Updated 2016 Nightingale island rock lobster assessment

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Summary

This paper provides an 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 (2013-2015) high GLM standardised CPUE values (and biomass survey index values) at the island were not initially anticipated, and suggest that the impact of the OLIVA on adults may have been overestimated. The recent high CPUE indicates that the adult mortality in 2011 due to the OLIVA incident was much less than originally assumed. The 2016 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 constant catches at 75 MT, though there may be a brief downturn in catch rates shortly if the OLIVA incident led to a high mortality of juveniles at that time.

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 2015 (Johnston and Butterworth 2015). This 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.

This 2016 assessment model is fit to the following data.

1) Standardised longline CPUE data for 1997-20**15**[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**15**, with 2008 data absent).
3) Catch-at-length data from the onboard observers (males and females separate) (1997-**2015, *with 2000 missing***).
4) Catch-at-length data from the Leg1 biomass survey (males and females separate) (2006-2015, with 2008 data absent).
5) Discard % (1997-**2015,** with 2011 missing).

[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 assumes the following:

i) an 80% once off mortality of lobsters aged 1, 2 and 3 years during the 2011 season (as in 2014), 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 assumptions[2], but recent CPUE data indicate that it is very unlikely there was much if any impact on the adults.

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 the 2013, and of 70 initially but increasing in midseason to 75 MT for the 2014 and 2015 seasons due to good catch rates and in accordance with the pre-specified management recommendations.

Sensitivity tests

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

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

SEN2: a 50% once off mortality on adults (ages 4+) during the 2011 season (and 80% once off juvenile mortality) [Note these are the assumptions made for the 2014 and 2015 assessments.]

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

Nightingale model development

Similar changes to those implemented for Inaccessible and Gough in the way time variability is modelled in the selectivity functions continue to be applied here, as was the case for the 2014 and 2015 assessments. Random variation in the μ parameter values is modelled as follows:

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

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

where

$$\varepsilon_y^m \sim N(\,0, (\sigma_\mu^2)\,\,) \quad (3)$$

$$\varepsilon_y^f \sim N(\,0, (\sigma_\mu^2)\,\,) \quad (4)$$

Consequently a penalty term is added to the likelihood:

$$-lnL \rightarrow -lnL + \frac{1}{2\sigma_\mu^2}\sum_{1997}^{2015}[(\varepsilon_y^m)^2 + \left(\varepsilon_y^f\right)^2] \quad (5)$$

Furthermore, the –lnL contribution was modified in order to prevent the model from giving too much weight to the CPUE data (i.e. fitting the CPUE data perfectly by allowing for the residual ε_y values to all become unrealistically small). The contribution of the abundance data to the negative of the log-likelihood function (after removal of constants) is given by:

$$-\ln L = \sum_y \left[\left(\varepsilon_y\right)^2 / 2(\sigma^2 + c^2) + \frac{1}{2}\ln(\sigma^2 + c^2) \right] \quad (6)$$

where

$\varepsilon_y = lnCPUE_y - \ln(q\hat{B}_y)$,

σ is the residual CPUE standard deviation estimated in the fitting procedure by its maximum likelihood value:

$$\hat{\sigma} = \sqrt{1/n\sum_y \left(\ln CPUE_y - \ln \hat{q}\ \hat{B}_y\right)^2} \quad \text{and} \quad (7)$$

c is a constant used to prevent the CPUE data receiving too much weight in the likelihood.

In order to keep the realised CPUE residual standard deviation to a reasonable value ~ 0.10-0.15, the following values were selected:

σ_{μ}=0.02

c = 0.6

It was observed in 2014 that allowing the female scaling parameter "*P*" to vary over time also produced better fits of the model to the CAL data. Thus equation (2) was further modified to:

$$S_{y,l}^{f,comm} = (P + \varepsilon_y^P)\frac{e^{-(\mu_y^f + \varepsilon_y^f)l}}{1 + e^{-\delta^f(l - l_*^f)}} \tag{8}$$

where

$$\varepsilon_y^P \sim N(\,0, (\sigma_P^2)\;\;) \tag{9}$$

Consequently, a further penalty term was added to the log-likelihood:

$$-lnL = -lnL + \frac{1}{2\sigma_p^2}\sum_{1997}^{2015}\;(\varepsilon_y^P)^2 \tag{10}$$

and σ_P was fixed at 0.2.

Somatic growth rate model

In previous years (prior to 2015) two alternate somatic growth rate models have been used to model the growth at Nightingale. Here, as for the 2015 assessment, only the "James Glass" somatic growth model is used, as this has since been shown to produce better fits to the observed data (Johnston and Butterworth 2012).

Projections

The resource is projected forwards to 2033 under a constant catch of either 70 MT or 75 MT. The future (2014+) stock-recruit residuals are modelled as follows.

The model estimates residuals for 1992-2013. For 2014+ recruitment is set equal to its expected values 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.

Results and Discussion

The recent (2013-2015) high GLM standardized CPUE and biomass survey indices reported at Nightingale (Johnston *et al.* 2016 and Johnston 2016) were not initially anticipated at the time of the OLIVA incident, and suggest that the impact of the OLIVA incident on the resource has been overestimated. For this reason, the RC assumptions to take into account the possible effects of the OLIVA on adult mortality have been 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).

Table 1 compares the 2016 updated RC Nightingale assessment along with results of the two sensitivity tests (SEN1 which assumes an additional juvenile mortality and SEN2 which assumes a greater adult mortality). SEN2 can be compared directly with the 2015 RC results which are also reported in the last column. Figure 1 contains plots of the 2016 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 2015 RC estimated values are provided in these plots (note that the 2015 RC model assumed a 50% adult mortality in 2011). Note that the recent high catch rates, and hence abundances, are ascribed to particularly strong recruitment in 2005 and 2006. Figure 2 reports parameter estimates for the RC selectivity function, whilst Figures 3 and 4 respectively show fits to the commercial and to the biomass survey CAL data averaged over years, as well as the residual plots and annual fits to the 2013-2015 observed values.

Comparing the first and last columns of Table 1, it is clear that the assumption of zero adult mortality due to the OLIVA has a positive impact on the results. The 2016 RC assessment is clearly (and expectedly) more optimistic. Recent exploitable biomass trends and Bsp/K estimates are also more optimistic – see Figure 1.

The three 2016 models reported estimate the current spawning biomass as a fraction of the unexploited equilibrium level to be between 0.39 (SEN2) and 0.86 (SEN1). The RC estimates this value at 0.65.

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 good, except for the first six year period.

The plot of the RC selectivity μ residuals in Figure 2a indicate 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).

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, though there is a pattern of overestimation of males in size classes 100 mm CL and larger. Figure 3b shows some poor fits to some of the smaller size classes in recent 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 average biomass survey CAL data. Again, the fits are reasonably good, but as with the commercial catch the proportion of large lobsters is overestimated. Figure 4c for the survey CAL by year also shows some poor fits to recent data.

Figure 5a compares the estimated exploitable biomass trends, in units of CPUE, for the RC, and for SEN1 and SEN2.

It is also interesting to note the best model fit to the overall data is achieved for the RC model (compared with SEN1 and SNE2), as evidenced in the total –lnL values reported in Table 1. This supports the model assumption that adult mortality due to the OLIVA is likely to have been small, but the extent of any juvenile mortality impact remains unclear and will be monitored. The effects of any substantial effect on the juveniles will only now start to become evident due to the lag effect until the juvenile affected by the OLIVA incident grow to the legally catchable sized portion of the population.

Projections

Projections under two alternate future constant catch levels (70 MT and 75 MT) have been run. Table 2 reports the *Bsp/K* value in 2033 for the two CC scenarios for the RC. Figure 6a reports the resultant CR (catch rate) and *Bsp/K* trajectories for the RC where results are compared between the CC=70 MT and CC=75 MT scenarios. The future catch rates differ very slightly between a future CC of 70 MT or 75 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. *Bsp/K* in 2033 remains high at over 0.90 for both catch scenarios. Figure 6b shows similar results but for SEN1 (where only 20% mortality on the juveniles due to the OLIVA incident is assumed). Here it is clear that the large drop in CR and Bsp seen in Figure 6a is entirely a function of the juvenile mortality due to the OLIVA assumption.

Management Advice

Results in this paper would support a future CC of 75 MT. It is suggested that the initial TAC is set at 70 MT (for precautionary measures) and that the CPUEs are monitored on a monthly basis. In November if catch rates are above the average of the three years prior to the OLIVA incident, and the biomass survey index remain high, then the TAC should be increased to 75 MT.

References

Johnston, S.J. and Butterworth, D.S. 2012. Updated 2012 rock lobster assessment of the Tristan da Cunha group of islands. MARAM/Tristan/2012/Jul/10. 20pp

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.

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Johnston, S.J. 2016. Biomass survey results for Nightingale which include the recent February 2016 Leg 2 survey results. MARAM/Tristan/2016/APR/06.

Johnston, S.J., Brandao, A. and Butterworth, D.S. 2016. Updated 2016 GLMM-standardised lobster CPUE from the Tristan da Cunha outer group of islands. MARAM/Tristan/2016/JUN/09.

Table 1: Updated Nightingale 2016 assessment results. The 2015 RC assessment results are reported (last column) to allow for comparisons. The shaded values are fixed on input. Values in parentheses are estimated σ values. (Note that the –lnL values are not comparable between the 2015 and 2016 assessments.) Results are reported for the RC, and the SEN1 and SEN2 sensitivity tests.

	2016 assessment RC (2011 adult mortality due to OLIVA = 0% and juvenile mortality=80%)	**2016 assessment SEN1 (2011 adult mortality due to OLIVA = 0% and juvenile mortality=20%)**	**2016 assessment SEN2 (2011 adult mortality due to OLIVA = 50% and juvenile mortality=80%)**	2015 assessment RC (2011 adult mortality due to OLIVA = 50% and juvenile mortality=80%)
# parameters estiamted	97	97	97	93
σ_R	0.4	0.4	0.4	0.4
K	489	457	972	663
h	0.79	0.84	0.48	0.56
F_{2009} fixed at	0.3	0.3	0.3	0.3
θ	0.282	0.302	0.143	0.209
-lnL total	-14.11	-13.80	-7.15	-7.26
-lnL CPUE T	-20.23	-21.26	-20.30	-16.05
-lnL CPUE longline	-15.78 (0.134)	-16.08 (0.119)	-14.62 (0.179)	-12.74 (0.216)
-lnL CPUE Survey Leg1	-4.46 (0.491)	-5.18 (0.466)	-5.67 (0.416)	-3.31 (0.468)
-lnL CAL T	-34.97	-20.99	-36.35	-52.17
-lnL CAL onboard observer	-32.02 (0.075)	-21.40 (0.076)	-31.89 (0.075)	-43.97 (0.073)
-lnL CAL Survey Leg 1	-2.95 (0.098)	0.411 (0.101)	-4.46 (0.097)	-8.19 (0.097)
SR1 pen	3.87	4.10	8.10	7.19
-lnL discard	3.56	4.03	3.92	3.37
Bsp(1990)/Ksp	0.26	0.28	0.13	0.19
Bsp(2013)/Ksp	0.92	1.06	0.39	0.47
Bsp(2014)/Ksp	0.80	1.00	0.36	0.43
Bsp(2015)/Ksp	0.72	0.95	0.37	0.43
Bsp(2016)/Ksp	**0.65**	**0.86**	**0.39**	**-**
Bsp(2013)/Bsp(1990)	3.53	3.75	2.95	2.40
Bsp(2014)/Bsp(1990)	3.03	3.55	2.72	2.20
Bsp(2015)/Bsp(1990)	2.73	3.35	2.74	2.23
Bsp(2016)/Bsp(1990)	2.45	3.03	2.88	-
Bexp(2012)/Bexp(1990)	3.59	3.50	2.56	2.27
Bexp(2013)/Bexp(1990)	3.99	4.09	3.32	2.72
Bexp(2014)/Bexp(1990)	3.70	3.83	3.08	2.37
Bexp(2015)/Bexp(1990)	2.74	3.22	2.53	-
Programs	Night16a.tpl	Night16b.tpl	Night16.tpl	Night15.tpl

Table 2: Model estimated Bsp/K values in 2033 under levels of future constant catch or CC = 70 MT or CC = 75 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**	**CC = 70 MT**	**CC = 75 MT**
RC	80%	0%	0.96	0.95
SEN1	20%	0%	0.96	0.95
SEN2	80%	50%	0.90	0.90

Figure 1: Nightingale 2016 **RC** assessment results. The exploitable biomass and *B*sp/*K* trends from the 2015 RC assessment are also plotted for comparative purposes (but note that for the 2015 RC a 50% adult mortality was assumed to occur in 2011 due to the OLIVA incident).

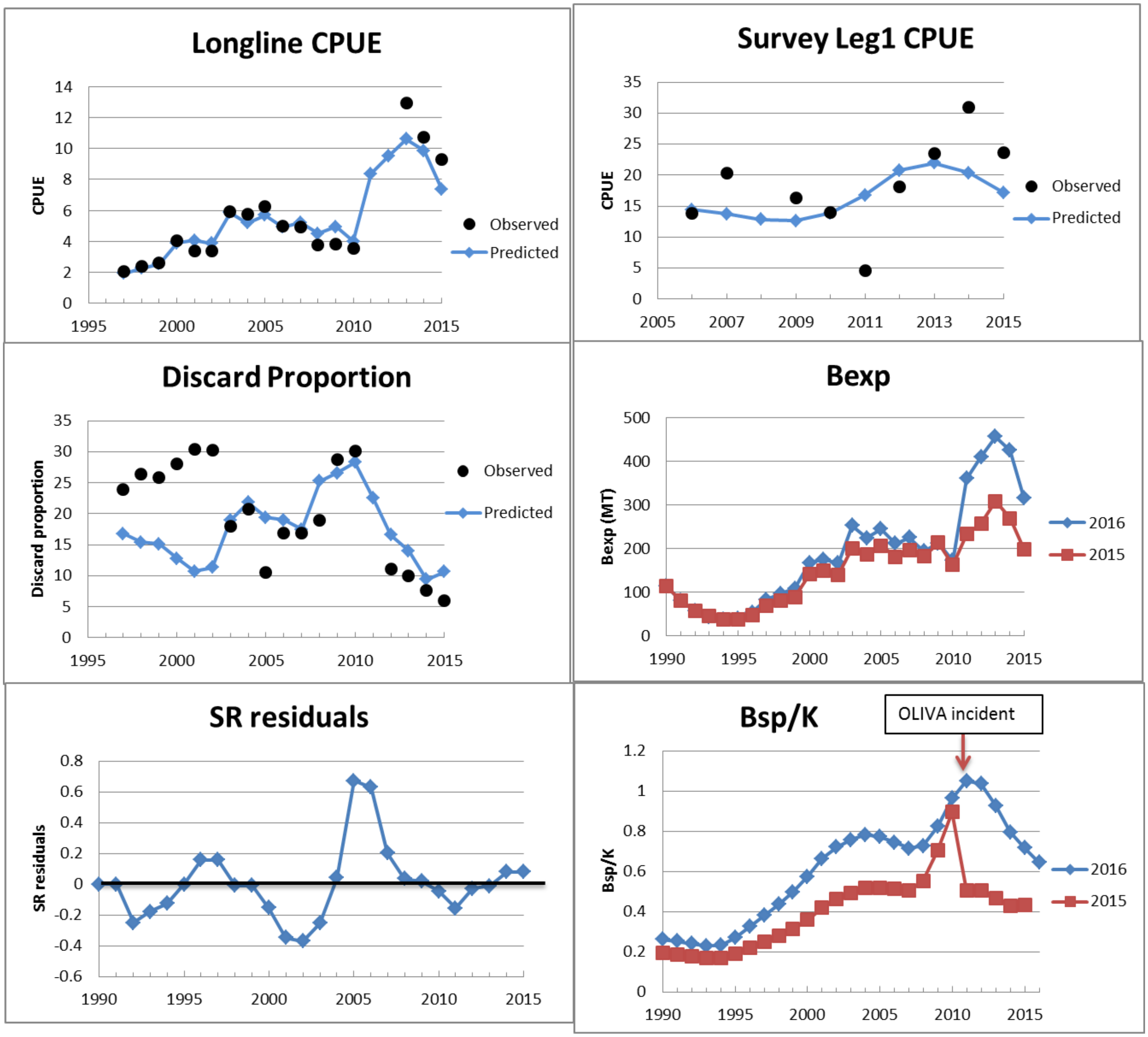


Figure 2a: Nightingale **RC** estimated μ residuals (used for selectivity function variability).

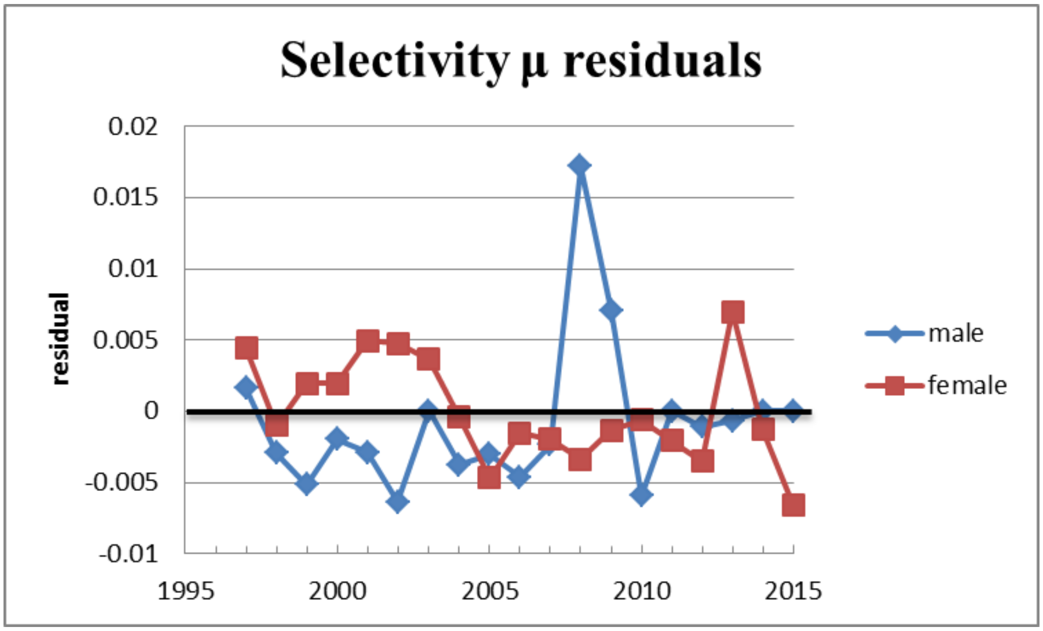


Figure 2b: Nightingale **RC** estimated female scalar variability (used for selectivity function variability).

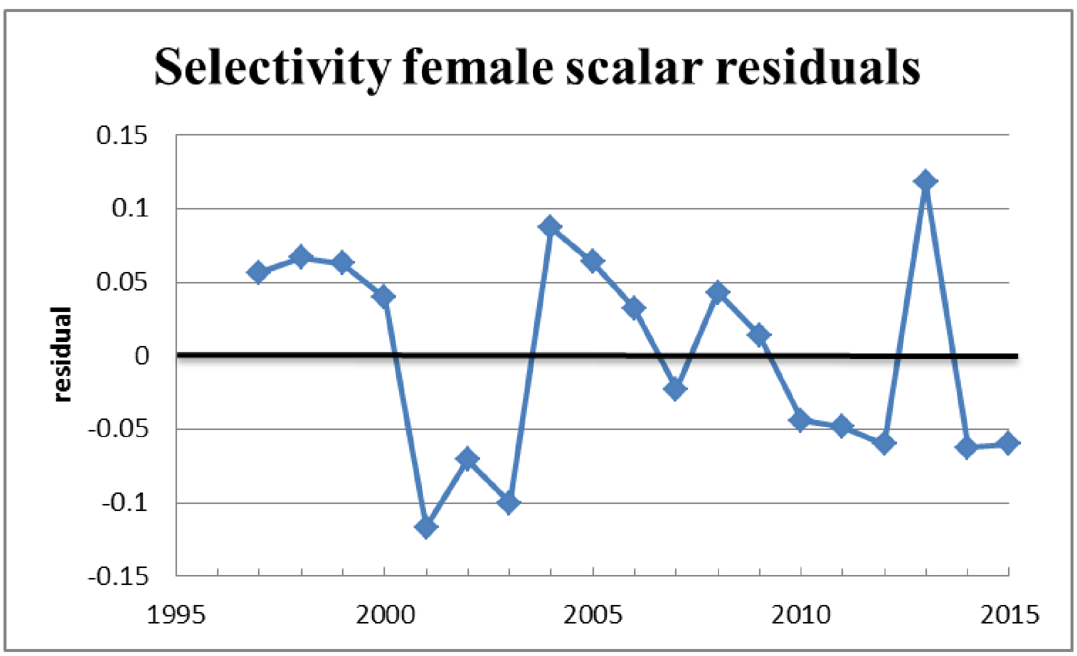


Figure 3a: Nightingale commercial longline **RC** CAL fits averaged over years.

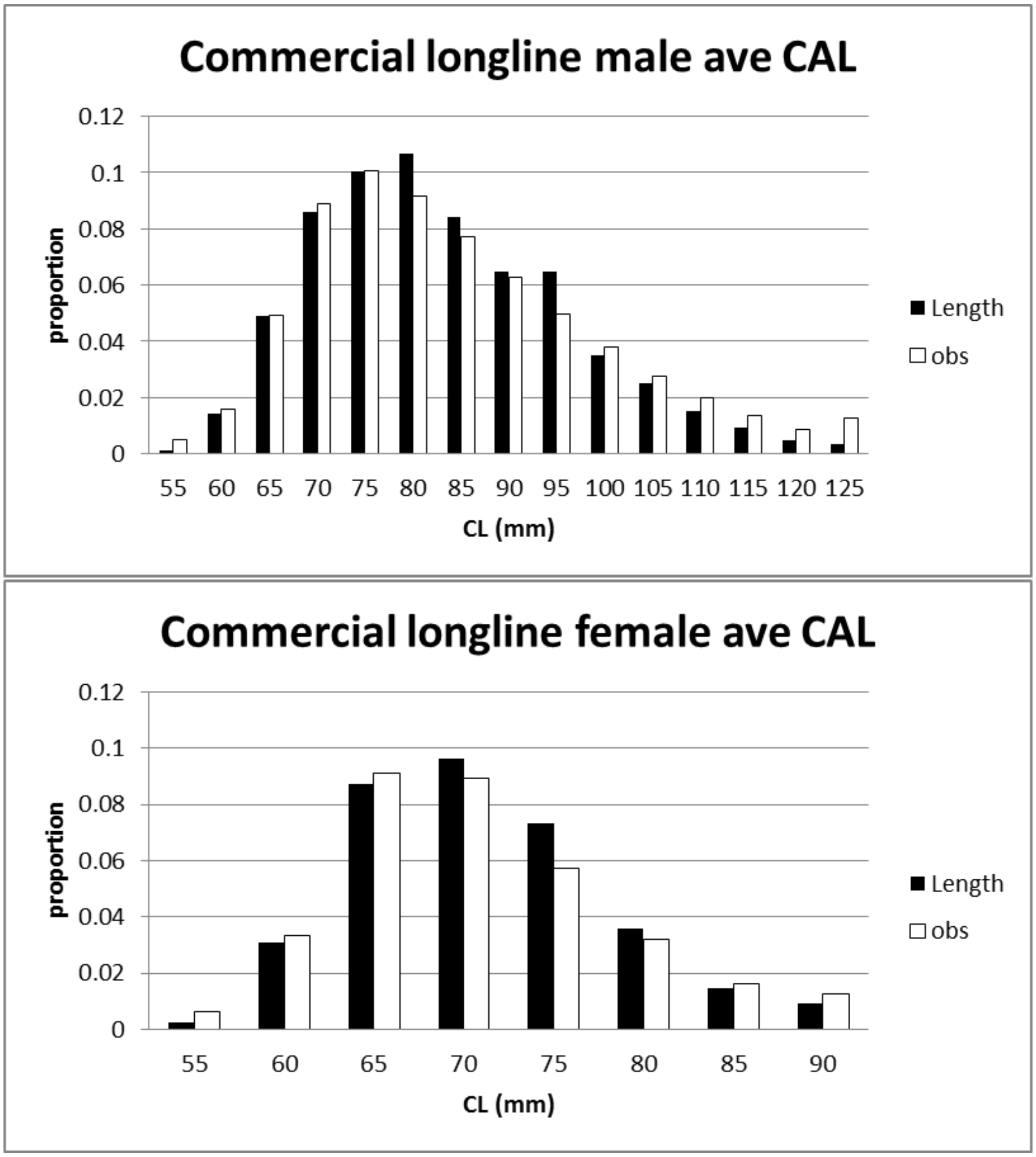


Figure 3b: Nightingale standardized commercial longline CAL residuals for the **RC** model The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

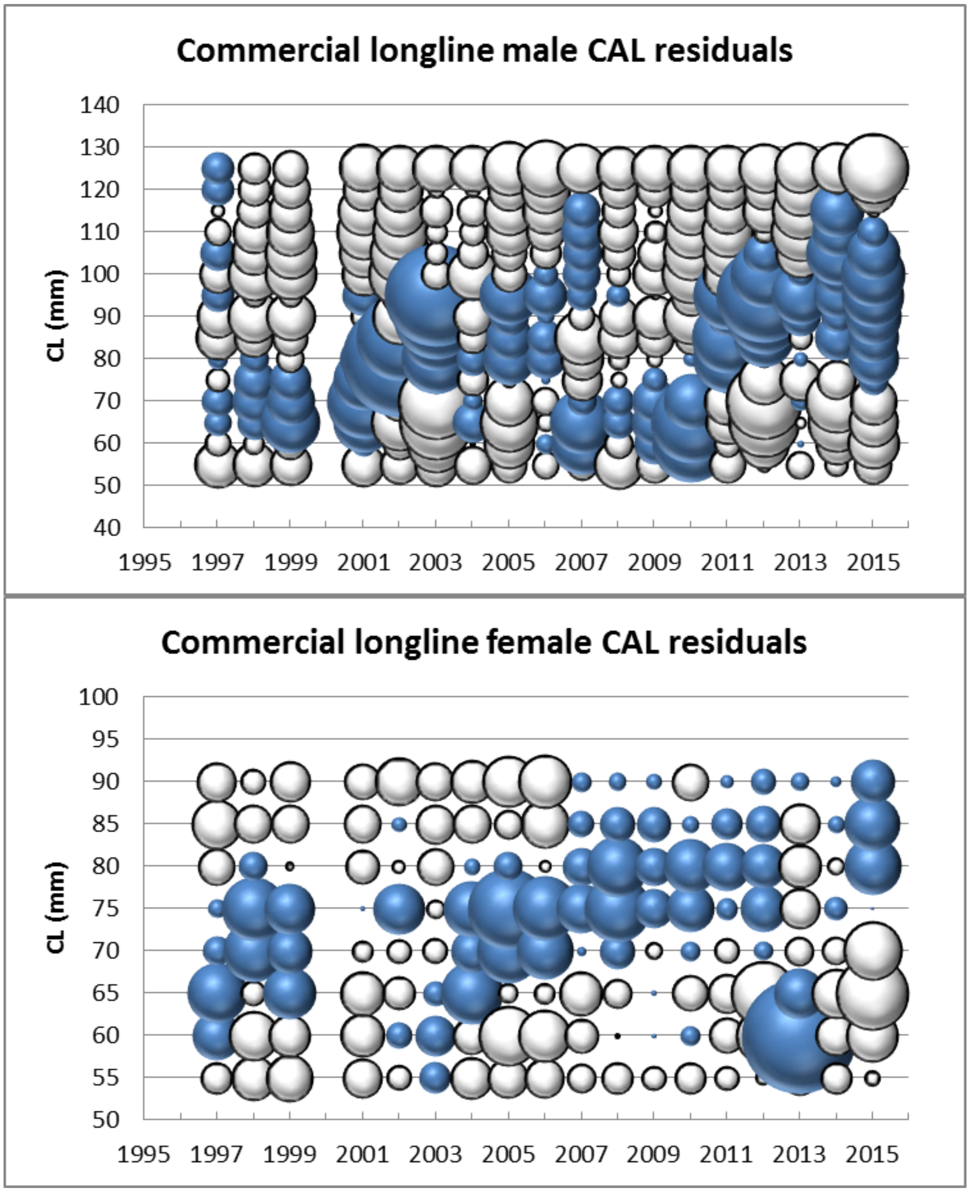


Figure 3c: Nightingale commercial longline **RC** CAL fits for 2013-2015.

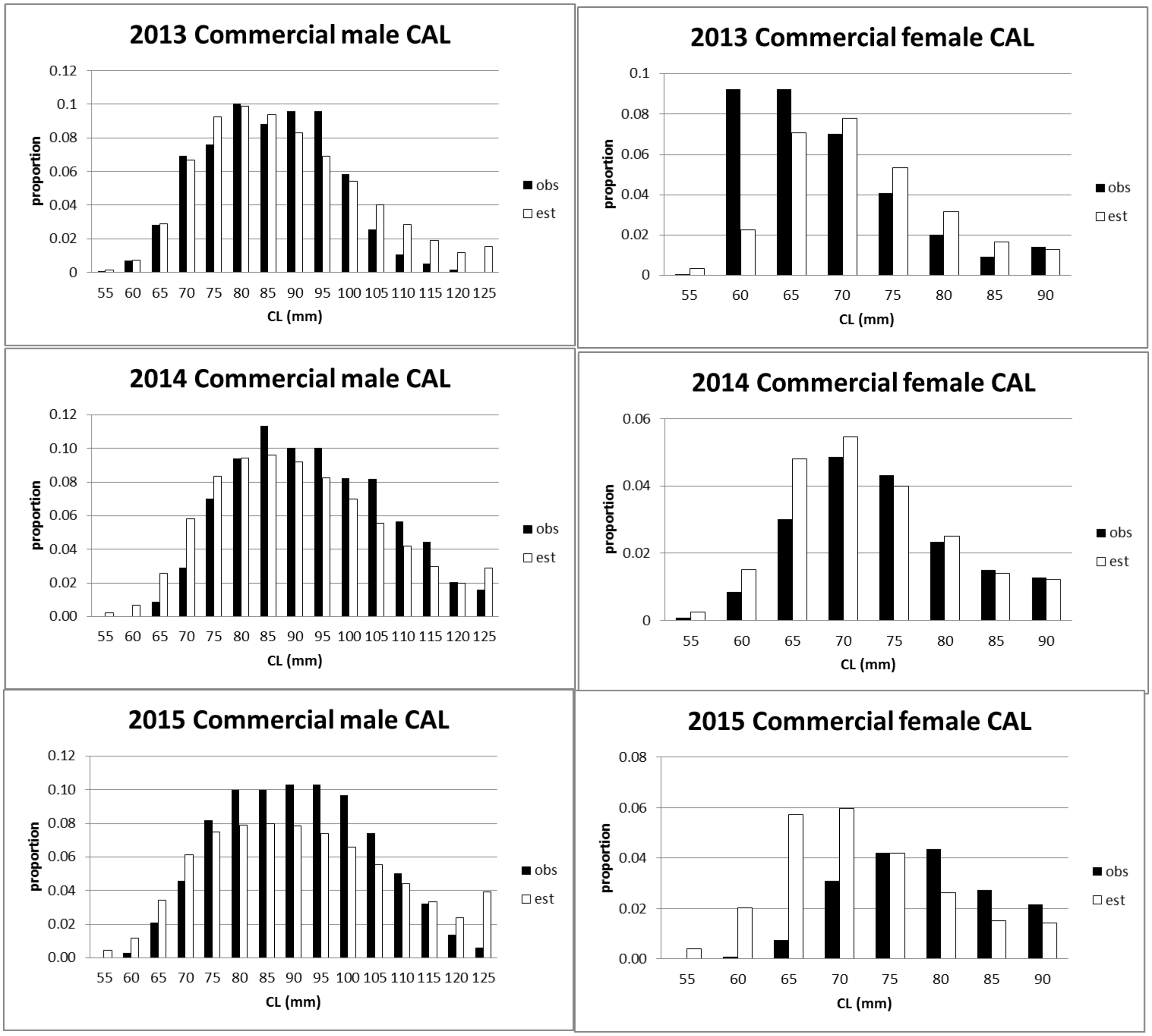
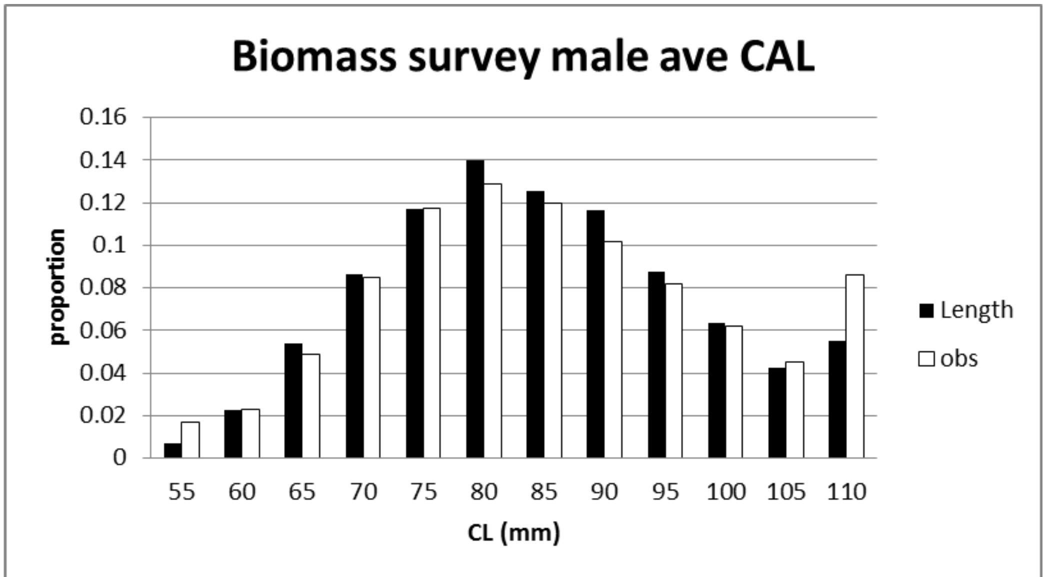


Figure 4a: Nightingale biomass survey Leg1 **RC** CAL fits averaged over years.



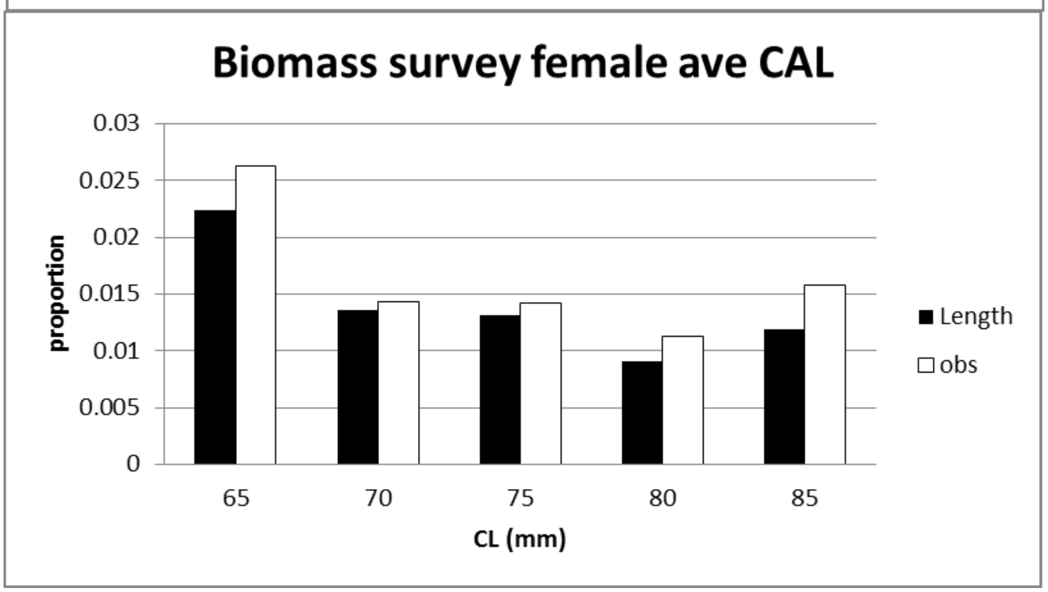
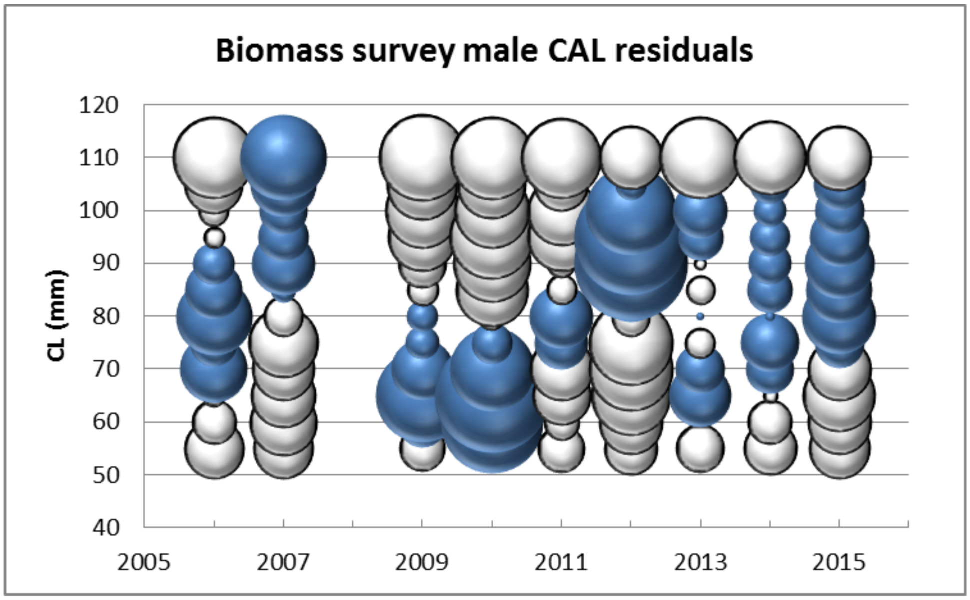


Figure 4b: Nightingale standardized biomass survey Leg 1 CAL residuals for the **RC** model The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.



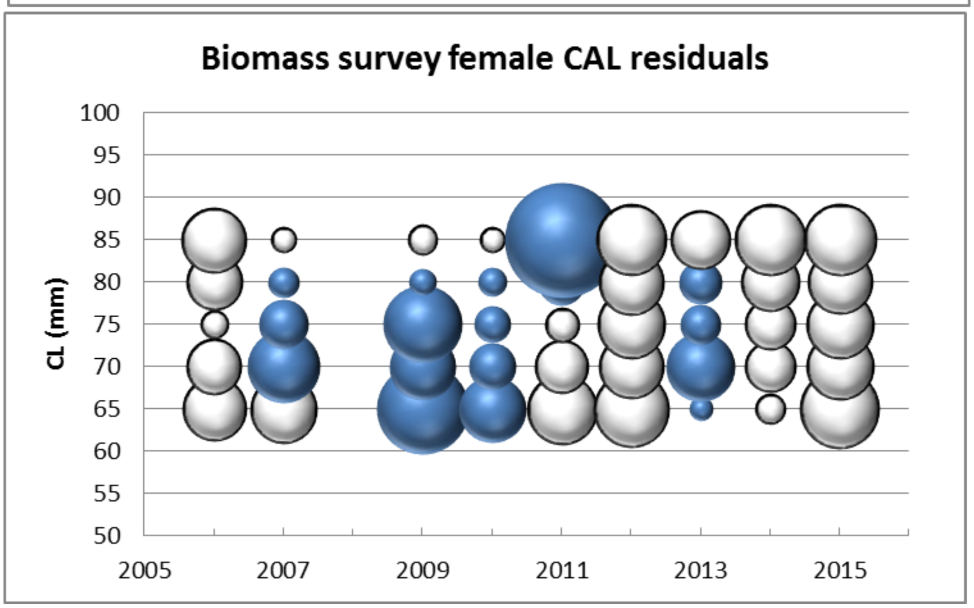


Figure 4c: Nightingale biomass survey Leg1 **RC** CAL fits for 2013-2015.

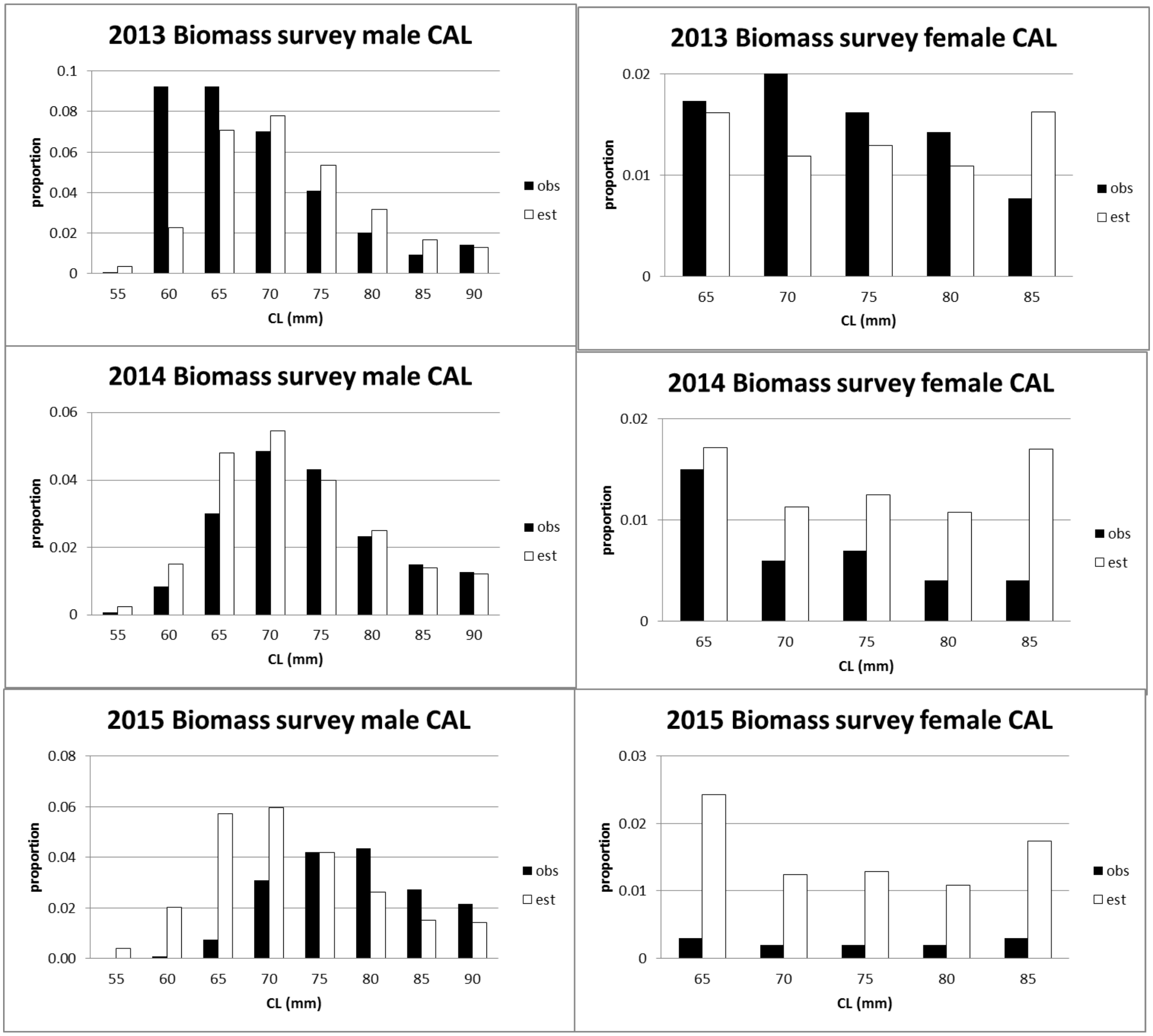


Figure 5a: Comparative plots of the estimated longline catch rates (CPUE) for the **RC** (80% juvenile and 0% adult mortality in 2011 due to OLIVA), **SEN1** (**20%** juvenile and **80%** adult mortality in 2011 due to OLIVA), and **SEN2** (80% juvenile and **50%** adult mortality in 2011 due to OLIVA). The observed GLM longline CPUE data are shown as black circles.

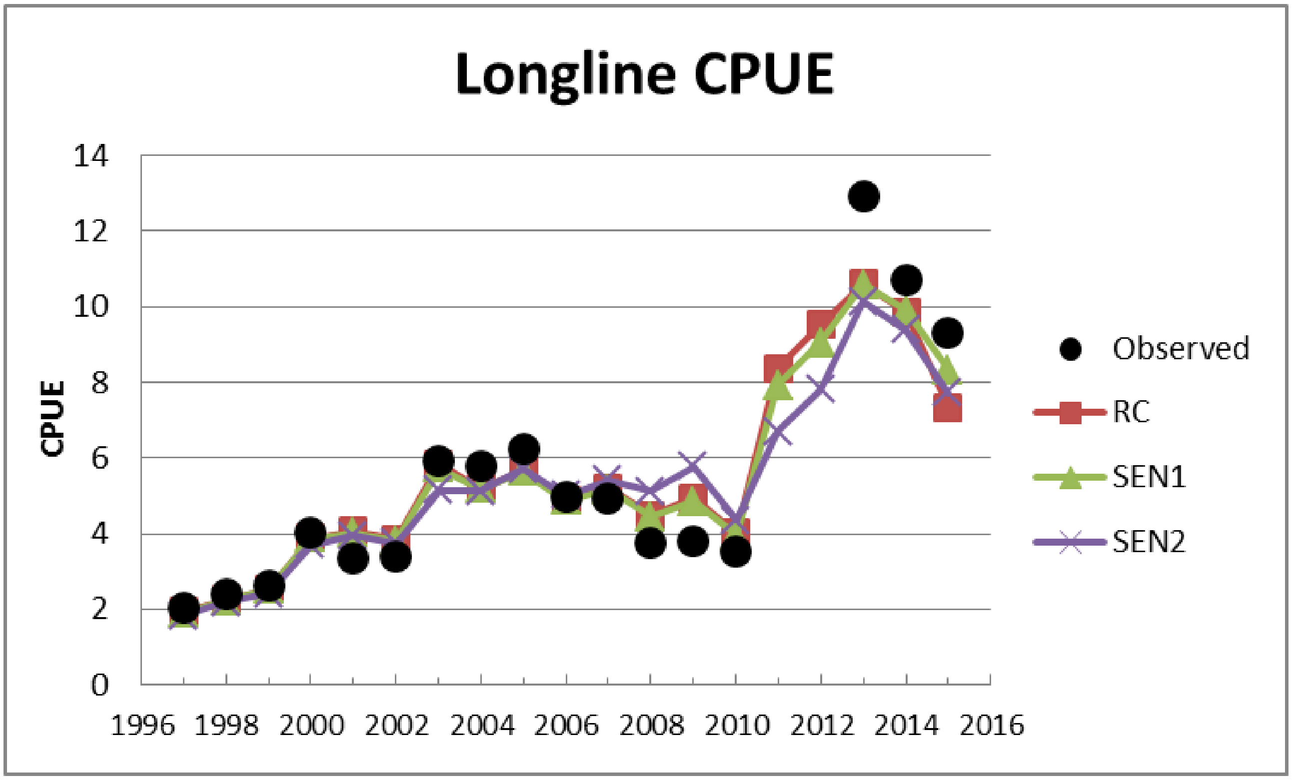


Figure 5b: Comparative plots of the estimated biomass survey indices for the **RC** (80% juvenile and 0% adult mortality in 2011 due to OLIVA), **SEN1** (**20%** juvenile and **80%** adult mortality in 2011 due to OLIVA), and **SEN2** (80% juvenile and **50%** adult mortality in 2011 due to OLIVA). The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

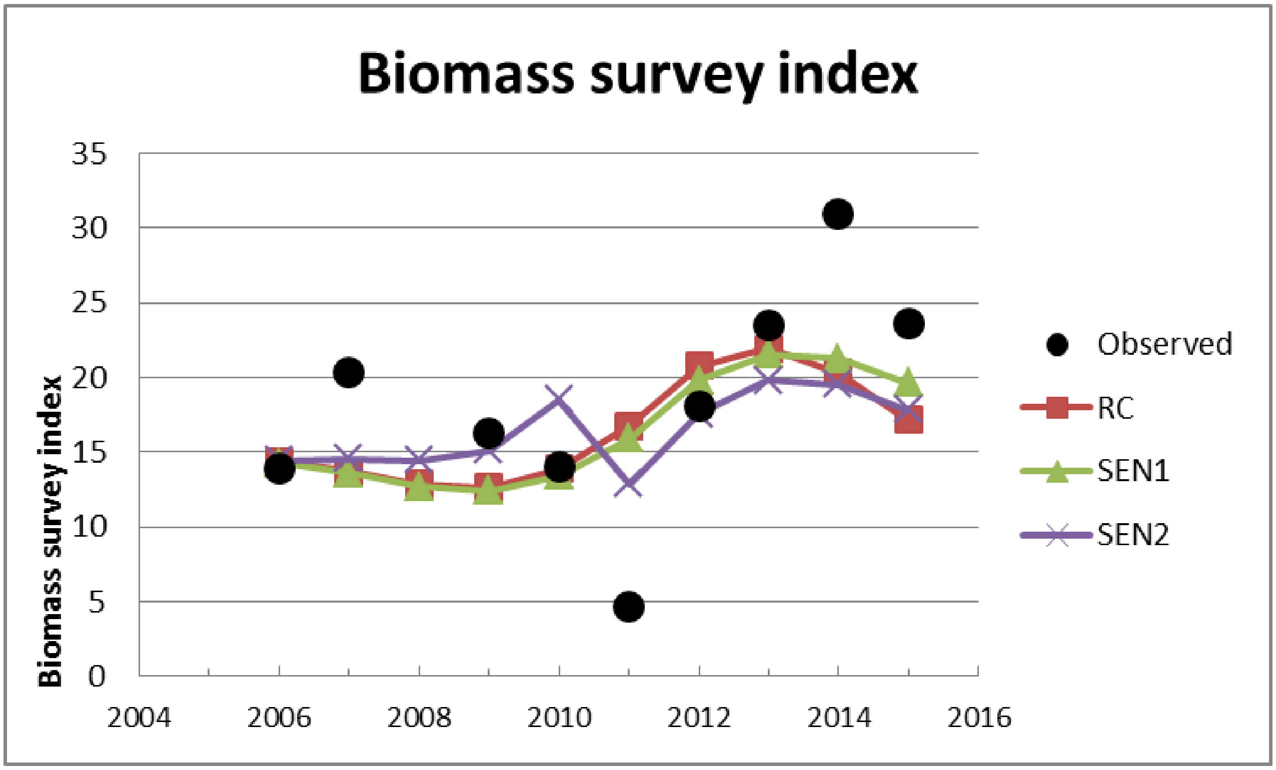


Figure 6a: **RC** projections of the resource into the future for levels of constant catch CC=70 MT and CC= 75 MT. The top plot shows the different catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K*.

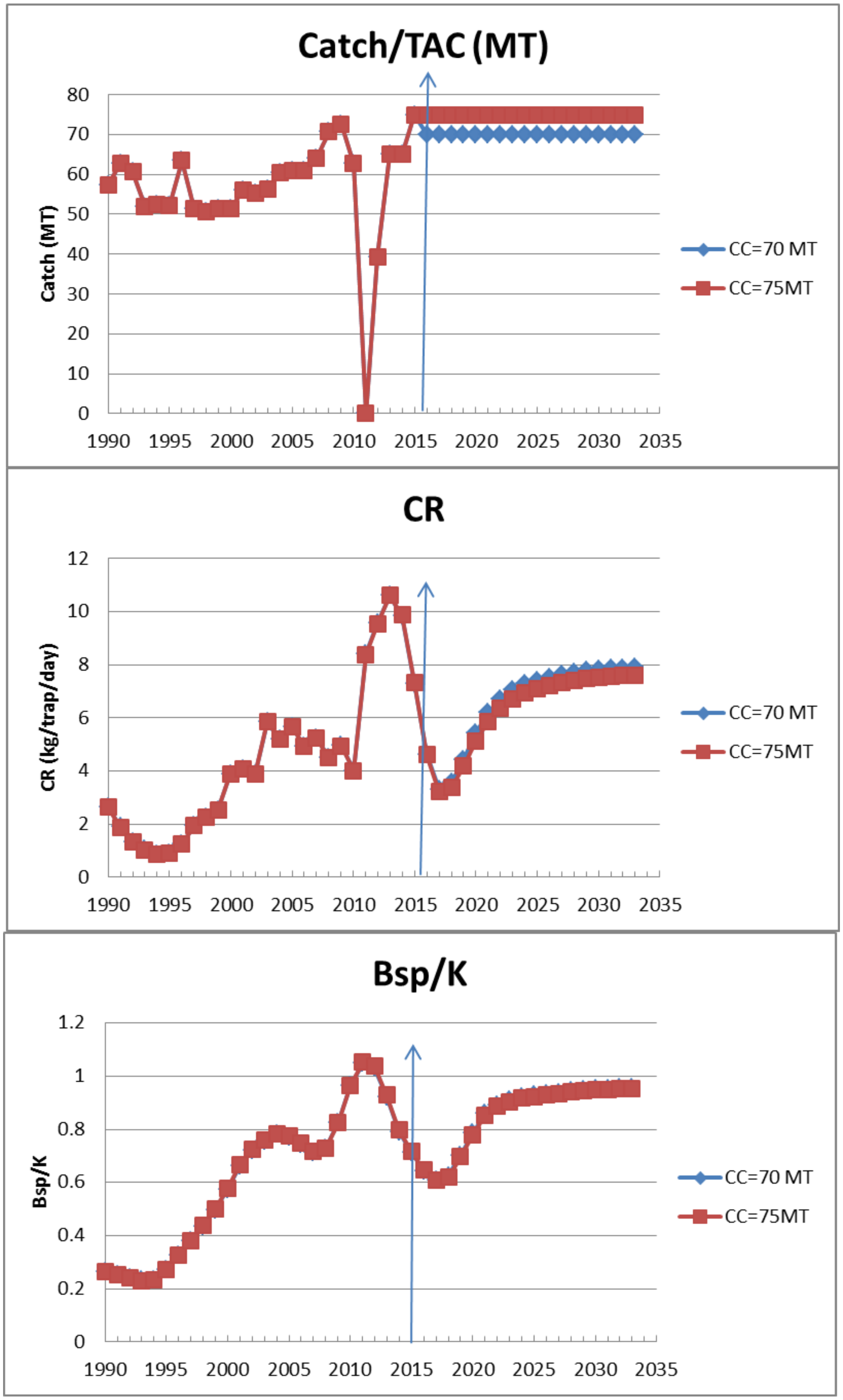


Figure 6b: **SEN1** (0% adult and 20% juvenile mortaltity due to OLIVA in 2011) projections of the resource into the future for levels of constant catch CC=70 MT and CC= 75 MT. The top plot shows the different catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K*.