Updated 2014 Inaccessible and Gough island assessments

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Summary

This paper provides updated assessments of the rock lobster resources at Inaccessible and Gough islands. These assessments include updated data from the commercial fishery and biomass index data from the Leg1 annual biomass surveys. These updated assessment models will function as the underlying baseline operating models in the development of OMPs for each island.

Introduction

The age-structured population model used for these assessments is described fully in Johnston and Butterworth (2013a). The assessments are identical to those provided in 2013 (Johnston and Butterworth 2013b) except that these 2014 assessment models are fit to one year's further data with that year indicated in bold below:

1) Standardised longline CPUE data for 1997-**2012**.
2) Biomass survey Leg1 CPUE data (2006-**2013**, with 2008 data absent).
3) Catch-at-length data from the onboard observers (males and females separate) (1997-**2012**).
4) Catch-at-length data from the Leg1 biomass survey (males and females separate) (2006-2012, with 2008 data absent). (The 2013 CAL data are not yet available.)
5) Discard % (1997-**2012**).

Impact of the OLIVA on Inaccessible

The impact that the OLIVA had on the resource at Inaccessible is modelled by assuming a 35% once off mortality of lobsters aged 1, 2 and 3 years during the 2011 season, as previously considered the most reasonable assumption[1].

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

Inaccessible model development

The first step in the updated assessments was to simply add the new data and run the previous (2013) assessment model. This is named "Model 1". It was notable that the 2012 commercial CAL data showed a particularly strong shift towards larger lobsters, so the assessment model was modified to allow for the selectivity to change again for the 2012+ period. This formed Model 2. Model 3 is however the preferred model to be used as a baseline; this allows the selectivity "μ" values for both males and females to be vary in the model fitting process (in contrast to having three or four fixed periods of time varying selectivity) to allow for more flexibility in fitting to the data. These "μ" values determine the shape of the descending limb of the selectivity curve. The selectivity functions have previously been defined as follows for the commercial fishery:

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

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

The estimable parameters were thus:

- $l_*^{m/f}$,
- $\delta^{m/f}$,
- $\mu^{m/f}$ (with three values for each of the three selectivity periods selected]), and
- *P* (the female scaling parameter).

The selectivity functions for males are scaled so that the maximum selectivity value is 1.0, and the female selectivity function is scaled by the multiplicative parameter *P* so that the maximum selectivity value for females is equal to *P*.

For Model 3, equations (1) and (2) above are modified to allow random variation in the μ parameter values as follows:

$$S_{y,l}^{m,comm} = \frac{e^{-(\mu^m+\varepsilon_y^m)l}}{1+e^{-\delta^m (l-l_*^m)}} \quad (3)$$

$$S_{y,l}^{f,comm} = P\frac{e^{-(\mu^f+\varepsilon_y^f)l}}{1+e^{-\delta^f (l-l_*^f)}} \quad (4)$$

where

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

$$\varepsilon_y^f \sim N(\,0, (\sigma_\mu^2)\,) \quad (5)$$

Consequently a penalty term is added to the likelihood:

$$-lnL \rightarrow -lnL + \frac{1}{2\sigma_\mu^2}\sum_{1997}^{2012}[(\varepsilon_y^m)^2 + (\varepsilon_y^f)^2] \quad (6)$$

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 ε_y values to vary sufficiently. The contribution of the abundance data to the negative of the log-likelihood function (after removal of constants) is given by:

$$-\ln L = \sum_y \left[(\varepsilon_y)^2 / 2(\sigma^2 + c^2) + \ln(\sigma + c)\right] \quad (7)$$

where

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

$$\hat{\sigma} = \sqrt{1/n\sum_y \left(\ln CPUE_y - \ln \hat{q}\,\hat{B}_y\right)^2} \quad (8)$$

and 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:

ε_μ=0.02

c = 0.6.

Gough model development

Previously for Gough, two alternate somatic growth models have been used – the Pollock growth model and the James Glass growth model (see Johnston and Butterworth 2011, 2013 for further details). Recent data from the tagging study (provided by James Glass, pers. commn) show clearly that the "Pollock" growth model is more suited than the "James Glass" growth model for Gough (see Appendix 1 for further details). The 2014 updated baseline assessment for Gough has thus been developed assuming the "Pollock" growth model to apply.

As for the 2013 assessment, it was found that modifications to the selectivity function for smaller sized lobsters was required to improve the model fit. These have been retained (with slight adjustment to the actual values of the fixed parameters) and are reported in Appendix 2.

The "Model 3" form was also used to provide the baseline Gough 2014 updated assessment, i.e. the μ selectivity parameter values for both males and females were estimated in the model fitting procedure, as described above for Inaccessible. It was found however, that allowing the female scaling parameter "P" to vary over time also produced better fits of the model to the CAL data. Thus equation (4) was further modified to:

$$S_{y,l}^{f,comm} = (P + \varepsilon_y^P)\frac{e^{-(\mu_y^f + \varepsilon_y^f)l}}{1 + e^{-\delta^f (l - l_*^f)}} \qquad (9)$$

where

$$\varepsilon_y^P \sim N(\,0, (\sigma_P^2)\quad) \qquad (10)$$

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

$$-lnL = -lnL + \frac{1}{2\sigma_\mu^2}\sum_{1997}^{2012} (\varepsilon_y^P)^2 \qquad (11)$$

and σ_P is fixed at 0.2.

Results

Updated Inaccessible assessment

Table 1 reports the Inaccessible 2014 updated assessment results for Models 1, 2 and 3, and provides the 2013 assessment results for comparison. Note that the total –lnL values are not comparable as the 2013 assessment uses additional data, and Model 3 includes further estimable parameters and contributions to the likelihood.

Figures 1a-f show results for Model 1 – a simple update of the 2013 assessment with new data, i.e. no changes to the assessment model. Figures 2a-f show results for the preferred baseline Model 3 which include changes to the way the selectivity is estimated.

From Figure 2a, it is evident that the fits to the CPUE data are good, and the fit to the catch-at-length data has been much improved (see the –lnL CAL T values in Table 1). Estimates of the spawning biomass (Bsp) in 1990 relative to pristine are lower (0.27) than that estimated in 2013 (0.49). The current Bsp/K remains high and is estimated to be at a healthy 0.87K.

The model continues to underestimate the discard proportion. This current underestimation is not seen as an immediate major concern because the manner in which these data are collected – fairly rough onboard estimates of amounts discarded – means that they are probably not very accurate. The fits to both the longline and biomass survey catch-at-length data are good in terms of aggregates over years (Figures 2c and d), but residual patterns do remain at the annual level (Figures 2e and f). The recent exploitable biomass trend is increasing whilst the spawning biomass is estimated to be fairly steady (Figure 2a). Note, however, that the OLVIA effect of an assumed 35% mortality of the age 1-3 year olds in 2011 does not yet impact the assessment results, and that this possible effect will become evident only around 2016.

Updated Gough Assessment

Table 2 reports the Gough 2014 updated assessment results, and provides the 2013 assessment results for comparison. As with Inaccessible, Model 3 is the preferred baseline model, producing improved fits to the commercial CAL data in particular.

Current Bsp/K is again estimated to be healthy (0.86K), although the current Bsp trend is decreasing. The overall fits to discard proportion data remain poor (as for the Inaccessible assessment), although this appears to improve in more recent years (see Figure 3a).

References

Edwards, C.E. and Rademeyer, R. A. 2013. Fisheries advice to the Tristan da Cunha Administration. Phase ii: Development of a new management plan for rock lobster fisheries in the Tristan da Cunha archipelago. MRAG Ltd London, 23 pp.

Johnston, S.J. and D.S. Butterworth. 2011. Summary of growth rate data and analyses available for the Tristan da Cunha group of islands. MARAM document, MARAM/TRISTAN/2011/Jun/09. 8pp.

Johnston, S.J. and Butterworth, D.S. 2013a. 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. 2013b. updated 2013 rock lobster assessments for Inaccessible and Gough islands. MARAM/Tristan/2013/Sep/12. 27pp.

Table 1: Inaccessible 2014 assessment results. The 2013 assessment results are reported to allow comparison. The shaded values are fixed on input. Apart from Model 1 and 2, the –lnL values are not comparable. Values in parentheses are estimated σ values.

	2013 assessment	**2014 assessment Model 1 (selectivity as for 2013)**	**2014 assessment Model 2 (allow for selectivity to shift again in 2012)**	**2014 assessment Model 3 (the male and female μ values all estimated; $\sigma_{\mu} = 0.02$)**
# parameters	**42**	**42**	**42**	**69**
K	1284	1421	1404	1569
h	0.91	0.81	0.83	0.91
M	0.2	0.2	0.2	0.2
d (discard mortality rate)	0.1	0.1	0.1	0.1
σ_{length}	0.2	0.2	0.2	0.2
F_{2009} fixed at	0.3	0.3	0.3	0.3
Male selectivity μ 90-00	0.023	0.011	0.011	All μ values estimated separately for male and females for years for which CAL data are available
Male selectivity μ 01-03	0.013	0.011	0.012	
Male selectivity μ 04-05	0.001	0.002	0.002	
Male selectivity μ 06+	0.032	0.033	0.035	
Male selectivity μ 12+	-	-	0.017	
Female selectivity μ 90-00	0.149	0.145	0.150	
Female selectivity μ 01-03	0.179	0.174	0.181	
Female selectivity μ 04+	0.198	0.196	0.210	
Female selectivity μ 12+	-	-	0.133	
θ	0.522	0.258	0.268	0.291
-lnL total	-21.83	-23.96	-26.16	-6.95
-lnL CPUE T	-28.83	-29.96	-32.58	-10.21
-lnL CPUE longline	-22.97	-24.72	-26.97	-4.94 (0.111)
-lnL CPUE Survey Leg1	-5.86	-5.24	-5.61	-5.27 (0.214)
-lnL CAL T	-10.97	-42.58	-36.78	-62.02
-lnL CAL onboard observer	12.28	2.31	4.09	-30.45 (0.066)
-lnL CAL Survey Leg 1	-23.15	-44.89	-40.90	-31.57 (0.078)
SR1 pen; μ pen	5.02; -	6.55; -	6.20; -	2.14; 4.38
-lnL discard	3.75	4.14	4.39	3.60
Bsp(1990)/Ksp	0.49	0.24	0.25	0.27
Bsp(2012)/Ksp	0.82	0.84	0.81	0.83
Bsp(2013)/Ksp	0.81	0.87	0.81	0.85
Bsp(2014)/Ksp	-	0.89	0.84	0.87
Bsp(2011)/Bsp(1990)	1.70	3.41	3.20	3.00
Bsp(2012)/Bsp(1990)	1.68	3.52	3.24	3.08
Bsp(2013)/Bsp(1990)	1.69	3.61	3.28	3.16
Bsp(2014)/Bsp(1990)	-	3.72	3.36	3.23
Bexp(2012)/Bexp(1990)	1.52	3.06	3.54	3.47
Bexp(2013)/Bexp(1990)	-	3.48	4.01	3.88
Program	Test4.*	Inac13x.*	z.tpl*	Inacran.tpl; iran6.rep

Table 2: Gough 2014 assessment results for the "Pollock" growth model. The 2013 assessment results are reported to allow comparison. The shaded values are fixed on input. Apart from Model 1 and 2, the –lnL values are not comparable. Values in parentheses are estimated σ values.

	2013	**2014 assessment Model 1 (selectivity as for 2013)**	**2014 assessment Model 2 (allow for selectivity to shift again in 2012)**	**2014 assessment Model 3 (the male and female μ values all estimated; $\sigma_\mu = 0.02$)**
# parameters	41	41	43	85
K	258	271	272	311
h	0.98	0.96	0.96	0.93
M	0.2	0.2	0.2	0.2
d (discard mortality rate)	0.1	0.1	0.1	0.1
σ_{length}	0.2	0.2	0.2	0.2
F_{2009} fixed at	0.3	0.3	0.3	0.3
Male selectivity μ 90-01	0.001	0.001	0.003	All μ and female selectivity scalar values estimated separately for male and females for years for which CAL data are available
Male selectivity μ 02-06	0.0002	0.001	0.001	
Male selectivity μ 07-11	0.011	0.001	0.008	
Male selectivity μ 12+	0.011	0.001	0.001	
Female selectivity μ 90-01	0.491	0.300	0.272	
Female selectivity μ 02-06	0.458	0.260	0.234	
Female selectivity μ 07-11	0.482	0.278	0.253	
Female selectivity μ 12+	0.482	0.278	0.001	
θ	0.916	0.829	0.831	0.752
-lnL total	-6.08	-4.56	-4.84	10.98
-lnL CPUE T	-23.50	-25.71	-25.57	-7.70
-lnL CPUE longline	-20.19	-21.42	-21.37	-3.47 (0.158)
-lnL CPUE Survey Leg1	-3.31	-4.28	-4.29	-4.22 (0.319)
-lnL CAL T	32.42	64.68	60.8	-9.00
-lnL CAL onboard observer	93.55	127.58	124.69	54.48 (0.095)
-lnL CAL Survey Leg 1	-61.13	-62.90	-63.89	-63.47 (0.070)
SR1 pen	3.36	3.99	3.91	2.72
-lnL discard	11.09	10.78	10.78	15.62
Bsp(1990)/Ksp	0.86	0.78	0.75	0.70
Bsp(2012)/Ksp	0.92	0.97	0.96	0.95
Bsp(2013)/Ksp	0.88	0.92	0.92	0.90
Bsp(2014)/Ksp	-	0.88	0.87	0.86
Bsp(2012)/Bsp(1990)	1.08	1.25	1.24	1.35
Bsp(2013)/Bsp(1990)	1.02	1.19	1.18	1.29
Bsp(2014)/Bsp(1990)	-	1.13	1.13	1.23
Bexp(2012)/Bexp(1990)	1.12	1.34	1.21	1.36
Bexp(2013)/Bexp(1990)	-	1.21	1.20	1.19
Programs	Ptry.tpl;ptry.rep	G14.tpl	G14x.tpl	Gran.tpl

Figure 1a: Inaccessible 2014 assessment results – Model 1.

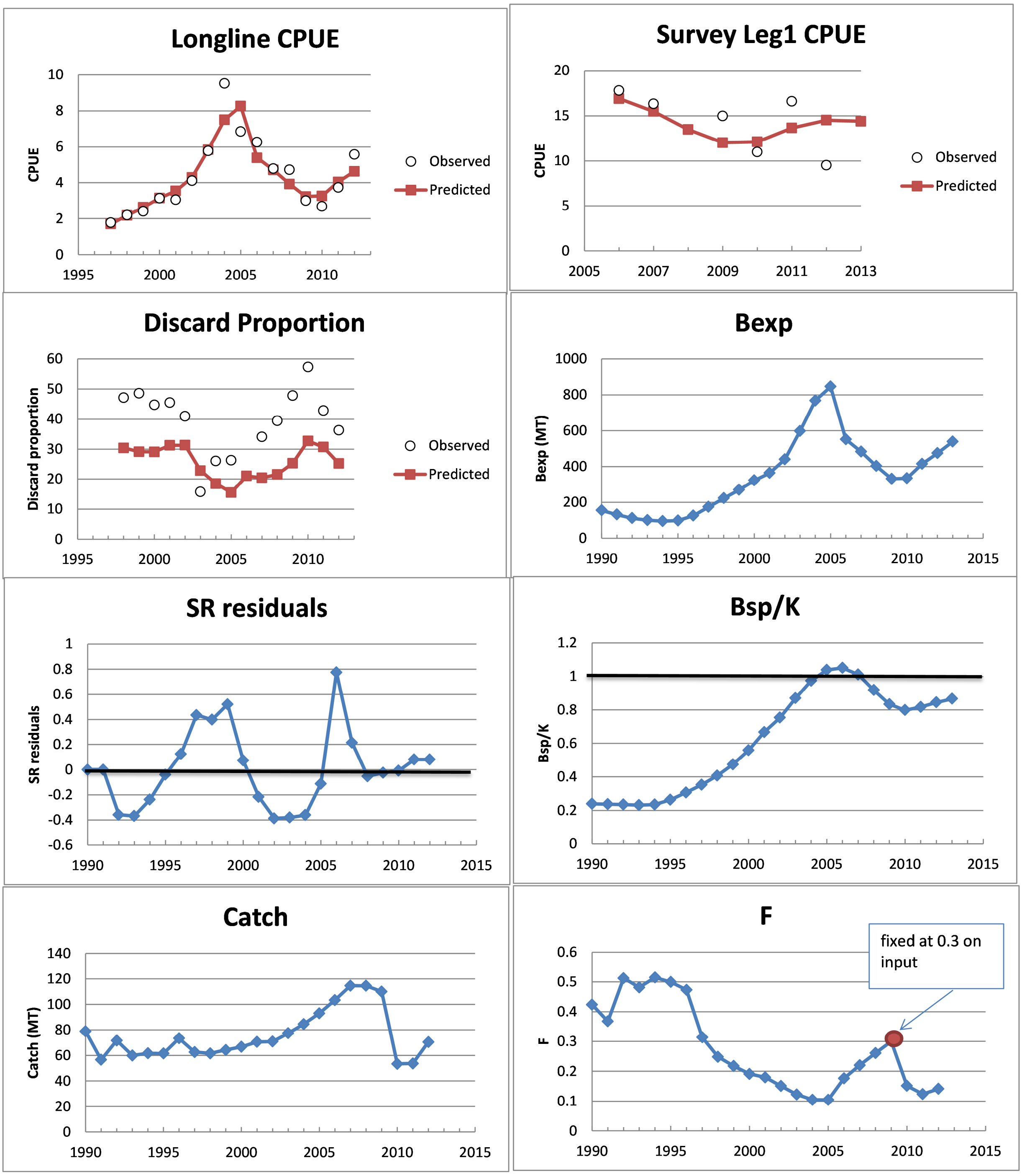


Figure 1b: Inaccessible selectivity functions – Model 1.

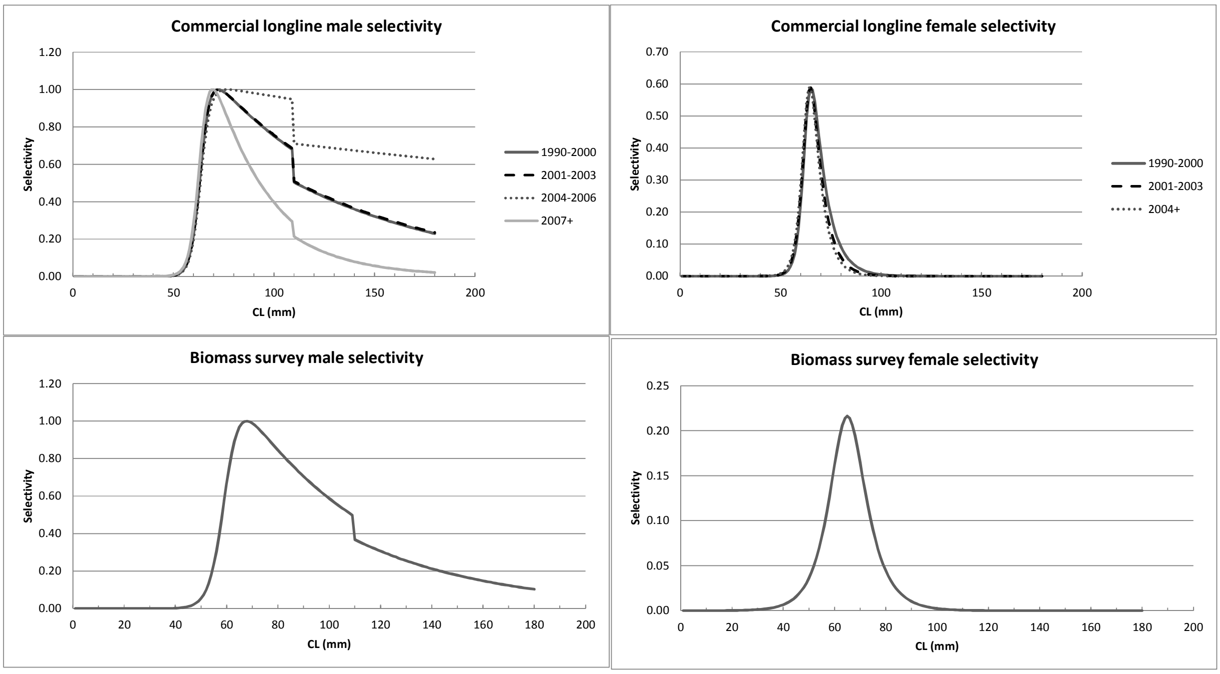
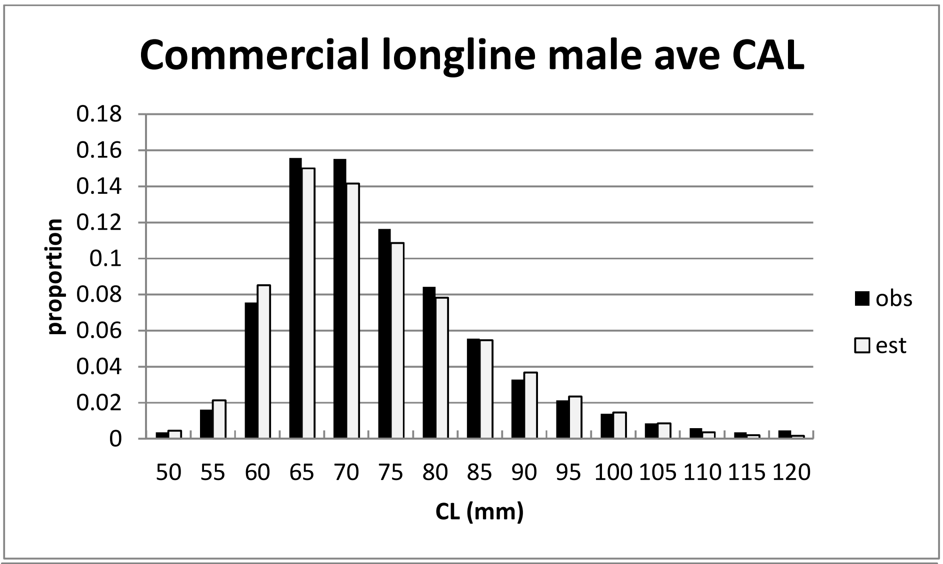


Figure 1c: Inaccessible commercial longline CAL fits averaged over years – Model 1.



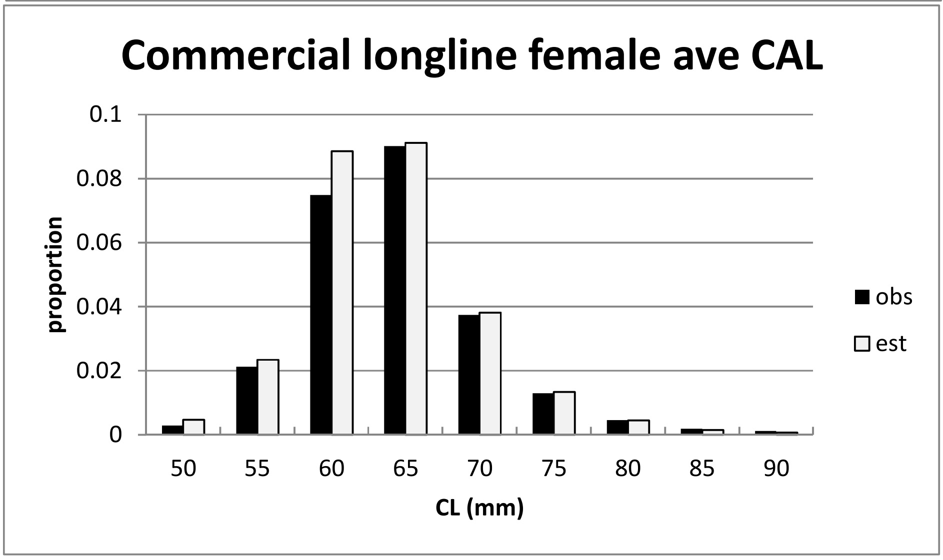
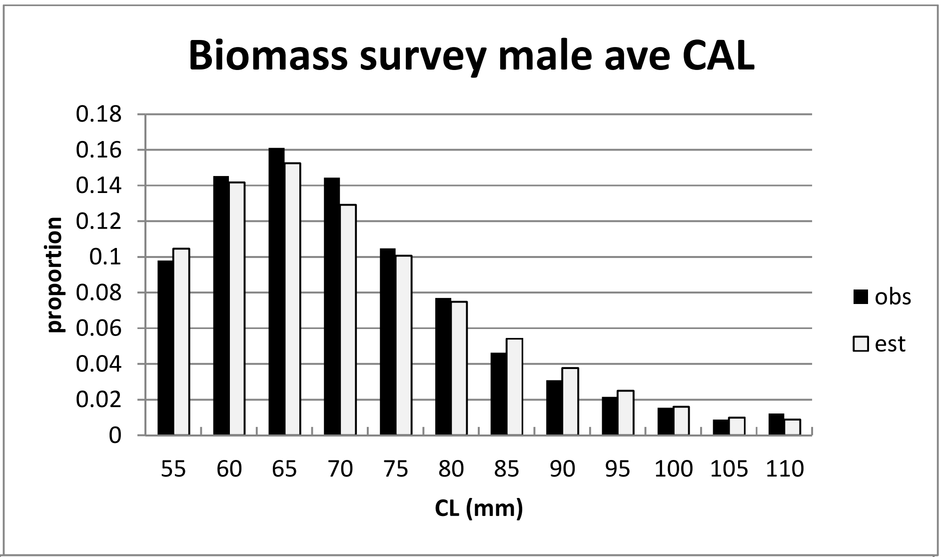


Figure 1d: Inaccessible biomass survey Leg1 CAL fits averaged over years – Model 1.



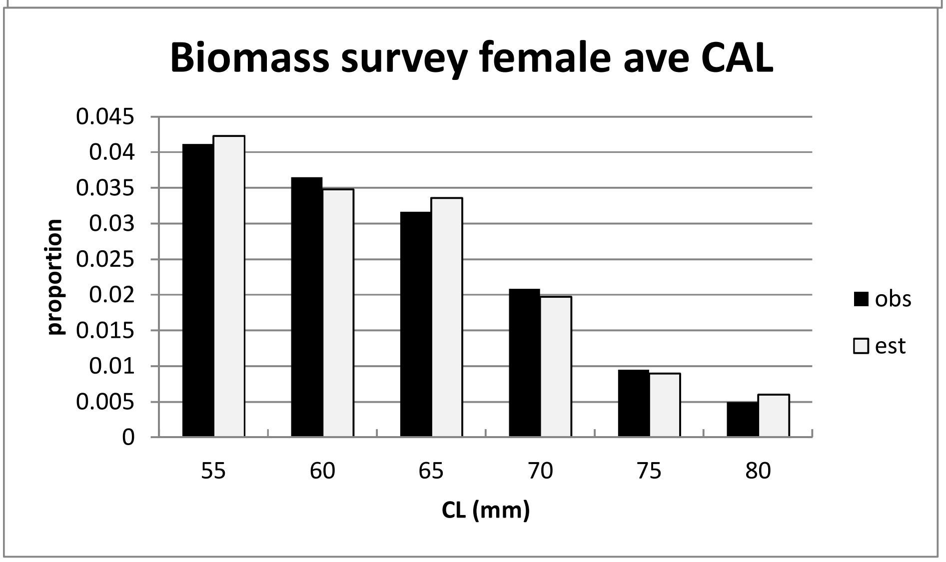
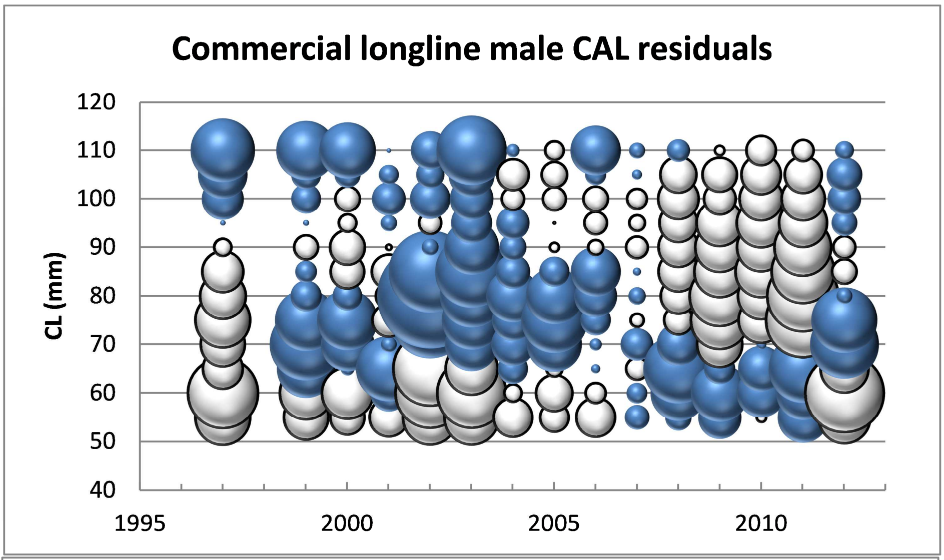


Figure 1e: Inaccessible standardised commercial longline CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals – Model 1.



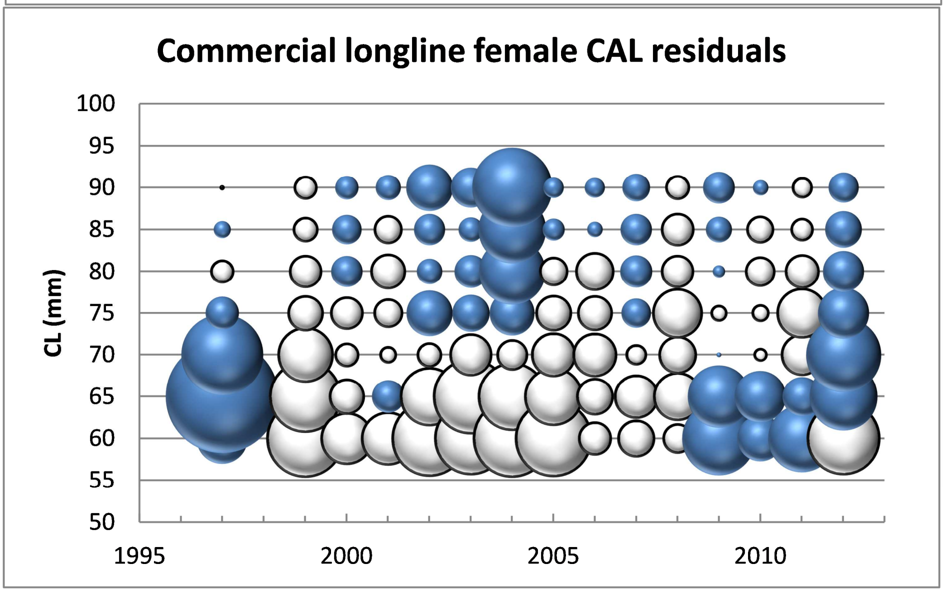


Figure 1f: Inaccessible standardised biomass survey Leg1 CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals – Model 1.

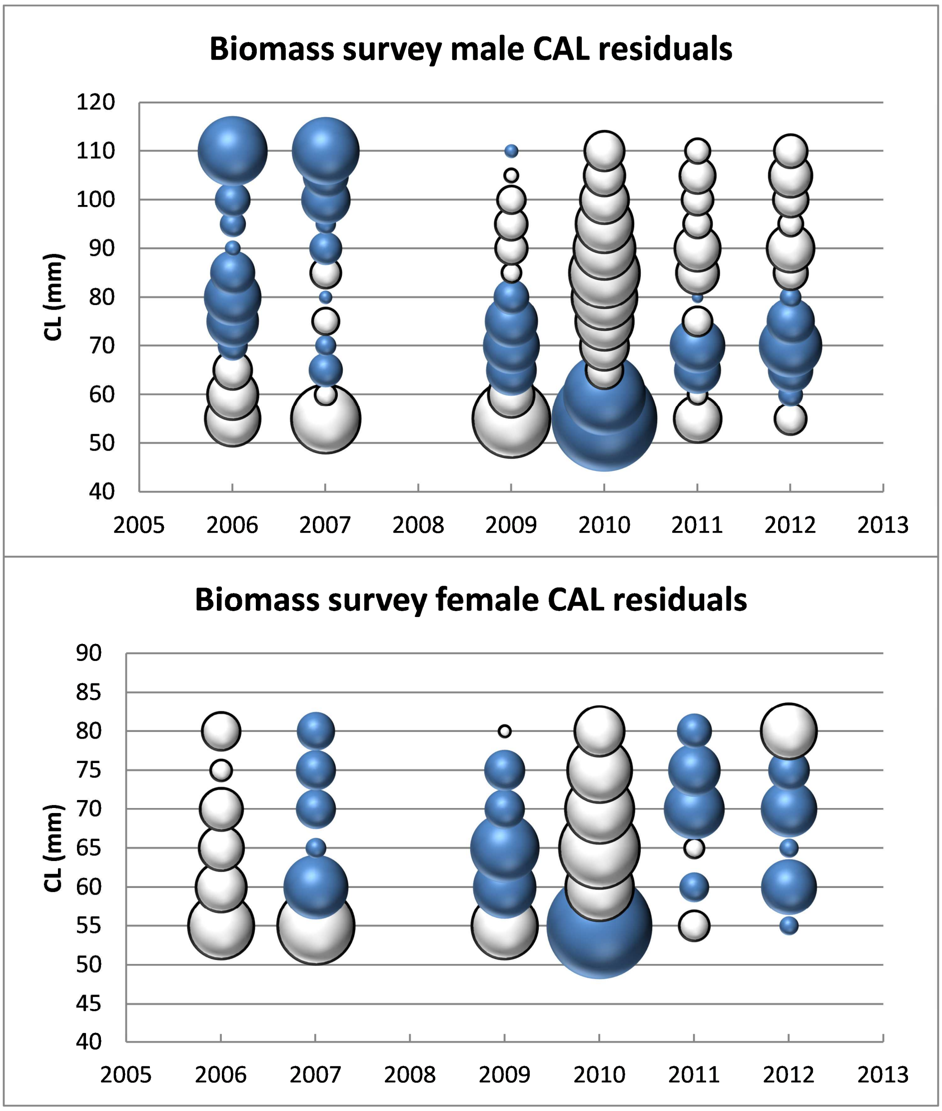


Figure 2a: Inaccessible 2014 assessment results – Model 3.

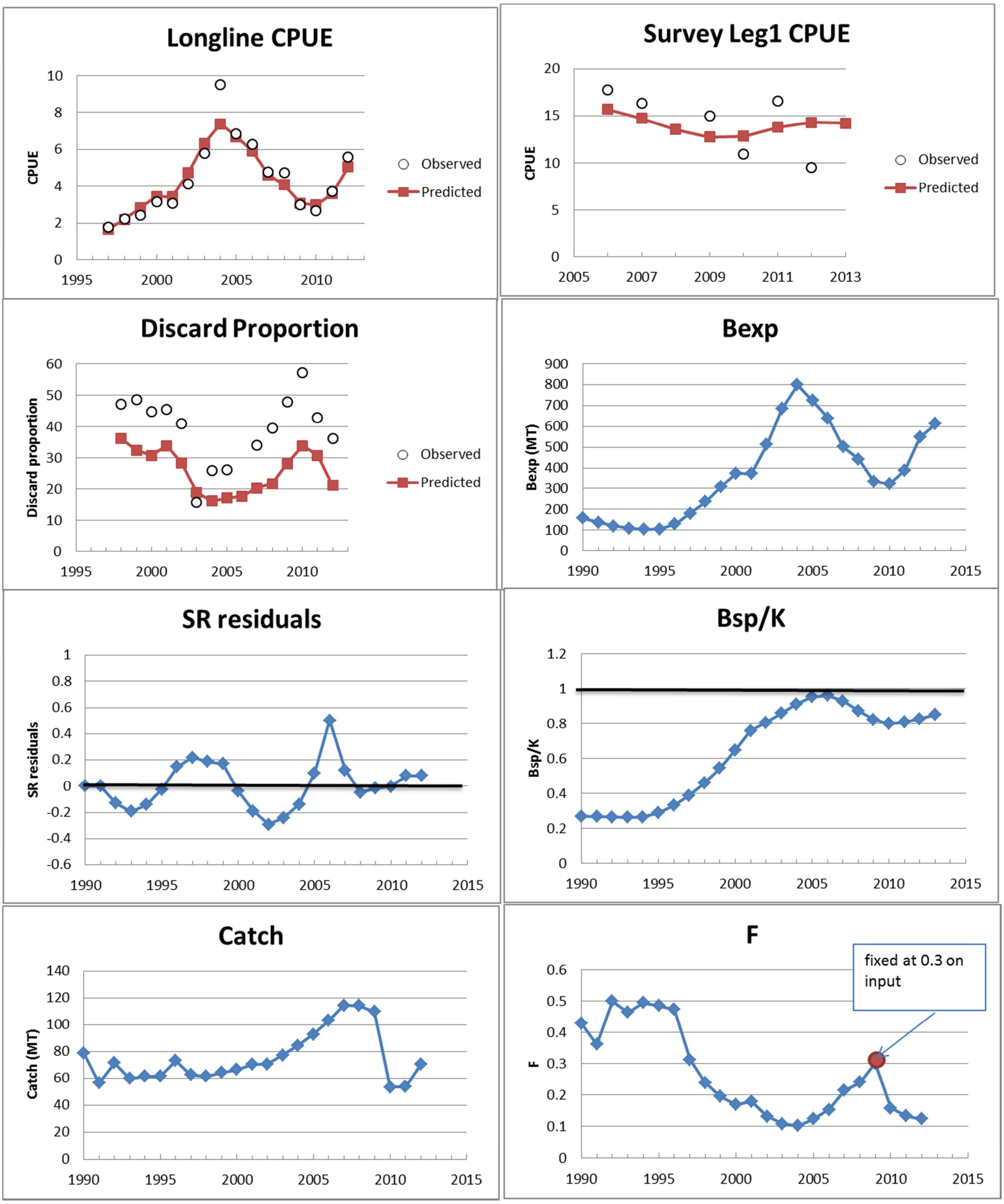


Figure 2bi: Inaccessible selectivity functions – Model 3.

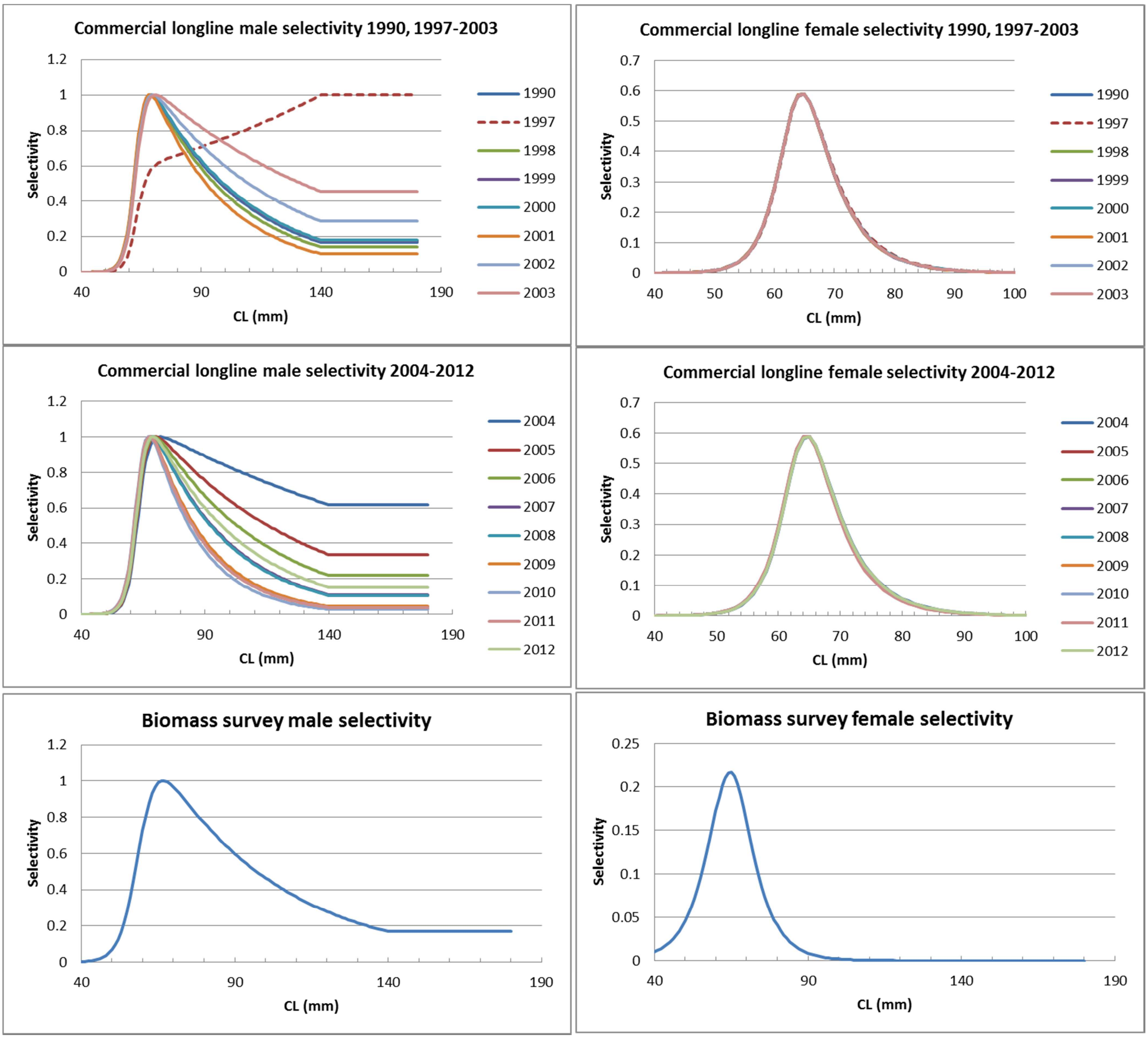


Figure 2bii: Inaccessible estimated μ residuals(used for selectivity function variability) – Model 3.

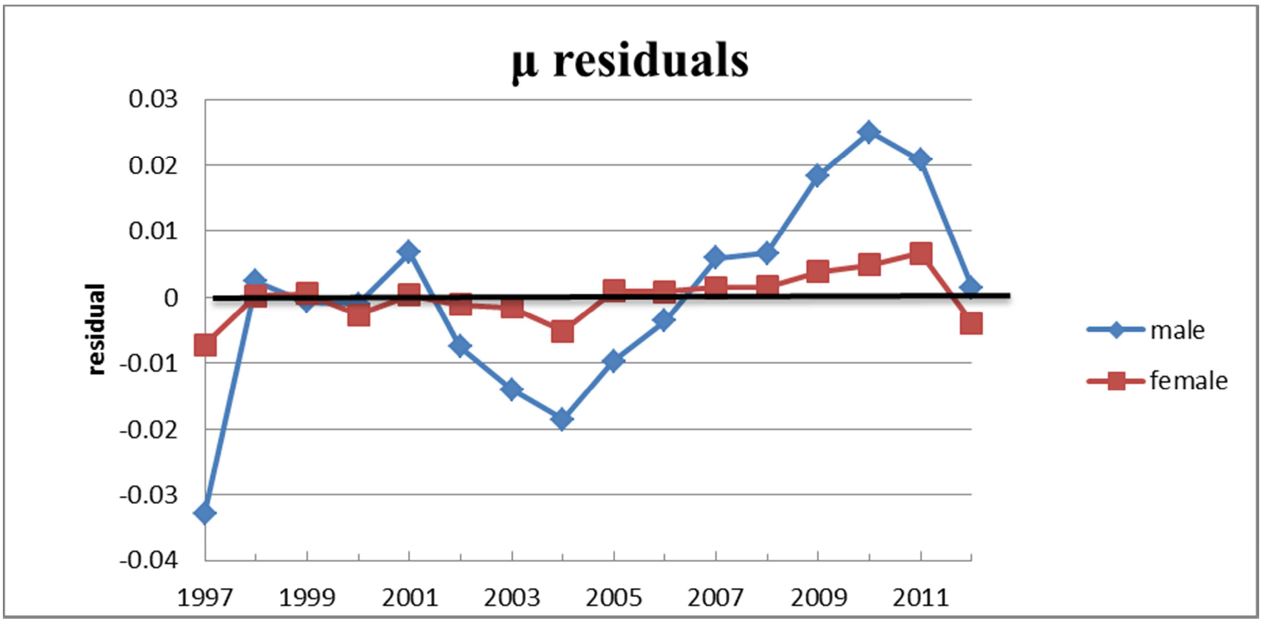
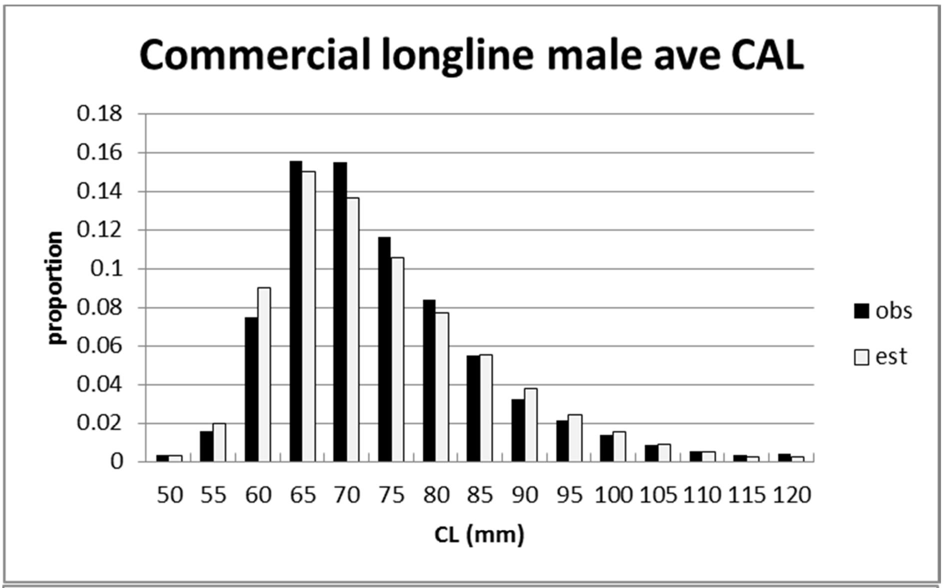


Figure 2c: Inaccessible commercial longline CAL fits averaged over years – Model 3.



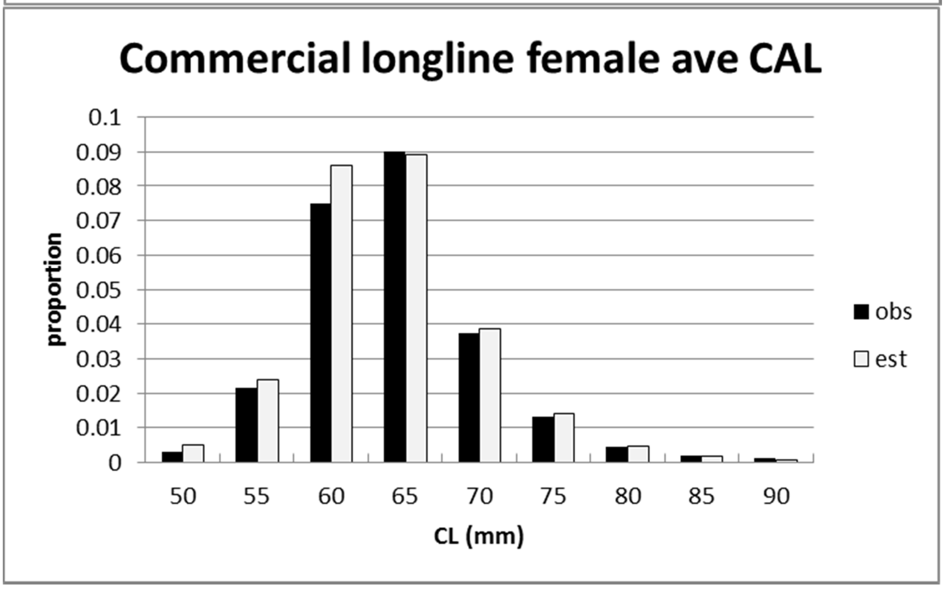
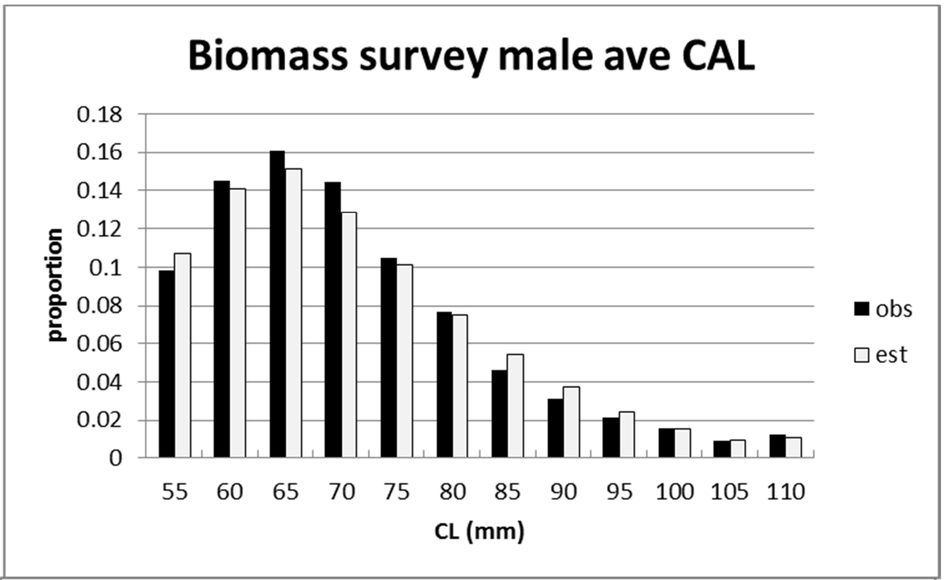


Figure 2d: Inaccessible biomass survey Leg1 CAL fits averaged over years – Model 3.



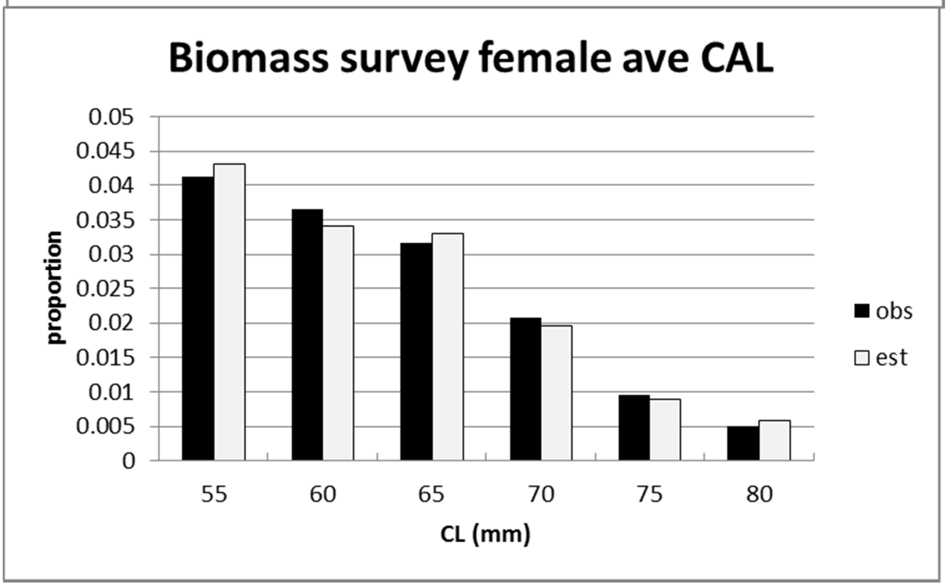


Figure 2e: Inaccessible standardised commercial longline CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals – Model 3.

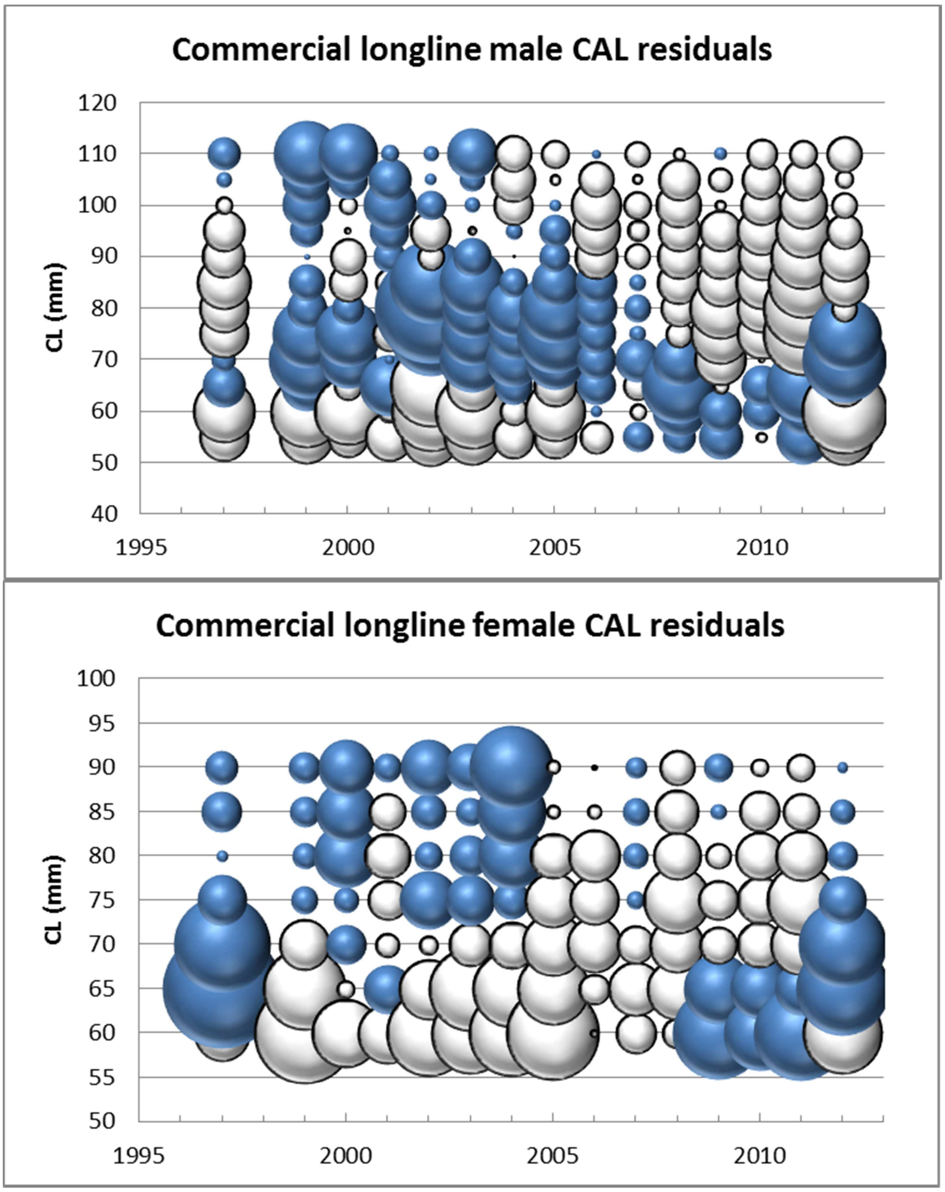


Figure 2f: Inaccessible standardised biomass survey Leg1 CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals – Model 3.

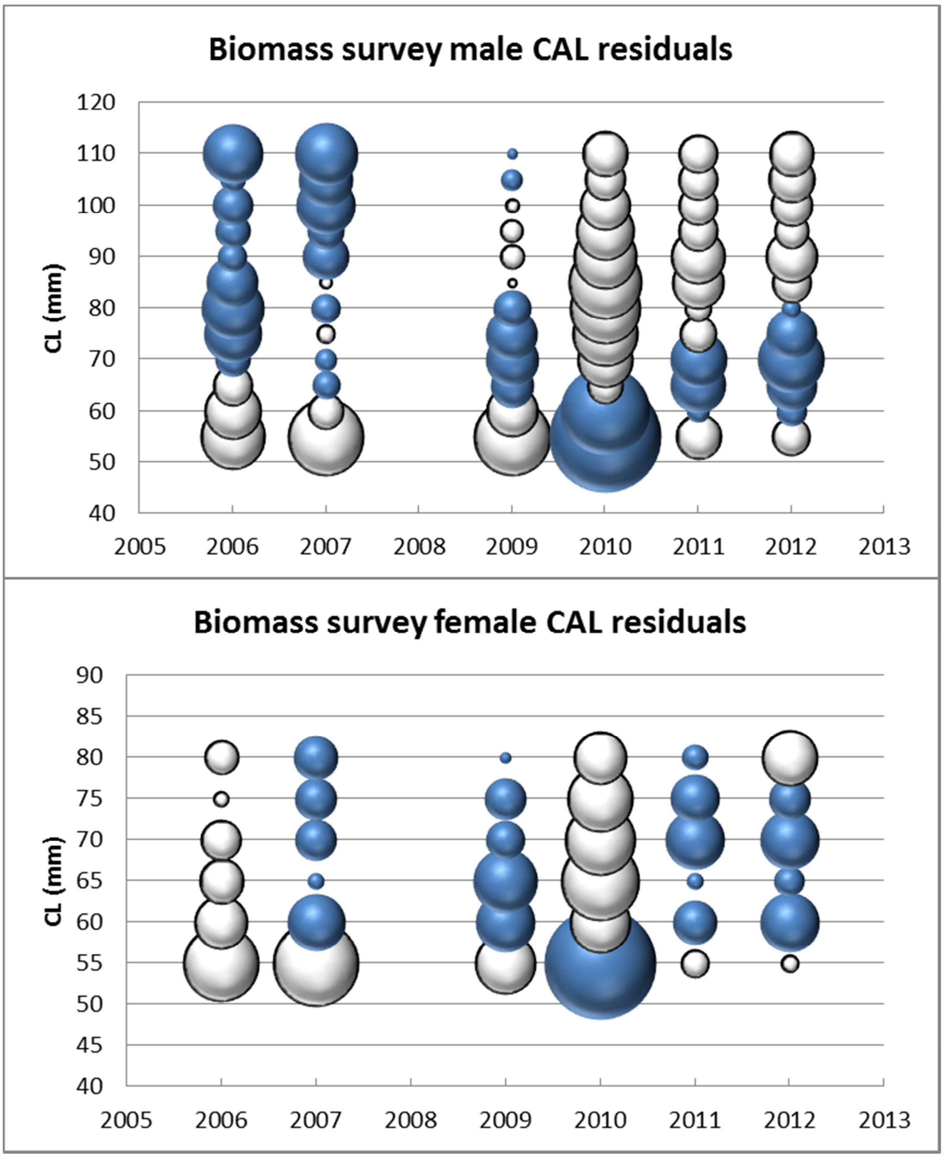


Figure 3a: Gough 2014 assessment results (for the Pollock growth model) – Model3.

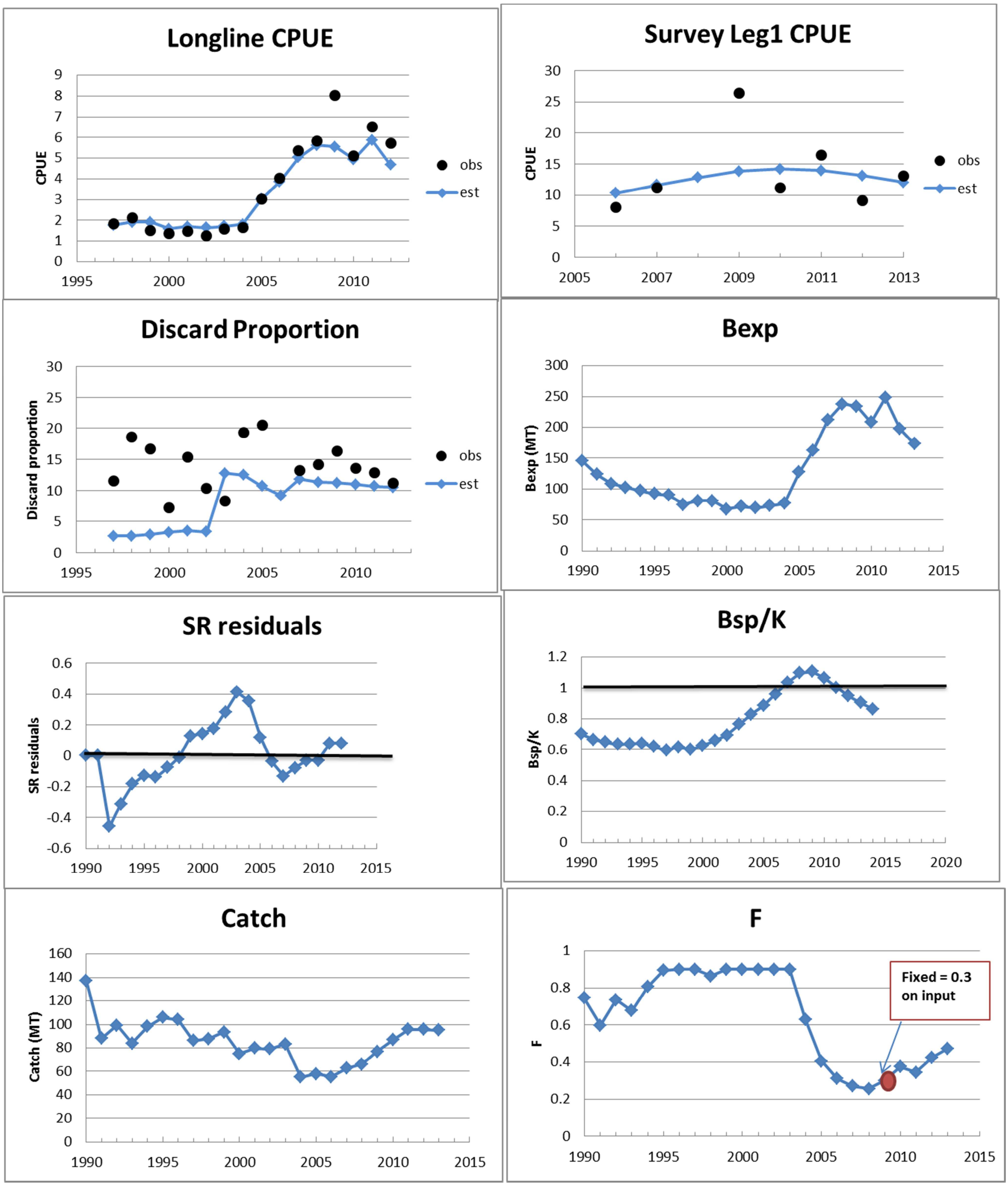


Figure 3bi: Gough selectivity functions – Model 3.

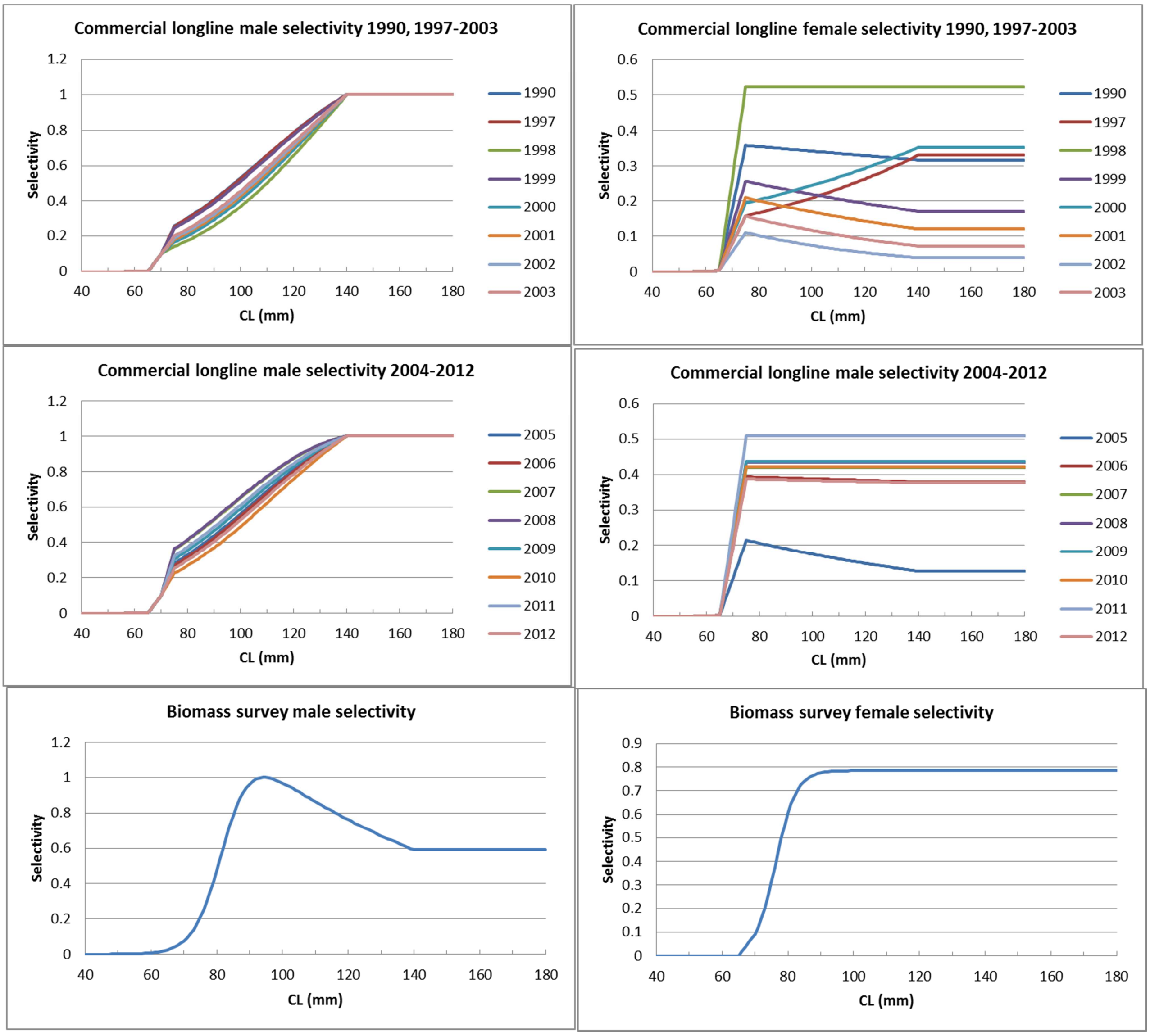


Figure 3bii: Gough estimated μ residuals (used for selectivity function variability) – Model 3.

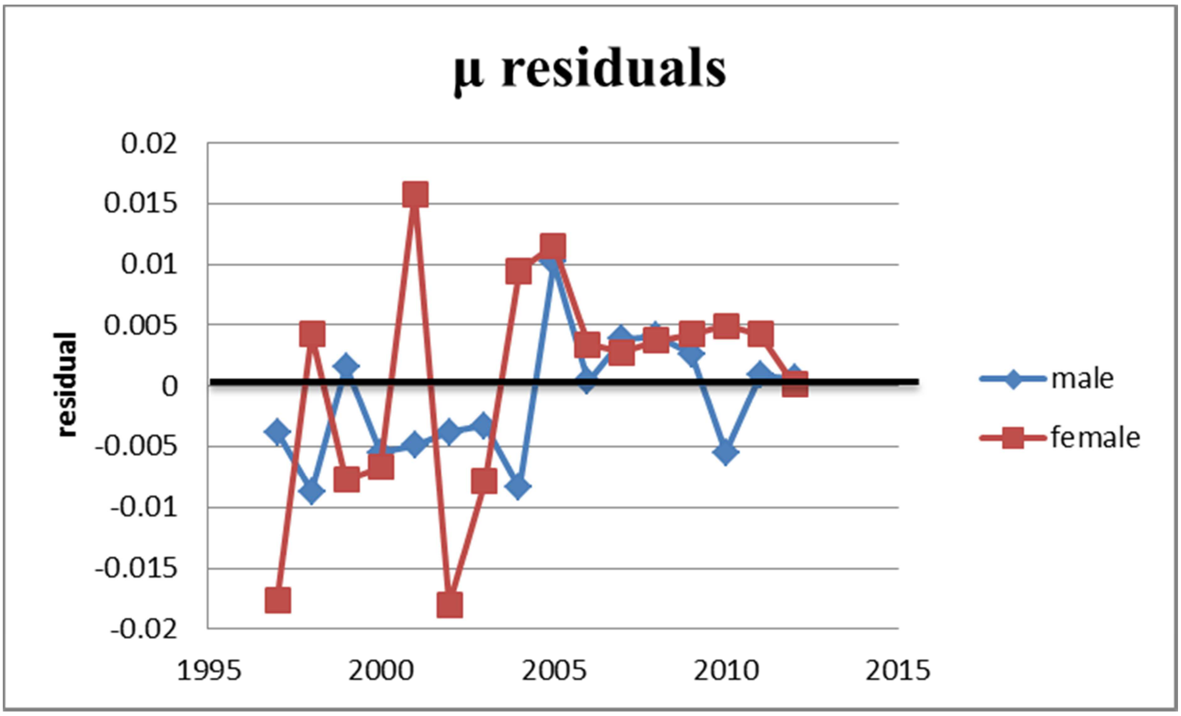
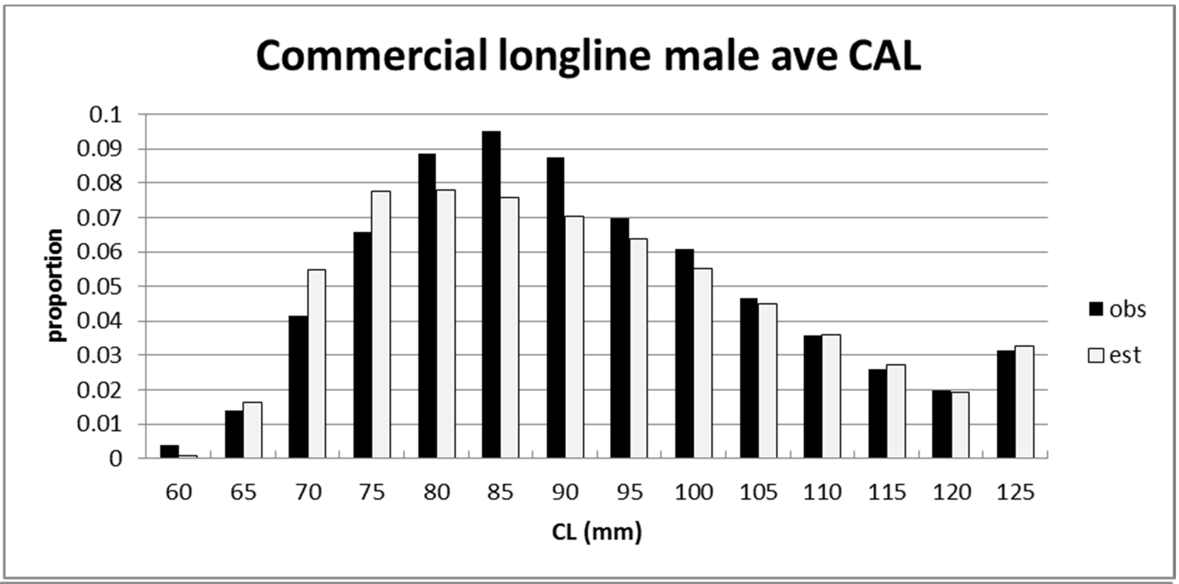


Figure 3c: Gough commercial longline CAL fits averaged over years – Model 3.



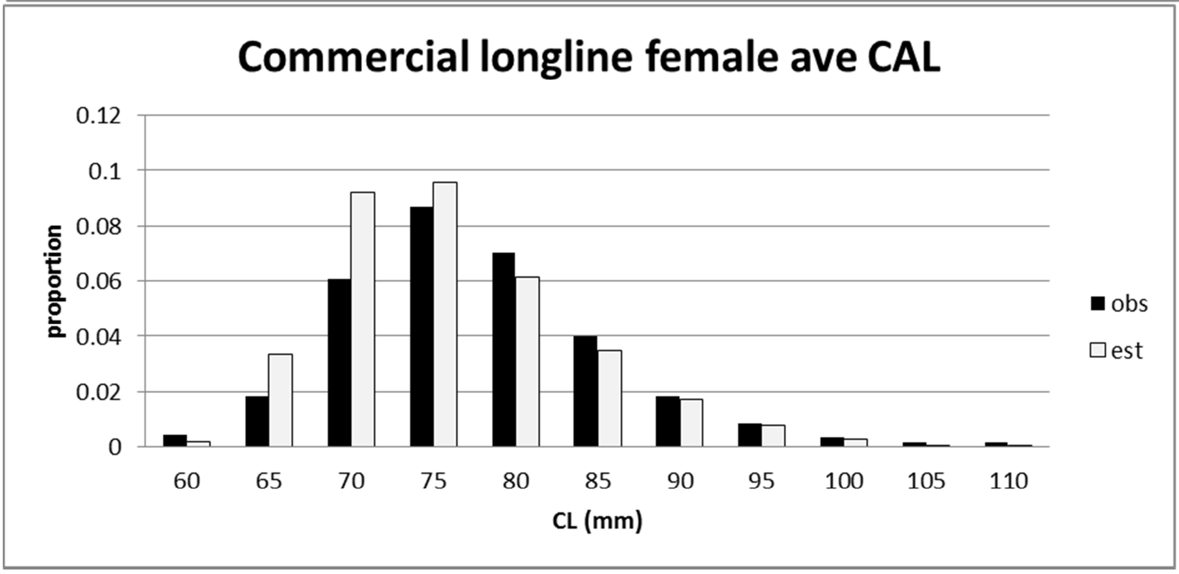
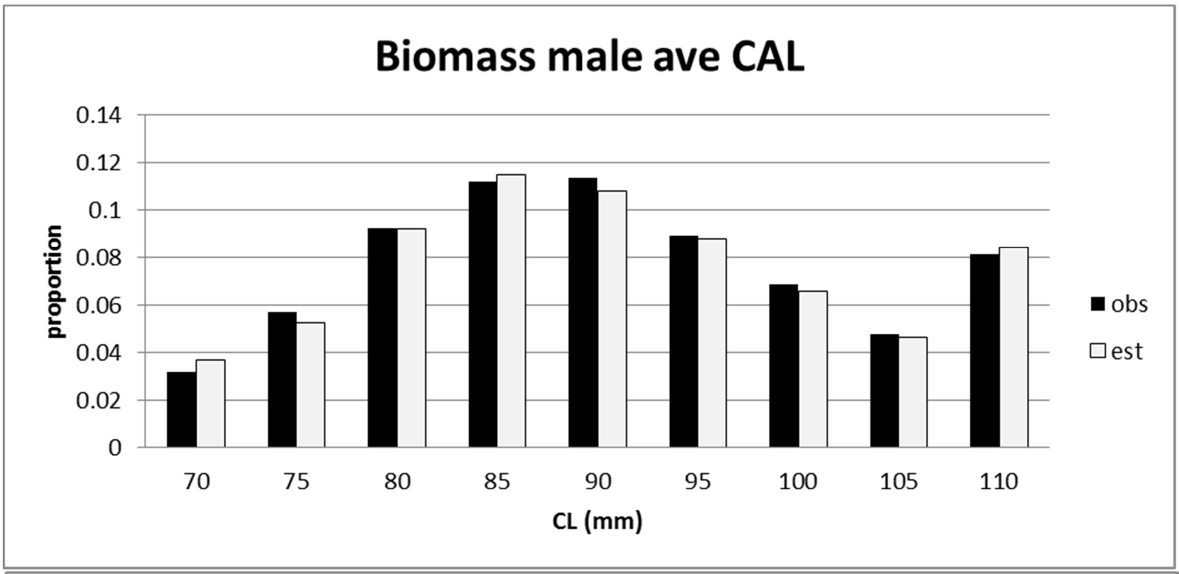


Figure 3d: Gough biomass survey Leg1 CAL fits averaged over years – Model 3.



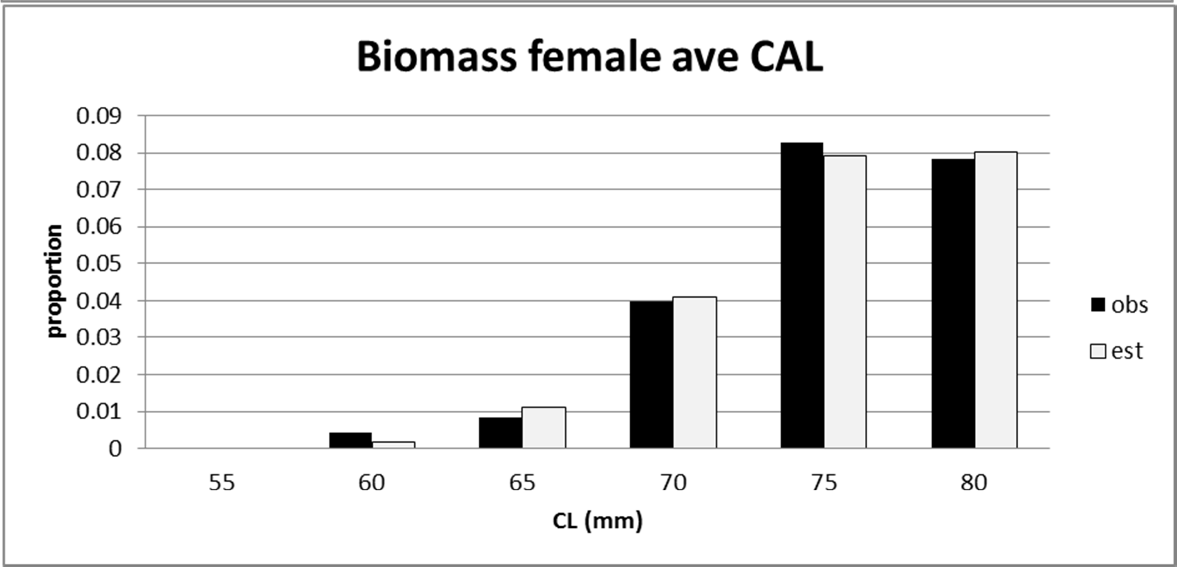


Figure 3e: Gough standardised commercial longline CAL residuals – Model 3. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

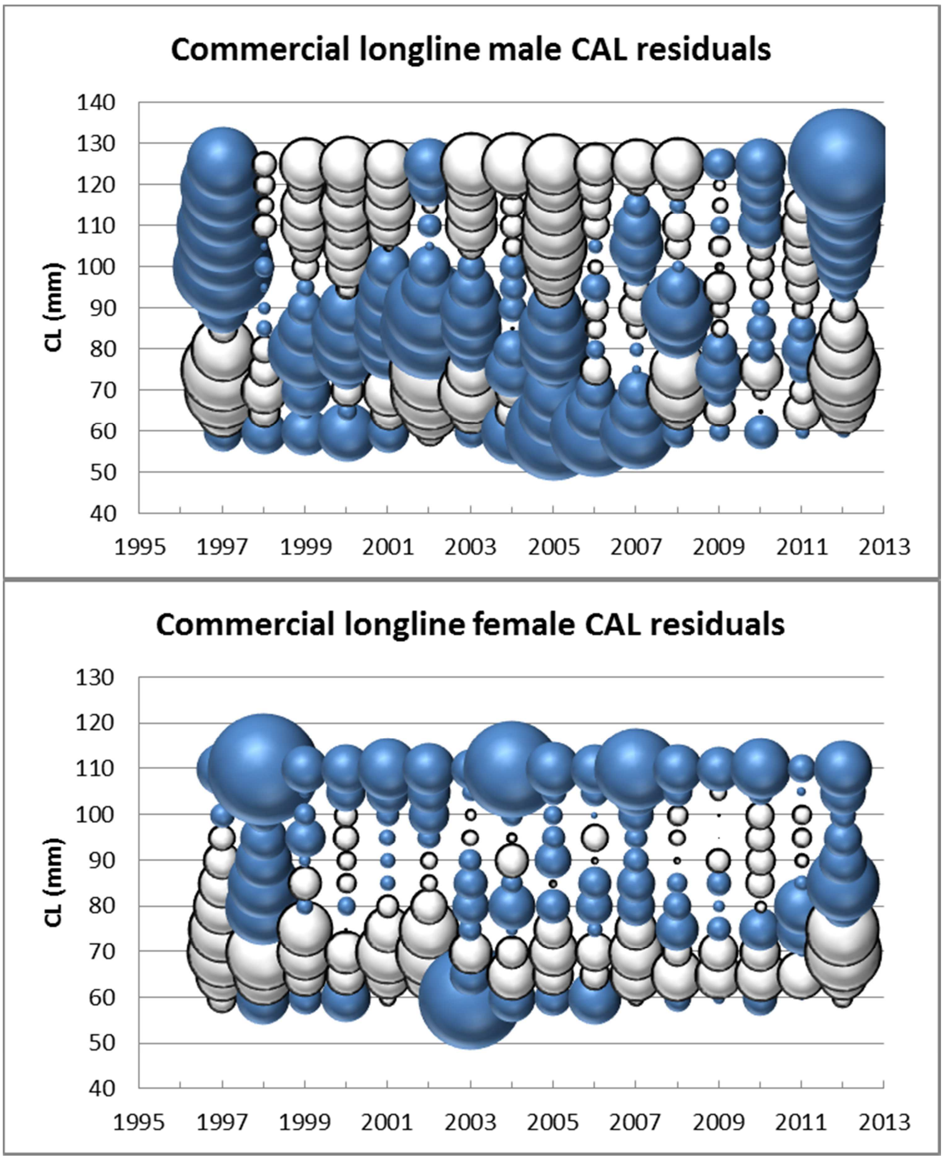
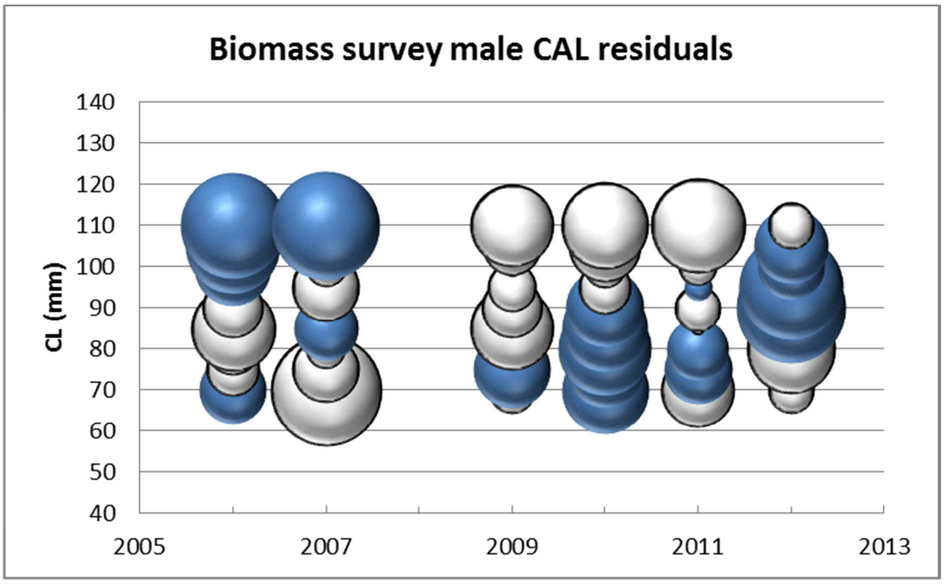
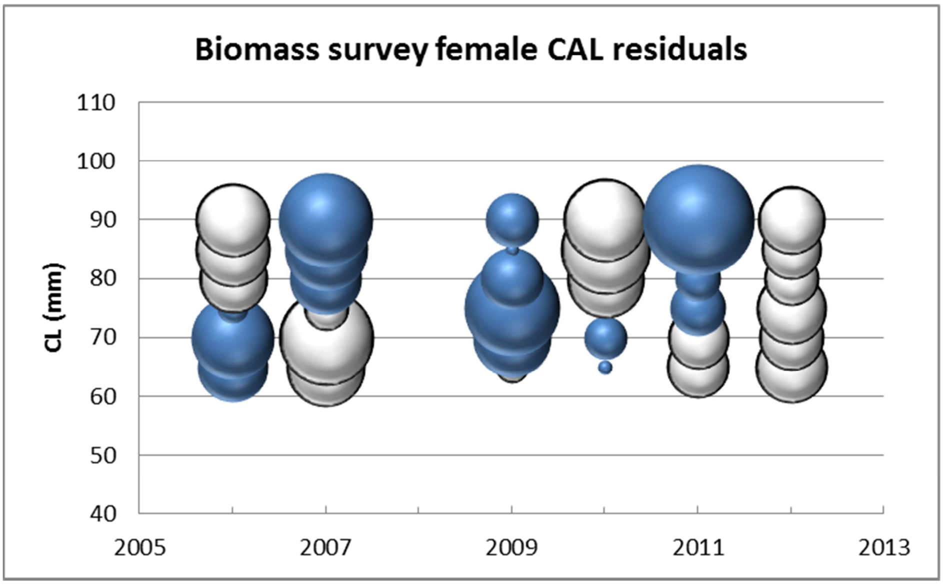


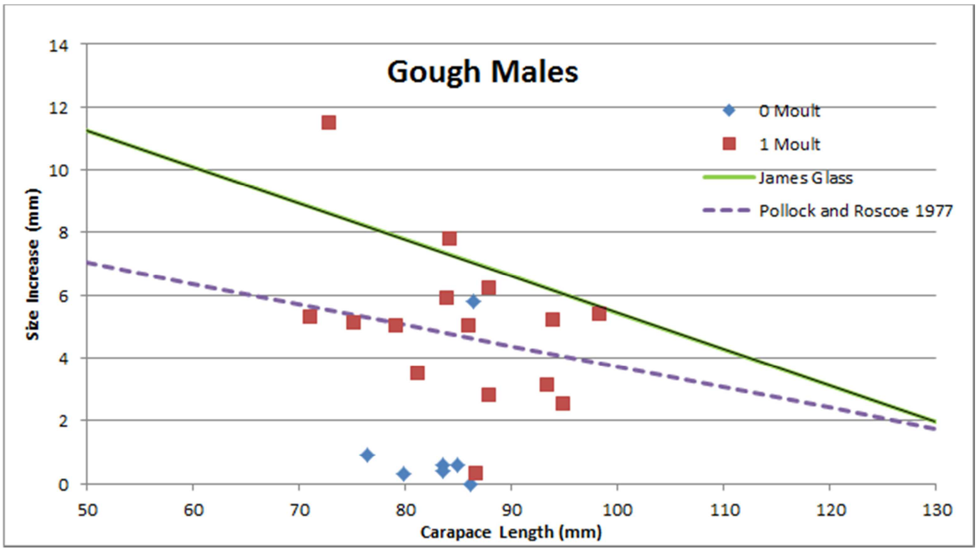
Figure 3f: Gough standardised biomass survey Leg1 CAL residuals – Model 3. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.





Appendix 1: Gough male moult increment data and models

Figure A1.1: A plot of the tagging data recently provided is shown below. The diamonds show lobsters that are unlikely to have moulted, whilst the squares show those that are likely to have moulted once. This distinction is made on the basis that the moulting period is February-July. The James Glass growth model is shown as a solid line, with the "Pollock" (from Pollock and Roscoe 1977) growth model shown as a hashed line. Plot produced by Rebecca Pieterse (Ovenstones) using the tagging data provided by James Glass.



Appendix 2: Modification of the Gough selectivity functions

Commercial Males: $S_l^{m,comm} = 0$ $\quad l \leq 40$mm CL

$S_l^{m,comm}$ linear increase from 0 at 40mm CL to P1a at 50mm CL

i.e. $S_l^{m,comm} = \frac{P1a}{10} l - 40\frac{P1a}{10}$ $\quad 40mm\ \text{CL}\ \leq l \leq 50mm\ \text{CL}$

$S_l^{m,comm}$ linear increase from P1a at 50mm CL to P1b at 55mm CL

i.e. $S_l^{m,comm} = \left(\frac{P1b-P1a}{5}\right) l + P1a - 50(\frac{P1b-P1a}{5})$ $\quad 50mm\ \text{CL}\ \leq l \leq 55mm\ \text{CL}$

$S_l^{m,comm}$ linear increase from P1b at 55mm CL to P1c at 60mm CL

i.e. $S_l^{m,comm} = \left(\frac{P1c-P1b}{5}\right) l + P1b - 55(\frac{P1c-P1b}{5})$ $\quad 55mm\ \text{CL}\ \leq l \leq 60mm\ \text{CL}$

$S_l^{m,comm}$ linear increase from P1c at 60mm CL to P1d at 65mm CL

i.e. $S_l^{m,comm} = \left(\frac{P1d-P1c}{5}\right) l + P1c - 60(\frac{P1d-P1c}{5})$ $\quad 60mm\ \text{CL}\ \leq l \leq 65mm\ \text{CL}$

$S_l^{m,comm}$ linear increase from P1d at 65mm CL to P1e at 70mm CL

i.e. $S_l^{m,comm} = \left(\frac{P1e-P1d}{5}\right) l + P1d - 65(\frac{P1e-P1d}{5})$ $\quad 65mm\ \text{CL}\ \leq l \leq 70mm\ \text{CL}$

$S_l^{m,comm}$ linear increase from P1e at 70mm CL to $S_{75}^{m,comm}$ at 75mm CL

i.e. $S_l^{m,comm} = \left(\frac{S_{75}^{m,comm}-P1e}{5}\right) l + P1e - 70(\frac{S_{75}^{m,comm}-P1e}{5})$ $\quad 70mm\ \text{CL}\ \leq l \leq 75mm\ \text{CL}$

Commercial Females:

$S_l^{f,comm} = 0$ $\quad l \leq 55$mm CL

$S_l^{f,comm}$ linear increase from 0 at 55mm CL to P2 at 65mm CL

i.e. $S_l^{f,comm} = \frac{P2}{10} l - 55\frac{P2}{10}$ $\quad 55mm\ \text{CL}\ \leq l \leq 65mm\ \text{CL}$

$S_l^{f,comm}$ linear increase from P2 at 65mm CL to $S_{70}^{f,comm}$ at 70mm CL

i.e. $S_l^{f,comm} = \left(\frac{S_{70}^{f,comm}-P2}{5}\right) l + P2 - 65(\frac{S_{70}^{f,comm}-P2}{5})$ $\quad 65mm\ \text{CL}\ \leq l \leq 70mm\ \text{CL}$

Survey Females:

$S_l^{f,SURV} = 0 \qquad\qquad l \leq 40$mm CL

$S_l^{f,SURV}$ linear increase from 0 at 40mm CL to P3 at 65mm CL

$S_l^{f,SURV}$ linear increase from P3 at 65mm CL to $S_{70}^{f,SURV}$ at 70mm CL

i.e. $S_l^{f,SURV} = \left(\frac{S_{70}^{f,SURV} - P3}{5}\right) l + P3 - 65\left(\frac{S_{70}^{f,SURV} - P3}{5}\right) \qquad 65mm\text{ CL } \leq l \leq 70mm\text{ CL}$

The parameter values listed below were fixed on input:

P1a = 0.00001

P1b = 0.0001

P1c = 0.0013

P1d = 0.0014

P1e = 0.1

P2 = 0.003

P3 = 0.0003