Updated 2017 Nightingale island rock lobster assessment

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Summary

This paper provides a further updated assessment of the rock lobster resource at Nightingale island. This assessment includes updated data from both the commercial fishery and the biomass surveys. The recent (2013-2016) high GLM standardised CPUE values (and biomass survey index values) at the island which were not initially anticipated, suggest that the negative impact of the OLIVA incident on adults may have been overestimated previously. The recent high CPUE indicates that the adult mortality in 2011 due to the OLIVA incident was much less than originally assumed. The 2017 RC assessment thus now assumes zero adult mortality in 2011 due to the OLIVA incident, but continues to assume an 80% juvenile mortality due to this incident in 2011. Projections suggest that the resource could readily sustain future catches kept constant at 75 MT or somewhat higher, though there may be a brief downturn in catch rates in the near future if the OLIVA incident led to a high mortality of juveniles at that time. An OMP is to be developed for this fishery to be used in setting the TAC for the next 2017/18 season.

Introduction

The age-structured population model used for this assessment is described fully in Johnston and Butterworth (2013). The last assessment of the Nightingale resource was presented in 2016 (Johnston and Butterworth 2016). This previous 2016 assessment took GLM standardised CPUE data into account only to 2014. Scenarios for additional mortality due to the OLIVA incident which occurred in March 2011 were developed and implemented in 2014 and 2015.

The updated 2017 assessment model is fit to the following data.

1) Standardised longline CPUE data for 1997-20**16**[1] (previous assessment only to 2014). (2011 and 2012 CPUE not included due to closure/test fishing).
2) Biomass survey Leg1 CPUE data (2006-20**16**, with 2008 data absent).
3) Catch-at-length data from the onboard observers (males and females separate) (1997-**2016, *with 2000 missing***).
4) Catch-at-length data from the Leg1 biomass survey (males and females separate) (2006-2016, with 2008 data absent).
5) Discard % (1997-**2016,** with 2011 missing).

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[1] The split season is referenced by the first year, i.e. 2010 refers to the 2010/2011 season.

Impact of the OLIVA on Nightingale

Reference case model assumptions

The impact that the OLIVA had on the resource at Nightingale has been modified since the 2014 and 2015 assessments and now assumes the following:

i) an 80% once off mortality of juvenile lobsters aged 1, 2 and 3 years during the 2011 season, and
ii) a 0% once off mortality on adults (ages 4+) during the 2011 season (whereas a value of 50% was used for the 2014 and 2015 RC models).

The 80% juvenile/50% adult mortality assumptions were previously considered the most reasonable[2], but recent CPUE data indicate that it is very unlikely that there was much if any impact on the adults following the OLIVA event.

The commercial fishery at Nightingale was closed for the 2011 season. A precautionary TAC of 40 MT was set for 2012, of 65 MT for 2013, and of 70 initially but increasing in midseason to 75 MT for the 2014-2016 seasons due to good catch rates and in accordance with the pre-specified management recommendations.

The selectivity functions

The model estimation procedure allows for the commercial selectivity functions to vary over time. Random variation in the μ parameter values are modelled as follows:

$$S_{y,l}^{m,comm} = \frac{e^{-(\mu^m + \varepsilon_y^m)l}}{1 + e^{-\delta^m (l - l_*^m)}} \tag{1}$$

$$S_{y,l}^{f,comm} = P \frac{e^{-(\mu^f + \varepsilon_y^f)l}}{1 + e^{-\delta^f (l - l_*^f)}} \tag{2}$$

where

$$\varepsilon_y^m \sim N(\, 0, \left(\sigma_\mu^2\right) \ ) \tag{3}$$

$$\varepsilon_y^f \sim N(\, 0, \left(\sigma_\mu^2\right) \ ) \tag{4}$$

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[2] Cape Town Workshop held 16-18 November 2011.

Consequently a penalty term is added to the likelihood:

$$-lnL \rightarrow -lnL + \frac{1}{2\sigma_{\mu}^{2}} \sum_{1997}^{2016} [(\varepsilon_{y}^{m})^{2} + (\varepsilon_{y}^{f})^{2}] \quad (5)$$

The female scaling parameter "P" also varies over time to improve fits of the model to the commercial CAL data. Thus equation (2) is further modified to:

$$S_{y,l}^{f,comm} = (P + \varepsilon_{y}^{P}) \frac{e^{-(\mu_{y}^{f} + \varepsilon_{y}^{f})l}}{1 + e^{-\delta^{f}(l - l_{*}^{f})}} \quad (6)$$

where

$$\varepsilon_{y}^{P} \sim N(\, 0, (\sigma_{P}^{2}) \quad) \quad (7)$$

Consequently, a further penalty term is added to the likelihood:

$$-lnL = -lnL + \frac{1}{2\sigma_{p}^{2}} \sum_{1997}^{2016} \, (\varepsilon_{y}^{P})^{2} \quad (8)$$

and σ_{P} is fixed at 0.2.

New additions to the assessment model to improve model fits to CAL data

In past assessments, there has been a fairly consistent overestimation of lobsters in the largest size classes. In order to rectify this problem, the normal distribution associated with the length-at-age of lobsters was modified to be truncated at the upper level by 1.5 SD and the lower level by 3.0 SD (as previously). This prevents the model from estimated unrealistically large lobsters and secures an improved fit to these data.

It was also evident that the model produced a poor average fit to the female CAL data from the biomass surveys. To improve this fit, a further component to the –lnL function was added:

$$-lnL \rightarrow -lnL + w \sum_{l=65}^{l=85} \left[CAL_{ave,l}^{obs} - CAL_{ave,l}^{mod}\right]^{2} \quad (9)$$

Improved fits were found when the weight *w* was set at 1000.

Sensitivity tests

The following sensitivity tests are run which assume a lesser impact of mortality in 2011 on the **juvenile** lobsters due to the OLIVA incident:

SEN1: a 20% (instead of 80%) once off mortality on juveniles (ages 1-3) during the 2011 season (retaining the assumption of 0% adult mortality), and

SEN2: a 0% (instead of 80%) once off mortality on juveniles (ages 1-3) during the 2011 season (retaining the assumption of 0% adult mortality)

Projections

The resource is projected forwards to 2033 under a constant catch of either 75 MT or 80 MT. The future (2015+) recruitment is modelled as follows.

> The model estimates residuals for 1992-2014. For 2015+ recruitment is set equal to its expected value given the fitted stock-recruit relationship. The relationship itself is $R_y = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}} e^{\varepsilon_y - \sigma_R^2/2}$ where $\varepsilon_y \sim N(0, \sigma_R^2)$ and $\sigma_R = 0.4$. This means that the expected recruitment $E[R_y] = \frac{\alpha B_y^{sp}}{\beta + B_y^{sp}}$.

Deterministic projections are carried out for the RC model, as well as for the two sensitivity tests.

Results and Discussion

The recent (2013-2016) high GLM standardized CPUE and biomass survey indices reported at Nightingale (Johnston *et al.* 2017 and Johnston 2017) were not initially anticipated at the time of the OLIVA incident – and in both cases are the four highest recorded values in the time series. This suggests that the impact of the OLIVA incident on the resource was initially overestimated. For this reason, the RC assumptions to take into account the possible effects of the OLIVA on adult mortality have remain modified from the initial 50% (once off 2011 adult mortality) to a value of zero. The OLIVA impact on juveniles for the RC remains at 80% (again a once off mortality in 2011 due to the OLIVA incident) in order to be cautious as a possible delayed impact of such enhanced juvenile mortality could be yet to be observed – although given the very high 2016 CPUE value (the highest on record) this possibility is becoming increasingly unlikely with time. The reality of a lesser OLIVA related juvenile mortality than 80% thus is clearly becoming increasingly likely.

Table 1 compares the 2017 updated RC Nightingale assessment with results of the two sensitivity tests (which assume lesser OLIVA related juvenile mortality in 2011). The 2016 RC results are also reported in the second column for comparison. Figure 1 contains plots of the 2017 RC assessment fits to both the longline CPUE and biomass survey Leg1 CPUE data, as well as further model estimated trends. Some comparisons to the 2016 RC estimated values are provided in these plots. Note that the recent high catch rates, and hence abundances, are ascribed to particularly strong recruitment in 2005 and 2006.

The plot of the RC selectivity μ residuals in Figure 2a relate to how fast the right hand limb of the selectivity function decreases. Figure 2b plots the female multiplicative scalar residuals which indicate how the relative selectivity for females has changed over time, e.g. for the period 2002-2004 there was a reduced female selectivity (compared to the norm). Figure 2c shows the actual estimated selectivity functions for males and females for both the commercial and the biomass surveys.

Figures 3 and 4 respectively show fits to the commercial and to the biomass survey CAL data averaged over all years, as well as the residual plots and annual fits to the 2013-2016 observed values.

The three 2017 models reported estimate the current (2017) spawning biomass as a fraction of the unexploited equilibrium level to be between 0.62 (RC) and 0.87 (SEN2).

Figure 1 indicates that the RC model fits the longline CPUE data reasonably well, but remains unable to fully replicate the very high CPUE values observed recently. Fits to the discard proportion data are reasonably good, except for the first six year period.

The RC fits to the commercial longline catch-at-length (CAL) data are good (Figure 3) when averaged over the full time period for which data are available. The changes made to the growth model distributions of length-at-age have improved these fits. Figure 3c shows some poor fits to some of the female smaller size classes in recent years. This could be the result of a lack of observations at smaller lengths in these years. This should be carefully monitored in the future as this may relate to an impact on juvenile survival from the OLIVA incident. Future work will explore improving this lack of fit. Figure 4 reports the RC model fit to the biomass survey CAL data. Again, the fits are reasonably good. The addition of an extra weight in the likelihood to improve the overall fits to the female biomass survey data has been successful. Figure 4c for the survey CAL data by year also shows some poor fits to recent data. The current model does not allow for time varying selectivity for the biomass survey selectivity functions. Future work will explore improving fits to the biomass survey CAL data by allowing for time variability in some of the selectivity function parameters (as for the commercial selectivity functions).

Figure 5a compares the estimated exploitable biomass trends, in units of CPUE, for the RC, SEN1 and SEN2. Figure 5b males similar comparisons but for the biomass survey CPUE.

It is also interesting to note the better model fits to the overall data are achieved for the SEN1 (20% juvenile mortality in 2011) and SEN2 (0% juvenile mortality in 2011) model (compared with the RC and SEN2), as evidenced in the various –lnL values reported in Table 1. The effects of any substantial effect on the juveniles could still however become evident in the future due to the lag effect arising for the juveniles affected by the OLIVA incident needing time to grow to the legally catchable sized component of the population. These two sensitivity tests do fit the recent CPUE data better, but not to the extent that the high 2016 values are "explained" or there is no recent decline in resource biomass. This is because that decline is primarily a consequence of the model assumptions reflecting more normal recruitment over recent years compared to the high recruitment in 2005-2006 that explains the high CPUE since the OLIVA incident. Future data may show, together with the 2016 CPUE values, that recruitment has in fact stayed higher for a longer period, hence contributing to the higher CPUE for 2016.

Projections

Projections under two alternate future constant catch levels (75 MT and 80 MT) have been run. Table 2 reports the *Bsp/K* value in 2015 and 2033 for the two CC scenarios for the RC and two sensitivity models. Figure 6a reports the resultant CR (catch rate) and *Bsp/K* trajectories for the RC where results are compared between the CC=75 MT and CC=80 MT scenarios. The future catch rates differ only very slightly between a future CC of 75 MT or 80 MT. The CR is predicted to decline to low levels (< 4 kg/trap/day) from around 2016. This is due to the assumption of an oil induced mortality on the juveniles in 2011 as a result of the OLIVA impact feeding through the population into the "legal sized" portion of the stock. The values of *Bsp/K* in 2025 and 2033 remain high at over 0.90 for both catch scenarios. Results are similar for both the sensitivity tests (Figures 6b and c).

Management Advice

Results in this paper would certainly support a future CC of 75-80 MT. The intention is however to develop an OMP for this fishery for use in setting the TAC for the 2017/18 season. This OMP will be target based (as for the OMPs developed for the other three islands).

References

Johnston, S.J. and Butterworth, D.S. 2013. The age structured population modeling approach for the assessment of the rock lobster resources at the Tristan da Cunha group of islands. MARAM/Tristan/2013/Mar/07. 15pp.

Johnston, S.J. and Butterworth, D.S. 2016. Updated 2016 Nightingale island rock lobster assessment. MARAM/Tristan/2016/JUN/10.

Johnston, S.J., Brandao, A. and Butterworth, D.S. 2017. Updated 2017 GLMM-standardised lobster CPUE from the Tristan da Cunha outer group of islands. MARAM/Tristan/2017/MAY/06.

Johnston, S.J. 2017. Tristan group biomass survey (Leg1) results including data from the 2016 season. MARAM/Tristan/2017/FEB/03.

Table 1: Updated Nightingale 2017 assessment results. The 2016 RC assessment results are reported in the shaded second column to allow for comparisons. The values in *italics* are fixed on input. Values in parentheses are estimated σ values. (Note that the –lnL values are not comparable between the 2016 and 2017 assessments.) Results for 2017 are reported for the RC, and the SEN1 and SEN2 sensitivity tests.

	2017 assessment RC (2011 adult mortality due to OLIVA = 0% and juvenile mortality=80%)	**2016 assessment RC (2011 adult mortality due to OLIVA = 0% and juvenile mortality=80%)**	**2017 assessment SEN1 (2011 adult mortality due to OLIVA = 0% and juvenile mortality=20%)**	**2017 assessment SEN2 (2011 adult mortality due to OLIVA = 0% and juvenile mortality=0%)**
# parameters estimated	101	97	101	101
σ_R	*0.4*	*0.4*	*0.4*	*0.4*
K	607	489	543	529
h	0.73	0.79	0.79	0.82
F_{2009} fixed at	*0.3*	*0.3*	*0.3*	*0.3*
θ	0.239	0.282	0.271	0.280
-lnL total	-2.31	-14.11	-14.44	-4.33
-lnL CPUE T	-18.26	-20.23	-19.97	-20.28
-lnL CPUE longline	-12.79 (0.261)	-15.78 (0.134)	-14.00 (0.226)	-14.28 (0.218)
-lnL CPUE Survey Leg1	-5.48 (0.462)	-4.46 (0.491)	-5.96 (0.450)	-6.00 (0.448)
-lnL CAL T	-77.46	-34.97	-86.09	-85.02
-lnL CAL onboard observer	-63.91 (0.070)	-32.02 (0.075)	-69.37 (0.069)	-68.71 (0.069)
-lnL CAL Survey Leg 1	-13.55 (0.095)	-2.95 (0.098)	-16.27 (0.093)	-16.31 (0.093)
SR1 pen	8.15	3.87	7.76	7.91
-lnL discard	3.66	3.56	3.92	3.96
Bsp(1990)/Ksp	0.22	0.26	0.23	0.26
Bsp(2013)/Ksp	1.06	0.92	1.06	1.26
Bsp(2014)/Ksp	0.92	0.80	1.02	1.22
Bsp(2015)/Ksp	0.82	0.72	0.98	1.15
Bsp(2016)/Ksp	0.69	0.65	0.92	0.96
Bsp(2017)/Ksp	**0.62**	-	**0.85**	**0.87**
Bsp(2013)/Bsp(1990)	4.55	3.53	4.51	4.53
Bsp(2014)/Bsp(1990)	3.97	3.03	4.36	4.47
Bsp(2015)/Bsp(1990)	3.65	2.73	4.18	4.32
Bsp(2016)/Bsp(1990)	3.47	2.45	3.91	4.03
Bsp(2017)/Bsp(1990)	2.29		3.63	3.72
Bexp(2012)/Bexp(1990)	5.32	3.59	5.03	5.01
Bexp(2013)/Bexp(1990)	5.65	3.99	5.73	5.76
Bexp(2014)/Bexp(1990)	5.53	3.70	5.48	5.50
Bexp(2015)/Bexp(1990)	4.48	2.74	4.64	4.71
Bexp(2016)/Bexp(1990)	2.78	-	3.34	3.50
Programs	NRC.tpl	Night16a.tpl	Nsen1.rep	Nsen2.tpl

Table 2: Model estimated Bsp/K values in 2025 and 2033 under levels of future constant catch of CC = 75 MT and 80 MT. Values are reported for the RC and two sensitivity tests.

	Juvenile mortality in 2011 due to OLIVA	**Adult mortality in 2011 due to OLIVA**	**Bsp(2025)/K**		**Bsp(2033)/K**	
	Juvenile mortality in 2011 due to OLIVA	**Adult mortality in 2011 due to OLIVA**	**CC = 75 MT**	**CC = 80 MT**	**CC = 75 MT**	**CC = 80 MT**
RC	80%	0%	0.92	0.91	0.96	0.95
SEN1	20%	0%	0.94	0.94	0.95	0.95
SEN2	0%	0%	0.95	0.95	0.94	0.95

Figure 1: Nightingale 2017 **RC** assessment results. The exploitable biomass trends from the 2016 RC assessment are also plotted for comparative purposes.

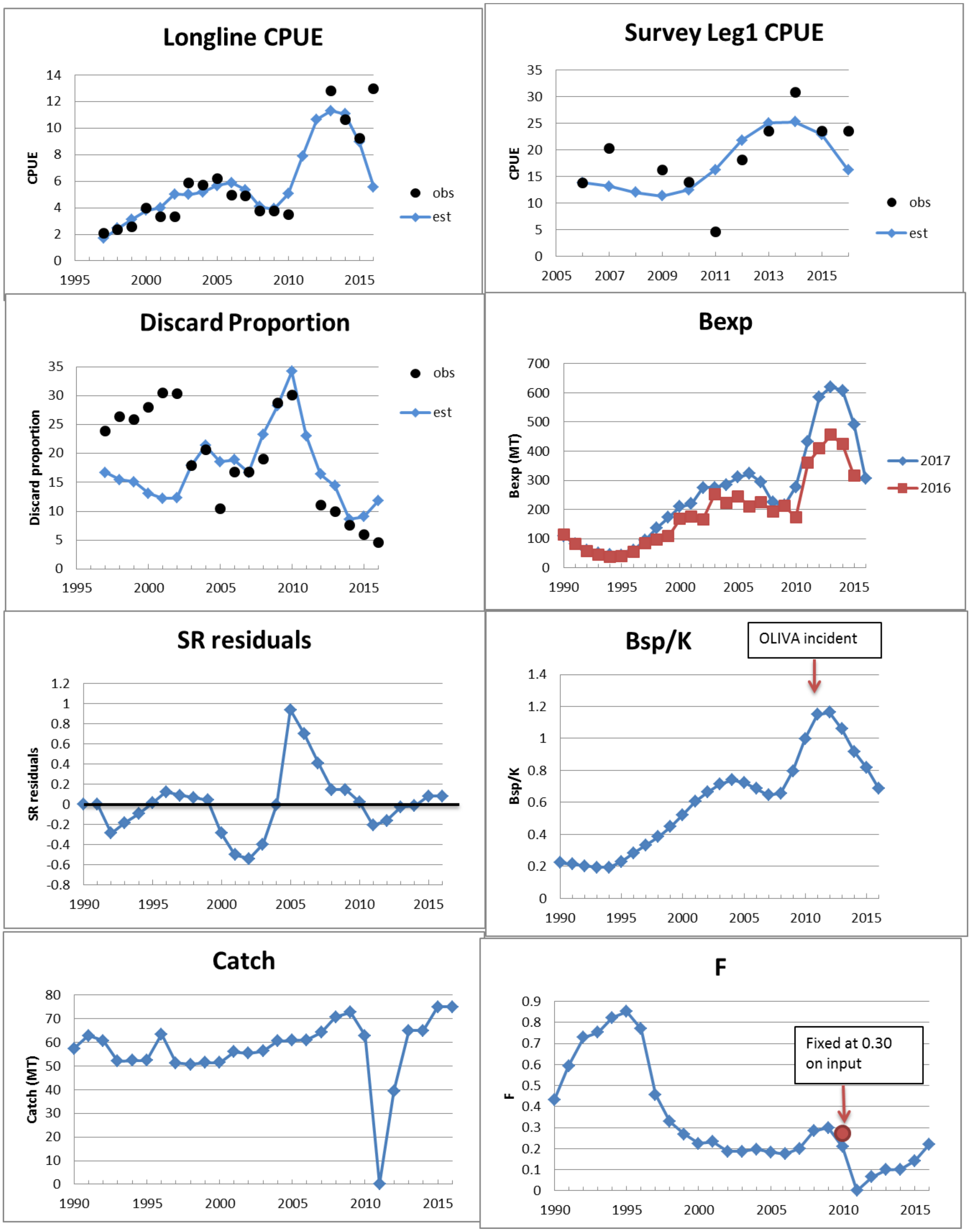

Figure 2a: Nightingale **RC** estimated μ residuals (used to allow commercial selectivity function variation from year to year).

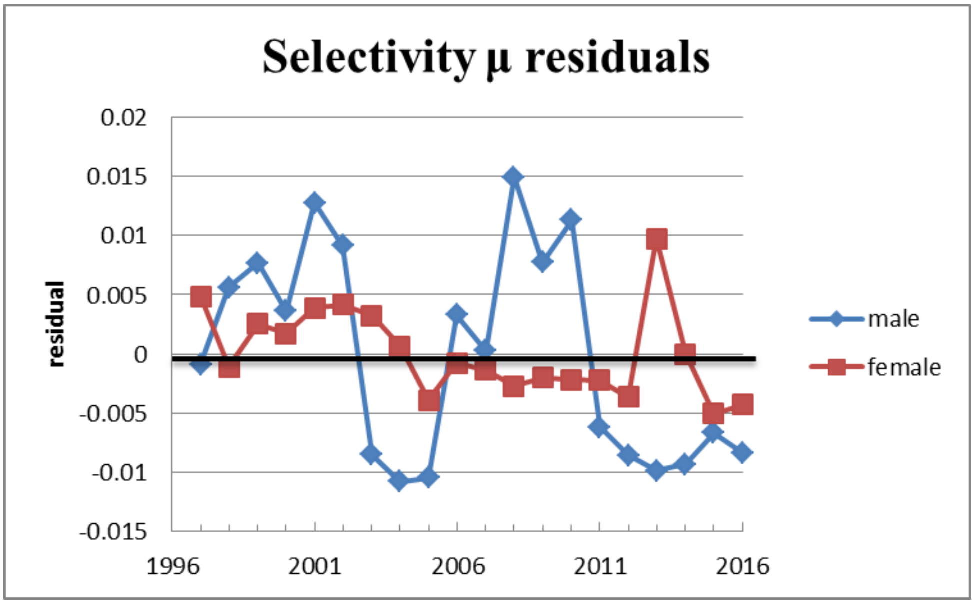

Figure 2b: Nightingale **RC** estimated female selectivity scalar residuals (used for commercial selectivity function variation from year to year).

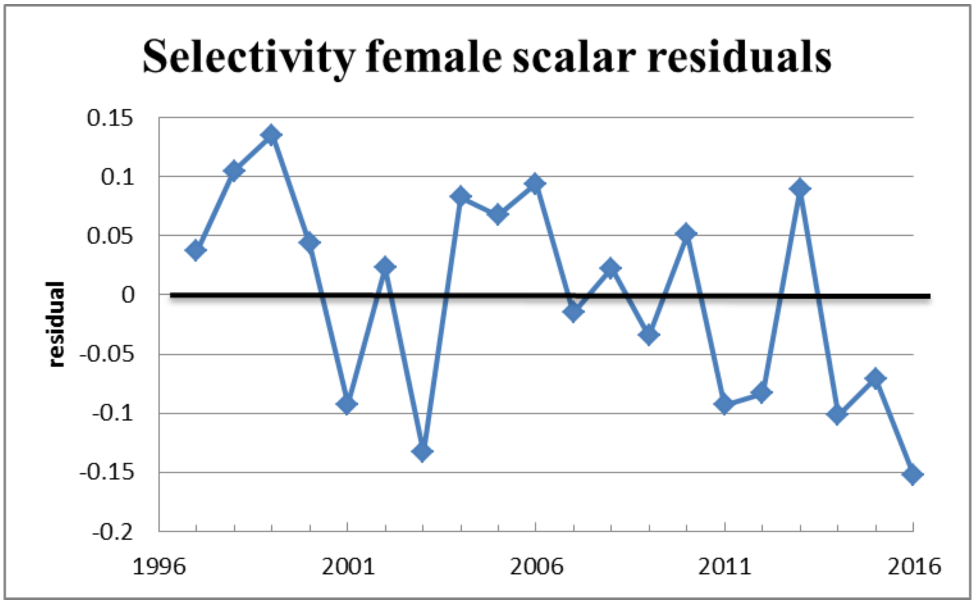

Figure 2c: Male (left) and female (right) estimated selectivity functions for both the commercial and the biomass survey.

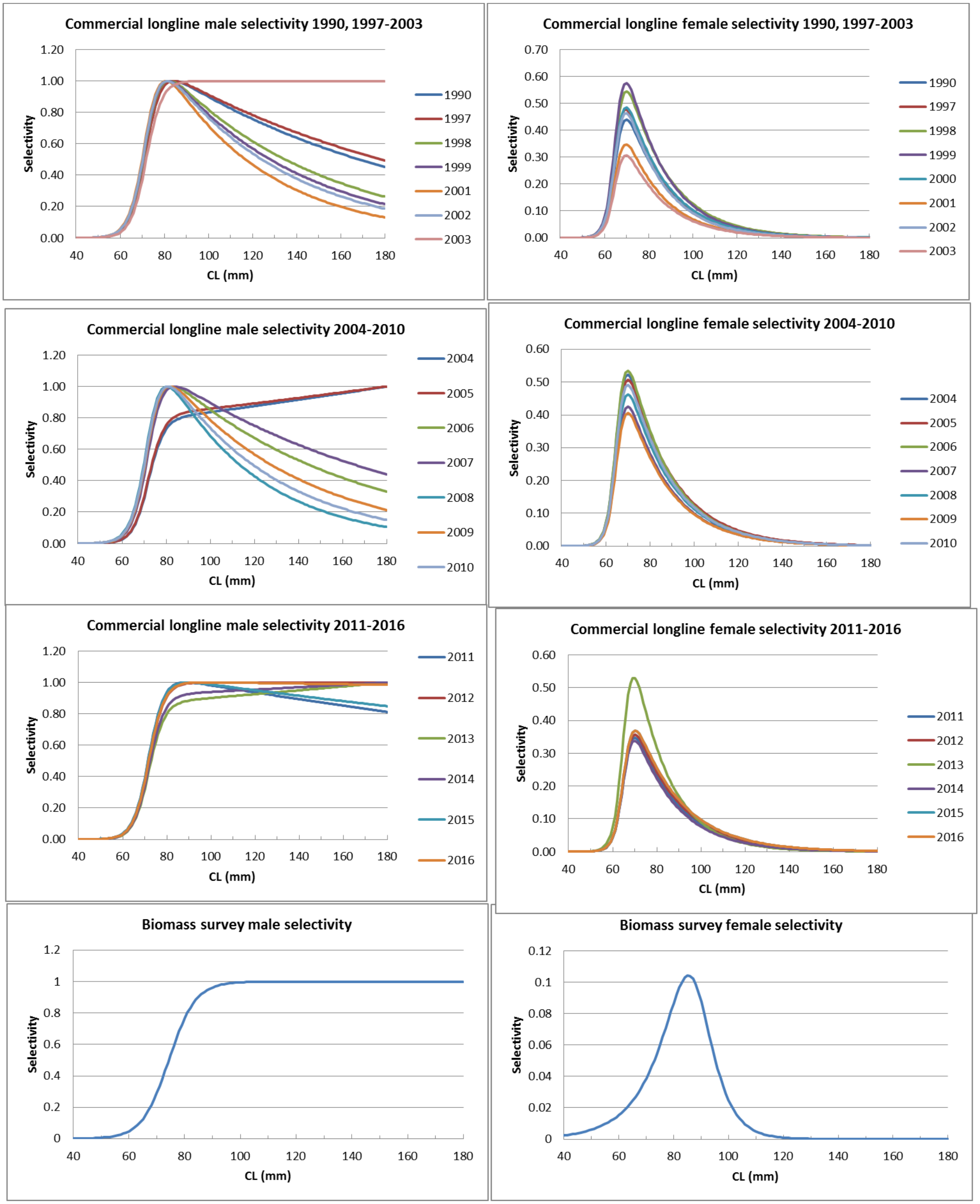

Figure 3a: Nightingale commercial longline **RC** CAL fits averaged over years.

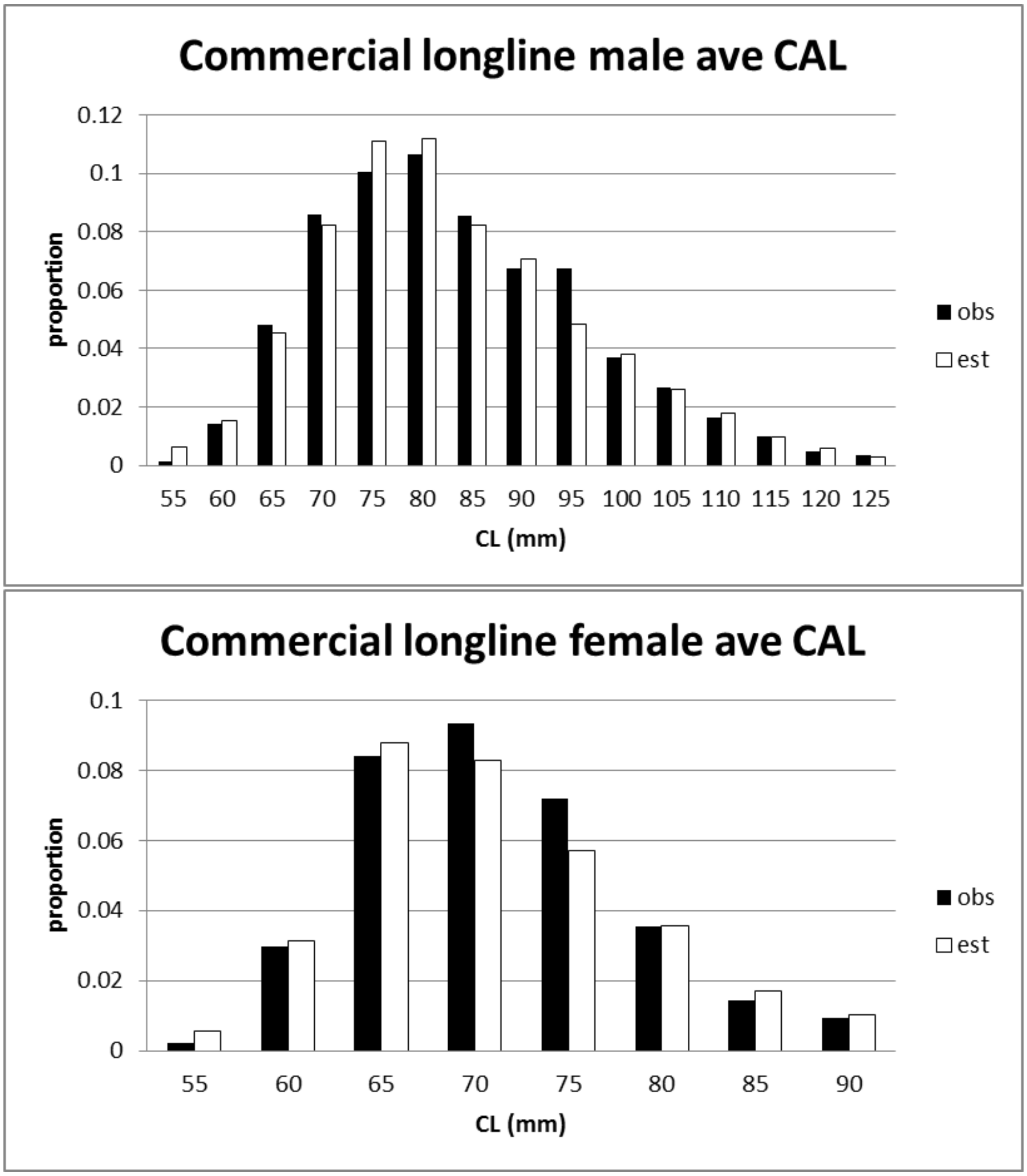

Figure 3b: Nightingale standardized commercial longline CAL residuals for the **RC** model The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

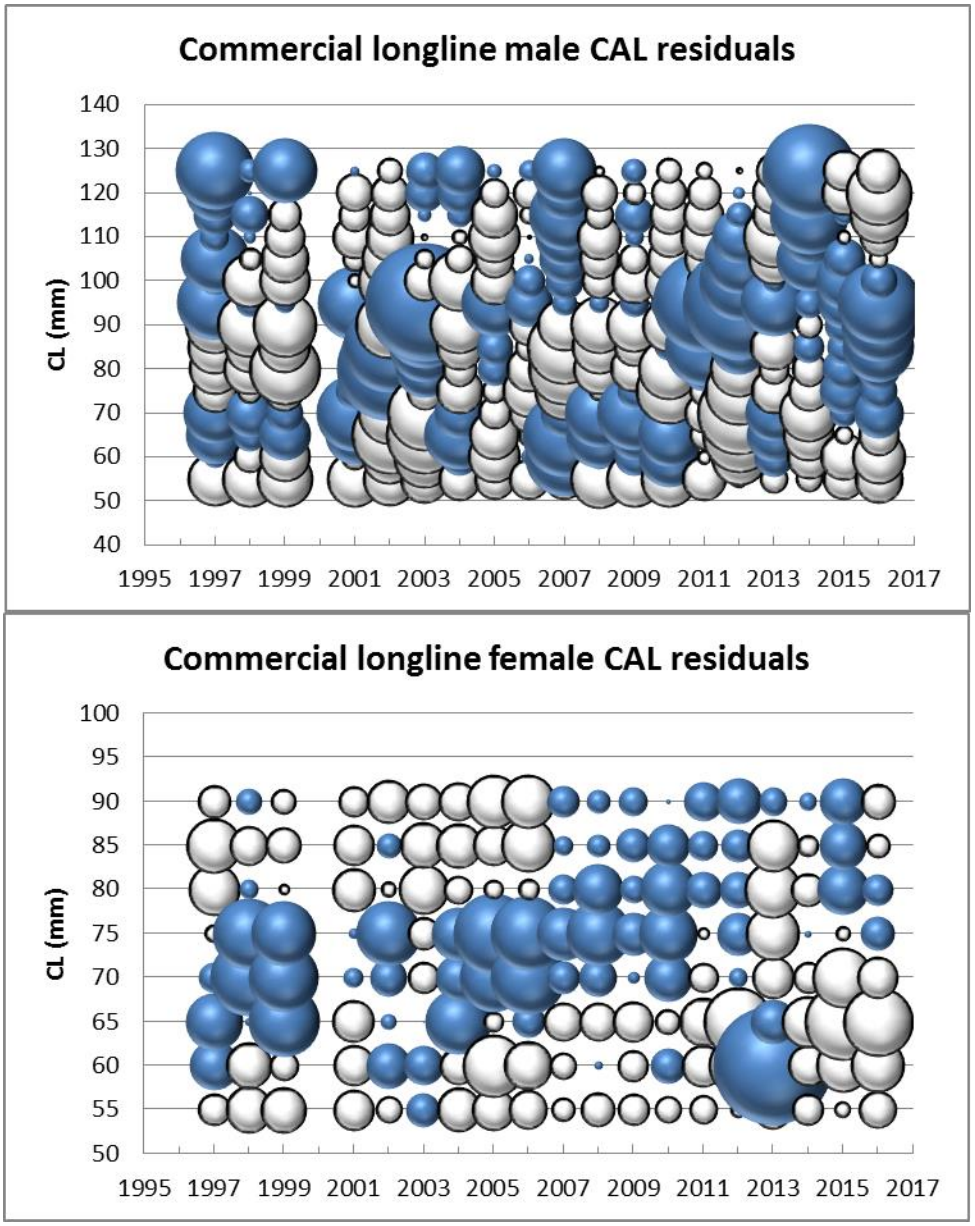

Figure 3c: Nightingale commercial longline **RC** CAL fits for each of the years from 2013 to 2016.

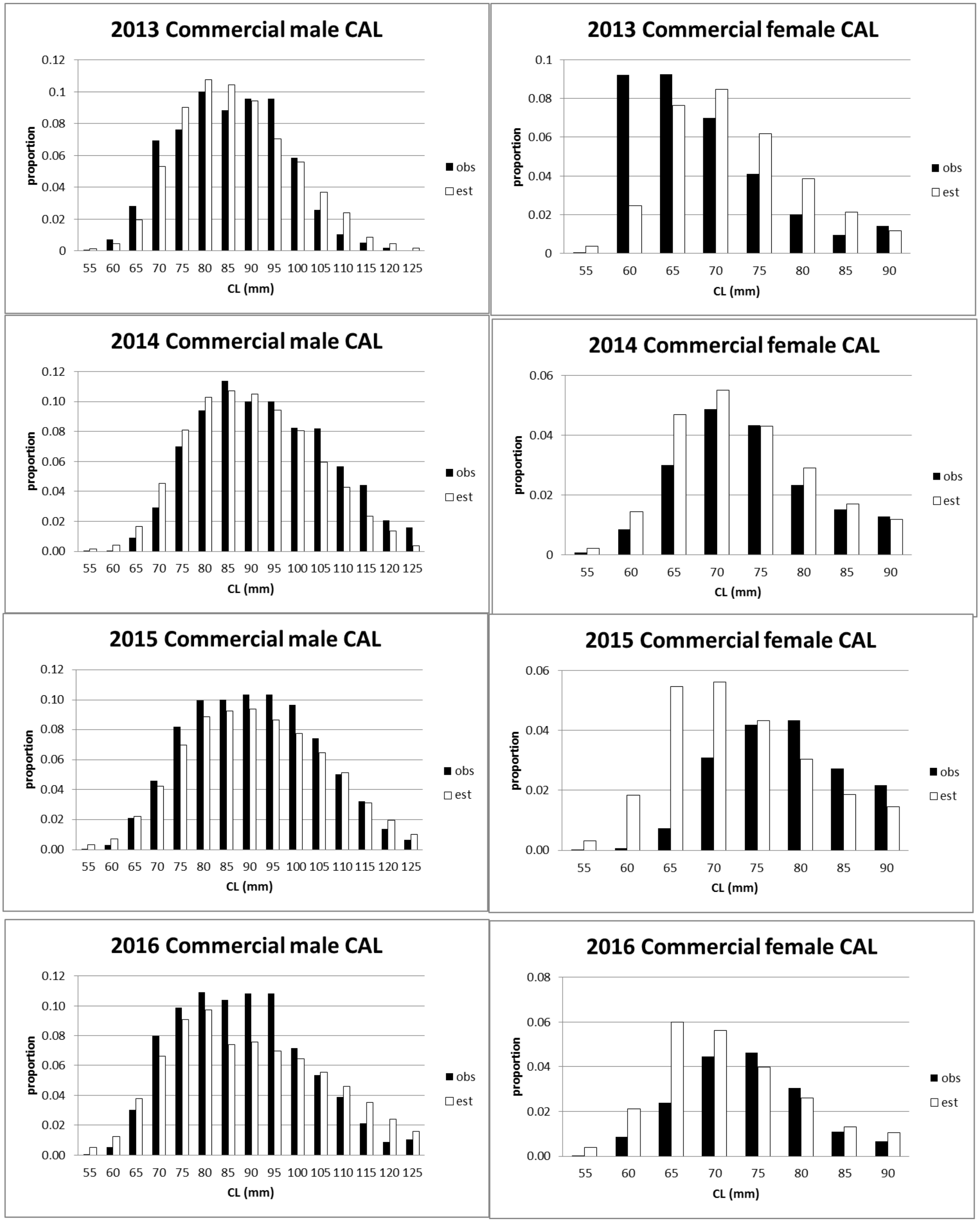

Figure 4a: Nightingale biomass survey Leg1 **RC** CAL fits averaged over years.

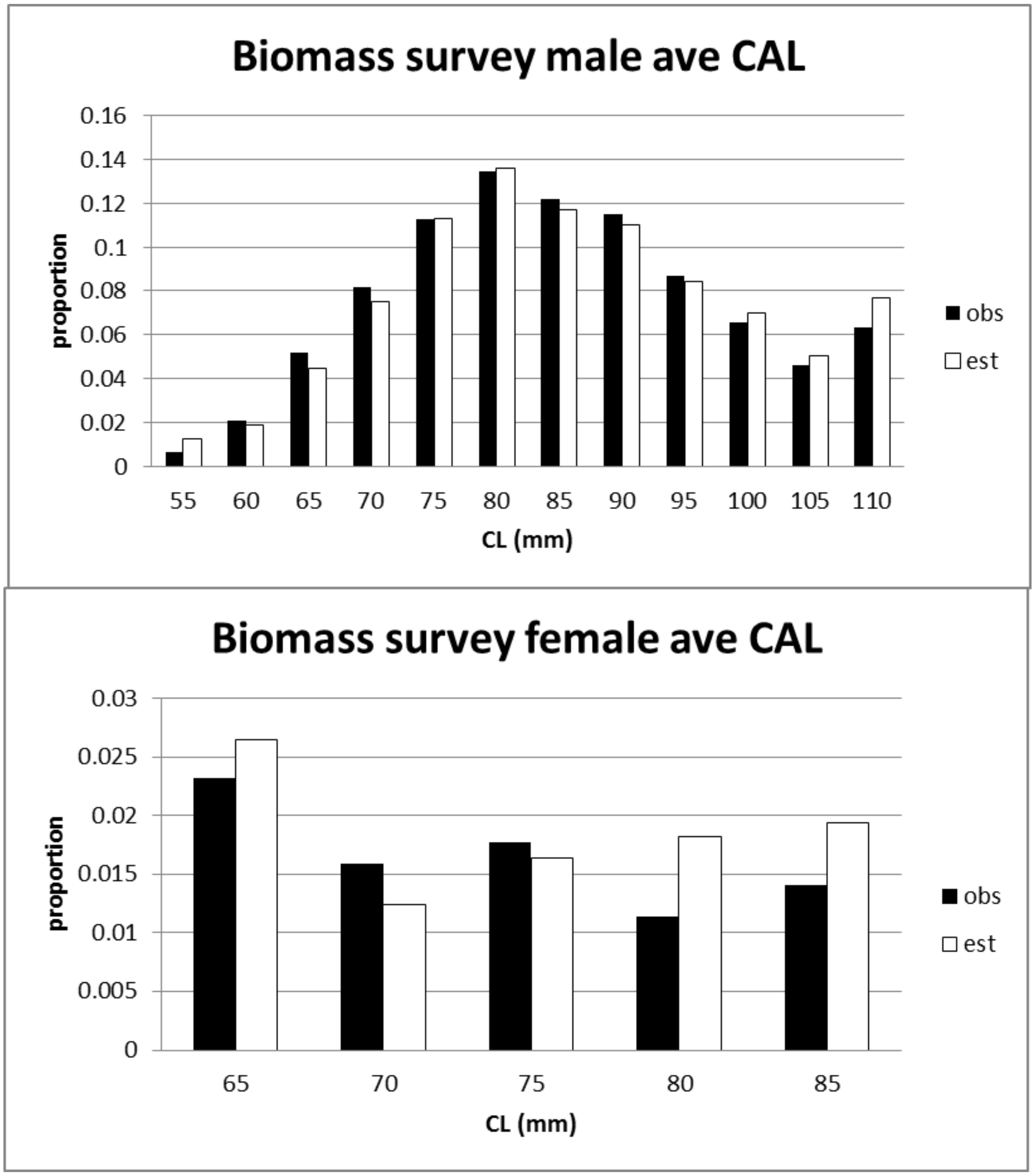

Figure 4b: Nightingale standardized biomass survey Leg 1 CAL residuals for the **RC** model. The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

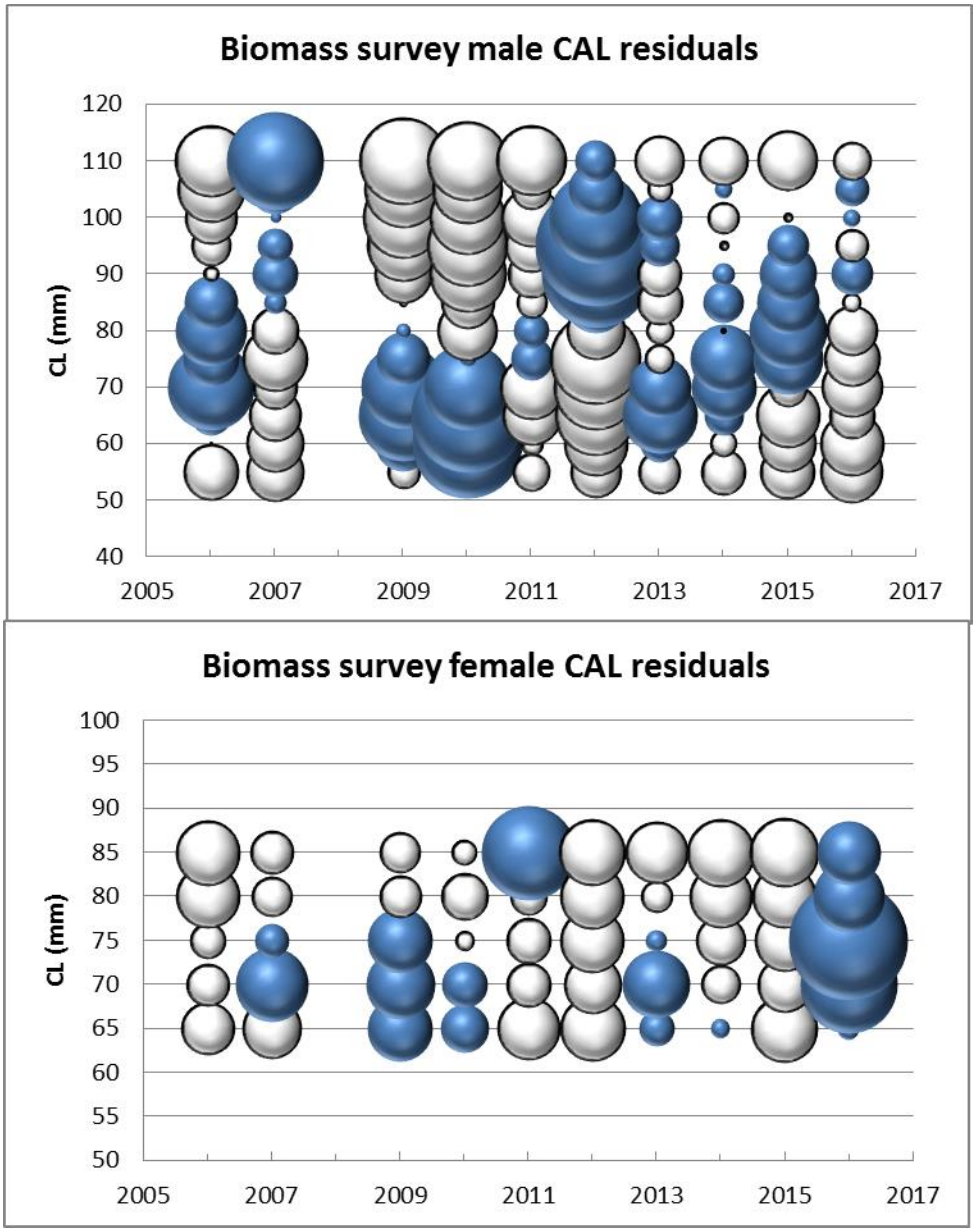

Figure 4c: Nightingale biomass survey Leg1 **RC** CAL fits for each of the years from 2013 to 2016.

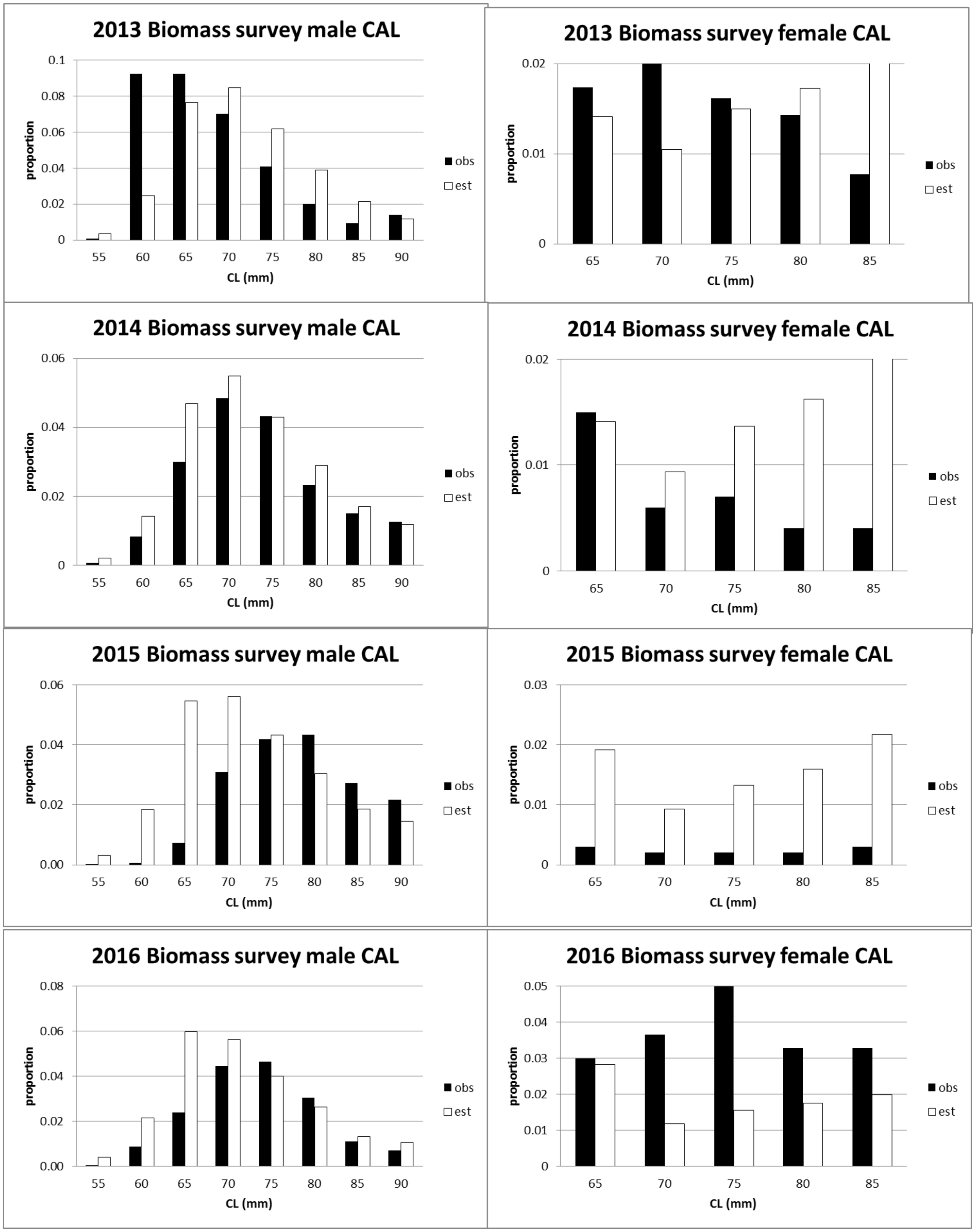

Figure 5a: Comparative plots of the estimated longline catch rates (CPUE) for the **RC** (80% juvenile and 0% adult mortality in 2011 due to OLIVA), **SEN1** (**20%** juvenile and 0% adult mortality in 2011 due to OLIVA), and **SEN2** (**0%** juvenile and 0% adult mortality in 2011 due to OLIVA). The GLM longline CPUE values derived from data are shown as black circles.

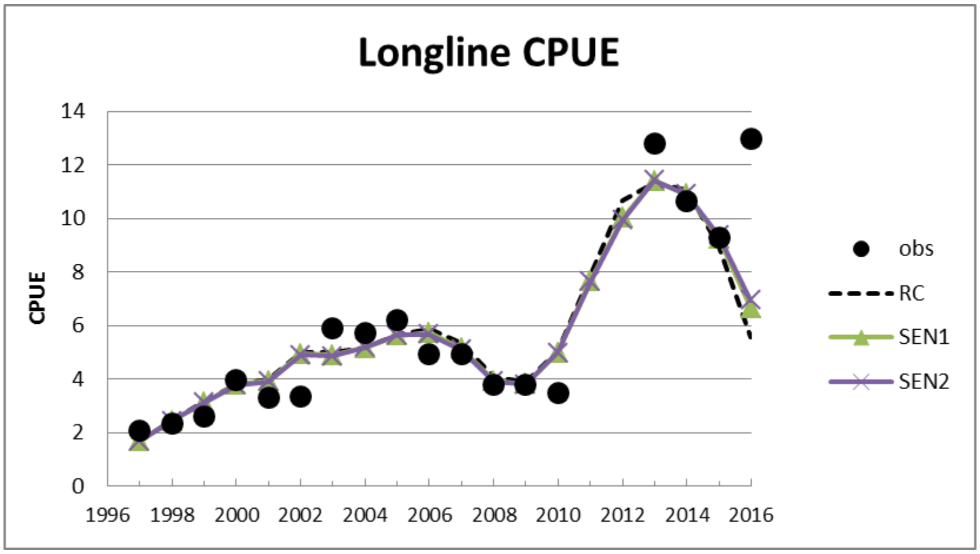

Figure 5b: Comparative plots of the estimated biomass survey indices for the **RC** (80% juvenile and 0% adult mortality in 2011 due to OLIVA), **SEN1** (**20%** juvenile and **0%** adult mortality in 2011 due to OLIVA), and **SEN2** (**0%** juvenile and **50%** adult mortality in 2011 due to OLIVA). The biomass survey indices derived from data are shown as black circles.

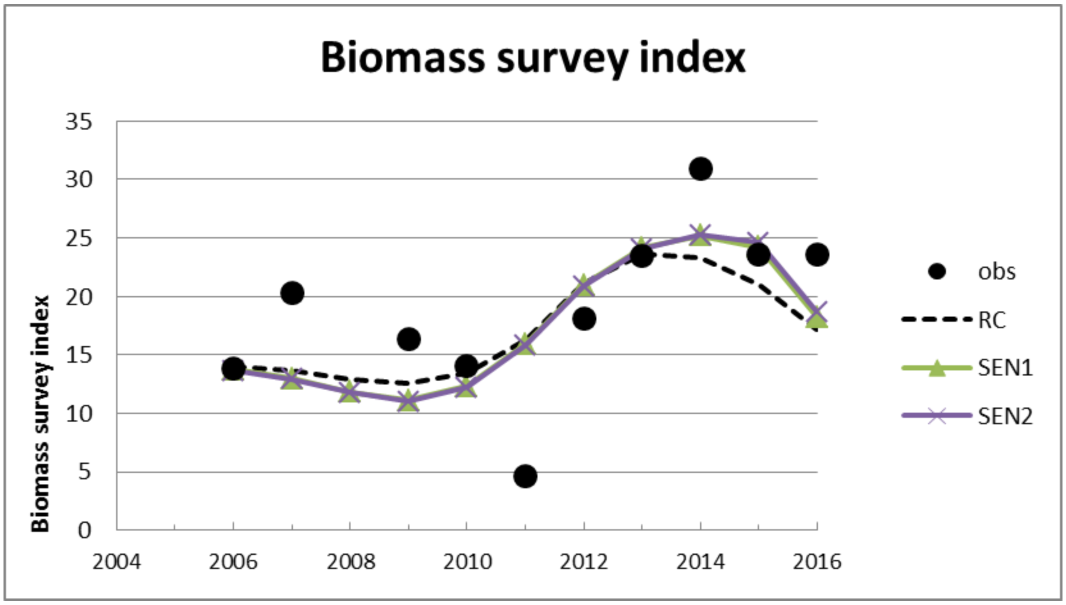

Figure 6a: **RC** projections of the resource into the future for levels of constant catch CC= 75 MT and CC=80 MT. The top plot shows the catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K* trajectory.

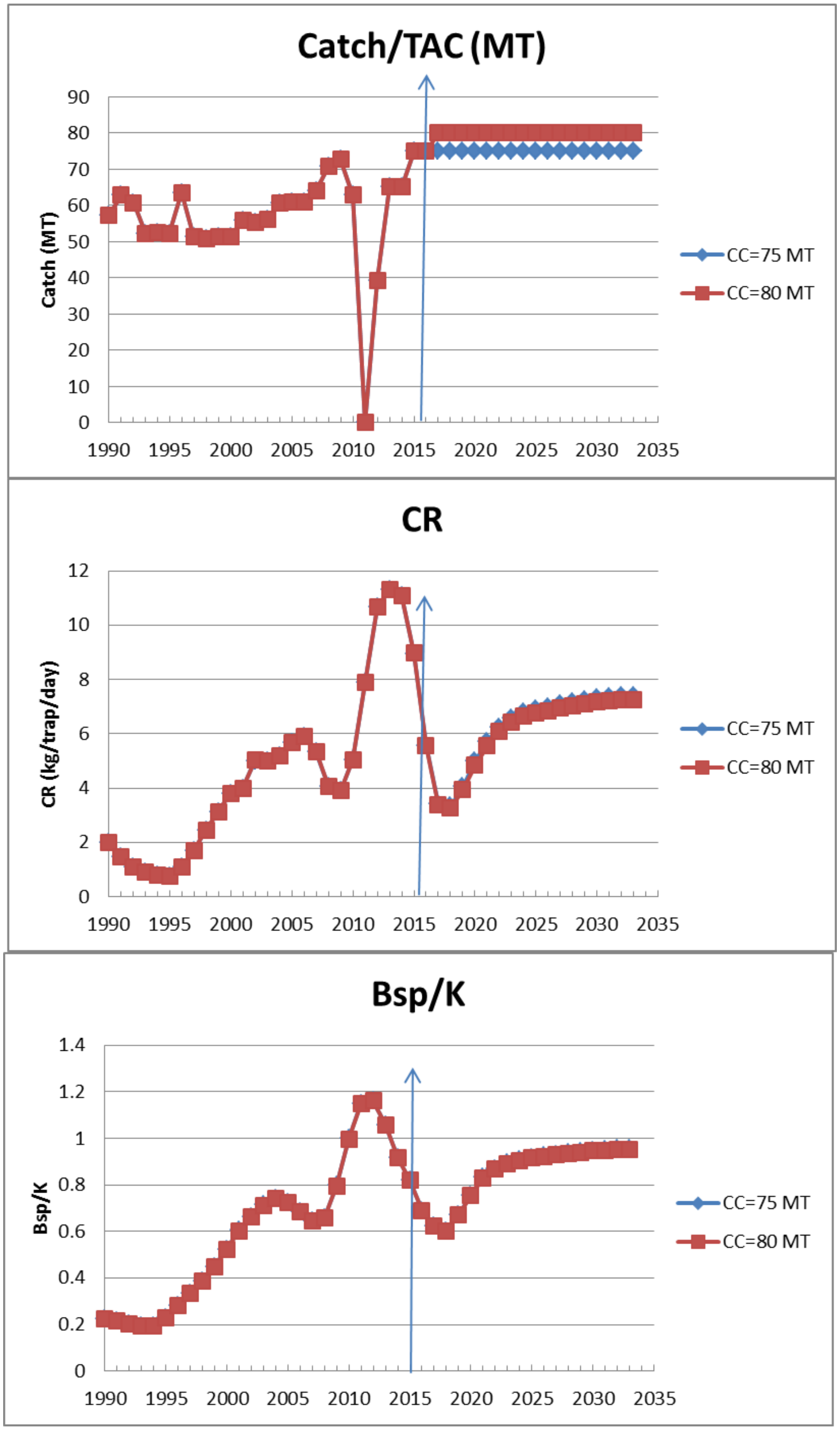

Figure 6b: **SEN1** projections of the resource into the future for levels of constant catch CC= 75 MT and CC=80 MT. The top plot shows the catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K* trajectory.

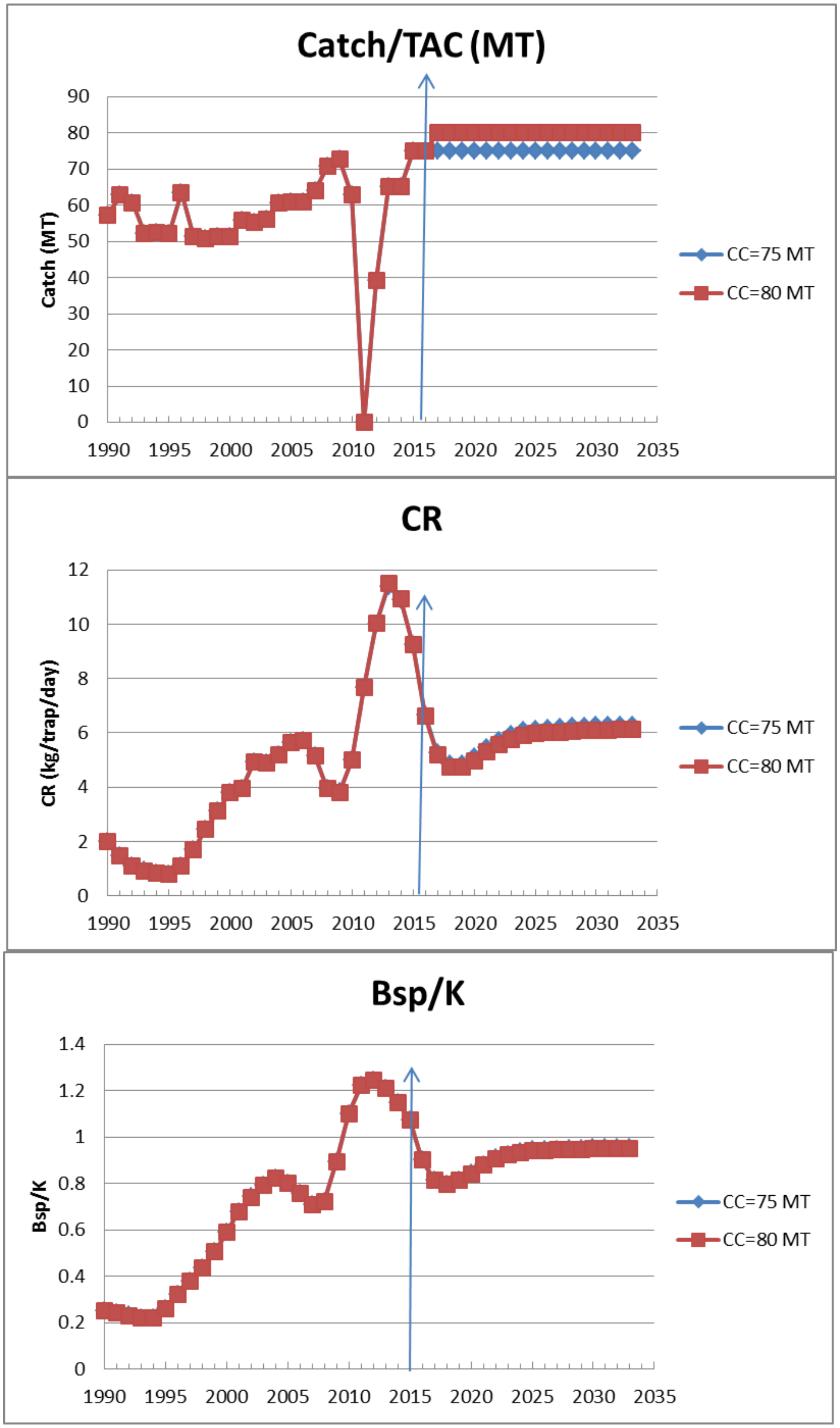

Figure 6c: **SEN2** projections of the resource into the future for levels of constant catch CC= 75 MT and CC=80 MT. The top plot shows the catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K* trajectory.