DRAFT REPORT to the Southern Inshore Stock Assessment Working Group (SINS WG). For SINS WG Discussions Only – Not for release without written approval

PREDICTION OF 2015/16 FLA 3 CPUE AND OPERATION OF FLA 3 MANAGEMENT PROCEDURE

PAUL J. STARR
TERESE H. KENDRICK
NOKOME BENTLEY
TROPHIA LTD.

This draft report is not for publication or release in any other form, unless specifically authorised in writing by the Ministry for Primary Industries

Working Group papers are "works in progress" whose role is to facilitate the discussion of the Working Groups. They often contain preliminary results that are receiving peer review for the first time and, as such, may contain errors or preliminary analyses that will be superseded by more rigorous work. For these reasons, no-one may release information contained in Working Group papers to external media. In general, Working Group papers should never be cited. Exceptions may be made in rare instances by obtaining permission in writing from the MPI Chief Scientist and the authors of the paper.

FLATFISH (FLA 3)

REPORT TO SOUTHERN INSHORE STOCK ASSESSMENT WORKING GROUP: PREDICTION OF 2015/16 FLA 3 CPUE AND OPERATION OF FLA 3 MANAGEMENT PROCEDURE

PAUL J. STARR
TERESE H. KENDRICK
NOKOME BENTLEY
TROPHIA LTD.

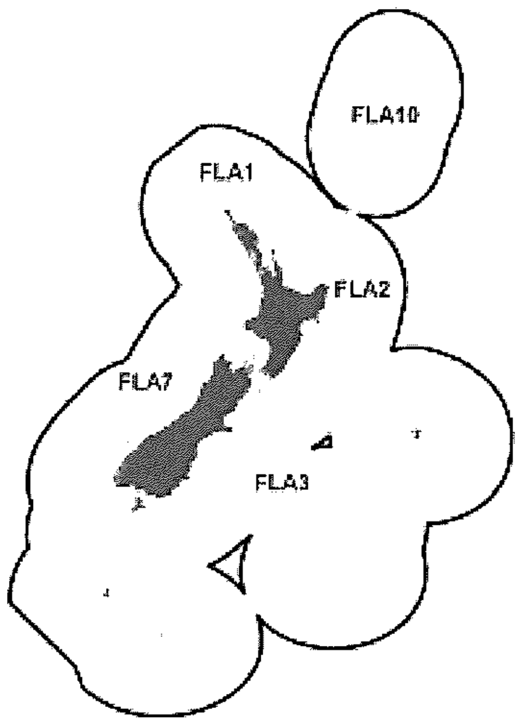

Figure 1. Map of FLA QMAs.

1. INTRODUCTION

The FLA 3 Fishstock has landings dominated by three species: Lemon Sole (LSO), New Zealand Sole (ESO) and Sand Flounder (SFL), but comprises up to 19 flatfish species in this species aggregate. Most of these flatfish species are relatively short lived, resulting in considerable variation in annual abundance and the associated CPUE.

The TACC for flatfish in FLA 3 was reduced on 01 October 2007 from 2,681 t to 1,430 t, a level that was more in keeping with the average historical catch from this QMA. This was done in order to reduce the amount of available TACC that remained uncaught which in turn provided opportunities for a low cost entry into the inshore trawl fishery. However, with this reduction, it was now possible for the TACC to be exceeded in years following strong recruitment events and consequently not allowing for increased utilisation when abundance was high. Flatfish were included in the Second Schedule of the Fisheries Act (1996), which meant that, under section 13(7), the Minister could implement an in-season increase to the TACC. Such an increase needed to be based on current information from the fishery and the Ministry for Primary Industries (MPI) commissioned work to develop such a procedure.

In 2010, a management procedure (MP) was developed for FLA 3 which used the catch per unit effort (CPUE) from the first three months (October to December) of the fishing year to predict the final annual CPUE for the fishing year. This CPUE prediction was then multiplied by the slope of a regression which related realised catch with the annual CPUE over the 18 year period from 1989/90 to 2006/07 when the FLA 3 catch was relatively unconstrained. In effect, this slope is an estimate of the 18-year average exploitation rate and the incorporation of this slope estimate into the FLA 3 MP ensures that any recommended catch would be consistent with this historical exploitation rate. The procedure developed in 2010 did not recalculate the standardised CPUE when operating the MP. Instead, the procedure simulated the standardisation procedure, using data from a fixed suite of vessels identified in the initial 2010 analysis. By 2015, the SINSWG recognised that this approach led to an increasingly smaller share of the available data as vessels dropped out of the core fleet without replacement.

The FLA 3 MP was reviewed and revised in 2015 through MPI project FLA 2014–02. The basic structure of the original MP, where the final annual CPUE was predicted from partial year data and then applying that CPUE prediction to the slope of the 18-year catch/CPUE regression, was retained. However, two changes to the MP were proposed and approved by the SINSWG. The first was to re-estimate the standardised CPUE analysis with each operation of the MP, using all the available data and reselecting the core vessel component. This change made the procedure more responsive to changes in fleet dynamics as well as making the analysis more understandable with it being consistent with the original evaluation of the MP. The second was to base the annual CPUE prediction on the first two months (October and November), allowing for a more rapid evaluation of any potential increase. This change was made because the 2015 MP analysis did not show an appreciable improvement in predictive performance of the MP when December was added to the procedure. Shortening the period allowed for more time for consultation and an earlier implementation of any eventual increase.

This report documents the first application of the revised 2015 FLA 3 MP. Figure 2 documents the TACC and catch history for FLA 3 up to the 2014–15 fishing year.

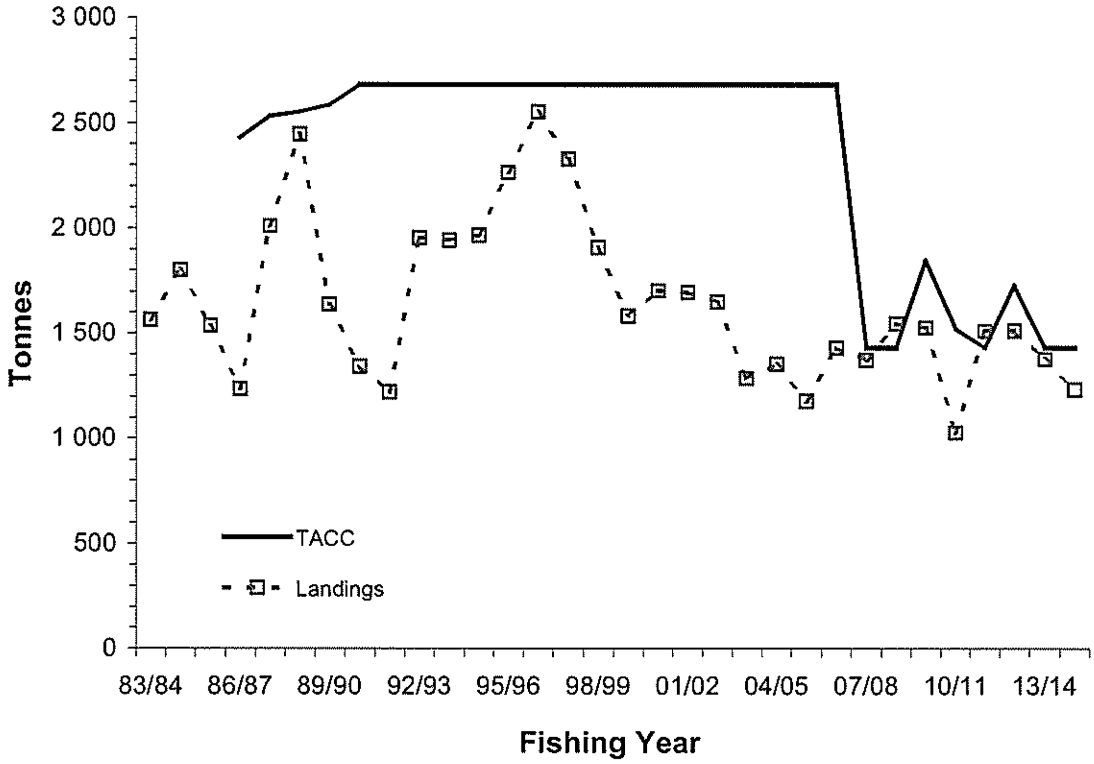

Figure 2. Catch history and TACC (t) for FLA 3 from 1983–84 to 2014–15 (Table 1).

Table 1. Reported landings (t) and TACC (t) of flatfish in FLA 3 from 1983–84 to 2014–15 (Data sources: QMR [1986–87 to 2000–01]; MHR [2001–02 to 2014–15).

Fishing Year	QMR_y	$TACC_y$	Fishing Year	QMR_y	$TACC_y$
1983–84	1 564	–	1999–00	1 583	2 682
1984–85	1 803	–	2000–01	1 703	2 682
1985–86	1 537	–	2001–02	1 693	2 682
1986–87	1 235	2 430	2002–03	1 650	2 682
1987–88	2 009	2 532	2003–04	1 286	2 682
1988–89	2 447	2 552	2004–05	1 353	2 682
1989–90	1 637	2 585	2005–06	1 177	2 682
1990–91	1 341	2 681	2006–07	1 429	2 682
1991–92	1 219	2 681	2007–08	1 371	1 430
1992–93	1 953	2 682	2008–09	1 544	1 430
1993–94	1 941	2 682	2009–10	1 525	1 846[1]
1994–95	1 966	2 682	2010–11	1 027	1 520[1]
1995–96	2 265	2 682	2011–12	1 511	1 430
1996–97	2 552	2 682	2012–13	1 512	1 727[1]
1997–98	2 328	2 682	2013–14	1 376	1 430
1998–99	1 907	2 682	2014–15	1 231	1 430

[1] in-season adjustment level

2. METHODS

2.1 DATA PREPARATION

An MPI data extract (replog 10366b) was obtained which covered the period from 1 October 1989 to 30 November 2015. This extract was designed to retrieve all bottom trawl (BT) trips that may have fished in inshore areas of FLA 3 with the potential of catching any of 19 flatfish species codes. Landing data for these trips were requested such that landings which specified non-standard codes for FLA species other than "FLA" would also be obtained. This was done because the 2015 FLA 3 analysis (Starr et al. 2015) discovered that many FLA 3 landings, especially in the late 1990s, used codes other than "FLA".

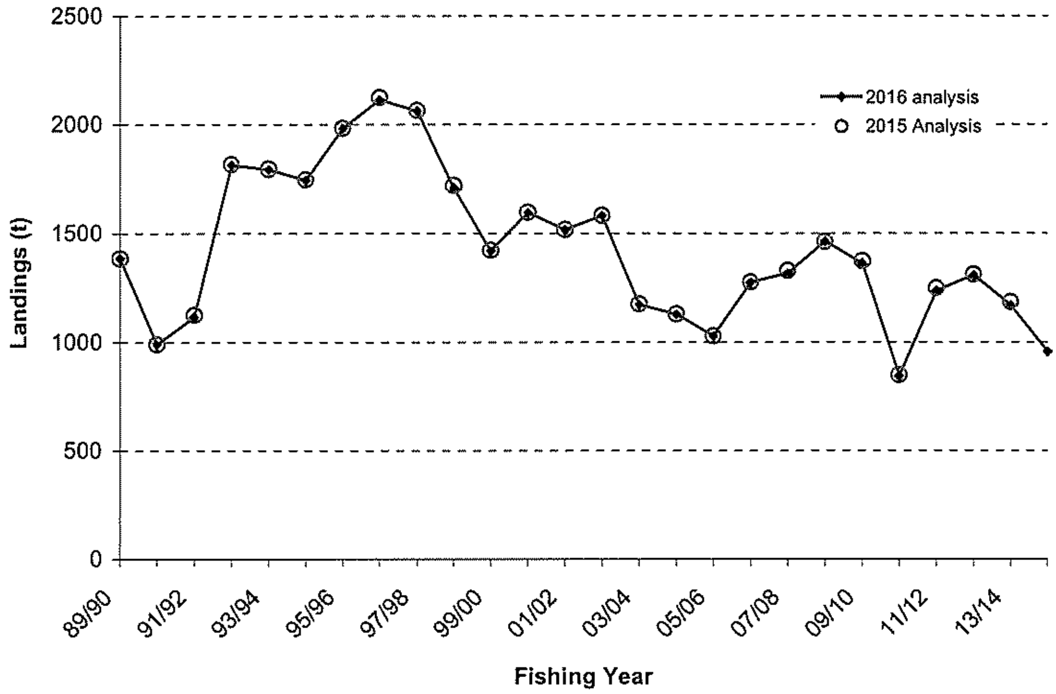

Figure 3: Comparison of the total catch in the "analysis" data set used to estimate the 2016 FLA 3 standardised CPUE with the equivalent data set use to estimate the 2015 FLA 3 CPUE (Starr et al. 2015).

The 2015 analysis identified 79 trips which were deemed "spurious" by comparing, on a trip basis, declared green weight, calculated processed weight and total estimated catch. Trips where there was substantial disagreement between these three estimates were discarded. The new data from replog 10366b, which post-dated the 2015 analysis, were investigated for similar discrepancies (none were found) and the same 79 trips were discarded during this data preparation phase.

All the event-based data were prepared using the "daily stratum method" (Langley 2014), a method which collapses tow-by-tow data within a trip into a single daily record. Each composite daily record is then assigned the modal statistical area and the modal target species for the day, weighted by the number of tows. In the event of ties, the mode with the largest estimated catch is used. Target species which are unlikely to catch flatfish (based on an analysis of the distribution of estimated catch by target species) are discarded when using this method, but, when they occur in a trip, the entire trip is discarded to avoid any potential bias in the effort data. This method is used to emulate how data appeared to have been recorded before reporting forms were changed from daily to event-based on 1 October 2007, thus allowing a continuous series to be estimated from 1 October 1989.

Landing and effort data for each trip are then combined, with the landed catch allocated to each daily record proportionate to the estimated catch for the day. For the purposes of this analysis, all 19 species of estimated catch were treated as if they were "FLA" as well as changing all non-standard landing codes to FLA 3. There is almost no difference between the total catch available in this 2016 data set with the equivalent data set used for the 2015 MP analysis (Figure 3). The data used in the FLA 3 MP analysis track the landings very well except for a period in the 1990s (1992–93 to 1998–99: Figure 4).

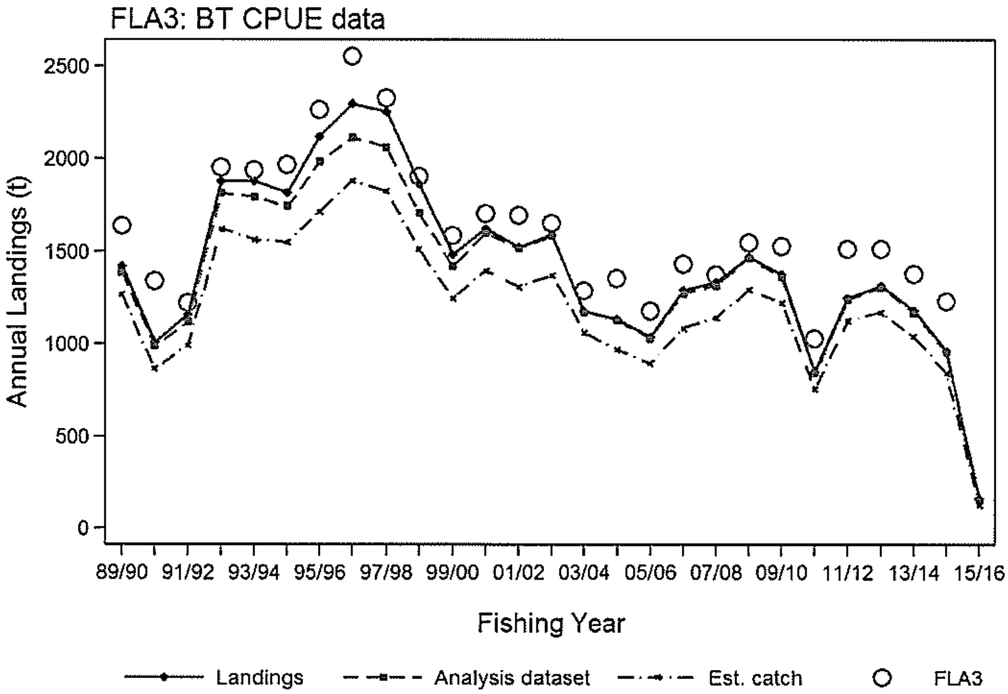

Figure 4: Comparison of the total landings after edits (after dropping 79 "spurious" trips: labelled "Landings") with the data available for standardised CPUE analysis (labelled "Analysis") and the estimated catches (labelled "Est. catch") in the "analysis" data set. Also shown are the total QMR/MHR landings for FLA 3. Only October and November data are available in 2015–16.

2.2 DATA SELECTION

Data in the "analysis" data set were filtered using the following criteria:

core vessels: 10 trips in at least 5 years
statistical areas: 020, 022, 024, 025, 026, 030
bottom trawl
target species FLA (with all non-FLA flatfish codes treated as FLA)
drop daily records with >24 hours duration
drop daily records with >12 tows
trip landings scaled to estimated daily catches of total (all codes) FLA

The core vessel definition resulted in selecting 124 vessels, representing 91% of the total catch in the "analysis" data set.

2.3 COMPARISON OF THE 2015–16 DATA WITH PREVIOUS FISHING YEARS

A comparison of the 2015–16 October and November totals for tows, trips, vessels and catch with the equivalent totals for fishing years 2011–12 to 2014–15 shows a considerable shortfall for each quantity in both months except for number trips in October, where there were fewer trips in October 2011–12 (Table 2). This suggests that the available 2015–16 data are probably incomplete, given the totals observed in recent years. This shortfall could be the result of one of at least three processes: 1) fewer opportunities to fish in 2015–16 because of poor weather or other fishing opportunities; 2) failure to submit catch forms on time; or 3) submitted catch forms have not yet been entered into the MPI database. If the first option is true, there would be a shortfall in the monthly totals regardless of how well the data are processed. The other two options are procedural and could be improved with a greater commitment of resources. It will not be possible to distinguish between these options until next year, when presumably all the available data have been processed. In the meantime, it is best to proceed as if the available 2015–16 data are sufficiently complete to be fully representative of the final totals.

Table 2: Monthly totals for tows, trips, vessels and catch for the four most recent complete fishing years and the October/November totals in the FLA 3 standardised CPUE data set (after applying the filters described in Section 2.2).

					Fishing year					Fishing year
	11/12	12/13	13/14	14/15	15/16	11/12	12/13	13/14	14/15	15/16
Month					Number tows					Number trips
Oct	680	591	835	704	390	137	189	228	200	149
Nov	814	1092	1250	907	529	163	222	257	194	148
Dec	900	764	888	766		168	151	165	155	
Jan	873	818	549	844		175	165	147	176	
Feb	886	1113	1041	673		171	253	227	150	
Mar	1041	1110	1002	836		279	270	249	194	
Apr	1002	751	669	507		239	238	201	146	
May	808	835	740	614		211	235	224	165	
Jun	372	682	708	328		116	180	204	115	
Jul	833	653	667	446		233	198	156	101	
Aug	915	1102	731	614		188	199	208	115	
Sep	764	883	771	450		200	218	194	102	
					Number vessels					Total catch (t)
Oct	38	37	43	39	29	62.9	56.8	79.6	69.3	34.5
Nov	40	42	48	40	28	95.7	147.5	129.2	99.0	69.5
Dec	38	40	37	38		99.0	98.6	89.9	81.7	
Jan	35	37	43	33		112.8	83.4	48.5	85.6	
Feb	38	39	41	30		107.2	119.4	123.5	75.3	
Mar	40	40	40	34		101.0	112.2	97.6	95.2	
Apr	42	40	38	34		89.1	57.8	59.4	53.1	
May	38	40	35	35		77.4	79.5	66.1	50.0	
Jun	33	38	37	32		28.0	68.0	47.9	15.4	
Jul	37	36	33	34		107.3	65.4	88.8	49.5	
Aug	40	40	38	31		154.6	175.6	86.2	91.4	
Sep	41	44	44	30		90.7	130.2	96.0	47.5	

2.4 GLM ANALYSIS PROCEDURE

The standardised CPUE analysis used to operate the 2016 FLA 3 MP was conducted in the same manner as was done with the 2015 FLA 3 MP analysis. These options include:

- positive catch model (only 3% of records equal zero)
- lognormal distribution forced (other underlying distributions not considered)
- six variables offered to the model: fishing year, vessel, month, statistical area, number tows and tow duration (the first four variables offered as categorical variables and the final two offered as continuous variables approximated as third order polynomials)
- note that the standardisation data set includes the partial fishing year 2015–16 represented by the October and November data only. This is coded as 2016 in the following diagnostic plots

3. GLM RESULTS

The final model was forced to include all six variables (Table 3). This was because the variable [month] would have been dropped under a 1% exclusion rule (R^2 improvement for [month] was about 0.5%). However, it was felt that this would be an useful variable to keep in the model, given that the MP data set was incomplete with respect to seasonal data.

Table 3: Results of stepwise selection of variables into the 2016 FLA 3 standardised CPUE model. Variables with an '*' were selected for inclusion in the model.

Variable	Degrees of freedom	Log likelihood	AIC	Nagelkerke pseudo-R^2 (%)	Acceptance flag
fishing year	28	-666 437	1 332 929	2.1	*
number tows (polynomial)	31	-643 824	1 287 710	37.5	*
vessel	154	-630 489	1 261 286	52.0	*
tow duration (polynomial)	157	-626 184	1 252 681	56.0	*
statistical area	162	-624 348	1 249 019	57.5	*
month	173	-623 716	1 247 777	58.1	*

Diagnostic plots show the following properties:

- there is good overlap for all vessels in the analysis (Figure 5). The vessels in this fishery are all previously represented in the fishery but about 10 of the recent participating vessels are not represented (from a total of about 40 in 2014–15);
- residuals from the fitted regression show reasonable adherence to the lognormal distributional assumption, except for deviations at the lower end of the residual distribution (Figure 6);
- the addition of the [tows] variable resulted in a considerable upturn in the estimated annual CPUE (Figure 7) but the addition of subsequent variables tended to drop the estimated CPUE, except for [statistical area] which raised the CPUE slightly;
- the influence plot for [tows] (Figure 8) showed a tendency for fewer tows per day in recent years, thus raising the CPUE;
- this CPUE increase is negated by the participation of top catching [vessels] (Figure 9) and a trend to longer tow [duration] (Figure 10);
- the majority of the 2015–16 effort occurred on the east coast, South Island (areas 20–24). These areas tend to have lower than average CPUE (Figure 11) which raised the overall estimated CPUE;
- the CPUE for October/November tend to be average or slightly better than average (Figure 12). This lowers the estimated CPUE but the effect is small;
- the plots of residual implied coefficients for area indicate that CPUE trends tend to differ between areas (Figure 13). This is not surprising, given that FLA 3 comprises a mixed species composition with a differing species distribution by area (Starr et al. 2015). This analysis represents an average effect over time across these 19 species.

Figure 14 shows that the 2016 FLA 3 MP analysis is consistent with previous analyses while Figure 15 shows that the most recent 2015–16 estimated CPUE is increased relative to CPUE observations in 2013–14 and 2014–15.

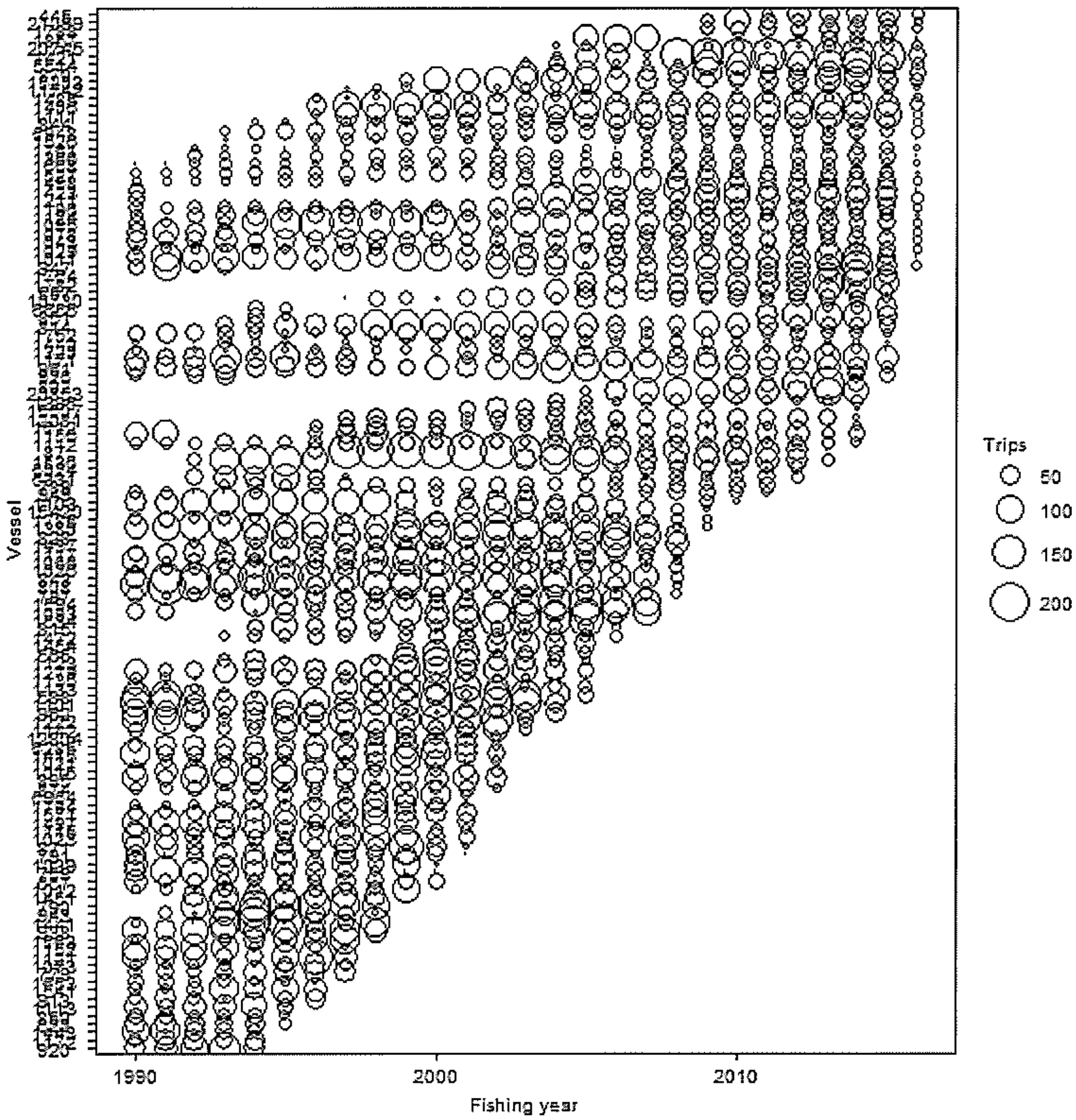

Figure 5: Number of records for each vessel in each fishing year for the selected core vessels (based on at least 10 trips in 5 or more fishing years.

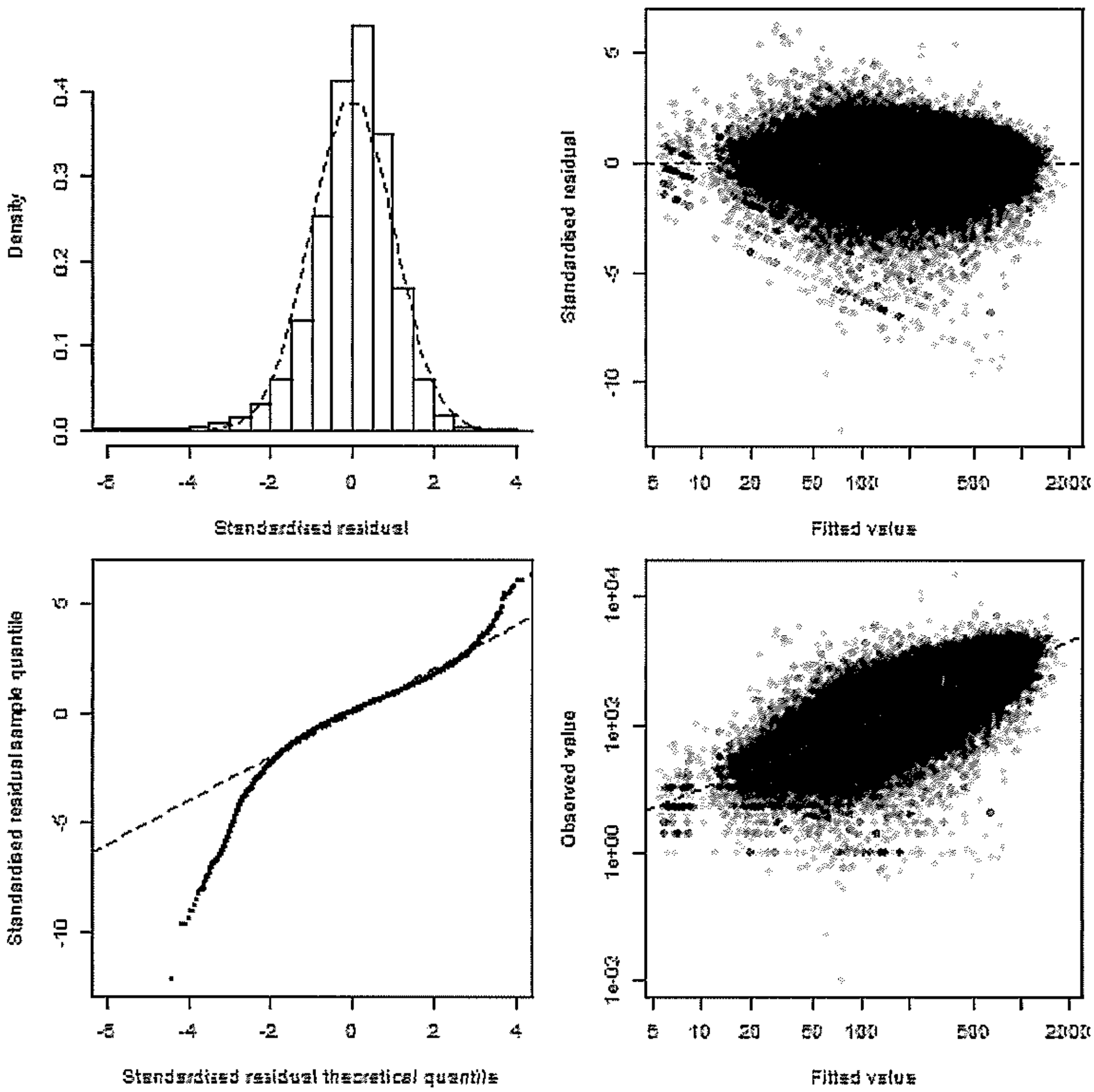

Figure 6: Plots of the fit of the standardised CPUE model to successful catches of flatfish in the FLA 3_BT fishery. [Upper left] histogram of the standardised residuals compared to a lognormal distribution [Upper right] Standardised residuals plotted against the predicted model catch per trip; [Lower left] Q-Q plot of the standardised residuals; [Lower right] Observed catch per record plotted against the predicted catch per record.

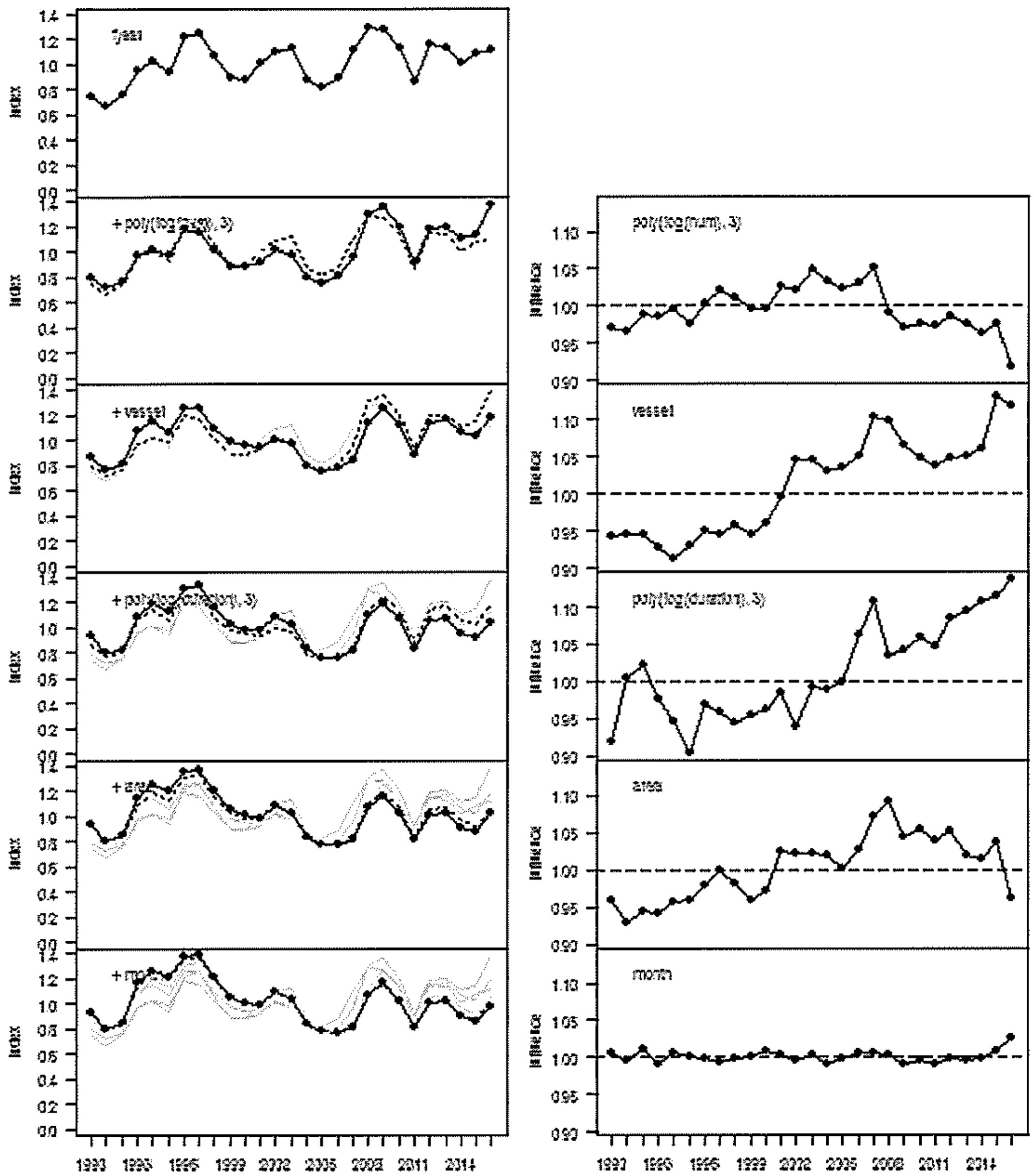

Figure 7: Stepwise and annual influence plot for FLA 3_BT. (a) CPUE index at each step in the selection of variables. The index obtained in the previous step is shown by a dotted line and for steps before that by grey lines. (b) Annual influence on observed catches arising from a combination of its GLM coefficients and its distributional changes over years, for each explanatory variable in the final model.

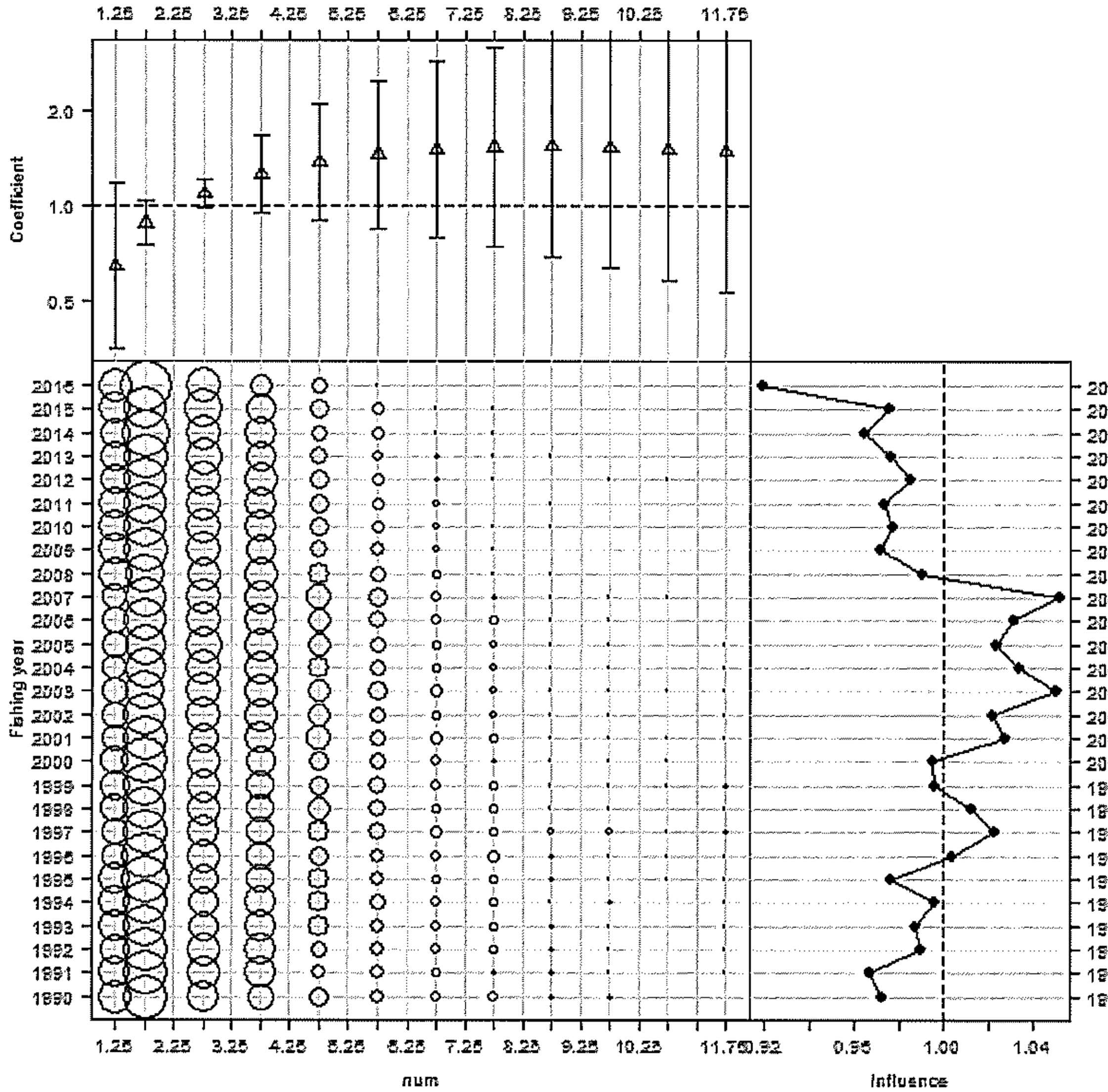

Figure 8: Effect of [number tows] in the lognormal model for the FLA 3_BT fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

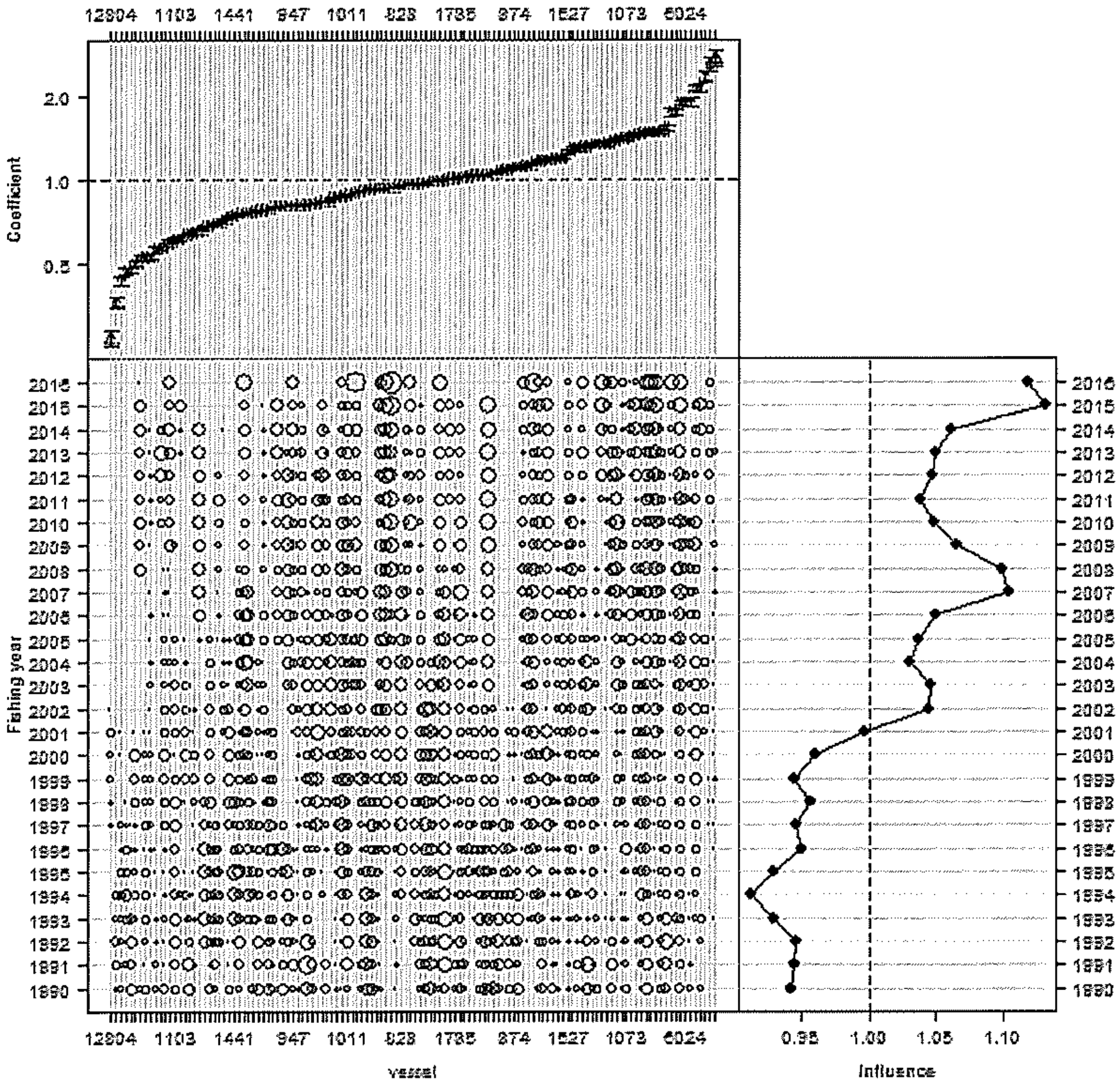

Figure 9: Effect of [vessel] in the lognormal model for the FLA 3_BT fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

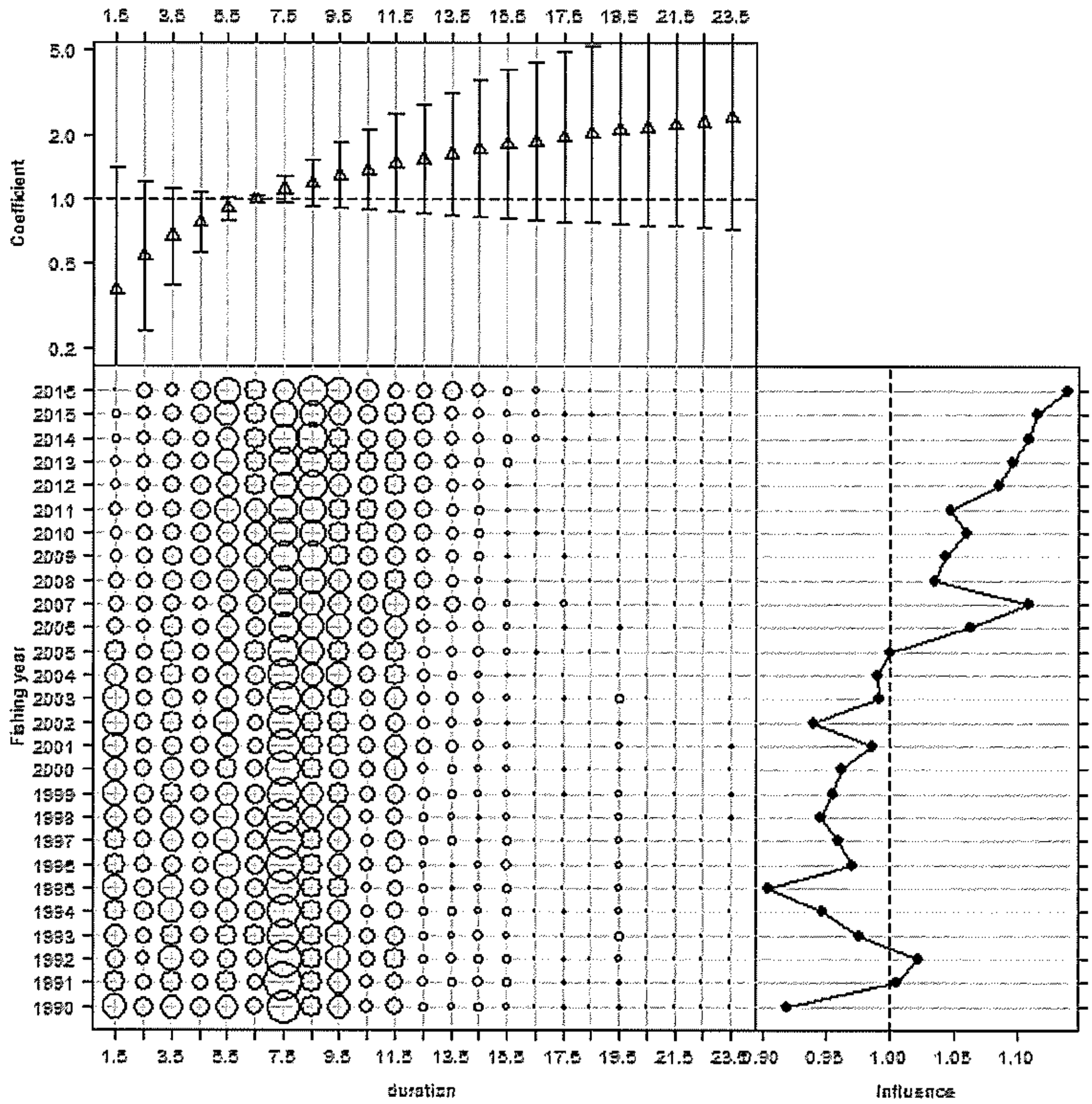

Figure 10: Effect of [tow duration] in the lognormal model for the FLA 3_BT fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

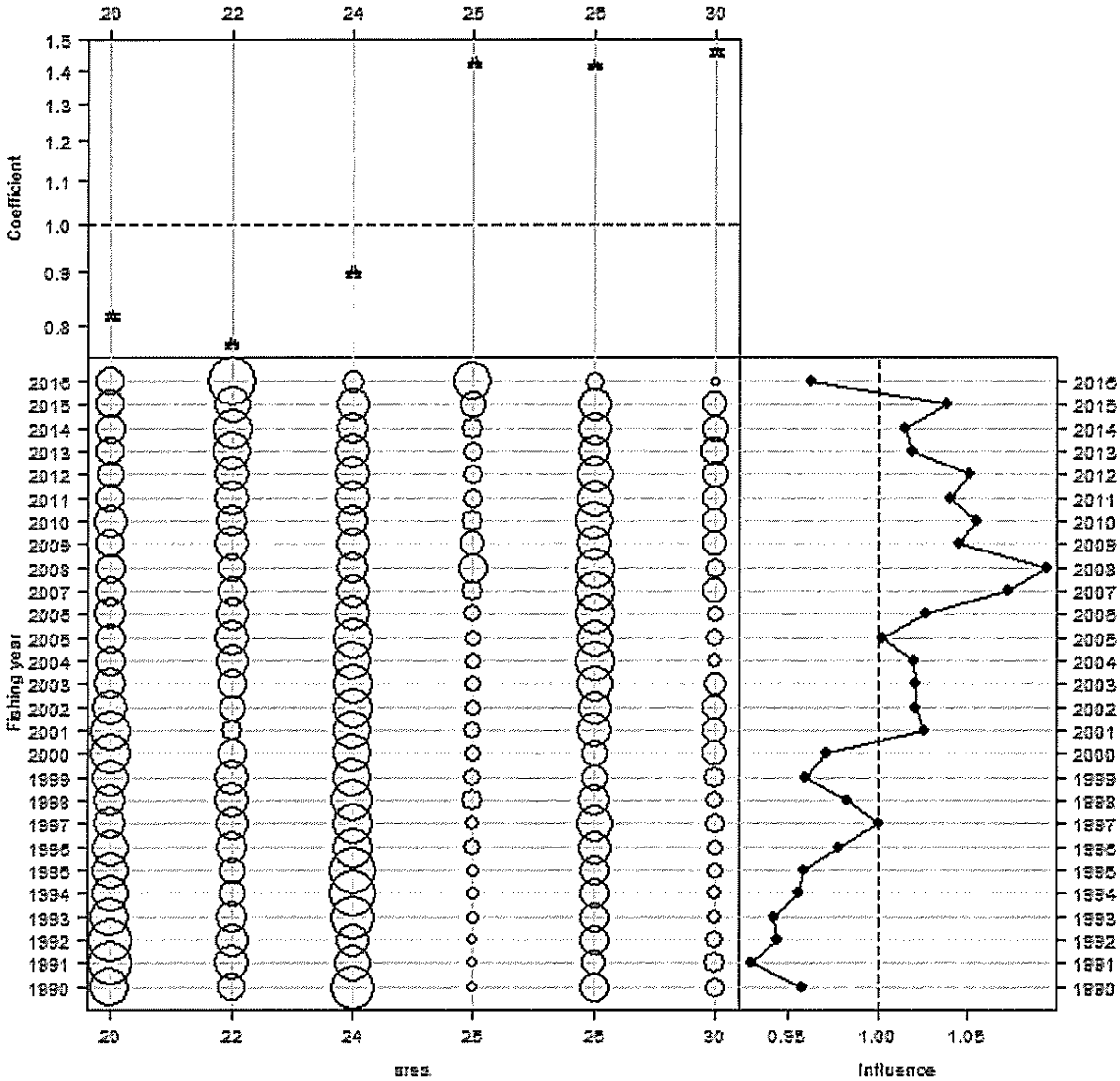

Figure 11: Effect of [statistical area] in the lognormal model for the FLA 3_BT fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

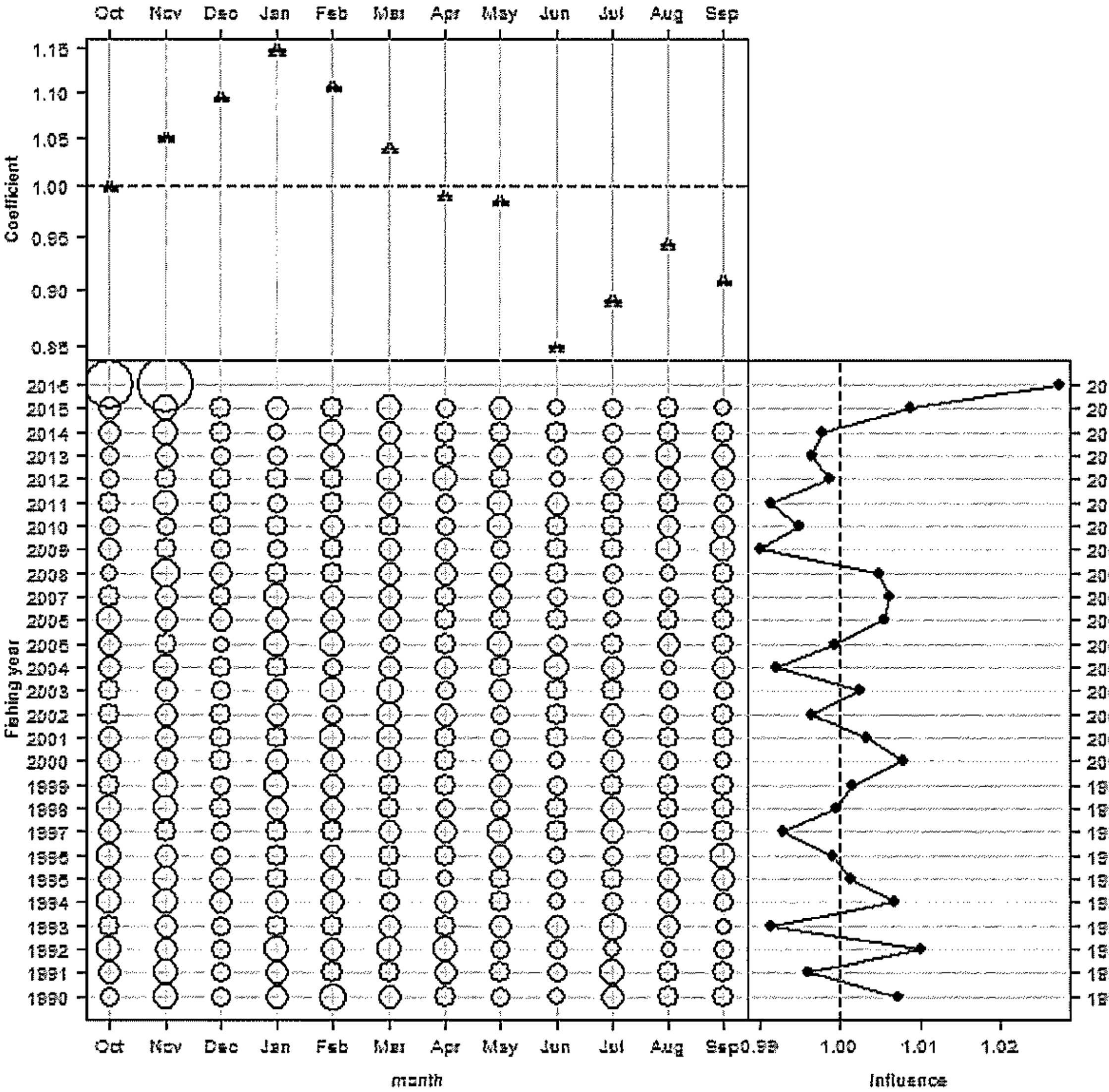

Figure 12: Effect of [month] in the lognormal model for the FLA 3_BT fishery. Top: effect by level of variable. Bottom-left: distribution of variable by fishing year. Bottom-right: cumulative effect of variable by fishing year.

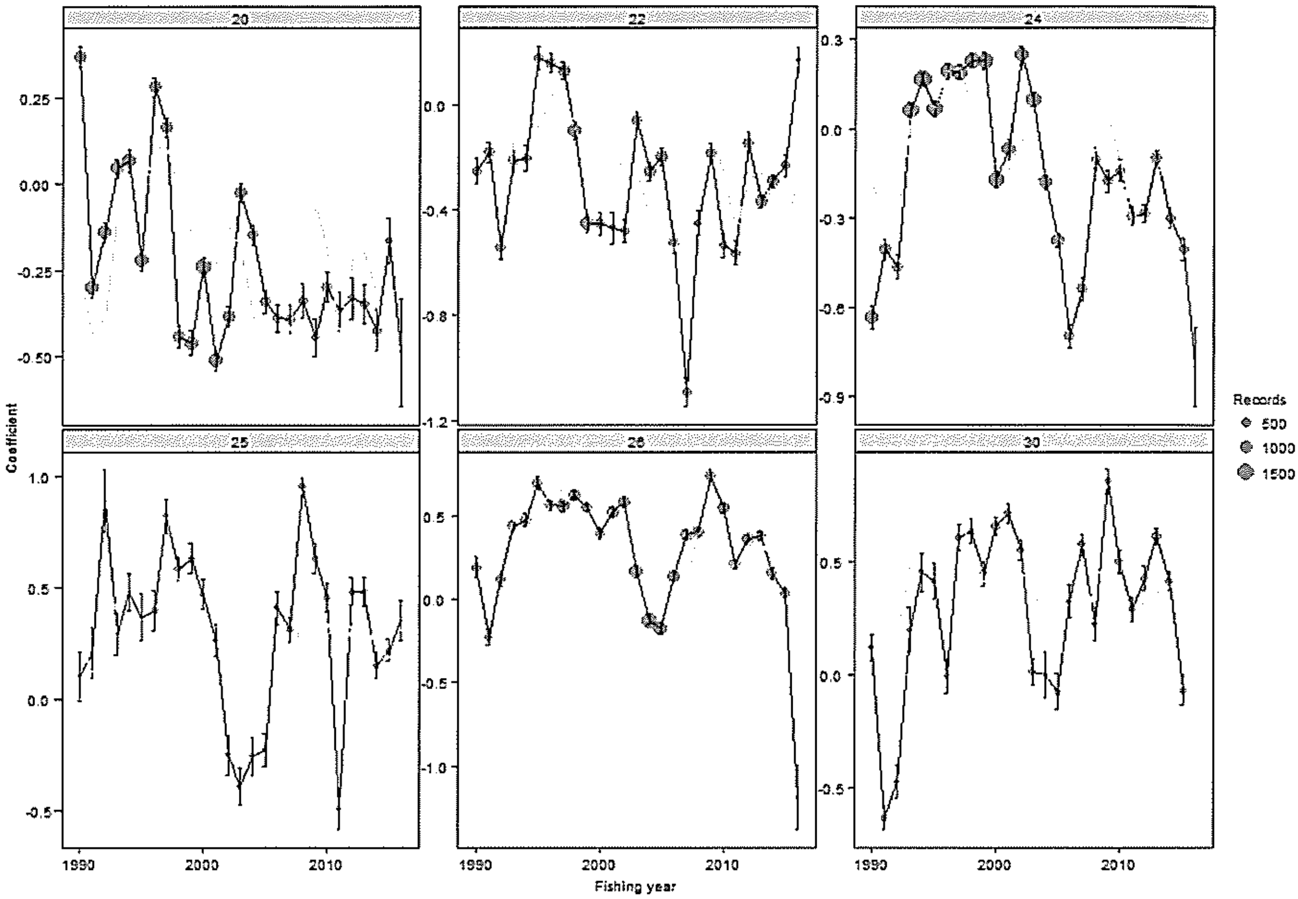

Figure 13: Residual implied coefficients for each area in each fishing year in the FLA 3_BT fishery. Implied coefficients are calculated as the sum of the fishing year coefficient plus the mean of the residuals in each fishing year in each area. The error bars indicate one standard error of residuals. The grey line indicates the model's overall fishing year coefficients.

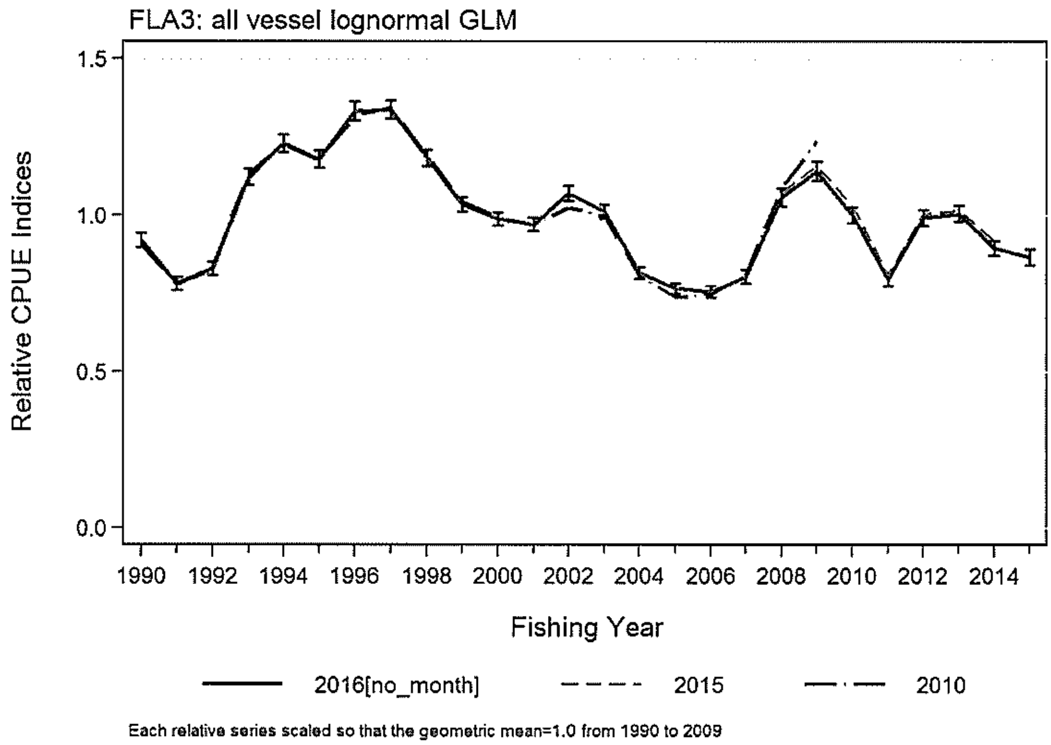

Figure 14: Comparison of three equivalent FLA 3 standardised CPUE analyses. The 2016 analysis has dropped the [month] variable for comparability with previous analyses.

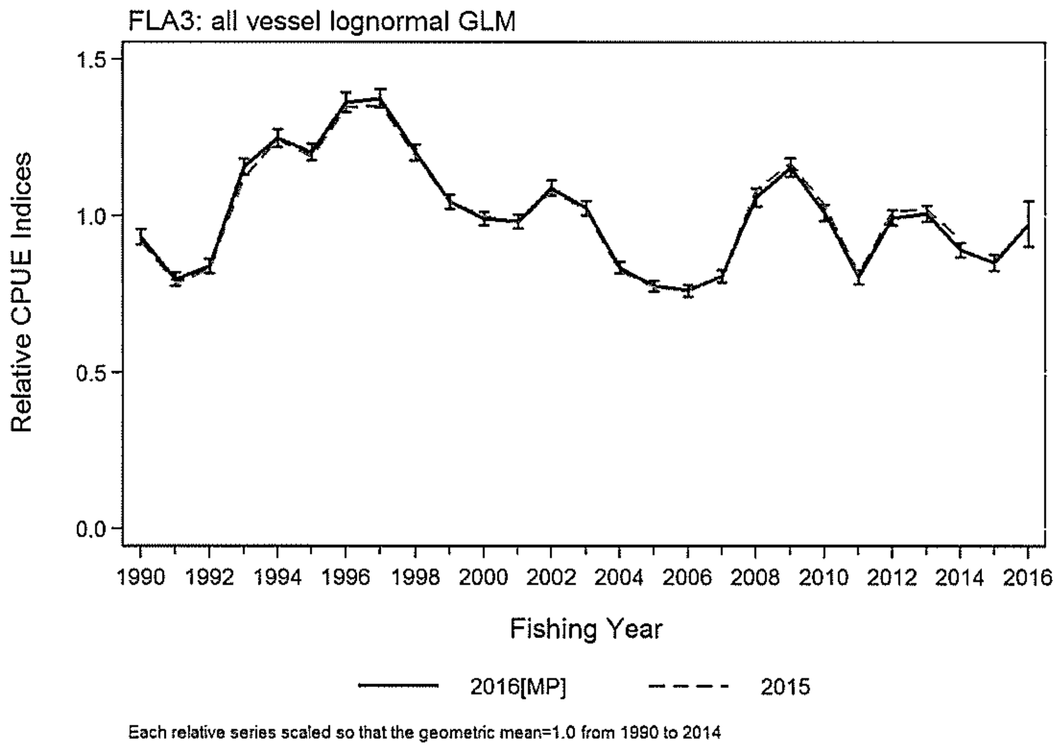

Figure 15: Comparison of the 2016 FLA 3_BT standardised CPUE analysis with the equivalent 2015 analysis.

4. OPERATION OF THE FLA 3 MP

The FLA 3 MP begins by establishing a relationship between realised catches and the associated CPUE from the Table 3 regression over the 18 year period between 1989–90 and 2006–07. This period is used because catches were relatively unconstrained during these years, given that the TACC was never exceeded and only briefly approached between 1995–96 and 1997–98 (Table 1). The fit of these catches with the CPUE is shown in Figure 16 (regression forced through zero), with the slope equal to 1676 t and an R^2 equal to 0.994. Predicted catches obtained when this slope is applied to the estimated CPUE values are shown in Table 4 and Figure 17. The recommended level of 1650 t for 2015–16 (Table 4) is generated by applying the estimated 2015–16 CPUE based on the October/November 2015 data from the Table 3 model and the Figure 16 slope (Figure 17).

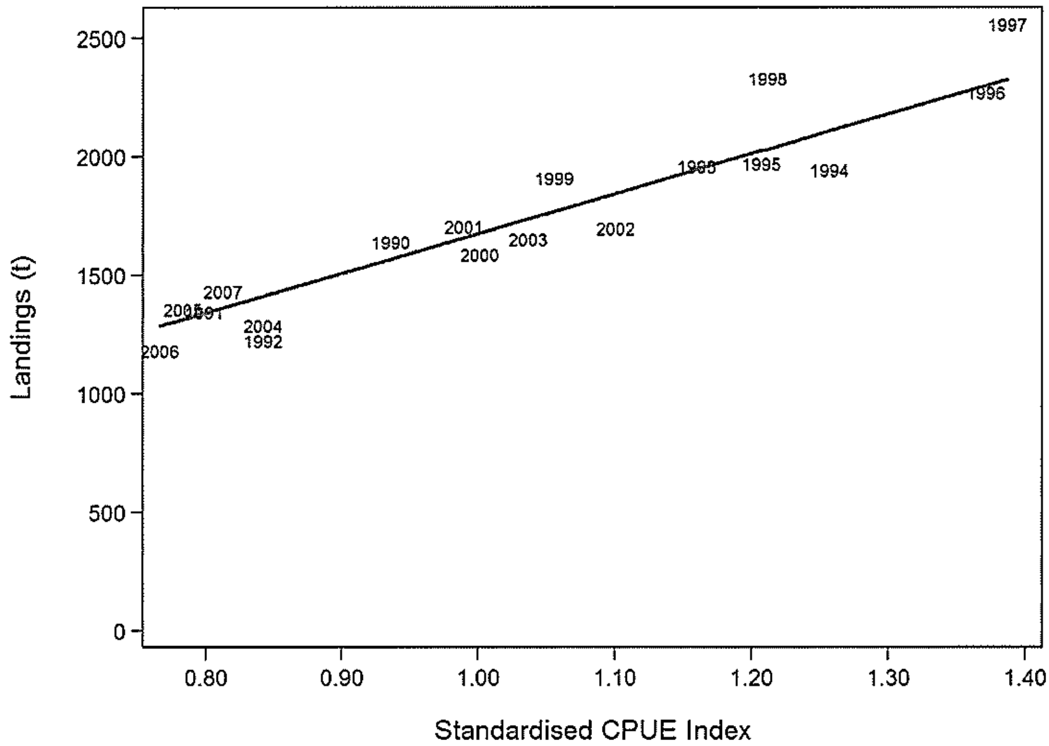

Figure 16: Relationship of the standardised CPUE indices from 1989–90 to 2006–07 with the realised catch levels in the same fishing year. Dark red line shows the fitted regression to these 18 year pairs (slope=1676 t; R^2=0.994)

Figure 15 shows that the underlying standardisation regression used to operate the 2016 FLA 3 MP is completely comparable to the equivalent analyses that were used to evaluate the MP in 2015. Although the design of the MP is unbalanced, this is an expected outcome of the approach, given the use of partial year data. The diagnostic plots provided in Figure 7 to Figure 12 show that the standardised model is compensating for at least some of the unbalanced distributional aspects of the data from the incomplete fishing year. The main issue associated with this analysis is the potential that the available data are incomplete and potentially unrepresentative of the actual 2015–16 data. This type of bias was not evaluated in 2015 because such shortfalls are not easily predicted or simulated. Only the operation of this MP over the next few years will give an indication of the potential for bias from this source. In the meantime, it is recommended that the data capture and data entry components of the MP be improved and expedited, as these are components that are presently under the control of government.

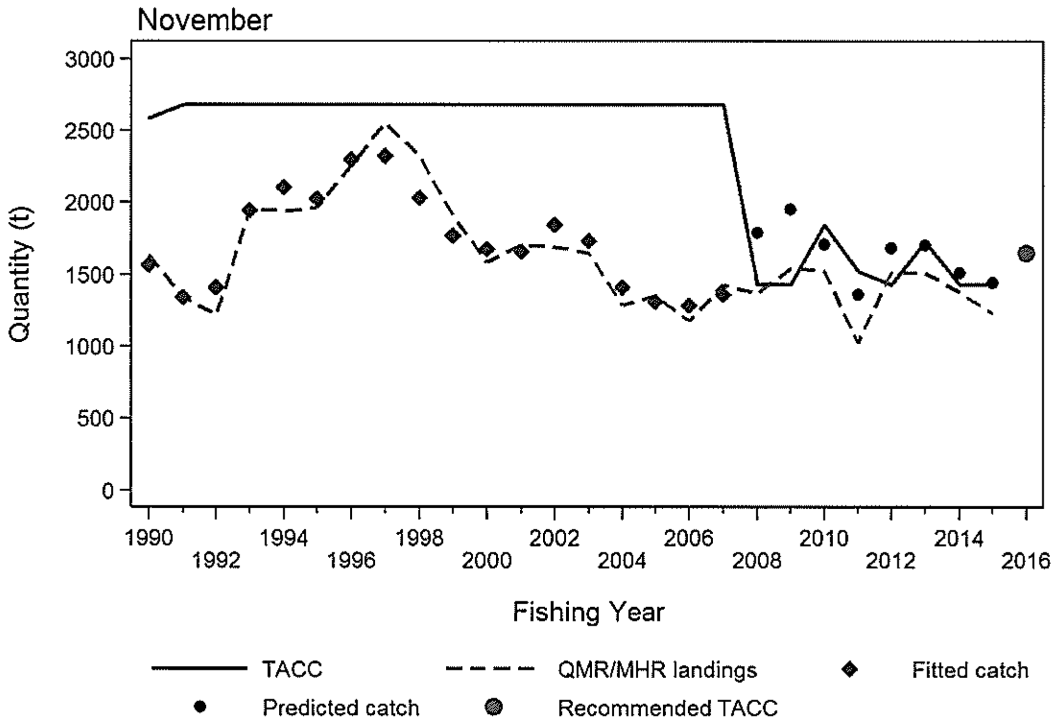

Figure 17: Operation of the FLA 3 MP. Green markers show the position of the fitted catches using the regression shown in Figure 16. Blue markers show the predicted catch resulting from the Figure 16 regression. The red circle shows the recommended TACC based on the Figure 16 regression. –

Table 4: CPUE estimates by fishing year generated by the model reported in Table 3 along with the predicted landings associated with the regression model shown in Figure 16. The realised landings and TACC are as reported in Table 1.

Fishing year	CPUE	Predicted Landings	Realised Landings	TACC	Fishing year	CPUE	Predicted Landings	Realised Landings	TACC
1990	0.936	1,568	1,637	2,585	2004	0.842	1,412	1,286	2,682
1991	0.799	1,340	1,341	2,681	2005	0.783	1,313	1,353	2,682
1992	0.842	1,412	1,219	2,681	2006	0.767	1,285	1,177	2,682
1993	1.160	1,945	1,953	2,682	2007	0.813	1,363	1,429	2,682
1994	1.257	2,107	1,941	2,682	2008	1.067	1,789	1,371	1,430
1995	1.207	2,024	1,966	2,682	2009	1.166	1,955	1,544	1,430
1996	1.371	2,299	2,265	2,682	2010	1.020	1,709	1,525	1,846
1997	1.387	2,325	2,552	2,682	2011	0.812	1,361	1,027	1,520
1998	1.211	2,030	2,328	2,682	2012	1.004	1,683	1,511	1,430
1999	1.056	1,769	1,907	2,682	2013	1.017	1,704	1,512	1,727
2000	1.001	1,678	1,583	2,682	2014	0.900	1,509	1,376	1,430
2001	0.989	1,658	1,703	2,682	2015	0.859	1,440	1,231	1,430
2002	1.100	1,844	1,693	2,682	2016	0.984	1,650	–	–
2003	1.036	1,737	1,650	2,682					

5. REFERENCES:

Langley, A.D. (2104) Updated CPUE analyses for selected South Island inshore finfish stocks. SINSWG-2014-05. 104 p. (Unpublished document held by Ministry for Primary Industries, Wellington N.Z.: http://cs.fish.govt.nz/forums/thread/9530.aspx)

Starr, P.J.; Kendrick, T.H.; Bentley, N.; Langley, A.D. (2015). Fishery characterisation and CPUE analysis of FLA 3. Plenary-2015-10. 159 p. (Unpublished document held by Ministry for Primary Industries, Wellington N.Z.: http://cs.fish.govt.nz/forums/thread/11092.aspx)