 8.5 | 5.9 | 0.2 | 14.6 |
| 99/00 | 1.3 | 19.0 | 58.3 | 8.3 | 2.1 | 0.4 | 89.5 | 3.9 | 6.4 | 0.3 | 10.5 |
| 00/01 | 1.9 | 27.3 | 45.6 | 6.2 | 3.9 | 0.2 | 85.0 | 5.9 | 8.2 | 0.9 | 15.0 |
| 01/02 | 1.6 | 20.9 | 52.1 | 8.3 | 5.9 | 0.1 | 88.9 | 4.4 | 6.2 | 0.5 | 11.1 |
| 02/03 | 1.1 | 12.1 | 63.6 | 6.0 | 5.8 | 0.0 | 88.7 | 4.2 | 6.7 | 0.3 | 11.3 |
| 03/04 | 1.1 | 14.9 | 60.4 | 4.5 | 8.7 | 0.0 | 89.6 | 5.1 | 5.0 | 0.3 | 10.4 |
| 04/05 | 0.6 | 10.8 | 64.4 | 5.8 | 6.3 | 0.0 | 87.9 | 4.8 | 7.0 | 0.2 | 12.1 |
| 05/06 | 0.5 | 12.6 | 61.7 | 4.9 | 7.5 | 0.0 | 87.2 | 5.9 | 6.5 | 0.4 | 12.8 |
| 06/07 | 0.3 | 14.5 | 57.1 | 4.1 | 8.0 | 0.0 | 83.9 | 6.6 | 8.8 | 0.7 | 16.1 |
| 07/08 | 1.4 | 8.3 | 60.3 | 5.3 | 7.3 | 0.0 | 82.7 | 8.8 | 8.1 | 0.4 | 17.3 |
| 08/09 | 0.4 | 11.1 | 54.8 | 8.2 | 6.3 | 0.0 | 80.8 | 7.9 | 10.4 | 0.9 | 19.2 |
| 09/10 | 2.4 | 9.5 | 56.6 | 10.5 | 6.1 | 0.0 | 85.1 | 4.9 | 9.3 | 0.7 | 14.9 |
| 10/11 | 1.9 | 12.3 | 58.4 | 8.3 | 5.6 | 0.0 | 86.5 | 5.0 | 8.0 | 0.5 | 13.5 |
| Mean | 1.2 | 15.5 | 58.4 | 7.5 | 4.7 | 0.1 | 87.5 | 5.0 | 7.1 | 0.5 | 12.5 |
| Set net distribution (%) | | | | | | | | | | | |
| 89/90 | 1.0 | 4.0 | 64.1 | 27.6 | 0.3 | – | 96.9 | 2.8 | 0.2 | 0.1 | 3.1 |
| 90/91 | 2.2 | 5.4 | 54.6 | 29.9 | 1.3 | – | 93.4 | 3.7 | 2.9 | – | 6.6 |
| 91/92 | 5.0 | 3.9 | 52.9 | 22.9 | 0.2 | – | 84.9 | 4.9 | 10.1 | 0.0 | 15.1 |
| 92/93 | 4.0 | 1.7 | 59.6 | 19.8 | 0.2 | – | 85.2 | 3.2 | 10.6 | 0.9 | 14.8 |
| 93/94 | 5.1 | 1.3 | 55.3 | 28.7 | 0.6 | – | 91.0 | 6.5 | 2.0 | 0.5 | 9.0 |
| 94/95 | 3.2 | 1.0 | 64.8 | 19.1 | 0.0 | – | 88.2 | 9.3 | 2.4 | 0.2 | 11.8 |
| 95/96 | 5.5 | 4.5 | 47.8 | 32.0 | 0.1 | 0.1 | 90.1 | 5.0 | 4.8 | 0.1 | 9.9 |
| 96/97 | 3.0 | 2.0 | 64.5 | 24.3 | 0.1 | 0.0 | 94.0 | 0.7 | 5.3 | 0.0 | 6.0 |
| 97/98 | 4.6 | 2.3 | 69.0 | 16.3 | 0.3 | – | 92.6 | 3.4 | 3.9 | 0.2 | 7.4 |
| 98/99 | 2.5 | 2.4 | 76.0 | 11.1 | 0.2 | – | 92.3 | 3.2 | 4.5 | 0.0 | 7.7 |
| 99/00 | 1.6 | 1.2 | 76.2 | 15.2 | – | – | 94.3 | 2.4 | 3.3 | 0.0 | 5.7 |
| 00/01 | 3.3 | 1.2 | 71.3 | 17.3 | – | – | 93.1 | 1.4 | 5.5 | – | 6.9 |
| 01/02 | 9.0 | 2.5 | 60.9 | 17.8 | 0.1 | – | 90.4 | 1.5 | 8.0 | 0.1 | 9.6 |
| 02/03 | 4.3 | 2.3 | 77.9 | 12.5 | – | – | 97.2 | 0.3 | 2.2 | 0.3 | 2.8 |
| 03/04 | 5.0 | 0.5 | 78.1 | 12.0 | – | – | 95.6 | 2.1 | 2.3 | 0.0 | 4.4 |
| 04/05 | 2.9 | 0.9 | 76.2 | 9.6 | 0.8 | – | 90.4 | 2.9 | 6.6 | 0.1 | 9.6 |
| 05/06 | 0.9 | 3.0 | 72.3 | 11.7 | 0.0 | – | 87.9 | 4.5 | 7.5 | 0.2 | 12.1 |
| 06/07 | 0.8 | 2.6 | 76.0 | 12.6 | 2.6 | – | 94.5 | 3.0 | 2.3 | 0.2 | 5.5 |
| 07/08 | 0.5 | 1.0 | 71.2 | 10.1 | 0.4 | – | 83.3 | 8.6 | 8.1 | 0.1 | 16.7 |
| 08/09 | 0.4 | 0.1 | 81.4 | 10.6 | 1.1 | – | 93.5 | 4.4 | 1.5 | 0.6 | 6.5 |
| 09/10 | 0.9 | 0.3 | 76.6 | 8.8 | 0.6 | – | 87.3 | 9.6 | 2.6 | 0.5 | 12.7 |
| 10/11 | 2.2 | 0.3 | 74.9 | 11.1 | 0.5 | – | 89.1 | 5.2 | 5.6 | 0.1 | 10.9 |
| Mean | 2.9 | 1.8 | 70.2 | 15.7 | 0.4 | 0.0 | 91.0 | 4.1 | 4.7 | 0.2 | 9.0 |

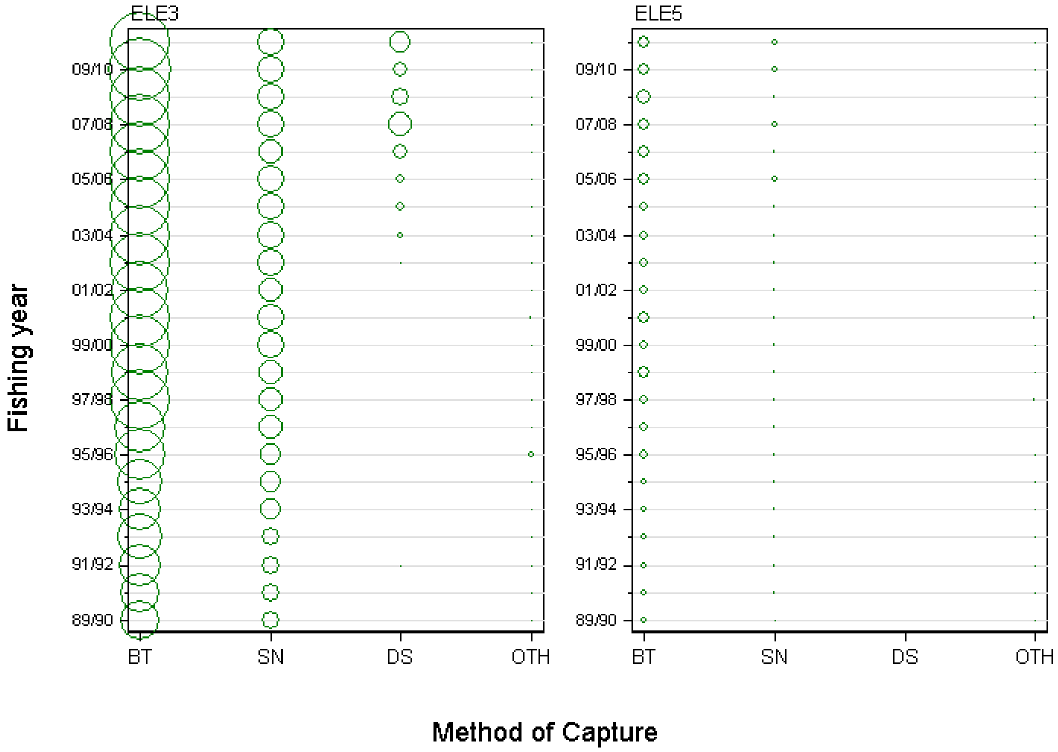


**Figure 6: Distribution of catches for the major fishing methods by fishing year from trips which landed ELE 3 or ELE 5. Circles are proportional to the catch totals by method and fishing year across the two subgraphs, with the largest circle representing 861 t (in 2009–10 for BT in ELE 3).**

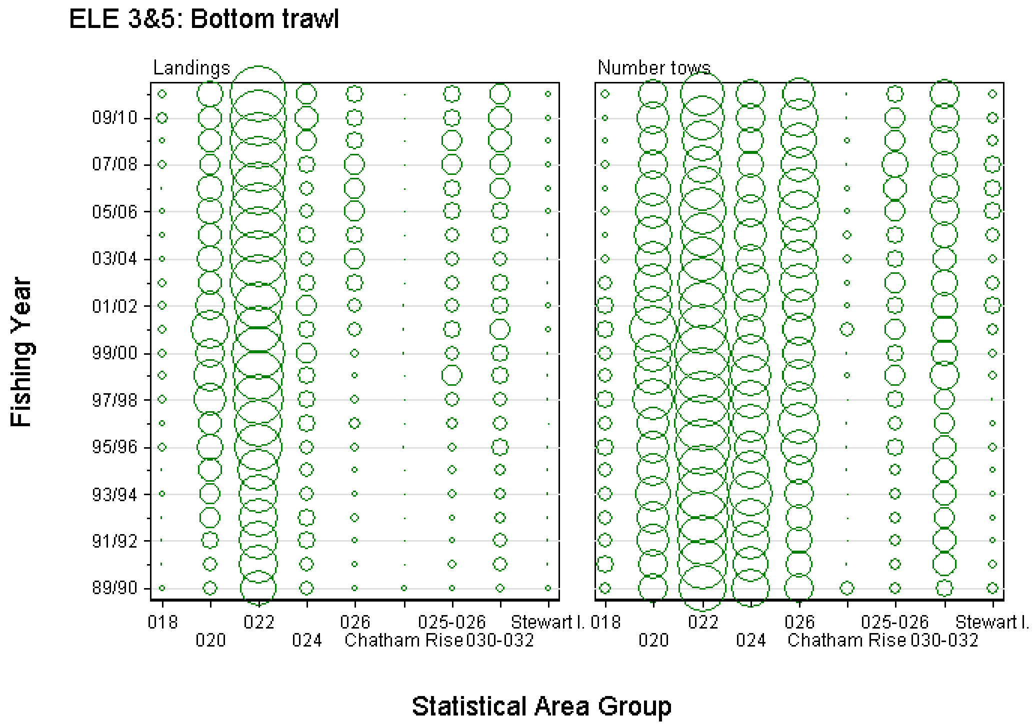


**Figure 7: Distribution of landings and effort for the bottom trawl method by statistical area group (Table 11) and fishing year from trips which landed ELE 3&5. Circles are proportional: [catches] largest circle=589 t in 2007–08 for 022; [effort] largest circle=6 580 tows in 1997–98 for 022. The final three columns in each subgraph are ELE 5 and the remaining columns are ELE 3.**

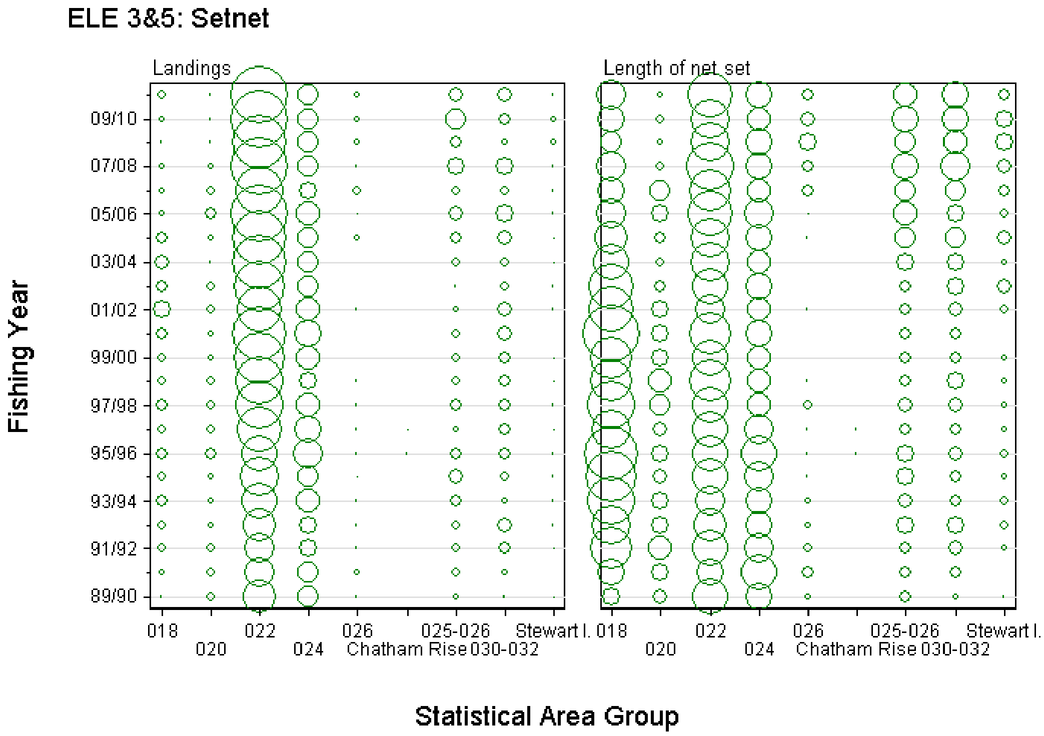


**Figure 8: Distribution of landings and effort for the setnet method by statistical area group (Table 11) and fishing year from trips which landed ELE 3&5. Circles are proportional: [catches] largest circle=150 t in 2009–10 for 022; [effort] largest circle=1 300 km in 2000–01 for 018. The final three columns in each subgraph are ELE 5 and the remaining columns are ELE 3.**

### 2.4.3.3 Fine scale distribution of landings and CPUE for bottom trawl and setnet

Fine scale landings and effort data are available for the total bottom trawl fleet taking elephantfish in ELE 3 and ELE 5 from 1 Oct 2007 onwards. A plot (Figure 9) of total landings gridded into 0.1×0.1° cells, summed over four years, shows that elephantfish are taken near the coast all the way from immediately south of Kaikoura to Te Wae Wae Bay, west of Foveaux Strait. Catch concentrations are especially high in Pegasus Bay, all through Canterbury Bight and Te Wae Wae Bay (Figure 9). Bottom trawl elephantfish CPUE is more concentrated, with areas of the highest catch rates in the Canterbury Bight, Foveaux Strait and Te Wae Wae Bay (Figure 10).

Elephantfish landings using the setnet method are concentrated in the southern part of Canterbury Bight and extend southward to nearly the Otago Peninsula. Fine scale data are available for an additional earlier fishing year (2006–07) (Figure 11). Setnet catch rates are even more localised, with the areas of the highest catch rates to be found in southern Canterbury Bight and just off Timaru (Figure 12).

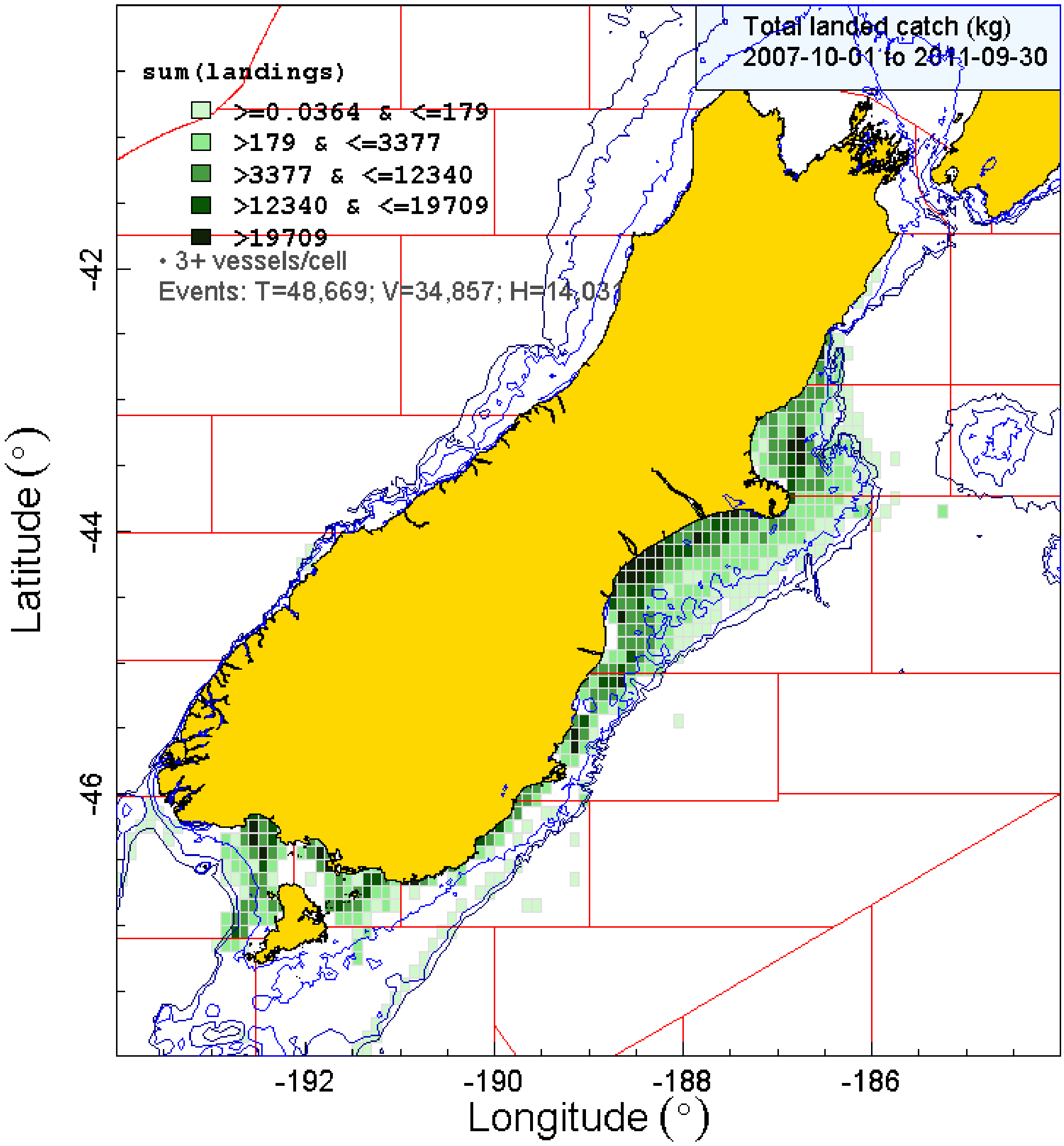


**Figure 9: Total bottom trawl landings for elephantfish in ELE 3 and ELE 5, arranged in 0.1°×0.1° grids and summed from 2007–08 to 2010–11. Legend colours divide the distribution of total landings into approximate 0–25%, 25–50%, 50–75%, 75–90% and +95% quantiles. Only grids with at least three reporting vessels are plotted, with the legend showing the total (T), visible (V) and hidden (H) events caused by this rule. Boundaries for the general statistical areas (Appendix B) are shown and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

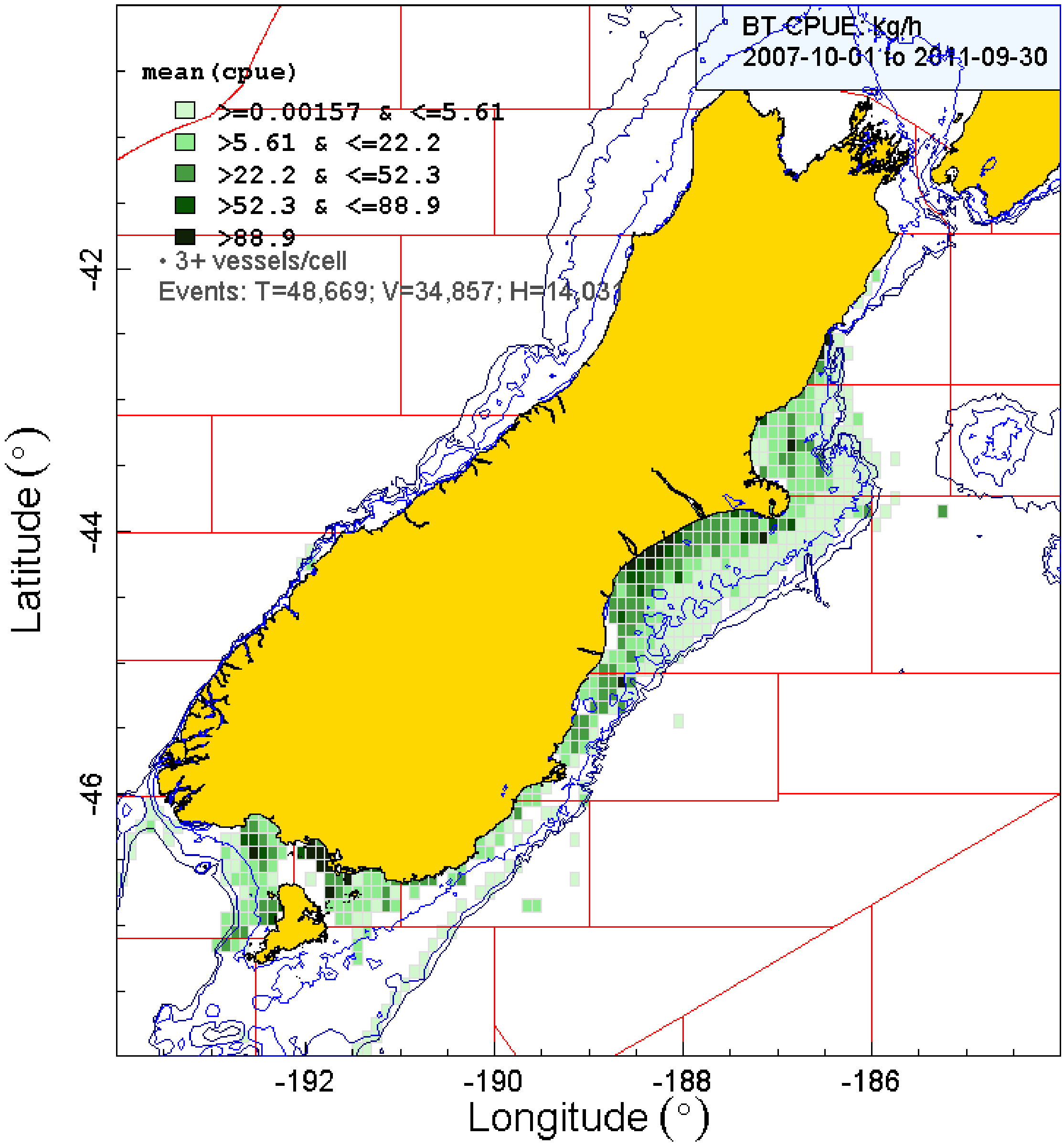


**Figure 10: Mean bottom trawl CPUE (kg/h) for elephantfish in ELE 3 and ELE 5, arranged in 0.1°×0.1° grids and averaged over 2007–08 to 2010–11. Legend colours divide the distribution of total landings into approximate 0–25%, 25–50%, 50–75%, 75–90% and +95% quantiles. Only grids with at least three reporting vessels are plotted with the legend showing the total (T), visible (V) and hidden (H) events caused by this rule. Boundaries for the general statistical areas (Appendix B) are shown and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

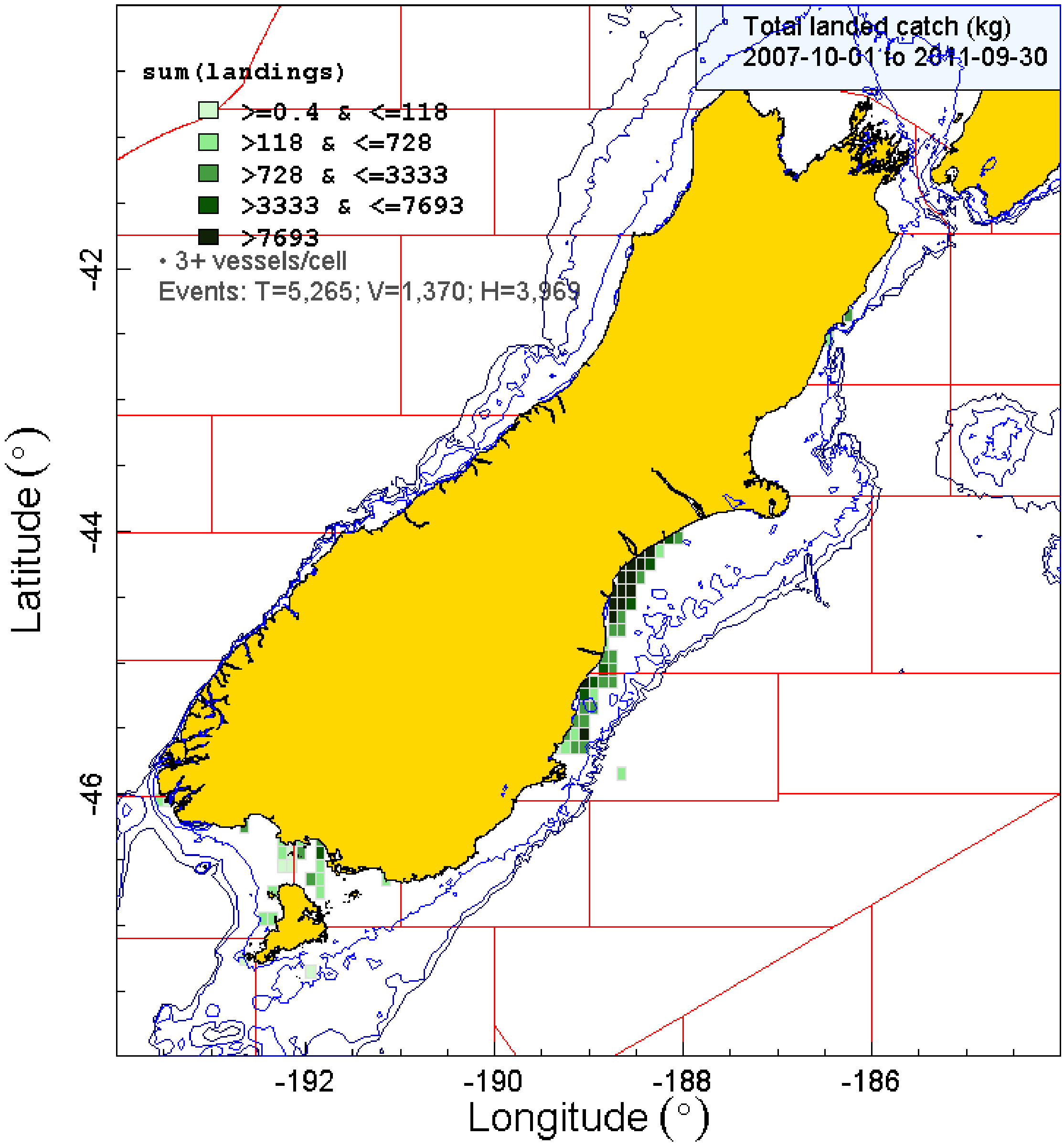


**Figure 11: Total setnet landings for elephantfish in ELE 3 and ELE 5, arranged in 0.1°×0.1° grids and summed from 2007–08 to 2010–11. Legend colours divide the distribution of total landings into approximate 0–25%, 25–50%, 50–75%, 75–90% and +95% quantiles. Only grids with at least three reporting vessels are plotted with the legend showing the total (T), visible (V) and hidden (H) events caused by this rule. Boundaries for the general statistical areas (Appendix B) are shown and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

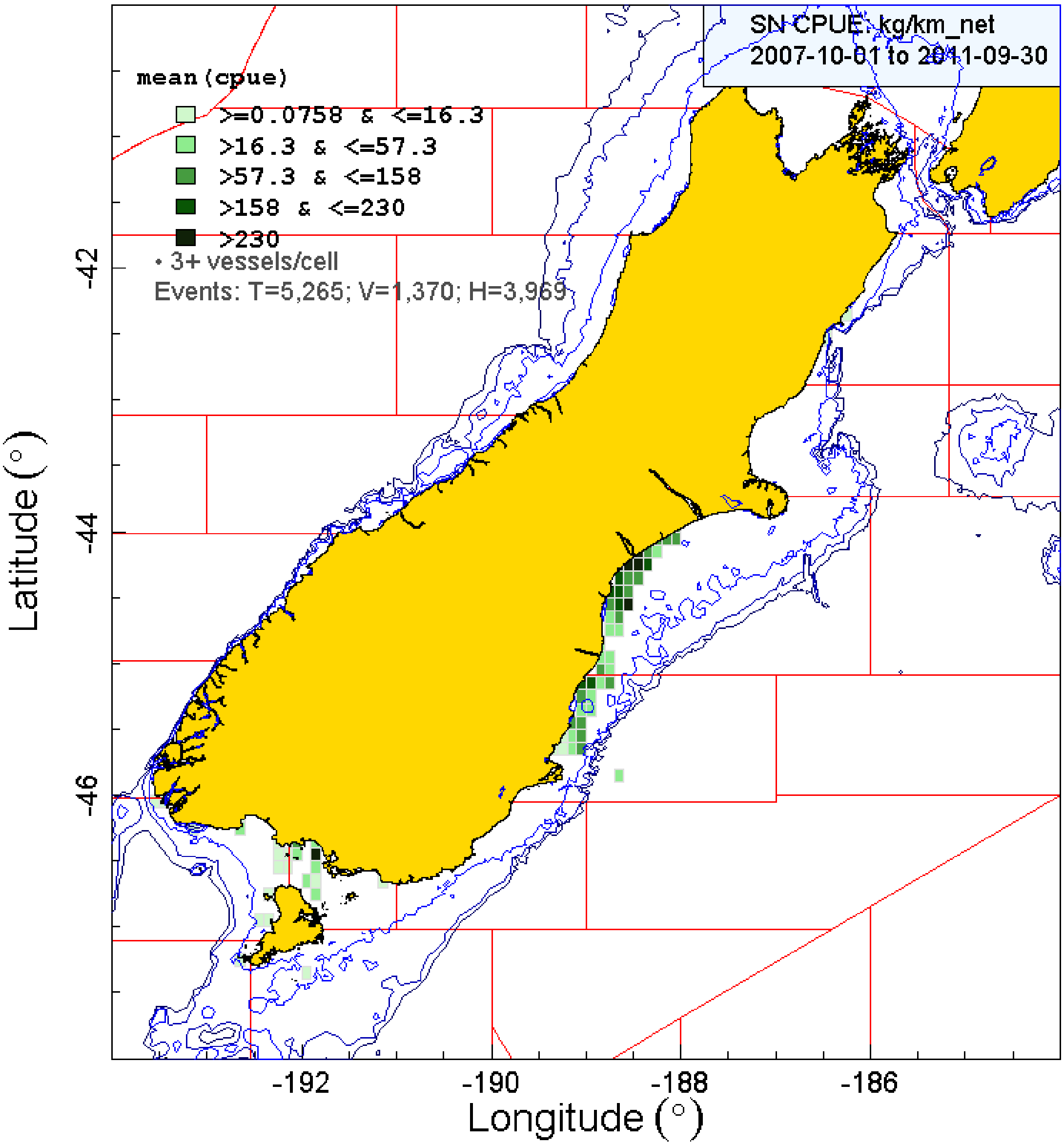


**Figure 12: Mean setnet CPUE (kg/km of net) for elephantfish in ELE 3 and ELE 5, arranged in 0.1°×0.1° grids and averaged over 2007–08 to 2010–11. Legend colours divide the distribution of total landings into approximate 0–25%, 25–50%, 50–75%, 75–90% and +95% quantiles. Only grids with at least three reporting vessels are plotted with the legend showing the total (T), visible (V) and hidden (H) events caused by this rule. Boundaries for the general statistical areas (Appendix B) are shown and the bathymetry indicates the 100 m, 200 m and 400 m depth contours.**

### 2.4.3.4 Seasonal distribution of landings

There is a broad seasonal distribution of bottom trawl catch from ELE 3 which clearly tapers off in the latter half of the fishing year (Table 14A; Figure 13), with little change in the monthly distribution of catch across years. The ELE 5 bottom trawl fishery shows more variation seasonally between years, but it is also more evenly spread out across the months compared to the equivalent plot for ELE 3 (Table 14B; Figure 13). The ELE 3 setnet fishery occurs almost exclusively between November and February, with some spillover into October and March (Figure 13). The timing of the ELE 5 setnet fishery is primarily concentrated in the same months as the ELE 3 setnet fishery, but there is more variation due to the relatively small amount of landings in this fishery (between 10 and 25 t/year).

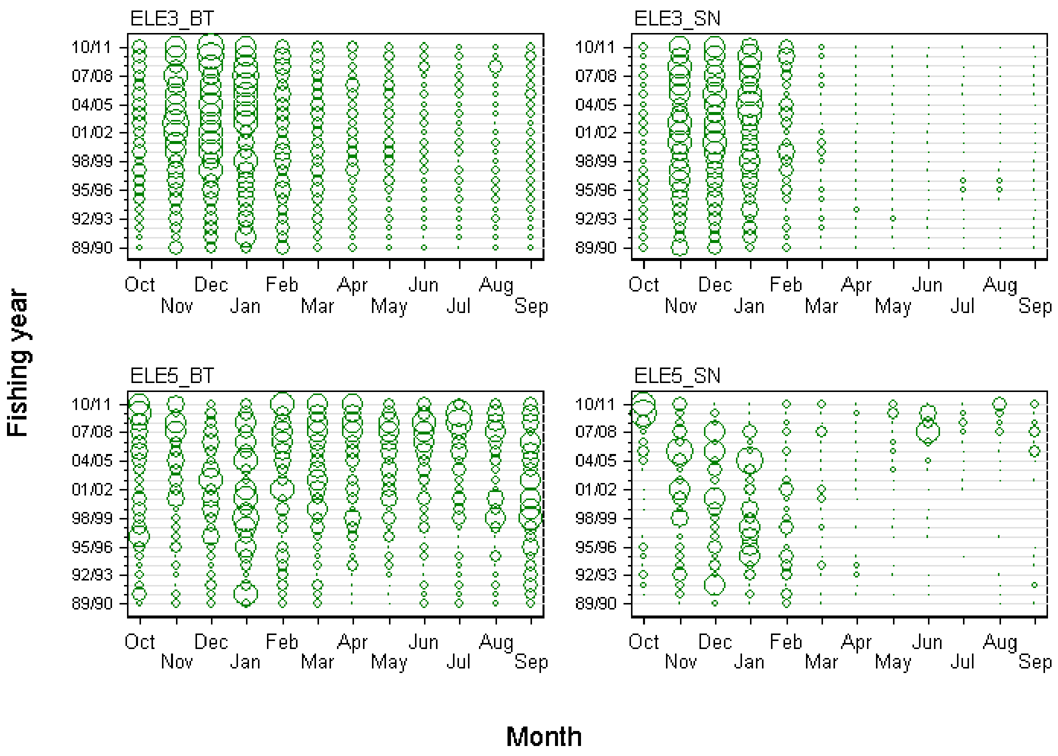


**Figure 13: Total landings by month and fishing year for bottom trawl and setnet based on trips landing ELE 3 or ELE 5 Circle sizes are proportional in each panel: [ELE 3 BT] largest circle= 223 t in 2007–08 for Jan; [ELE 3 SN] largest circle= 69 t in 2004–05 for Jan; [ELE 5 BT] largest circle= 28 t in 2009–10 for Jul; [ELE 5 SN] largest circle= 11 t in 2009–10 for Oct.**

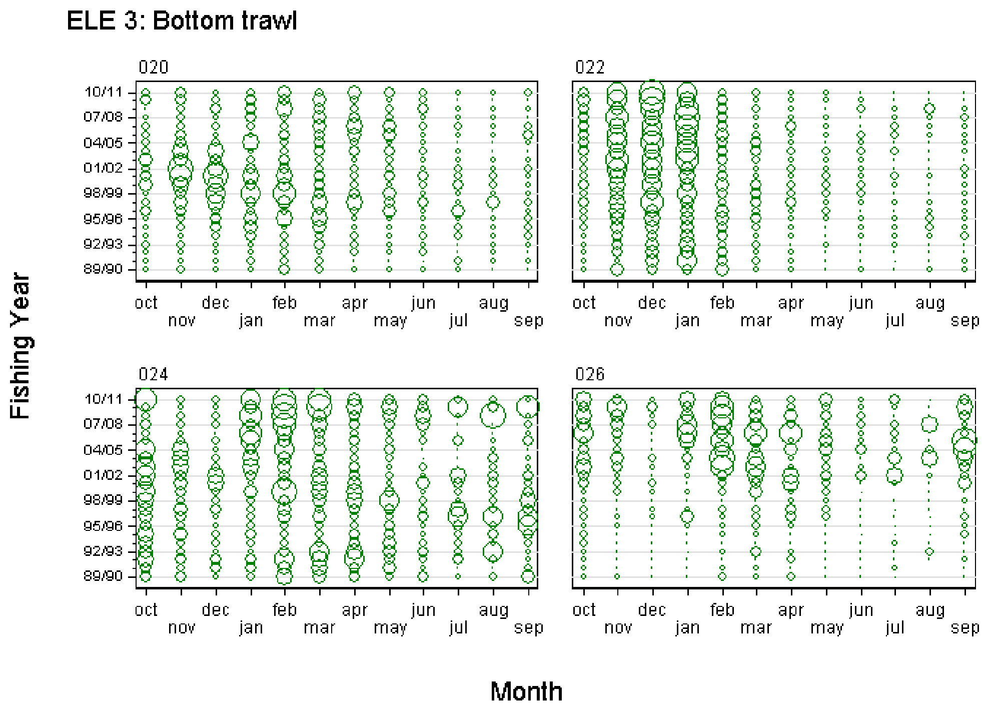


**Figure 14A: Distribution of landings for the bottom trawl method for the four most important grouped statistical areas (Table 11) for BT in ELE 3 by month and fishing year. Circle sizes are proportional within each panel: maximum values: [020]: largest circle 71 t in 2000–01 for Dec; [022]: largest circle 215 t in 2010–11 for Dec; [024]: largest circle 21 t in 1999–00 for Feb; [026]: largest circle 23 t in 2005–06 for Sep.**

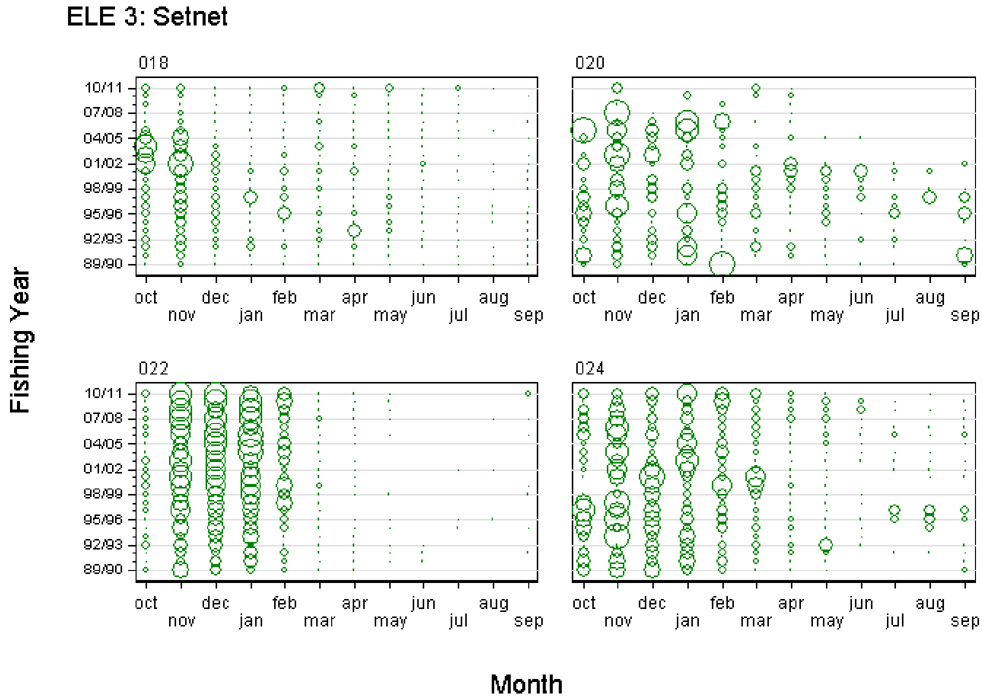


**Figure 14B: Distribution of landings for the setnet method for the four most important grouped statistical areas (Table 11) for SN in ELE 3 by month and fishing year. Circle sizes are proportional within each panel: maximum values: [018]: largest circle 7.3 t in 2001–02 for Nov, [020]: largest circle 2.3 t in 1989–90 for Feb; [022]: largest circle 59 t in 2004–05 for Jan; [024]: largest circle 14 t in 1993–94 for Nov.**

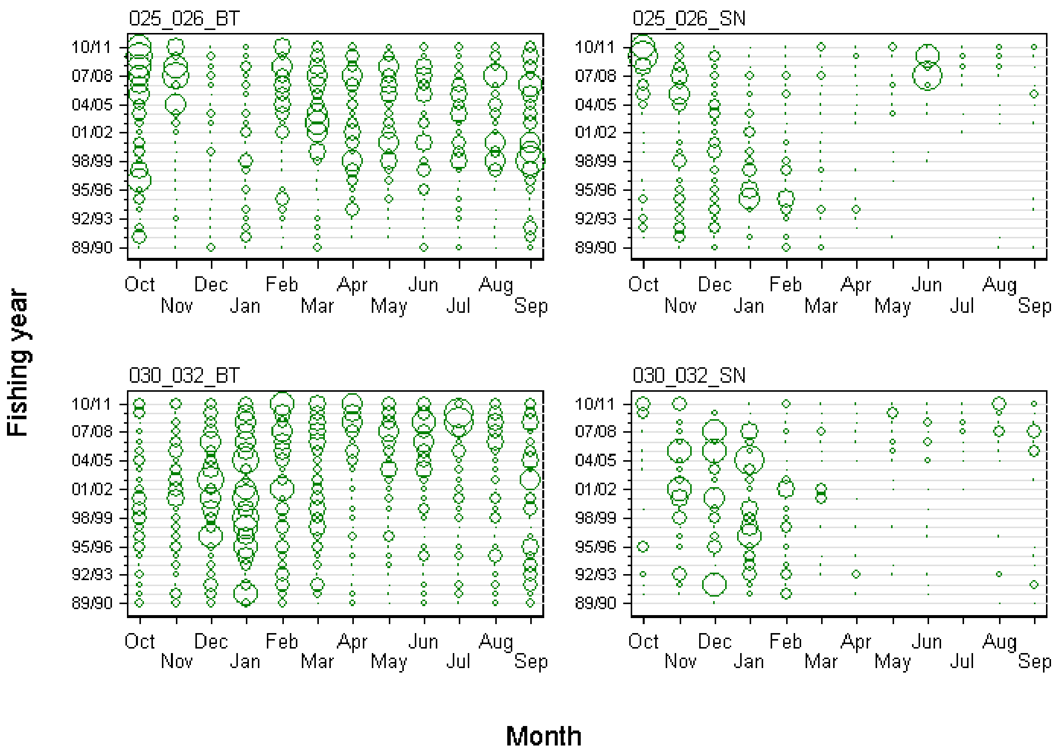


**Figure 14C: Distribution of landings for the bottom trawl and setnet methods for the two most important grouped statistical areas (Table 11) in ELE 5 for month and fishing year. Circle sizes are proportional within each panel: maximum values: [025_026_BT]: largest circle 23 t in 1998–99 for Sep, [025_026_SN]: largest circle 10 t in 2007–08 for Jun; [030_032_BT]: largest circle 27 t in 2009–10 for Jul; [030_032_SN]: largest circle 11 t in 2004–05 for Jan.**

Seasonal bottom trawl catches by ELE 3 statistical area show the same pattern as the overall ELE 3 BT fishery, although there is a suggestion that landings may be more evenly distributed by months south of Canterbury Bight, thus more closely resembling the seasonal distribution in Foveaux Strait than in Canterbury Bight (Figure 14A). The ELE 3 setnet seasonal distribution by statistical area is dominated by Area 022, with the other areas showing variability attributable to low catches (Figure 14B). Both ends of Foveaux Strait show similar seasonal distributions for both bottom trawl (Figure 14C) and setnet (Figure 14C).

**Table 14A: Percent distribution of landings by month and total annual landings (t) of ELE 3 from 1989–90 to 2010–11 for the bottom trawl and setnet methods for trips which landed ELE 3. Landings (t) have been scaled to the QMR totals using Eq. 1; [–]: no landings in this cell.**

| Fishing | | | | | | | | | | | Month | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total (t) |
| | Bottom trawl distribution (%) | | | | | | | | | | | | |
| 89/90 | 4.4 | 18.3 | 11.6 | 13.3 | 22.0 | 7.9 | 7.1 | 2.8 | 4.0 | 1.3 | 3.2 | 4.1 | 351 |
| 90/91 | 4.3 | 5.6 | 20.8 | 33.1 | 12.1 | 8.4 | 3.5 | 3.2 | 1.1 | 2.0 | 2.2 | 3.6 | 365 |
| 91/92 | 6.8 | 14.1 | 15.4 | 16.8 | 16.6 | 6.6 | 8.8 | 2.9 | 4.3 | 2.8 | 2.8 | 2.0 | 379 |
| 92/93 | 4.8 | 14.7 | 15.8 | 20.4 | 10.0 | 11.8 | 5.1 | 5.1 | 2.8 | 2.6 | 5.3 | 1.7 | 429 |
| 93/94 | 6.9 | 9.5 | 13.9 | 19.3 | 14.4 | 6.5 | 5.8 | 3.5 | 4.3 | 4.5 | 4.1 | 7.2 | 385 |
| 94/95 | 7.6 | 14.6 | 15.1 | 19.5 | 9.8 | 10.9 | 3.9 | 2.5 | 2.1 | 4.5 | 5.3 | 4.2 | 485 |
| 95/96 | 6.2 | 13.5 | 17.2 | 15.5 | 16.3 | 12.0 | 2.0 | 3.3 | 3.0 | 2.9 | 3.9 | 4.3 | 576 |
| 96/97 | 7.5 | 19.4 | 13.8 | 14.7 | 12.0 | 6.4 | 4.5 | 6.5 | 1.5 | 5.5 | 3.3 | 5.0 | 599 |
| 97/98 | 8.9 | 15.4 | 22.8 | 11.2 | 6.5 | 8.5 | 9.4 | 3.8 | 3.8 | 2.9 | 4.4 | 2.3 | 774 |
| 98/99 | 4.0 | 11.7 | 14.5 | 24.3 | 14.6 | 7.3 | 6.8 | 7.8 | 3.6 | 0.8 | 1.7 | 3.0 | 719 |
| 99/00 | 9.9 | 16.4 | 20.5 | 10.6 | 14.8 | 7.9 | 4.4 | 4.6 | 3.7 | 2.4 | 1.8 | 2.8 | 798 |
| 00/01 | 6.7 | 19.8 | 21.2 | 14.9 | 9.7 | 5.3 | 5.0 | 4.5 | 4.3 | 4.0 | 2.3 | 2.3 | 785 |
| 01/02 | 7.1 | 26.7 | 22.2 | 10.7 | 6.9 | 5.8 | 5.2 | 2.9 | 2.2 | 4.7 | 1.8 | 3.8 | 721 |
| 02/03 | 8.6 | 25.7 | 16.9 | 23.3 | 8.9 | 5.3 | 2.3 | 3.5 | 2.4 | 0.9 | 0.8 | 1.3 | 798 |
| 03/04 | 7.3 | 15.8 | 16.3 | 21.9 | 8.4 | 8.3 | 4.8 | 5.5 | 3.7 | 3.2 | 1.7 | 3.1 | 814 |
| 04/05 | 7.4 | 19.3 | 21.0 | 21.4 | 8.7 | 8.1 | 3.8 | 2.7 | 2.1 | 1.0 | 0.9 | 3.4 | 787 |
| 05/06 | 7.2 | 17.3 | 16.3 | 19.6 | 10.9 | 4.9 | 4.7 | 5.0 | 3.2 | 3.0 | 1.8 | 6.0 | 829 |
| 06/07 | 6.6 | 11.8 | 17.9 | 23.1 | 7.3 | 7.3 | 10.3 | 4.4 | 1.8 | 4.2 | 1.8 | 3.5 | 785 |
| 07/08 | 7.1 | 19.9 | 13.7 | 27.7 | 9.1 | 5.7 | 3.9 | 3.3 | 1.9 | 3.0 | 2.0 | 2.6 | 807 |
| 08/09 | 7.4 | 8.5 | 20.8 | 22.0 | 11.9 | 7.1 | 3.5 | 2.4 | 4.9 | 1.8 | 7.3 | 2.2 | 831 |
| 09/10 | 9.1 | 16.1 | 24.3 | 14.2 | 11.8 | 7.2 | 4.0 | 4.1 | 2.2 | 2.1 | 0.8 | 4.1 | 861 |
| 10/11 | 7.8 | 17.7 | 26.2 | 18.1 | 8.4 | 5.9 | 5.3 | 4.0 | 2.2 | 1.1 | 1.0 | 2.3 | 850 |
| Mean | 7.2 | 16.5 | 18.7 | 18.8 | 10.8 | 7.3 | 5.1 | 4.1 | 3.0 | 2.7 | 2.6 | 3.3 | 14 727[1] |
| | Setnet distribution (%) | | | | | | | | | | | | |
| 89/90 | 9.0 | 37.6 | 26.8 | 11.8 | 9.1 | 2.5 | 2.1 | 0.1 | 0.1 | 0.1 | 0.0 | 0.7 | 71 |
| 90/91 | 8.3 | 21.0 | 24.5 | 33.7 | 7.3 | 1.4 | 1.4 | 0.5 | 0.3 | 0.0 | 0.0 | 1.6 | 69 |
| 91/92 | 4.9 | 20.5 | 18.6 | 35.7 | 12.0 | 3.8 | 2.1 | 1.0 | 0.6 | 0.2 | 0.2 | 0.4 | 62 |
| 92/93 | 7.8 | 29.5 | 35.0 | 11.2 | 4.2 | 4.6 | 1.5 | 5.3 | 0.4 | 0.1 | – | 0.4 | 72 |
| 93/94 | 8.8 | 25.6 | 22.6 | 35.5 | 1.9 | 1.8 | 3.5 | 0.3 | 0.0 | 0.1 | – | 0.0 | 89 |
| 94/95 | 7.5 | 30.5 | 30.4 | 18.5 | 7.2 | 2.4 | 0.6 | 0.5 | 0.1 | 0.3 | 1.8 | 0.1 | 96 |
| 95/96 | 7.4 | 25.6 | 21.6 | 21.7 | 13.3 | 2.5 | 1.1 | 0.4 | 0.1 | 2.0 | 2.7 | 1.5 | 105 |
| 96/97 | 10.3 | 31.9 | 22.4 | 22.3 | 6.8 | 0.5 | 0.2 | 0.3 | 0.0 | 2.0 | 1.8 | 1.4 | 131 |
| 97/98 | 7.1 | 29.2 | 21.4 | 21.8 | 18.0 | 0.8 | 0.2 | 0.5 | 0.2 | 0.1 | 0.4 | 0.3 | 137 |
| 98/99 | 2.6 | 23.1 | 26.5 | 32.2 | 11.0 | 3.5 | 0.4 | 0.3 | 0.1 | – | 0.0 | 0.2 | 122 |
| 99/00 | 3.6 | 20.4 | 24.9 | 23.7 | 19.9 | 6.2 | 0.9 | 0.2 | 0.1 | 0.0 | – | 0.1 | 152 |
| 00/01 | 3.1 | 34.2 | 29.9 | 19.7 | 6.0 | 5.1 | 0.9 | 0.3 | 0.3 | 0.1 | 0.1 | 0.1 | 167 |
| 01/02 | 7.2 | 32.9 | 29.6 | 24.3 | 2.8 | 1.8 | 0.8 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 132 |
| 02/03 | 6.7 | 35.6 | 26.6 | 22.9 | 7.8 | 0.1 | 0.0 | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 | 151 |
| 03/04 | 4.7 | 23.0 | 22.9 | 33.9 | 14.2 | 0.8 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | – | 159 |
| 04/05 | 2.2 | 16.1 | 25.4 | 42.4 | 12.5 | 0.8 | 0.2 | 0.3 | 0.1 | 0.0 | – | 0.0 | 163 |
| 05/06 | 4.5 | 25.8 | 29.7 | 34.8 | 3.0 | 1.0 | 0.2 | 0.3 | 0.1 | 0.4 | 0.0 | 0.2 | 179 |
| 06/07 | 4.2 | 32.5 | 28.3 | 24.6 | 7.8 | 1.6 | 0.3 | 0.1 | 0.0 | 0.2 | 0.1 | 0.2 | 124 |
| 07/08 | 3.8 | 30.0 | 26.5 | 27.3 | 7.3 | 3.0 | 0.9 | 0.9 | 0.1 | 0.0 | 0.0 | 0.3 | 165 |
| 08/09 | 3.3 | 34.7 | 17.8 | 31.4 | 8.8 | 1.2 | 1.0 | 0.8 | 0.8 | 0.0 | 0.0 | 0.3 | 151 |
| 09/10 | 1.2 | 18.5 | 25.4 | 30.8 | 20.4 | 1.3 | 0.8 | 1.0 | 0.6 | 0.0 | – | 0.0 | 171 |
| 10/11 | 6.0 | 28.3 | 27.6 | 20.5 | 12.9 | 2.4 | 0.6 | 0.5 | 0.0 | 0.2 | 0.0 | 0.9 | 174 |
| Mean | 5.2 | 27.5 | 25.7 | 26.9 | 10.1 | 2.2 | 0.8 | 0.5 | 0.2 | 0.3 | 0.3 | 0.3 | 2 842[1] |

[1] total of all years

**Table 14B: Percent distribution of landings by month and total annual landings (t) of ELE 5 from 1989–90 to 2010–11 for the bottom trawl and setnet methods for trips which landed ELE 5. Landings (t) have been scaled to the QMR totals using Eq. 1; [–]: no landings in this cell.**

| Fishing Year | Month Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Total (t) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bottom trawl distribution (%) | | | | | | | | | | | | |
| 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 | 3.9 | 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 | 5.5 | 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 | 22.6 | 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 | 27.1 | 4.2 | 21.7 | 15.3 | 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 | 23.2 | 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 | 7.6 | 8.0 | 9.1 | 15.9 | 2.8 | 4.1 | 5.2 | 8.8 | 6.4 | 7.6 | 10.9 | 13.7 | 138 |
| 01/02 | 3.1 | 6.7 | 5.8 | 17.8 | 23.6 | 14.5 | 11.6 | 8.5 | 1.5 | 4.6 | 2.1 | 0.2 | 90 |
| 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 | 7.1 | 6.8 | 12.8 | 5.6 | 6.4 | 15.1 | 2.0 | 12.6 | 9.7 | 9.8 | 4.3 | 7.9 | 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 |
| 08/09 | 6.9 | 7.7 | 2.6 | 8.4 | 7.7 | 9.6 | 8.9 | 9.2 | 11.7 | 13.5 | 6.5 | 7.3 | 198 |
| 09/10 | 14.0 | 1.7 | 4.8 | 6.4 | 6.9 | 7.9 | 9.1 | 6.0 | 6.6 | 18.8 | 8.1 | 9.8 | 151 |
| 10/11 | 13.9 | 9.9 | 2.8 | 4.6 | 18.4 | 11.7 | 12.0 | 5.3 | 6.2 | 3.8 | 5.5 | 5.9 | 133 |
| Mean | 8.9 | 6.3 | 7.4 | 12.5 | 9.7 | 9.6 | 7.2 | 6.8 | 7.0 | 7.4 | 6.5 | 10.7 | 2 109[1] |
| | Setnet distribution (%) | | | | | | | | | | | | |
| 89/90 | – | 4.5 | 17.5 | 8.3 | 46.2 | 12.1 | – | – | – | – | 1.3 | 10.0 | 2.3 |
| 90/91 | 0.2 | 34.1 | 3.9 | 18.9 | 37.3 | 1.3 | 3.3 | 0.7 | 0.1 | – | 0.3 | – | 4.9 |
| 91/92 | 7.3 | 15.7 | 65.4 | 2.9 | 1.1 | – | 0.1 | – | 0.1 | – | 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 | – | 1.8 | – | 13 |
| 93/94 | 2.2 | 13.2 | 19.8 | 16.9 | 20.8 | 16.8 | 9.8 | 0.1 | – | – | – | 0.4 | 8.9 |
| 94/95 | 5.2 | 9.0 | 6.0 | 48.6 | 27.1 | 0.0 | 2.0 | – | – | 0.1 | – | 2.0 | 13 |
| 95/96 | 12.5 | 11.9 | 29.5 | 40.5 | 3.6 | 1.9 | – | – | – | – | – | 0.1 | 12 |
| 96/97 | 1.8 | 8.5 | 12.6 | 71.0 | 3.2 | 0.2 | – | 0.2 | 1.4 | – | 1.1 | – | 8.4 |
| 97/98 | – | 0.4 | 8.2 | 56.3 | 26.7 | 4.0 | 1.8 | 2.3 | 0.2 | – | – | – | 11 |
| 98/99 | – | 45.9 | 16.9 | 22.0 | 13.3 | 0.3 | – | 0.1 | 1.5 | – | – | – | 10 |
| 99/00 | 0.2 | 5.4 | 32.5 | 51.7 | 8.6 | 1.2 | – | 0.0 | 0.4 | – | – | – | 9.2 |
| 00/01 | 0.1 | 32.5 | 51.4 | 0.7 | 2.9 | 12.5 | 0.0 | – | – | – | – | – | 12 |
| 01/02 | 0.1 | 46.6 | 2.1 | 13.0 | 26.3 | 10.2 | 0.6 | 0.0 | 0.0 | 1.1 | – | – | 14 |
| 02/03 | – | 20.5 | 20.7 | 29.8 | 22.9 | 0.2 | 1.3 | 0.2 | – | 1.3 | 0.4 | 2.6 | 4.4 |
| 03/04 | 2.9 | 5.6 | 50.4 | 29.2 | 2.6 | 1.4 | 0.7 | 6.0 | 0.9 | 0.0 | 0.3 | – | 7.2 |
| 04/05 | 5.9 | 17.3 | 6.8 | 63.1 | 1.1 | 1.0 | 0.3 | 0.6 | 3.6 | 0.1 | 0.1 | 0.2 | 17 |
| 05/06 | 11.5 | 43.0 | 25.2 | 2.8 | 3.8 | 0.9 | 0.1 | 1.4 | – | 0.0 | 0.3 | 11.1 | 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 | 7.3 |
| 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 |
| 08/09 | 33.4 | 16.6 | 5.1 | 0.9 | 3.9 | 0.3 | 0.7 | 0.5 | 17.0 | 8.7 | 5.0 | 7.9 | 10 |
| 09/10 | 45.2 | 3.6 | 6.4 | 0.8 | 0.8 | 0.2 | 2.1 | 8.6 | 23.2 | 3.3 | 5.4 | 0.2 | 25 |
| 10/11 | 41.3 | 17.7 | 0.8 | 0.2 | 6.2 | 4.7 | 1.3 | 5.1 | 1.2 | 1.2 | 15.8 | 4.7 | 21 |
| Mean | 12.1 | 19.3 | 17.7 | 20.6 | 9.5 | 3.4 | 1.4 | 2.0 | 7.3 | 1.1 | 2.6 | 3.1 | 280[1] |

[1] total of all years

### 2.4.3.5 Distribution of landings by declared target species

The predominant bottom trawl fisheries taking elephantfish in ELE 3 are, in order of importance in terms of total elephantfish landings, those targeted at red cod, elephantfish and flatfish (Table 15). These fisheries take collectively about 80% of the total landings of elephantfish in ELE 3. Other target trawl fisheries which take elephantfish include barracouta, rig, and tarakihi (Table 15; Figure 15). The relative importance of the ELE 3 red cod bottom trawl fishery has diminished from 2001–02 with the decline in red cod stocks on the east coast of the South Island (Table 16A). There has been a compensatory increase in the bottom trawl target fishery for elephantfish, which has contributed around 40% of the ELE 3 landings since 2006–07 (Table 16A). Two target bottom trawl fisheries dominate the landings of elephantfish in ELE 5, with the target flatfish and stargazer fisheries accounting for over 70% of the total landings (Table 16A). There has also been shift in the relative importance of ELE 5 bottom trawl fisheries over time, with a decrease in the importance of the bycatch of elephantfish in the flatfish fishery and a rise in the importance of the target stargazer fishery (Table 16A). However, there has been no corresponding increase in the level of target elephantfish bottom trawl fishing as seen in ELE 3.

The ELE 3 setnet fishery is almost entirely targeted at elephantfish and rig (Table 16B; Figure 15). Target setnet fishing for elephantfish has approximately the same importance in the late 2000s as was seen in the early 1990s, after having decreased in importance in the late 1990s and early 2000s (Table 16B). The ELE 5 setnet fishery is targeted exclusively at school shark and rig, with negligible targeting at elephantfish (Table 16B).

**Table 15: Landings (t) and distribution of landings (%) of elephantfish from trips which landed ELE 3 or ELE 5 by target species and important fishing methods (Table 11), summed from 1989–90 to 2010–11. Landings (t) have been scaled to the QMR totals using Eq. 1. [–]: no landings in this cell.**

| Target | Fishing Method | | | | | Fishing Method | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Species | BT | SN | DS | Other | Total | BT | SN | DS | Other | Total |
| ELE 3 | Total landings (t) | | | | | Distribution of landings (%) | | | | |
| RCO | 5 446 | 2.9 | 160 | 0.1 | 5 609 | 30.2 | 0.02 | 0.9 | 0.0004 | 31.1 |
| ELE | 3 014 | 1 259 | 63 | – | 4 337 | 16.7 | 7.0 | 0.4 | – | 24.0 |
| FLA | 3 240 | 0.2 | 155 | 2.9 | 3 399 | 18.0 | 0.001 | 0.9 | 0.02 | 18.8 |
| BAR | 1 842 | – | – | 0.2 | 1 842 | 10.2 | – | – | 0.001 | 10.2 |
| SPO | 83 | 1 086 | 28 | 5.2 | 1 203 | 0.5 | 6.0 | 0.2 | 0.03 | 6.7 |
| TAR | 473 | 11 | 46 | – | 530 | 2.6 | 0.1 | 0.3 | – | 2.9 |
| SCH | 17 | 357 | 0.4 | – | 375 | 0.1 | 2.0 | 0.002 | – | 2.1 |
| GUR | 293 | 0.02 | 0.9 | – | 294 | 1.6 | 0.0001 | 0.005 | – | 1.6 |
| SPD | 25 | 69 | 1.1 | – | 95 | 0.1 | 0.4 | 0.01 | – | 0.5 |
| WAR | 73 | 10 | – | – | 83 | 0.4 | 0.1 | – | – | 0.5 |
| OTH | 220 | 46 | 0.9 | 2.3 | 269 | 1.2 | 0.3 | 0.01 | 0.01 | 1.5 |
| Total ELE 3 | 14 727 | 2 842 | 456 | 11 | 18 035 | 81.7 | 15.8 | 2.5 | 0.1 | 100 |
| | Total landings (t) | | | | | Distribution of landings (%) | | | | |
| FLA | 974 | – | – | 2.2 | 977 | 40.6 | – | – | 0.1 | 40.6 |
| STA | 541 | – | – | – | 541 | 22.5 | – | – | – | 22.5 |
| ELE | 294 | 34 | – | – | 328 | 12.2 | 1.4 | – | – | 13.7 |
| SPD | 115 | 19 | – | – | 134 | 4.8 | 0.8 | – | – | 5.6 |
| SPO | 14 | 118 | – | – | 132 | 0.6 | 4.9 | – | – | 5.5 |
| SCH | 1 | 108 | – | 0.1 | 109 | 0.03 | 4.5 | – | 0.005 | 4.5 |
| GUR | 71 | – | – | 0.7 | 72 | 3.0 | – | – | 0.03 | 3.0 |
| OTH | 99 | 0.04 | – | 11 | 111 | 4.1 | 0.002 | – | 0.5 | 4.6 |
| Total ELE 5 | 2 109 | 280 | – | 14 | 2 403 | 87.8 | 11.6 | – | 0.6 | 100 |

Bottom trawl fishing in ELE 3 by target species and statistical area shows some spatial variation, with most of the target fishing for elephantfish taking place in Canterbury Bight (Area 022) (Figure 16A). Bycatch of elephantfish in the target bottom trawl flatfish fishery predominates in Area 024, while target bottom trawl fishing for red cod predominates in Area 022, along with some target fishing for flatfish and barracouta in the same Area (Figure 16A). The catch of elephantfish in the ELE 3 setnet fishery is mainly taken by rig target fishing in Areas 018 and 020, while target fishing for elephantfish and rig predominate in Areas 022 and 024 (Figure 16B). The ELE 5 bottom trawl fishery targets flatfish at both ends of Foveaux Strait, but stargazer target fishing appears to take place mainly to the west of Stewart Island (Figure 16C). Both ends of Foveaux Strait show similar patterns of elephantfish bycatch in the setnet target fishing for rig and schoolshark (Figure 16C).

**Table 16A: Percent distribution of landings by target species (Table 11) from 1989–90 to 2010–11 for the bottom trawl method for trips which landed ELE 3 and ELE 5. Annual landings by method are available in Table 14; [–]: no landings in this cell.**

| Fishing | | | | | | | | | | Target species |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | RCO | FLA | ELE | BAR | STA | TAR | GUR | SPD | SPO | Other |
| | ELE 3 Bottom trawl distribution (%) | | | | | | | | | |
| 89/90 | 22.2 | 22.8 | 23.6 | 14.6 | 2.4 | 3.1 | 5.4 | 0.1 | 0.02 | 5.8 |
| 90/91 | 24.1 | 21.7 | 14.7 | 31.5 | 0.1 | 3.8 | 2.1 | 0.1 | 0.2 | 1.8 |
| 91/92 | 32.6 | 28.6 | 12.7 | 14.8 | 1.7 | 5.5 | 1.9 | 0.03 | 1.4 | 0.9 |
| 92/93 | 42.5 | 22.6 | 11.8 | 12.7 | 0.1 | 5.5 | 1.1 | 1.8 | 0.2 | 2.0 |
| 93/94 | 55.0 | 20.8 | 9.9 | 5.2 | 0.2 | 6.0 | 1.2 | 0.002 | 0.6 | 1.1 |
| 94/95 | 67.9 | 14.8 | 5.1 | 8.2 | 0.0 | 1.6 | 1.5 | 0.02 | 0.2 | 0.7 |
| 95/96 | 53.4 | 17.5 | 5.7 | 13.5 | 0.5 | 6.2 | 0.3 | 0.1 | 0.2 | 2.6 |
| 96/97 | 53.9 | 24.3 | 3.5 | 12.4 | 0.3 | 3.4 | 0.7 | 0.01 | 0.7 | 1.0 |
| 97/98 | 63.1 | 23.1 | 2.1 | 8.3 | 0.1 | 2.0 | 0.6 | 0.003 | 0.1 | 0.5 |
| 98/99 | 46.4 | 38.3 | 1.7 | 11.1 | 0.1 | 0.6 | 0.1 | 0.004 | 0.004 | 1.7 |
| 99/00 | 43.3 | 37.7 | 3.5 | 12.4 | 0.5 | 1.6 | 0.2 | 0.1 | 0.03 | 0.6 |
| 00/01 | 52.5 | 25.3 | 3.6 | 13.7 | 0.9 | 1.3 | 1.7 | – | 0.001 | 1.0 |
| 01/02 | 48.9 | 23.4 | 9.8 | 12.6 | 0.3 | 1.7 | 1.4 | 0.4 | 0.7 | 0.8 |
| 02/03 | 35.1 | 18.3 | 14.1 | 28.7 | 0.3 | 0.9 | 1.0 | 0.02 | 0.02 | 1.5 |
| 03/04 | 37.4 | 15.4 | 27.8 | 15.1 | 0.3 | 1.5 | 0.8 | 0.003 | 0.2 | 1.4 |
| 04/05 | 35.0 | 19.5 | 31.9 | 9.8 | 0.1 | 1.5 | 1.2 | 0.1 | – | 0.9 |
| 05/06 | 42.2 | 15.0 | 27.2 | 7.3 | 0.04 | 3.5 | 2.4 | 0.5 | 0.0003 | 1.8 |
| 06/07 | 22.2 | 16.0 | 37.9 | 13.4 | 0.2 | 5.7 | 1.9 | 0.4 | 0.9 | 1.3 |
| 07/08 | 19.7 | 20.6 | 39.3 | 9.4 | 0.1 | 5.1 | 3.3 | 0.1 | 0.2 | 2.4 |
| 08/09 | 15.6 | 17.5 | 42.6 | 12.6 | 0.3 | 5.8 | 2.8 | 0.3 | 1.5 | 1.2 |
| 09/10 | 9.8 | 22.6 | 41.0 | 10.0 | 0.1 | 3.6 | 6.0 | 0.1 | 2.8 | 4.2 |
| 10/11 | 13.3 | 20.6 | 43.8 | 6.1 | 0.8 | 4.2 | 5.2 | 0.04 | 1.8 | 4.2 |
| Mean | 37.0 | 22.0 | 20.5 | 12.5 | 0.4 | 3.2 | 2.0 | 0.2 | 0.6 | 1.7 |
| | ELE 5 Bottom trawl distribution (%) | | | | | | | | | |
| 89/90 | 0.2 | 23.2 | 11.6 | 0.7 | 38.0 | 5.6 | 5.5 | 8.8 | – | 6.3 |
| 90/91 | 0.0 | 50.1 | 9.8 | 0.4 | 34.6 | 0.8 | 2.2 | 0.004 | 0.3 | 1.8 |
| 91/92 | 0.0 | 50.1 | 6.8 | – | 39.5 | 0.2 | 1.6 | – | 0.1 | 1.7 |
| 92/93 | 0.1 | 52.9 | 0.4 | 0.5 | 44.1 | – | 0.1 | – | 0.1 | 1.8 |
| 93/94 | 0.2 | 27.9 | 4.8 | 0.0 | 51.0 | 8.9 | 4.2 | – | 1.9 | 1.0 |
| 94/95 | 11.5 | 45.0 | 5.1 | 0.0 | 35.4 | – | 2.0 | – | 0.8 | 0.1 |
| 95/96 | 0.1 | 43.4 | 21.8 | 11.8 | 4.7 | – | 4.0 | – | 11.9 | 2.2 |
| 96/97 | – | 80.5 | 13.0 | – | 6.2 | – | 0.3 | – | – | 0.005 |
| 97/98 | – | 82.7 | 7.1 | – | 10.2 | – | 0.03 | – | – | – |
| 98/99 | – | 79.8 | 1.0 | 5.9 | 12.1 | – | 1.0 | – | – | 0.2 |
| 99/00 | 1.4 | 81.7 | 1.0 | – | 7.9 | – | 7.7 | – | – | 0.2 |
| 00/01 | – | 85.8 | – | 0.7 | 11.0 | – | 1.2 | – | – | 1.3 |
| 01/02 | 3.9 | 59.2 | 5.0 | 3.0 | 16.4 | 0.2 | 3.2 | – | – | 9.1 |
| 02/03 | 1.0 | 47.7 | 27.1 | 0.2 | 18.5 | 3.2 | 1.2 | – | – | 1.1 |
| 03/04 | 1.2 | 43.2 | 15.9 | 0.6 | 32.0 | – | 5.5 | – | 0.9 | 0.7 |
| 04/05 | 1.5 | 23.5 | 33.8 | 0.1 | 30.5 | 0.3 | 7.4 | 1.6 | 1.1 | 0.2 |
| 05/06 | – | 20.4 | 26.5 | 0.0 | 31.7 | – | 5.6 | 12.4 | – | 3.3 |
| 06/07 | – | 29.4 | 19.5 | 1.6 | 28.4 | 0.1 | 7.4 | 12.9 | – | 0.7 |
| 07/08 | – | 43.0 | 18.8 | 0.9 | 24.2 | 0.01 | 0.8 | 11.0 | 0.2 | 1.1 |
| 08/09 | 0.1 | 27.9 | 13.5 | 0.6 | 31.8 | 0.3 | 3.0 | 22.3 | 0.4 | 0.2 |
| 09/10 | 0.0 | 29.4 | 19.6 | 0.0 | 38.4 | 0.03 | 2.4 | 4.1 | 1.2 | 4.9 |
| 10/11 | 1.1 | 22.4 | 12.2 | 4.3 | 41.6 | 0.8 | 4.9 | 5.2 | 0.03 | 7.6 |
| Mean | 0.8 | 46.2 | 13.9 | 1.4 | 25.6 | 0.5 | 3.4 | 5.4 | 0.6 | 2.0 |

**Table 16B: Percent distribution of landings by target species (Table 11) from 1989–90 to 2010–11 for the setnet method for trips which landed ELE 3 and ELE 5. Annual landings by method are available in Table 14; [–]: no landings in this cell.**

| Fishing | Target species | | | | | | | Target species | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | ELE | SPO | SCH | SPD | HPB | MOK | Other | ELE | SPO | SCH | SPD | Other |
| | ELE 3 Setnet distribution (%) | | | | | | | ELE 5 Setnet distribution (%) | | | | |
| 89/90 | 57.3 | 23.5 | 4.5 | 11.4 | 0.9 | 0.2 | 2.2 | 50.4 | 19.2 | 30.4 | – | – |
| 90/91 | 79.1 | 4.9 | 5.9 | 6.2 | 0.8 | 0.6 | 2.5 | 66.4 | 14.2 | 19.4 | – | – |
| 91/92 | 64.6 | 16.5 | 7.9 | 5.6 | 1.5 | 0.3 | 3.6 | 72.4 | 16.5 | 11.1 | – | 0.1 |
| 92/93 | 37.0 | 17.1 | 34.0 | 4.7 | 5.0 | 0.2 | 2.0 | 46.6 | 39.1 | 13.9 | 0.3 | 0.2 |
| 93/94 | 44.0 | 24.3 | 24.6 | 3.3 | 1.3 | 0.2 | 2.2 | 20.9 | 20.2 | 59.0 | – | – |
| 94/95 | 41.4 | 21.5 | 30.0 | 3.8 | 1.6 | 0.1 | 1.8 | 2.2 | 20.2 | 77.6 | – | – |
| 95/96 | 42.6 | 22.3 | 20.9 | 8.8 | 0.4 | 0.9 | 4.1 | 2.9 | 35.1 | 62.0 | – | 0.1 |
| 96/97 | 38.2 | 29.6 | 24.7 | 4.1 | 0.7 | 1.0 | 1.7 | 70.4 | 19.5 | 10.1 | – | – |
| 97/98 | 21.6 | 46.1 | 20.4 | 5.8 | 0.6 | 1.6 | 3.9 | – | 12.5 | 87.5 | – | – |
| 98/99 | 23.1 | 42.8 | 30.5 | 1.3 | 0.1 | 0.1 | 2.0 | 13.6 | 43.8 | 42.7 | – | – |
| 99/00 | 12.6 | 49.6 | 35.1 | 0.1 | 0.7 | 0.1 | 1.7 | 42.7 | 31.5 | 25.8 | – | – |
| 00/01 | 16.5 | 53.7 | 26.8 | 0.9 | 0.4 | 0.2 | 1.6 | 16.2 | 65.9 | 12.6 | 5.3 | – |
| 01/02 | 27.4 | 63.4 | 3.6 | 4.8 | 0.1 | 0.0 | 0.6 | – | 61.1 | 38.9 | – | – |
| 02/03 | 37.6 | 55.9 | 5.5 | 0.7 | 0.0 | 0.1 | 0.2 | 3.8 | 41.7 | 54.5 | – | – |
| 03/04 | 42.2 | 53.1 | 2.8 | 1.6 | 0.0 | 0.0 | 0.2 | – | 59.6 | 40.4 | – | – |
| 04/05 | 67.0 | 27.7 | 2.4 | 0.4 | 0.8 | 0.9 | 0.9 | – | 92.4 | 7.6 | – | – |
| 05/06 | 58.4 | 38.0 | 0.4 | 2.5 | 0.31 | 0.1 | 0.2 | – | 70.7 | 23.1 | 6.2 | – |
| 06/07 | 55.7 | 40.5 | 2.0 | 0.8 | 0.4 | 0.2 | 0.4 | – | 54.5 | 43.3 | 2.2 | – |
| 07/08 | 51.6 | 42.0 | 4.0 | 0.3 | 0.2 | 1.2 | 0.6 | – | 41.4 | 27.7 | 30.9 | – |
| 08/09 | 66.3 | 29.0 | 2.7 | 0.0 | 0.6 | 1.0 | 0.3 | – | 45.7 | 54.3 | – | – |
| 09/10 | 57.7 | 35.5 | 4.7 | 0.6 | 0.1 | 1.0 | 0.5 | – | 32.9 | 46.6 | 20.5 | – |
| 10/11 | 53.0 | 39.7 | 5.3 | 0.0 | 0.2 | 1.3 | 0.6 | – | 20.4 | 71.3 | 8.3 | – |
| Mean | 44.3 | 38.2 | 12.6 | 2.4 | 0.6 | 0.6 | 1.3 | 12.2 | 42.2 | 38.7 | 7.0 | 0.01 |

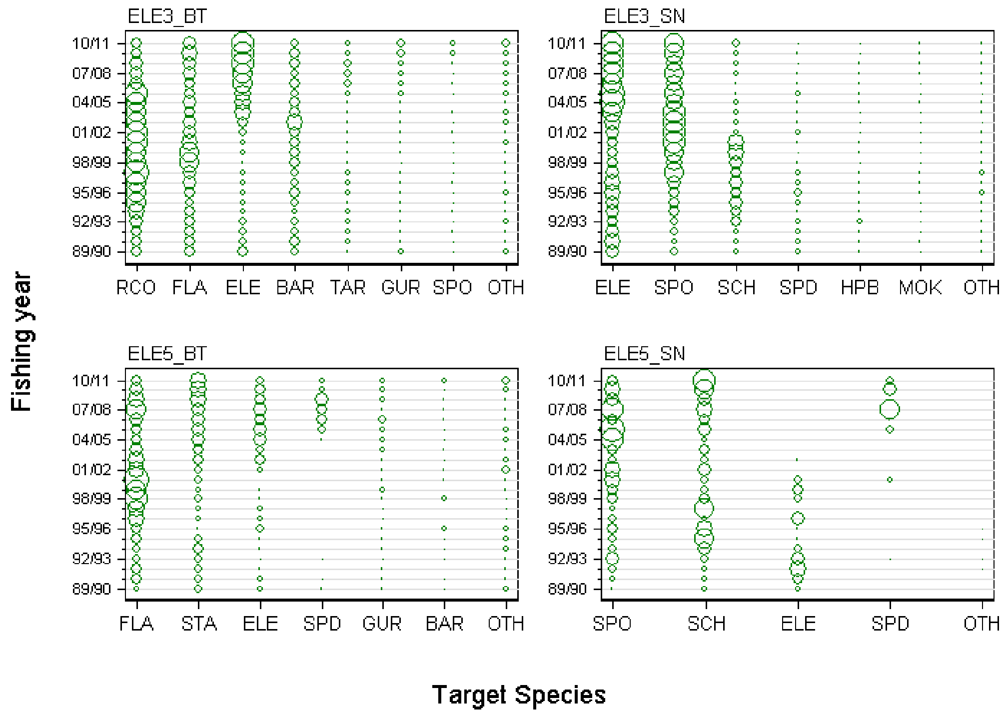


**Figure 15: Total landings by target species (Table 11) and fishing year for bottom trawl or setnet based on trips which landed ELE 3 or ELE 5. Circle sizes are proportional in each panel: [ELE 3 BT] largest circle= 489 t in 1997–98 for RCO; [ELE 3 SN] largest circle= 109 t in 2004–05 for ELE; [ELE 5 BT] largest circle= 119 t in 2000–01 for FLA; [ELE 5 SN] largest circle= 17 t in 2005–06 for SPO.**

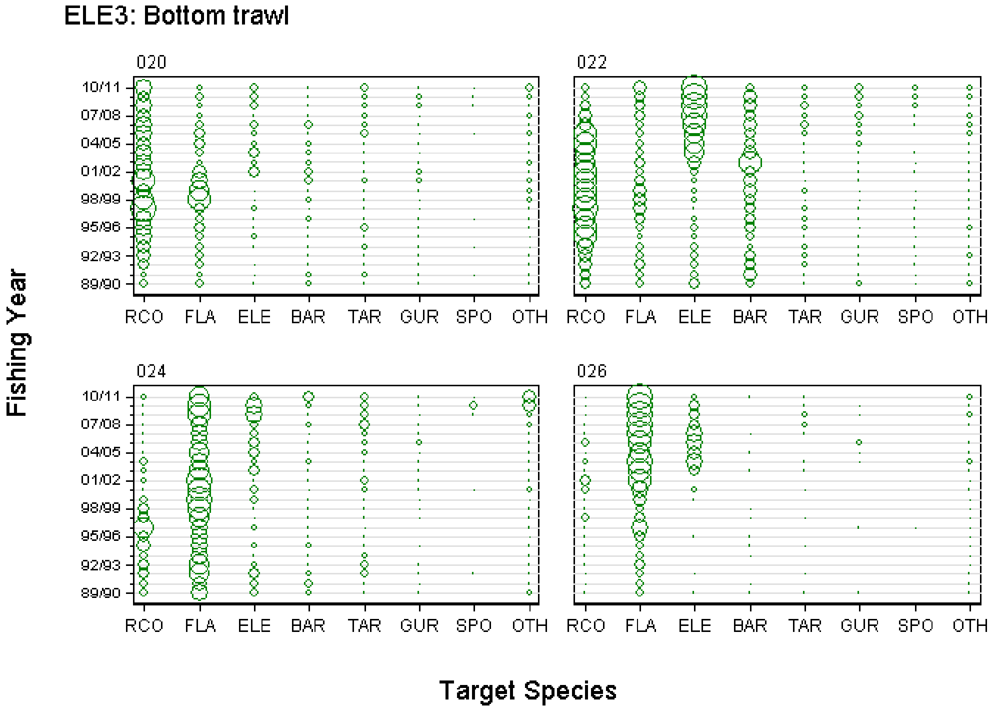


**Figure 16A: Distribution of landings for the bottom trawl method for the four most important grouped statistical areas (Table 11) for BT in ELE 3 by target species (Table 11) and fishing year. Circle sizes are proportional within each panel: maximum values: [020]: largest circle 166 t in 1997–98 for RCO; [022]: largest circle 338 t in 2010–11 for ELE; [024]: largest circle 63 t in 1999–00 for FLA; [026]: largest circle 57 t in 2007–08 for FLA.**

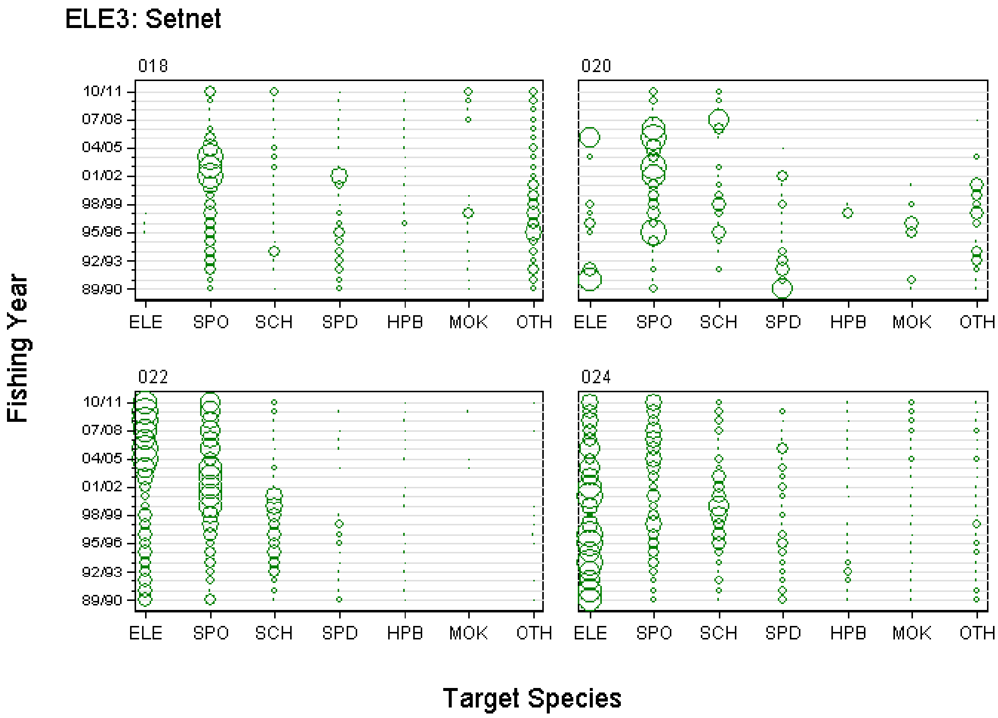


**Figure 16B: Distribution of landings for the setnet method for the four most important grouped statistical areas (Table 11) for setnet in ELE 3 by target species (Table 11) and fishing year. Circle sizes are proportional within each panel: maximum values: [018]: largest circle 8.9 t in 2001–02 for SPO, [020]: largest circle 3.9 t in 2005–06 for SPO; [022]: largest circle 103 t in 2004–05 for ELE; [024]: largest circle 22 t in 1995–96 for ELE.**

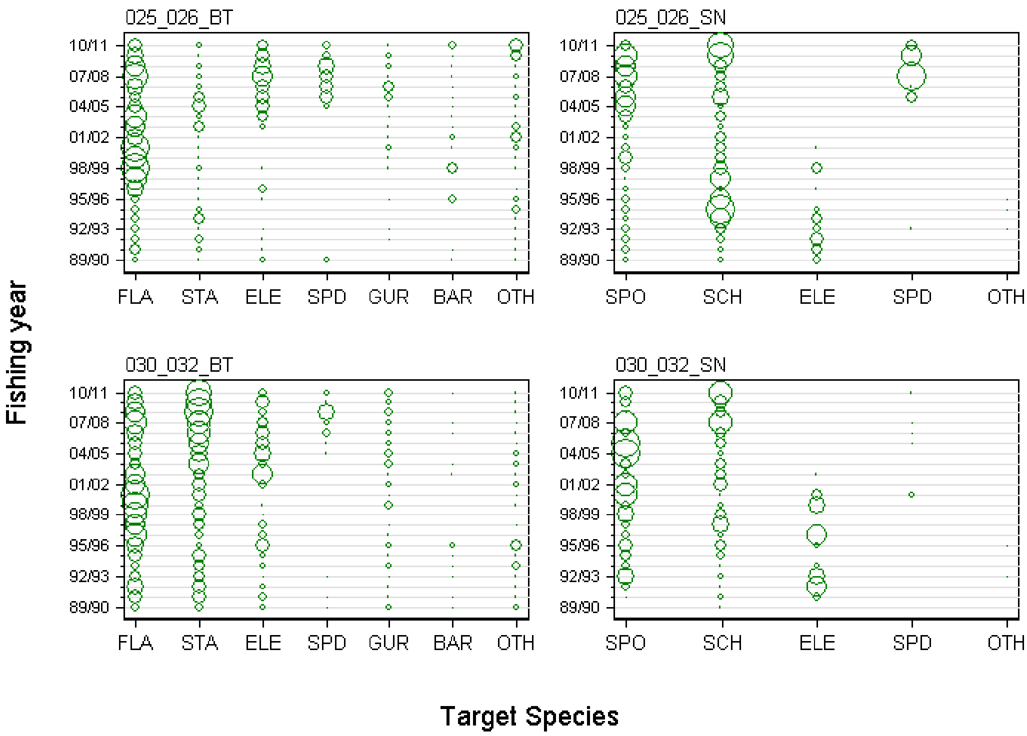


**Figure 16C: Distribution of landings for the bottom trawl and setnet methods for the two most important grouped statistical areas (Table 11) in ELE 5 for month and fishing year. Circle sizes are proportional within each panel: maximum values: [025_026_BT]: largest circle 59 t in 1998–99 for FLA, [025_026_SN]: largest circle 10 t in 2007–08 for SPD; [030_032_BT]: largest circle 61 t in 2000–01 for FLA; [030_032_SN]: largest circle 13 t in 2005–06 for SPO.**

### 2.4.3.6 Preferred bottom trawl fishing depths for elephantfish

Prior to the introduction of the TCER form in October 2007, depth information was only available from TCEPR forms. NCELR forms, although by individual set, do not record depth information. The TCEPR and TCER forms provide tow-by-tow information about the depth of capture of elephantfish which are obtained from those tows where elephantfish were either declared as the target species or there was an estimated catch of elephantfish recorded for the tow. A summary of these reports stratified by the declared target species showed that elephantfish in ELE 3 are mainly taken between 15 and 90 m of depth, with mean and median values between 40 and 50 m (Table 17). Depths for elephantfish in ELE 5 are deeper (reflecting the predominant STA fishery), with the upper 95% quantile at 136 m depth and with mean and medians near to or above 50 m.

The depth distribution of tows which caught or targeted elephantfish in ELE 3 showed differences between fisheries which reflected the preferred depth range for each declared target species. For instance, the target red cod and barracouta fisheries appear to take elephantfish at shallower depths than the tarakihi and stargazer bottom trawl fisheries, which is likely to be a function of how the fishery operates on its target species (Figure 17A). At the more shallow extreme, the target flatfish fishery in QMA 3 operates in a very similar depth range to the target elephantfish fishery. Observations are similar in ELE 5, with the target flatfish fishery operating at a very similar depth range to the target elephantfish fishery while the target stargazer and barracouta fisheries showed a much deeper range of depths compared to the target ELE and FLA fisheries (Figure 17B). There appears to be a seasonal component to the depths fished, with an apparent shift to a deeper depth range for the target ELE fisheries in both ELE 3 (Figure 18A) and ELE 5 (Figure 18B) in the autumn and winter months compared to the spring and summer period. A similar shift occurs in the BAR, RCO and STA fisheries in both ELE 3 and ELE 5 (Table 18). This shift may reflect a similar shift in the target species depth distribution rather than the ELE depth distribution because the shift to deeper depths is not seen in the FLA fishery in either ELE 3 or ELE 5 (Table 18).

**Table 17: Annual summary statistics from distributions of bottom depth from bottom trawl TCER and TCEPR records for effort that targeted or caught elephantfish by target species category in valid statistical areas for ELE 3 or ELE 5. This table is based on all tows in the dataset (1989–90 to 2010–11).**

| | | Depth (m) | | | |
|---|---|---|---|---|---|
| Target species category | Number of observations | Lower 5% of distribution | Mean of distribution | Median (50%) of distribution | Upper 95% of distribution |
| ELE 3 Bottom trawl | | | | | |
| FLA | 8 214 | 15 | 37 | 38 | 65 |
| RCO | 4 078 | 21 | 52 | 50 | 90 |
| BAR | 3 376 | 20 | 54 | 50 | 100 |
| ELE | 2 797 | 12 | 33 | 29 | 65 |
| TAR | 1 702 | 42 | 67 | 63 | 100 |
| GUR | 655 | 18 | 37 | 37 | 55 |
| WAR | 354 | 34 | 51 | 46 | 95 |
| SPO | 220 | 12 | 33 | 27 | 94 |
| STA | 143 | 57 | 91 | 97 | 118 |
| SPE | 93 | 64 | 89 | 90 | 113 |
| Other | 356 | 15 | 170 | 54 | 1 116 |
| Total | 21 988 | 15 | 47 | 44 | 90 |
| | | | | | |
| ELE 5 Bottom trawl | | | | | |
| FLA | 5 687 | 15 | 44 | 45 | 70 |
| STA | 1 918 | 29 | 95 | 96 | 155 |
| ELE | 303 | 13 | 44 | 40 | 80 |
| SPD | 257 | 27 | 48 | 43 | 80 |
| TAR | 160 | 37 | 54 | 52 | 85 |
| GUR | 148 | 30 | 53 | 53 | 80 |
| BAR | 63 | 25 | 70 | 70 | 102 |
| Other | 131 | 13 | 63 | 62 | 117 |
| Total | 8 667 | 17 | 56 | 49 | 136 |

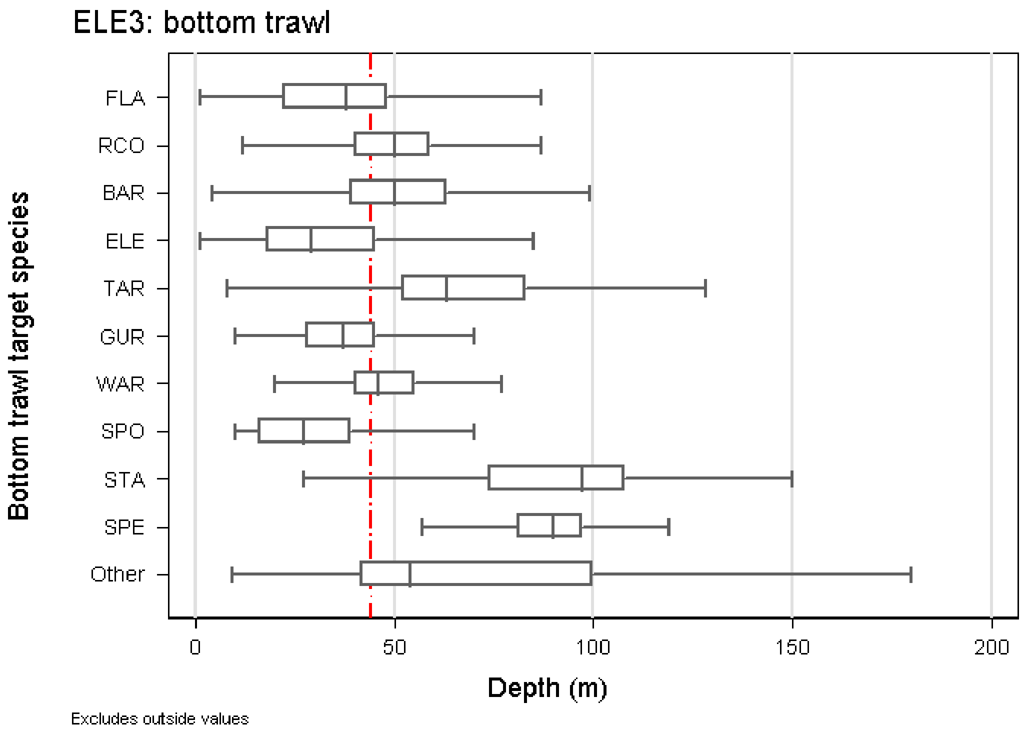


**Figure 17A: Box plot distributions of depth from combined bottom trawl TCEPR and TCER records for tows that targeted or caught elephantfish by target species category in statistical areas valid for ELE 3 between 1989–90 to 2010–11. Vertical line indicates the median depth from all tows which caught or targeted elephantfish.**

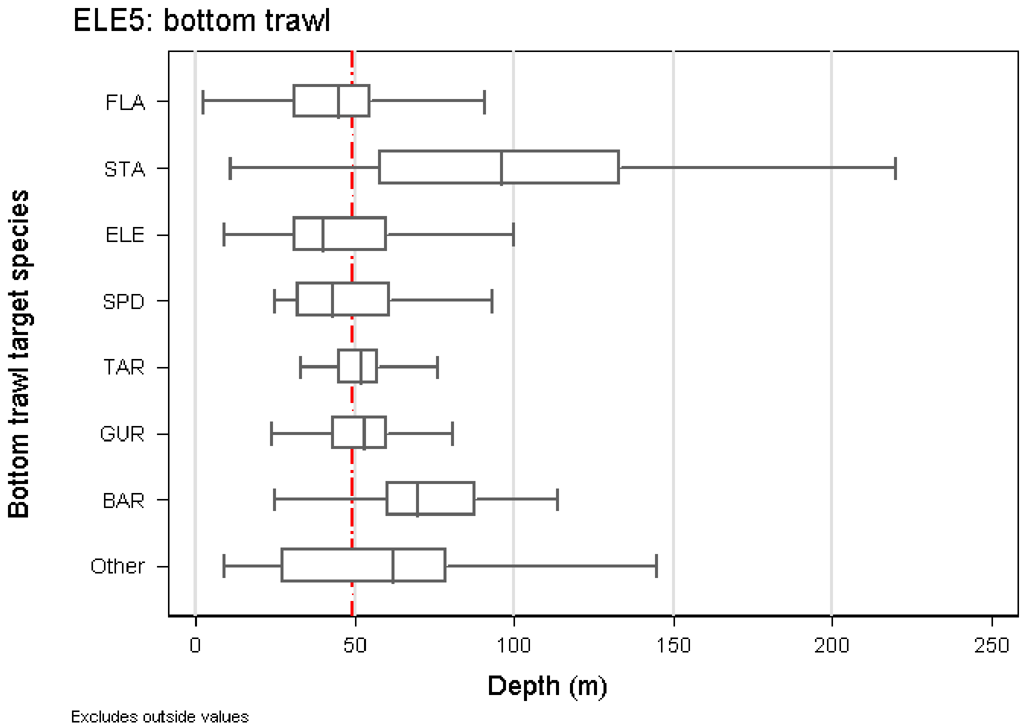


**Figure 17B: Box plot distributions of depth from combined bottom trawl TCEPR and TCER records for tows that targeted or caught elephantfish by target species category in statistical areas valid for ELE 5 between 1989–90 to 2010–11. Vertical line indicates the median depth from all tows which caught or targeted elephantfish.**

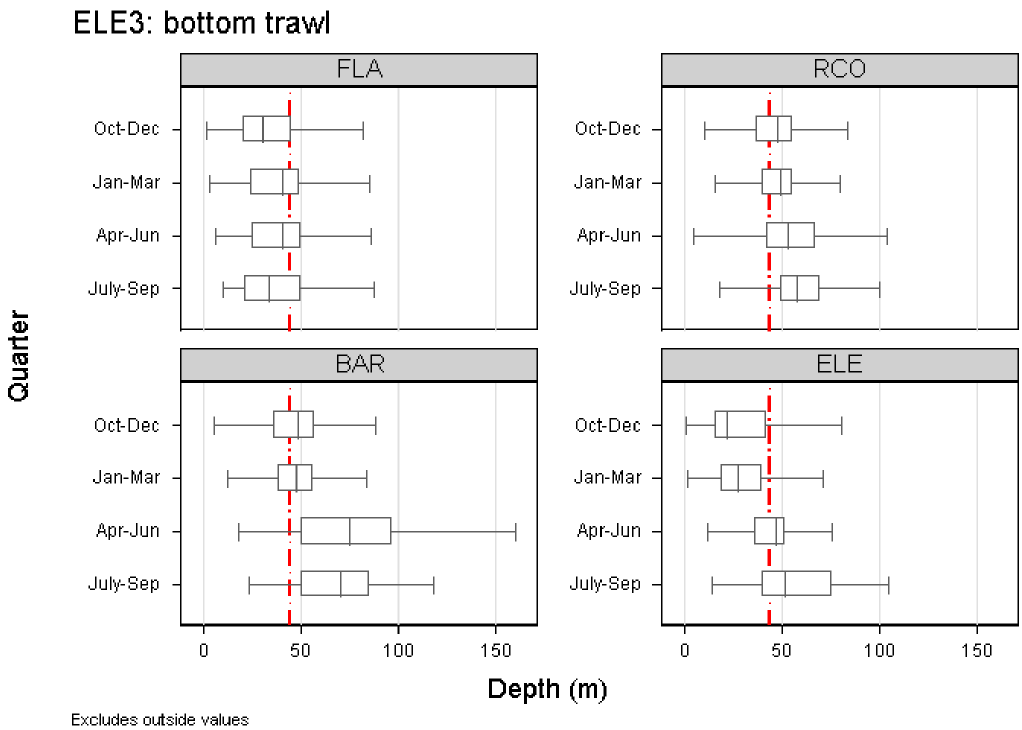


**Figure 18A: Box plot distributions showing quarterly depth distributions from bottom trawl TCEPR and TCER records for tows that targeted or caught elephantfish by the four major target species categories in statistical areas valid for ELE 3 between 1989–90 to 2010–11. Vertical line indicates the median depth from all tows which caught or targeted elephantfish.**

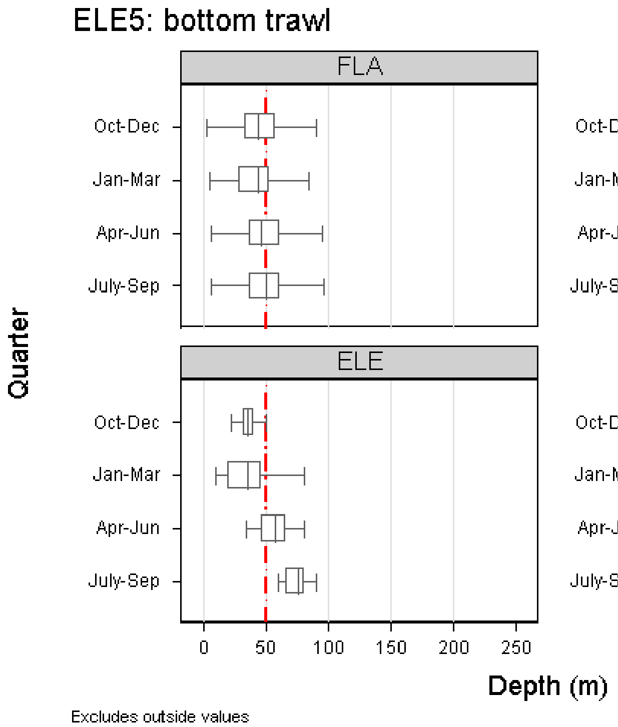


**Figure 18B: Box plot distributions showing quarterly depth distributions from bottom trawl TCEPR and TCER records for tows that targeted or caught elephantfish by the four major target species categories in statistical areas valid for ELE 3 between 1989–90 to 2010–11. Vertical line indicates the median depth from all tows which caught or targeted elephantfish.**

**Table 18: Quarterly summary statistics from distributions of bottom depth from bottom trawl TCER and TCEPR records for effort that targeted or caught elephantfish for the four target species categories with the greatest number of depth observations in valid statistical areas for ELE 3 or ELE 5. This table is based on all tows in the dataset (1989–90 to 2010–11). Annual totals can be found in Table 17.**

| | | | | | Depth (m) |
|---|---|---|---|---|---|
| Target species and quarter | Number of observations | Lower 5% of distribution | Mean of distribution | Median (50%) of distribution | Upper 95% of distribution |
| ELE 3 Bottom trawl | | | | | |
| FLA | | | | | |
| Oct-Dec | 2 759 | 14 | 34 | 30 | 65 |
| Jan-Mar | 3 609 | 15 | 38 | 40 | 63 |
| Apr-Jun | 1 381 | 15 | 40 | 40 | 66 |
| July-Sep | 465 | 13 | 38 | 33 | 80 |
| RCO | | | | | |
| Oct-Dec | 1 246 | 18 | 47 | 48 | 72 |
| Jan-Mar | 1 555 | 27 | 50 | 49 | 77 |
| Apr-Jun | 1 075 | 25 | 57 | 53 | 105 |
| July-Sep | 201 | 26 | 58 | 58 | 88 |
| BAR | | | | | |
| Oct-Dec | 1 816 | 20 | 48 | 48 | 82 |
| Jan-Mar | 825 | 24 | 51 | 47 | 100 |
| Apr-Jun | 542 | 32 | 75 | 75 | 117 |
| July-Sep | 193 | 38 | 69 | 70 | 103 |
| ELE | | | | | |
| Oct-Dec | 1 654 | 12 | 29 | 22 | 57 |
| Jan-Mar | 774 | 14 | 30 | 28 | 53 |
| Apr-Jun | 219 | 20 | 47 | 47 | 83 |
| July-Sep | 150 | 29 | 58 | 52 | 96 |

**Table 18 (cont.)**

| Target species and quarter | Number of observations | Depth (m) Lower 5% of distribution | Mean of distribution | Median (50%) of distribution | Upper 95% of distribution |
|---|---|---|---|---|---|
| ELE 5 Bottom trawl | | | | | |
| FLA | | | | | |
| Oct-Dec | 1,832 | 16 | 44 | 44 | 70 |
| Jan-Mar | 2,319 | 15 | 41 | 43 | 65 |
| Apr-Jun | 958 | 17 | 46 | 46 | 70 |
| July-Sep | 578 | 16 | 47 | 50 | 80 |
| STA | | | | | |
| Oct-Dec | 335 | 25 | 61 | 52 | 125 |
| Jan-Mar | 637 | 23 | 76 | 73 | 137 |
| Apr-Jun | 587 | 54 | 120 | 130 | 160 |
| July-Sep | 359 | 58 | 120 | 131 | 160 |
| ELE | | | | | |
| Oct-Dec | 110 | 24 | 40 | 35 | 78 |
| Jan-Mar | 110 | 12 | 36 | 35 | 70 |
| Apr-Jun | 42 | 12 | 54 | 58 | 80 |
| July-Sep | 41 | 40 | 70 | 75 | 82 |
| SPD | | | | | |
| Oct-Dec | 6 | 34 | 48 | 51 | 60 |
| Jan-Mar | 150 | 28 | 51 | 50 | 80 |
| Apr-Jun | 72 | 26 | 42 | 35 | 88 |
| July-Sep | 29 | 30 | 49 | 49 | 83 |

## 3. STANDARDISED CPUE ANALYSIS

### 3.1 ELE 3

Two bottom trawl fishery definitions were selected for monitoring ELE 3 when this Fishstock was last reviewed by the AMP Working Group (Ministry of Fisheries 2011). The use of setnet fisheries to monitor ELE 3 was discontinued because of the strong management actions taken to protect Hector's dolphins (see Section 2.3.2). The 2009 AMPWG (Adaptive Management Working Group) review made the following recommendation:

> The [AMP]WG requested that the effect of the new TCER form on the trip stratum roll-up in the BT(RCO) index be explored by calculating a BT(TRIP) index, collapsing the data for trips which targeted RCO at least once up to a full trip, thereby removing the form-type effect. In addition, a mixed target BT(MIX) index using effort from a wider range of target species should be calculated. These two indices were presented to the WG, and are shown in Figure 5. The BT(FLA) and BT(MIX) targeted indices across all valid statistical areas should be the main CPUE indices calculated for this stock in future. Statistical area should be an explanatory variable in the standardised models, and effects of (Area * Year) interaction checked to make sure that the indices are not diverging (Ministry of Fisheries 2011).

The ELE 3 bottom trawl fisheries defined for this report were:

a) **ELE3(RCO): East coast target red cod bottom trawl –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026, target RCO;

b) **ELE3(MIX): East coast mixed target species bottom trawl –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026, target RCO, STA, BAR, ELE or TAR;

A third series was prepared as a sensitivity for the effects of switching to a new formtype (Appendix G.1):

c) **ELE3(MIX)-trip: East coast, mixed target species bottom trawl, trip level stratification –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026; this dataset consisted of trips which targeted RCO, STA, BAR, ELE or TAR at least once[1], which then qualified the complete trip. These trips were amalgamated to the level of a statistical area, which effectively created a trip level data set because few trips would enter more than one statistical area within the period of a trip.

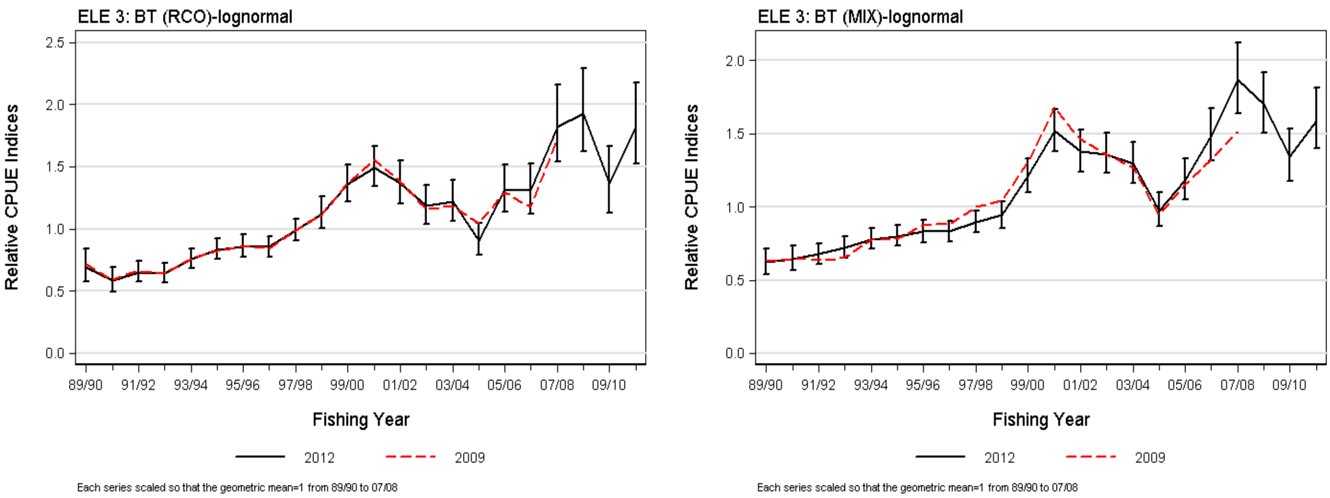


**Figure 19: Comparison of 2009 standardised CPUE analyses with the equivalent prepared for this report: [left panel]: ELE3(RCO) red cod target east coast South Island bottom trawl fishery; [right panel]: ELE3(MIX) mixed target species east coast South Island bottom trawl fishery. Each series is based on an assumed lognormal distribution and error bars show plus or minus two Standard Errors.**

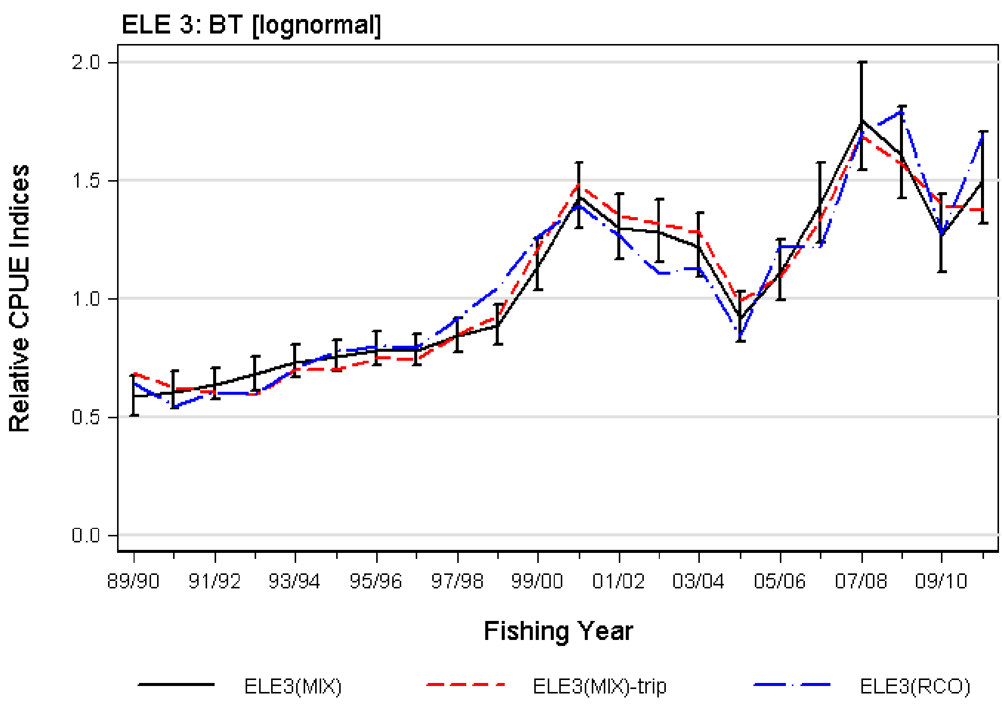


**Figure 20: Comparison of two ELE3(MIX) standardised CPUE analyses with the ELE3(RCO) analysis: a) the ELE3(MIX) and the ELE3(RCO) are "trip-stratum" based analyses and b) ELE3(MIX)-trip analysis uses data rolled up to the level of an effective trip. Error bars show plus or minus two Standard Errors.**

[1] The equivalent analysis in 2009 was based only on RCO targeting. However, the SINSWG requested that the definition of this analysis be expanded in 2012 to be equivalent to the ELE3(MIX) trip-stratum analysis.

Data were prepared in the same manner as described in Section 2.4.1 and detailed results, including all diagnostics, are presented for each of the above CPUE series in Appendix E.

There is agreement between the two trip-stratum series accepted by the 2009 AMP review (see quotation above from Ministry of Fisheries 2011) with the equivalent series generated for this report (Figure 19).

There is almost no difference between the ELE3(MIX) series based on the trip-stratum level of amalgamation and analysis based on a similar dataset but amalgamated to the level of a "trip" [ELE3(MIX)-trip], showing that the change to the TCER form type from the 2007–08 fishing year did not affect the estimated CPUE trend (Figure 20). Finally, the comparison between the two models [ELE3(RCO) and ELE3(MIX)] indicates that the two series show very similar trajectories, which have levelled out since 2007–08, which was the final fishing year in the 2009 review of ELE 3 (Figure 20).

### 3.2 ELE 5

Two fisheries were selected for monitoring ELE 5 when this Fishstock was last reviewed by the AMPWG (Ministry of Fisheries 2011). That review made the following comments:

> The [AMP]WG previously noted that differences between trends in different areas [statistical areas 025 and 030] may reflect inter-annual changes in availability or targeting in these fishery components, rather than actual abundance. There is also a strong seasonal signal in the trawl indices, with summer catch rates being 6 times greater than the winter catch rates, raising the question of whether the summer fishery dominated index is an index of abundance, or just an index of targeted effort on nearshore summer aggregations.
>
> Following these conclusions and a comparison with the approach taken for equivalent fisheries in ELE 3, the [AMP]WG recommended that a more appropriate index for ELE 5 would be a BT(MIX) (All Areas) index, with explicit modelling of the effect of target species on CPUE and including data from all valid ELE 5 statistical areas. In addition to an all areas index, the [AMP]WG recommended that a similar mixed target species index (BT(MIX)30) be calculated based on data originating only from Area 30, because there was considerably more data, particularly in recent years, than in Area 25 (Ministry of Fisheries 2011).

The ELE 5 CPUE series[2] defined for this report was:

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

Data were prepared in the same manner as described in Section 2.4.1 and detailed results, including all diagnostics, are presented for the above CPUE series in Appendix E. In addition, a second series was prepared as a sensitivity for the effects of switching to a new formtype (Appendix G.1):

b) **ELE5(MIX)-trip: South coast, mixed species bottom trawl, trip level stratification –** bottom trawl in all ELE 5 statistical areas; this dataset consisted of trips which targeted any of ELE, FLA, STA, BAR, RCO, or SPD at least once, which then qualified the complete trip. These trips were amalgamated to the level of a statistical area, which effectively created a trip level data set because few trips would enter more than one statistical area within the period of a trip.

There is reasonable agreement between the ELE5(MIX) series and the equivalent series accepted by the 2009 AMP review (see quotation above from Ministry of Fisheries, 2011) (Figure 21). The reasons for the apparent differences are not known, but may be due to the relatively small amount of data used in these analyses which may make the series sensitive to relative small shifts in the underlying data.

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[2] A preliminary review of this report by the SINSWG led to the recommendation that the additional ELE5(MIX)Area30 analysis presented in 2009 showed the same trend as the ELE 5(MIX), but with much wider error bars. The SINSWG concluded that the ELE5(MIX)Area30 analysis could be omitted

The differences between the ELE5(MIX) series based on the trip-stratum level of amalgamation and the associated ELE5(MIX)-trip analysis (based on the same data but with amalgamated to the level of a “trip”) are relatively minor and the general upward trend is clearly preserved (Figure 22). The differences between the two series shown in Figure 22 are likely to be due to the relatively small amount of catch effort data available for ELE 5 and the consequent sensitivity to small shifts in the data, including the selection of core vessels (these differences were not investigated).

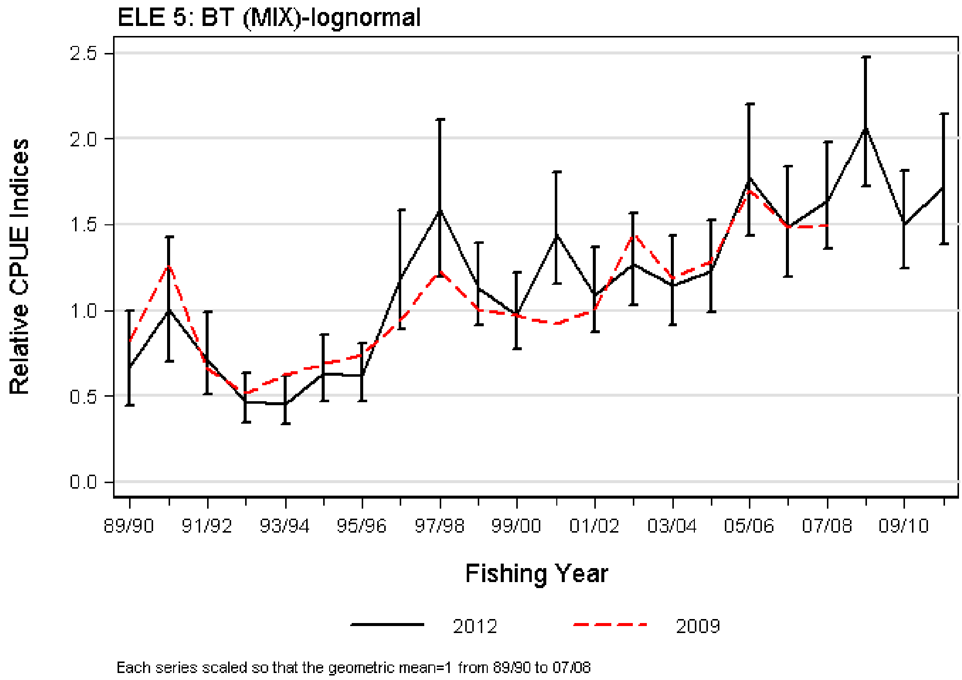


**Figure 21: Comparison of the 2009 standardised CPUE analysis with the equivalent ELE 5(MIX) mixed target species series prepared for this report. Each series is based on an assumed lognormal distribution and error bars show plus or minus two Standard Errors.**

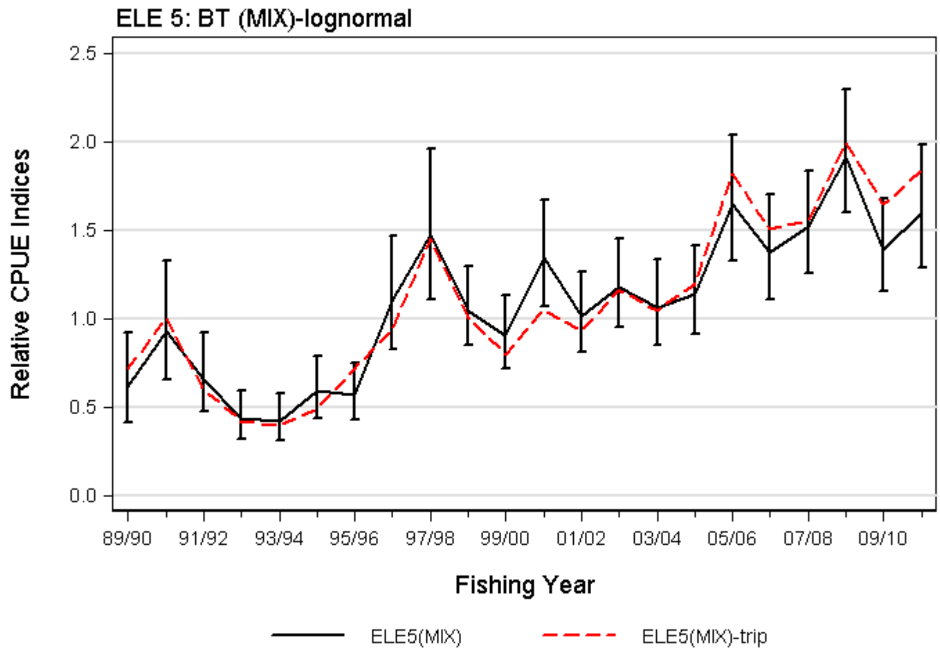


**Figure 22: Comparison of two 2012 ELE5_BT (MIX) standardised CPUE analyses: a) “trip-stratum” based analysis and b) “trip” analysis using data rolled up to the level of an effective trip, selecting trips with at least one ELE, FLA, STA, BAR, RCO, or SPD target event.**

# 4. TRAWL SURVEY ABUNDANCE INDICES

## 4.1 Trawl survey biomass indices

### 4.1.1 Winter RV *Kaharoa* surveys

The time series of east coast South Island winter (May-June) trawl surveys (Beentjes & Stevenson 2000) conducted by the RV *Kaharoa* showed variable elephantfish abundance over the period 1991 to 1996 with a large increase in 1996 (Table 19; Figure 23). Survey c.v.s were high (greater than 30%) and this survey was not thought, at the time, to be a reliable indicator of abundance for this species. The primary reason for this conclusion was that the survey only covered bottom depths from 30 m to 400 m, leaving out the shallow depths which are important habitat for this species. This survey was resumed in May 2007 for reasons described in Section 4.1.4 and was repeated in May-June of 2008 and 2009. Results for these resumed surveys appear to be consistent with the previous surveys, both in terms of estimated biomass levels and c.v.s (Table 19; Figure 25). Plots of the locations of tows which captured elephantfish are presented by survey in Figure 24A (five early surveys) and Figure 24B (resumed 2007 to 2009 surveys). Note that the 10–30 m strata accounted for a large quantity of elephantfish in 2007, but these strata captured relatively few elephantfish in 2008 and an intermediate amount in 2009 (Figure 24B).

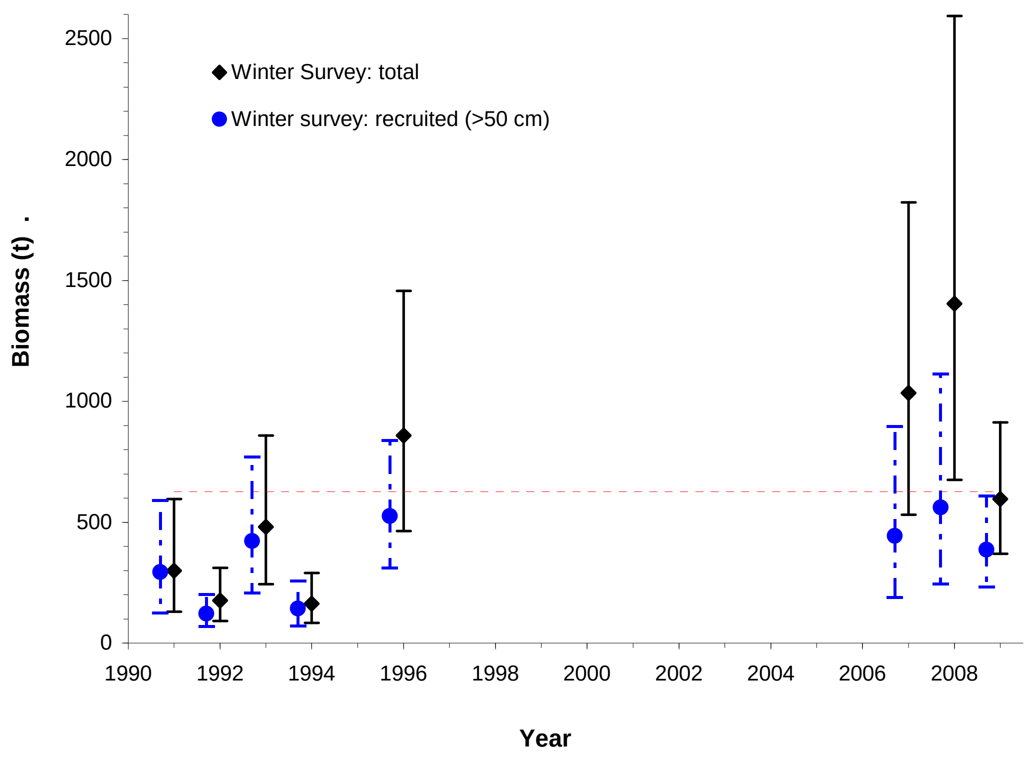


**Figure 23: Total and recruited biomass indices for elephantfish from the east coast South Island winter (May–June) trawl surveys. Approximate 95% confidence intervals are estimated from the survey c.v.s assuming a lognormal distribution. Horizontal dotted line indicates mean total biomass from the seven surveys.**

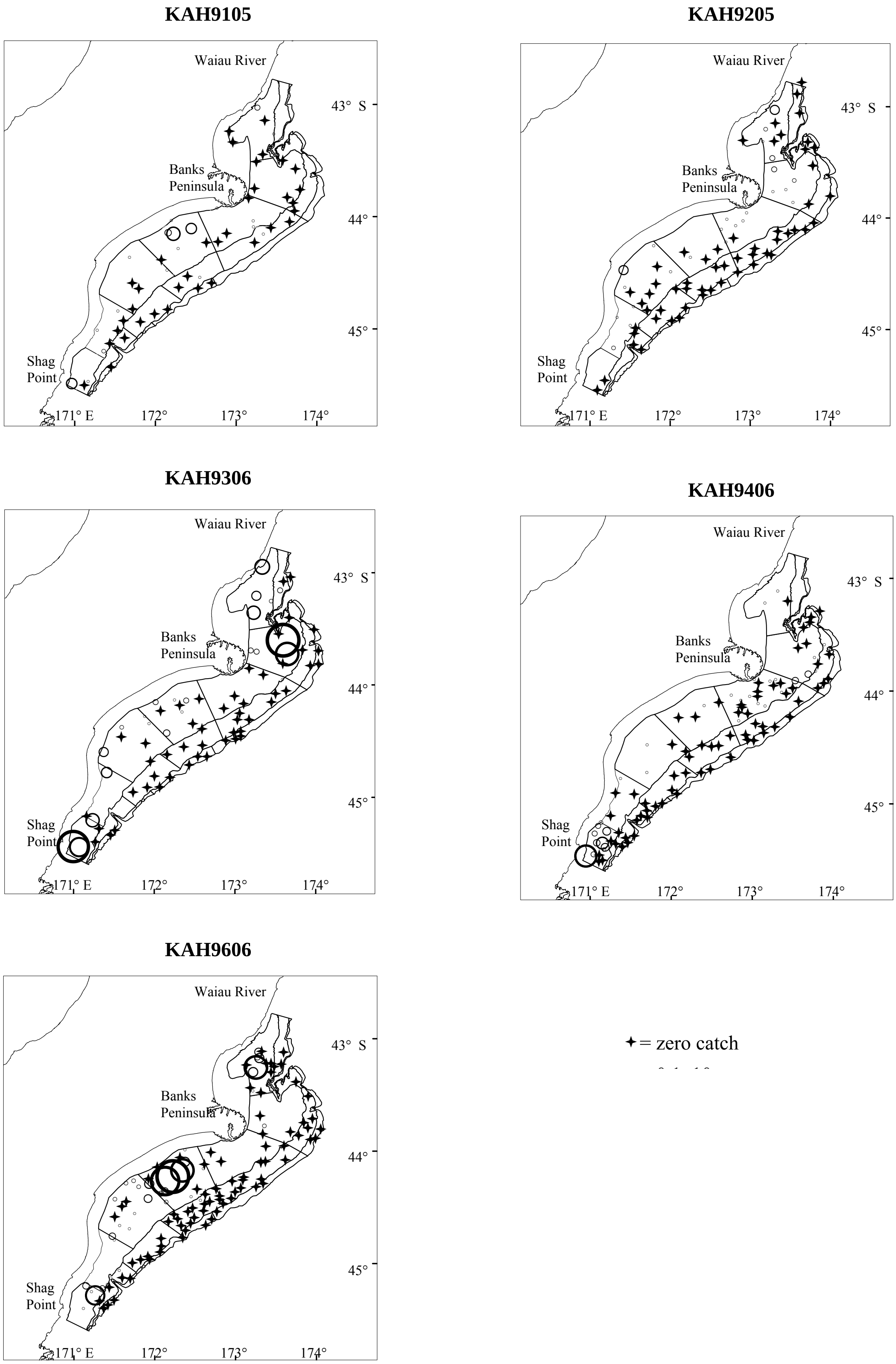


**Figure 24A: Maps showing the location of all tows for the first five winter east coast South Island RV *Kaharoa* surveys (Table 19) with the tows taking elephantfish indicated by circles proportional to the density of the tow (maximum circle size for all panels is 994 kg/km$^2$).**

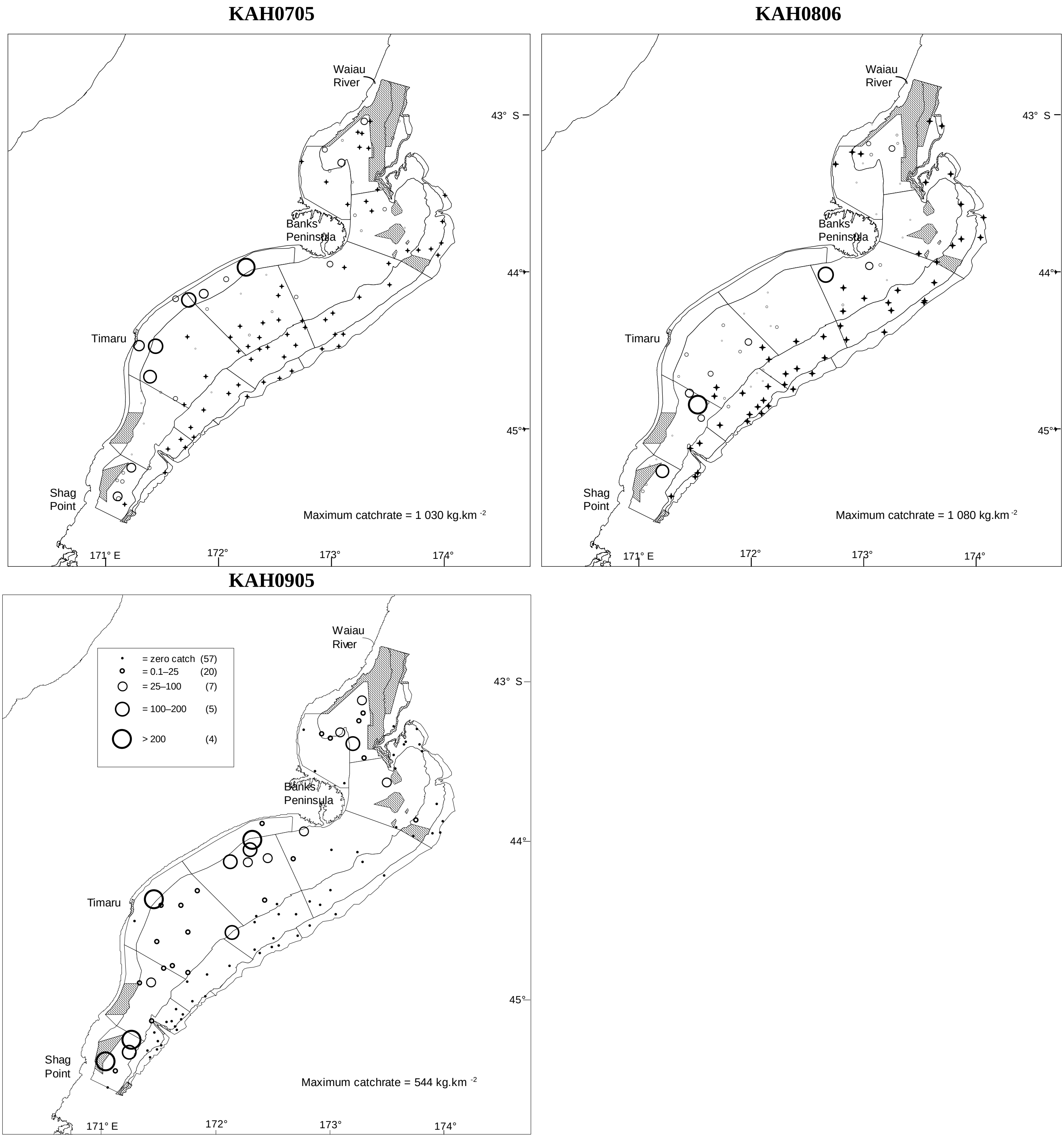


**Figure 24B: Maps showing the location of all tows for the resumed series of winter east coast South Island RV *Kaharoa* surveys (Table 19) with the tows taking elephantfish indicated by circles proportional to the density of the tow as indicated in each panel. Note that the shallow 10–30 m strata are shown but were not included in the biomass estimates.**

**Table 19: Total and recruited biomass indices with survey coefficients of variation (c.v.) for elephantfish from the east coast South Island winter (May–June) trawl surveys. Data are from Beentjes & Stevenson (2000) and Beentjes & Stevenson (2008, 2009, 2010). Corrected 1994 survey estimate are from M. Stevenson (NIWA *pers. comm.*). Recruited biomass estimates include elephantfish greater than 50 cm fork length.**

| Year | Trip code | Number stations | Number + stations[3] | Total Biomass (t) | c.v. (%) | Recruited Biomass (t) | c.v. (%) |
|---|---|---|---|---|---|---|---|
| 1991 | KAH9105 | 55 | 18 | 300 | 40 | 294 | 41 |
| 1992 | KAH9205 | 80 | 21 | 176 | 32 | 122 | 28 |
| 1993 | KAH9306 | 74 | 22 | 481 | 33 | 423 | 34 |
| 1994 [1] | KAH9406 | 100 | 31 | 164 | 32 | 143 | 34 |
| 1996 | KAH9606 | 118 | 37 | 858 | 30 | 526 | 26 |
| 2007 [2] | KAH0705 | 94 | 34 | 1 034 | 32 | 444 | 42 |
| 2008 [2] | KAH0806 | 96 | 43 | 1 404 | 35 | 562 | 40 |
| 2009 [2] | KAH0905 | 87 | 34 | 596 | 23 | 387 | 25 |

[1] these biomass estimates differ from those in Beentjes & Stevenson (2000) due to the exclusion of four tows with usability code >2

[2] excludes shallow 10–30 m strata for comparability to the earlier winter surveys

[3] stations with ELE catch

### 4.1.2 Summer RV *Kaharoa* surveys

The winter survey design was replaced in 1996 by a summer survey directed at elephantfish, among other species (Beentjes & Stevenson 2001). Additional shallow water (10 m to 30 m) strata were added to the design from Cape Wanbrow in the south to the Kowai River in the north. These new strata were within the boundaries of the previous winter survey and were added to improve the coverage of elephantfish and red gurnard.

This survey was initiated in December 1996–January 1997 and was repeated in each year up to December 2000–January 2001(Table 20; Figure 25). In order to provide comparability between the summer and winter series, a "recruited" biomass estimate standardised to include only elephantfish greater than 50 cm fork length and excluding the 10–30 m strata, was calculated for all surveys (Table 20). A biomass index based only on large elephantfish is presented to account for the fact that a smaller cod end was used in the summer surveys than in the winter surveys (30 mm compared to 60 mm). Figure 23 shows that there is little difference between the recruited and total biomass estimates for the 1991 to 1994 surveys. This was as expected because it is thought that relatively fewer small elephantfish are available in the winter months. However, there is a much greater difference between the total and recruited biomass estimates for 1996, 2007 and 2008 winter surveys and all the summer survey indices (Figure 23 and Figure 25). However, the recruited biomass summer and winter indices are all within the error bars of the equivalent total biomass indices and show similar trends.

**Table 20: Relative biomass indices (t) and coefficients of variation (c.v.) for elephantfish from the east coast South Island summer (December—January) trawl surveys. 1996–97 to 1999–2000 data are from Beentjes & Stevenson. (2001) and the 2000–01 estimate from Stevenson & Beentjes (2002). Total biomass estimates for the FV *Compass Rose* for 1999–00 and 2000–01 are also given in this table (Mike Stevenson *pers. comm.*). Recruited biomass estimates include elephantfish greater than 50 cm fork length**

| Survey Year | Trip code | Total Biomass | c.v. (%) | Recruited Biomass | c.v. (%) | Trip code | Total Biomass | c.v. (%) |
|---|---|---|---|---|---|---|---|---|
| 1996–97 | KAH9618 | 1 127 | 31 | 1 056 | 31 | – | – | – |
| 1997–98 | KAH9704 | 404 | 18 | 241 | 18 | – | – | – |
| 1998–99 | KAH9809 | 1 718 | 28 | 1 457 | 33 | – | – | – |
| 1999–00 | KAH9917 | 1 097 | 25 | 949 | 24 | COM9901 | 1 278 | 55 |
| 2000–01 | KAH0014 | 696 | 18 | 561 | 21 | COM0001 | 1 314 | 27 |

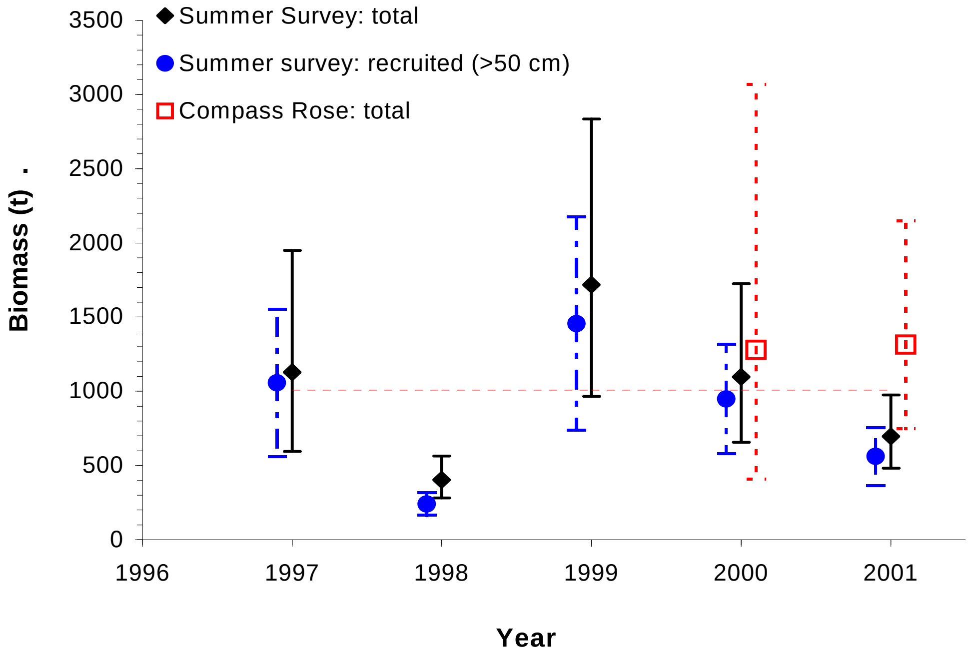


**Figure 25: Total and recruited biomass indices for elephantfish from the east coast South Island summer (December–January) trawl surveys. Approximate 95% confidence intervals are estimated from the survey c.v.s assuming a lognormal distribution. Horizontal dotted line indicates mean total biomass from the summer survey. Also plotted are the two Compass Rose total biomass indices**

A review of the survey design by the Inshore Fishery Assessment Working Group (IFAWG) in March 1997 concluded that this survey was likely to be suitable for monitoring elephantfish. However, catches of elephantfish were very low in the 1997–98 survey and the distribution of catches indicated that the survey did not cover the full depth range occupied by elephantfish. Therefore, the IFAWG recommended in 1999 that additional strata be added to this survey to monitor elephantfish at depths less than 10 m. This was accomplished by using a commercial fishing vessel (the FV *Compass Rose*) to survey elephantfish habitat from the 5 m to 30 m depth range over the same period that the RV *Kaharoa* was doing the standard summer east coast South Island survey (Table 20).

### 4.1.3 Compass Rose summer surveys

The additional surveys by the FV *Compass Rose* showed that there is a significant population of elephantfish in the 5 to 10 m depth band (Table 21), particularly during the 1999–2000 survey. Both of the *Compass Rose* surveys estimated a greater biomass estimate for the 10–30 m depth band than the equivalent estimate for the RV *Kaharoa*. However, this may simply reflect differences in catchability between the two vessels. Given the high c.v. for the 1999–2000 *Compass Rose* survey (both for the total survey and the 10–30 m stratum), it is not possible to conclude that these two surveys are providing different estimates of biomass (Figure 25).

**Table 21: Comparison of biomass estimates of elephantfish in comparable strata for the 2000 and 2001 surveys on the east coast South Island (Stevenson [NIWA] *pers. comm.*).**

| Survey | Depth | *Kaharoa* | | *Compass Rose* | |
|---|---|---|---|---|---|
| Year | Range (m) | Biomass (t) | c.v. (%) | Biomass (t) | c.v. (%) |
| 1999–00 | 5–10 | – | – | 475 | 79 |
| | 10–30 | 369 | 25 | 802 | 73 |
| 2000–01 | 5–10 | – | – | 84 | 23 |
| | 10–30 | 346 | 19 | 1229 | 29 |

### 4.1.4 Resumption of the winter series of east coast South Island trawl surveys

The IFAWG agreed at a meeting held on 27 March 2001 that the current summer east coast South Island trawl survey was not reliably monitoring many of the fish populations in FMA 3 and that it would be discontinued (WG-INSHORE-01/29). This was due to the apparent patterns of changing catchability between survey years which appeared to exceed likely changes in population abundance (see Francis et al. 2001 for an analysis of the large number of correlated between-species biomass shifts observed in the summer series). Analysis of the existing data for both the winter and summer trawl surveys (Francis & Horn 2005) led to the decision to resume the winter series of east coast South Island trawl surveys, beginning in May 2007. This decision was based on the reasoning that the resumed series would be comparable to five earlier surveys conducted from 1991 to 1996, thus allowing for long-term comparisons for a range of species in this important fishery (Table 19).

## 4.2 Trawl Survey Length Frequency Data

### 4.2.1 Winter RV *Kaharoa* Surveys (1991–1996, 2007, 2008)

Scaled numbers at length for elephantfish by sex from the winter series of east coast South Island trawl surveys are highly variable between years, with one survey (KAH9205) showing a bimodal distribution created by incoming recruits (Figure 26A). Cumulative plots of the same data show great instability between the survey years, with 1992 having the smallest elephantfish (both males and females) of all the surveys (Figure 27). The three recent surveys appear to have distributions which consist mainly of small fish and lie to the left of all the earlier distributions except for KAH9205. The remaining surveys show larger mean sizes, with no particular pattern. The survey with the greatest mean length (1991) is immediately followed by the survey with the smallest mean length (1992; Table 22).

**Table 22: Mean total length (cm) of female and male elephantfish for each of the winter and summer surveys of the east coast South Island.**

| Winter Survey | | | | | Summer Survey | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Survey | All Fish | | Fish ≥ 50 cm F.L. | | | All Fish | | Fish ≥ 50 cm F.L. | |
| Year | Female | Male | Female | Male | Survey Year | Female | Male | Female | Male |
| 1991 | 65.7 | 61.3 | 68.4 | 62.4 | 1996–97 | 58.2 | 52.5 | 66.4 | 57.9 |
| 1992 | 38.0 | 35.2 | 68.3 | 61.1 | 1997–98 | 26.4 | 27.7 | 63.3 | 58.1 |
| 1993 | 60.0 | 56.9 | 64.2 | 59.7 | 1998–99 | 41.2 | 38.2 | 72.1 | 60.9 |
| 1994 | 62.1 | 55.2 | 67.4 | 59.7 | 1999–00 | 40.0 | 39.5 | 65.4 | 59.0 |
| 1996 | 49.7 | 48.3 | 60.4 | 55.2 | 2000–01 | 41.2 | 41.5 | 72.1 | 60.1 |
| 2007 | 42.8 | 39.4 | 67.2 | 58.2 | | | | | |
| 2008 | 47.0 | 44.2 | 65.8 | 57.3 | | | | | |
| 2009 | 46.2 | 48.2 | 63.7 | 57.9 | | | | | |

### 4.2.2 Summer RV *Kaharoa* Surveys (1996–97 to 2000–01)

Summarised length frequency data for elephantfish by sex from the summer series of east coast South Island trawl surveys appear to be even more variable between years than the winter surveys. The cumulative plots of the same data show considerable variation between the survey years, with 1997–98 showing very few large fish of either sex, while 1996–97 had almost no small elephantfish (Figure 28; Table 22). The other years show intermediate distributions but it is clear that this survey is not sampling the population consistently across all size classes.

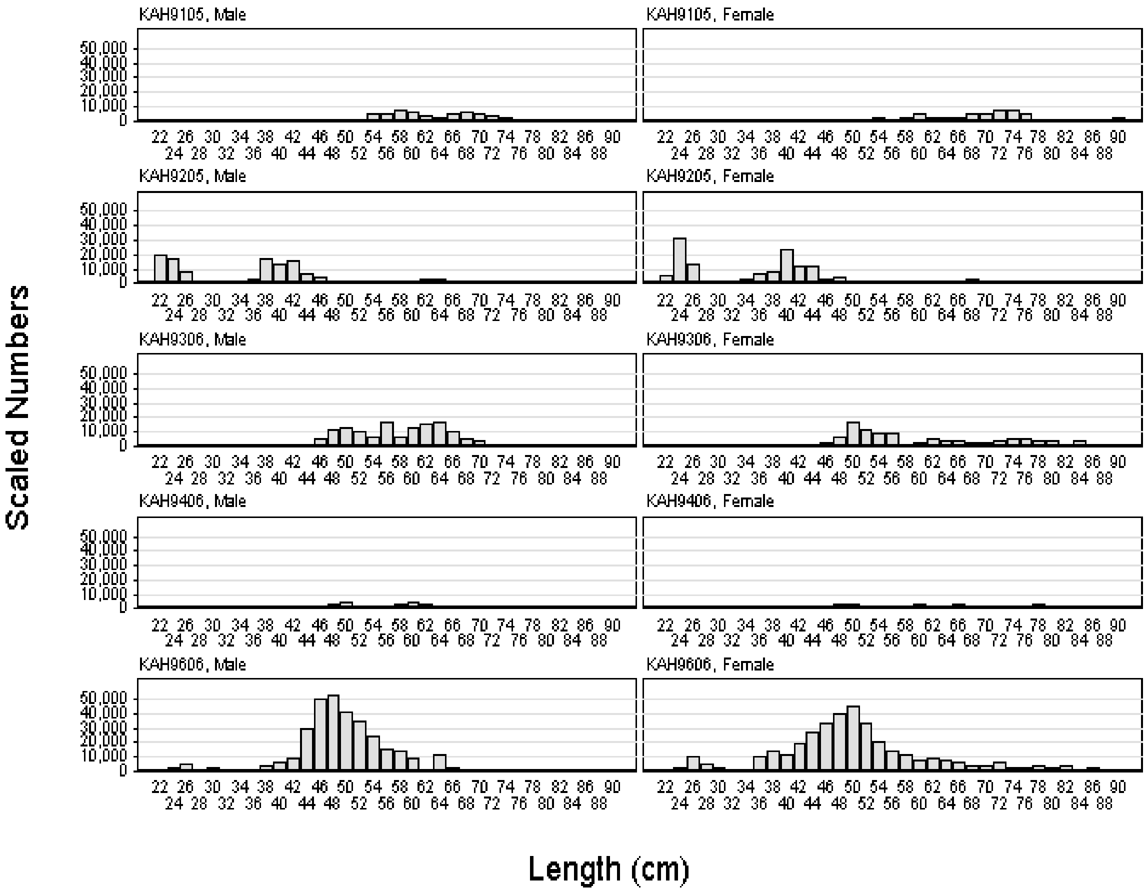


**Figure 26A: Scaled numbers of elephantfish (combined 30-400 m strata) by sex and length for the winter east coast South Island trawl surveys from 1991 to 1996. Data have been binned into 2 cm length classes.**

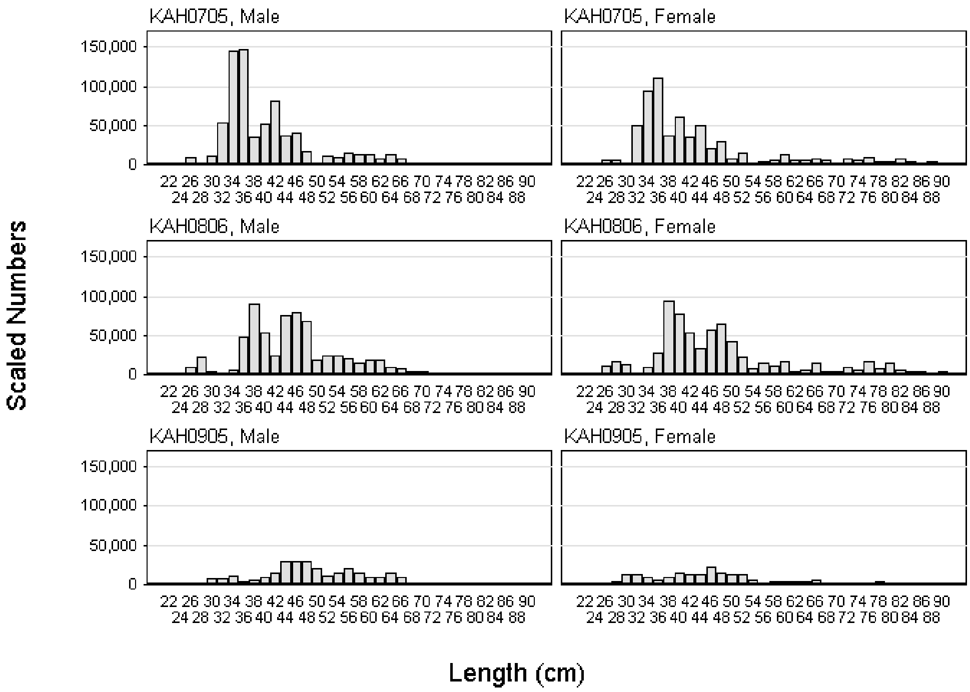


**Figure 26B: Scaled numbers of elephantfish (combined 30-400 m strata) by sex and length for the winter east coast South Island trawl surveys from 2007 to 2009. Data have been binned into 2 cm length classes.**

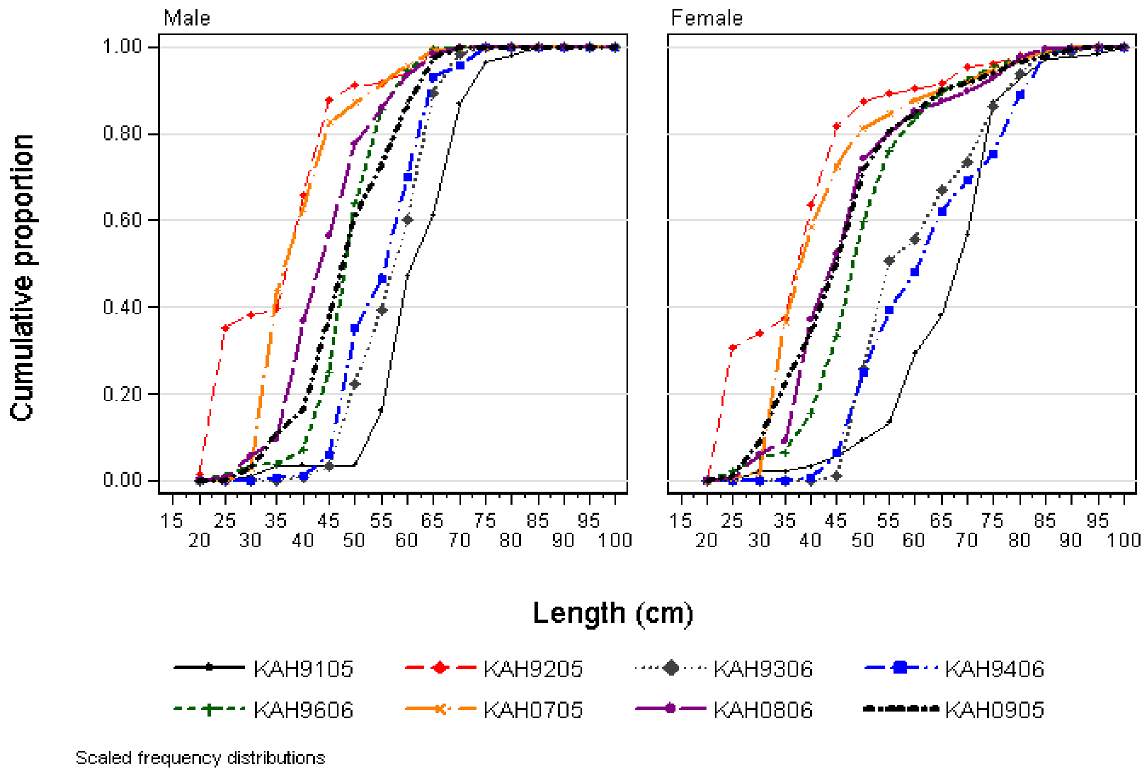


**Figure 27: Cumulative length frequencies for all elephantfish (combined 30–400 m strata) for each sex for the winter east coast South Island trawl surveys from 1991 to 1996 and 2007 to 2009.**

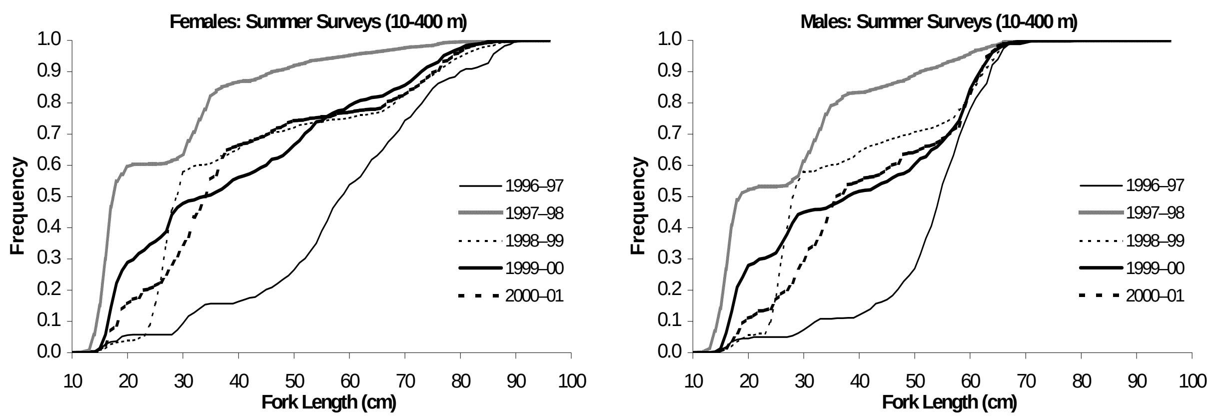


**Figure 28: Cumulative length frequencies for all elephantfish (combined 10-400 m strata) for each sex for the summer east coast South Island trawl surveys (1996–97 to 2000–01).**

### 4.2.3 Length frequencies from the Compass Rose surveys and comparison with RV *Kaharoa* length frequency data

The codend of the FV *Compass Rose* net was changed from a 100 mm mesh size in the 1999–00 survey to a 28 mm mesh size in the 2000–01 survey. This made the codend of the two east coast South Island surveys comparable in term of mesh size. This change is clearly apparent in the cumulative length frequencies for the FV *Compass Rose* in the two sampled depth intervals (Figure 29), with the 1999–00 survey showing a distribution with much larger fish than the 2000–01 survey in both depth intervals. Note that there appears to be little difference in the length frequency distributions between the two sexes in each survey year in the 10–30 m depth interval and for males in the 5–10 m depth interval (Figure 29).

A comparison of length frequency distributions between the RV *Kaharoa* and the FV *Compass Rose* shows considerable differences in the length frequency distributions from the same strata in both years and for both sexes (Figure 30). This would be expected in the 1999–00 survey as the codend mesh sizes were quite different (100 mm for the FV *Compass Rose* and 28 mm for the RV *Kaharoa*). However, the differences in that survey year are in the opposite direction than would be expected, with the RV *Kaharoa* taking larger elephantfish compared to the FV *Compass Rose* for both sexes, in spite of having a much smaller mesh size (Figure 30). This difference is exacerbated in the following survey, especially with the smaller codend mesh size used on the FV *Compass Rose*.

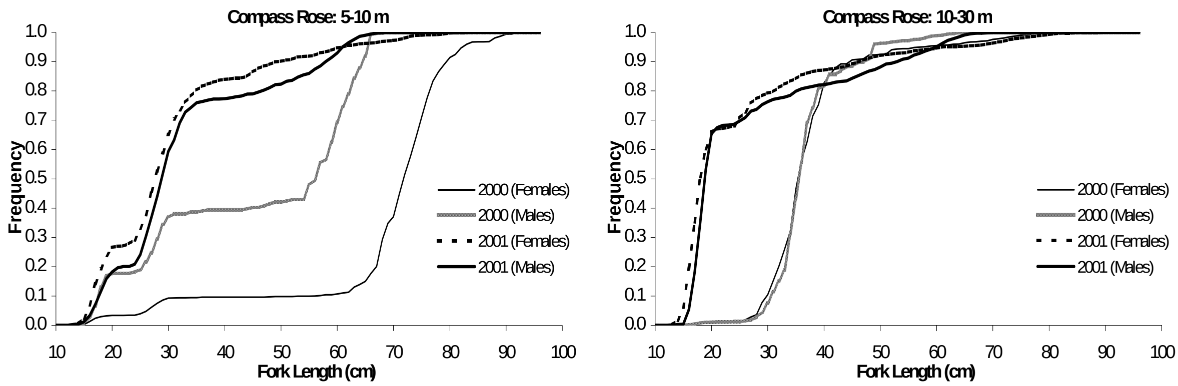


**Figure 29: Cumulative length frequency distributions for the FV *Compass Rose*: [Left panel] distributions in the 5-10 m depth interval for male and female elephantfish for the 1999–00 (2000) survey and the 2000–01 (2001) survey; [Right panel] distributions in the 10–30 m depth interval for male and female elephantfish for the 1999–00 (2000) survey and the 2000–01 (2001) survey.**

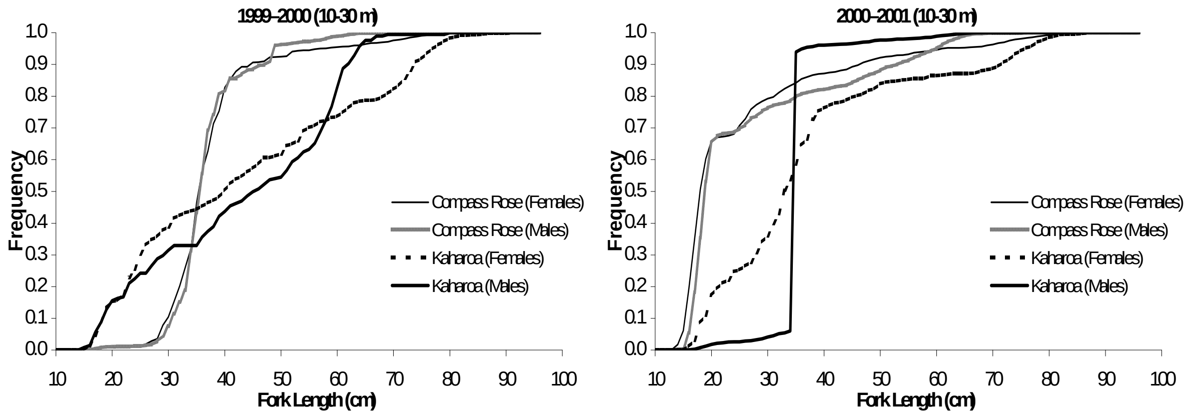


**Figure 30: Cumulative length frequency distributions in the 10–30 m depth interval between Banks Peninsula and Timaru [Left panel] distributions from the RV *Kaharoa* and the FV *Compass Rose* for male and female elephantfish for the 1999–2000 survey; [Right panel] distributions from the RV *Kaharoa* and the FV *Compass Rose* for male and female elephantfish for the 2000–2001 survey.**

## 4.3 Comparison of Available Biomass Indices for ELE 3

Figure 31 plots the available index series for ELE 3 (winter surveys, summer surveys and both CPUE biomass series (ELE3(MIX) and ELE3(RCO), Figure 20). It also plots the QMR/MHR catches on the same relative scale. The CPUE indices pass through the centre of both the summer and winter series but are less variable than either of the two survey series (Figure 31). There is consistency between the CPUE series, the index derived from the QMR catches and the winter survey series, all of which show a gradually increasing trend (with the exception of the 2009 winter survey index, which lies well below the 2009 CPUE index). It is difficult to draw a conclusion about the summer survey index series, given the large changes in index values between successive years.

The large between-year variations in the biomass estimates for elephantfish in the summer east coast South Island trawl survey and in the winter series biomass indices from the 1990s (Figure 23, Figure 25 and Figure 31) indicate that the catchability for this species is probably varying for reasons other than fish abundance. The instability in the sampled length frequency distributions (Figure 26A and Figure 26B) also indicate that there are likely to be annual variations in catchability which are undesirable for monitoring this population. Given this high level of interannual variability, it would seem that continued monitoring with CPUE data is also required for this Fishstock.

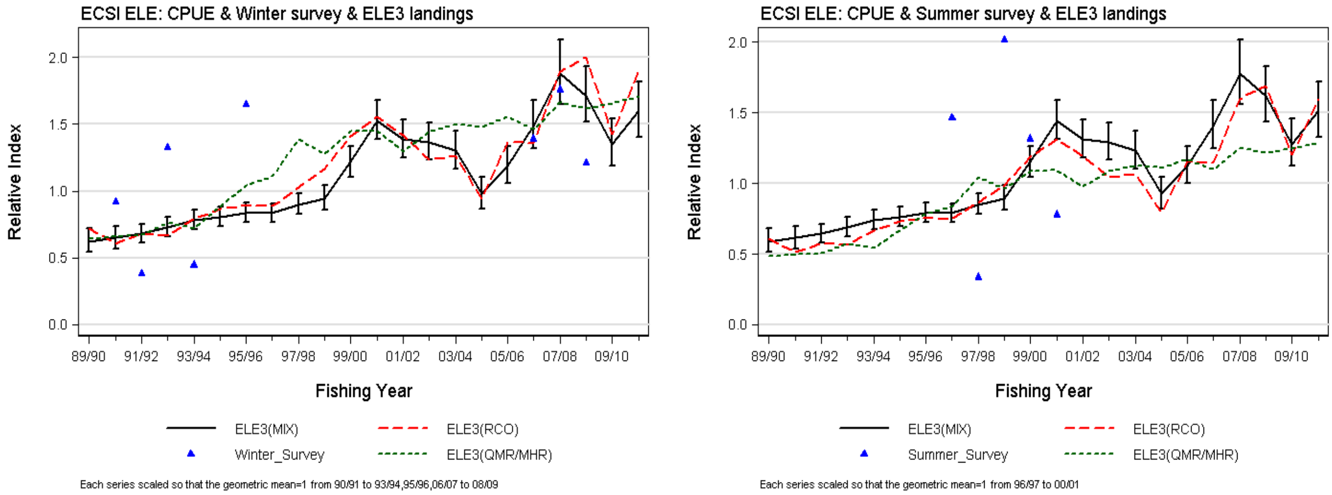


**Figure 31: Comparison of available ELE 3 index series: 1989–90 to 2010–11. Series include the indices of total survey biomass (winter or summer), the non-zero ELE3(MIX) and ELE3(RCO) CPUE indices (Figure 20) and the total ELE 3 QMR/MHR landings. Each series has been plotted relative to the geometric mean of the years shown at the bottom of each graph panel.**

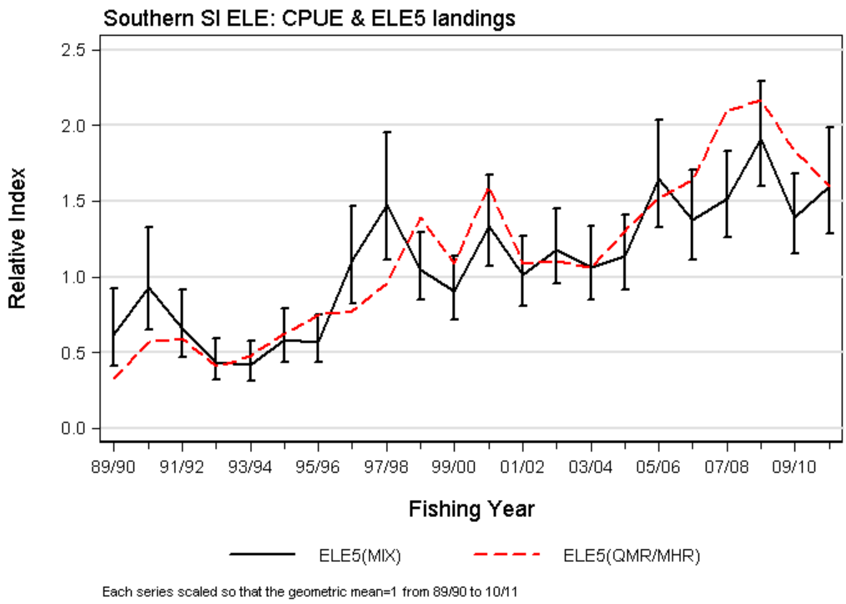


**Figure 32: Comparison of available ELE 5 index series: 1989–90 to 2010–11. Series include the non-zero ELE5(MIX) (Figure 20) CPUE and the total ELE 5 QMR/MHR landings. Each series has been plotted relative to the geometric mean of the years shown at the bottom of each graph panel.**

## 4.4 Comparison of Available Biomass Indices for ELE 5

Figure 32 plots the two available index series for ELE 5: a CPUE biomass series [ELE5(MIX), Figure 22]) and the QMR/MHR catches on the same relative scale. There is consistency between these two series, both of which show a gradually increasing trend, with a dip in the final two years.

# 5. SUMMARY

The available information points to two Fishstocks which are presently in a period of apparent high abundance. There is no information available about how long this situation may last apart from the observation that the 2007 ECSI winter survey had much smaller fish than the succeeding surveys (Figure 27) which may indicate a pulse of new recruitment. These fish may be the cohort which is currently maintaining the east and south coast South Island bottom trawl fisheries at their present high level.

# 6. ACKNOWLEDGEMENTS

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

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

| Term/Abbreviation | Definition |
|---|---|
| AMP & AMPWG | Adaptive Management Programme and AMP Working Group: MPI Fishery Assessment Working Group charged with evaluation of the progress of these projects |
| analysis dataset | data set available after completion of grooming procedure (Starr 2007) |
| arithmetic CPUE | Sum of catch/sum of effort, usually summed over a year within the stratum of interest |
| CDI plot | Coefficient-distribution-influence plot (see Figure G.7 for an example) (Bentley et al. 2011) |
| CELR | Catch Effort Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels less than 28 m. Fishing events are reported on a daily basis on this form |
| CLR | Catch Landing Return (Ministry of Fisheries 2010): active since July 1989 for all vessels not using the CELR or NCELR forms to report landings |
| CPUE | Catch Per Unit Effort |
| destination code | code indicating how each landing was directed after leaving vessel (see Table 6) |
| EEZ | Exclusive Economic Zone: marine waters under control of New Zealand |
| estimated catch | an estimate made by the operator of the vessel of the weight of elephantfish captured, which is then recorded as part of the "fishing event". Only the top 5 species are required for any fishing event in the CELR and TCEPR data (expanded to 8 for the TCER form type) |
| fishing event | a "fishing event" is a record of activity in trip. It is a day of fishing within a single statistical area, using one method of capture and one declared target species (CELR data) or a unit of fishing effort (usually a tow or a line set) for fishing methods using other reporting forms |
| fishing year | 1 October – 30 September for elephantfish |
| IFAWG | MPI Inshore Fishery Assessment Working Group: no longer active; replaced by the SINSWG (South Island) and North Island Inshore Working Group |
| landing event | weight of elephantfish off-loaded from a vessel at the end of a trip. Every landing has an associated destination code and there can be multiple landing events with the same destination code for a trip |
| LCER | Lining Catch Effort Return (Ministry of Fisheries 2010): active since October 2003 for lining vessels larger than 28 m and reports set-by-set fishing events |
| LFR | Licensed Fish Receiver: processors legally allowed to receive commercially caught species |
| LTCER | Lining Trip Catch Effort Return (Ministry of Fisheries 2010): active since October 2007 for lining vessels between 6 and 28 m and reports individual set-by-set fishing events |
| MHR | Monthly Harvest Return: monthly returns used after 1 October 2001. Replaced QMRs but have same definition and utility |
| MPI | New Zealand Ministry for Primary Industries |
| NCELR | Netting Catch Effort Landing Return (Ministry of Fisheries 2010): active since October 2006 for inshore vessels using setnet gear between 6 and 28 m and reports individual fishing events |
| QMA | Quota Management Area: legally defined unit area used for elephantfish management (see Appendix B) |
| QMR | Quota Management Report: monthly harvest reports submitted by commercial fishermen to Ministry for Primary Industries. Considered to be best estimates of commercial harvest. In use from 1986 to 2001. |
| QMS | Quota Management System: name of the management system used in New Zealand to control commercial and non-commercial catches |
| Replog | data extract identifier issued by Ministry for Primary Industries data unit |
| residual implied coefficient plots | plots which mimic interaction effects between the year coefficients and a categorical variable by adding the mean of the categorical variable residuals in each fishing year to the year coefficient, creating a plot of the "year effect" for each value of the categorical variable |
| Rollup | a term describing the average number of records per "trip-stratum" |
| RTWG | MPI Recreational Technical Working Group |
| SEFMC | Southeast Finfish Management Company Ltd: industry group representing stakeholders in ELE 3 and ELE 5 |
| SINSWG | MPI Southern Inshore Working Group |

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

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

| Code | Definition | Code | Description |
|---|---|---|---|
| BLL | Bottom longlining | BAR | Barracouta |
| BPT | Bottom trawl—pair | BCO | Blue Cod |
| BS | Beach seine/drag nets | BNS | Bluenose |
| BT | Bottom trawl—single | BYX | Alfonsino & Long-finned Beryx |
| CP | Cod potting | ELE | Elephant Fish |
| DL | Drop/Dahn lines | FLA | Flats |
| DS | Danish seining—single | GSH | Ghost Shark |
| HL | Handlining | ELE | Elephantfish |
| MW | Midwater trawl—single | HOK | Hoki |
| RLP | Rock lobster potting | HPB | Hapuku & Bass |
| SLL | Surface longlining | JDO | John Dory |
| SN | Set netting (including Gill nets) | JMA | Jack Mackerel |
| T | Trolling | KIN | Kingfish |
| TL | Trot lines | LIN | Ling |
| | | MOK | Moki |
| EN | East Northland | RBY | Ruby Fish |
| BoP | Bay of Plenty | RCO | Red Cod |
| ECNI | East Coast North Island | RSN | Red Snapper |
| ECSI | East Coast South Island | SCH | School Shark |
| WCNI | West Coast North Island | SCI | Scampi |
| | | SKI | Gemfish |
| | | SNA | Snapper |
| | | SPD | Spiny Dogfish |
| | | SPE | Sea Perch |
| | | SQU | Arrow Squid |
| | | STA | Giant Stargazer |
| | | SWA | Silver Warehou |
| | | ELE | Elephantfish |
| | | TRE | Trevally |
| | | WAR | Blue Warehou |

# Appendix B. MAP OF MINISTRY FOR PRIMARY INDUSTRIES STATISTICAL AND MANAGEMENT AREAS

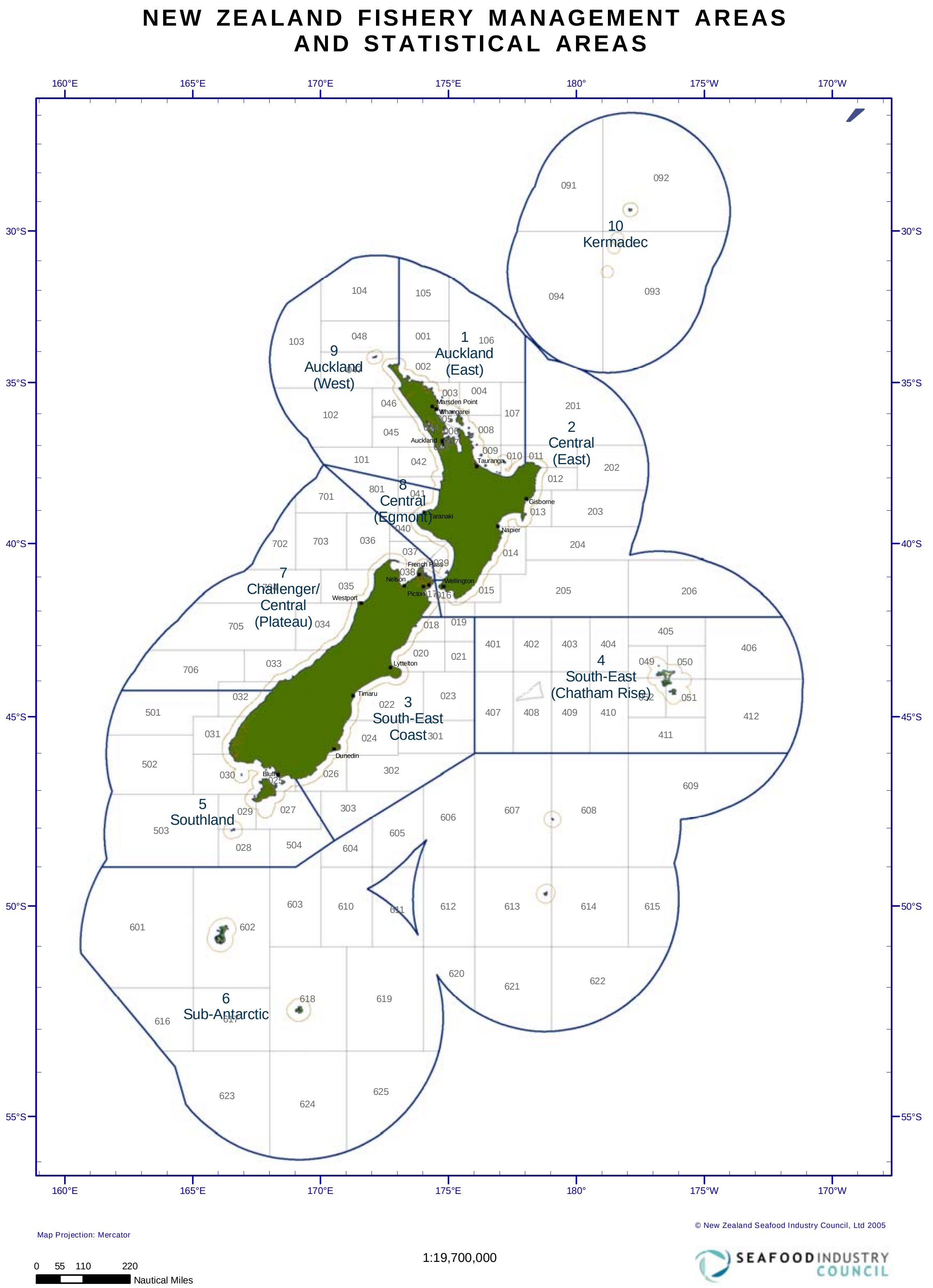



**Figure B.1: Map of Ministry for Primary Industries statistical areas and Fishery Management Areas (FMA) and statistical area boundaries, showing locations where FMA boundaries are not contiguous with the statistical area boundaries.**

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

## C.1 Introduction

The method previously used to identify "implausibly large" landings used arithmetic CPUE, with the presumption that trips with extremely large arithmetic CPUE values existed because the contributing landings were implausibly large. This method had two major problems: one was that the arithmetic CPUE for mixed-method trips could not be easily calculated and the other was that there was a lot of subjectivity in the process (how does one identify an "implausibly large" arithmetic CPUE?). Dropping "implausibly large" landings is necessary because there are large landings which are due to data errors (possibly at the data entry step), with landings from single trips occasionally exceeding 100–300 t for some species. These errors can result in substantial deviations from the accepted QMR/MHR catches and affect the credibility of the characterisation and CPUE analyses. The previous method transferred the problem of identifying "implausibly large" landings to identifying unreasonably large CPUE values. A further problem with the procedure was that the CPUE method was difficult to automate, requiring intermediate evaluations.

## C.2 Methods

The method used for this new procedure is less subjective and can be automated, evaluating trips with very large landings based on internal evidence within the trip that potentially corroborate the landings. The method proceeds in two steps:

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

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

A two-way grid search was implemented for this procedure across a range of empirical quantiles (Step 1) and test ratio values (Step 2). The reason for stepping down through the quantiles was to minimise the number of trips removed by starting with trips that returned the largest catches. Similarly, the search starting with the most extreme $rat_{t,s}$ values and stepped down from there. For each pair of values, the "fit" ($SSq^z$; Eq. C.3) of the annual sum of the landings was evaluated against the QMR/MHR totals, using a least-squares criterion. The pair of quantile and $rat_{t,s}$ values which gave the lowest $SSq^z$ was used to select the set of candidate trips to drop because the resulting landings totals would be the closest overall to the QMR/MHR total catch. The search covered a plausible range for the ratio ($rat_{t,s}$: Eq. C.2), looking for the ratio and trip landing thresholds which resulted in the closest totals to the observed QMR/MHR landings.

## C.3 Equations

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

Eq. C.1

$$G_{t,s}^{d} = \sum_{i=1}^{n_t} gwt_{t,s,i}$$

$$G_{t,s}^{c} = \sum_{i=1}^{n_t} CF_s * W_{t,i} * B_{t,i}$$

$$G_{t,s}^{e} = \sum_{j=1}^{m_t} est_{t,s,j}$$

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

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

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

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

Eq. C.2

$$r1_{t,s} = G_{t,s}^{d} / G_{t,s}^{c}$$

$$r2_{t,s} = G_{t,s}^{d} / G_{t,s}^{e}$$

$$rat_{t,s} = \min(r1_{t,s}, r2_{t,s})$$

where $G_{t,s}^{d}$, $G_{t,s}^{c}$ and $G_{t,s}^{e}$ are defined in Eq. C.1, and ignoring $r1_{t,s}$ or $r2_{t,s}$ if missing when calculating $rat_{t,s}$.

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

Eq. C.3

$$gg_{y}^{z} = \sum_{1}^{p_{y}^{z}} L_{y}^{z}$$

$$Ssq^{z} = \sum_{y=89/90}^{y=10/11} \left( gg_{y}^{z} - MHR_{y} \right)^{2}$$

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

$L_{y}^{z}$ is a landing record included in year *y* for iteration *z*.

$MHR_{y}$ is the corresponding MHR/QMR landing total for (ELE 3 + ELE 5) in year *y*.

## C.4 Results

This approach dropped 21 trips in ELE 3 from a total of 69 000 ELE 3 trips and none in ELE 5 from 7500 ELE 5 trips (Table C.1). The dropped trips in ELE 3 represented 579 t from a total of 18 000 t landed (before editing) from ELE 3. By comparison, 17 trips representing 560 t were dropped in the previous ELE 3 analysis performed in 2009 (Starr et al. 2009). For the ELE 3 data set, the procedure removed some obvious outliers in 1994–95, 1996–97 and 1998–99, resulting in better agreement between the annual landings totals and the QMR/MHR totals (Figure C.1 [left panel]). No adjustment was required for the ELE 5 landings (Figure C.1 [right panel]).

**Table C.1: Results from a search over two parameters defined above: A) a quantile cut-off which selected the set of large landings over which to search and B) the ratio (Eq. C.2) defining the maximum criterion for accepting a landing. The quantile/ratio pair with the lowest $Ssq^z$ (Eq. C.3) is highlighted in colour (maximum ratio accepted=9.0 and quantile cut-off=97%).**

| Quantile | Minimum ratio $(rat_{t,s})$ cut-off | | | | | | Minimum ratio $(rat_{t,s})$ cut-off | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| cut-off: | 4 | 5 | 6 | 7 | 8 | 9 | 4 | 5 | 6 | 7 | 8 | 9 |
| | ELE 3: Number trips dropped | | | | | | ELE 3: total least squares “fit” to the QMR/MHR | | | | | |
| 97 | 29 | 28 | 26 | 25 | 23 | 21 | 2 998 | 2 993 | 3 005 | 3 019 | 3 104 | 2 865 |
| 98 | 22 | 21 | 19 | 18 | 18 | 17 | 3 169 | 3 164 | 3 176 | 3 200 | 3 200 | 2 954 |
| 99 | 18 | 17 | 16 | 16 | 16 | 15 | 3 200 | 3 195 | 3 157 | 3 157 | 3 157 | 2 910 |
| 99.5 | 13 | 12 | 12 | 12 | 12 | 11 | 3 198 | 3 193 | 3 193 | 3 193 | 3 193 | 2 946 |
| 99.9 | 8 | 8 | 8 | 8 | 8 | 7 | 3 381 | 3 381 | 3 381 | 3 381 | 3 381 | 3 134 |
| 99.99 | 5 | 5 | 5 | 5 | 5 | 5 | 4 331 | 4 331 | 4 331 | 4 331 | 4 331 | 4 331 |
| | ELE 5: Number trips dropped | | | | | | ELE 5: total least squares “fit” to the QMR/MHR | | | | | |
| 97 | 1 | 1 | 1 | 1 | 1 | 1 | 624 | 624 | 624 | 624 | 624 | 624 |
| 98 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 603 | 603 | 603 | 603 |
| 99 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 603 | 603 | 603 | 603 |
| 99.5 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 603 | 603 | 603 | 603 |
| 99.9 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 603 | 603 | 603 | 603 |
| 99.99 | 0 | 0 | 0 | 0 | 0 | 0 | 603 | 603 | 603 | 603 | 603 | 603 |

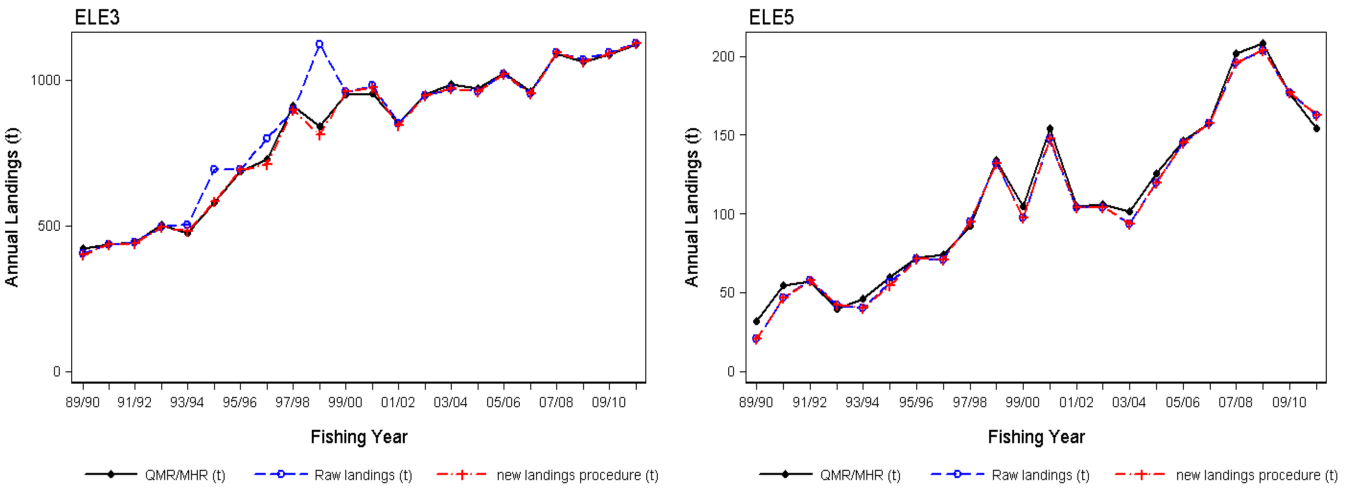



**Figure C.1: Comparison of QMR/MHR annual total landings for ELE 3 (left panel) and ELE 5 (right panel) with two extracts: A: unedited or “raw” landings; B: total landings after dropping the 21 landings identified using the two-way search algorithm described in Table C.1 which resulted in the lowest $Ssq^z$ criterion as defined in Eq. C.3.**

## Appendix D. COMPARISON BY STATISTICAL AREA OF TWO DATA PREPARATION METHODS

This appendix compares combined ELE 3 and ELE 5 landings by statistical area from data sets prepared in two ways:

1. "Fishstock expansion": uses the method of Starr (2007) where trips are dropped which fished in statistical areas valid for more than one Fishstock and which declared more than one Fishstock in the landing data;
2. "Statistical area expansion": scales all estimated catches by statistical area within a trip by the total trip landings, without reference to the Fishstock of capture.

Table D.1 provides a measure of how much data are lost as a consequence of dropping trips which fished in the ambiguous statistical areas and landed to multiple ELE Fishstocks. The "Fishstock expansion" procedure is necessary to provide Fishstock-specific advice because catches using the "Statistical Area expansion" procedure will potentially contain catches from multiple Fishstocks. The latter procedure retains landings from ambiguous statistical areas, but the capacity to trace the landings to specific Fishstocks has been lost. Approximately 300 t are dropped from the entire data set when using the "Fishstock expansion" method compared to "Statistical area expansion" method, representing just over 1% of the total valid landings in the dataset (Table D.1). About 250 t of dropped landings occur in three Statistical Areas located at the bottom of the South Island (025, 027 and 030, all shaded grey in Table D.1). These dropped landings represent less than 10% of the landings in each of these Statistical Areas, but the remaining landings will be adequate to characterise these areas. Statistical Area 028 (colour shaded in Table D.1) loses almost all of its landings, but the total landings in this statistical area are less than 10 t over the 22 years in the data set.

**Table D.1: Total catch (1989–90 to 2010–11) by statistical area resulting from the "Fishstock expansion" data preparation procedure compared with the equivalent catch resulting from the "Statistical Area expansion" preparation procedure (described above). Only statistical areas valid for ELE 3 or ELE 5 are included in this table.**

| Statistical Area | Statistical area expansion | Fishstock expansion | Difference (t) | Difference (%) | Statistical Area | Statistical area expansion | Fishstock expansion | Difference (t) | Difference (%) |
|---|---|---|---|---|---|---|---|---|---|
| 018 | 298.6 | 287.0 | - 11.6 | -3.9% | 404 | 0.6 | 0.5 | - 0.1 | -16.1% |
| 019 | 0.2 | 0.2 | 0.0 | 5.2% | 405 | 0.9 | 0.9 | 0.0 | 0.0% |
| 020 | 2 768.6 | 2 768.1 | - 0.5 | 0.0% | 406 | 0.4 | 0.4 | 0.0 | 0.0% |
| 021 | 41.6 | 41.4 | - 0.2 | -0.4% | 407 | 0.2 | 0.3 | 0.0 | 3.7% |
| 022 | 11 871.5 | 11 857.6 | - 13.9 | -0.1% | 408 | 4.8 | 4.8 | 0.0 | 0.0% |
| 023 | 18.6 | 18.3 | - 0.3 | -1.5% | 409 | 0.1 | 0.1 | 0.0 | -4.6% |
| 024 | 1 708.0 | 1 700.0 | - 8.1 | -0.5% | 410 | 0.0 | 0.0 | 0.0 | -0.3% |
| 025 | 921.3 | 836.1 | - 85.2 | -9.2% | 412 | 0.3 | 0.3 | 0.0 | 0.0% |
| 026 | 886.2 | 828.6 | - 57.7 | -6.5% | 502 | 0.0 | 0.0 | 0.0 | -100.0% |
| 027 | 36.8 | 34.3 | - 2.5 | -6.9% | 503 | 0.0 | 0.0 | 0.0 | 0.0% |
| 028 | 9.0 | 1.8 | - 7.2 | -80.1% | 504 | 1.7 | 0.3 | - 1.4 | -82.2% |
| 029 | 54.0 | 49.5 | - 4.5 | -8.4% | 602 | 1.3 | 0.5 | - 0.8 | -59.5% |
| 030 | 1 308.0 | 1 217.3 | - 90.8 | -6.9% | 603 | 0.1 | 0.1 | 0.0 | 10.3% |
| 031 | 1.5 | 1.3 | - 0.1 | -9.5% | 604 | 0.2 | 0.0 | - 0.2 | -100.0% |
| 032 | 13.5 | 11.2 | - 2.3 | -17.0% | 605 | 0.0 | 0.0 | 0.0 | -100.0% |
| 049 | 0.2 | 0.2 | 0.0 | -2.0% | 606 | 0.0 | 0.0 | 0.0 | -1.4% |
| 050 | 0.4 | 0.1 | - 0.3 | -80.2% | 607 | 0.0 | 0.0 | 0.0 | -67.3% |
| 051 | 1.7 | 1.7 | 0.0 | 0.0% | 608 | 0.0 | 0.0 | 0.0 | -51.0% |
| 052 | 0.0 | 0.0 | 0.0 | 30.4% | 610 | 0.3 | 0.2 | - 0.1 | -43.8% |
| 301 | 0.1 | 0.1 | 0.0 | 0.0% | 611 | 0.0 | 0.0 | 0.0 | -0.4% |
| 302 | 10.2 | 8.9 | - 1.3 | -13.0% | 618 | 0.0 | 0.0 | 0.0 | -24.9% |
| 303 | 0.1 | 0.1 | 0.0 | 0.0% | 619 | 0.0 | 0.0 | 0.0 | -15.6% |
| 401 | 0.4 | 0.4 | 0.0 | 11.8% | 624 | 0.1 | 0.0 | - 0.1 | -99.9% |
| 402 | 1.6 | 1.6 | 0.1 | 3.9% | 625 | 0.0 | 0.0 | 0.0 | 0.0% |
| 403 | 4.6 | 4.6 | 0.0 | -0.1% | Total | 19 956.6 | 19 670.2 | - 286.4 | -1.4% |

# Appendix E. EAST AND SOUTH COAST SOUTH ISLAND ELEPHANTFISH CPUE ANALYSIS

## E.1 General overview

The high catch rates and the difficulty of remaining within the ELE 3 and ELE 5 TACCs have prompted the investigation of a wide range of CPUE analyses in these two Fishstocks. A number of CPUE analyses were developed: setnet fisheries in both areas targeted at a number of shark species, single species target red cod bottom trawl fishery on the east coast South Island and mixed target species bottom trawl fisheries on both the east and south coasts of the South Island.

In 2009, the AMPWG rejected the target shark setnet fisheries for monitoring abundance changes in ELE 3 and ELE , based on the following reasoning (Ministry of Fisheries 2011):

> "....the WG concluded that the SN(SHK) index had been substantially affected by management interventions (including measures to reduce the by-catch of Hector's dolphins) and did not appear to be an appropriate index of ELE abundance. Future emphasis should be on the BT(RCO) and the related BT(MIX) index."

The above quotation applies to ELE 3, but it is clear from the context in ELE 5 that the setnet series was equally dropped.

The AMP WG was also concerned about the effect of the new tow-by-tow TCER forms which replaced the daily CELR forms would have on the indices. Specifically the WG noted:

> When the data collected on these new [TCER] forms were summarised on a trip basis (for comparability with the older form type), there was a substantial change in the number of tows per trip-stratum (where a "trip-stratum" is a method/target species/statistical area "roll-up" of data within a trip), with the average number of trip-strata within a trip increasing from 2 to 3 and the number of tows per trip-stratum decreasing from 4 to 2.5. The WG was concerned that this shift in underlying data may have contributed to an apparent sharp increase in CPUE observed in 2007–08 and hence an anomalous effect stemming from the change in data reporting procedures. (Ministry of Fisheries 2011)

As a consequence of this change, the WG recommended that:

> To specifically investigate the effect of the change in roll-up, an index series based on a trip-level resolution (rolling up all data within a trip: BT(TRIP)) was prepared for all trips that targeted RCO at least once and fished in ELE3. This would remove the differences between the TCEPR, TCER and CELR forms, but lose any targeting or statistical area information. (Ministry of Fisheries 2011)

The "trip-level" analyses described in the above paragraph have been continued in ELE 3 and a new similar analysis has been created for ELE 5. As well, three of the four bottom trawl analyses specified by Ministry of Fisheries (2011), defined by target species or area, have been repeated[3]. These fisheries are described below and in Sections 3.1 and 3.2.

## E.2 Methods

### E.2.1 Data Preparation

The identification of candidate trips for these analyses and the methods used to prepare the data have been described in Section 2.4.1. The potential data variables available from each trip include estimated and landed catch of elephantfish, the number of 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 based on the estimated catches which apportion the landings to each trip stratum. Trips were not dropped

[3] see Footnote 2 (page 38)

because they targeted more than one species or fished in more than one statistical area. Trips landing more than one Fishstock of any species from one of the straddling statistical areas were entirely dropped

The alternative "trip-level" ELE 3 and ELE 5 datasets were prepared by selecting trips from each Fishstock which targeted any of RCO, STA, BAR, ELE or TAR (for ELE 3)[4] or any of ELE, FLA, STA, BAR, RCO, or SPD (for ELE 5) at least once, which then qualified the complete trip. These trips were amalgamated to the level of a statistical area, which effectively created a trip level data set because few trips entered more than one statistical area within the period of a trip. These data sets are identified as "trip" in the remainder of this report.

### E.2.2 Analytical methods for standardisation

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

Eq. E.1
$$\hat{A}_y = \frac{\sum_{i=1}^{n_y} C_{i,y}}{\sum_{i=1}^{n_y} E_{i,y}}$$

where $C_{i,y}$ is the [*catch*] and $E_{i,y} = T_{i,y}$ ([*tows*]) or $E_{i,y} = H_{i,y}$ ([*hours_fished*]) for record *i* in year *y*, and $n_y$ is the number of records in year *y*.

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

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

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

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

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

where $I_i = C_i$ for the *i*th record, $Y_{y_i}$ is the year coefficient for the year corresponding to the *i*th record, $\alpha_{a_i}$ and $\beta_{b_i}$ are the coefficients for factorial variables *a* and *b* corresponding to the *i*th record, and $f\left(\chi_i\right)$ and $f\left(\delta_i\right)$ are polynomial functions (to the 3rd order) of the continuous variables $\chi_i$ and $\delta_i$ corresponding to the *i*th record, *B* is the intercept and $\varepsilon_i$ is an error term. The actual number of

[4] see Footnote 1 (page 37)

factorial and continuous explanatory variables in each model depends on the model selection criteria. Fishing year was always forced as the first variable, and month (of landing), statistical area, target species, and a unique vessel identifier were also offered as categorical variables. Tows $\left(\ln\left(T\right)_i\right)$ and fishing duration $\left(\ln\left(H_i\right)\right)$ were offered to the model as continuous third order polynomial variables.

This model was fit in two steps to the successful (positive) catch records. First, alternative regressions based on five statistical distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) predicted catch based on a dataset with a reduced set of six explanatory variables (year, month, area, vessel, target species and $\left(\ln\left(T_i\right)\right)$. The distribution which resulted in the model with the lowest negative log-likelihood was then selected for use in the final model. The second step involved repeating the regression using the selected distribution: regressing log(catch) against the full set of explanatory variables in a stepwise procedure, selecting variables one at a time until the improvement in the model $R^2$ was less than 0.01. The order of the variables in the selection process was based on the variable with the lowest AIC, so that the degrees of freedom were minimised. Datasets were restricted to core fleets of vessels, defined by their activity in the fishery, thus selecting only the most active vessels without unduly constraining the amount of catch and effort available for analysis.

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

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

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

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

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

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

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

$P_0$ = proportion zero for base year *0*

Confidence bounds, while straightforward to calculate for the binomial and lognormal models, were not calculated for the combined model because a bootstrap procedure (recommended by Francis 2001) had not yet been implemented in the available software. The positive catch model almost always represents the major portion of the signal in the combined model and there is concern that the information added by the binomial model may be an artefact of the data amalgamation procedure and not always interpretable as a biomass index. The binomial model is presented here for information and to contrast with the positive catch model.

### E.2.3 Fishery definitions for CPUE analysis

#### E.2.3.1 ELE 3

Three fisheries were selected for monitoring ELE 3 when this Fishstock was last reviewed by the AMP Working Group (see discussion above in Section E.1 and in the main text in Section 3.1; Ministry of Fisheries 2011):

a) **ELE3(RCO): East coast target red cod bottom trawl –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026, target RCO. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates;

b) **ELE3(MIX): East coast mixed target species bottom trawl –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026, targeting RCO, STA, BAR, ELE or TAR. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates.

The following sensitivity analysis was performed at a coarser record resolution to explore the effect of the switch in form type on the reporting of effort.

c) **ELE3(MIX)-trip: East coast, mixed species bottom trawl, trip level stratification –** ELE 3 bottom single trawl in Statistical Areas 018, 020, 022, 024, and 026; this dataset consisted of trips which targeted RCO, STA, BAR, ELE or TAR at least once[5], which then qualified the complete trip. These trips were amalgamated to the level of a statistical area, which effectively created a trip level data set because few trips would enter more than one statistical area within the period of a trip.

#### E.2.3.2 ELE 5

Two fisheries were selected for monitoring ELE 5 when this Fishstock was last reviewed by the AMP Working Group (see discussion above in Section E.1 and in the main text in Section 3.2; Ministry of Fisheries 2011)). The ELE 5 CPUE series[6] defined for this report was:

a) **ELE5(MIX): South coast red cod bottom trawl –** total ELE 5 bottom single trawl in all ELE 5 statistical areas, target ELE, FLA, STA, BAR, RCO, or SPD. This definition allowed the use of total effort and not just successful effort in the analysis of catch rates;

The following sensitivity analysis was performed at a coarser record resolution to explore the effect of the switch in form type on the reporting of effort. This analysis was not performed in 2009:

b) **ELE5(MIX)-trip: South coast, mixed species bottom trawl, trip level stratification –** bottom trawl in all ELE 5 statistical areas; this dataset consisted of trips which targeted any of ELE, FLA, STA, BAR, RCO, or SPD at least once, which then qualified the complete trip. These trips were amalgamated to the level of a statistical area, which effectively created a trip level data set because few trips would enter more than one statistical area within the period of a trip.

## E.3 Unstandardised CPUE

### E.3.1 ELE 3: unstandardised CPUE

#### E.3.1.1 ELE3(RCO): red cod bottom trawl

The number of trips in this fishery peaked in 1997–98 at over 200% of the 1989–90 levels and has since dropped to less than third of that original level (Figure E.1). Catch rates of elephantfish in successful trips have increased almost six-fold over the period to around 100 kg/tow in successful trips

[5] see Footnote 1 (page 37)
[6] see Footnote 2 (page 38)

in 2010–11 (Figure E.1). The proportion of trips that reported zero catches declined steadily from over 60% in 1989–90 to about 30 % in 2010–11 (Figure E.2).

An increasing trend in the number of tows per stratum is evident in the data roll-up but not in the number of original records per stratum, which leads to the conclusion this trend is inherent in the data rather than a consequence of amalgamation procedures. The final four years shows the effect of the switch to the TCER form which is in tow-by-tow format.

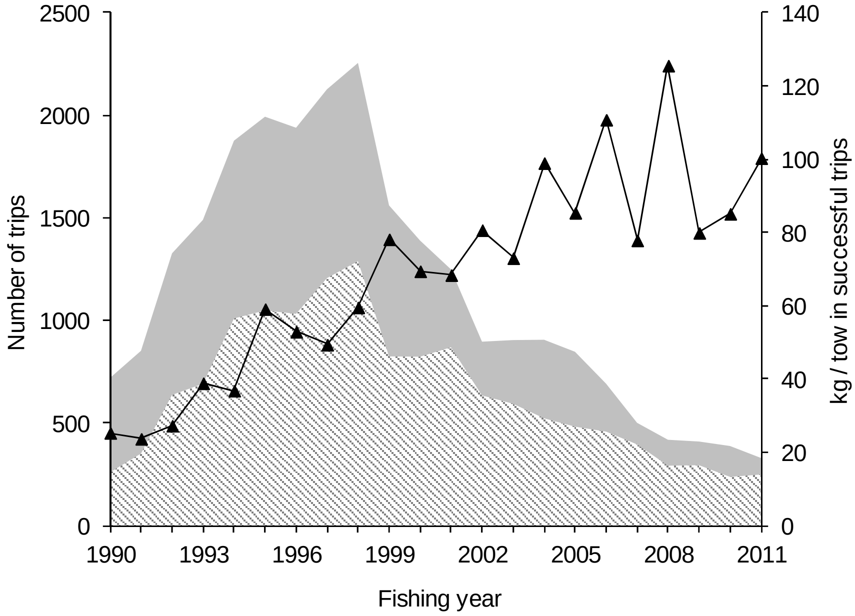



**Figure E.1: Number of trips targeting red cod by bottom trawl in ELE3(RCO), (dark area), the number in trips that landed ELE3(RCO) (light area) and the simple catch rate (kg/tow) of ELE3(RCO) in successful trips, by fishing year.**

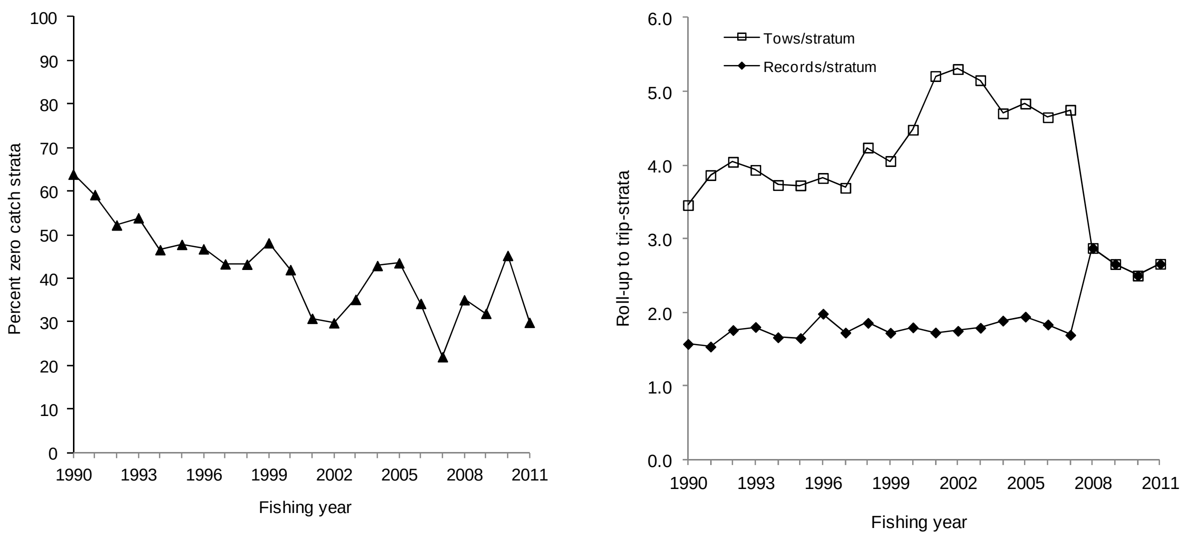



**Figure E.2: The proportion of zero catch trip-strata in all qualifying ELE3(RCO) trips (before selection of core vessels) [left], and the effect of data roll-up indicated by the ratio of original records per trip-stratum, and number of tows per trip-stratum by fishing year [right].**

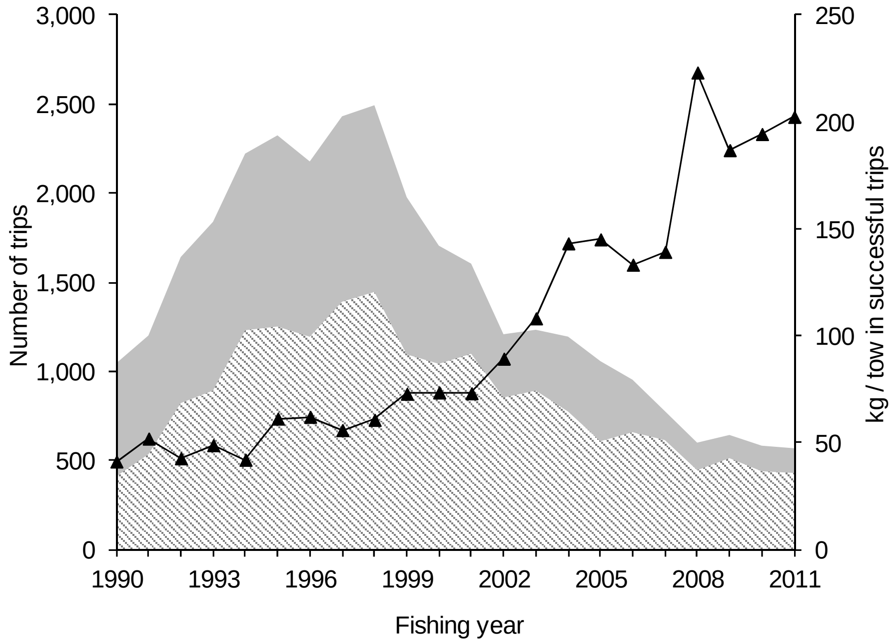
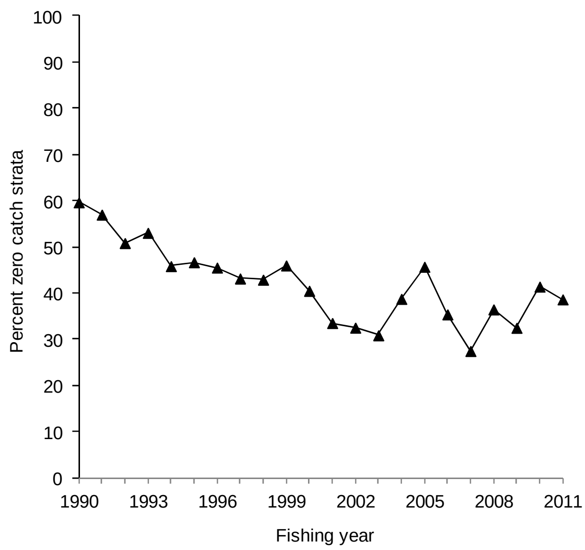



**Figure E.3: Number of trips that targeted elephantfish by bottom trawl in ELE3(MIX), (dark area), the number in trips that landed ELE3(MIX) (light area) and the simple catch rate (kg/tow) of ELE3(MIX) in successful trips, by fishing year.**



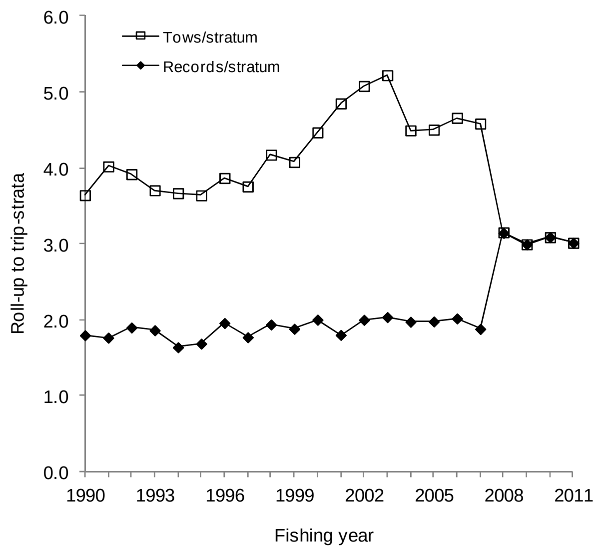




**Figure E.4: The proportion of zero catch trip-strata in all qualifying ELE3(MIX) trips (before selection of core vessels) [left], and the effect of data roll-up indicated by the ratio of original records per trip-stratum, and number of tows per trip-stratum by fishing year [right].**

### E.3.1.2 ELE3(MIX): mixed target bottom trawl

The ELE3(MIX) bottom trawl fishery resembles the ELE3(RCO ) fishery but includes additional effort and exhibits higher unstandardised catch rates. Effort has declined similarly but success rate and catches in successful trips have increased substantially over the study period (Figure E.3). Catch rates of elephantfish in this fishery have increased four-fold to around 200 kg per in 2010–11 and may still be increasing.

Elephantfish are landed from about 60% of trip strata, and that proportion has increased steadily over the time series from 40% in 1989–90 (Figure E.4). There is a slight increase in the data roll-up that is mostly inherent in the reporting rather than a result of the data amalgamation procedures (Figure E.4).

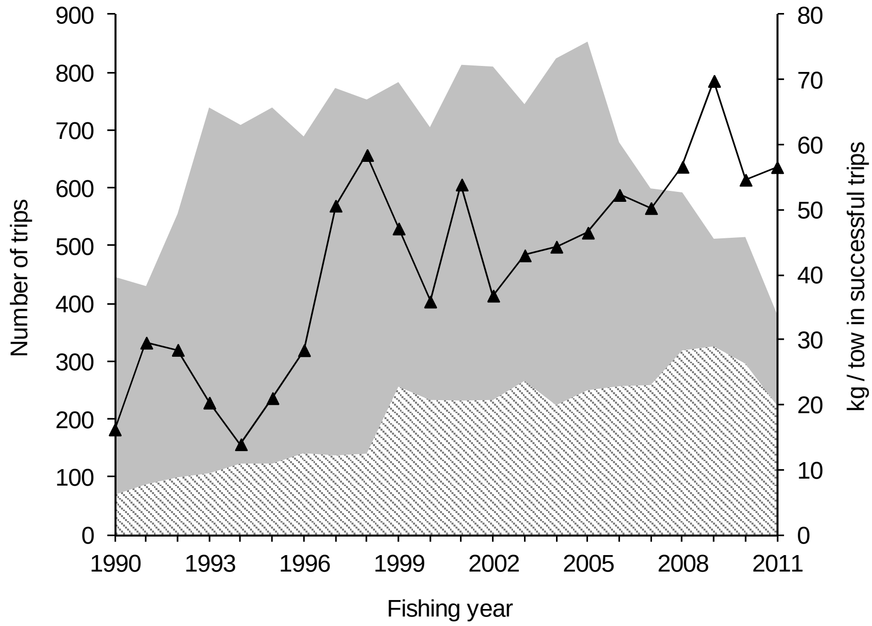



**Figure E.5: Number of trips that targeted ELE, FLA, STA, BAR, RCO, or SPD by bottom trawl in ELE5(MIX) (dark area), the number in trips that landed ELE5(MIX) (light area) and the simple catch rate (kg/tow) of ELE5(MIX) in successful trips, by fishing year.**

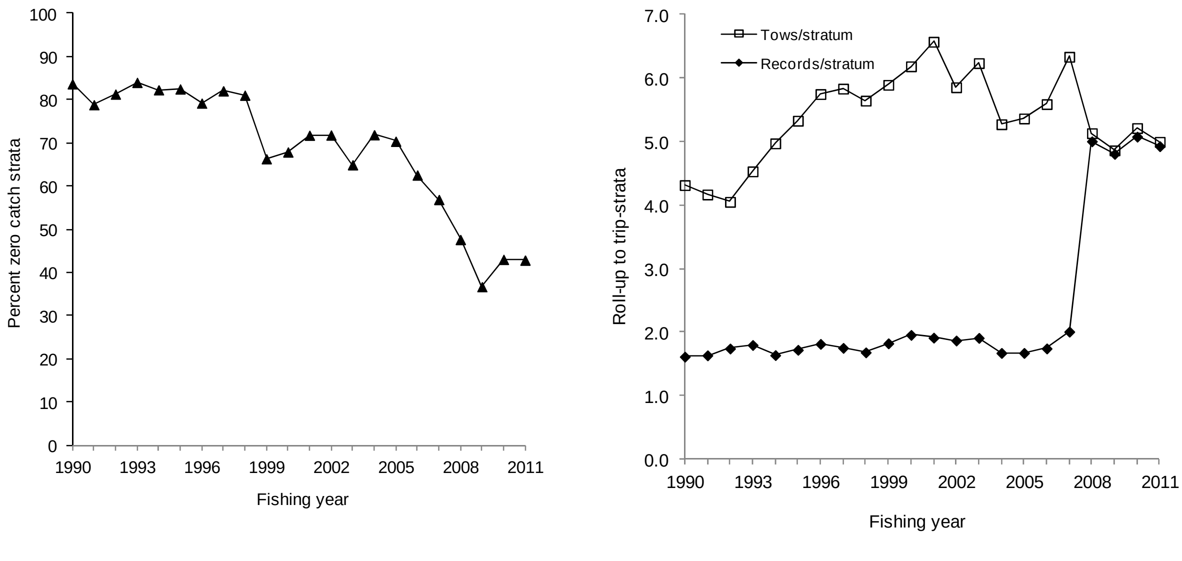



**Figure E.6: The proportion of zero catch trip-strata in all qualifying ELE5(MIX) trips (before selection of core vessels) [left], and the effect of data roll-up indicated by the ratio of original records per trip-stratum, and number of tows per trip-stratum by fishing year [right].**

## E.3.2 ELE 5: unstandardised CPUE

### E.3.2.1 ELE5(MIX): mixed target bottom trawl

The effort expended in the mixed species bottom trawl fishery in ELE 5 was relatively stable through the 1990s and 2000s but declined steeply after 2004–05 and again in 2010–11, which is presently at about 50 % of the peak level. Trip catch rate of 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. After a period of instability it continued to increase, and currently sits at a level similar to that seen in 1998–99 (Figure E.5).

The proportion of trips that have reported zero catches of elephantfish declined from greater than 80% at the beginning of the series to around 45% in 2010–11 (Figure E.6). 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 leads to the conclusion that this trend is inherent in the data rather than a consequence of amalgamation procedures (Figure E.6).

## E.4 Standardised CPUE analysis

### E.4.1 Core fleet definitions

The data sets used for the standardised CPUE analysis were further restricted to those vessels that participated with some consistency in the defined fishery. Core vessels were selected by specifying two variables: the number of trips that defined a qualifying year, and the number of years that each qualifying 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 F.1 and Figure F.2. The core fleet was selected by choosing variable values that resulted in the fewest vessels while maintaining the largest catch of elephantfish.

Core vessels in the ELE3(RCO) fishery were defined as those that had fished at least 10 trips in a minimum of 7 years (Figure F.1). These criteria resulted in a core fleet size of 44 vessels which took 88% of the catch. Core vessels in the ELE3(MIX) fishery were defined as those that had fished at least 10 trips in a minimum of 8 years (Figure F.2). These criteria resulted in a core fleet size of 43 vessels which took 84% of the catch. Data sets for the final core vessels are summarised in Table F.1.

Core vessels in the ELE5(MIX) fishery were defined as those that had fished at least 10 trips in a minimum of 6 years (Figure F.3). These criteria resulted in a core fleet size of 41 vessels which took 84% of the catch. Data sets for the final ELE 5 core vessels are summarised in Table F.2.

### E.4.2 ELE 3: model selection and trends in model year effects

#### E.4.2.1 ELE3(RCO): mixed target bottom trawl fishery

The lognormal distribution model provided the best fit to the positive catches in the ELE3(RCO) dataset (Figure G.1). The final model (Table E.1) explained 30% of the variance in log(catch), largely by standardising for changes in the duration of fishing. Target species, vessel and statistical area also entered the model but had little effect on the annual indices, as shown by the small amount of shift in the annual indices in the stepwise plot in Figure E.7.

Diagnostic residual plots for the final lognormal model are given in Figure F.4 and show an excellent fit over the range in which most of the data occurs, without much departure from the underlying lognormal assumption at the extremes of the residual distribution. Residual implied coefficient plots which model the area×fishingyear interactions indicate that there is a strong similarity among the area-specific year indices in Areas 20 and 22, which is where the majority of the data lie (Figure F.5). Areas 24 and 26 diverge from the overall annual indices since the mid-2000s, but they account for a relatively small proportion of the total catch (Areas 20 and 22 comprise about 75% of the total ELE 3 landings – Figure 9).

**Table E.1: Summary of final lognormal model for the ELE3(RCO) fishery based on the vessel selection criteria of at least 10 trips in 7 or more fishing years. Independent variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, $R^2$: proportion of deviance explained (Nagelkerke pseudo-$R^2$), Final: a flag indicating if the variable was included in final model; Fishing year (fyear) was forced as the first variable.**

| Term | DF | Log likelihood | AIC | $R^2$ (%) | Final |
|---|---|---|---|---|---|
| fyear | 23 | -90 706 | 181 457 | 4.97 | * |
| poly(log(duration) 3) | 26 | -89 427 | 178 906 | 20.00 | * |
| month | 37 | -88 943 | 177 960 | 25.05 | * |
| vessel | 298 | -88 413 | 177 422 | 30.21 | * |
| area | 302 | -88 342 | 177 288 | 30.87 | |
| form | 305 | -88 319 | 177 248 | 31.09 | |
| poly(log(num) 3) | 308 | -88 302 | 177 220 | 31.25 | |

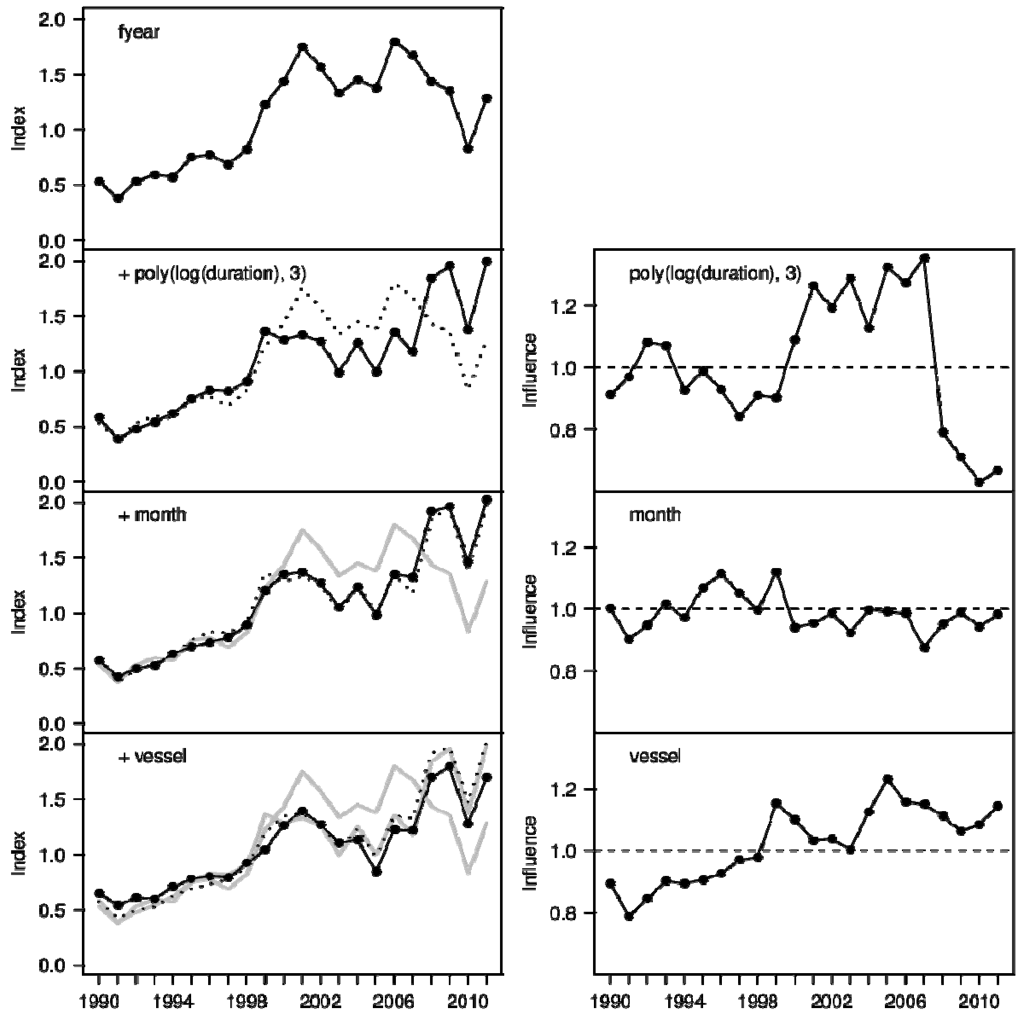



**Figure E.7: Step and annual influence plot for ELE3(RCO): (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its model coefficients and its distributional changes over years, for each explanatory variable in the final model.**

There is a trend of increasing duration from the late 1990s through to the mid 2000s, followed by a sharp decline to a low level that is coincident with the switch to the new form (Figure F.6). The effect of duration entering the model is to smooth the increase from the low in 1999–00 and to lift the indices in the most recent four years. The effect of changes in the month variable have been neutral over most of the study period (Figure F.7), but the gradual loss of the poorer performing vessels in the core fleet has been responsible for increasing the observed catch rate in this fishery and a consequent reduction in the year indices when these changes are standardised (Figure F.8).

### E.4.2.2 ELE3(MIX): mixed target species bottom trawl fishery

The lognormal distribution model provided the best fit to the positive catches in the ELE3(MIX) dataset (Figure G.4), as was seen with the ELE3(RCO) model. The final model (Table E.2) explained 38% of the variance in log(catch), with number of tows having the most explanatory power as well as being selected as the most informative measure of effort. Month and area also entered the model, but there was very little effect on the annual indices from the addition of these explanatory variables (Figure E.8), indicating that there has been little variation in the manner that these variables have operated in the fishery.

**Table E.2: Summary of final lognormal model based on the vessel selection criteria (at least 10 trips in 8 or more fishing years) in the ELE3(MIX) fishery. Independent variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, $R^2$: Proportion of deviance explained; Final: a flag indicating if the variable was included in final model. Fishing year (fyear) was forced as the first variable.**

| Term | DF | Log likelihood | AIC | $R^2$ (%) | Final |
|---|---|---|---|---|---|
| fyear | 23 | -131 065 | 262 177 | 4.90 | * |
| poly(log(num), 3) | 26 | -129 540 | 259 133 | 17.91 | * |
| target | 30 | -128 340 | 256 741 | 26.89 | * |
| month | 41 | -127 628 | 255 339 | 31.74 | * |
| area | 45 | -127 037 | 254 164 | 35.53 | * |
| vessel | 371 | -126 604 | 253 949 | 38.17 | * |
| poly(log(duration), 3) | 374 | -126 505 | 253 757 | 38.76 | |
| form | 377 | -126 450 | 253 655 | 39.08 | |

Diagnostic residual plots for the final lognormal model are given in Figure F.9 and show an excellent fit over the range in which most of the data occurs, without the departures in the residuals at the tails of the distributions. Residual implied coefficient plots which model the area×fishingyear interactions indicate that there is reasonable similarity among the area-specific year indices in areas 020 and 022 for all years up to 2010–11. Note that the area indices diverge in 2010–11, with all areas rising except for 022 (the area with the most observations) which declines (Figure F.10). There is some departure from the annual indices in Areas 024 and 026, but these are distant areas away from the main RCO fishery. Residual implied coefficient plots which model the target×fishingyear interactions indicate that there is very good similarity among each target-specific year indices for all of the major target species categories (Figure F.11).

The effort variable (number of tows), because of a shift to fewer tows per trip-stratum, lifts the unstandardised CPUE by a large amount (see Figure E.8 and Figure F.12). The effect of target species is to drop the annual indices because of the replacement of target fishing for ELE rather than RCO (Figure F.13). Both month (Figure F.14) and area (Figure F.15) entered the model, but neither variable had much impact on the model year indices. On the other hand, vessel, which entered the model in last position, has a greater impact than month or area because there has been a gradual loss from the core fleet of the poorer performing vessels has led to an increase in the unstandardised annual index and a drop in the standardised index as this effect is factored out (Figure F.16).

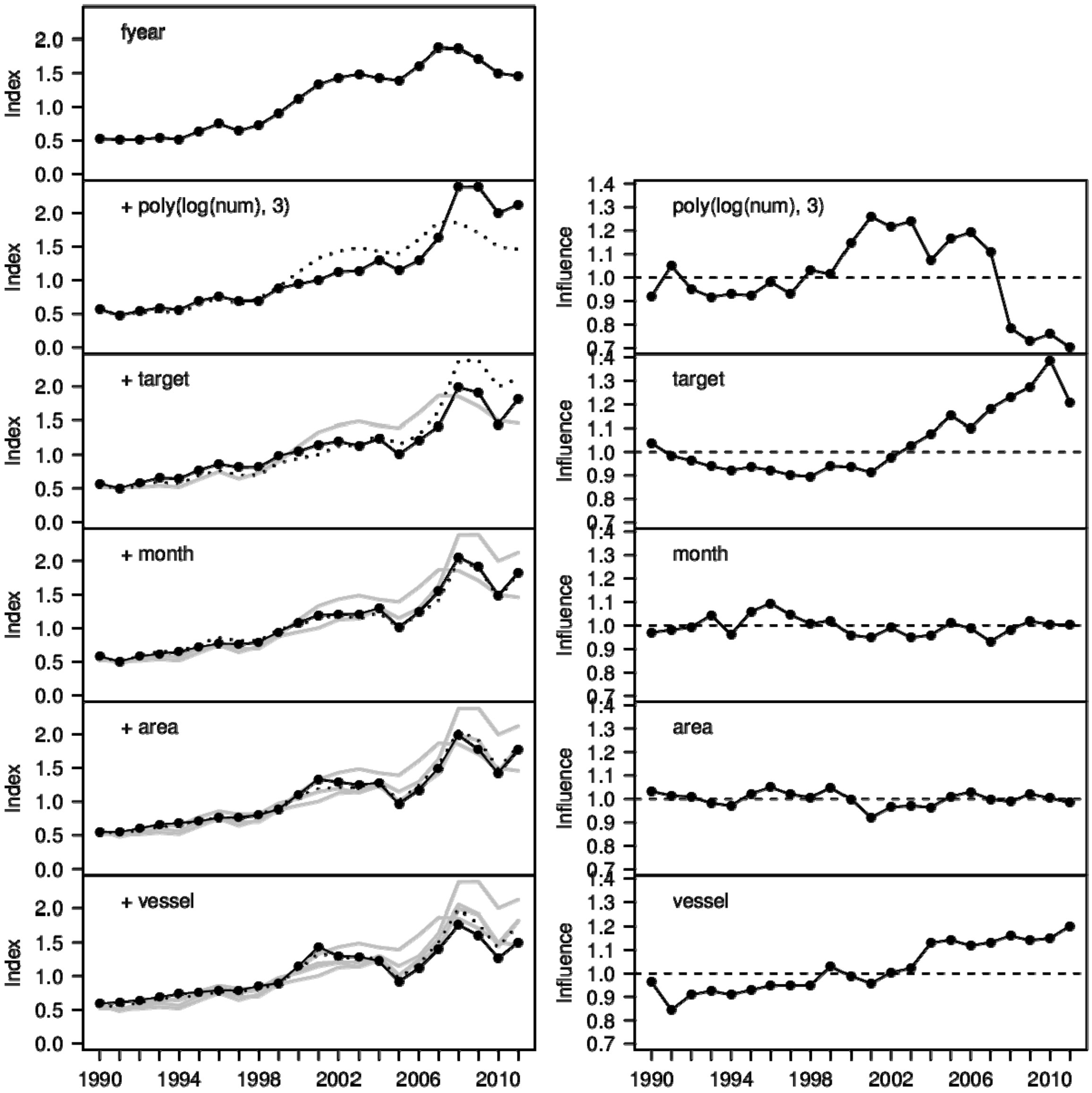



**Figure E.8: Step and annual influence plot for ELE3(MIX). (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its model coefficients and its distributional changes over years, for each explanatory variable in the final model.**

### E.4.3 ELE 5: model selection and trends in model year effects

#### E.4.3.1 ELE5(MIX): mixed target bottom trawl fishery

The lognormal distribution model provided the best fit to the positive catches in the ELE5(MIX) dataset (Figure G.8). The final model (Table E.3) explained 16% of the variance in log(catch), largely by standardising for changes in target species, month and statistical area. Most of the standardisation effect occurred when target species entered the model (Figure E.9). No effort polynomial nor vessel categorical entered the model (Table E.3).

Diagnostic residual plots for the final lognormal model are given in Figure F.17 and show a good fit over the range in which most of the data occurs, with relatively little departure from the underlying lognormal assumption at the extremes of the residual distribution. Residual implied coefficient plots, which model the area×fishingyear interactions, indicate that there is a strong similarity among the area-specific year indices in Areas 25 and 30, where almost all of the data lie (Figure F.18). The other areas diverge somewhat from the overall annual indices, but they are poorly determined and account for only a small proportion of the total catch (Areas 25 and 30 comprise about 85% of the total ELE 5 landings – see Figure 9). Residual implied coefficient plots which model the target×fishingyear interactions indicate that there is very good similarity among the target-specific year indices for STA and FLA, the two major target species categories (Figure F.19). The other target species categories have too little data to determine whether they are substantially different from the overall trend.

**Table E.3: Summary of final lognormal model for the ELE5(MIX) fishery based on the vessel selection criteria of at least 10 trips in 6 or more fishing years. Independent variables are listed in the order of acceptance to the model. AIC: Akaike Information Criterion, $R^2$: proportion of deviance explained (Nagelkerke pseudo-$R^2$), Final: a flag indicating if the variable was included in final model; Fishing year (fyear) was forced as the first variable.**

| Term | DF | Log likelihood | AIC | $R^2$ (%) | Final |
|---|---|---|---|---|---|
| fyear | 23 | -30 795 | 61 637 | 5.40 | * |
| target | 28 | -30 657 | 61 369 | 10.55 | * |
| month | 39 | -30 550 | 61 179 | 14.31 | * |
| area | 45 | -30 493 | 61 076 | 16.27 | * |
| poly(log(num),3) | 48 | -30 472 | 61 039 | 17.00 | |

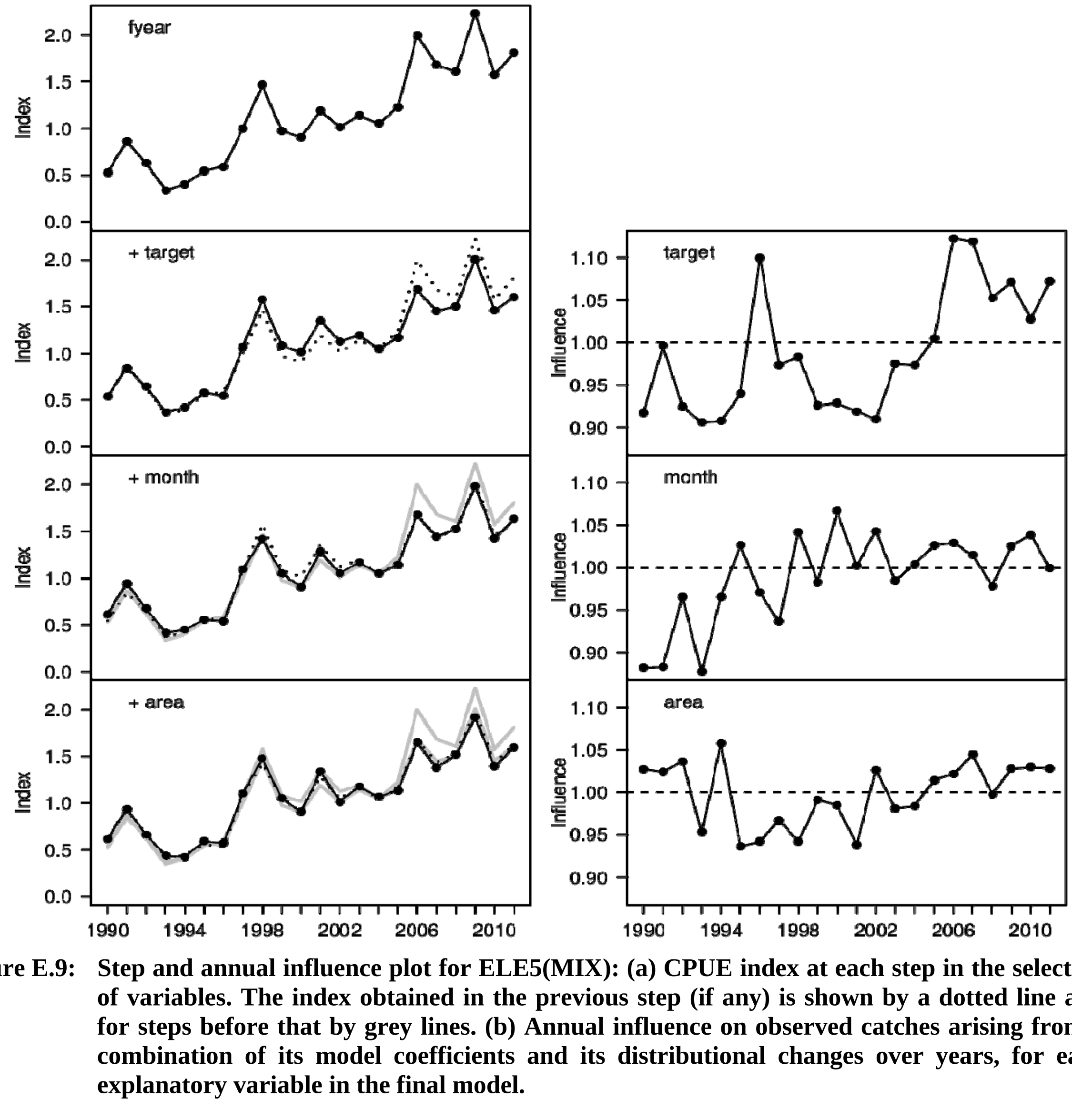



**Figure E.9: Step and annual influence plot for ELE5(MIX): (a) CPUE index at each step in the selection of variables. The index obtained in the previous step (if any) is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its model coefficients and its distributional changes over years, for each explanatory variable in the final model.**

Target species in this mixed target fishery has shifted over the 22 years of history, with a decline in the level of red cod targeting and an increase in the level of targeting towards elephantfish, spiny dogfish and stargazer (Figure F.20). This shift has resulted in a decrease in the standardised year coefficients because of the higher catch rates associated with elephantfish and spiny dogfish. The shift away from red cod preceded the change in form type. The effect of changes in the month variable have been mostly neutral or minor over most of the study period (Figure F.21). There is a slight recent positive trend in the area variable (Figure F.22), but it amounts to very little because the trend is minor. No effort polynomial or the vessel categorical variable were selected for this model.

## E.4.4 Trends in model year effects

### E.4.4.1 ELE 3(RCO): target red cod bottom trawl fishery

The standardised fishing year indices increase smoothly to a peak in 2000–01, decline over four years to a lower level, and have generally increased but also shown considerable interannual variance since 2004–05 with large error bars around each point reflecting the declining amount of data available from this target fishery (Figure E.10).

The effect of standardisation is slight for the first half of the series, but quite marked since then, describing a cyclical pattern that has a low point in 2004–05 followed by a recovery back to the highest level of the series in 2008–09. Both standardised and unstandardised CPUE agreed on an overall increasing trend to 2000–01 and a decline over two years to 2002–03. The two series then diverge as the model adjusts for increasing tow duration per trip and differences among vessels (Figure E.10). Both series agree on an increase in 2010–11.

The indices and the trends are reasonably well-determined with relatively close error bars in the first half of the series but become less reliable with the decline of effort in the RCO fishery in the 2000s. There is very good agreement with the previous series presented in 2009 for a similar model (Figure E.10).

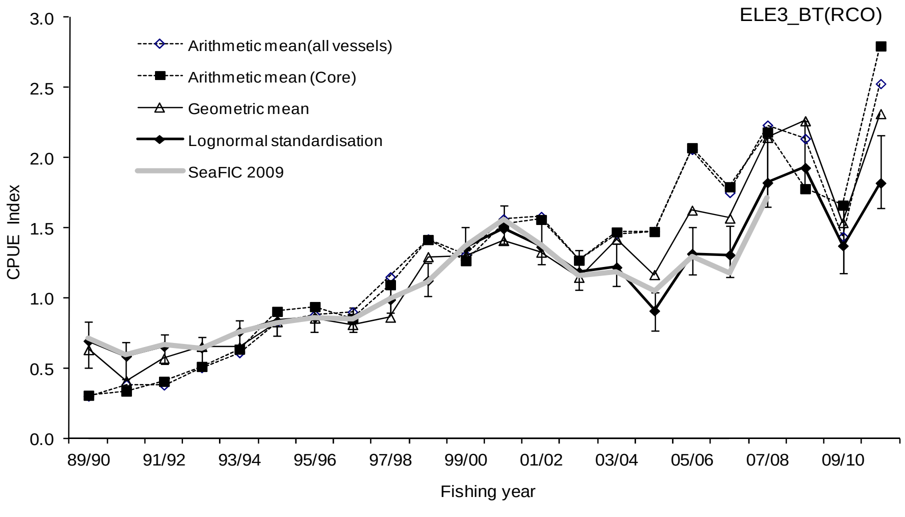



**Figure E.10: The effect of standardisation on the raw CPUE of ELE 3 in successful trips by core vessels in the ELE3(RCO) fishery. Broken line is the raw CPUE (kg/tow), the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with plus or minus two Standard Error bars. Grey line is the previous lognormal series presented in 2009 for this fishery. All series are relative to the geometric mean over the years in common.**

The binomial index corroborates the trajectory of the lognormal indices in describing a decline to a low in the mid 2000s and a subsequent recovery. The effect of combining the two series of indices is to emphasise the increase to peaks in 2000–01 and in 2007–08 (Figure G.3).

### E.4.4.2 ELE 3(MIX): mixed target species bottom trawl fishery

The lognormal indices for bycatch in the mixed target bottom trawl fishery also describe a sustained increasing trend that peaks over three years from 2000–01. The series then drops to a lower level in 2004–05, recovering by 2007–08 (Figure E.11).

The effect of standardisation is to lower the most recent eight points as the model adjusts for the shift away from red cod and towards more targeting of elephantfish (Figure E.11). Both standardised and unstandardised series agree on an increase in 2010–11 to a level that is near to the highest in the series. The indices and the trends are reasonably well-determined with relatively close error bars and changes in direction sustained over several years. There is very good agreement with the previous series presented in 2009 for a similar model.

The binomial index corroborates the trajectory of the lognormal indices in describing a decline to a low in the mid-2000s and a subsequent recovery. The effect of combining the two series of indices is to emphasise the increase to peaks in 2000–01 and in 2007–08 (Figure G.6).

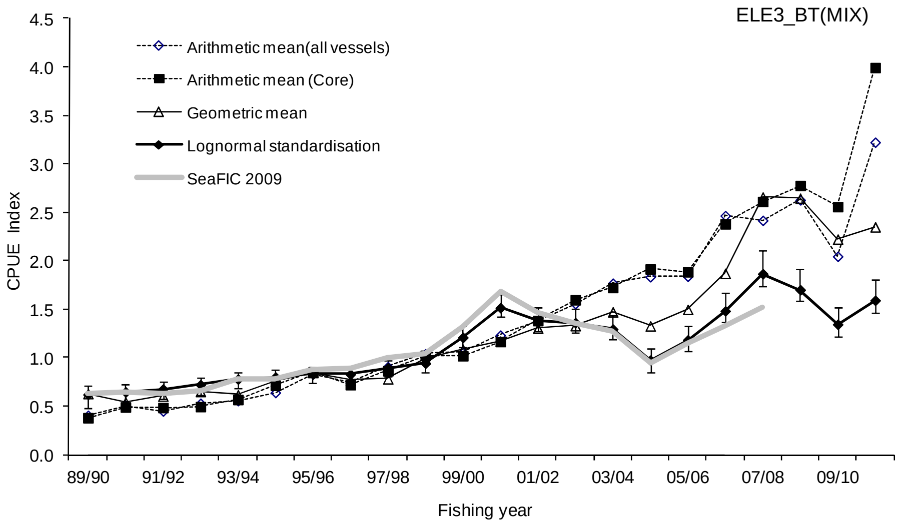



**Figure E.11: The effect of standardisation on the raw CPUE of ELE 3 in successful trips by core vessels in the ELE3(MIX) fishery. Broken line is the raw CPUE (kg/trip-stratum ), the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with plus or minus two Standard Error bars. Grey line is the previous lognormal series presented in 2009 for this fishery. All series are relative to the geometric mean over the years in common.**

### E.4.4.3 ELE 5(MIX): mixed target species bottom trawl fishery

The standardised indices for the ELE5(MIX) lognormal model increase steadily from their lowest point in 1992–93 to levels that currently are around four 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 E.12).

The effect of standardisation is only evident in the last half of the time series, diverging in the last six years from an unstandardised series based on catch per tow. This may indicate that there has been improved targeting of elephantfish by fishers but both the unstandardised and the standardised CPUE indicate that there has been a sustained increase in abundance over the study period. There is good agreement over the years in common with the previous series estimated from a similar model.

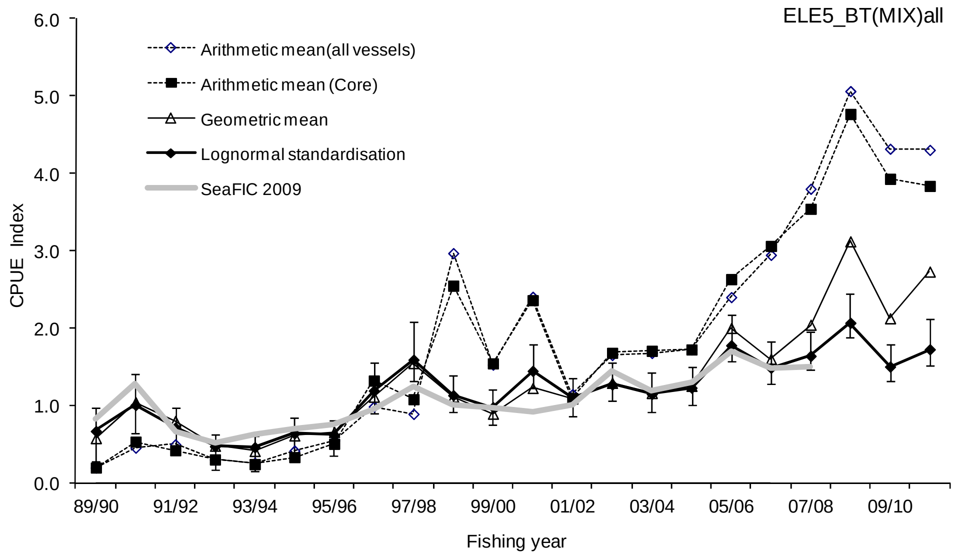



**Figure E.12: The effect of standardisation on the raw CPUE of ELE5 in successful trips by core vessels in the ELE5(MIX) fishery. Broken line is the raw CPUE (kg/tow), the solid line is the unstandardised CPUE (annual geometric mean), the bold line is the standardised CPUE canonical indices with plus or minus two Standard Error bars. Grey line is the previous lognormal series presented in 2009 for this fishery. All series are relative to the geometric mean over the years in common.**

# Appendix F. DIAGNOSTICS FOR ELEPHANTFISH CPUE STANDARDISATIONS

## F.1 Core vessel selection

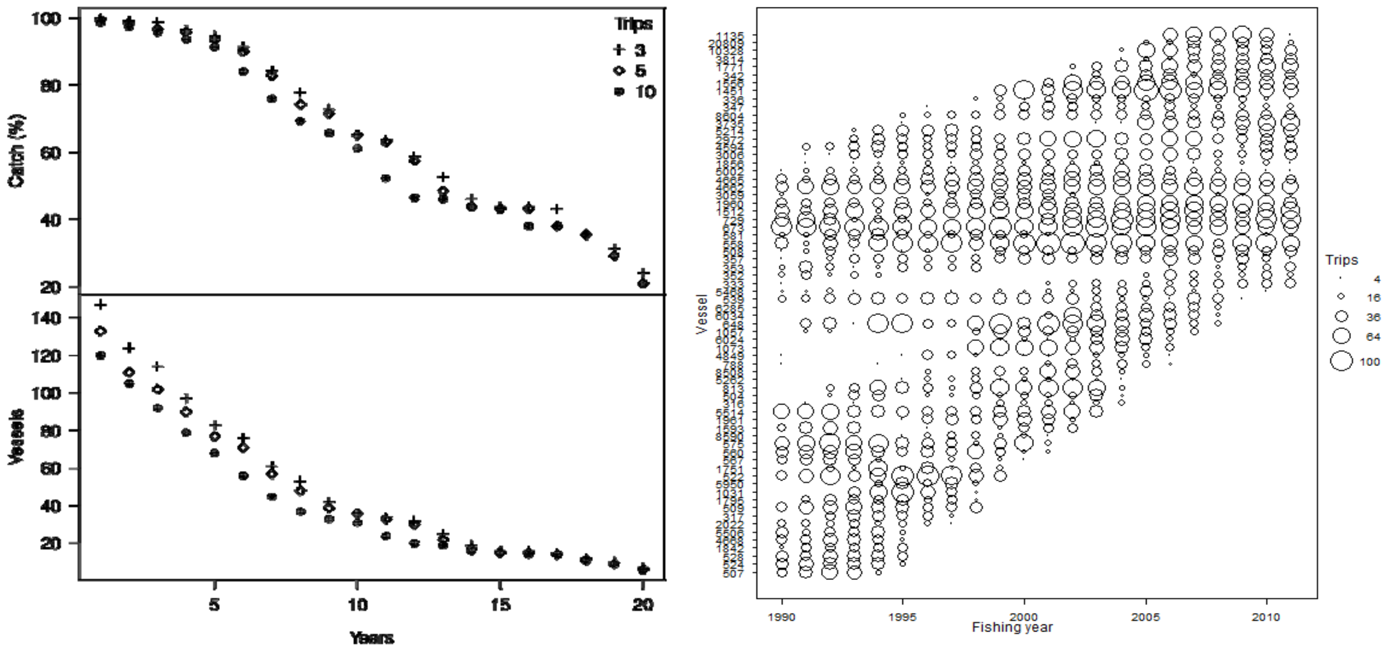



**Figure F.1: Total landed ELE 3 [top left] and the number of vessels [bottom left] retained in the ELE3(RCO) dataset depending on the minimum number of qualifying years and the minimum number of trips used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 7 years) is shown on the right.**

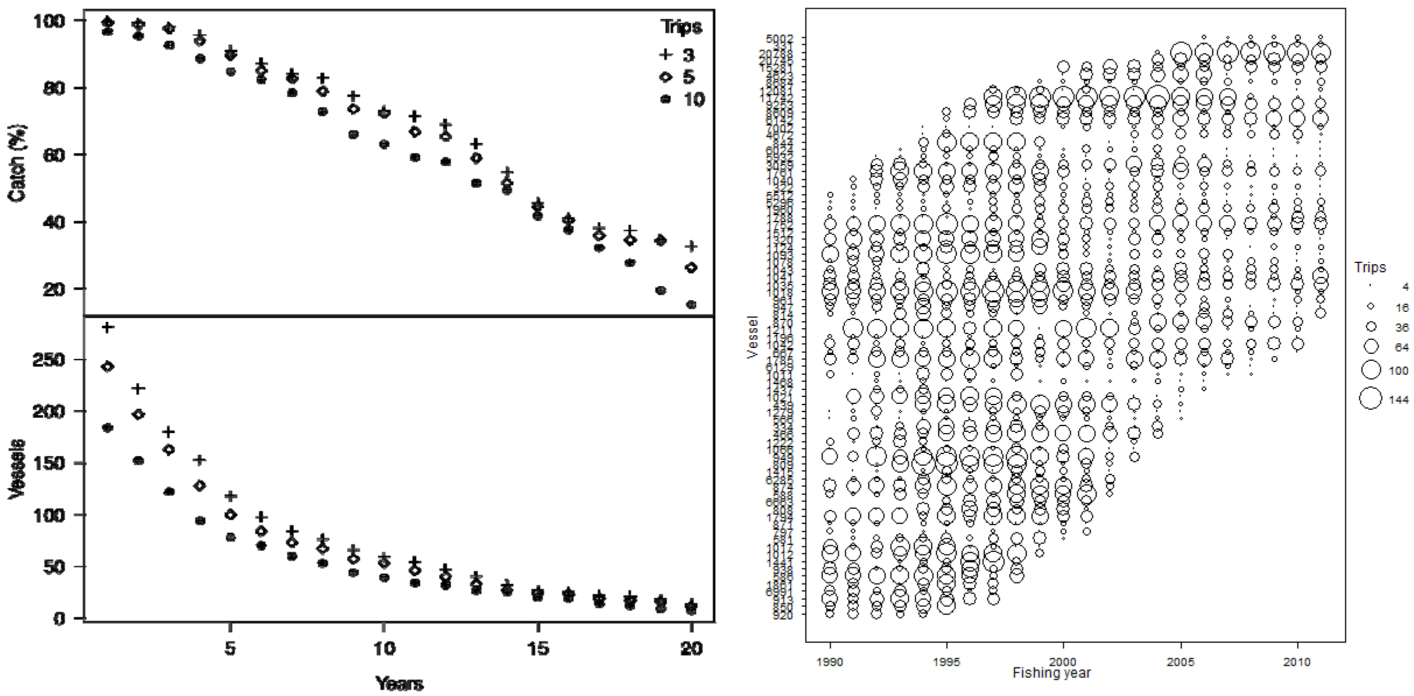



**Figure F.2: Total landed ELE 3 [top left] and the number of vessels [bottom left] retained in the ELE3 dataset depending on the minimum number of qualifying years and the minimum number of trips used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 8 years) is shown on the right.**

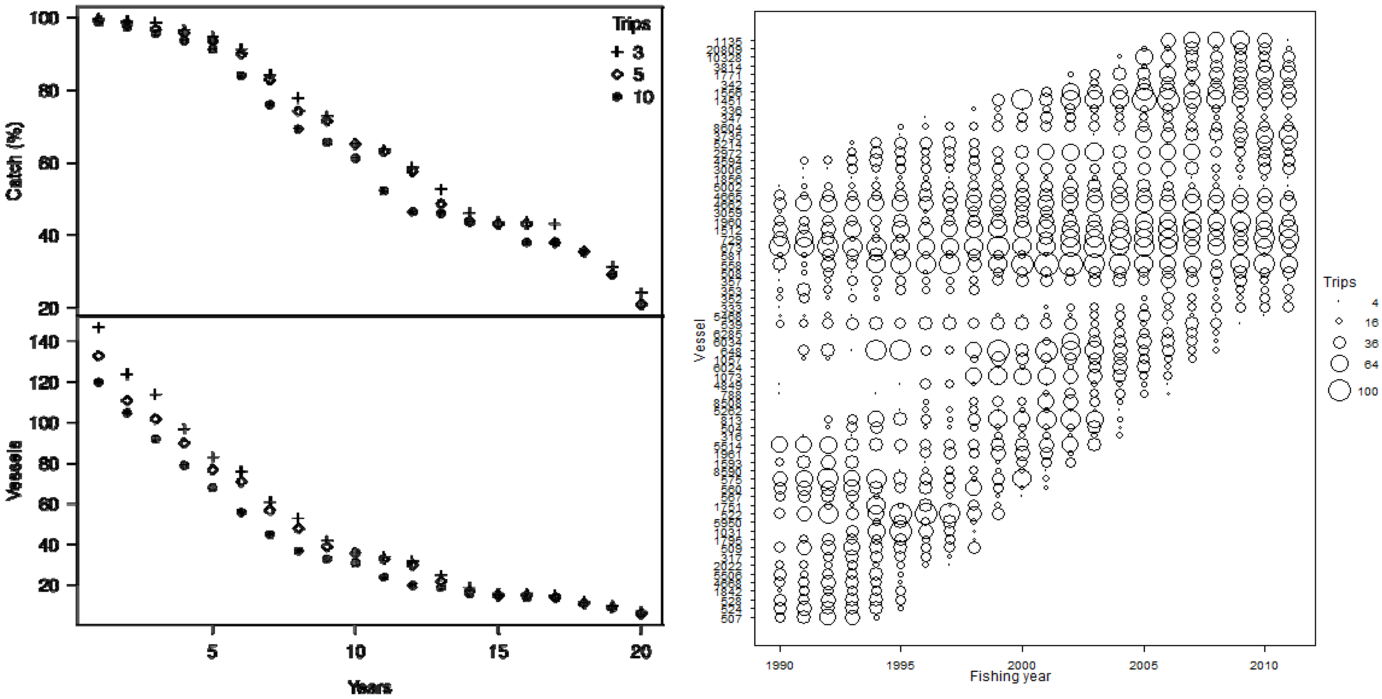



**Figure F.3: Total landed ELE 5 [top left] and the number of vessels [bottom left] retained in the ELE5(MIX) dataset depending on the minimum number of qualifying years and the minimum number of trips used to define core vessels. The distribution of trips by fishing year for the selected core vessels (defined as 10 trips per year in 6 years) is shown on the right.**

## F.2 Data summaries

**Table F.1: Number of vessels, trips, trip strata, events, sum of catch, sum of tows (or net length) and sum of hours fishing for core vessels in the ELE3(RCO) and ELE3(MIX) CPUE analyses by fishing year.**

| | ELE3(RCO) | | | | | | | | ELE3(MIX) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Fishing year | Vessel | Trips | Trip-strata | events | Catch | Tows | Hours | % zero | Vessel | Trips | Trip-strata | events | Catch | Tows | Hours | % zero |
| 1990 | 23 | 720 | 742 | 1 168 | 29 | 2 566 | 8 717 | 63.9 | 23 | 1 043 | 1 231 | 2 213 | 89 | 4 484 | 15 578 | 59.6 |
| 1991 | 26 | 852 | 885 | 1 361 | 39 | 3 421 | 11 379 | 59.2 | 29 | 1 199 | 1 371 | 2 421 | 147 | 5 513 | 18 598 | 57.0 |
| 1992 | 34 | 1 328 | 1 390 | 2 449 | 85 | 5 624 | 20 872 | 52.2 | 34 | 1 639 | 1 942 | 3 690 | 180 | 7 611 | 28 230 | 50.8 |
| 1993 | 33 | 1 491 | 1 561 | 2 816 | 126 | 6 144 | 23 389 | 53.9 | 34 | 1 837 | 2 101 | 3 914 | 203 | 7 789 | 28 839 | 53.0 |
| 1994 | 36 | 1 878 | 1 944 | 3 234 | 166 | 7 252 | 24 303 | 46.6 | 37 | 2 219 | 2 425 | 3 976 | 232 | 8 897 | 29 813 | 45.8 |
| 1995 | 37 | 1 995 | 2 058 | 3 401 | 280 | 7 670 | 26 519 | 47.8 | 38 | 2 322 | 2 504 | 4 226 | 345 | 9 115 | 31 234 | 46.7 |
| 1996 | 36 | 1 941 | 2 017 | 4 002 | 265 | 7 717 | 25 086 | 46.8 | 36 | 2 175 | 2 334 | 4 572 | 367 | 9 030 | 29 292 | 45.5 |
| 1997 | 38 | 2 128 | 2 253 | 3 894 | 261 | 8 321 | 26 536 | 43.3 | 38 | 2 429 | 2 610 | 4 626 | 348 | 9 806 | 31 579 | 43.1 |
| 1998 | 38 | 2 257 | 2 403 | 4 469 | 394 | 10 187 | 30 664 | 43.2 | 38 | 2 491 | 2 695 | 5 225 | 450 | 11 252 | 34 244 | 42.9 |
| 1999 | 36 | 1 562 | 1 612 | 2 781 | 307 | 6 539 | 19 389 | 48.1 | 35 | 1 975 | 2 095 | 3 944 | 381 | 8 546 | 26 231 | 46.0 |
| 2000 | 34 | 1 390 | 1 458 | 2 621 | 323 | 6 533 | 20 286 | 42.0 | 36 | 1 703 | 1 858 | 3 722 | 433 | 8 303 | 25 980 | 40.5 |
| 2001 | 33 | 1 250 | 1 273 | 2 201 | 371 | 6 633 | 21 903 | 30.8 | 34 | 1 602 | 1 711 | 3 084 | 484 | 8 299 | 26 808 | 33.5 |
| 2002 | 30 | 897 | 921 | 1 614 | 304 | 4 886 | 15 395 | 29.8 | 34 | 1 206 | 1 357 | 2 716 | 455 | 6 894 | 22 204 | 32.5 |
| 2003 | 26 | 905 | 942 | 1 689 | 253 | 4 855 | 16 335 | 35.1 | 29 | 1 231 | 1 404 | 2 860 | 599 | 7 332 | 25 172 | 30.8 |
| 2004 | 28 | 906 | 939 | 1 775 | 261 | 4 417 | 14 685 | 42.9 | 29 | 1 193 | 1 384 | 2 735 | 591 | 6 222 | 20 939 | 38.7 |
| 2005 | 25 | 848 | 875 | 1 701 | 243 | 4 232 | 14 623 | 43.5 | 26 | 1 055 | 1 281 | 2 535 | 542 | 5 771 | 19 907 | 45.7 |
| 2006 | 23 | 692 | 716 | 1 315 | 282 | 3 330 | 12 052 | 34.2 | 24 | 951 | 1 131 | 2 283 | 536 | 5 272 | 19 107 | 35.4 |
| 2007 | 21 | 501 | 519 | 880 | 164 | 2 466 | 9 694 | 22.0 | 23 | 775 | 948 | 1 783 | 491 | 4 347 | 16 445 | 27.4 |
| 2008 | 17 | 418 | 542 | 1 559 | 147 | 1 559 | 5 494 | 35.1 | 23 | 598 | 941 | 2 959 | 497 | 2 967 | 10 892 | 36.5 |
| 2009 | 19 | 410 | 523 | 1 390 | 83 | 1 390 | 5 040 | 31.9 | 21 | 641 | 1 072 | 3 211 | 466 | 3 211 | 12 159 | 32.5 |
| 2010 | 19 | 388 | 504 | 1 261 | 64 | 1 261 | 4 192 | 45.2 | 23 | 581 | 1 027 | 3 173 | 426 | 3 173 | 11 945 | 41.4 |
| 2011 | 15 | 329 | 442 | 1 176 | 87 | 1 176 | 4 311 | 29.9 | 21 | 567 | 1 005 | 3 030 | 418 | 3 030 | 11 833 | 38.6 |

**Table F.2: Number of vessels, trips, trip strata, events, sum of catch, sum of tows (or net length) and sum of hours fishing for core vessels in the ELE5(MIX) CPUE analysis by fishing year.**

| | ELE5(MIX) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Fishing year | Vessel | Trips | Trip-strata | Events | Catch | Tows | Hours | % zero |
| 1990 | 18 | 446 | 459 | 741 | 8 | 1 981 | 4 878 | 83.7 |
| 1991 | 17 | 430 | 463 | 757 | 17 | 1 930 | 5 147 | 78.8 |
| 1992 | 21 | 555 | 588 | 1 025 | 18 | 2 383 | 6 003 | 81.3 |
| 1993 | 26 | 739 | 806 | 1 449 | 16 | 3 653 | 9 321 | 84.0 |
| 1994 | 26 | 709 | 728 | 1 193 | 14 | 3 621 | 8 723 | 82.3 |
| 1995 | 28 | 739 | 799 | 1 376 | 21 | 4 259 | 10 027 | 82.5 |
| 1996 | 32 | 689 | 774 | 1 405 | 32 | 4 450 | 10 866 | 79.2 |
| 1997 | 34 | 773 | 830 | 1 455 | 53 | 4 843 | 10 963 | 82.1 |
| 1998 | 30 | 753 | 812 | 1 366 | 64 | 4 585 | 10 034 | 81.0 |
| 1999 | 27 | 783 | 849 | 1 549 | 91 | 5 005 | 11 964 | 66.3 |
| 2000 | 29 | 705 | 766 | 1 499 | 68 | 4 739 | 12 405 | 67.9 |
| 2001 | 33 | 813 | 903 | 1 727 | 103 | 5 936 | 15 012 | 71.8 |
| 2002 | 31 | 810 | 880 | 1 645 | 61 | 5 154 | 12 683 | 71.8 |
| 2003 | 30 | 745 | 821 | 1 568 | 81 | 5 121 | 11 932 | 64.9 |
| 2004 | 29 | 824 | 878 | 1 469 | 74 | 4 631 | 11 418 | 71.9 |
| 2005 | 29 | 853 | 918 | 1 536 | 88 | 4 925 | 12 200 | 70.4 |
| 2006 | 29 | 679 | 737 | 1 285 | 103 | 4 121 | 11 163 | 62.6 |
| 2007 | 26 | 599 | 647 | 1 299 | 109 | 4 100 | 11 819 | 56.9 |
| 2008 | 23 | 592 | 710 | 3 554 | 124 | 3 645 | 10 325 | 47.6 |
| 2009 | 23 | 512 | 635 | 3 053 | 151 | 3 088 | 8 916 | 36.7 |
| 2010 | 21 | 515 | 644 | 3 271 | 113 | 3 358 | 9 896 | 43.0 |
| 2011 | 21 | 382 | 467 | 2 302 | 79 | 2 334 | 7 070 | 42.8 |

## F.3 ELE3(RCO): diagnostic plots

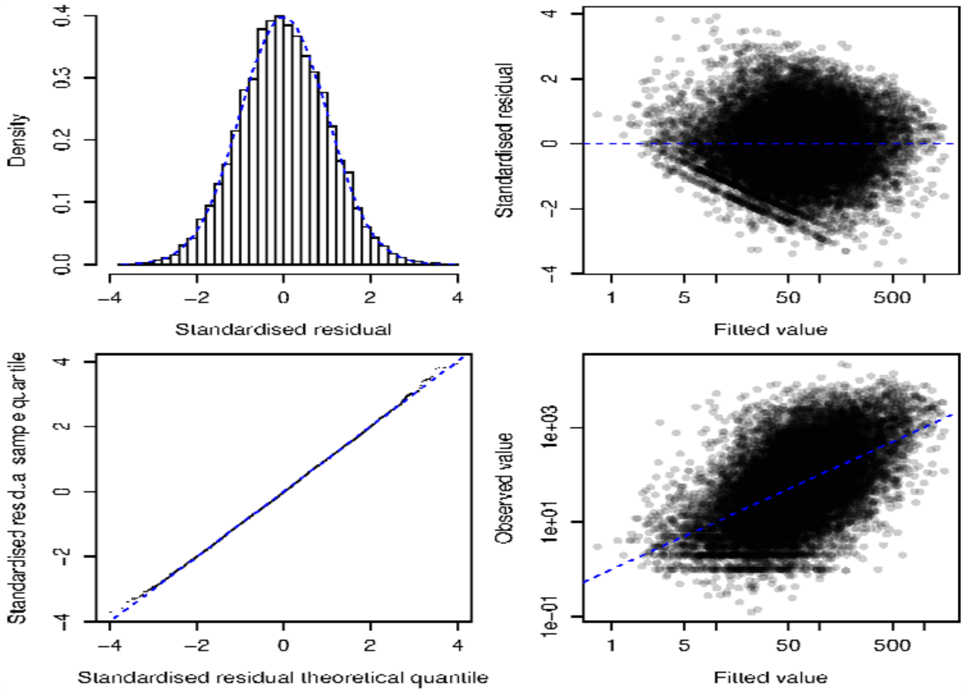



**Figure F.4: Plots of the fit of the standardised CPUE model to successful catches of elephantfish in the ELE3(RCO) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.**

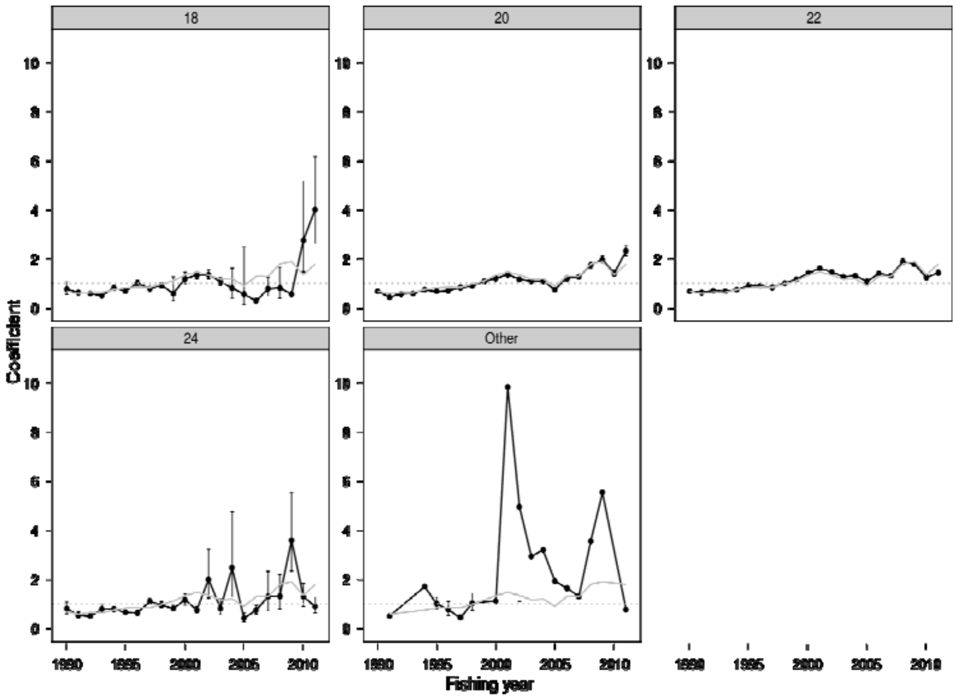



**Figure F.5: Residual implied coefficients for each area in each fishing year for the ELE3(RCO) CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.**

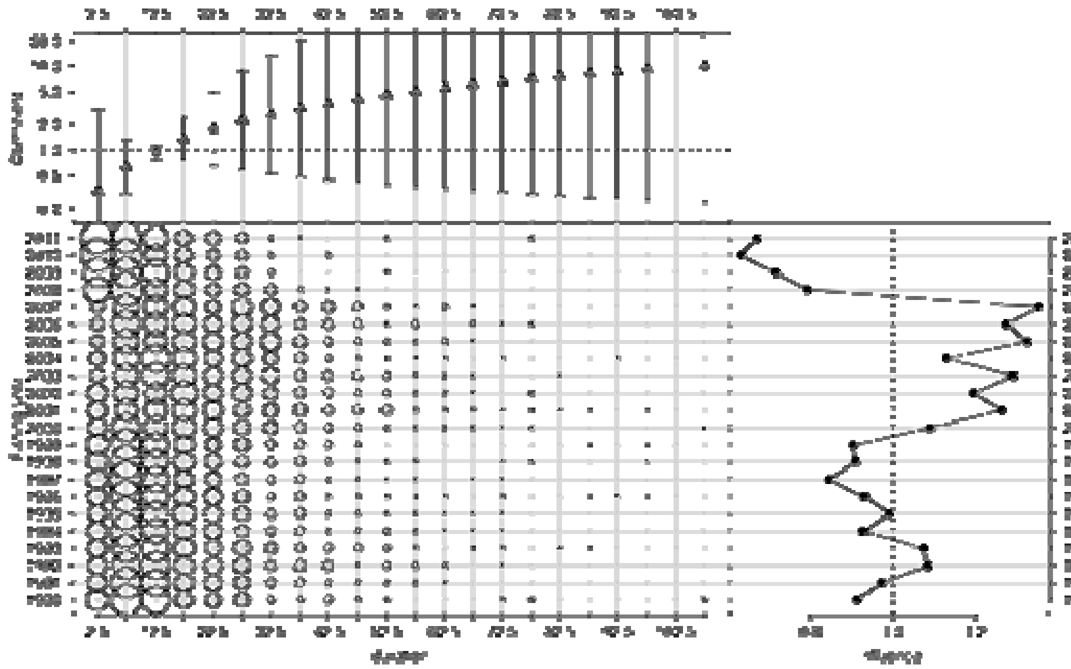


**Figure F.6: Effect of duration in the lognormal model for the ELE3(RCO) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

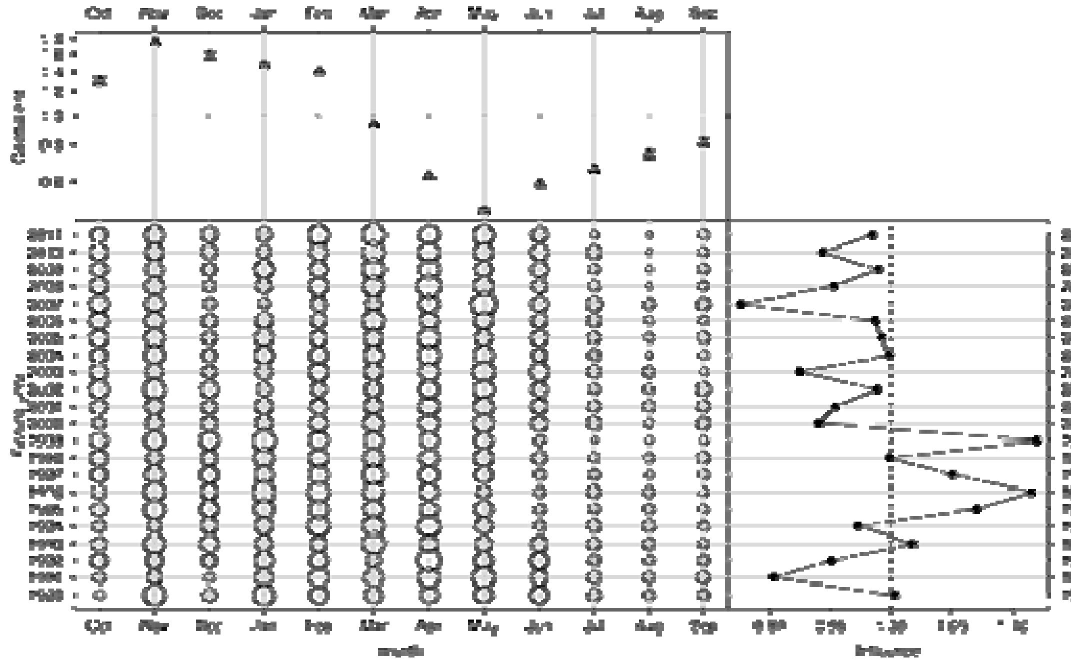


**Figure F.7: Effect of month in the lognormal model for the ELE3(RCO) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

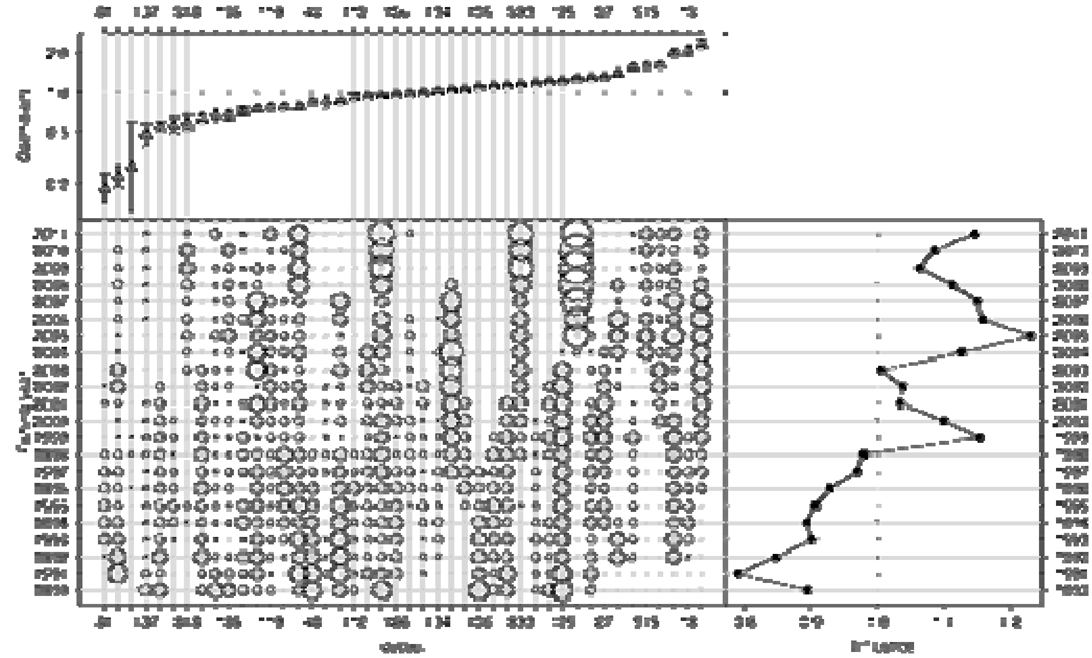


**Figure F.8: Effect of vessel in the lognormal model for the ELE3(RCO) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

## F.4 ELE3(MIX): diagnostic plots

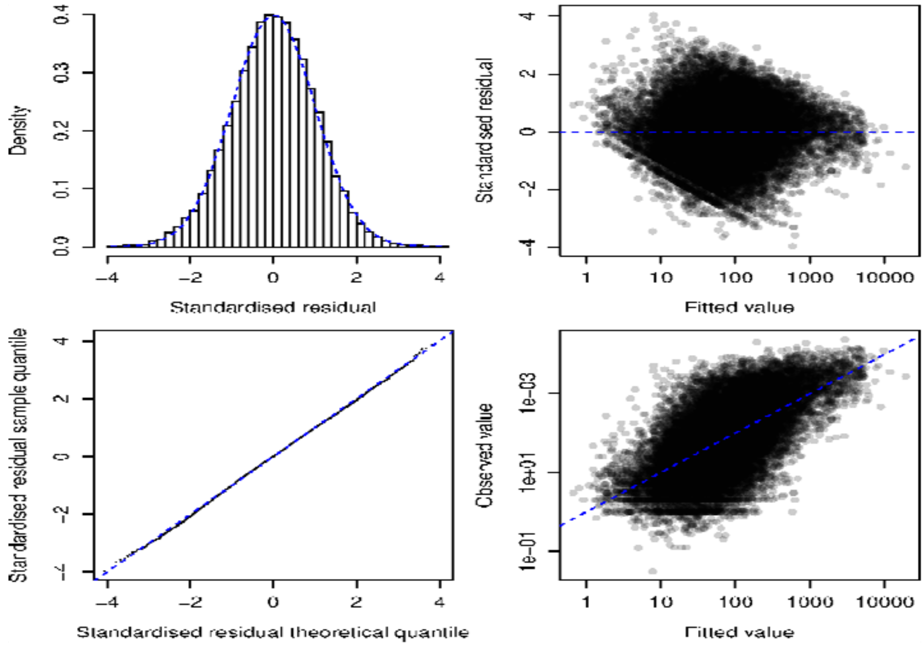



**Figure F.9: Plots of the fit of the standardised CPUE model to successful catches of elephantfish in the ELE3(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.**

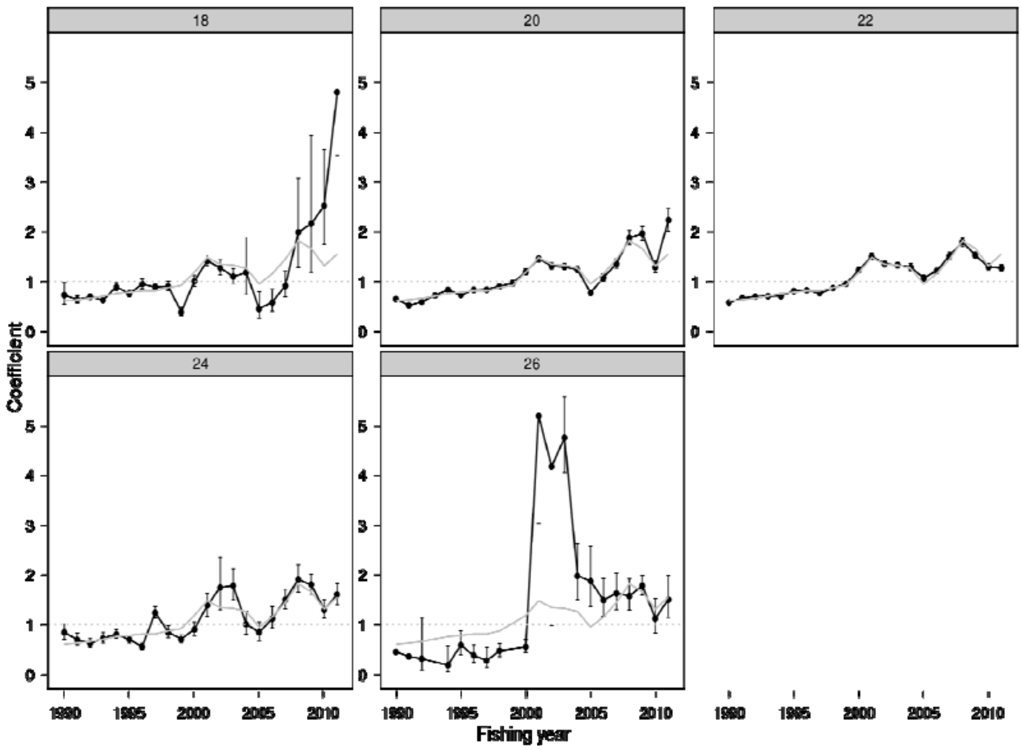



**Figure F.10: Residual implied coefficients for each area in each fishing year for the ELE3(MIX) CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.**

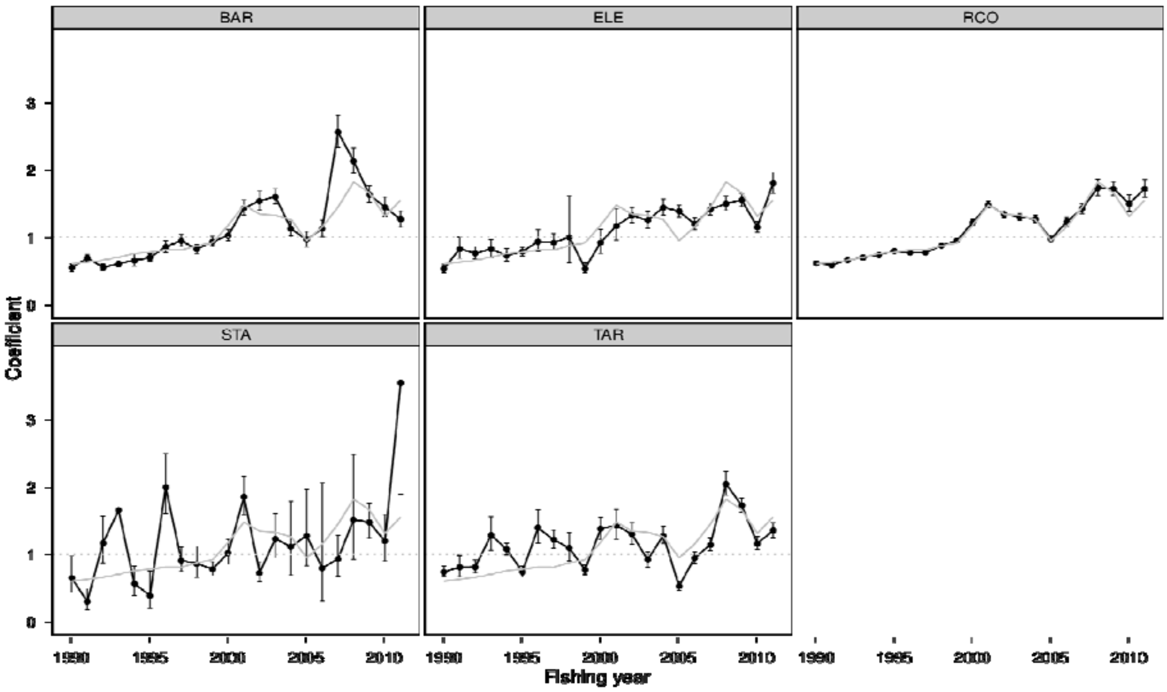



**Figure F.11: Residual implied coefficients for target×fishing year interactions in the ELE3(MIX) fishery. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals for each target in each fishing year. These values approximate the coefficients obtained when a target×year interaction term is fitted, particularly for those target×year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.**

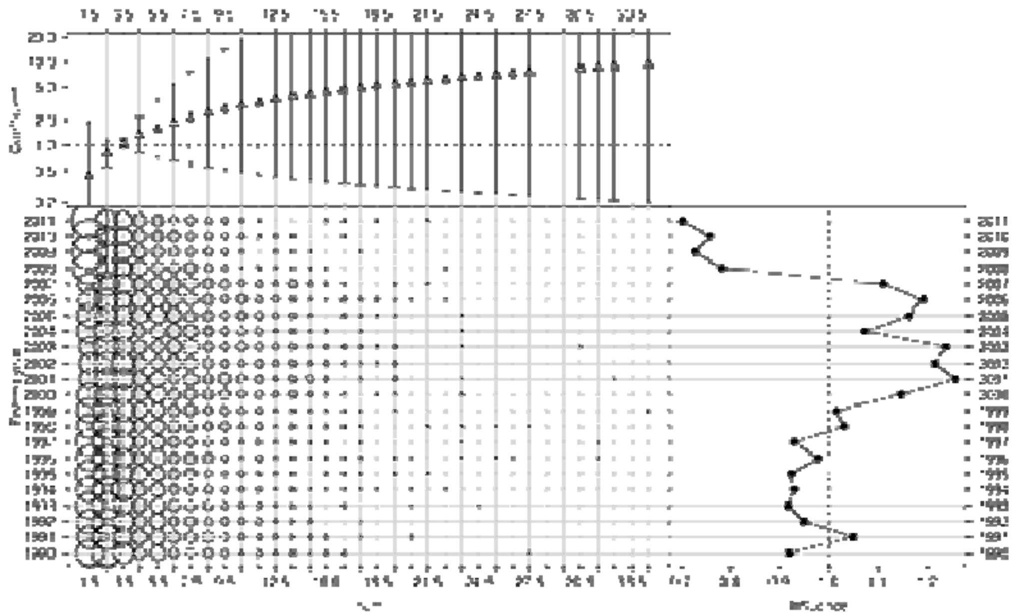


**Figure F.12: Effect of number of tows in the lognormal model for the ELE3(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

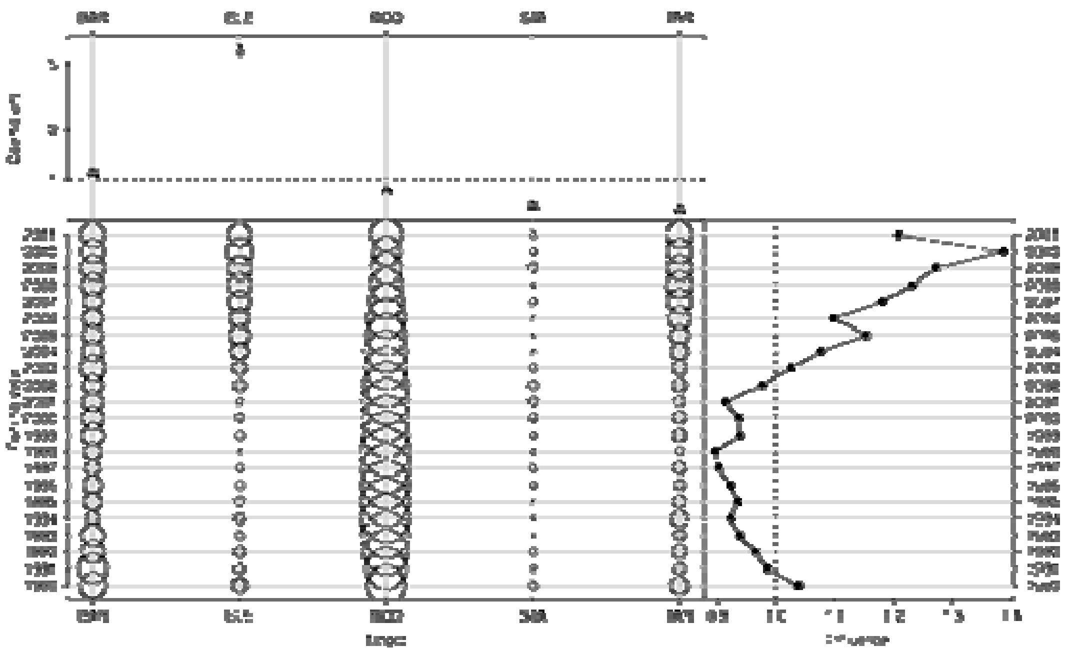


**Figure F.13: Effect of target species in the lognormal model for the ELE3(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

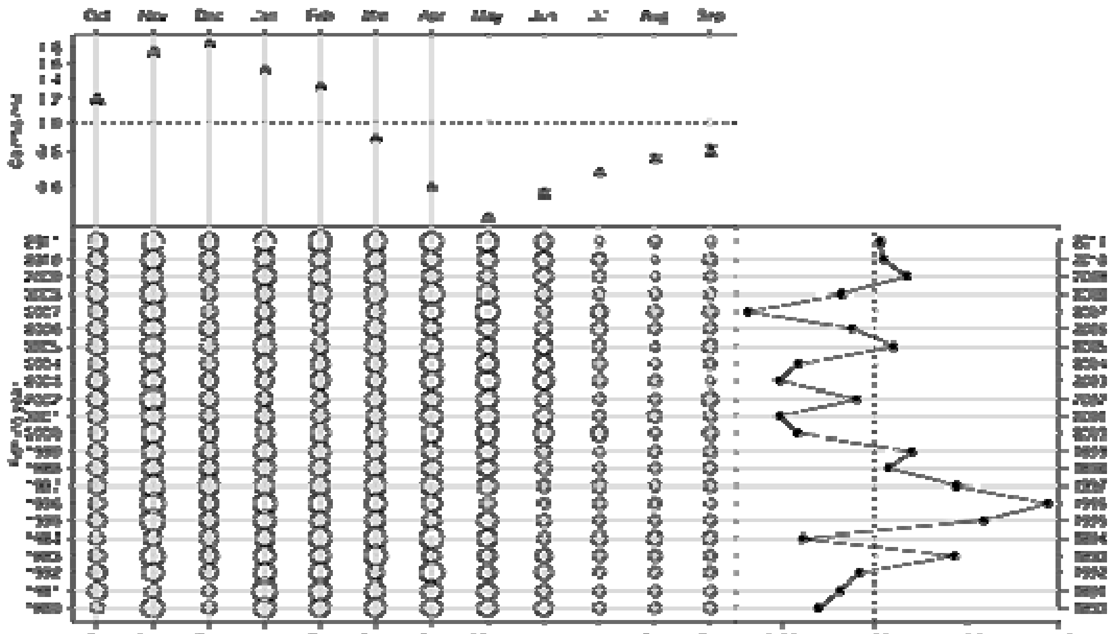



**Figure F.14: Effect of month in the lognormal model for the ELE3(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

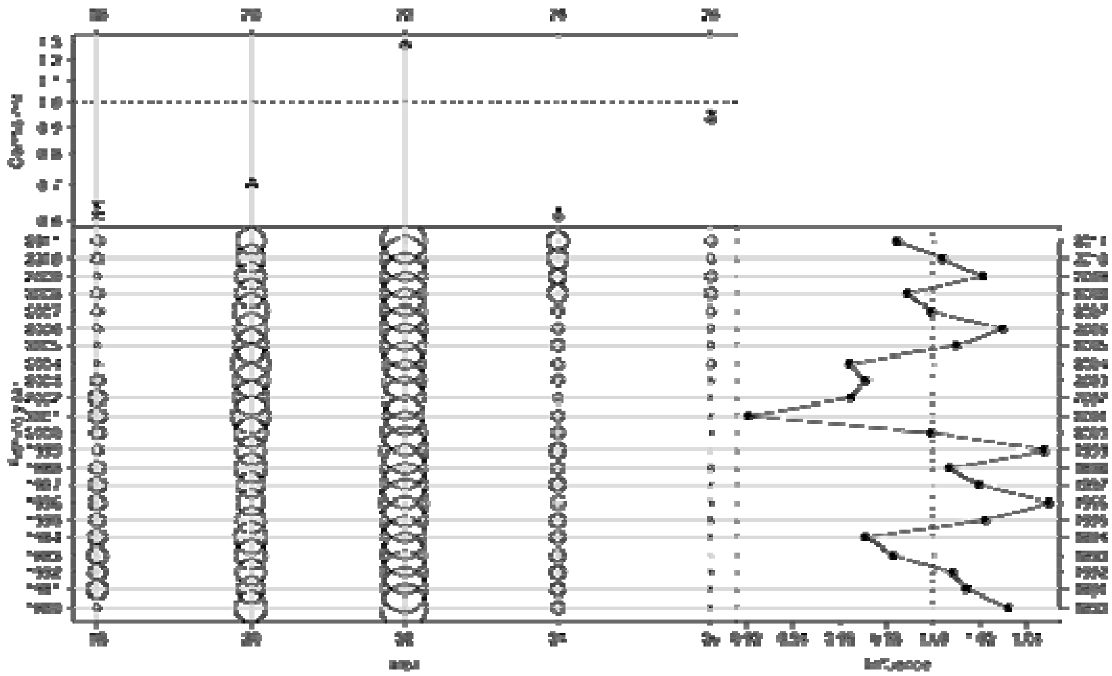


**Figure F.15: Effect of statistical area in the lognormal model for the ELE3(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

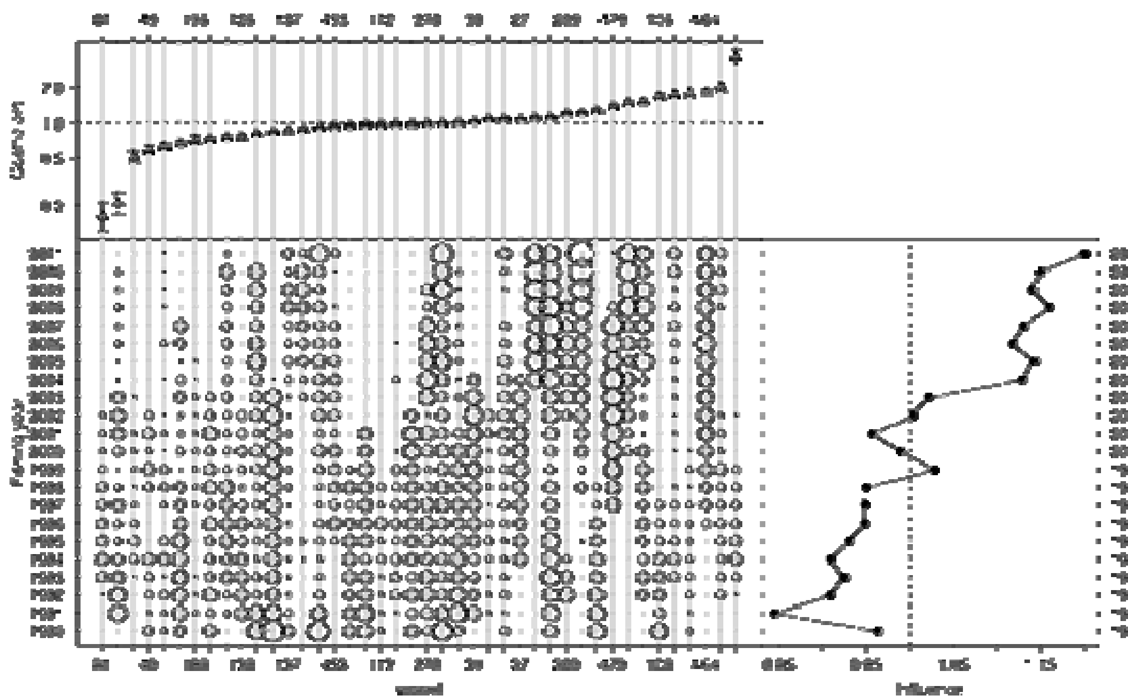


**Figure F.16: Effect of vessel in the lognormal model for the ELE3(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

## F.5 ELE5(MIX): diagnostic plots

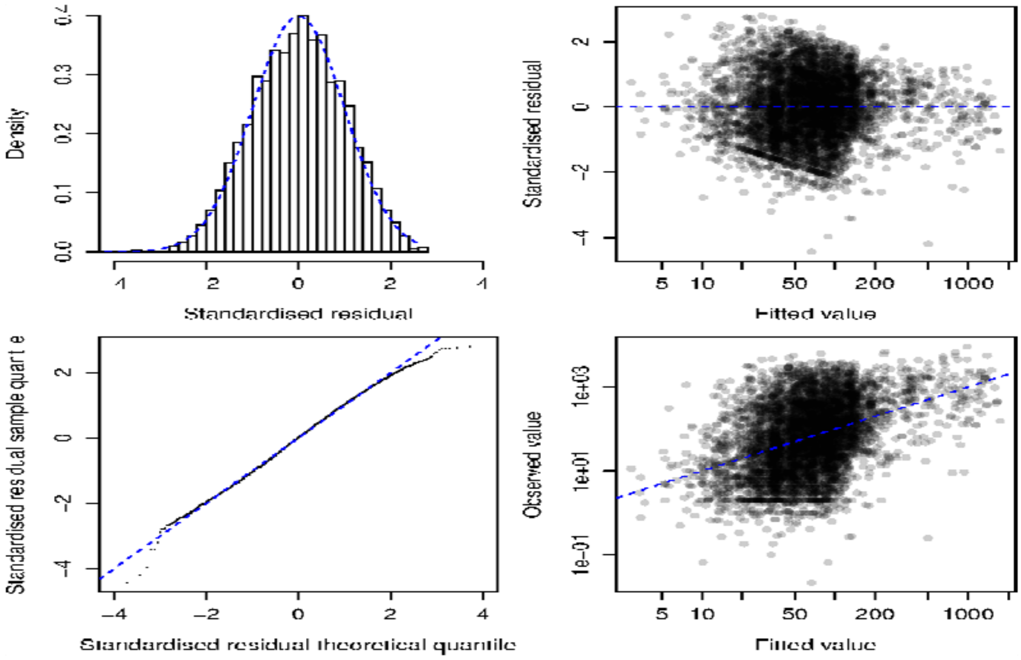



**Figure F.17: Plots of the fit of the standardised CPUE model to successful catches of elephantfish in the ELE5(MIX) fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution (SDSR: standard deviation of standardised residuals. MASR: median of absolute standardised residuals); [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.**

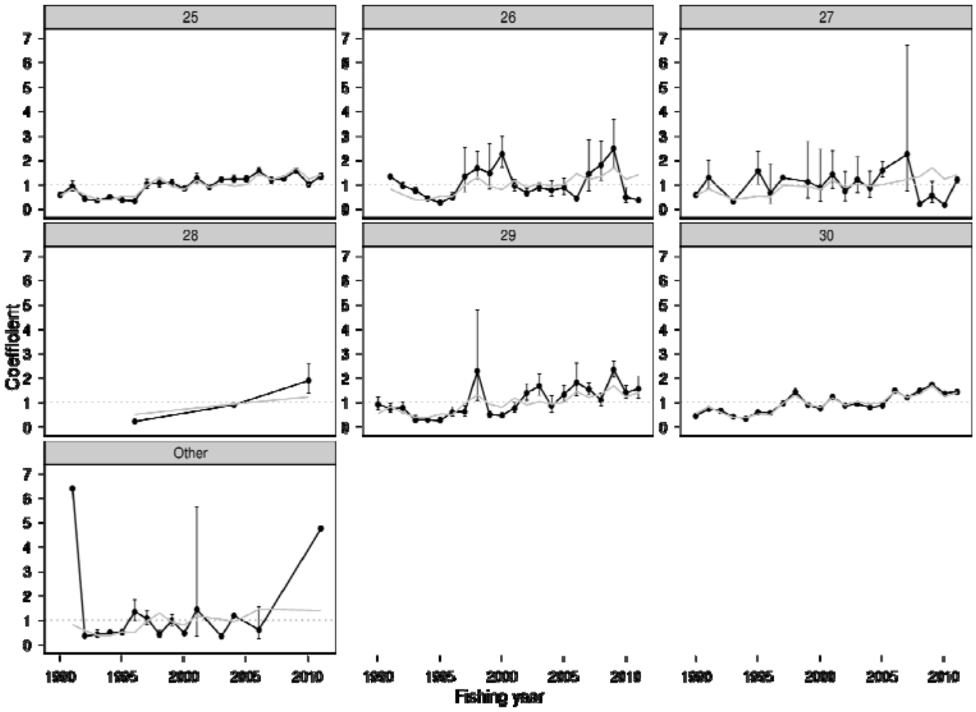



**Figure F.18: Residual implied coefficients for each area in each fishing year for the ELE5(MIX) CPUE analysis. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.**

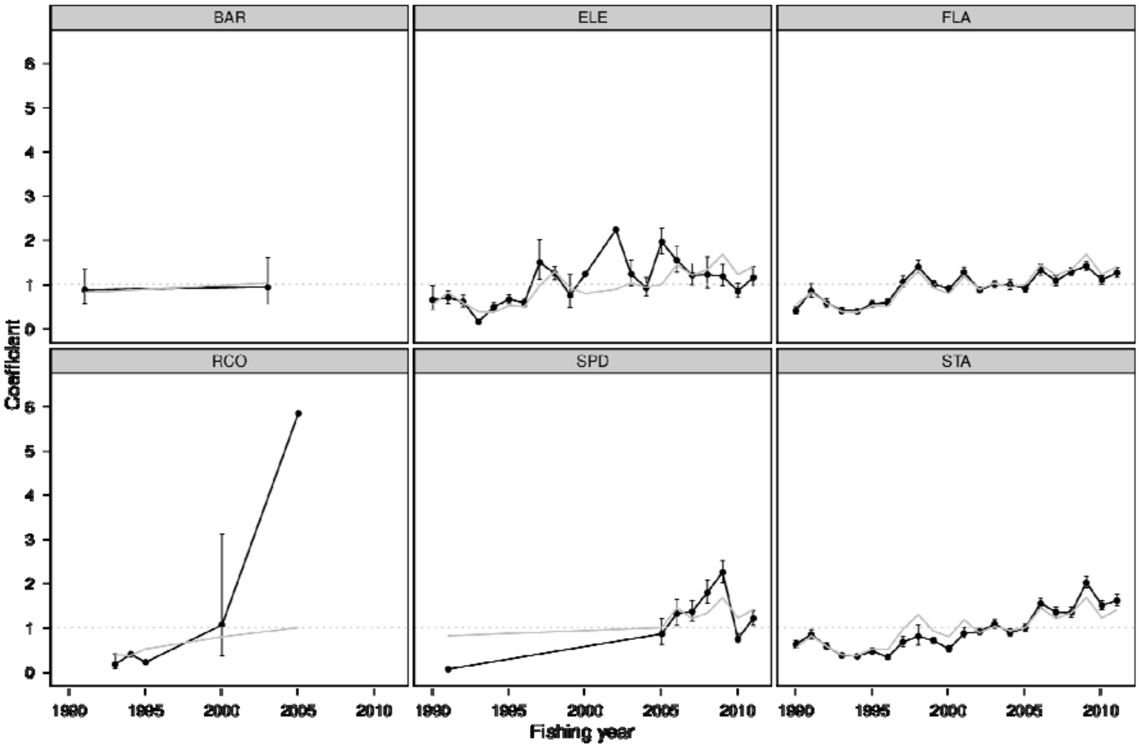



**Figure F.19: Residual implied coefficients for target×fishing year interactions in the ELE5(MIX) fishery. Implied coefficients (black points) are calculated as the normalised fishing year coefficient (grey line) plus the mean of the standardised residuals for each target in each fishing year. These values approximate the coefficients obtained when a target×year interaction term is fitted, particularly for those target×year combinations which have a substantial proportion of the records. The error bars indicate one standard error of the standardised residuals.**

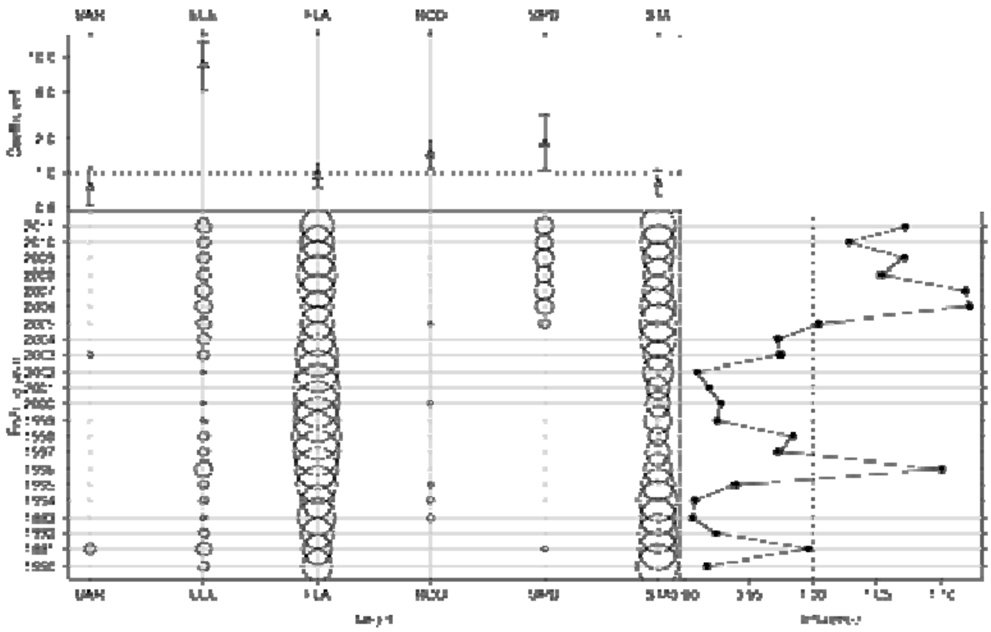


**Figure F.20: Effect of target in the lognormal model for the ELE5(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

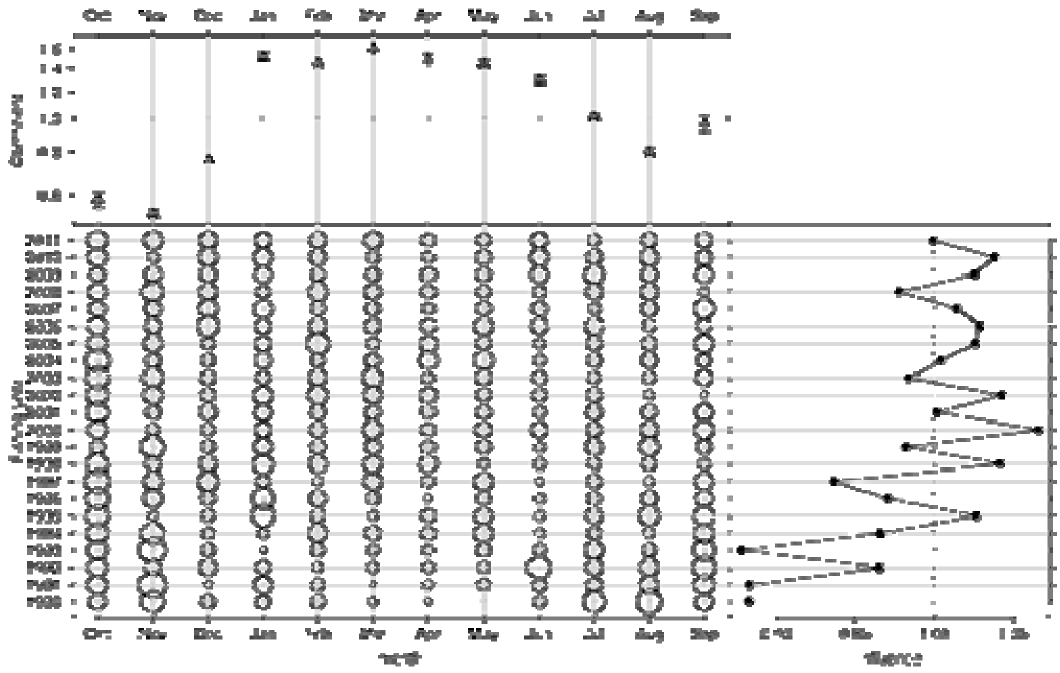


**Figure F.21: Effect of month in the lognormal model for the ELE5(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

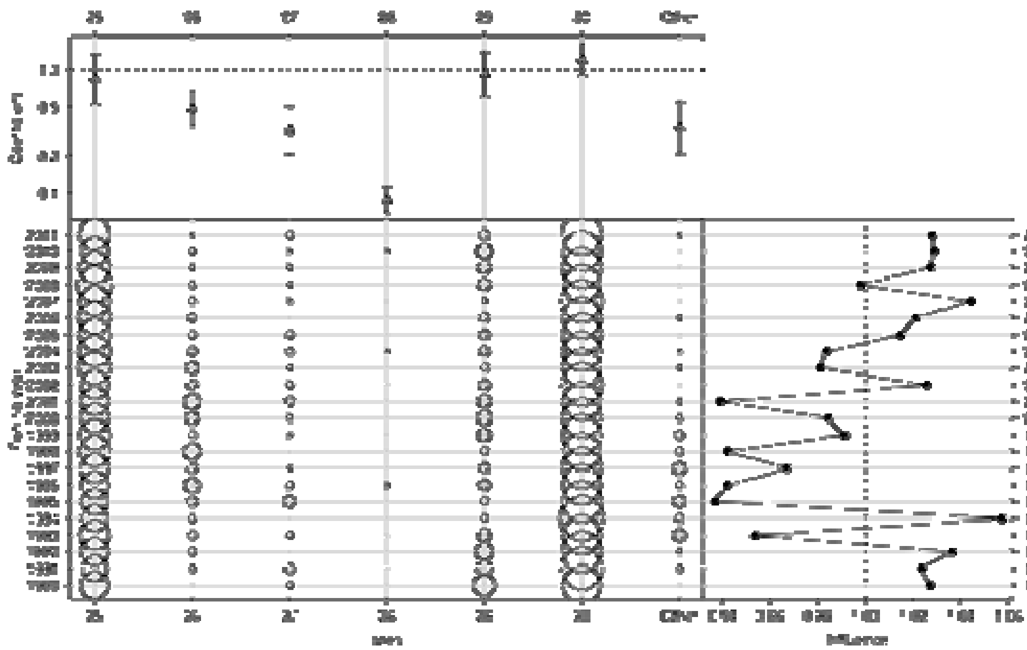


**Figure F.22: Effect of area in the lognormal model for the ELE5(MIX) fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.**

## F.6 CPUE indices

**Table F.3: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error for the core data set by fishing year for the two ELE 3 CPUE models.**

| | ELE3(RCO) | | | | | ELE3(MIX) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Fishing | All | Core | | | | All | Core | | | |
| Year | Arithmetic | Arithmetic | Geometric | Lognormal | SE | Arithmetic | Arithmetic | Geometric | Lognormal | SE |
| 1990 | 0.2721 | 0.2769 | 0.5734 | 0.6457 | 0.09687 | 0.3558 | 0.3263 | 0.5580 | 0.5849 | 0.07154 |
| 1991 | 0.3484 | 0.3033 | 0.3708 | 0.5440 | 0.08366 | 0.4422 | 0.4214 | 0.4803 | 0.6090 | 0.06578 |
| 1992 | 0.3441 | 0.3671 | 0.5174 | 0.6090 | 0.06340 | 0.3944 | 0.4165 | 0.5352 | 0.6380 | 0.05260 |
| 1993 | 0.4568 | 0.4630 | 0.5940 | 0.5995 | 0.06102 | 0.4654 | 0.4252 | 0.5774 | 0.6809 | 0.05175 |
| 1994 | 0.5540 | 0.5755 | 0.5898 | 0.7070 | 0.05243 | 0.4883 | 0.4879 | 0.5464 | 0.7335 | 0.04606 |
| 1995 | 0.7535 | 0.8208 | 0.7538 | 0.7771 | 0.05130 | 0.5621 | 0.6132 | 0.6750 | 0.7546 | 0.04541 |
| 1996 | 0.8019 | 0.8516 | 0.7781 | 0.8008 | 0.05158 | 0.7302 | 0.7312 | 0.7506 | 0.7840 | 0.04648 |
| 1997 | 0.8201 | 0.7743 | 0.7360 | 0.7941 | 0.04707 | 0.6543 | 0.6191 | 0.6803 | 0.7825 | 0.04295 |
| 1998 | 1.0478 | 0.9936 | 0.7835 | 0.9194 | 0.04568 | 0.7968 | 0.7429 | 0.6929 | 0.8445 | 0.04220 |
| 1999 | 1.2939 | 1.2859 | 1.1769 | 1.0465 | 0.05704 | 0.9138 | 0.8790 | 0.8756 | 0.8878 | 0.04831 |
| 2000 | 1.1916 | 1.1497 | 1.1853 | 1.2627 | 0.05568 | 0.9254 | 0.8752 | 0.9640 | 1.1403 | 0.04836 |
| 2001 | 1.4242 | 1.3915 | 1.2819 | 1.3916 | 0.05548 | 1.0822 | 1.0012 | 1.0395 | 1.4288 | 0.04859 |
| 2002 | 1.4404 | 1.4165 | 1.2062 | 1.2700 | 0.06386 | 1.2110 | 1.1878 | 1.1566 | 1.2981 | 0.05307 |
| 2003 | 1.1568 | 1.1522 | 1.0425 | 1.1037 | 0.06563 | 1.3682 | 1.3720 | 1.1799 | 1.2822 | 0.05163 |
| 2004 | 1.3268 | 1.3355 | 1.2910 | 1.1340 | 0.06918 | 1.5537 | 1.4809 | 1.3063 | 1.2204 | 0.05487 |
| 2005 | 1.3437 | 1.3381 | 1.0600 | 0.8457 | 0.07268 | 1.6113 | 1.6449 | 1.1776 | 0.9181 | 0.06045 |
| 2006 | 1.8757 | 1.8820 | 1.4785 | 1.2240 | 0.07350 | 1.6160 | 1.6198 | 1.3291 | 1.1148 | 0.05910 |
| 2007 | 1.5957 | 1.6287 | 1.4267 | 1.2167 | 0.07918 | 2.1662 | 2.0446 | 1.6601 | 1.3978 | 0.06095 |
| 2008 | 2.0347 | 1.9838 | 1.9503 | 1.6966 | 0.08660 | 2.1232 | 2.2425 | 2.3579 | 1.7587 | 0.06610 |
| 2009 | 1.9463 | 1.6166 | 2.0585 | 1.7954 | 0.08679 | 2.3085 | 2.3845 | 2.3476 | 1.6038 | 0.06134 |
| 2010 | 1.3096 | 1.5095 | 1.3981 | 1.2771 | 0.09741 | 1.7971 | 2.1976 | 1.9727 | 1.2671 | 0.06674 |
| 2011 | 2.3039 | 2.5421 | 2.1050 | 1.6949 | 0.09148 | 2.8309 | 3.4304 | 2.0851 | 1.5001 | 0.06586 |

**Table F.4: Arithmetic indices for the total and core data sets, geometric and lognormal standardised indices and associated standard error for the core data set by fishing year for the ELE5(MIX) CPUE model.**

| | ELE 5(MIX) | | | | |
|---|---|---|---|---|---|
| Fishing | All | Core | | | |
| Year | Arithmetic | Arithmetic | Geometric | Lognormal | SE |
| 1990 | 0.1563 | 0.1593 | 0.5027 | 0.6179 | 0.2031 |
| 1991 | 0.3662 | 0.4352 | 0.9097 | 0.9289 | 0.1798 |
| 1992 | 0.4016 | 0.3428 | 0.6985 | 0.6582 | 0.1682 |
| 1993 | 0.2407 | 0.2454 | 0.4168 | 0.4348 | 0.1560 |
| 1994 | 0.2060 | 0.1960 | 0.3572 | 0.4229 | 0.1560 |
| 1995 | 0.3351 | 0.2696 | 0.5327 | 0.5890 | 0.1499 |
| 1996 | 0.4437 | 0.4122 | 0.5732 | 0.5698 | 0.1400 |
| 1997 | 0.8000 | 1.0858 | 0.9732 | 1.1010 | 0.1459 |
| 1998 | 0.7216 | 0.8870 | 1.3537 | 1.4728 | 0.1439 |
| 1999 | 2.4147 | 2.0975 | 0.9720 | 1.0469 | 0.1072 |
| 2000 | 1.2405 | 1.2695 | 0.7806 | 0.9033 | 0.1152 |
| 2001 | 1.9553 | 1.9424 | 1.0721 | 1.3381 | 0.1134 |
| 2002 | 0.9313 | 0.8983 | 0.9517 | 1.0110 | 0.1143 |
| 2003 | 1.3413 | 1.3822 | 1.1308 | 1.1745 | 0.1065 |
| 2004 | 1.3627 | 1.4032 | 1.0150 | 1.0624 | 0.1144 |
| 2005 | 1.4001 | 1.4174 | 1.0959 | 1.1363 | 0.1095 |
| 2006 | 1.9514 | 2.1667 | 1.7530 | 1.6446 | 0.1092 |
| 2007 | 2.3956 | 2.5205 | 1.4029 | 1.3753 | 0.1085 |
| 2008 | 3.0918 | 2.9164 | 1.7901 | 1.5174 | 0.0950 |
| 2009 | 4.1204 | 3.9272 | 2.7360 | 1.9141 | 0.0919 |
| 2010 | 3.5134 | 3.2364 | 1.8627 | 1.3902 | 0.0957 |
| 2011 | 3.5013 | 3.1605 | 2.3926 | 1.5968 | 0.1104 |

## Appendix G. COMPARISONS WITH OTHER CPUE MODELS (SENSITIVITIES)

### G.1 ELE3(RCO): target red cod bottom trawl fishery

Regression models using five different distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) predicted catch based on a reduced set of explanatory variables (year, month, vessel, area, target and log(number of tows). These models were evaluated by examination of residual diagnostics and the model with the lowest negative log likelihood was selected for the final stepwise regression (Figure G.1). The lognormal error distribution provided the best fit of the positive catch records to the core dataset for the ELE3(RCO) regression. The sensitivity of the final model indices to the choice of error distribution is shown in Figure G.2.

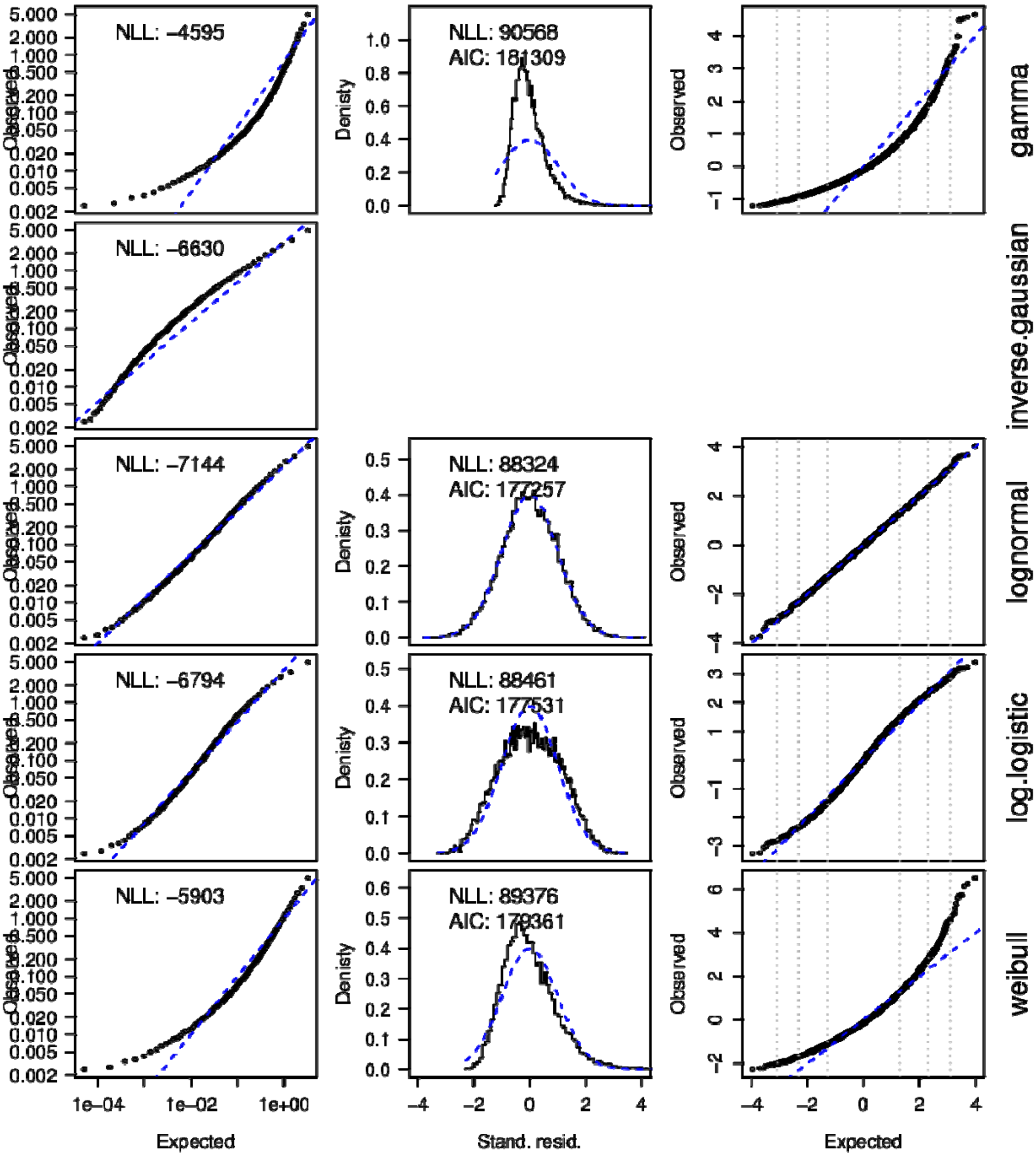



**Figure G.1: Diagnostics for alternative distributional assumptions for catch in the ELE3(RCO) fishery. Left: maximum likelihood fit (dotted) to observed catches (solid, scaled by their mean); Middle: standardised residuals from a model catch ~ fyear + month + area + vessel + target + poly(log(num); Right: quantile-quantile plot of standardised residuals of model. LL = log-likelihood of fit. The distribution with the lowest log-likelihood was lognormal.**

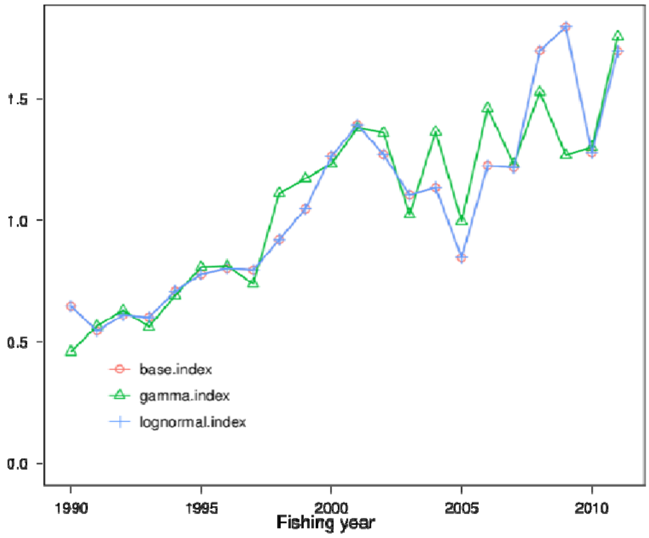



**Figure G.2: Comparison between the ELE 3(RCO) lognormal index (base) and indices from a gamma model fitted to the same dataset using the same parameterisation.**

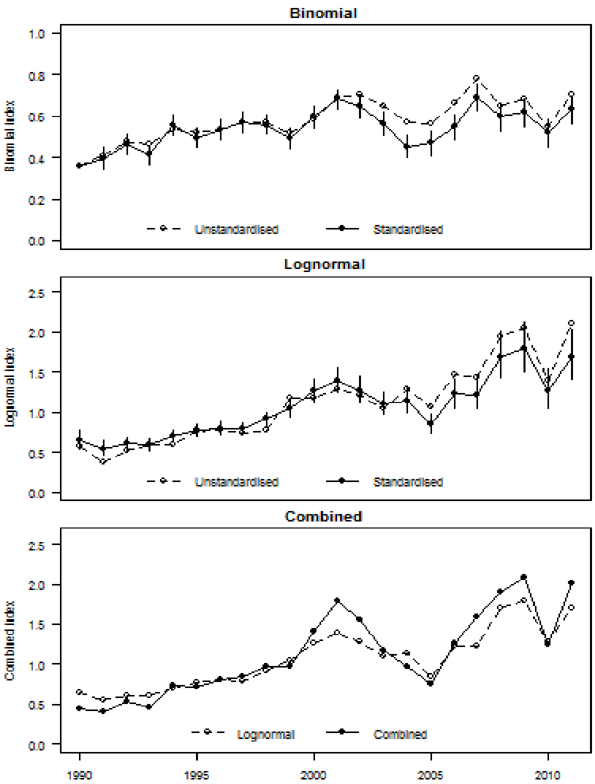



**Figure G.3: The effect of standardisation on the raw CPUE of elephantfish by core vessels in the ELE 3(RCO) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch, broken line is the raw CPUE (kg / tow), the solid line is the standardised CPUE canonical indices with plus or minus two standard error bars. Bottom: The effect on the Lognormal index from combining it with the Binomial index**

A binomial model of the probability of capture was fit to the full core dataset (including zero catches) and changes the unstandardised probability of capture very little, but the resulting year indices confirm the overall pattern of increase evident in standardised catch rates. When the binomial is combined with the lognormal model, the effect is slight, exaggerating the magnitude of the peaks and lows of that series without affecting the overall trends (Figure G.3). The binomial and combined models are not presented here in any further detail.

## G.2 ELE 3(MIX): ELE 3 mixed target bottom trawl fishery

Regression models using five different distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull) predicted catch based on a reduced set of explanatory variables (year, month, vessel, area, target and log(number of tows). These models were evaluated by examination of residual diagnostics and the model with the lowest negative log likelihood was selected for the final stepwise regression (Figure G.4). The lognormal error distribution provided the best fit of the positive catch records to the core dataset for the ELE 3(MIX) regression. The sensitivity of the final model indices to the choice of error distribution is shown in Figure G.5.

A binomial model of the probability of capture was fit to the full core dataset (including zero catches) and changes the unstandardised probability of capture very little, but the resulting year indices confirm the overall pattern of increase evident in standardised catch rates. The effect of combining the binomial series with a lognormal series was to estimate an even stronger increase in recent years (Figure G.6). The binomial and combined models are not presented here in any further detail.

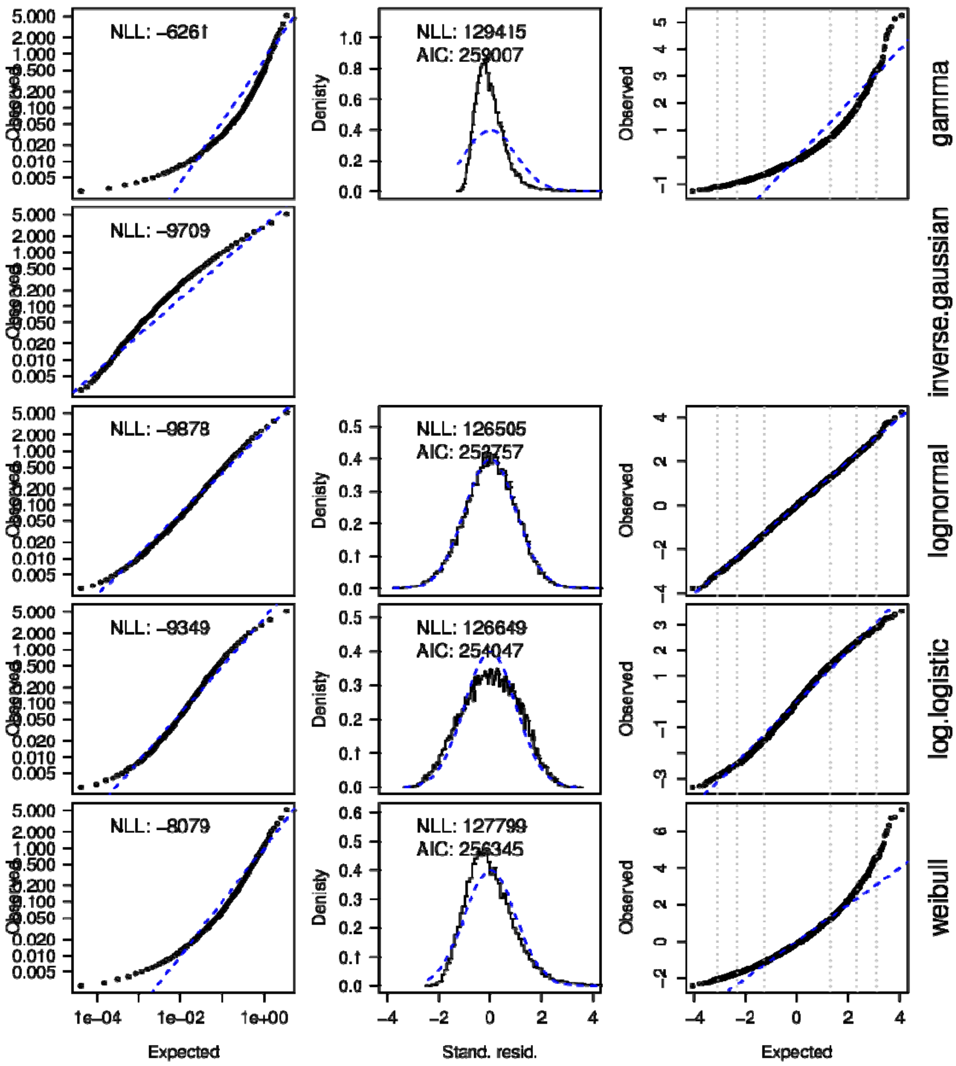



**Figure G.4: Diagnostics for alternative distributional assumptions for catch in the ELE 3(MIX) fishery. Left: maximum likelihood fit (dotted) to observed catches (solid, scaled by their mean); Middle: standardised residuals from a model catch ~ fyear + month + area + vessel + target + poly(log[num]); Right: quantile-quantile plot of standardised residuals of model. LL = log-likelihood of fit. The distribution with the lowest log-likelihood was lognormal.**

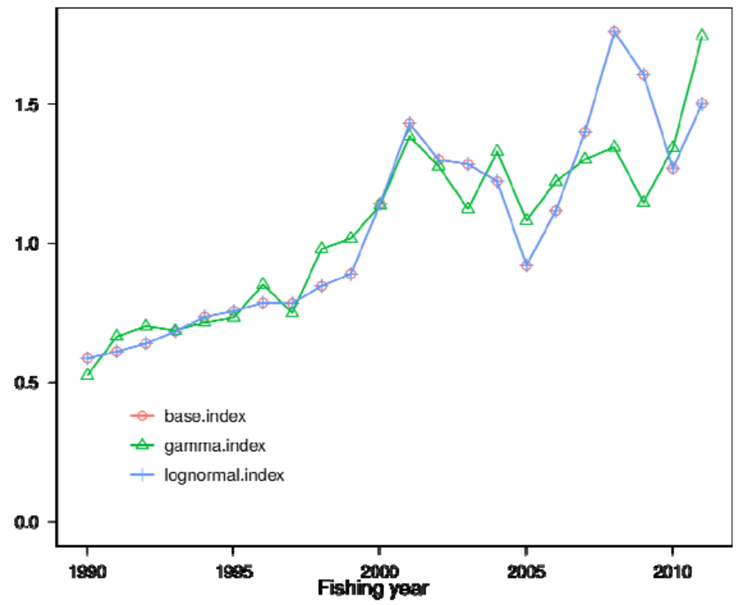



**Figure G.5: Comparison between the ELE3(MIX) lognormal index (base) and the indices from the gamma model fitted to the same dataset using the same parameterisation.**

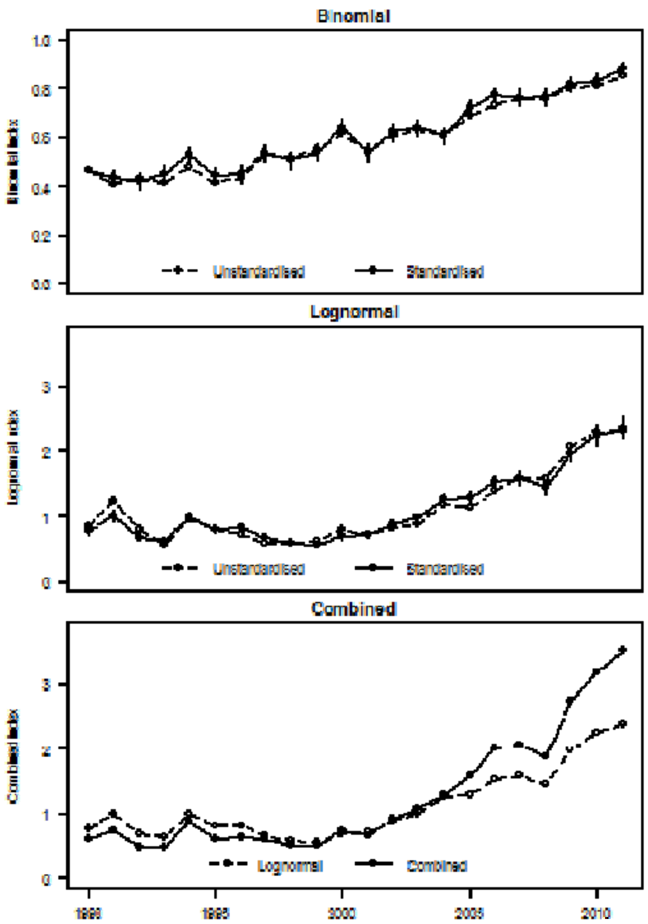



**Figure G.6: The effect of standardisation on the raw CPUE of ELE by core vessels in the ELE 3(MIX) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch, broken line is the raw CPUE (kg / tow), the solid line is the standardised CPUE canonical indices with plus or minus two Standard Error bars. Bottom: Combined index of expected catch.**

An alternative analysis done on data amalgamated to trip resolution is summarised in Table G.1 and the CDI plot describing the influence of effort at this resolution (which should be too coarse to be affected by the switch to the new form) is shown in Figure G.7.

**Table G.1: Summary of an alternative lognormal model for the ELE 3(MIX)-trip analysis based data amalgamated to trip resolution.**

| Term | DF | Log likelihood | AIC | $R^2$ (%) | Final |
|---|---|---|---|---|---|
| fyear | 23 | 23 | -129 106 - | 6.2 | * |
| poly(log(duration),3) | 26 | 26 | -127 561 - | 19.6 | * |
| month | 37 | 37 | -126 480 - | 27.8 | * |
| Area | 41 | 41 | -125 920 - | 31.7 | * |
| vessel | 374 | 374 | -125 378 - | 35.3 | * |
| poly(log(num),3) | 377 | 377 | -125 344 - | 35.5 | |

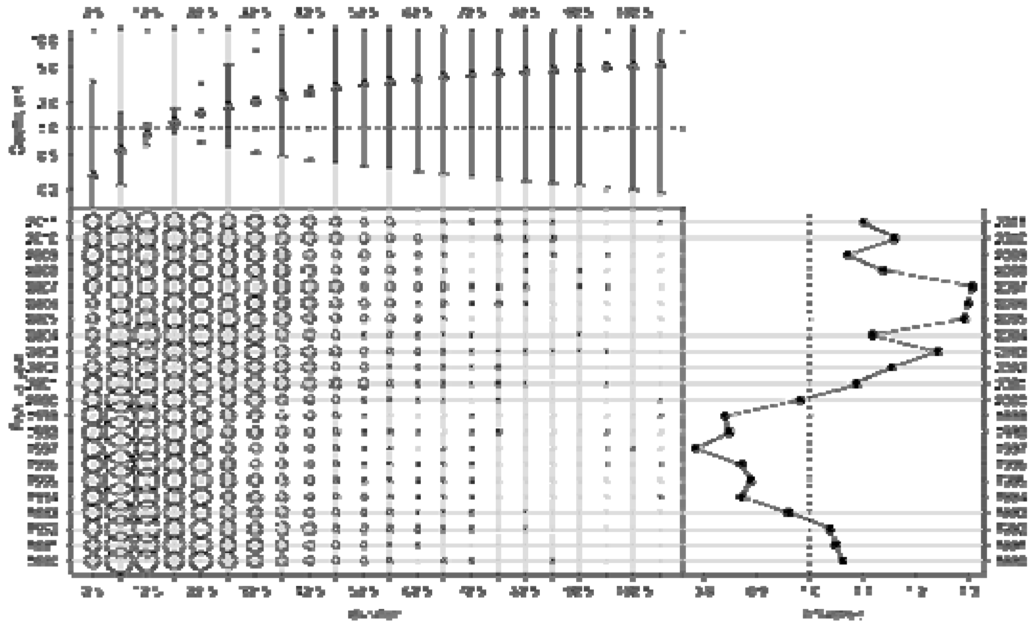


**Figure G.7: Effect of log(duration) in the lognormal model for the ELE 3(MIX)-trip analysis based on data amalgamated to trip resolution. [Top]: variable coefficients. [Bottom-left]: distribution of trips by fishing year for the effort variable; [Bottom-right]: cumulative effect of log(duration) by fishing year .**

## G.3 ELE5(MIX): ELE 5 mixed target bottom trawl fishery

Regression models using five different distributional assumptions (lognormal, log-logistic, inverse Gaussian, gamma and Weibull predicted catch based on a reduced set of explanatory variables (year, month, vessel, area, target and log(number of tows). These models were evaluated by examination of residual diagnostics and the model with the lowest negative log likelihood was selected for the final stepwise regression (Figure G.8). The lognormal error distribution provided the best fit of the positive catch records to the core dataset for the ELE5(MIX) regression. The sensitivity of the final model indices to the choice of error distribution is shown in Figure G.9.

A binomial model of the probability of capture was fit to the full core dataset (including zero catches) and changes the unstandardised probability of capture very little, but the resulting year indices confirm the overall pattern of increase evident in standardised catch rates. The effect of combining the binomial series with a lognormal series was to estimate an even stronger increase in recent years (Figure G.10). The binomial and combined models are not presented here in any further detail.

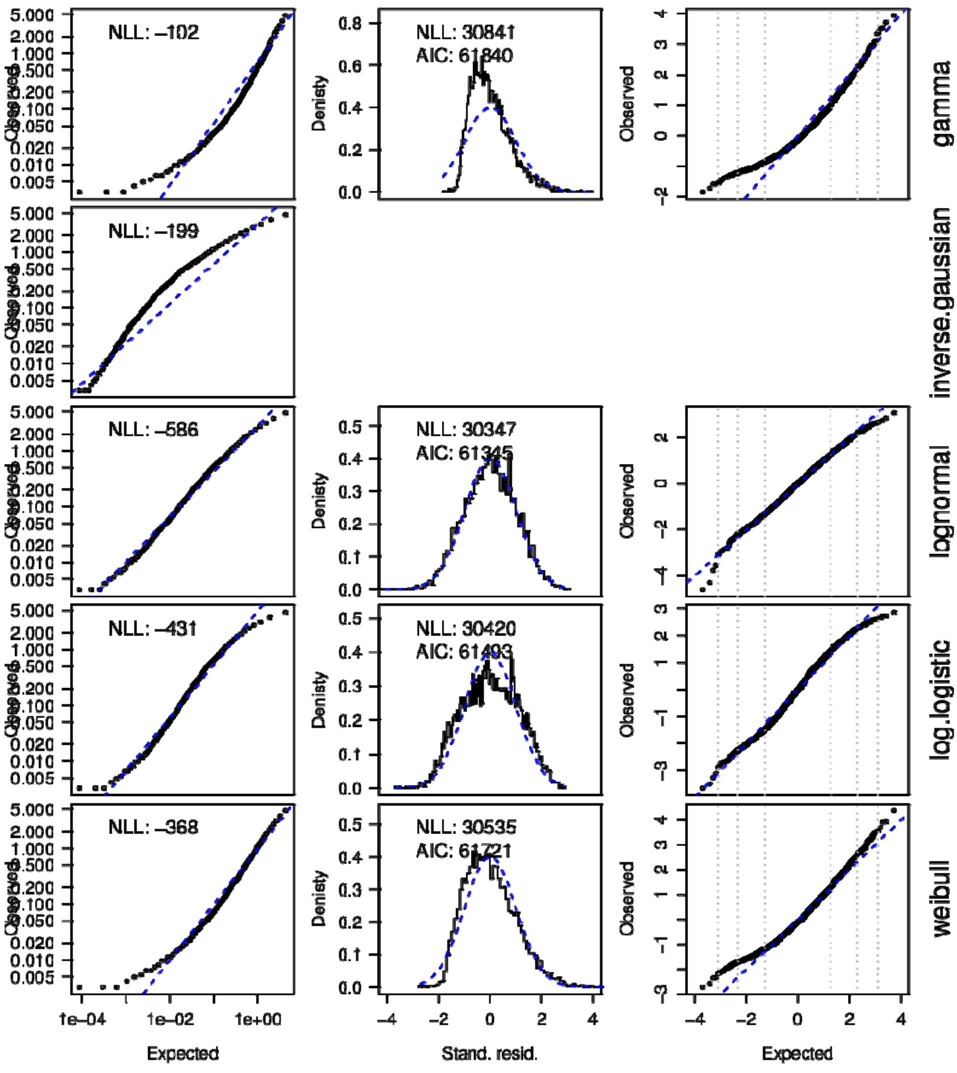



**Figure G.8: Diagnostics for alternative distributional assumptions for catch in the ELE5(MIX) fishery. Left: maximum likelihood fit (dotted) to observed catches (solid, scaled by their mean); Middle: standardised residuals from a model catch ~ fyear + month + area + vessel + target + poly(log[num]); Right: quantile-quantile plot of standardised residuals of model. LL = log-likelihood of fit. The distribution with the lowest log-likelihood was lognormal.**

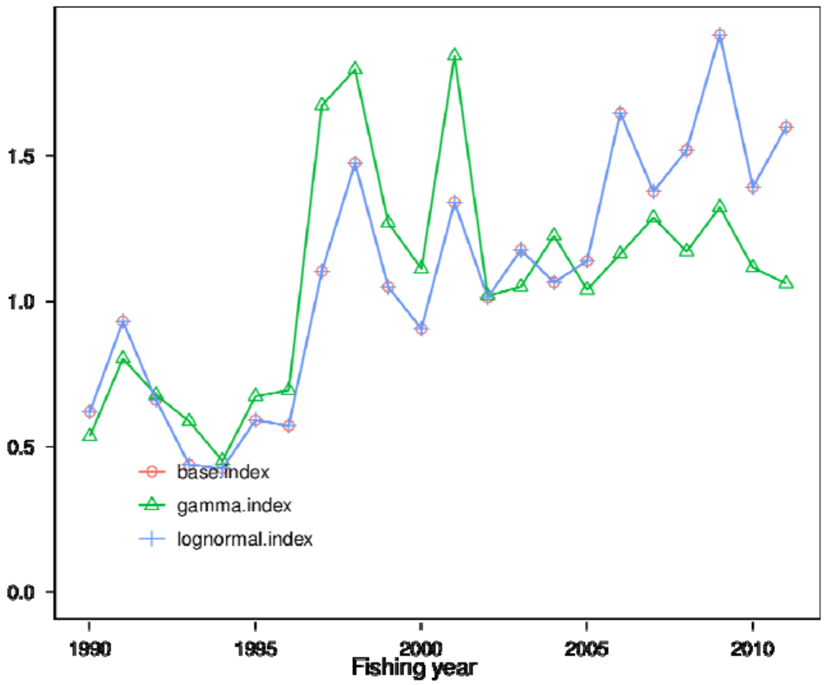



**Figure G.9: Comparison between the ELE5(MIX) lognormal index (base) and the indices from the gamma model fitted to the same dataset using the same parameterisation.**

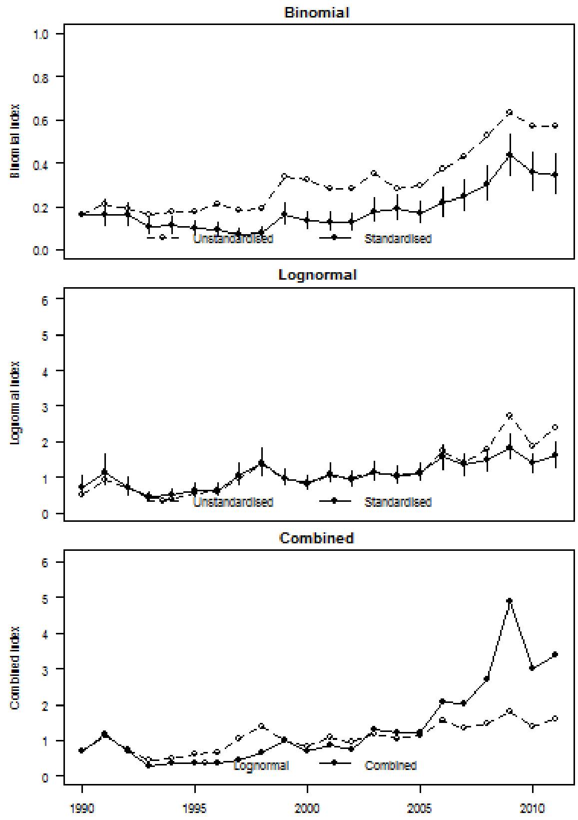



**Figure G.10: The effect of standardisation on the raw CPUE of ELE by core vessels in the ELE5(MIX) fishery. Top: Binomial index of probability of capture. Middle: Lognormal index of magnitude of catch., broken line is the raw CPUE (kg / tow), the solid line is the standardised CPUE canonical indices with plus or minus two Standard Error bars. Bottom: Combined index of expected catch.**

An alternative analysis done on data amalgamated to trip resolution (which should be too coarse to be affected by the switch to the new form) is summarised in Table G.2. Note that no effort variable was included in this model; consequently it was unnecessary to present a CDI plot describing the influence of effort at this resolution.

**Table G.2: Summary of an alternative lognormal model for the ELE5(MIX)-trip fishery based data amalgamated to trip resolution.**

| Term | DF | Log likelihood | AIC | R2 (%) | Final |
|---|---|---|---|---|---|
| fyear | 23 | -27 951 | 55 948 | 4.95 | * |
| month | 34 | -27 848 | 55 764 | 9.19 | * |
| area | 42 | -27 795 | 55 674 | 11.32 | * |
| poly(log(num)  3) | 45 | -27 784 | 55 658 | 11.75 | |
| poly(log(duration)  3) | 48 | -27 775 | 55 646 | 12.11 | |