Updated 2015 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 biomass surveys. The 2015 assessment updates take into account both possible additional adult and possible juvenile mortality due to the OLIVA incident in 2011. The recent (2013 and 2014) high GLM standardised CPUE values (and biomass survey index values) at the island were not anticipated, and suggest that the impact of the OLIVA may have been overestimated. A number of sensitivity trials are therefore run where alternate levels of both juvenile and adult mortality in 2011 due to the OLIVA incident are assumed. The implications of these assumptions for the future management of this resource are discussed. The recent high CPUE probably indicates that the adult mortality in 2011 due to the OLIVA incident was much less than originally assumed. However, the effect of any juvenile mortality due to the OLIVA will only become evident from CPUE trends over the next few years; such mortality could result in an appreciable drop in abundance over this period.

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 2014 (Johnston and Butterworth 2014). This assessment took GLM standardised CPUE data into account only to 2010. Scenarios for additional mortality due to the OLIVA incident which occurred in March 2011 were developed and implemented in 2014.

This 2015 assessment model is fit to the following data.

1) Standardised longline CPUE data for 1997-20**14**[1] (previous assessment only to 2010). (2011 and 2012 CPUE not included due to closure/test fishing).
2) Biomass survey Leg1 CPUE data (2006-20**14**, with 2008 data absent).
3) Catch-at-length data from the onboard observers (males and females separate) (1997-**2014,** ***with 2000 missing***).
4) Catch-at-length data from the Leg1 biomass survey (males and females separate) (2006-2014, with 2008 data absent).
5) Discard % (1997-**2014,** 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 is modelled as for the 2014 assessment by assuming the following:

i) an 80% once off mortality of lobsters aged 1, 2 and 3 years during the 2011 season, and
ii) a 50% once off mortality on adults (ages 4+) during the 2011 season.

These were previously considered the most reasonable assumptions[2].

The commercial fishery at Nightingale was closed for the 2011 season. A precautionary TAC of 40 MT was set for 2012, and of 65 MT for the 2013 and 2014 seasons.

Sensitivity tests

A sensitivity test is run which assumes a lesser impact of mortality in 2011 on the **juvenile** lobsters due to the OLIVA incident:

SEN0: a 20% once off mortality on juveniles (ages 1-3) during the 2011 season (retaining the assumption of 50% adult mortality)

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

SEN1: a 25% once off mortality on adults (ages 4+) during the 2011 season.

SEN2: a 10% once off mortality on adults (ages 4+) during the 2011 season.

A further sensitivity test is run which looks at a lesser mortalities for both the juvenile and adult lobsters in 2011:

SENBOTH: a 20% once off mortality on **juveniles** (ages 1-3) and a 10% once-off mortality on **adults** (ages 4+) during the 2011 season.

[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 are applied here. Random variation in the μ parameter values are modelled as follows:

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

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

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:

$$-lnL \rightarrow -lnL + \frac{1}{2\sigma_\mu^2}\sum_{1997}^{2012}[(\varepsilon_y^m)^2 + (\varepsilon_y^f)^2] \quad (5)$$

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:

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

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.

As for the Gough assessment, it was found 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:

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

where

$$\varepsilon_y^P \sim N(\,0, (\sigma_P^2)\quad) \quad (9)$$

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

$$-lnL = -lnL + \frac{1}{2\sigma_p^2}\sum_{1997}^{2012}\ (\varepsilon_y^P)^2 \quad (10)$$

and σ_P was fixed at 0.2.

Somatic growth rate model

Previously, two alternate somatic growth rate models have been used to model the growth at Nightingale. Here 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 2030 under a constant catch of either 65 MT or 75 MT. The future (2013+) stock-recruit residuals are modelled as follows:

The model estimates residuals for 1992-2012. For 2013+ 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, as well as for the sensitivity tests.

Results and Discussion

The recent (2013 and 2014) high GLM standardized CPUE and biomass survey indices reported at Nightingale (Johnston and Butterworth 2015a, b) were not anticipated, and suggest that the impact of the OLIVA incident on the resource may have been overestimated. High recent biomass survey index values have also been observed. Consideration of this is a primary focus of this section.

Table 1 compares the 2015 updated RC Nightingale assessment with the previous assessment reported in 2014. Table 1 also reports results of SEN0 for which a lesser amount of *juvenile* mortality is assumed due to the OLIVA incident in 2011, SEN1 and SEN2 where lesser amounts of *adult* mortality due to this incident are assumed, and for SENBOTH where lesser amounts of *both* juvenile and adult mortality are assumed. Figure 1 contains plots of the 2015 RC assessment fits to both the longline CPUE and biomass survey Leg1 CPUE data, as well as further model estimated trends. Comparisons to the 2014 RC estimated values are provided in these plots. 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. Results are reported for both the RC and for the SENBOTH sensitivity test.

Comparing the first two columns of Table 1, it is clear that the addition of new updated data to the 2015 assessment has had an impact on the results. The 2015 assessment (which now includes fitting to the more recent, and high, CPUE and biomass index values), is more optimistic. The *K* estimate has increased to 663 MT from 433 of the 2014 RC assessment (see Table 1). Recent exploitable biomass trends are also more optimistic – see Figure 1, although the *B*sp/*K* estimates are not substantially changed from the 2014 assessment.

The four sensitivity tests reported for which lesser amounts of juvenile and/or adult mortality is assumed to have occurred in 2011 due to the OLIVA incident estimate the current spawning biomass to be higher at between 0.60*K* and 0.89*K*.

Figure 1 indicates that the RC model fits the longline CPUE data reasonably well, but is unable to replicate the very high CPUE values observed recently. Fits to the discard proportion data are good, except for the first six year period. Note that the spawning biomass declines even after the impact of the assumed OLIVA adult mortality has had its effect. This is a consequence of the assumed OLIVA-related juvenile mortality increase.

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 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 with the norm).

The RC fits to the commercial longline catch-at-length (CAL) data are good (Figure 3), though there is a pattern of overestimation of males in size classes 100mm CL and larger. 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 wiith the commercial catch the proportion of large lobsters is overestimated.

Figure 5a compares the estimated exploitable biomass trends, in units of CPUE, for the RC, SEN0, SEN1, SEN2 and SENBOTH (which explore "lesser" amounts of adult mortality due to the OLVIA in 2011). These plots show clearly that the post-2011 trends are heavily dependent on the assumptions one makes regarding the extent of juvenile and adult mortality due to the OLIVA in 2011. The RC which assumes the most extreme case of mortalities in 2011 produces the most pessimistic estimated 2011+ biomass/CPUE trajectory.

It is also interesting to note the best model fits to the overall data are achieved for SEN2 (compared with SEN0, SEN1, SENBOTH or the RC), as evidenced in the total –lnL values reported in Table 1. Although the various fits to the CPUE data (Figure 5a) do not differ that greatly, the model estimates of Bexp and *Bsp* post 2010 are very different (clearly as a result of the different levels of OLIVA induced mortality assumed). SENBOTH, which assumes the least amount of OLIVA induced juvenile and adult mortality in 2011 (only 20% and 10% respectively) predicts a sharp increase in Bexp (and hence also CPUE) post 2010. It is clear that the SENBOTH 2013 and 2014 estimated CPUE values are the closest to the observed values – but still fall short of the observations. Qualitatively similar comments apply to the fits to the biomass survey data (Figure 5b). **This all suggests that the additional adult mortality in 2011 due to the OLIVA is likely to have been negligible.**

Projections

Projections under two alternate future constant catch levels (65 MT and 75 MT) have been run. Table 2 reports the *Bsp/K* value in 2033 for the two CC scenarios for the RC and the various sensitivity tests. Figures 6a-c report resultant CR (catch rate) and *Bsp/K* trajectories for the RC, SEN2 and SENBOTH respectively where results are compared between the CC=65 MT and CC=75MT scenarios. The future catch rates differ very slightly between a future CC of 65 MT or 75 MT. For both the RC and SEN2 (see Figures 6a and b) the CR is predicted to decline to low levels (< 4 kg/trap/day) from around 2016. This is due to the assumption of 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 all scenarios.

Figure 7 compares CR and *Bsp* trajectories for a future CC = 65 MT between the RC (80% juvenile and 50% adult mortality in 2011 due to OLIVA), SEN0 (20% juvenile and 50% adult mortality in 2011 due to OLIVA), SEN2 (80% juvenile 10% adult mortality in 2011 due to OLIVA) and SENBOTH (20% juvenile and 10% adult mortality in 2011 due to the OLIVA). This figure shows substantial differences between these models, particularly over the 2014-2020 period. The large decline in *Bsp* seen for the RC (and to a lesser degree in SEN2) is due to the assumption that 80% of all juvenile lobsters died in 2011 due to the OLIVA event. If one reduces this amount to only 20% (SEN0 and SENBOTH) one can immediately see that the predicted spawning biomass will be minimally affected in the future. Catch rates are similarly dependent on the levels of mortality assumed.

Management will need to monitor catch rates carefully in the future, as these will inform which of the various mortality scenarios considered here is most likely, as this in turn has important implications for TACs in the short to medium term.

Management Advice

Results in this paper indicate that in the longer term, Nightingale can sustain annual catches in excess of 65 MT. However, in the shorter term, biomass projections are heavily dependent on magnitudes of possible impacts on survival rates arising from the OLIVA incident. The very high CPUE at present suggests that the OLIVA incident did not give rise to high adult mortality. However, it is as yet too early to be able to determine whether there was a large impact on juvenile survival, which if it occurred could mean a sharply reduced catch rate over the next few years.

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. and Butterworth, D.S. 2015. Updated 2015 GLMM- and GLM standardized lobster CPUE from the Tristan da Cunha group of islands. MARAM/Tristan/2015/May/06.

Johnston, S.J. and Butterworth, D.S. 2015. Final Tristan Group biomass survey Leg1 results including data from the 2014 season. MARAM/Tristan/2015/MAY/04.

Table 1: Updated Nightingale 2015 assessment results. The 2014 RC assessment results are reported to allow comparison. The shaded values are fixed on input. Values in parentheses are estimated σ values. (Note that the –lnL values are not comparable between the 2014 and 2015 assessments.) Results are reported for the RC, SEN0, SEN1, SEN2 and SENBOTH sensitivity tests.

	2014 assessment RC (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%)**	**2015 assessment SEN0 (2011 adult mortality due to OLIVA = 50% and juvenile mortality=20%)**	**2015 assessment SEN1 (2011 adult mortality due to OLIVA = 25% and juvenile mortality=80%)**	**2015 assessment SEN2 (2011 adult mortality due to OLIVA = 10% and juvenile mortality=80%)**	**2015 assessment SENBOTH (2011 adult mortality due to OLIVA = 10%; and juvenile mortality=20%)**
# parameters	85	93	93	93	93	93
σ_R	0.4	0.4	0.4	0.4	0.4	0.4
K	433	663	534	494	473	457
h	0.88	0.56	0.66	0.75	0.80	0.83
F_{2009} fixed at	0.3	0.3	0.3	0.3	0.3	0.3
Male selectivity μ 90-99	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available
Male selectivity μ 00-06						
Male selectivity μ 07+						
Female selectivity μ 90-099						
Female selectivity μ 00-06						
Female selectivity μ 07+						
θ	0.312	0.209	0.260	0.278	0.291	0.302
-lnL total	-13.45	-7.26	-7.21	-11.67	-13.18	-12.85
-lnL CPUE T	-15.96	-16.05	-17.65	-17.23	-17.67	-18.62
-lnL CPUE longline	-13.30 (0.116)	-12.74 (0.216)	-13.34 (0.195)	-13.77 (0.179)	-14.34 (0.156)	-14.65 (0.142)
-lnL CPUE Survey Leg1	-2.66 (0.456)	-3.31 (0.468)	-4.31 (0.434)	-3.46 (0.488)	-3.32 (0.504)	-3.97 (0.483)
-lnL CAL T	-46.78	-52.17	-38.05	-47.10	-43.53	-33.21
-lnL CAL onboard observer	-46.37 (0.071)	-43.97 (0.073)	-32.07 (0.075)	-40.82 (0.073)	-39.12 (0.073)	-31.54 (0.075)
-lnL CAL Survey Leg 1	-0.41 (0.103)	-8.19 (0.097)	-5.99 (0.098)	-6.27 (0.098)	-4.41(0.099)	-1.67 (0.101)
SR1 pen	3.05	7.19	8.00	5.36	4.20	4.18
-lnL discard	3.30	3.37	3.84	3.23	3.17	3.55
Bsp(1990)/Ksp	0.29	0.19	0.24	0.26	0.27	0.28
Bsp(2013)/Ksp	0.43	0.47	0.68	0.72	0.81	0.95
Bsp(2014)/Ksp	0.39	0.43	0.71	0.63	0.70	0.92
Bsp(2015)/Ksp		**0.43**	**0.74**	**0.60**	**0.65**	**0.89**
Bsp(2013)/Bsp(1990)	1.48	2.40	2.82	2.77	2.98	3.39
Bsp(2014)/Bsp(1990)	1.33	2.20	2.93	2.43	2.58	3.27
Bsp(2015)/Bsp(1990)		2.23	3.05	2.30	2.37	3.17
Bexp(2012)/Bexp(1990)	1.58	2.27	2.20	2.93	3.31	3.17
Bexp(2013)/Bexp(1990)	1.43	2.72	2.78	3.26	3.53	3.62
Bexp(2014)/Bexp(1990)		2.37	2.71	2.80	3.03	3.36
Programs	Nightjg.tpl	Night15.tpl	Night1520.tpl	Night1525.tpl	Night1510.tpl	Night15b.tpl

Table 2: Model estimated Bsp/K values in 2033 under levels of future constant catch or CC = 65 MT or CC = 75 MT. Values are reported for the RC and four sensitivity tests.

	Juvenile mortality in 2011 due to OLIVA	**Adult mortality in 2011 due to OLIVA**	**CC = 65 MT**	**CC = 75 MT**
RC	80%	50%	0.94	0.94
SEN0	**20%**	50%	0.96	0.95
SEN1	80%	**25%**	0.96	0.95
SEN2	80%	**10%**	0.96	0.95
SENBOTH	**20%**	**10%**	0.96	0.95

Figure 1: Nightingale 2015 **RC** assessment results. The exploitable biomass and *B*sp/*K* trends from the 2014 assessment are also plotted for comparative purposes.

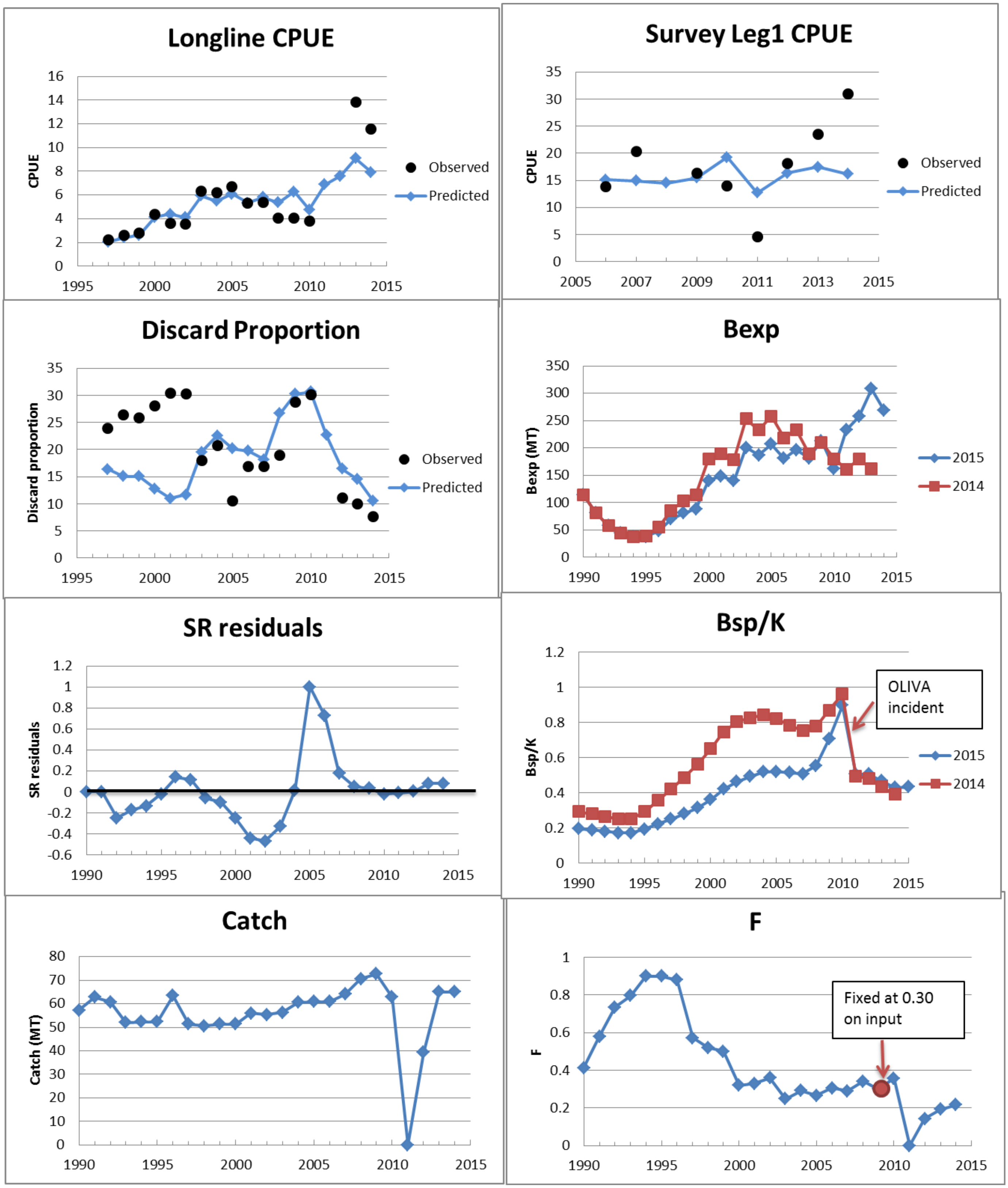


Figure 2a: Nightingale **RC** estimated μ residuals (used for selectivity function variability).

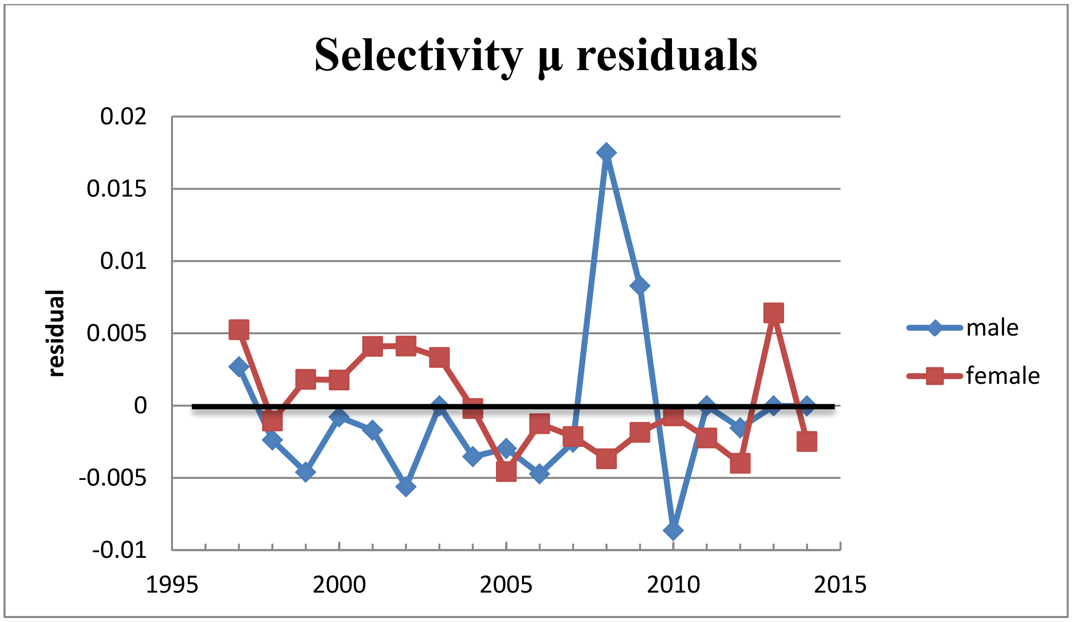


Figure 2b: Nightingale **RC** estimated female scalar variability (used for selectivity function variability).

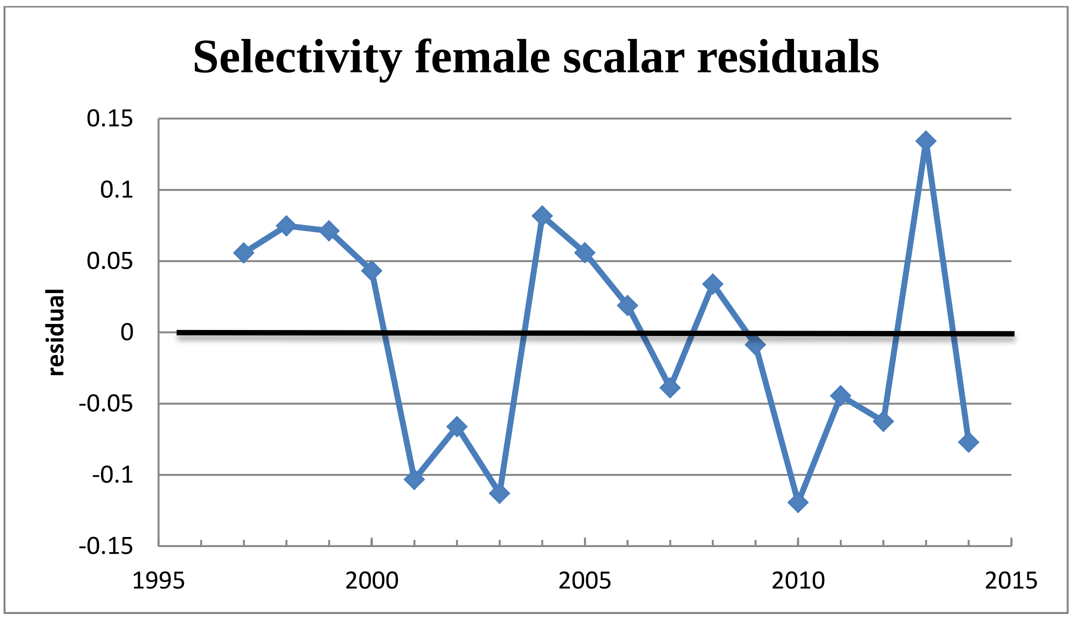
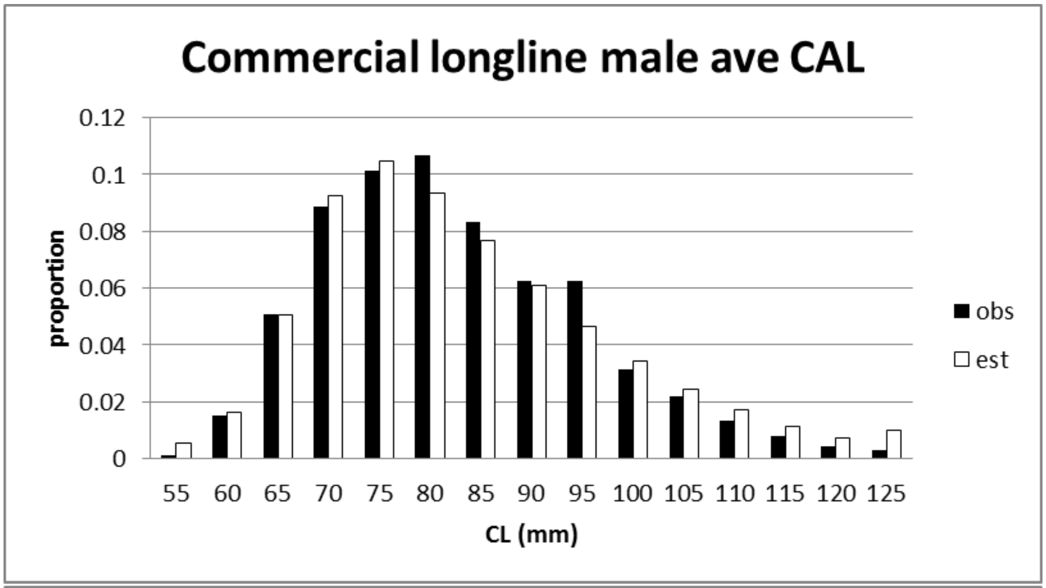


Figure 3a: Nightingale commercial longline **RC** CAL fits averaged over years.



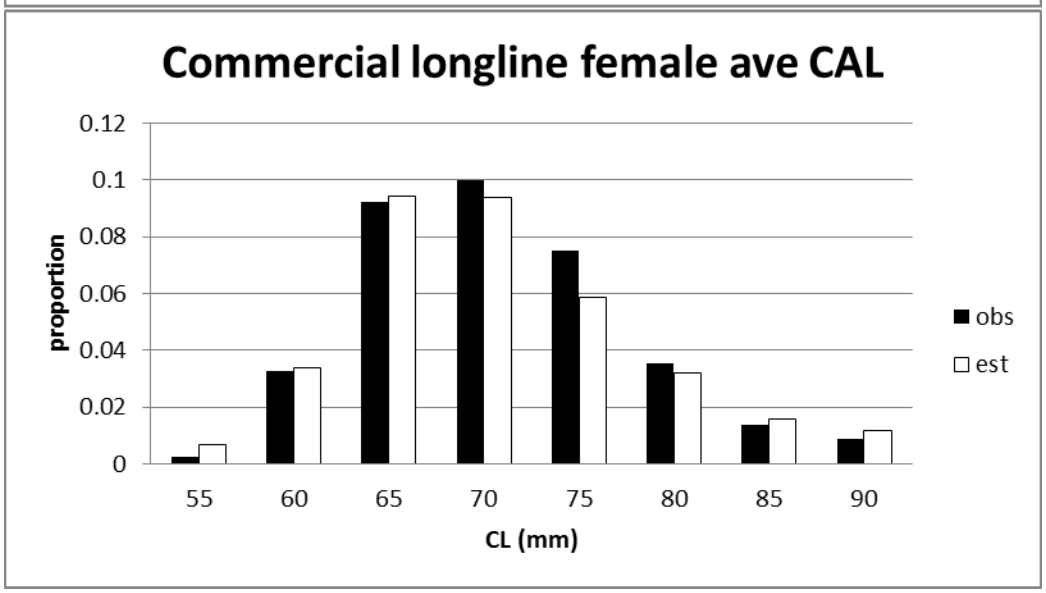


Figure 3b: Nightingale standardized commercial longline CAL residuals for the **RC** model The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

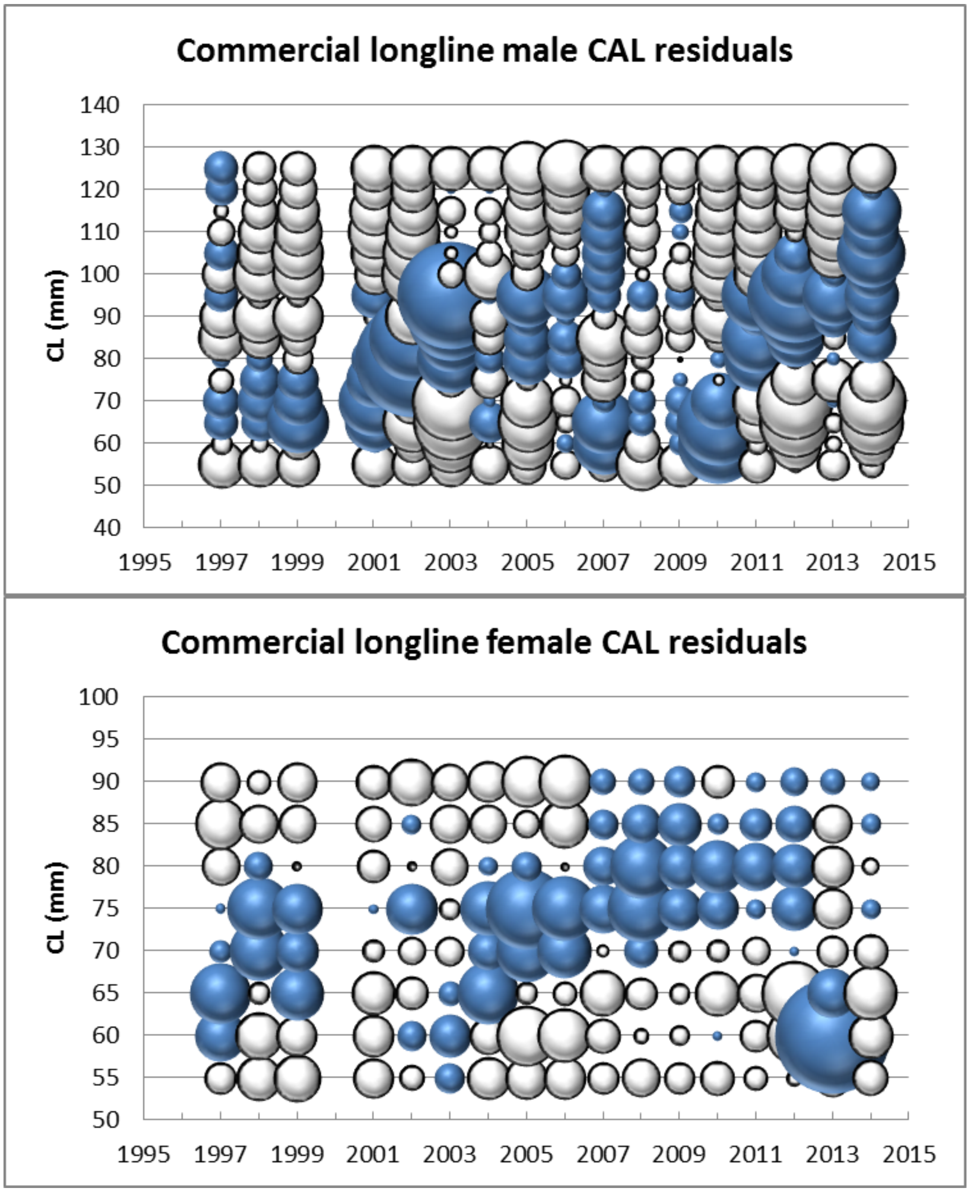
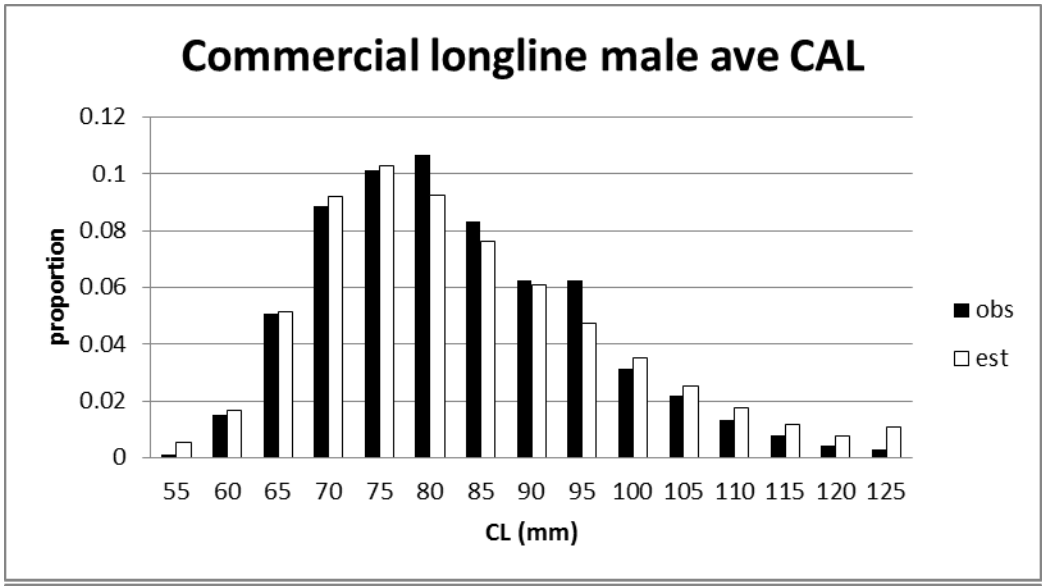


Figure 3c: Nightingale commercial longline CAL fits averaged over years for the **SENBOTH** sensitivity test.



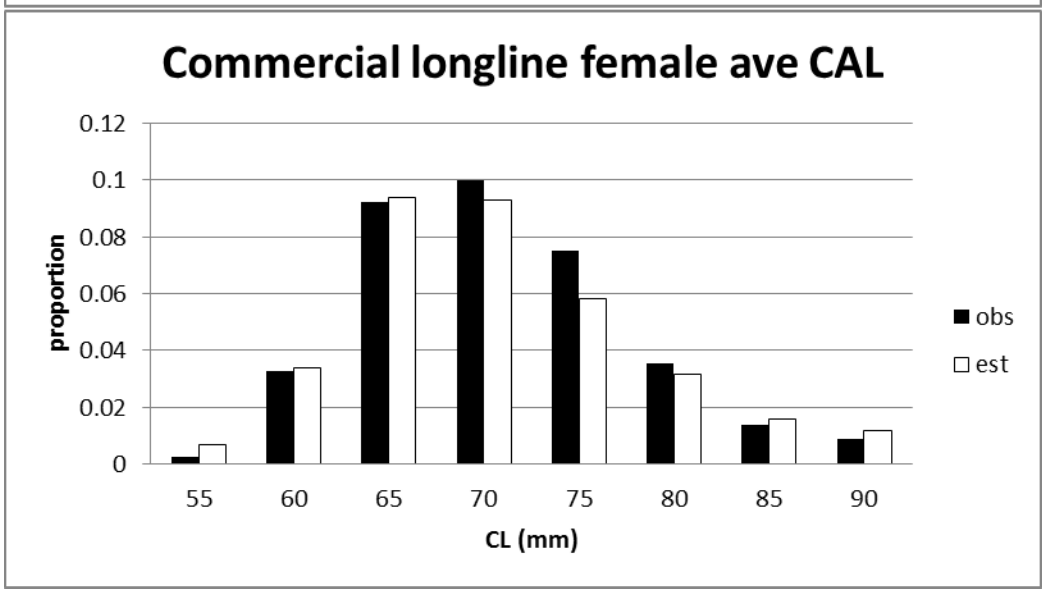


Figure 3d: Nightingale standardized commercial longline CAL residuals for the **SENBOTH** sensitivity test. The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

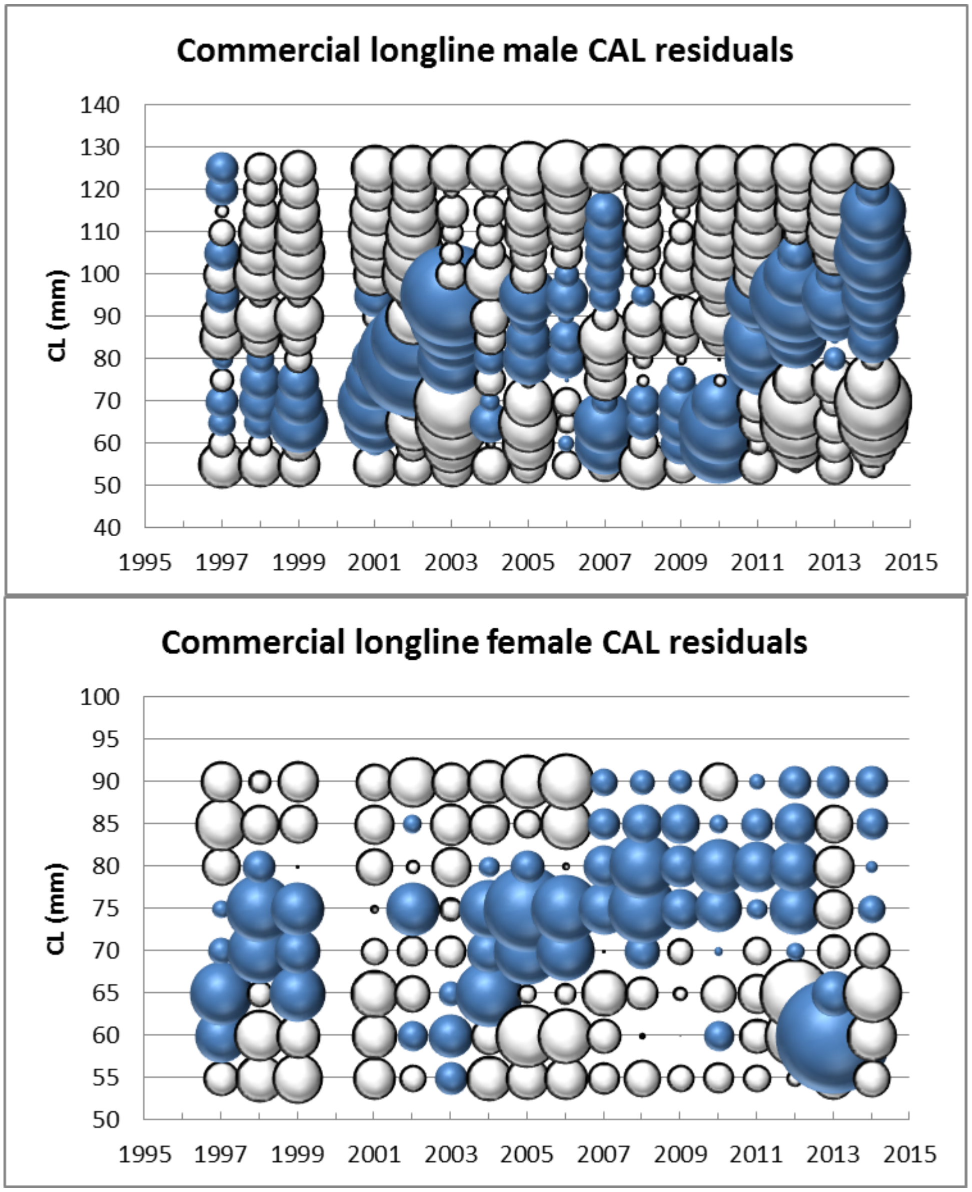
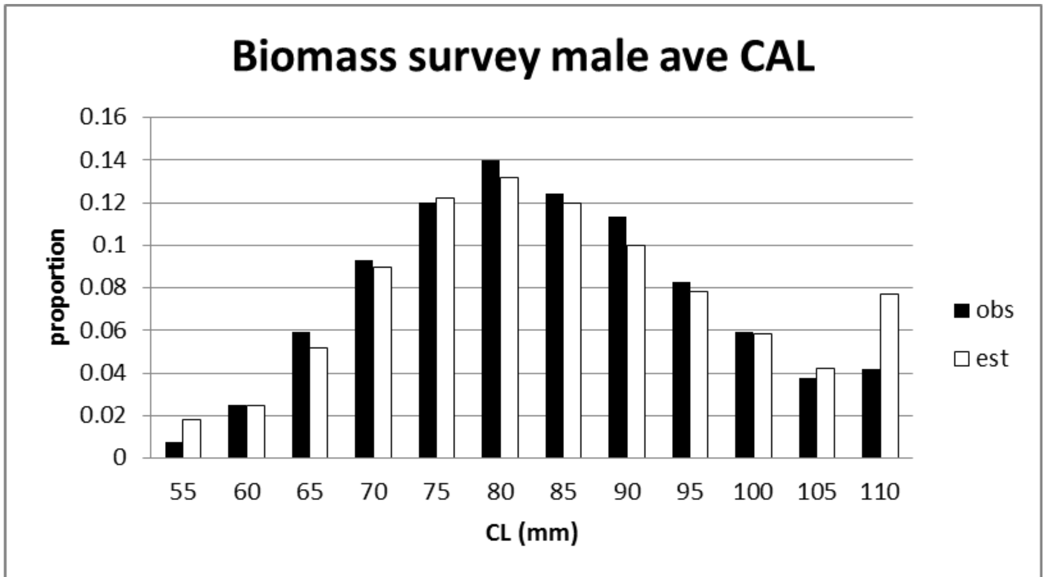


Figure 4a: Nightingale biomass survey Leg1 **RC** CAL fits averaged over years.



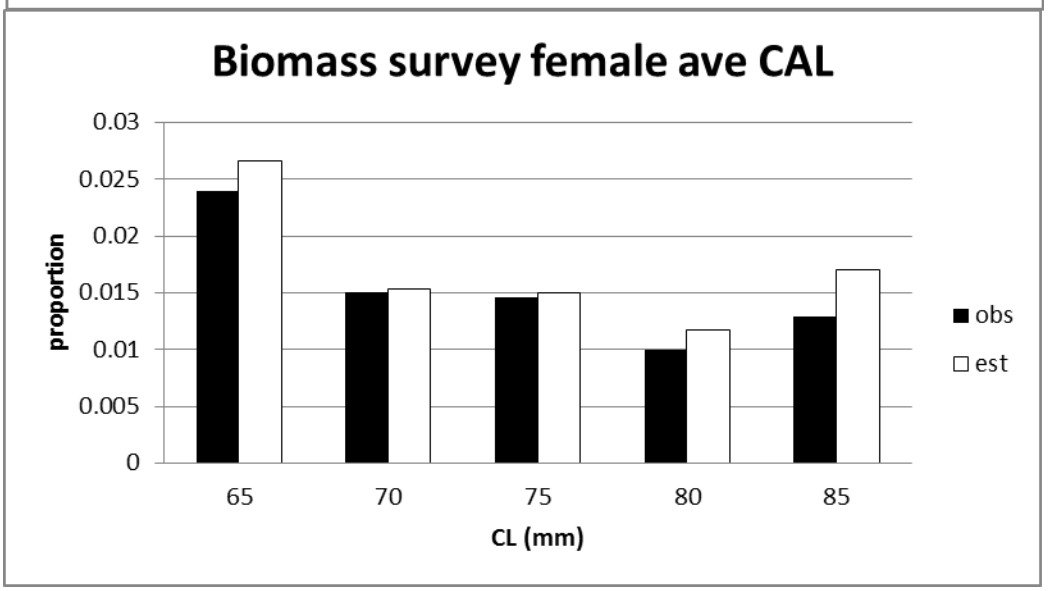
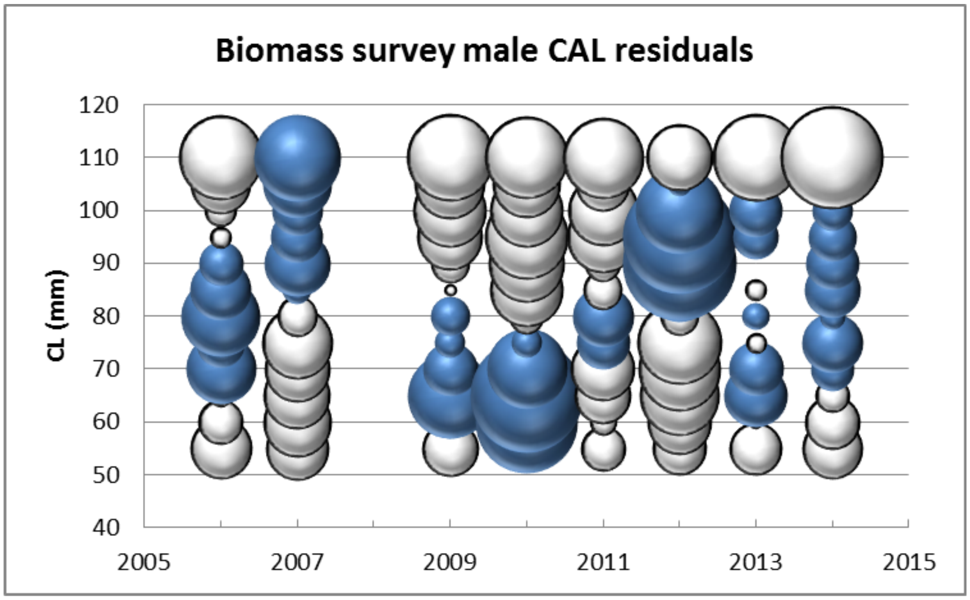


Figure 4b: Nightingale standardized biomass survey CAL residuals for the **RC** model The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.



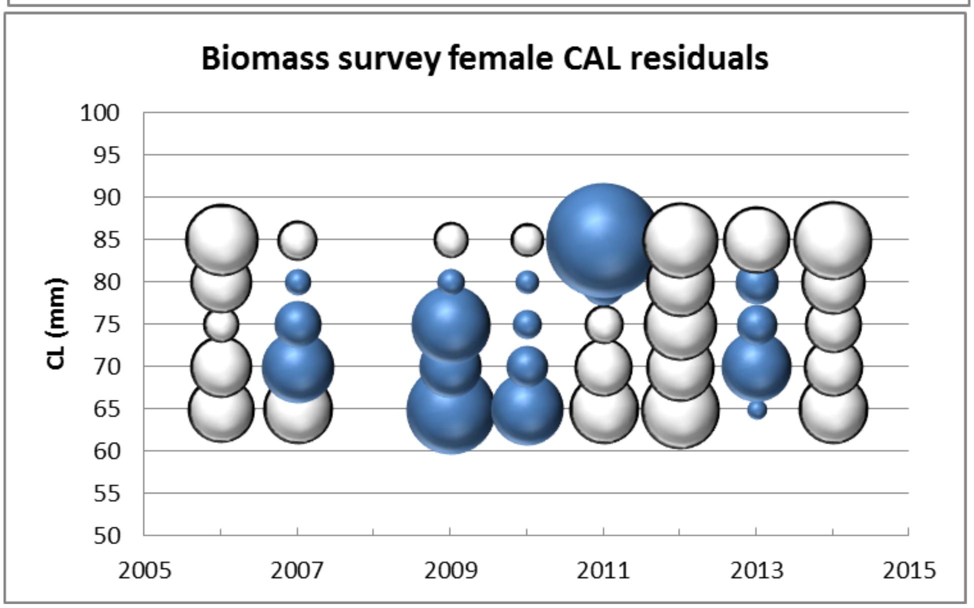
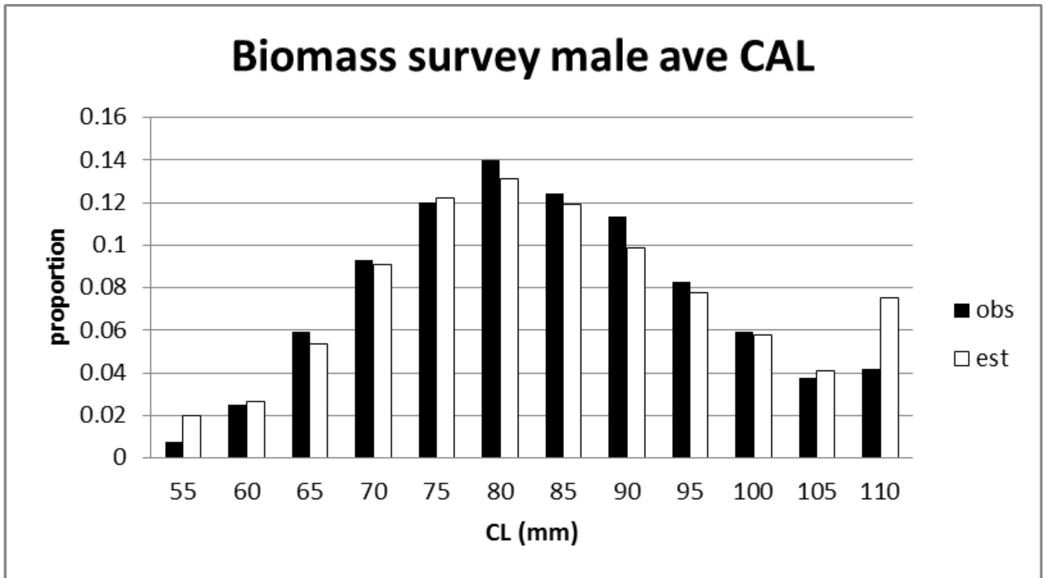


Figure 4c: Nightingale biomass survey Leg1 CAL fits averaged over years for the **SENBOTH** sensitivity test.



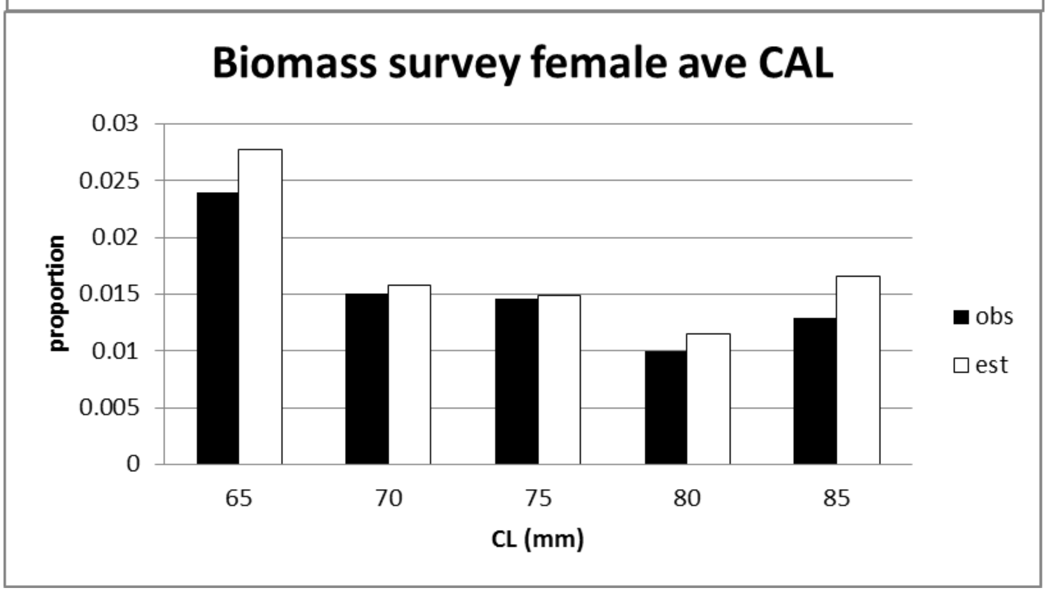
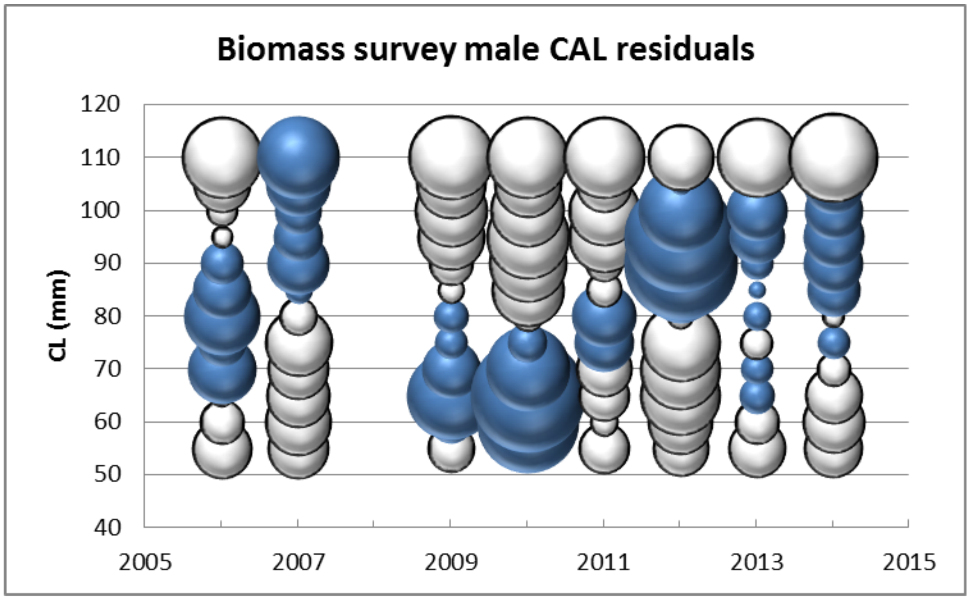


Figure 4d: Nightingale standardized biomass survey CAL residuals for the SENBOTH sensitivity test. The dark bubbles reflect positive and the light bubbles reflect negative residuals, with the bubble radii proportional to the magnitudes of the residuals.



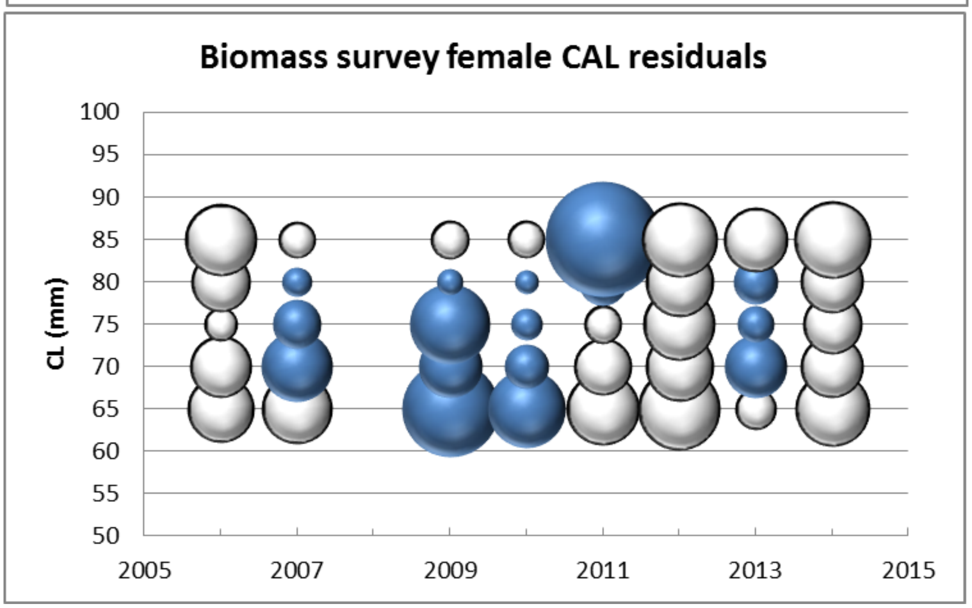


Figure 5a: Comparative plots of the estimated longline catch rates (CPUE) for the **RC** (80% juvenile and 50% adult mortality in 2011 due to OLIVA), **SEN0** (**20%** juvenile and 50% adult mortality in 2011 due to OLIVA), **SEN1** (80% juvenile and **25%** adult mortality in 2011 due to OLIVA), **SEN2** (80% juvenile and **10%** adult mortality in 2011 due to OLIVA) and **SENBOTH** (**20%** juvenile and **10%** adult mortality in 2011 due to OLIVA). The observed GLM longline CPUE data are shown as black circles.

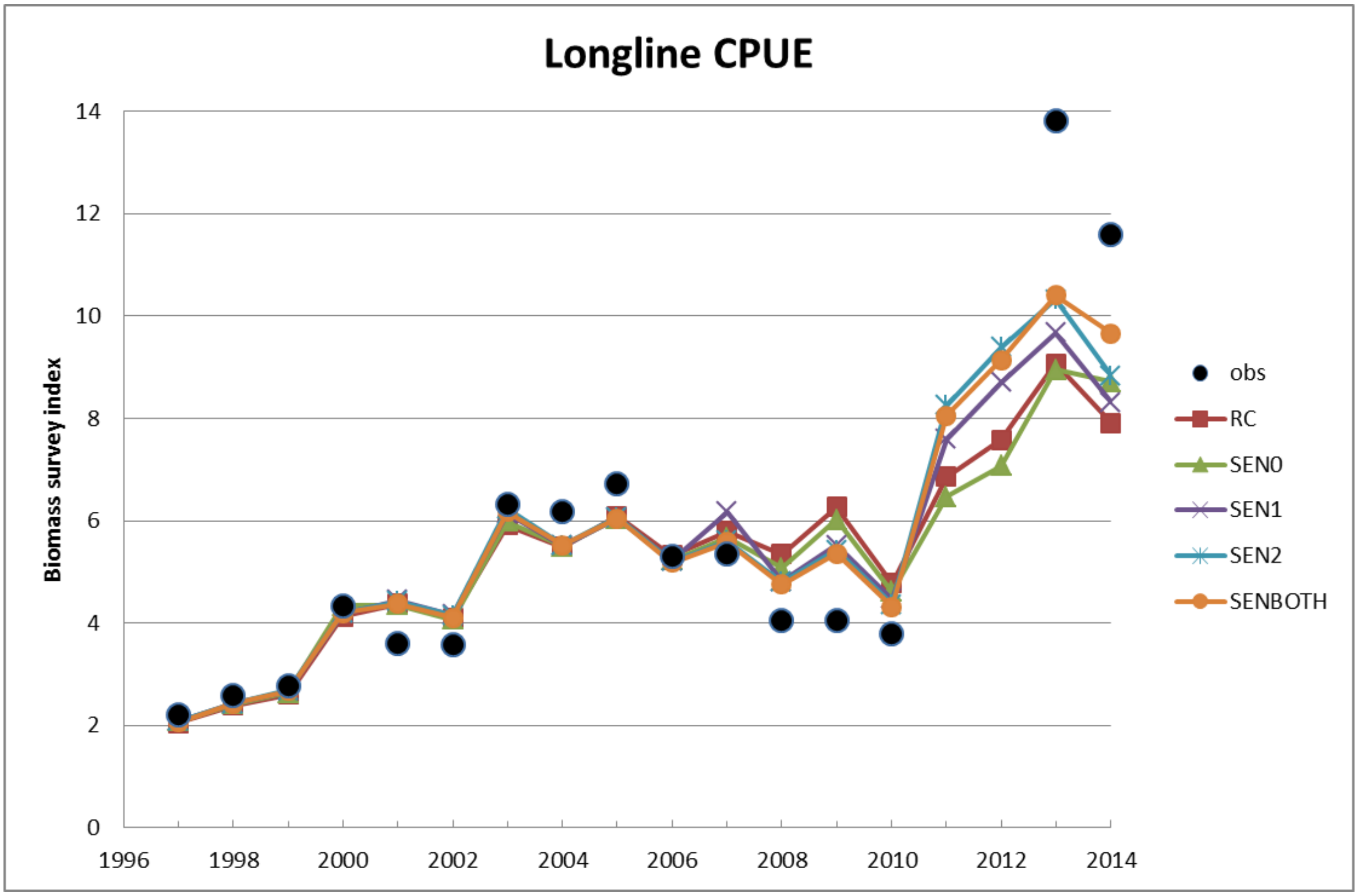


Figure 5b: Comparative plots of the estimated biomass survey indices for the **RC** (80% juvenile and 50% adult mortality in 2011 due to OLIVA), **SEN0** (**20%** juvenile and 50% adult mortality in 2011 due to OLIVA), **SEN1** (80% juvenile and **25%** adult mortality in 2011 due to OLIVA), **SEN2** (80% juvenile and **10%** adult mortality in 2011 due to OLIVA) and **SENBOTH** (**20%** juvenile and **10%** adult mortality in 2011 due to OLIVA). The observed biomass survey indices are shown as black circles.

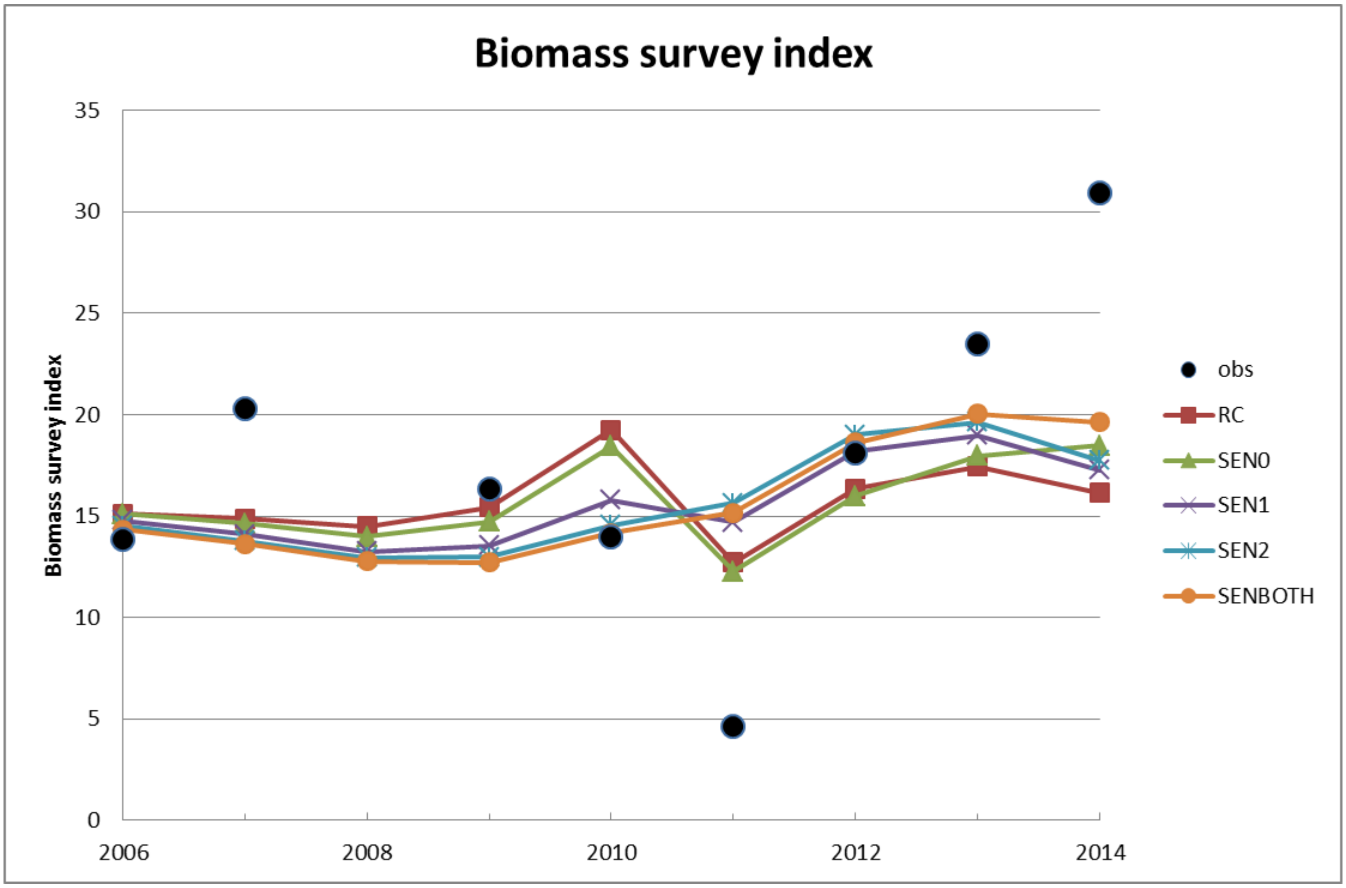


Figure 6a: **RC** projections of the resource into the future for levels of constant catch CC=65 MT and CC= 75 MT. The top plot shows the different catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K*.

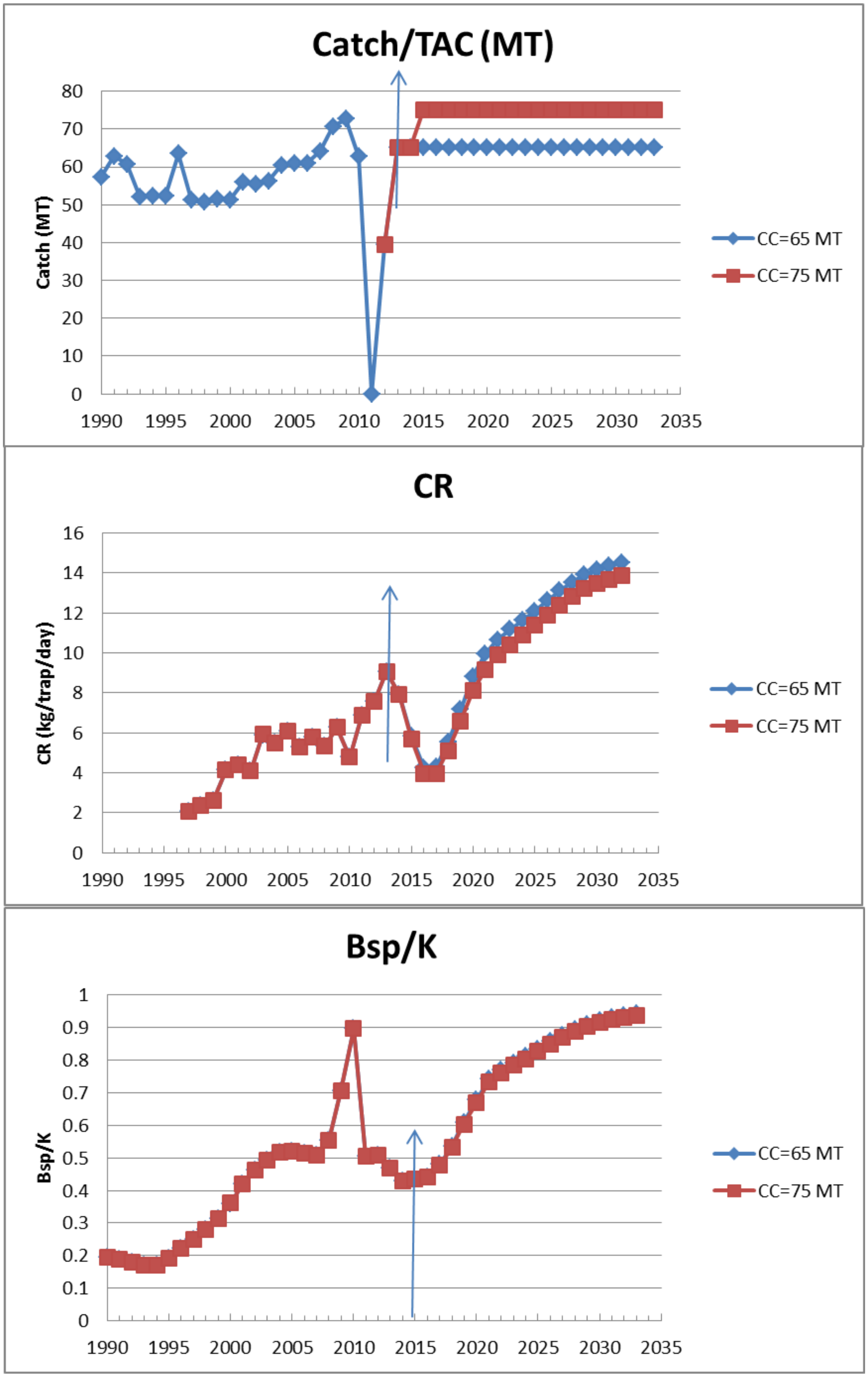


Figure 6b: **SEN2** (80% juvenile and **10%** adult mortality in 2011 due to OLIVA) projections of the resource into the future under levels of constant catch CC=65 MT and CC= 75 MT. The top plot shows the different catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K*.

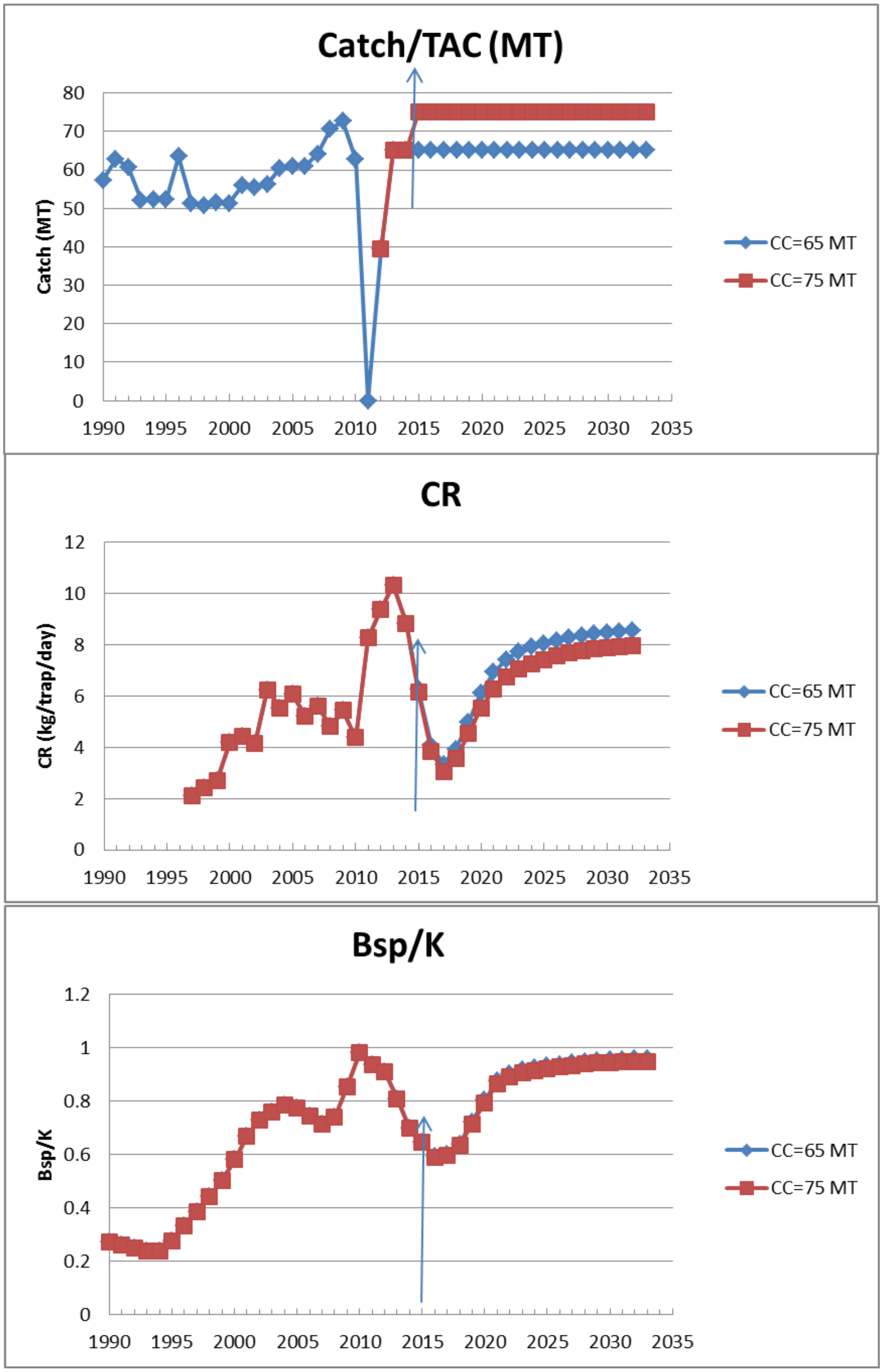


Figure 6c: **SENBOTH** (**20%** juvenile and **10%** adult mortality in 2011 due to OLIVA) projections of the resource into the future under levels of constant catch CC=65 MT and CC= 75 MT. The top plot shows the different catch levels (compared to levels since 1990), the middle plot shows the past and predicted catch rates (CR), and the bottom plot shows the *Bsp/K*.

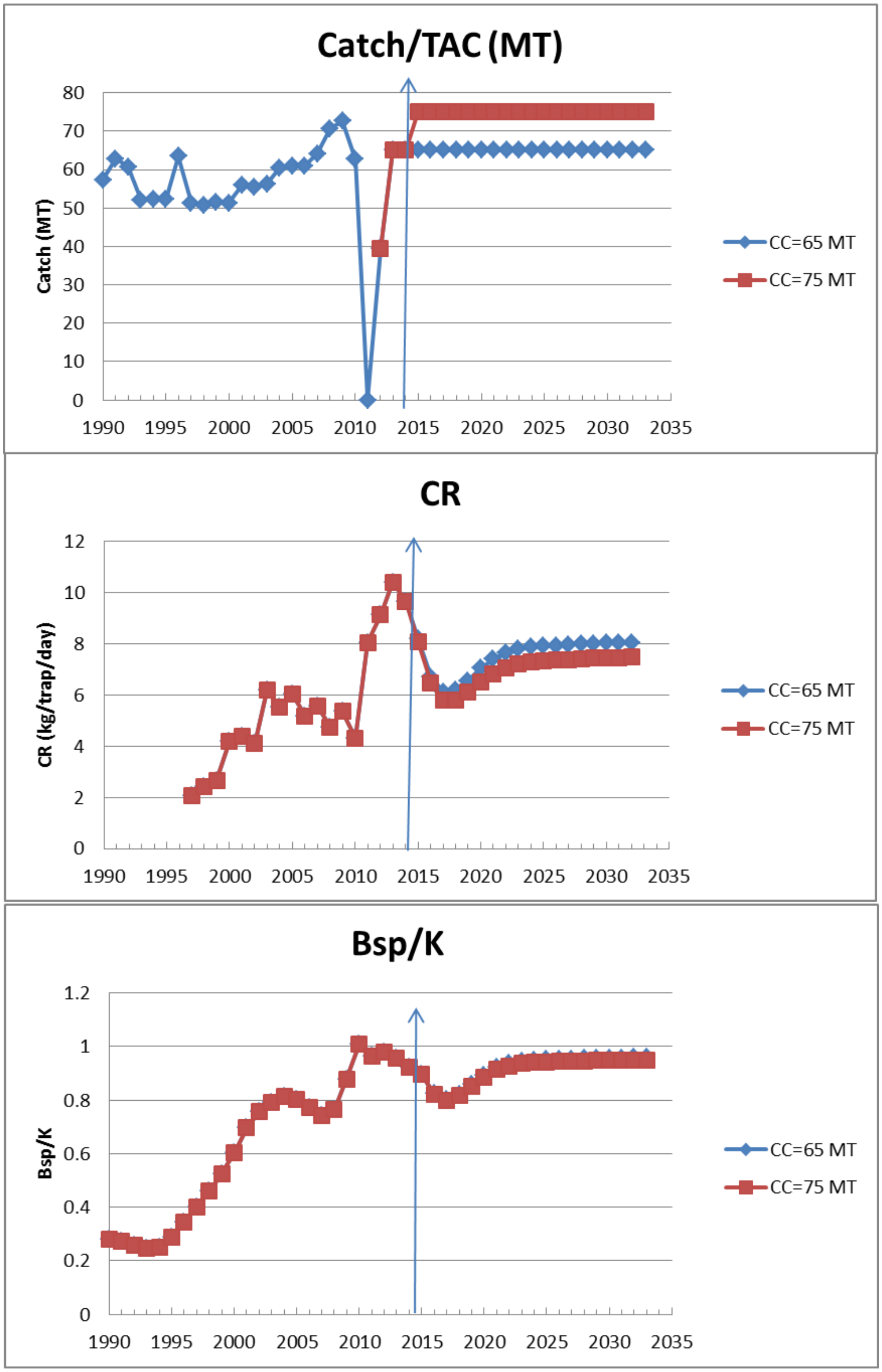


Figure 7: CR and *Bsp/K* Projections of a **CC = 65 MT** for the **RC** (80% juvenile and 50% adult mortality in 2011 due to OLIVA), **SEN0** (**20%** juvenile and 50% adult mortality in 2011 due to OLIVA, **SEN2** (80% juvenile and **10%** adult mortality in 2011 due to OLIVA) and **SENBOTH** (**20%** juvenile and **10%** adult mortality in 2011 due to OLIVA). The observed GLM longline CPUE data are shown as open circles.