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Tini a Tangaroa

Standardised CPUE analyses for paua (*Haliotis iris*) in PAU 2, 1989–90 to 2013–14

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EXECUTIVE SUMMARY

McKenzie, A. (2019). Standardised CPUE analyses for paua (*Haliotis iris*) in PAU 2, 1989–90 to 2013–14.

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For PAU 2 most of the commercial catch comes from the Wairarapa and Wellington south coast between Castle Point and Turakirae Head. Catch-effort data from this area was used for standardised CPUE analyses for PAU 2. Two separate standardised CPUE series were calculated: (i) one based on CELR data from 1990 to 2001, and (ii) another on PCELR data from 2002 to 2014.

For 1990 to 2001 the standardised index declines for the first four years, then increases, with a drop in the last year. For 2002 to 2014 the standardised index shows a slow decline from 2002 to 2012 with a slight increase since then.

As the standardised index shows little contrast since 2002, and there is little growth data available for PAU 2, stock assessment model estimates of biomass would be highly uncertain and not useful for management purposes. Because of this it was decided by the Shellfish Working Group that a full stock assessment should not be undertaken for PAU 2.

1. INTRODUCTION

This document summarises the standardised CPUE analyses for PAU 2. The work was conducted by NIWA under the Ministry for Primary Industries contract PAU201404 Objective 1.

The PAU 2 QMA covers a broad area covering the east, south, and west coasts of the North Island (Figure 1). It is within the old Statistical Areas 011, 012, 013, 014, 015, 016, 037, 038, 039, 040 and 041, but is now reported by the zones P201–P245 (Figure 2).

Most of the commercial catch comes from the Wairarapa and Wellington south coast between Castle Point and Turakirae Head (Table 1, Figure 3). The area between the Waikanae River and Turakirae Head has been closed to commercial fishing since 1972, due to concerns over depletion of the recreational fishery and the presence of sewerage outlets (Creswell 1995). A stock assessment model for PAU 2 would cover the area where most of the commercial catch comes from (old Statistical Areas 014, 015, 016; zones P201–P236).

A standardised CPUE for PAU 2 was last calculated in 2008, as a single series where CELR and PCELR data were combined (McKenzie et al. 2009). This showed an increase to 2001, after which the index was relatively flat (Figure 4).

In the sections that follow the available catch-effort data is examined in some detail, the CPUE standardisation methodologies are given, followed by the standardisations.

The fishing year for paua is from 1 October to 30 September and in this document we refer to the fishing year by the second year that it covers; thus we call the 1997–98 fishing year "1998".

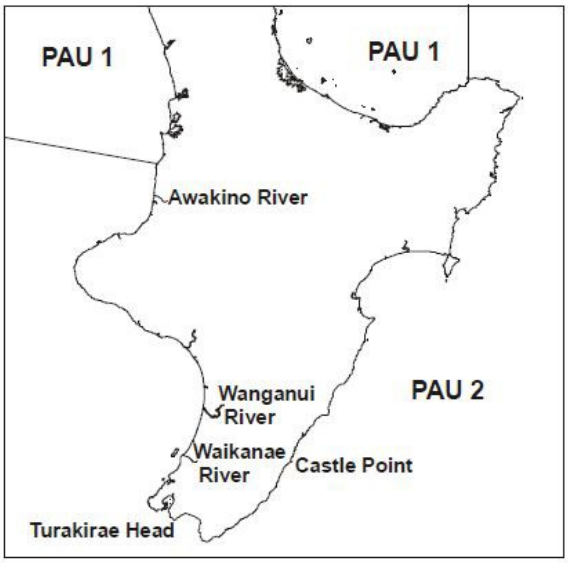


Figure 1: The location of the PAU 2 QMA.

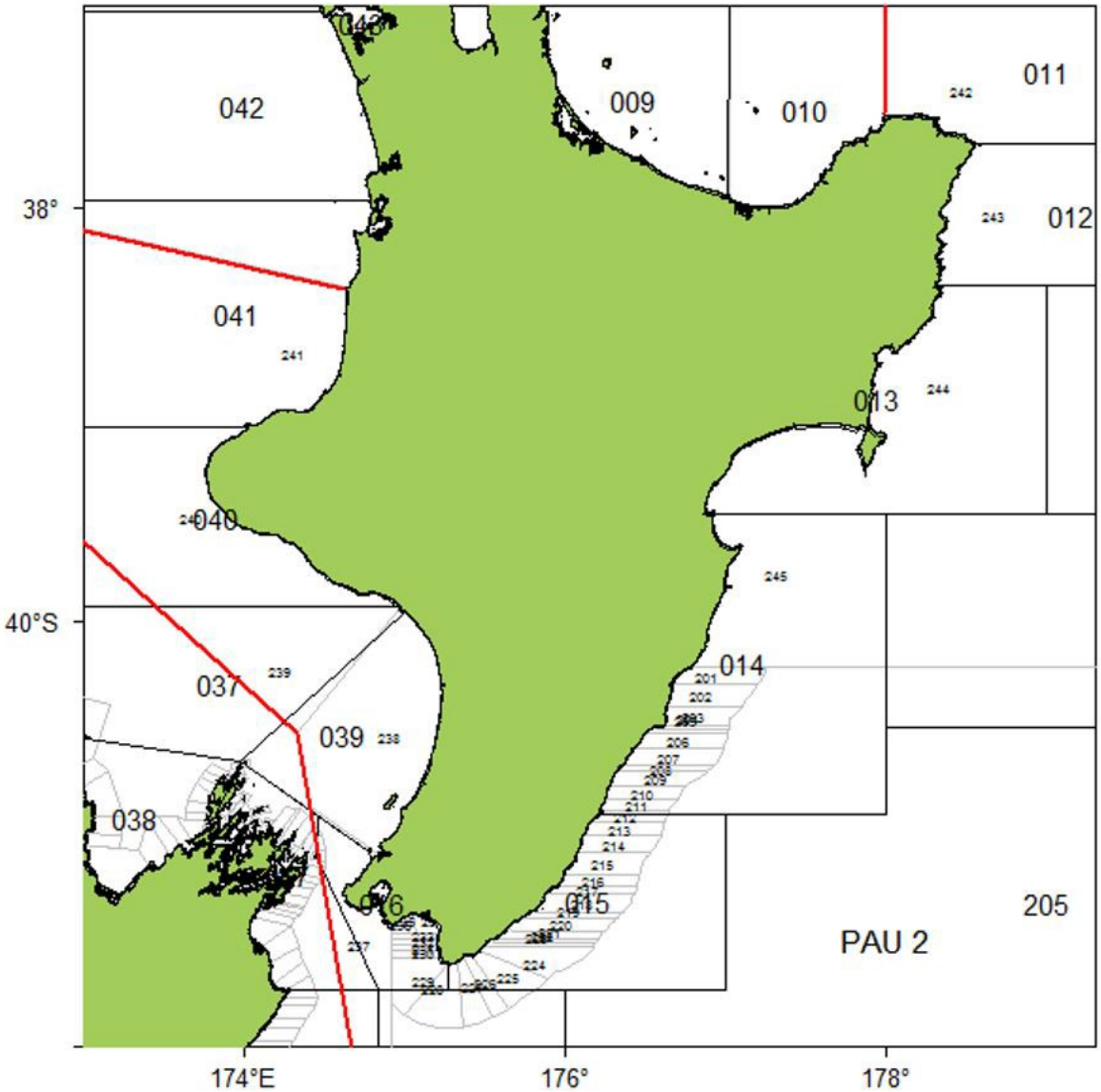


Figure 2: Old statistical areas boundaries and fine-scale statistical areas for PAU 2.

Table 1: Annual estimated proportion of the catch by old statistical area boundaries in PAU 2 for fishing years 1990–2013.

	011	012	013	014	015	016	037	039	040	041
1990	0.00	0.00	0.00	0.12	0.60	0.28	0.00	0.00	0.00	0.00
1991	0.00	0.00	0.00	0.11	0.60	0.29	0.00	0.00	0.00	0.00
1992	0.00	0.00	0.01	0.17	0.56	0.25	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.01	0.13	0.52	0.28	0.00	0.00	0.01	0.05
1994	0.00	0.00	0.01	0.11	0.67	0.19	0.00	0.00	0.00	0.02
1995	0.00	0.01	0.00	0.04	0.66	0.28	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.11	0.63	0.25	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.09	0.75	0.15	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.01	0.09	0.75	0.15	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.01	0.06	0.80	0.13	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.02	0.02	0.79	0.10	0.00	0.00	0.00	0.07
2001	0.00	0.00	0.01	0.06	0.72	0.11	0.00	0.00	0.00	0.09
2002	0.00	0.00	0.00	0.08	0.63	0.29	0.00	0.00	0.00	0.00
2003	0.00	0.00	0.00	0.02	0.67	0.31	0.00	0.00	0.00	0.00
2004	0.00	0.00	0.00	0.02	0.67	0.31	0.00	0.00	0.00	0.00
2005	0.00	0.00	0.00	0.05	0.60	0.35	0.00	0.00	0.00	0.00
2006	0.00	0.00	0.00	0.01	0.61	0.38	0.00	0.00	0.00	0.00
2007	0.00	0.00	0.00	0.07	0.70	0.23	0.00	0.00	0.00	0.00
2008	0.00	0.00	0.00	0.04	0.58	0.38	0.00	0.00	0.00	0.00
2009	0.00	0.00	0.00	0.06	0.73	0.21	0.00	0.00	0.00	0.00
2010	0.00	0.00	0.00	0.11	0.67	0.22	0.00	0.00	0.00	0.00
2011	0.00	0.00	0.00	0.04	0.62	0.34	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.06	0.52	0.42	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.03	0.79	0.19	0.00	0.00	0.00	0.00

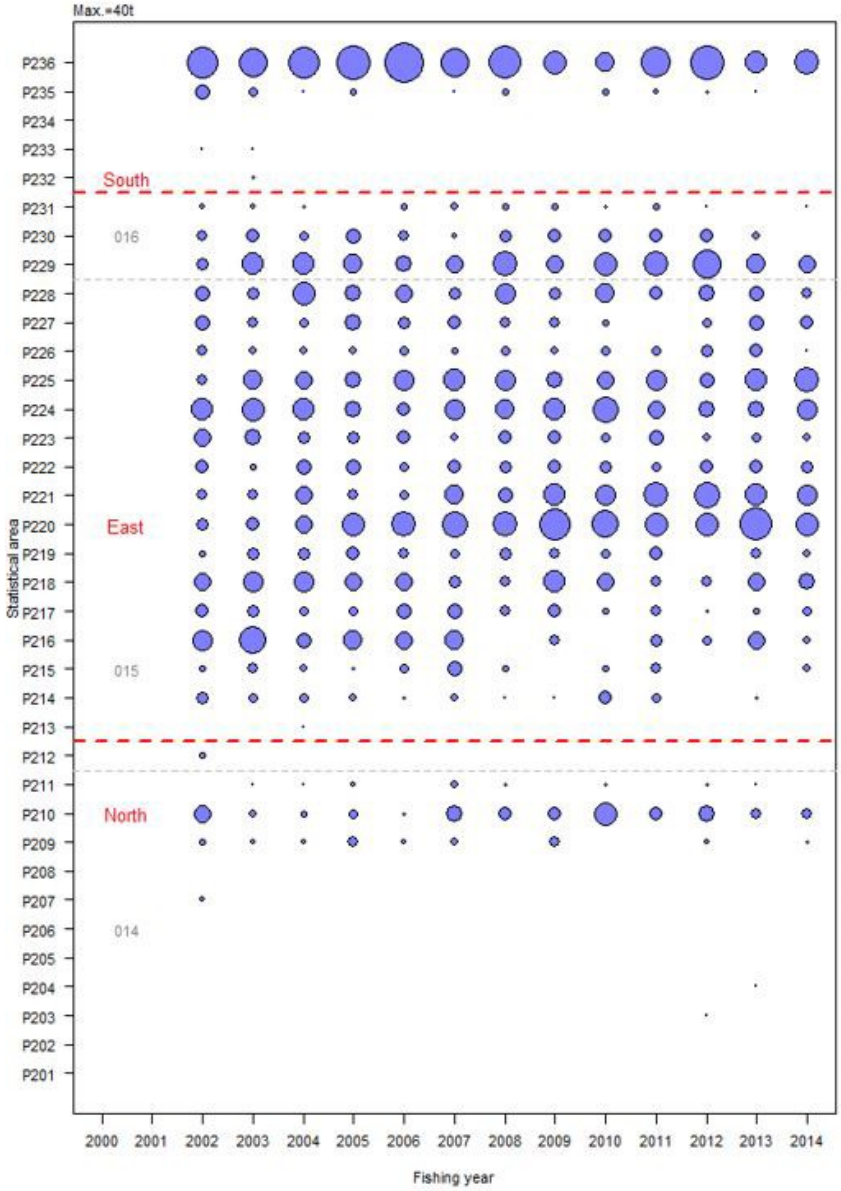


Figure 3: Annual estimated catch by fine-scale statistical area in PAU 2 for fishing years 2002–2014. The size of the circle is proportional to the catch. The red dashed lines delineate different regions.

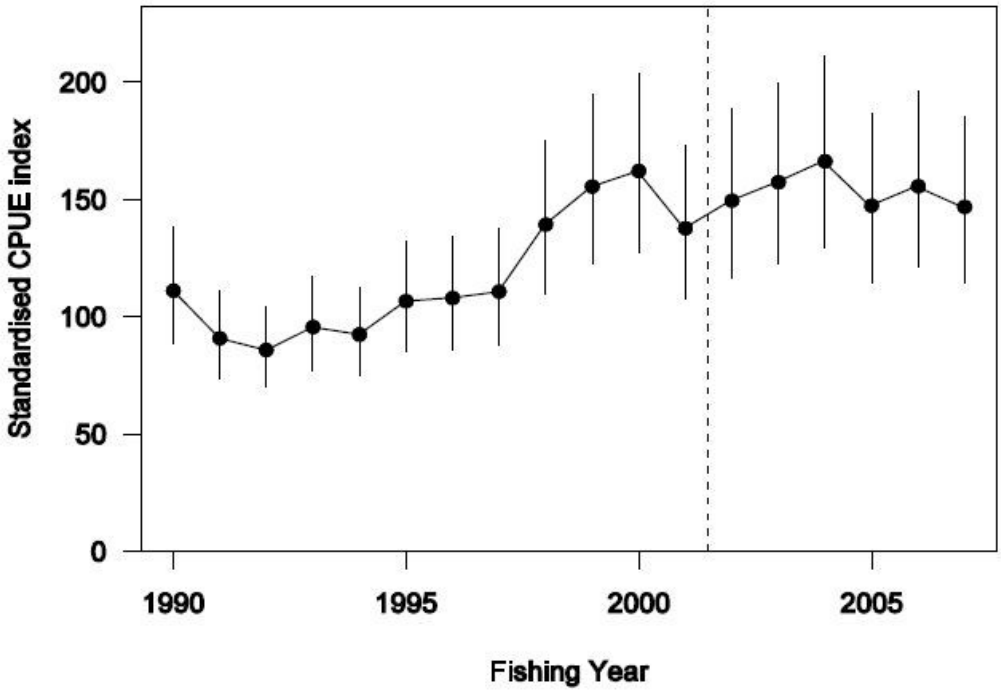


Figure 4: Previously calculated standardised CPUE index for PAU 2 1990–2007 with 95% confidence intervals. The vertical line delineates between CELR and PCELR data. Reproduced from McKenzie et al. (2009).

2. BACKGROUND ANALYSES FOR STANDARDISATION METHODOLOGY

In order to inform decisions regarding the standardisation data and methodology in this section we examine the utility of the FSU data, the possibility of serial depletion and data quality of the PCELR data, and changes in fishing duration for the CELR data.

2.1 Usefulness of FSU data

Problems uncovered in the past for the FSU data have included:

1. a high proportion of missing values for the vessel field
2. ambiguity and inaccuracies in what is recorded for the important fishing duration field, and
3. low coverage of the annual catch

The FSU catch-effort data covers the period 1983 to 1988 with a total of 2041 records (Table 2).

Table 2: Number of FSU records by fishing year.

Fishing year	1983	1984	1985	1986	1987	1988
Number of records	503	577	472	238	188	63

All records have a vessel associated with them. For the old FSU data set fewer of the records had vessel keys, but for the new_fsu data set vessel keys have been assigned for most of these (David Fisher, NIWA, pers. comm.).

In earlier analyses problems were found with the duration field in that values were recorded that were 10 times the likely values (Kendrick & Andrew 2000). These appear to have since been corrected with most values clustered around 4 hours duration (Figure 5).

However, the proportion of estimated annual catch covered, while good for the two years 1984 and 1985, declines rapidly after that (denoted by the white bars in Figure 6). The concern if this data was used in an assessment would be that the catch rates would be biased in some way.

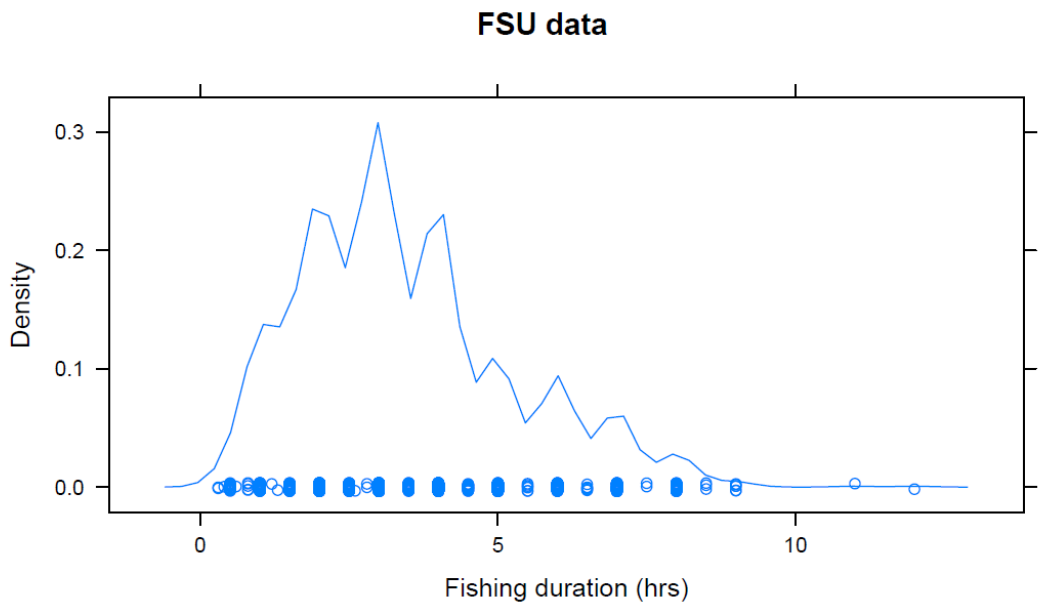


Figure 5: Density and strip plot for hours per diver.

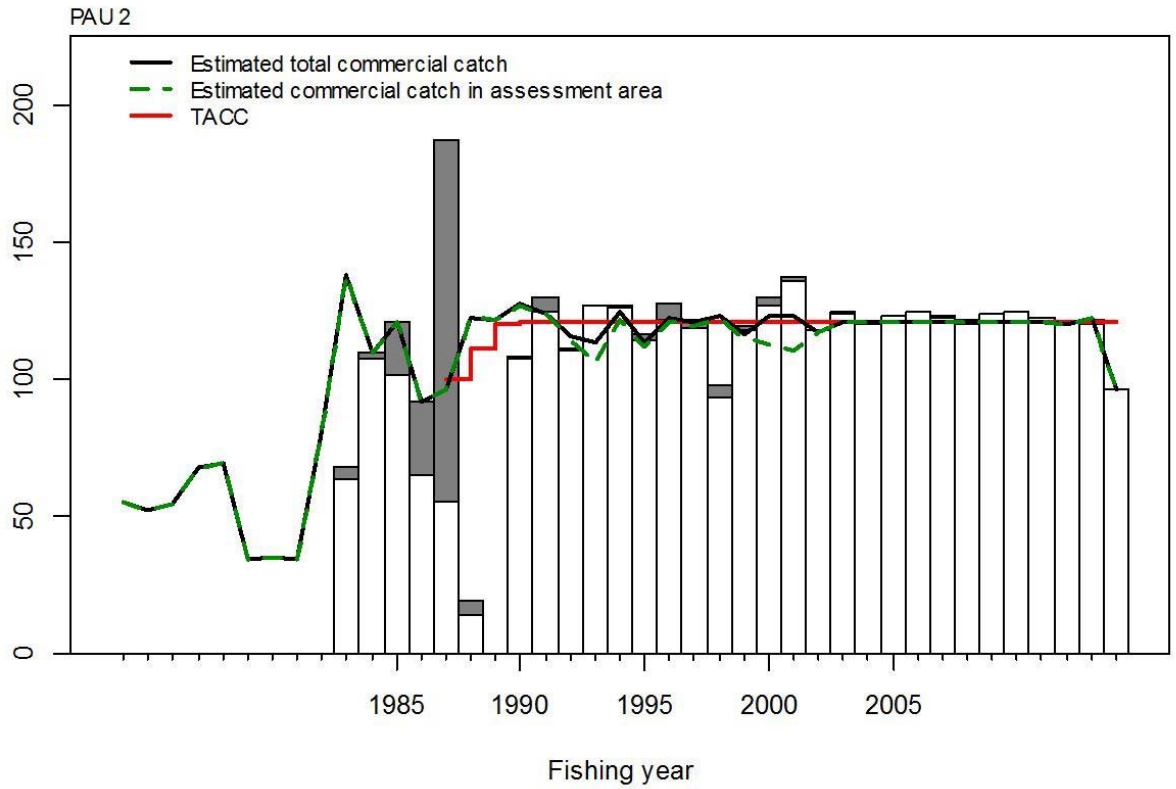


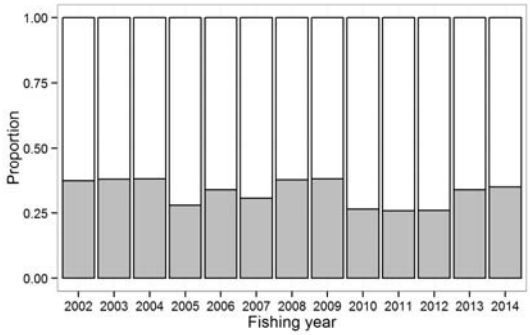
Figure 6: The estimated commercial catch history, TACC, and the FSU/CELR/PCELR catch (vertical bars) for fishing years 1983–2014 for PAU 2. The black portion of the bar represents estimated catch removed through data grooming; grey represents the estimated catch from records reported to straddling areas randomly allocated to PAU 2.

2.2 Serial depletion and data quality

There is little evidence for serial depletion over the past 13 years with no significant changes in the estimated catch distribution over this time period (see Figure 3).

The recorded resolution for the estimated catch and fishing duration for the PCELR data is comparable to other areas and is low. About 35% of the catch is recorded as multiples of 50 kg, and about 75% of recorded fishing durations are multiples of one hour (Figure 7a,b). In about 25% of fishing events the estimated catch was split equally among the divers (Figure 7c).

(a)



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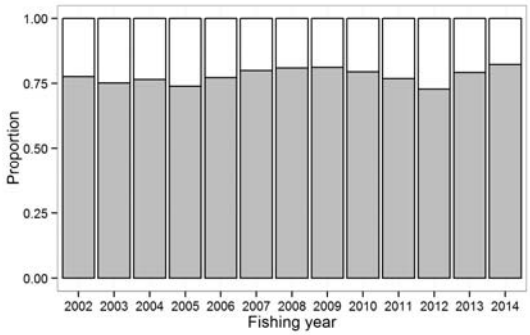

(c)

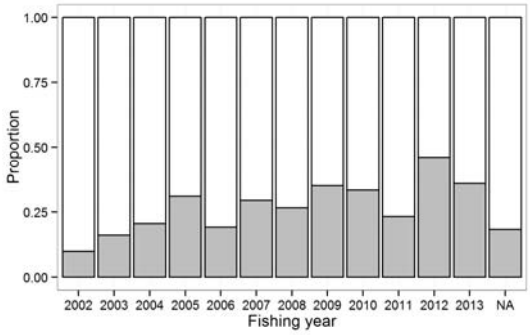

Figure 7: Diagnostic of data resolution on the PCELR forms within PAU 2: (a) proportion of records that recorded estimated catch in a multiple of 50 kg; (b) proportion of records that recorded hours fished in an exact multiple of 1 hour; (c) proportion of fishing events where recorded estimated catch was equally split among divers.

2.3 Changes in fishing duration for CELR data

For FSU data the fishing duration field is the daily fishing duration per diver (Fisher & Sanders 2011, p. 106 and p. 149). For the CELR data the fishing duration field is supposed to be the total fishing duration for all divers. It has been noted in some past analyses that there is ambiguity as to what is actually recorded for fishing duration for the CELR data, because it seems that a mixture of total and per diver durations are recorded, possibly attributable to confusion after the transition from the FSU forms.

For most trips the number of divers is four or less (Figure 8). One possible sign that fishing duration is incorrectly recorded as duration per diver, would be an decrease in the hours per diver as the number of divers goes up. The hours per diver drops by 25% going from one to two divers, but then goes up again

(Figure 9). Another sign of incorrect recording for fishing duration would be a bimodal distribution for the fishing duration when there are two or more divers. There are hints of this with one mode at about 4 hours and another to the right of this that increases as the number of divers increases (Figure 10).

Because of the ambiguity in what is recorded in the fishing duration field for CELR data, in recent analyses a subset of the data is taken for which this should be less ambiguous (Fu et al. 2014a; Fu et al. 2014b). The initial data set started included catch-effort records from areas 014, 015, and 016. Before subsetting, some grooming of the catch-effort records was undertaken: records were only retained where paua were targeted by diving, and records were dropped with missing values for the estimated catch or the number of divers (Table 3). The FIN and date were present for all records. This groomed data set has 4200 records (Table 4).

Following the subsetting procedure for PAU 3 the criteria used to subset the data were: (i) only one diver, or (ii) fishing duration at least 6 hours and number of divers at least 2 (Fu et al. 2014a). Note that for criterion (ii) a different cut-off of 8 hours is used for PAU 5B in which fishing duration for each diver appears to be longer.

Some further grooming was done in which records with NA for fishing duration were dropped (27 records), and records with a fishing duration per diver greater than 10 hours were dropped (42 records). This subsetting retained 77% of the records from 1990–2001 (Table 4). Of the retained records 50% had one diver (Table 5).

For the subsetted data, the recorded fishing duration for each record was divided by the number of divers to calculate the fishing duration per diver (hours per diver). Due to rounding in the fishing duration recorded there is some clumping in the fishing duration per diver (Figure 11). The median and mean fishing duration per diver indicate an increase in the duration in about 1996 (Figures 12–13).

Catch rates (daily kilograms per daily unit effort) were calculated using as the daily units of effort: (i) the number of divers, or (ii) total daily diving duration. Comparing the yearly geometric mean of these (i.e. a standardisation with just a year effect) shows that using the diving duration as a measure of effort, instead of number of divers, gives an index that show less of an increase from 1996 (Figure 14).

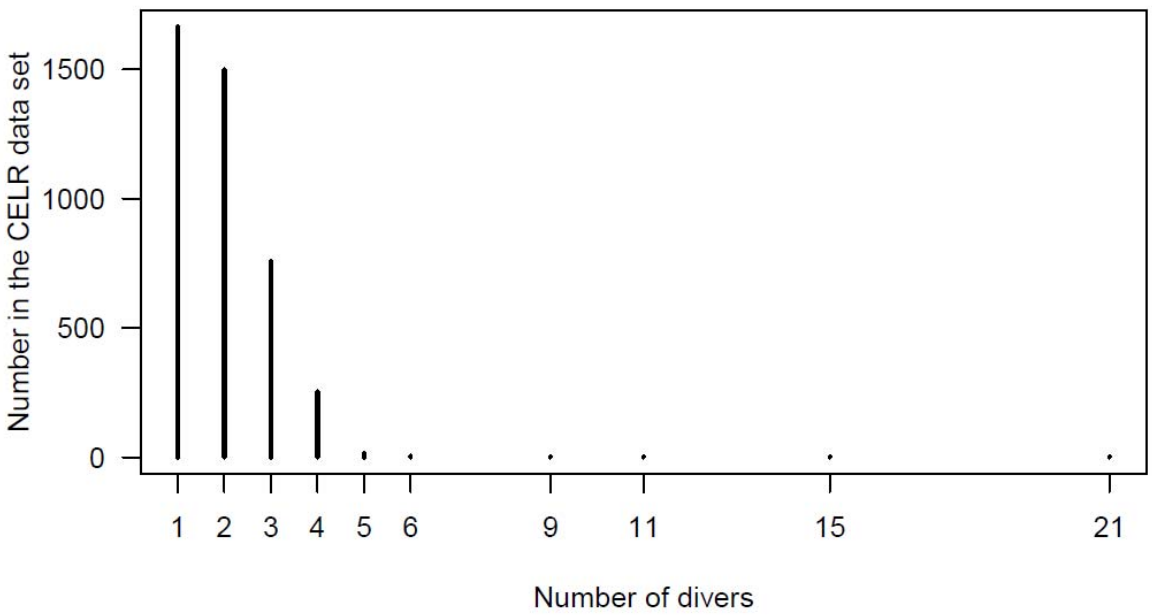

Figure 8: Distribution of the number of divers for a record.

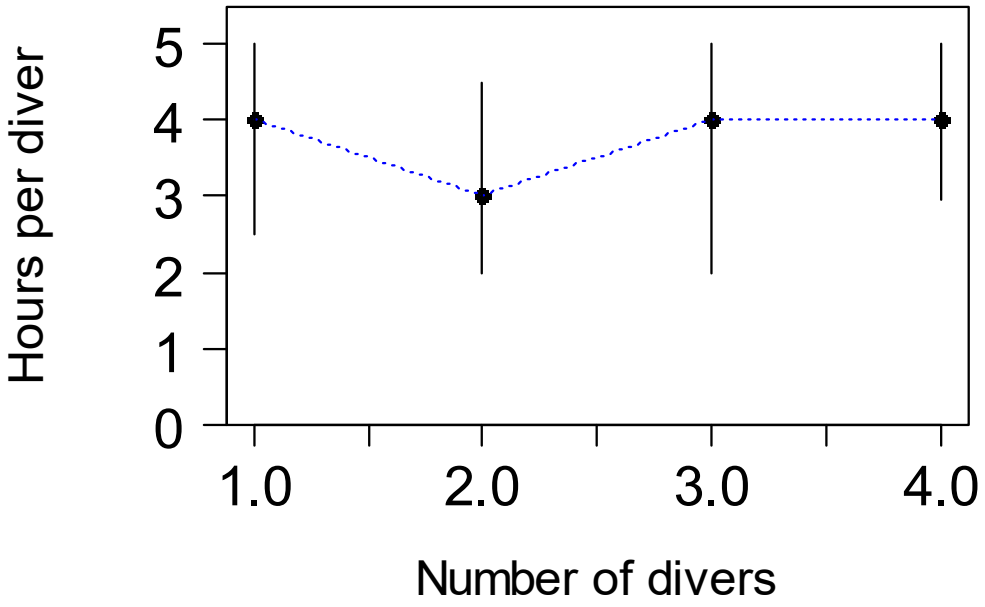

Figure 9: Quantiles by number of divers for the hours per diver: medians (dot) and lower and upper quartiles (vertical lines). The number of divers is restricted to no more than four.

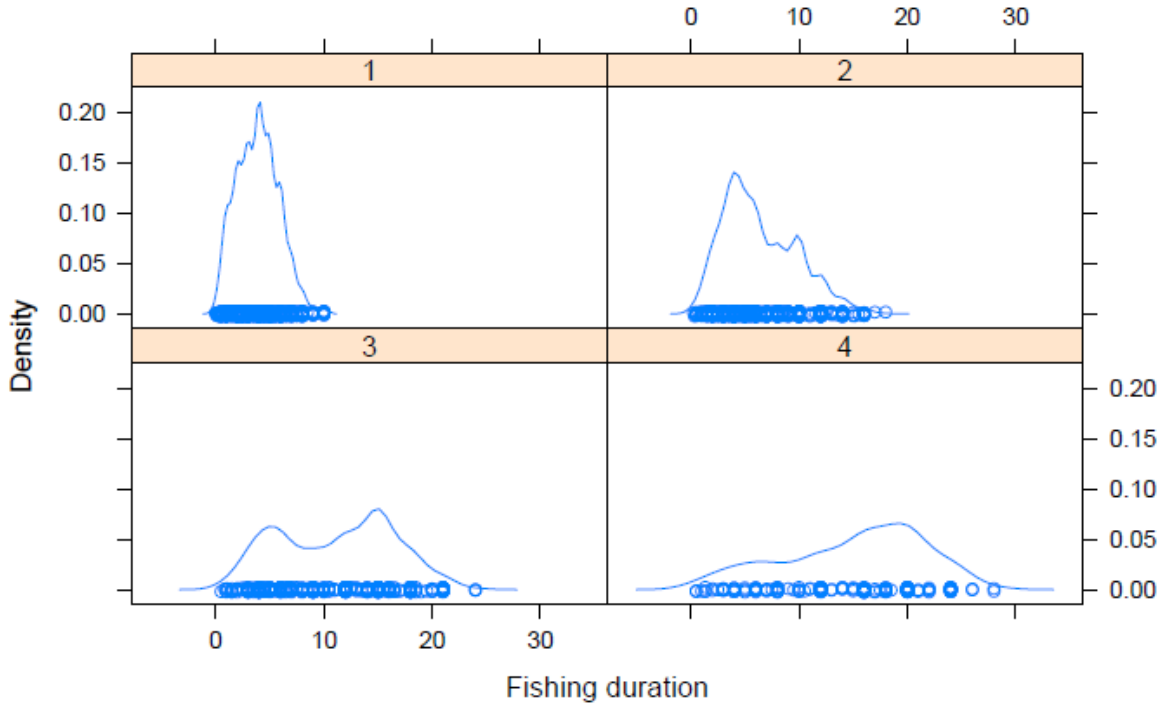

Figure 10: Density and strip plot for the recorded fishing duration, given the number of divers on a trip (restricted to no more than four).

Table 3: Number of CELR records removed by fishing year, where the order of grooming is from top to bottom.

	90	91	92	93	94	95	96	97	98	99	2000	2001	Total
Not targeting paua	0	0	0	0	0	0	0	0	0	0	0	0	0
Catch missing	0	3	0	0	0	0	4	2	4	1	0	0	14
Number divers missing	1	0	0	0	0	5	15	10	3	10	3	2	49
Method not diving	35	72	18	52	39	21	37	38	34	24	23	19	412

Table 4: Number of records in the groomed data before subsetting (but after grooming) and after subsetting.

Fishing year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
Before	332	497	404	386	374	366	378	377	249	287	284	266	4200
After	278	337	283	266	271	292	313	314	203	232	235	218	3242

Table 5: Distribution of the number of divers before and after subsetting.

Number of divers	1	2	3	4	5	6	7	8	9	10
Before	1663	1499	758	254	15	5	1	2	2	1
After	1615	776	607	226	14	3	1	0	0	0

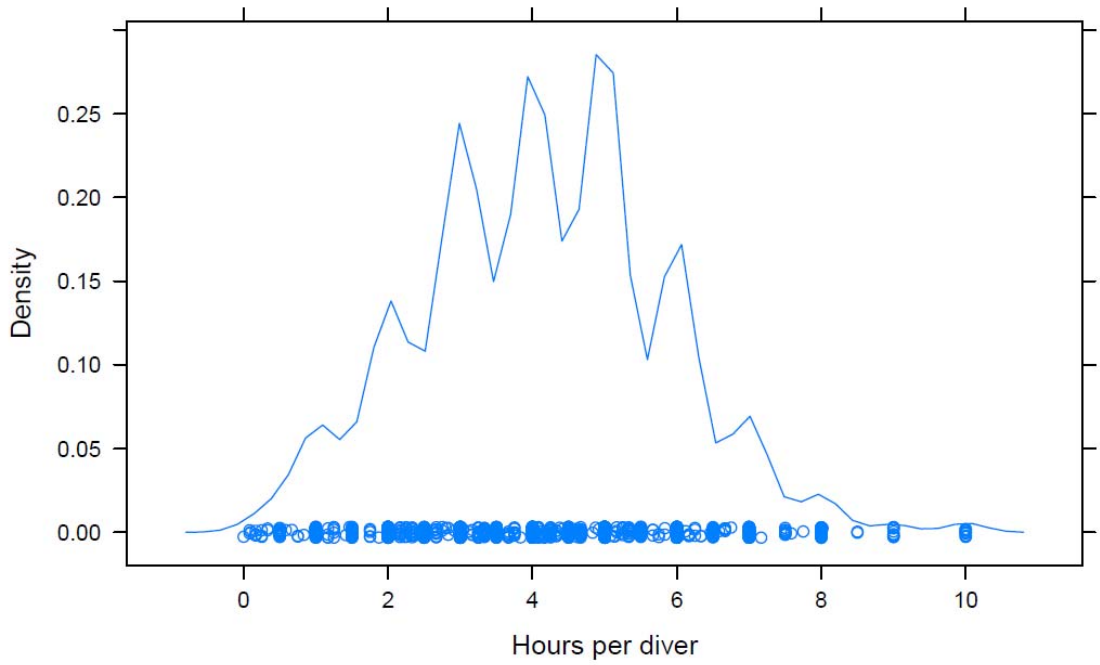

Figure 11: Density and strip plot for the hours per diver after subsetting.

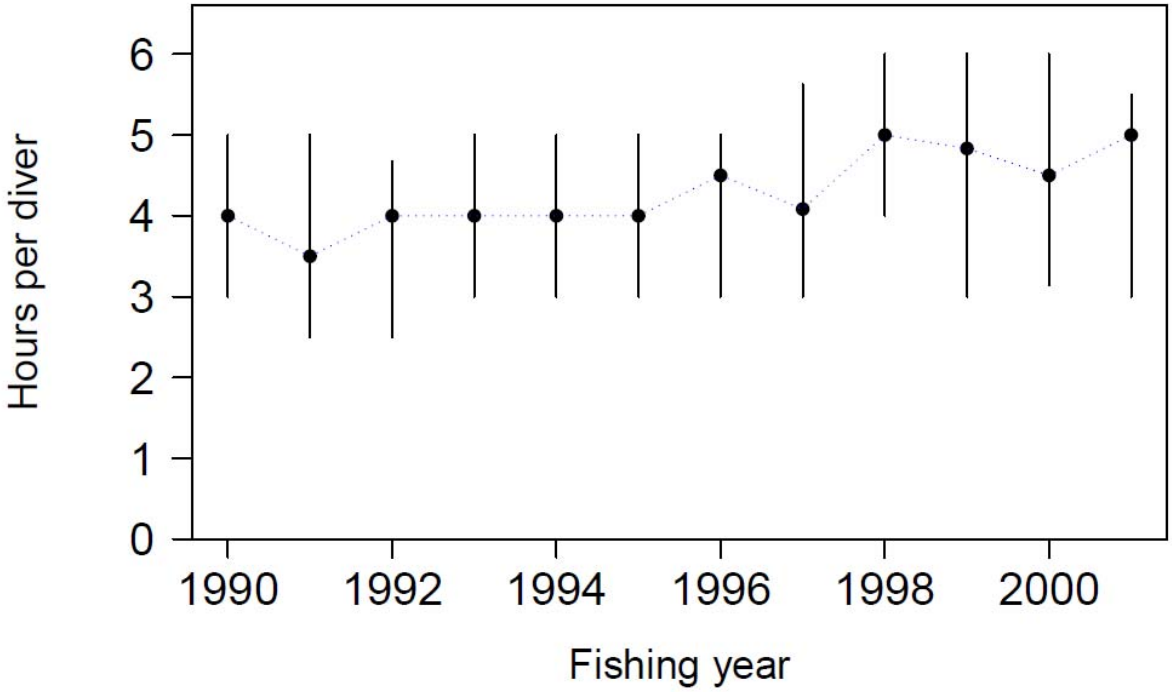

Figure 12: Quantiles by fishing year for the daily fishing duration per diver: medians (dot) and lower and upper quartiles (vertical lines).

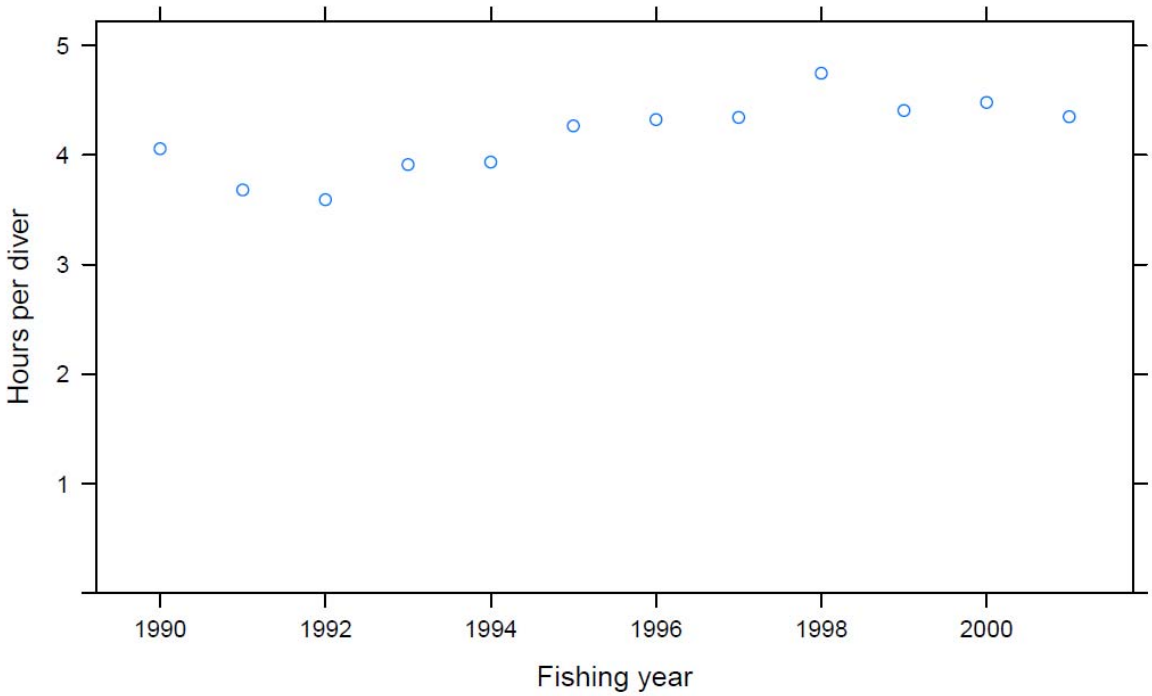

Figure 13: Mean values by fishing year for the daily duration per diver.

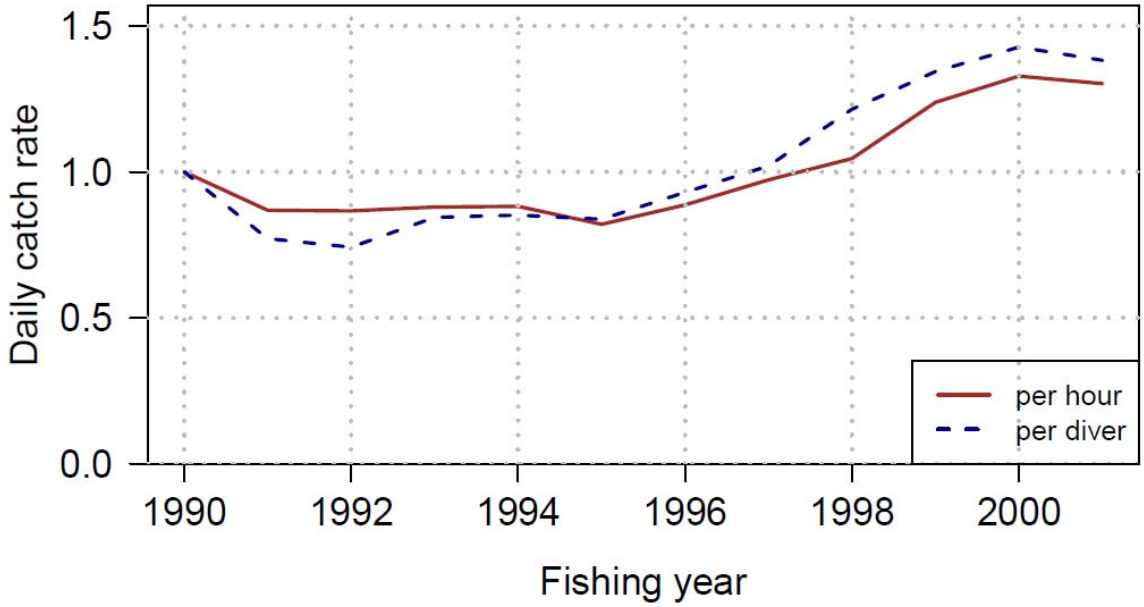

Figure 14: Geometric mean of the daily catch rate by year. The plots are scaled so that they both have the value one in 1990.

3. CPUE STANDARDISATIONS

3.1 Introduction

Two separate standardised CPUE series were calculated: (i) one based on CELR data from 1990 to 2001, and (ii) another on PCELR data from 2002 to 2014. The data set used, methods, and results are described in the following sections.

Based on the analyses in the previous section the following decisions were made by the Shellfish Working Group for the CPUE standardisations for PAU 2:

1. To drop FSU data from 1988 and previous years.

2. To use two series for the standardisation, one series one based on CELR data up to 2001, the other from 2002 onwards using the more fine scale PCELR data.

3. To restrict the catch-effort records to those from the old Statistical Areas 014, 015, 016 (CELR data) and zones P201–P236 (PCELR data). These are the same areas for which a stock assessment would most likely be restricted, as they contain most of the commercial catch.

4. For the CELR data standardisation to use a subset of the groomed data for which the recorded duration would be less ambiguous. The criteria to be used to subset the data are: (i) just one diver, or (ii) fishing duration ≥ 6 hours and number of divers ≥ 2. For this subsetted data set, offer both number of divers and duration (as a polynomial) to the model.

5. Do a sensitivity CELR data standardisation where the fishing duration cut-off is 4 hours: (i) just one diver, or (ii) fishing duration at least 4 hours and number of divers at least two.

6. To use Fisher Identification Number (FIN) in standardisation procedures instead of vessel.

7. Not to put in a year and area interaction in the standardisations (which would be used in a single area assessment), but to explore area differences in catch rates by doing separate standardisations where a year and area interaction is forced in at the start. For the CELR data the smallest possible area sub-divisions are 014, 015, and 016. For the PCELR data a close, but more natural division of the areas is South, East, and North (Figure 3), where the large East area can be broken up further based on the strata used for length-frequencies.

This standardisation differs from that done previously (McKenzie et al. 2009) in that:

• two separate standardised indices are calculated (based on CELR/PCELR data)

• a subset is used of the CELR data for which fishing duration is less ambiguous, and fishing duration is offered as a predictor in the standardisation

• FIN is used instead of vessel

3.2 CELR standardisation (1990–2001)

3.2.1 CELR: FIN subsetting of data

FIN is used to subset out a core group of records, with the requirement that there be a minimum number of records per year for a FIN, for a minimum number of years. The criterion of a minimum of 10 records per year for a minimum of four years was chosen, this retains 80% of the catch over 1990–2001 (Figure 15). Note that while over 80% of the catch is retained for many years, it is less than this for the last four years, although still greater than 60% (Figures 16–17). The number of days of effort retained after subsetting is 146 or more for every fishing year (Table 6, Figure 18). The number of FIN holders drops from 59 to 12 under the subsetting criteria.

There is good overlap in effort over time for the FIN holders after subsetting (Figures 19–20). Similarly for general statistical area and month (Figures 21–22).

3.2.2 CELR: the standardisation

CPUE was defined as daily catch. Year was forced into the model at the start and other predictor variables offered to the model were FIN, Statistical Area (014, 015, 016), month, fishing duration (as a cubic polynomial), number of divers, and a month:area interaction. Following previous standardisations, no interaction of fishing year with area was entered into the model, as the stock assessment for PAU 2 is a single area model. However, a separate standardisation is also done where a year:area interaction is forced in at the start.

The model explained 77% of the variability in CPUE with fishing duration (70%) explaining most of this followed by FIN (3%) (Table 7). The effects appear plausible and the model diagnostics were good (Figures 23–24). There is an apparent increasing effect for the catch taken after a fishing duration of 30 hours, though for the majority of records fishing duration is less than this (Figure 25). The standardised index declines for the first four years, then increases, with a drop in the last year (Table 8, Figure 26).

As a sensitivity test on the filtering criteria for the subsetted data set (in which the fishing duration field should be less ambiguous) another standardisation was done in which when the number of divers was at least 2 then the fishing duration has to be at least 4 hours (instead of 6 hours). The resulting index is very similar to that when 6 hours is used (Figure 27).

Forcing in a year:area interaction indicates that the indices are similar between the areas (Figure 28). Note that the fluctuating index for area 014 has a small number of records in many years (Table 9).

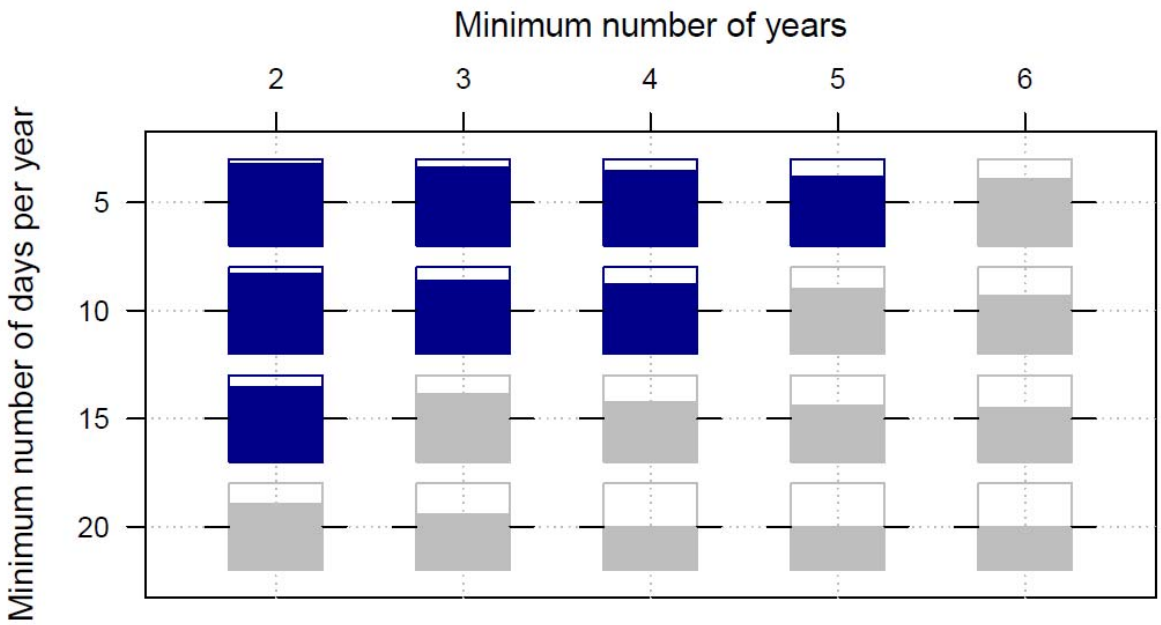

Figure 15: Proportion of the catch taken when sub-setting the data by FIN with the requirement of a minimum number of daily records per year, for a minimum number of years. Each bar shows the percentage of the total catch from 1990–2001 retained under the criteria, where the horizontal line for each bar represents 50%. Bars with a fill colour of blue retain 80% or more of the catch, otherwise they are coloured grey.

Table 6: Number of records before and after FIN subsetting.

Fishing year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
Before	278	337	283	266	271	292	313	314	203	232	235	218	3242
After	199	220	212	229	230	235	230	213	157	160	146	166	2397

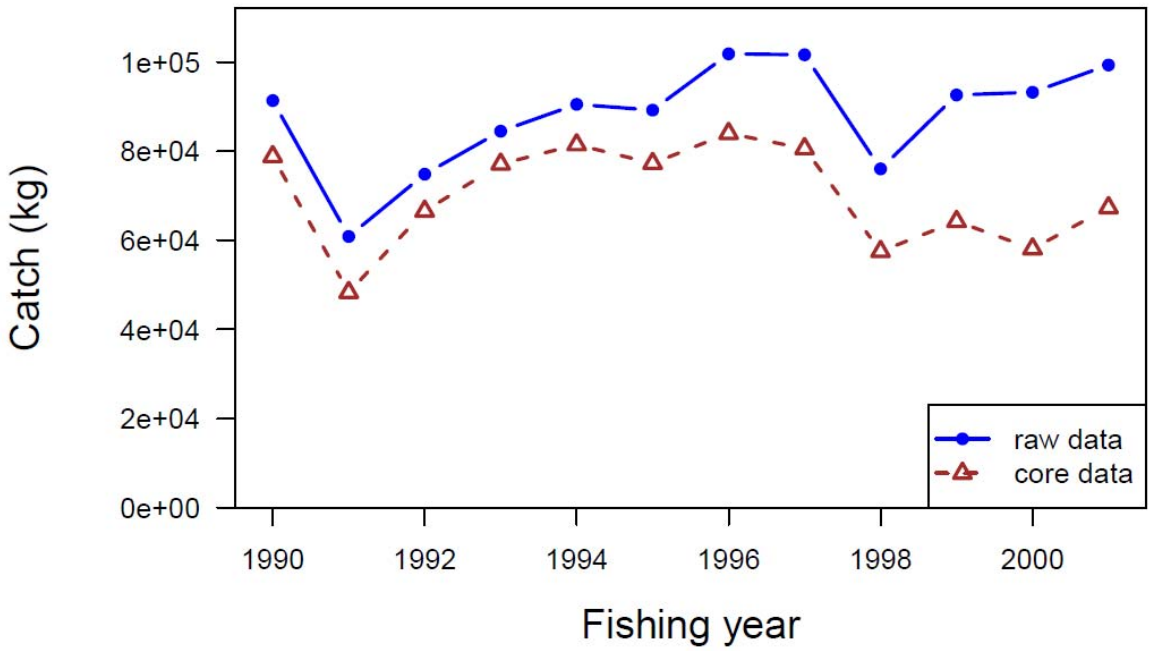

Figure 16: Catch by fishing year before FIN subsetting (raw data) and after (core data).

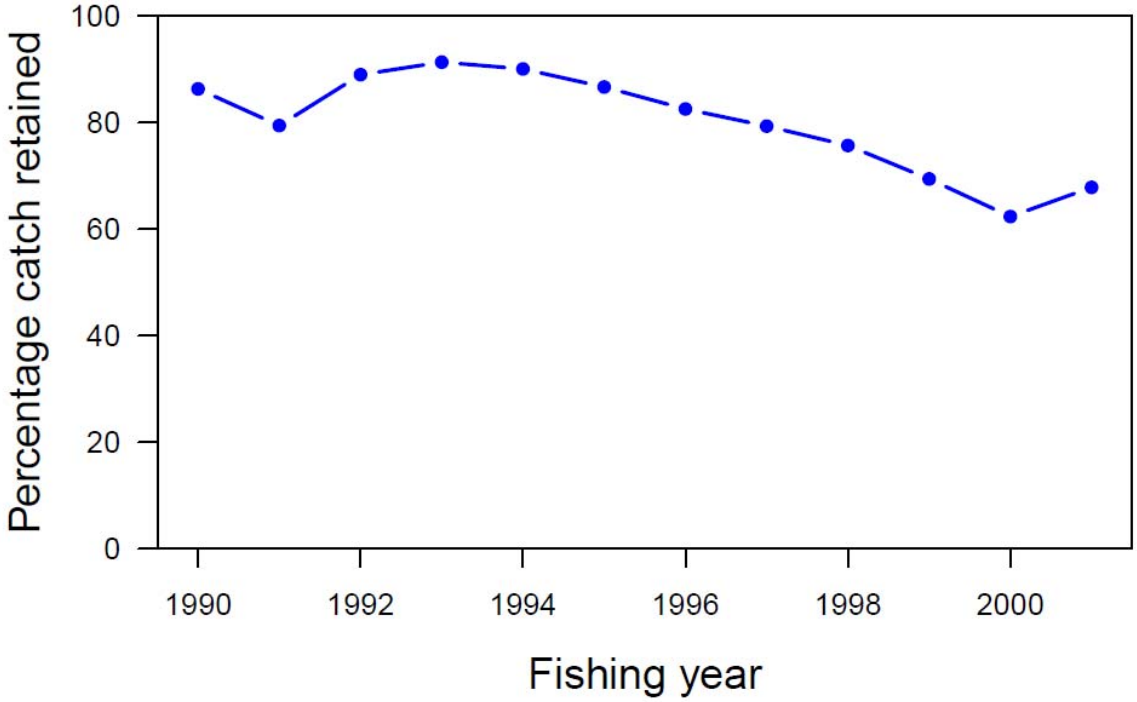

Figure 17: Percentage of the catch retained after FIN subsetting.

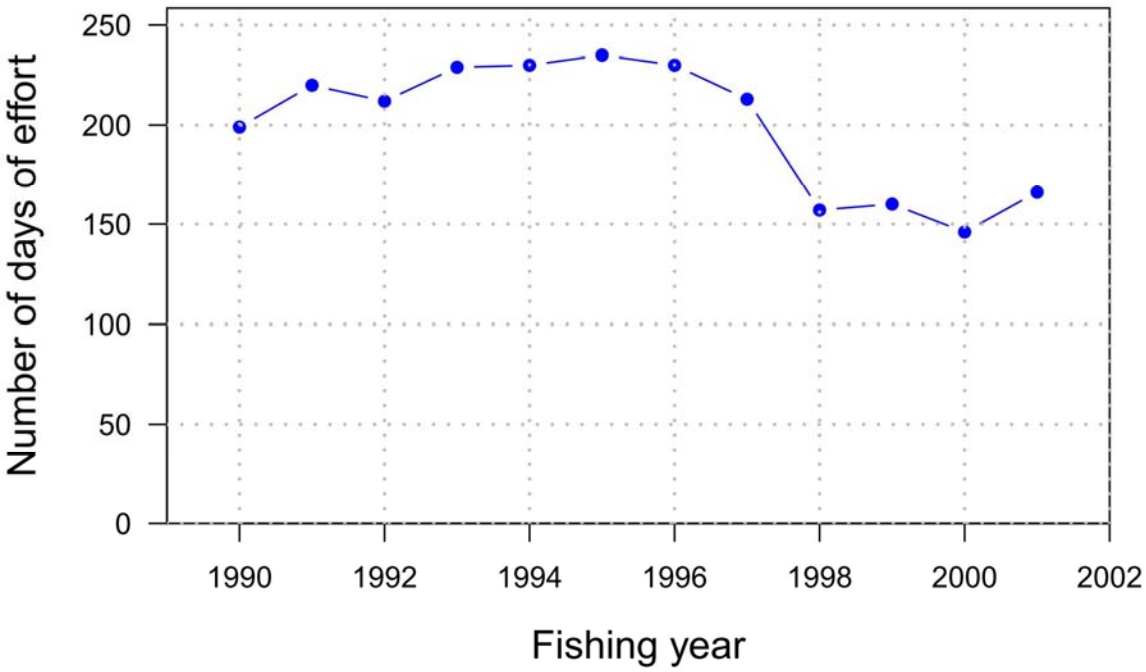

Figure 18: Number of days of effort retained after FIN subsetting.

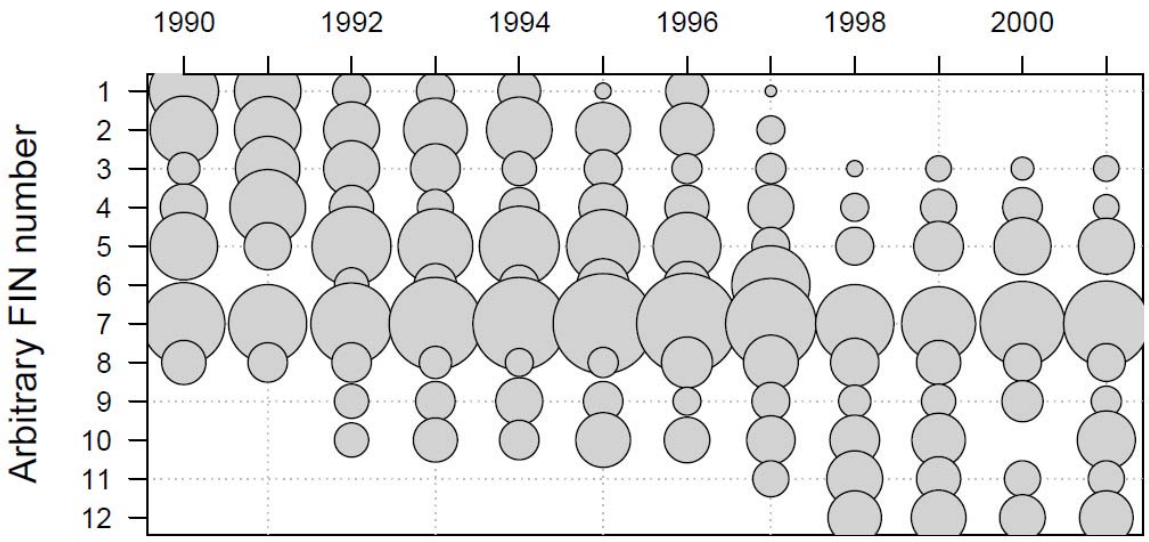

Figure 19: Number of days of effort by FIN and year. The area of a circle is proportional to the days of effort.

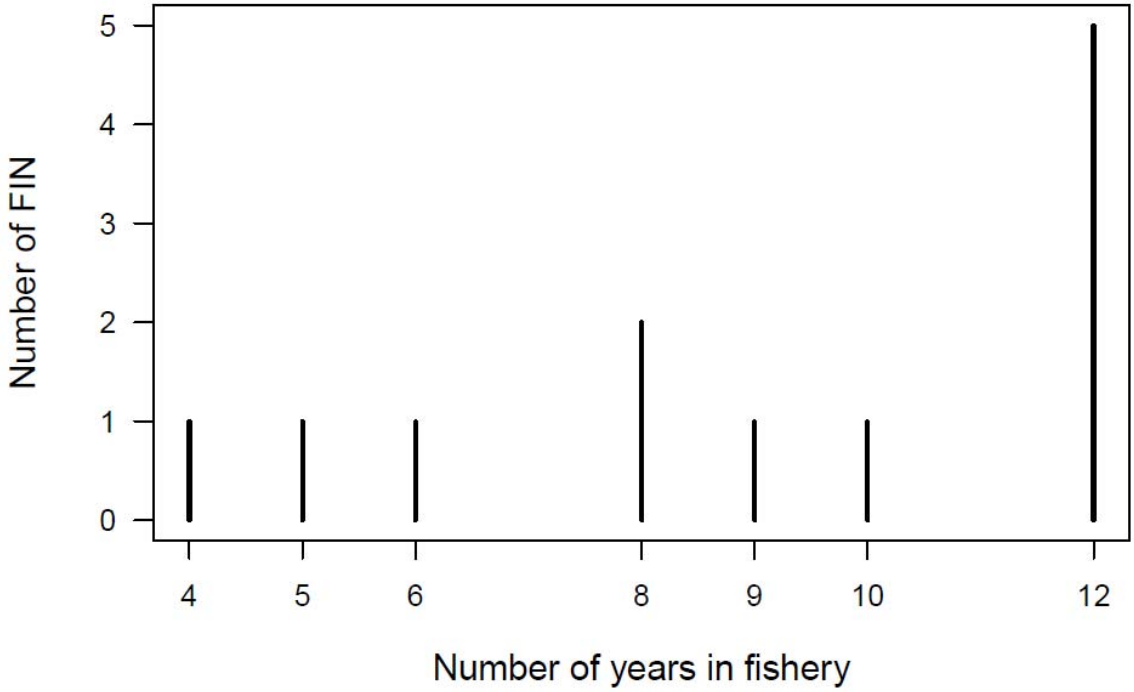

Figure 20: Number of years in the fishery for a FIN holder after sub-setting by FIN.

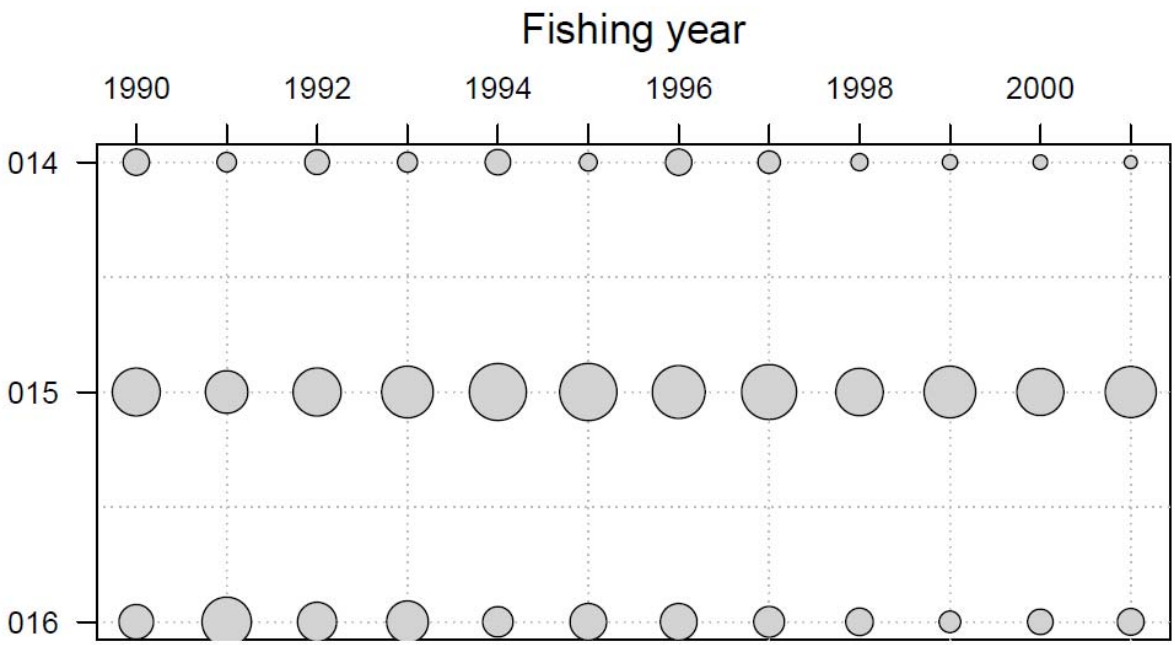

Figure 21: Number of days of effort by statistical area and fishing year. The area of a circle is proportional to the days of effort.

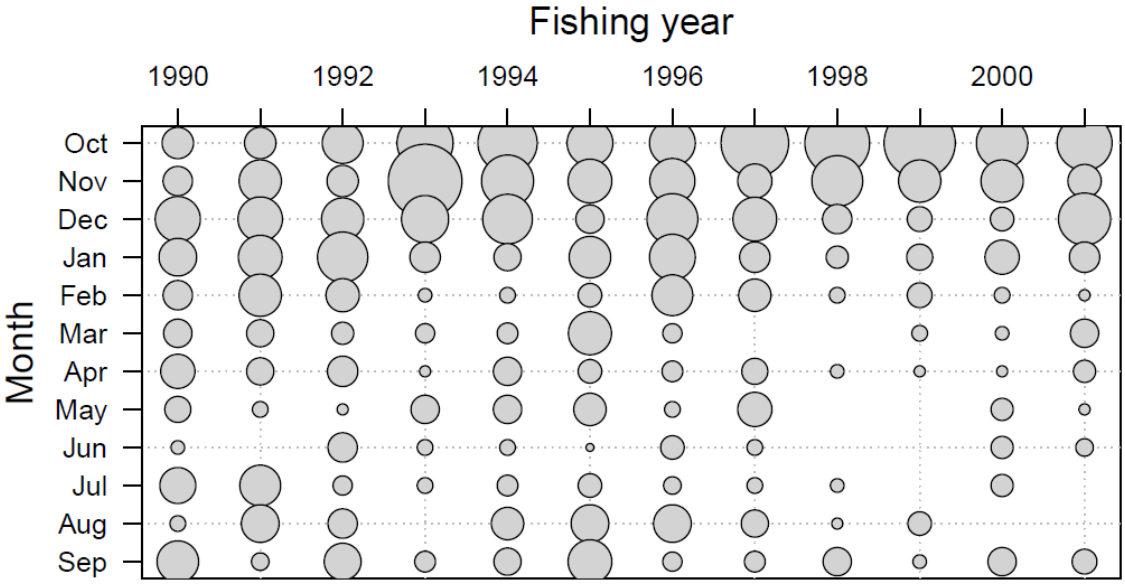

Figure 22: Number of days of effort by month and fishing year. The area of a circle is proportional to the days of effort.

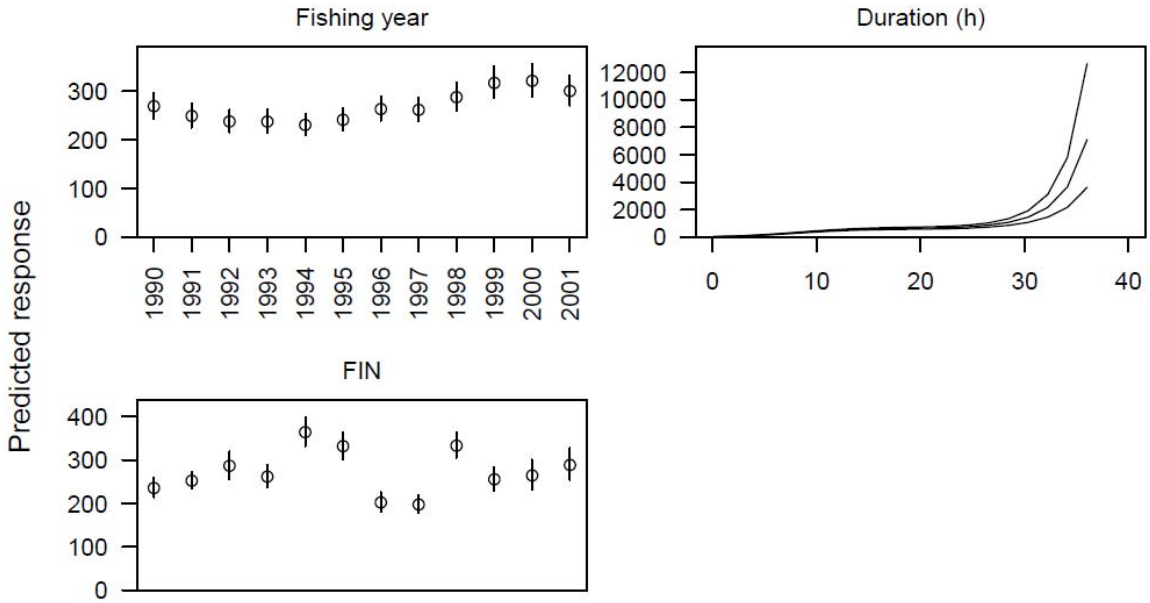

Figure 23: Effects for the standardisation model. Effects catch rates are calculated with other predictors fixed at the level for which median catch rates are obtained. Vertical lines are 95% confidence intervals.

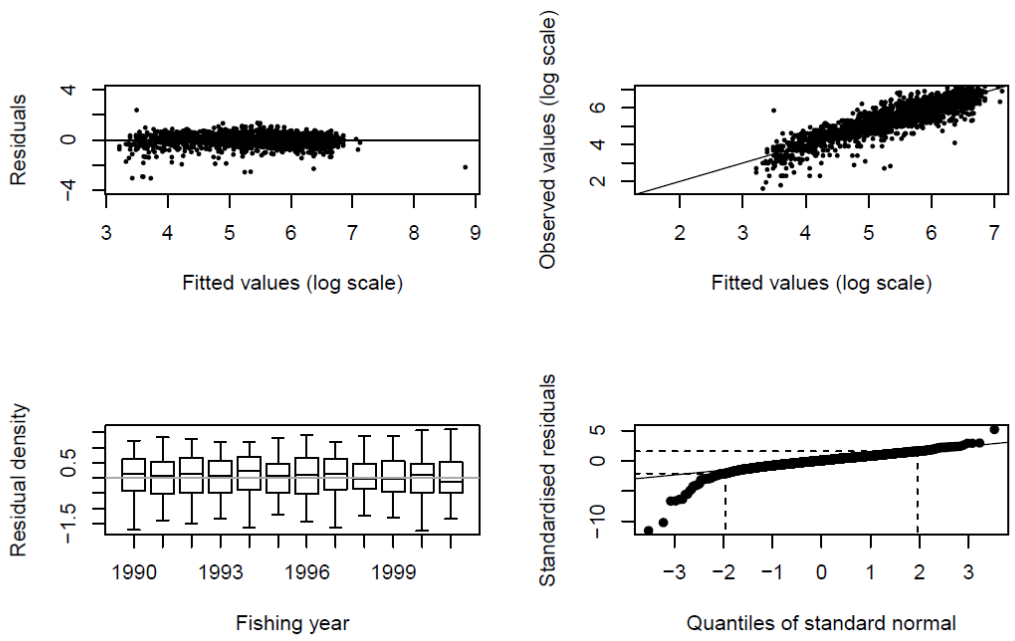

Figure 24: Residuals from the standardisation model.

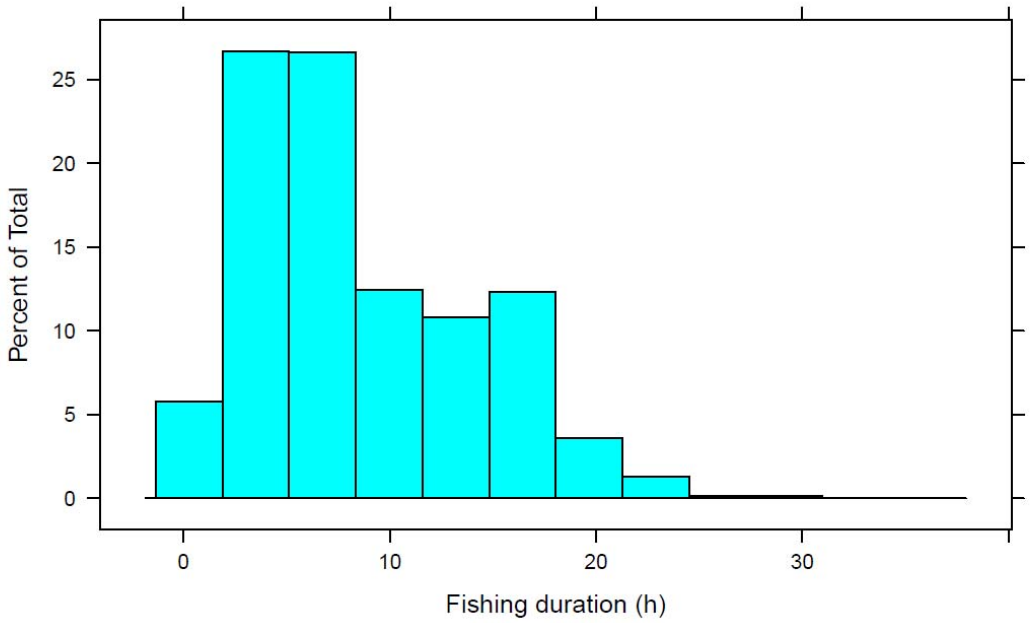

Figure 25: Distribution of fishing duration (h).

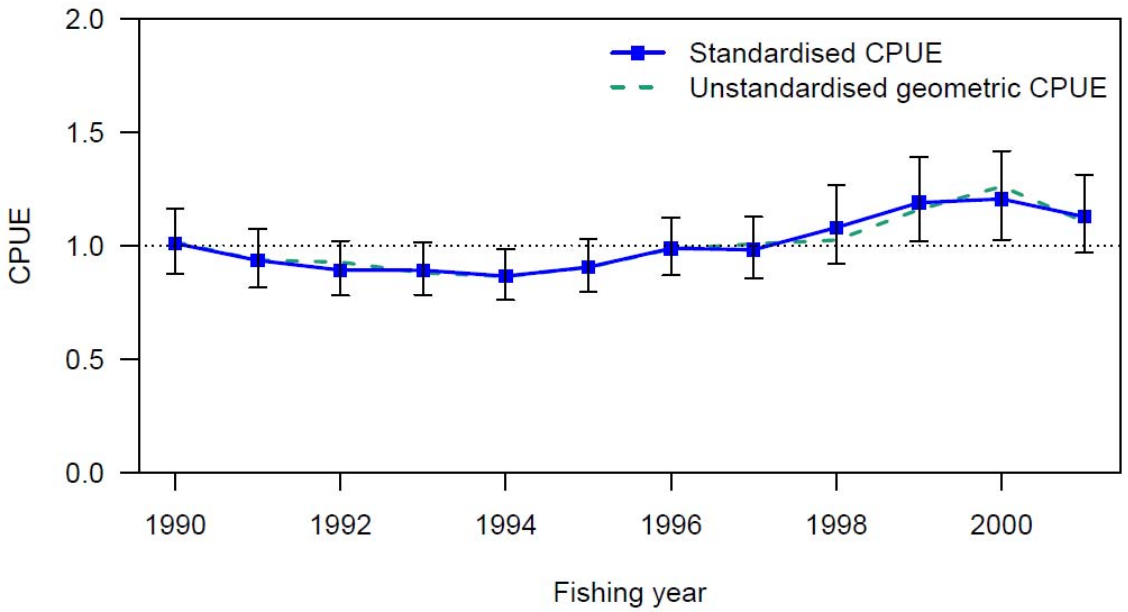

Figure 26: The standardised CPUE index with 95% confidence intervals. The unstandardised geometric CPUE is calculated as daily catch divided by daily fishing duration.

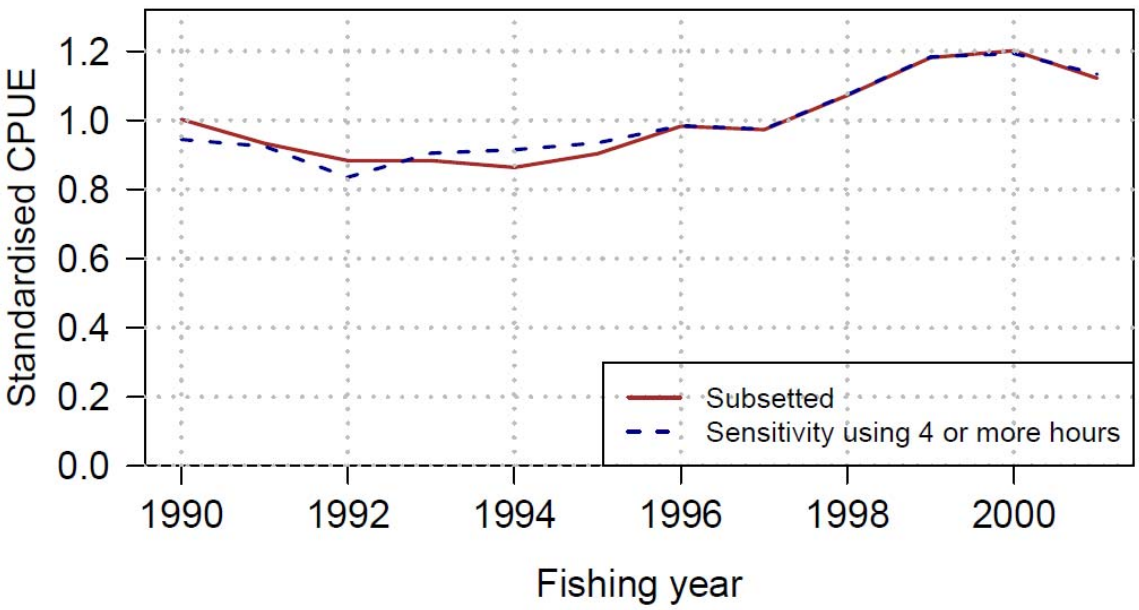

Figure 27: Sensitivity test of standardisation using a limit of four hours or more (for two or more divers).

Table 7: Variables accepted into the model (1% additional deviance explained), and the order in which they were accepted into the model, and their degrees of freedom (Df).

Predictors	Df	R-squared
fish year	11	0.04
poly(fishing duration, 3)	3	0.74
client key	11	0.77

Table 8: Standardised CELR index, lower and upper 95% confidence intervals, and c.v.

year	index	lower.CI	upper.CI	CV
1990	1.01	0.88	1.17	0.07
1991	0.94	0.81	1.07	0.07
1992	0.89	0.78	1.02	0.07
1993	0.89	0.78	1.01	0.06
1994	0.87	0.76	0.99	0.06
1995	0.91	0.80	1.03	0.06
1996	0.99	0.87	1.12	0.06
1997	0.98	0.86	1.13	0.07
1998	1.08	0.92	1.27	0.08
1999	1.19	1.02	1.39	0.08
2000	1.21	1.03	1.42	0.08
2001	1.13	0.97	1.31	0.08

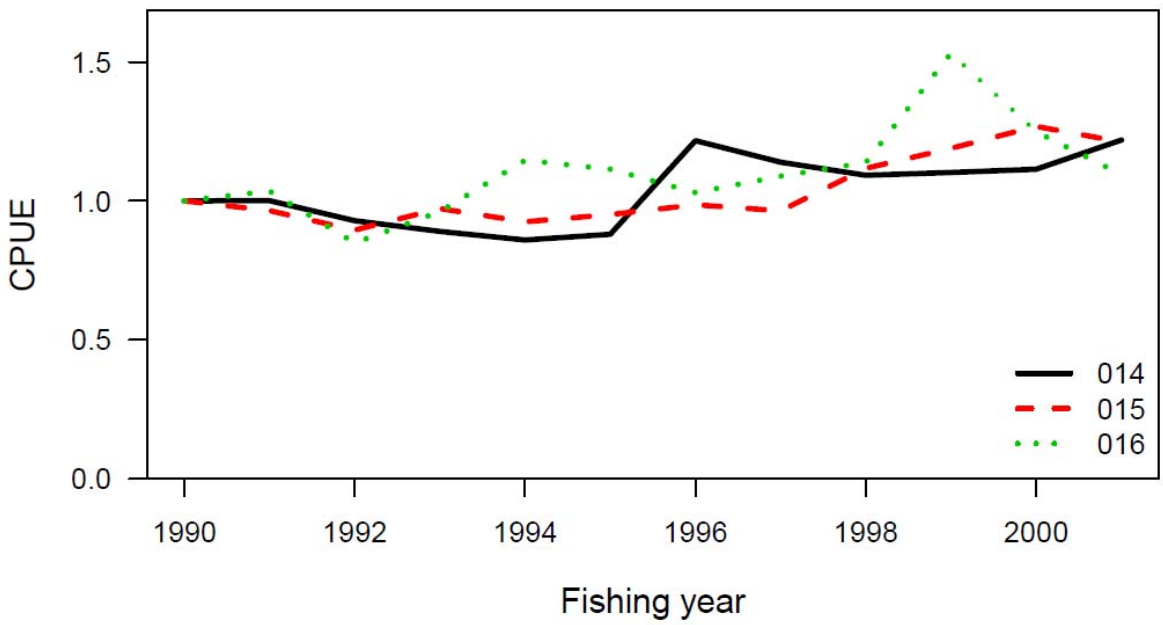

Figure 28: Standardised indices using the subsetted data with a year:area interaction forced into the model. The indices are scaled to have the value one in 1990.

Table 9: Number of records in the subsetted data by year and Statistical Area.

	014	015	016
1990	50	139	71
1991	31	117	158
1992	62	124	103
1993	41	156	105
1994	41	185	69
1995	17	176	92
1996	45	145	72
1997	32	150	50
1998	25	112	41
1999	12	136	30
2000	11	115	34
2001	13	130	40

3.3 PCELR standardisation (2002–2014)

3.3.1 Data grooming and subsetting

For the initial data set all records were for paua targeted by diving, and contained FIN, fine scale statistical area, catch weight, fishing duration, diver key, and date. For the standardisation some further grooming was made: 227 records were removed where no diving condition was recorded (Table 10).

Records were transformed into a daily format: total catch and dive time over a day for a diver (associated with a specific FIN, diving condition, and statistical area). CPUE was defined as the catch for a diver with fishing duration offered as a predictor in the model. Records with a CPUE greater than 200 kg/h were removed (9 records).

FIN was used to sub-set out a core group of records, with the requirement that there be a minimum number of records per year for a FIN, for a minimum number of years. The criterion of a minimum of 30 records per year for a minimum of 6 years were selected; this retained 81% of the catch over 2002–2014 (Figures 29–32). The number of FIN holders dropped from 40 to 8 under these criteria. There was good overlap in effort for the FIN holders after subsetting (Figures 33–34). The number of days of records retained after subsetting was 300 or more for every fishing year (Table 11).

To ensure that there was enough data to estimate statistical area and diver effects in the standardisation, only those statistical areas and divers with 10 or more diver days were retained (Table 11). This reduced the number of statistical areas from 26 to 23, and the number of divers from 234 to 58 (47% of divers have only one diving day - this is partly an artefact of the fact that a spelling mistake in the divers name looks like a completely new diver). There is very good temporal overlap for the other predictor variables statistical area, month, dive conditions, and diver (Figures 35–38).

Table 10: Number of records removed. Fishing year is denoted in short form (e.g. 02 = 2002).

Fishing year	02	03	04	05	06	07	08	09	10	11	12	13	14	Total
No diving condition	15	24	13	13	34	19	15	19	9	19	6	10	31	227

Table 11: Number of records remaining in the PCELR dataset after grooming, where grooming takes place in the order shown in the table. Prior to these grooming steps some records without information needed for the standardisation were removed (see the table above).

	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
Total records	541	556	531	608	535	567	582	551	608	591	590	537	421	7218
FIN subsetting	300	424	443	509	440	466	468	458	466	478	460	395	312	5619
Fine scale stat area>=10 dive days	298	422	443	509	440	466	468	458	466	478	456	395	312	5611
Divers with>=10 dive days	277	397	415	483	417	449	442	422	445	460	437	364	258	5266

3.3.2 PCELR: the standardisation

For the standardisation model CPUE (the dependent variable) was modelled as log of the diver catch with a normal error distribution. Fishing year was forced into the model at the start. Variables offered to the model were month, diver key, FIN, statistical area, duration (third degree polynomial), and diving condition. Following previous standardisations, no interaction of fishing year with area was entered into the model, because the stock assessment for PAU 2 is intended to be a single area model. However, a separate standardisation is also done where a year:area interaction is forced in at the start.

Except for month, all variables were accepted into the model, which explained 73% of the variability in CPUE (Table 12). Most of the variability was explained by duration (56%) and diver (9%). The effects appear plausible and the diagnostics are good (Figures 39–40). There is an apparent increasing effect for the catch taken after a fishing duration of 10 hours, although for the majority of records fishing duration is less than 10 hours (Figure 40).

The standardised index shows a slow decline from 2002 to 2012 with a slight increase since then (Table 13, Figure 42). As the standardised index shows little contrast since 2002, and there is little growth data available for PAU 2 (Fu 2014), stock assessment model estimates of biomass would be highly uncertain and not useful for management purposes. Because of this it was decided by the Shellfish Working Group that a full stock assessment should not be undertaken for PAU 2.

Some natural area breakages for the PCELR data are South, East, and North (Figure 3). Based on the strata used for the length-frequencies where there was a split between P119 and P120, the East area can be broken up further into East (northern), and East (southern). Forcing a year:area interaction into the model, gives indices that are similar for the different areas (Figure 43). The majority of the records are from the East (southern) area, with few from the North area (Table 14).

Table 12: Variables accepted into the model for the PCELR dataset (1% additional deviance explained), and the order in which they were accepted into the model.

Predictors	Df	R.squared
fish year	12	0.02
poly(fishing.duration.sum, 3)	3	0.58
diver key	57	0.67
condition type	4	0.69
start stats area code	22	0.71
client key	6	0.73

Table 13: Standardised index for the PCELR data set, lower and upper 95% confidence intervals, and CV.

year	index	lower.CI	upper.CI	CV
2002	1.13	0.99	1.28	0.06
2003	1.05	0.94	1.16	0.05
2004	1.05	0.95	1.16	0.05
2005	1.01	0.92	1.11	0.05
2006	1.04	0.94	1.15	0.05
2007	0.95	0.86	1.05	0.05
2008	0.94	0.86	1.04	0.05
2009	0.99	0.89	1.10	0.05
2010	0.97	0.88	1.08	0.05
2011	0.95	0.86	1.05	0.05
2012	0.95	0.86	1.05	0.05
2013	1.01	0.90	1.12	0.05
2014	0.98	0.86	1.11	0.07

Table 14: Number of records for the subsetted data by year and area.

	North	East (northern)	East (southern)	South
2002	10	67	159	41
2003	5	134	197	61
2004	5	79	270	61
2005	10	102	272	99
2006	3	77	215	122
2007	41	104	258	46
2008	24	52	305	61
2009	32	73	288	29
2010	26	71	322	26
2011	16	77	314	53
2012	32	15	323	67
2013	11	62	270	21
2014	6	36	190	26

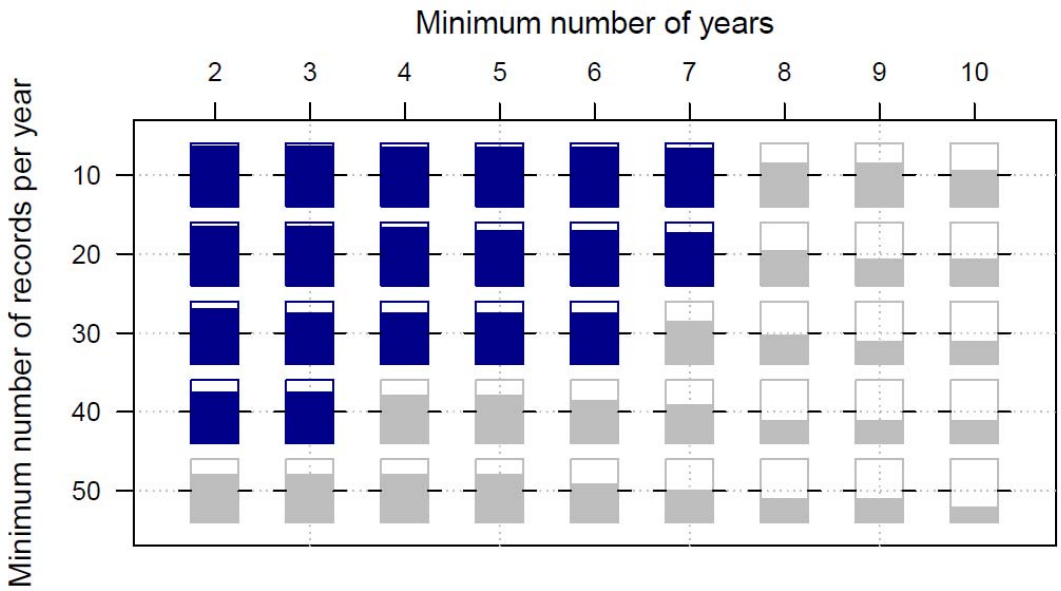

Figure 29: Proportion of the catch taken when subsetting the PCELR data by FIN with the requirement of a minimum number of daily records per year, for a minimum number of years. Each bar shows the percentage of the total catch from 2002–2014 retained under the criteria, where the horizontal line for each bar represents 50%. Bars with a fill colour of blue retain 80% or more of the catch, otherwise they are coloured grey.

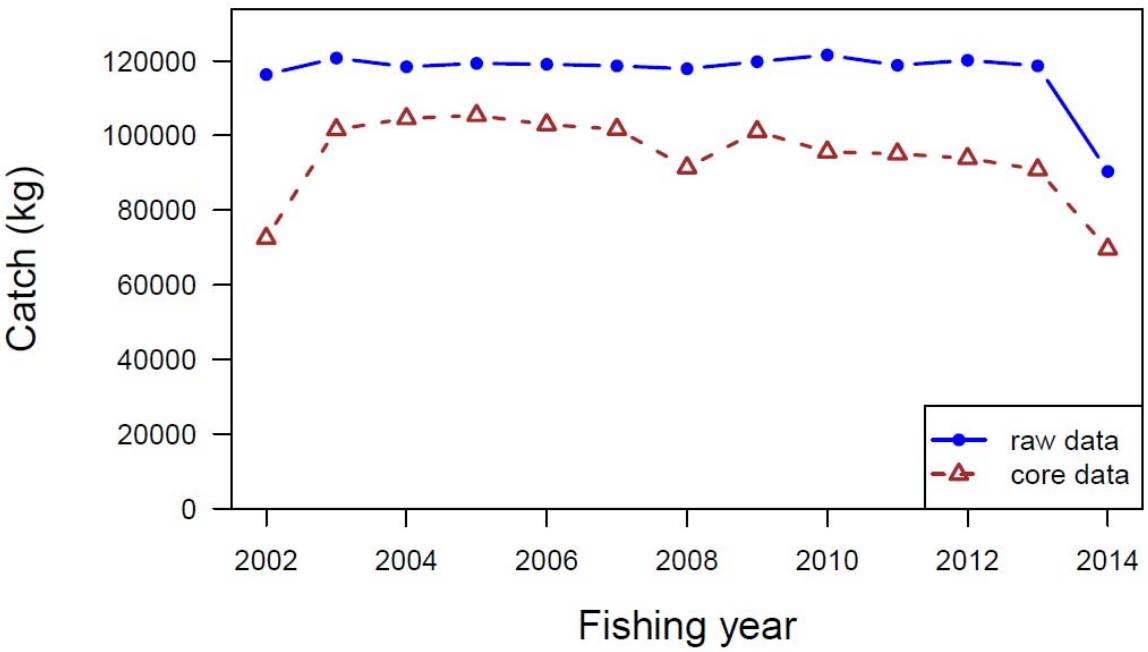

Figure 30: Catch by fishing year from the PCELR dataset before FIN subsetting (raw data) and after (core data).

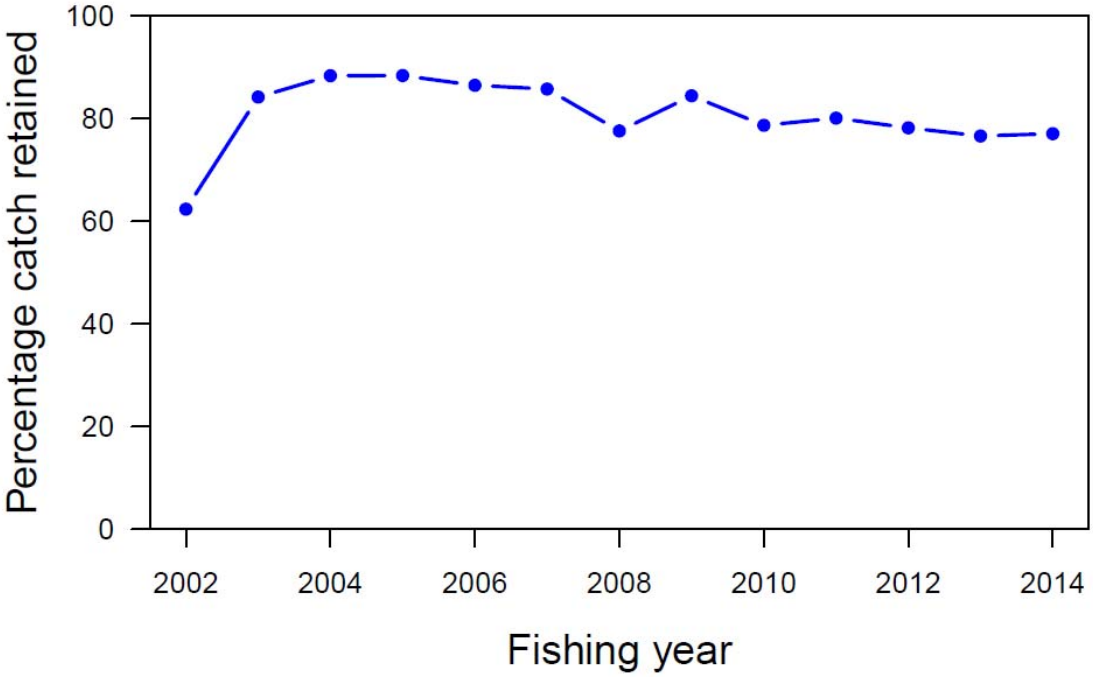

Figure 31: Percentage of the catch retained after FIN subsetting.

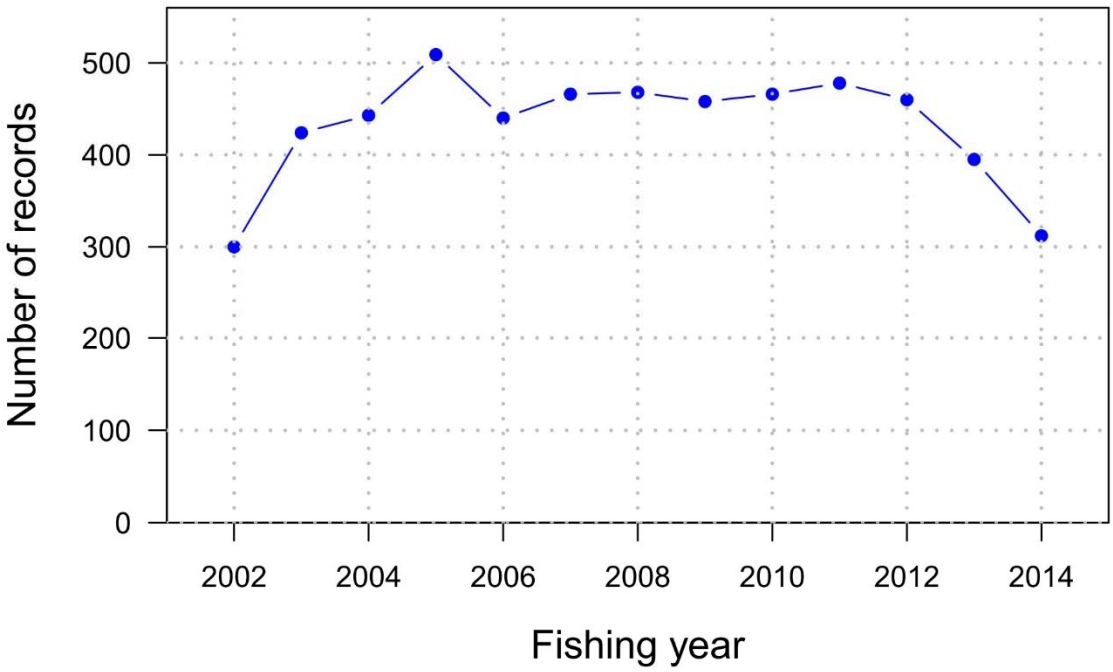

Figure 32: Number of records retained after subsetting by FIN.

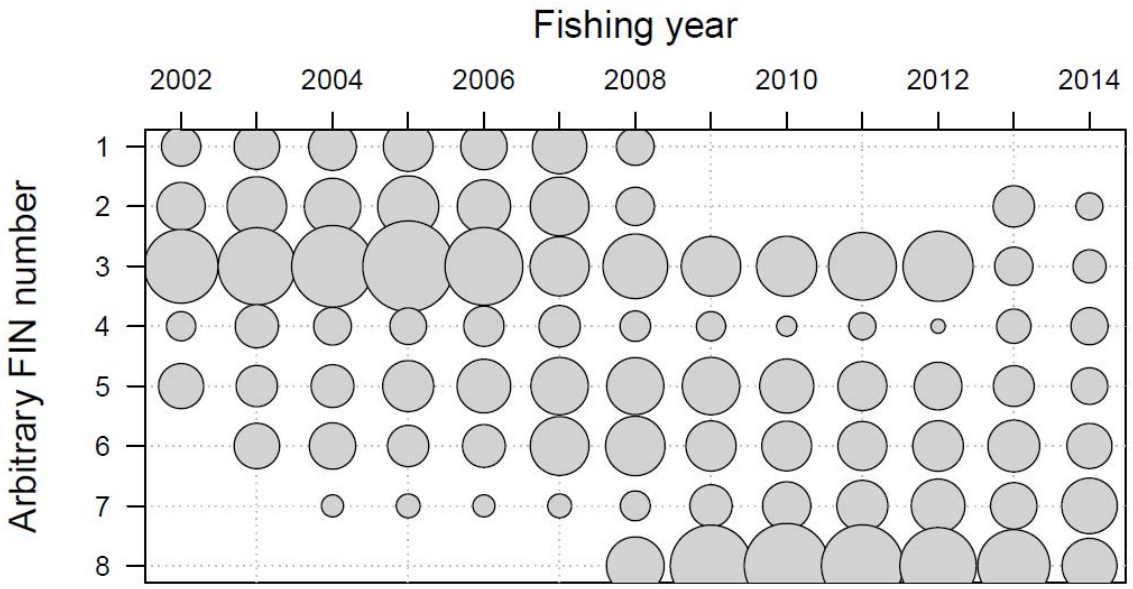

Figure 33: Number of records in the PCELR dataset by FIN and fishing year after subsetting by FIN. The area of a circle is proportional to the number of days of effort.

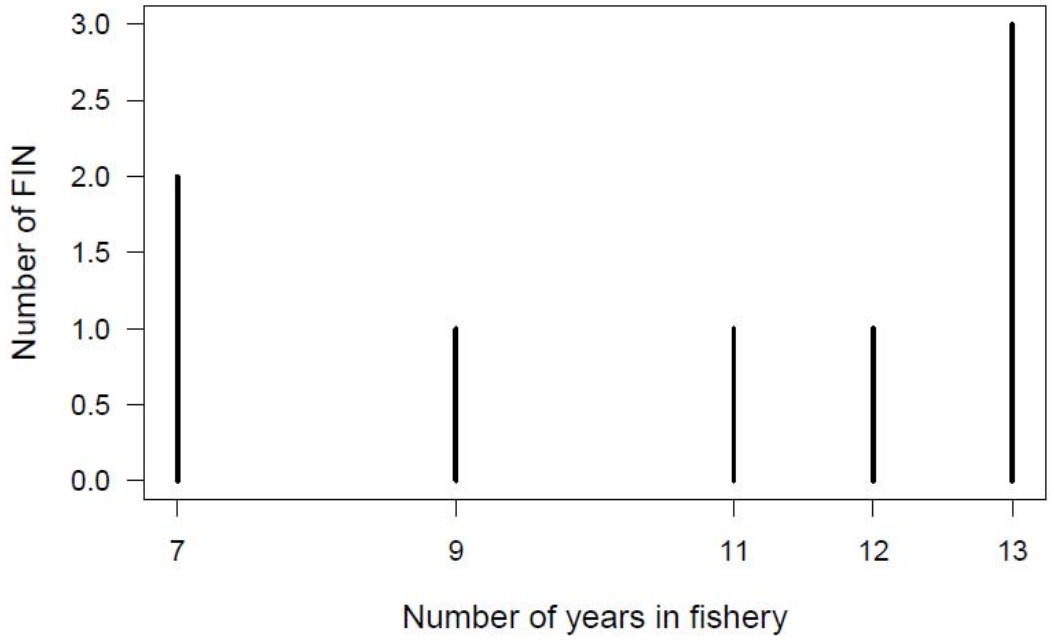

Figure 34: Number of years in the fishery for a FIN holder after subsetting by FIN.

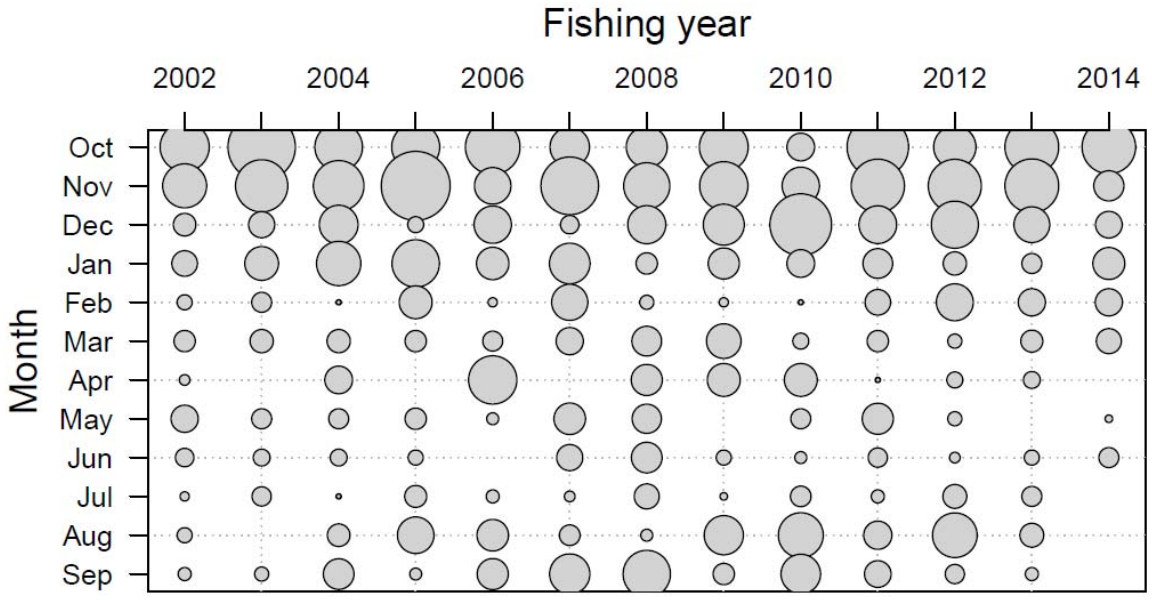

Figure 35: Number of records by month and fishing year. The area of a circle is proportional to the number of records.

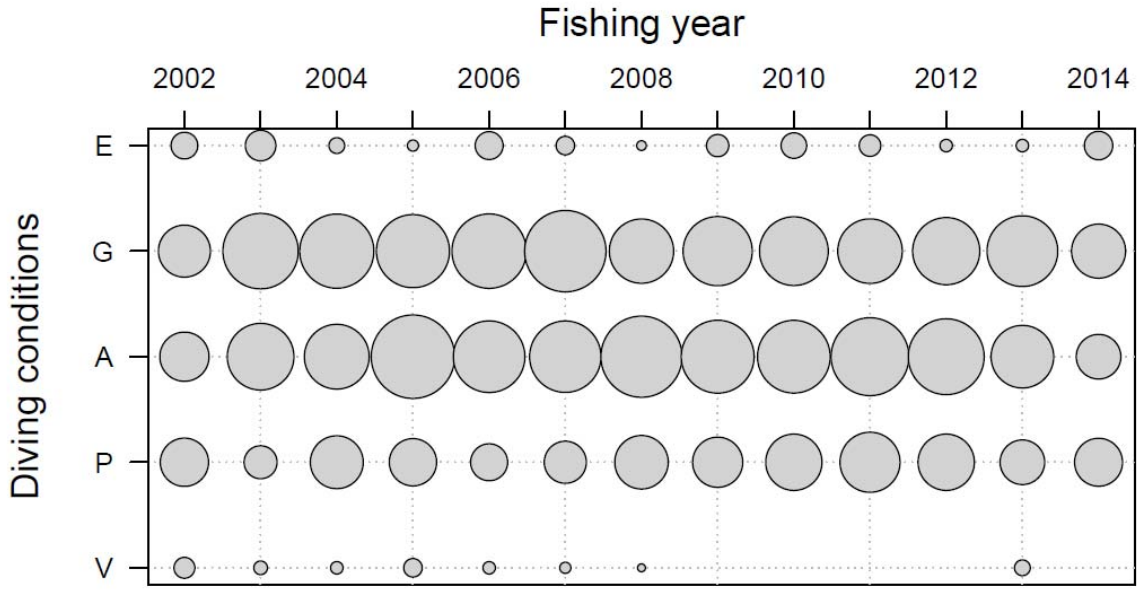

Figure 36: Number of PCELR records by diving condition (excellent, good, average, poor, very poor) and fishing year. The area of a circle is proportional to the number of records.

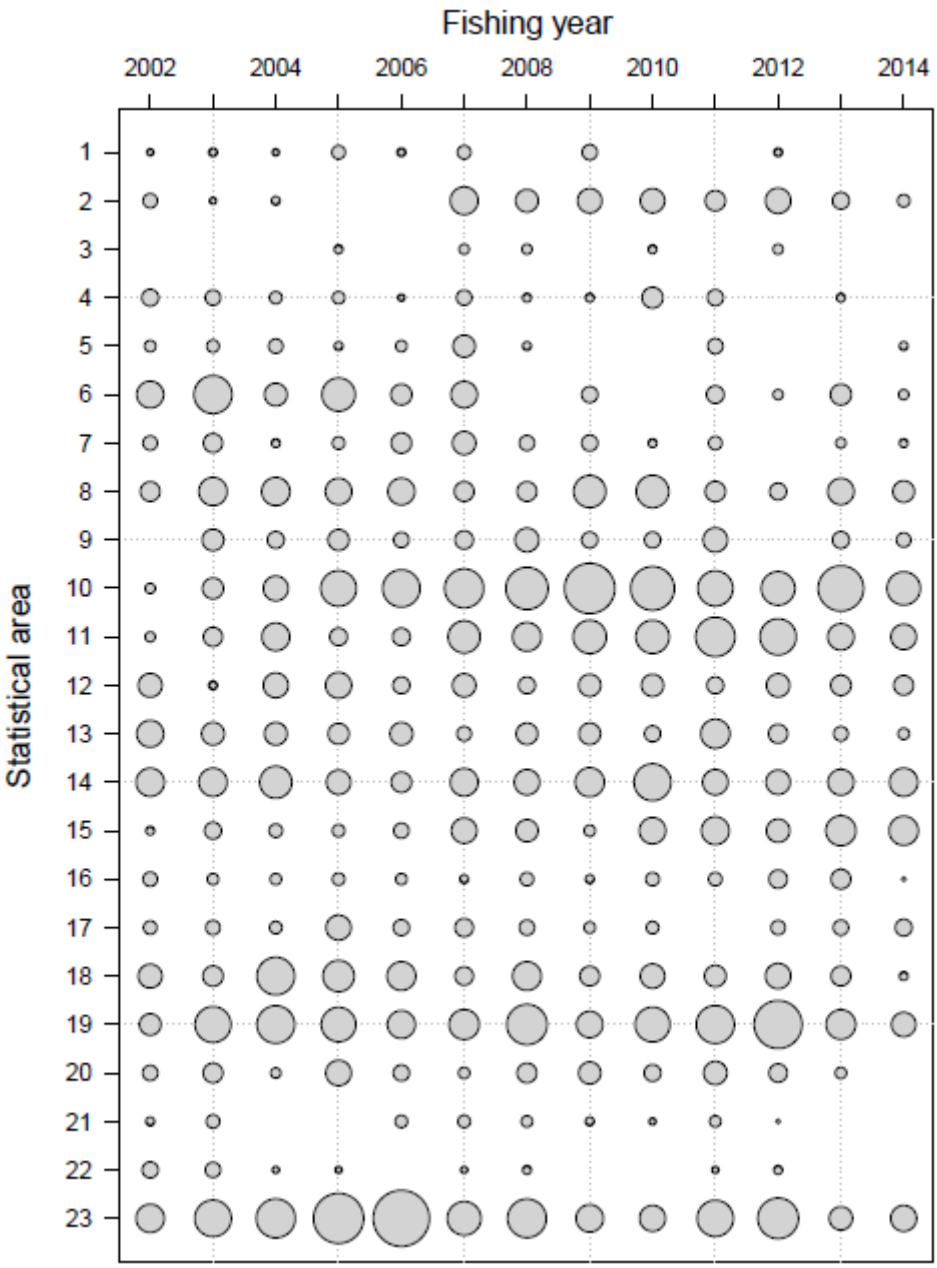

Figure 37: Number of PCELR records by statistical area and fishing year. The area of a circle is proportional to the number of days of effort. Arbitrary labels are used for the statistical areas.

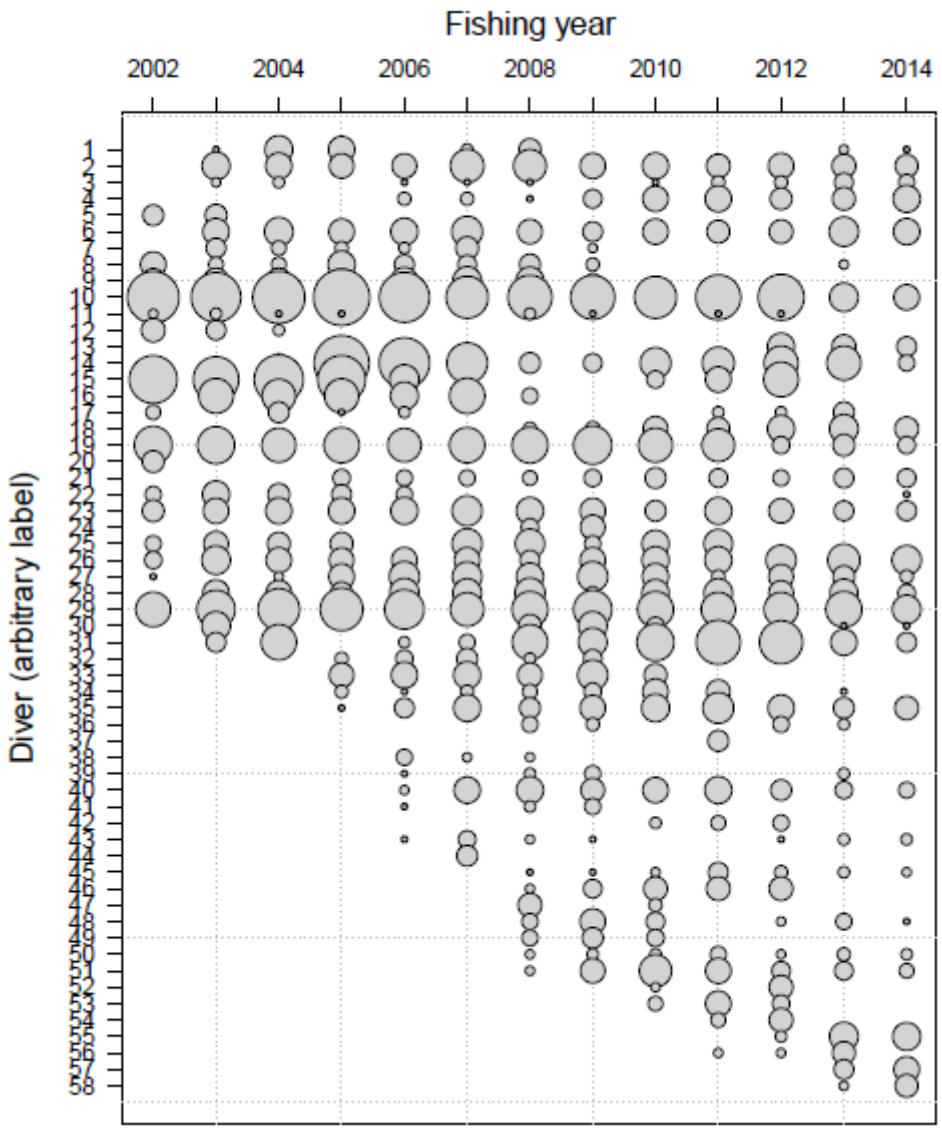

Figure 38: Number of PCELR records by diver key and fishing year. The area of a circle is proportional to the number of records.

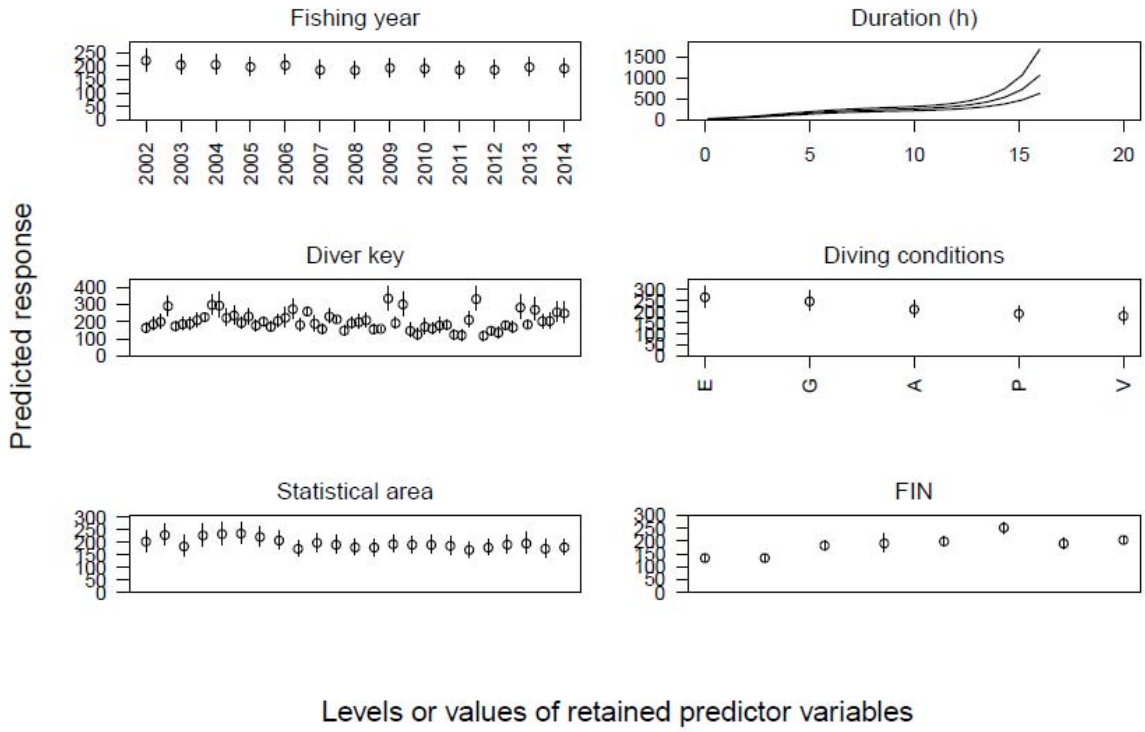

Figure 39: Effects for the PCELR standardisation model. Effects catch rates are calculated with other predictors fixed at the level for which median catch rates are obtained. Vertical lines are 95% confidence intervals.

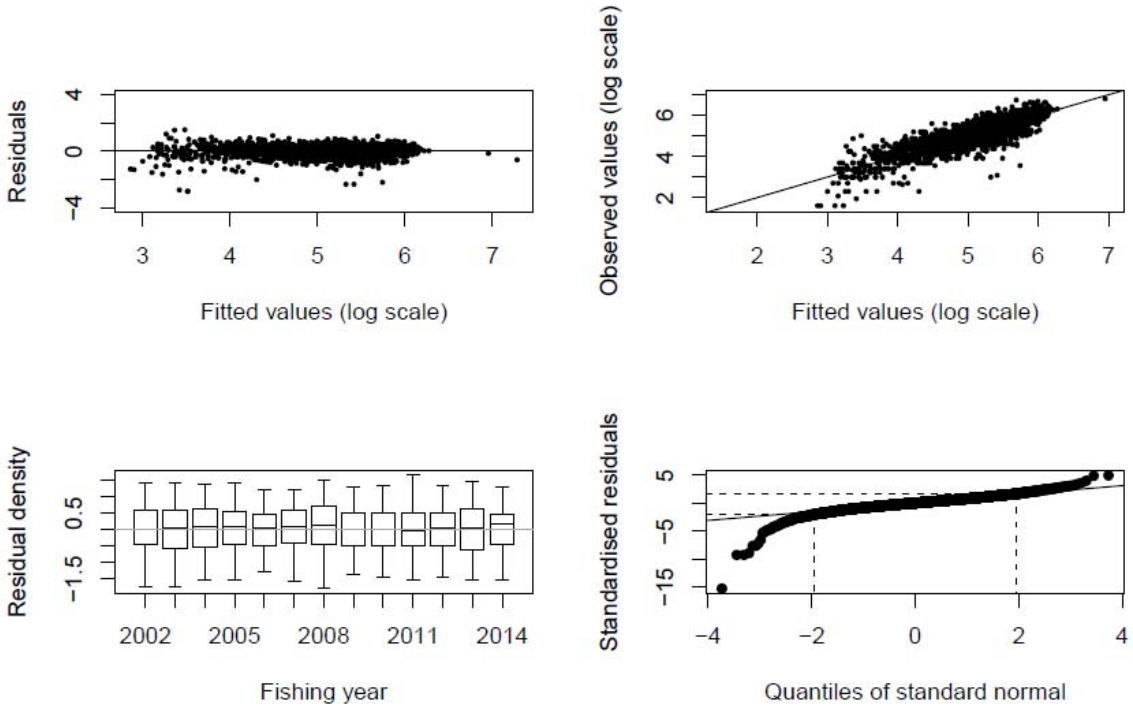

Figure 40: Diagnostic plots for the PCELR standardisation model.

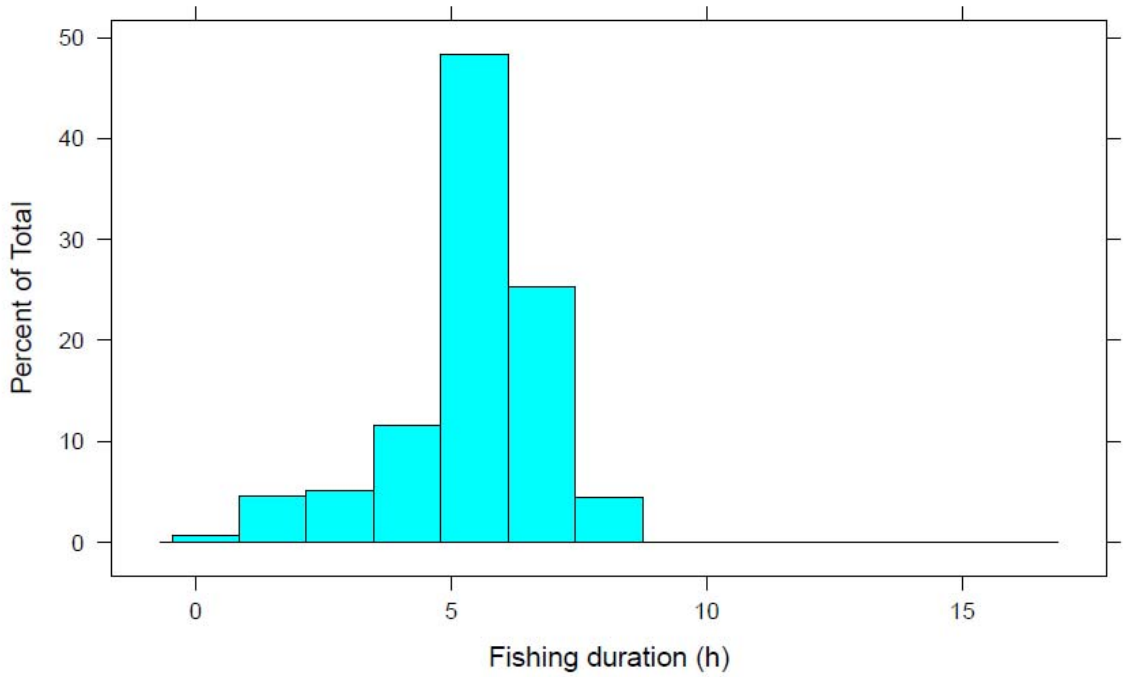

Figure 41: Distribution of fishing duration (h) for the PCELR dataset.

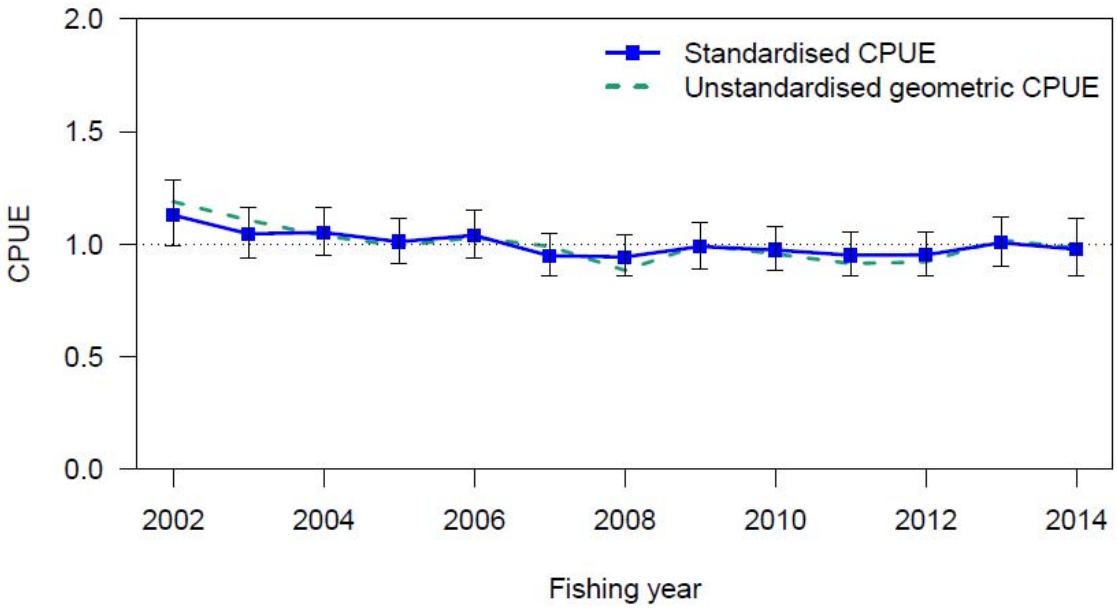

Figure 42: The standardised CPUE index for the PCELR dataset with 95% confidence intervals. The unstandardised geometric CPUE is calculated as daily catch divided by daily fishing duration.

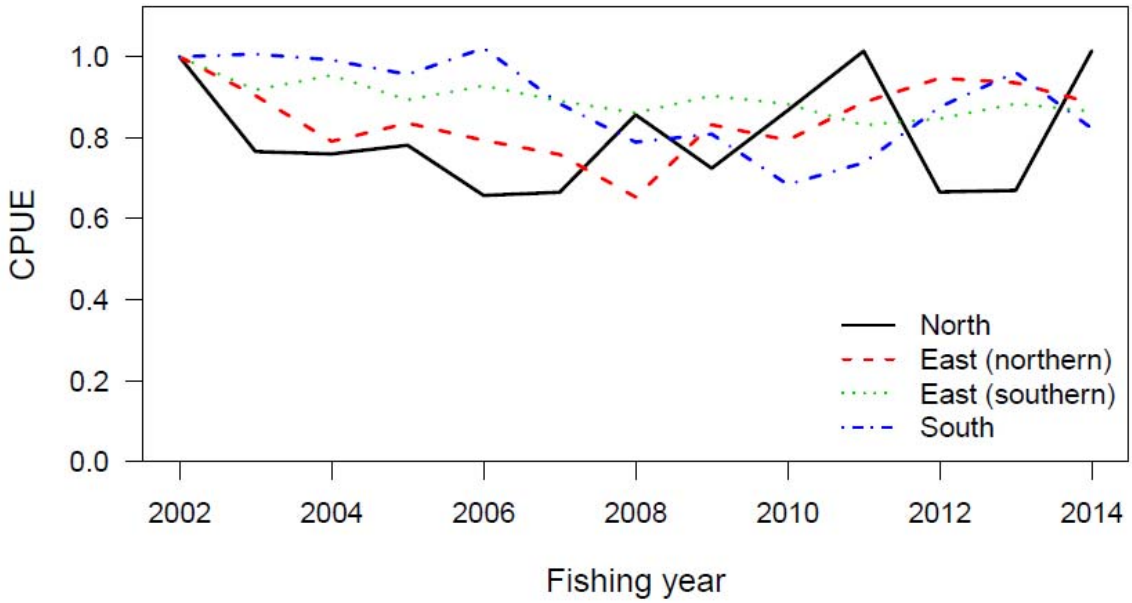

Figure 43: Standardised indices for the PCELR dataset with a year:strata interaction forced into the model. The areas are research strata. The indices are scaled to have the value one in 2002.

4. ACKNOWLEDGMENTS

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