

## Updated 2018 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. The assessments were last updated in 2014. These updated assessment models will function as the underlying baseline operating models in the development of new OMPs for each island.

### Introduction

The age-structured population model used for these assessments is described fully in Johnston and Butterworth (2013). The assessments were last updated in 2014. The updated 2018 assessment include the following data:

- 1) Standardised longline CPUE data for 1997-**2017**.
- 2) Biomass survey Leg1 CPUE data (2006-**2017**, with data for 2008 absent because there was no survey that year).
- 3) Catch-at-length data from the onboard observers (males and females separate) (1997-**2017**).
- 4) Catch-at-length data from the Leg1 biomass survey (males and females separate) (2006-**2017**, with 2008 data absent).
- 5) Discard % (1997-**2017**).

In most cases data to only either 2012 or 2013 were available for the previous 2014 assessment.

### 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<sup>1</sup>.

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<sup>1</sup> Cape Town Workshop held 16-18 November 2011.

### Inaccessible model development

The preferred assessment model is one that allows the selectivity “ $\mu$ ” values for both males and females to vary by year in the model fitting process (in contrast to having three or four fixed periods of fixed selectivity) to allow for more flexibility in fitting to the data. These “ $\mu$ ” values determine the shape of the descending limb of the selectivity curve. The estimable parameters are thus:

- $l_*^{m/f}$ ,
- $\delta^{m/f}$ ,
- $\mu^{m/f}$  (with values for each of years for which data are available), 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  $P$ .

Equations (1) and (2) below allow for random variation in the  $\mu$  parameter values as follows:

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

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

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:

$$-\ln L \rightarrow -\ln L + \frac{1}{2\sigma_\mu^2} \sum_{1997}^{2017} [(\varepsilon_y^m)^2 + (\varepsilon_y^f)^2] \quad (6)$$

Furthermore, the  $-\ln L$  contribution is 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  $\varepsilon_y$  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:

$$-\ln L = \sum_y \left[ \frac{\varepsilon_y^2}{2(\sigma^2 + c^3)} + \frac{1}{2} \ln(\sigma^2 + c^2) \right] \quad (7)$$

where

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

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

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  $\sim 0.10-0.15$ , the following values were selected:

$$\varepsilon_\mu = 0.02$$

$$c = 0.6.$$

### Gough model development

The assessment model used in the 2014 assessment has been updated with data that have become available since that assessment. No further model modifications have been made.

## Results

### Updated Inaccessible assessment

Table 1 reports the Inaccessible 2018 updated assessment results, and provides the 2014 assessment results for comparison. Note that the total  $-\ln L$  values are not comparable as the 2018 assessment uses additional data.

Figures 1a-f show various results for the updated inaccessible assessment. From Figure 1a, it is evident that the fits to the CPUE data remain good although they do not reproduce the continued increase in CPUE in the most recent years. (This may reflect in part an overestimation of the OLIVA effect on juvenile mortality.) The overall fits to the catch-at-length data are good. Estimates of the spawning biomass ( $B_{sp}$ ) in 1990 relative to pristine are slightly higher (0.32) than that estimated in 2014 (0.27). The current  $B_{sp}/K$  remains high and is estimated to be at a healthy 0.84.

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 – which 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 1c and d), but residual patterns do remain at the annual level (Figures 1e and f). The recent exploitable and spawning biomass trends are decreasing slightly (Figure 1a). The OLIVA effect of an assumed 35% mortality of the age 1-3 year olds in 2011 will start impacting the assessment results shortly, and this may in part account for the slight down turn predicted in recent biomass.

## Updated Gough Assessment

Table 2 reports the Gough 2018 updated assessment results, and provides the 2014 assessment results for comparison.

The current Bsp/K is also estimated to be healthy at 0.84, although the recent Bsp trend is decreasing. The overall fits to discard proportion data remain poor (as for the Inaccessible assessment), although this appears to improve for the more recent years (see Figure 2a). The model fit to the commercial CPUE data is particular good for recent years. Fits to these CAL data are not fully satisfactory however, exhibiting underestimates of males and overestimates of females (see below) near the centre of the length range for the commercial data.

### Future work

- Examine robustness to the assumption that the catch proportion in 2009 is 0.3. Previous sensitivity to this assumption has been examined and did not show any concerns at the time. This will be considered in OMP robustness testing.
- Improve fits to Gough CAL data – this may involve estimating time varying female scalar parameters.

### 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. 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. 2014. Updated 2014 rock lobster assessments for Inaccessible and Gough islands. MARAM/Tristan/2014/Jan/02.

Table 1: Inaccessible updated 2018 assessment results (last column). The 2014 assessment results are reported in the first column to allow comparison (italicised 2014 values are not comparable). The shaded values are fixed on input. Values in parentheses are estimated  $\sigma$  values.

	<b>2014 assessment</b>	<b>2018 assessment</b>
# parameters	<b>69</b>	<b>84</b>
$K$	1569	1662
$h$	0.91	0.92
$M$	0.2	0.2
$d$ (discard mortality rate)	0.1	0.1
$\sigma_{length}$	0.2	0.2
$F_{2009}$ fixed at	0.3	0.3
$\theta$	0.291	0.342
-lnL total	-6.95	-18.42
-lnL CPUE T	-10.21	-15.29
-lnL CPUE longline	-4.94 (0.111)	-7.60 (0.204)
-lnL CPUE Survey Leg1	-5.27 (0.214)	-7.69 (0.288)
-lnL CAL T	-62.02	-145.49
-lnL CAL onboard observer	-30.45 (0.066)	-80.67 (0.060)
-lnL CAL Survey Leg 1	-31.57 (0.078)	-64.81 (0.077)
SR1 pen	2.14	3.24
-lnL discard	3.60	3.75
Bsp(1990)/Ksp	0.27	0.32
Bsp(2013)/Ksp	0.85	0.87
Bsp(2014)/Ksp	0.87	0.90
Bsp(2017)/Ksp	0.-	0.86
Bsp(2018)/Ksp	-	0.84
Bsp(2012)/Bsp(1990)	3.08	2.63
Bsp(2013)/Bsp(1990)	3.16	2.74
Bsp(2014)/Bsp(1990)	3.23	2.85
Bsp(2017)/Bsp(1990)	-	2.70
Bsp(2018)/Bsp(1990)	-	2.66
Bexp(2012)/Bexp(1990)	3.47	2.98
Bexp(2013)/Bexp(1990)	3.88	2.90
Bexp(2017)/Bexp(1990)	-	3.24
Program	Inacran.tpl; iran6.rep	Inac18.tpl, .rep

Table 2: Gough updated 2018 assessment results. The 2014 assessment results are reported to allow comparison (italicised 2014 values are not comparable). The shaded values are fixed on input. Values in parentheses are estimated  $\sigma$  values.

	2014 assessment	2018 assessment
# parameters	85	105
$K$	311	302
$h$	0.93	0.90
$M$	0.2	0.2
$d$ (discard mortality rate)	0.1	0.1
$\sigma_{length}$	0.2	0.2
$F_{2009}$ fixed at	0.3	0.3
$\theta$	0.752	0.616
-lnL total	10.98	40.60
-lnL CPUE T	-7.70	-10.24
-lnL CPUE longline	-3.47 (0.158)	-6.20 (0.118)
-lnL CPUE Survey Leg1	-4.22 (0.319)	-4.04 (0.327)
-lnL CAL T	-9.00	347.39
-lnL CAL onboard observer	54.48 (0.095)	421.60 (0.176)
-lnL CAL Survey Leg 1	-63.47 (0.070)	-74.21 (0.07)
SR1 pen	2.72	2.86
-lnL discard	15.62	10.81
Bsp(1990)/Ksp	0.70	0.58
Bsp(2013)/Ksp	0.90	0.93
Bsp(2014)/Ksp	0.86	0.86
Bsp(2017)/Ksp	-	0.78
Bsp(2018)/Ksp	-	0.77
Bsp(2012)/Bsp(1990)	1.35	1.66
Bsp(2013)/Bsp(1990)	1.29	1.62
Bsp(2014)/Bsp(1990)	1.23	1.50
Bsp(2017)/Bsp(1990)	-	1.35
Bsp(2018)/Bsp(1990)	-	1.33
Bexp(2012)/Bexp(1990)	1.36	1.54
Bexp(2013)/Bexp(1990)	1.19	1.30
Bexp(2017)/Bexp(1990)	-	0.93
Programs	Gran.tpl	Gough18.tpl

Figure 1: Inaccessible 2018 assessment results.

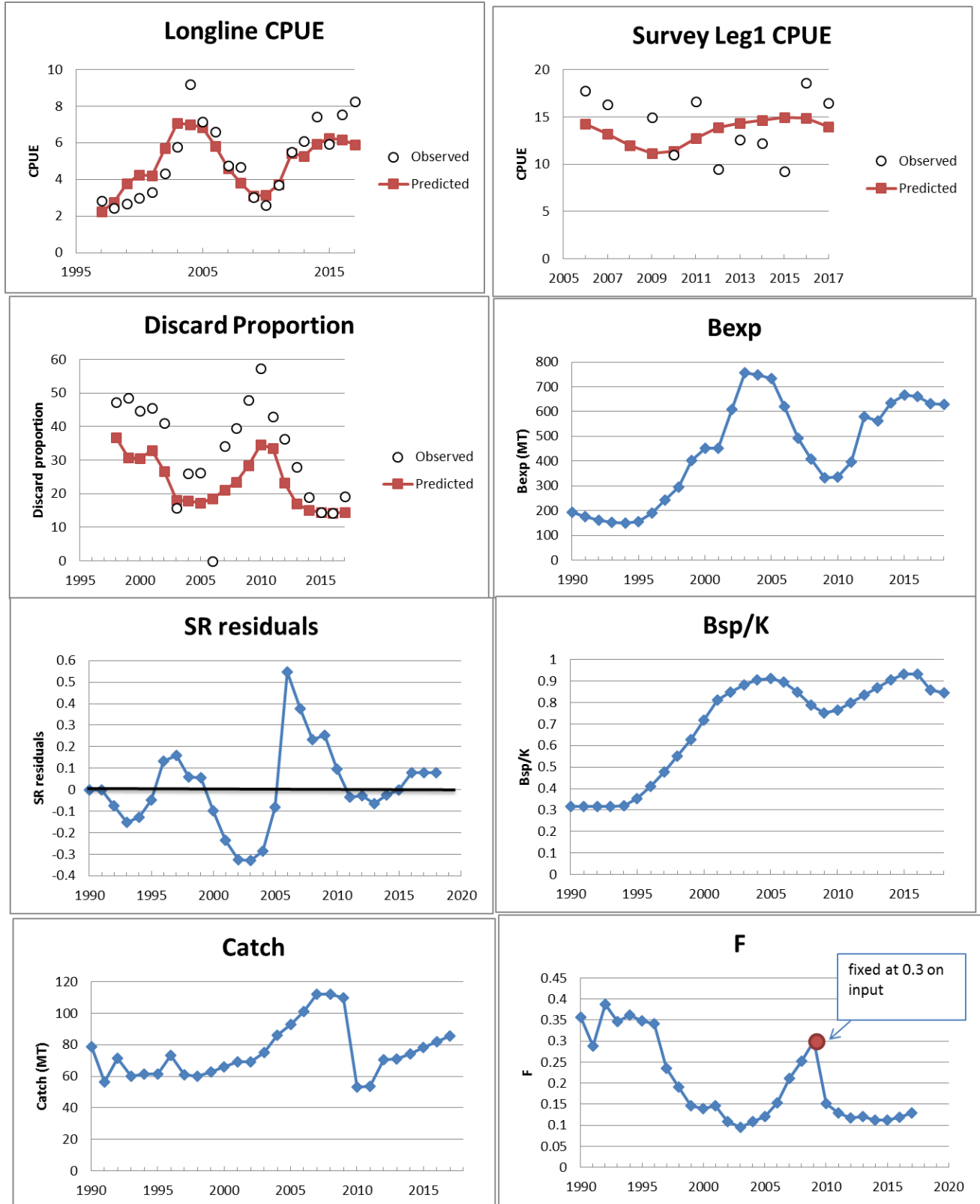


Figure 1bi: Inaccessible selectivity functions.

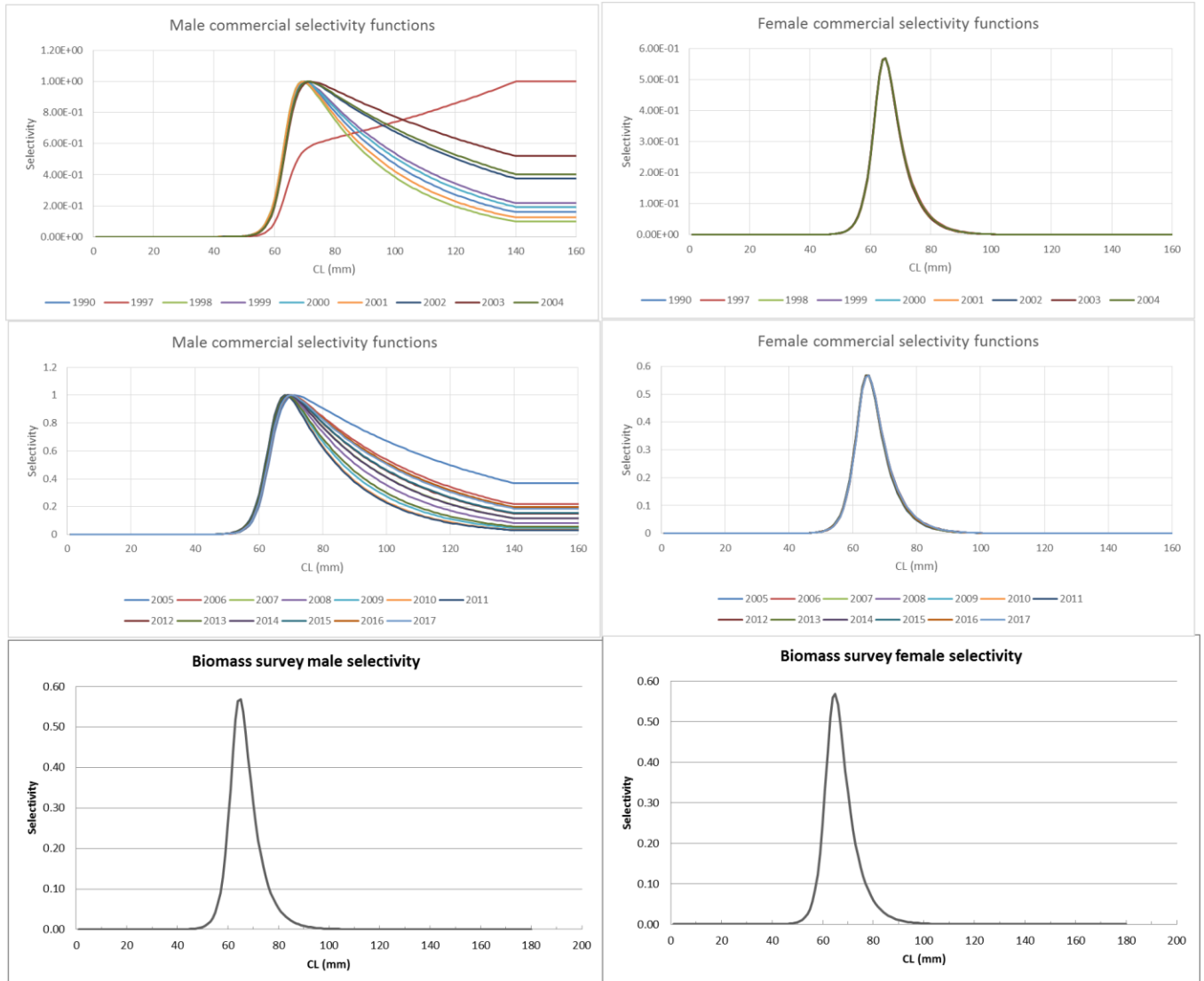


Figure 1bii: Inaccessible estimated  $\mu$  residuals (used for selectivity function variability).

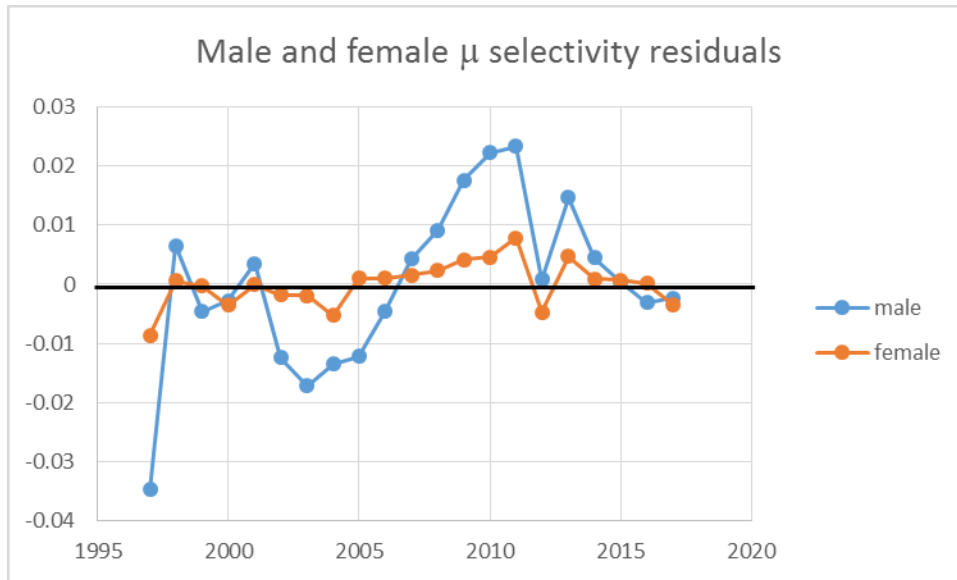


Figure 1c: Inaccessible commercial longline CAL fits averaged over years.

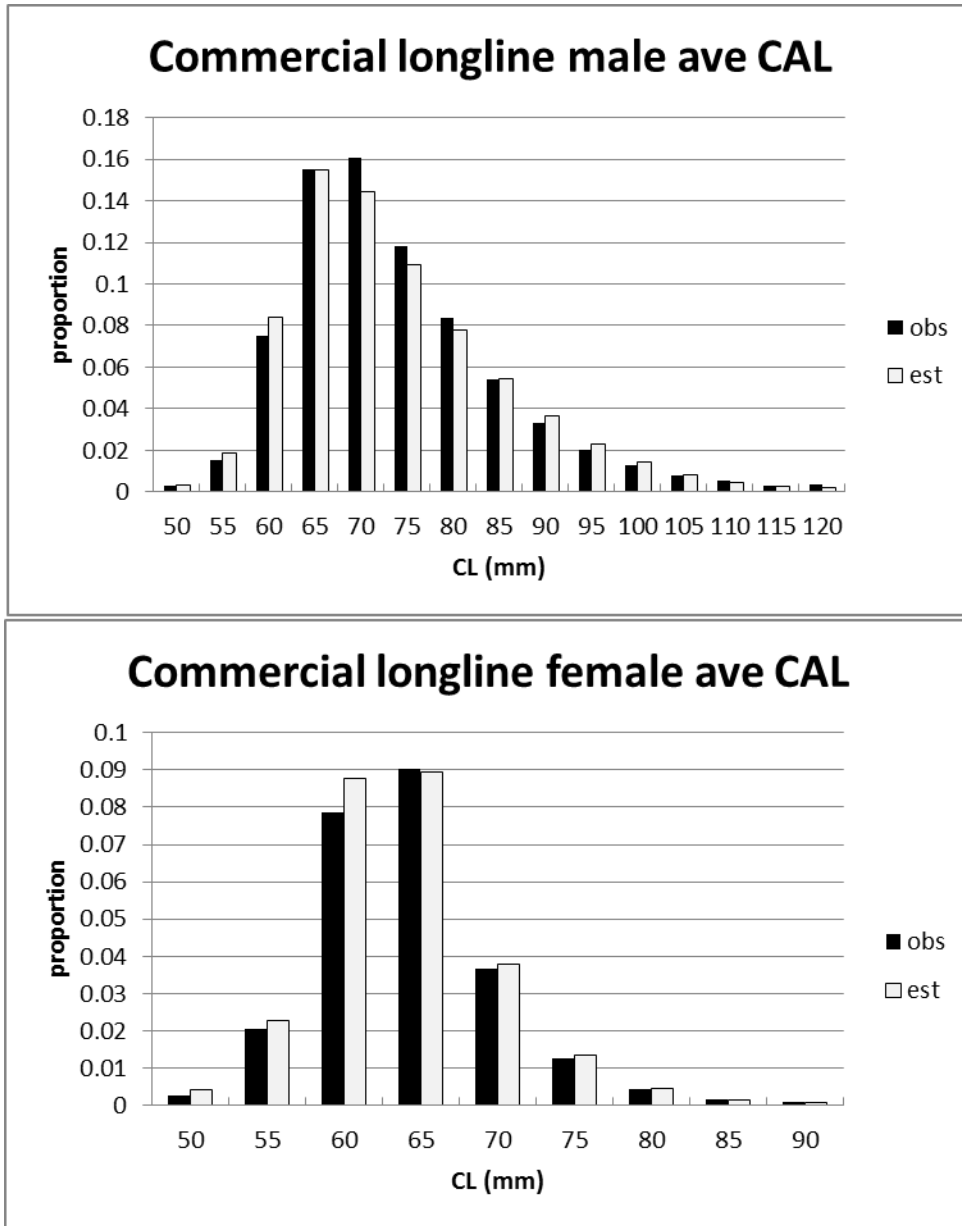


Figure 1d: Inaccessible biomass survey Leg1 CAL fits averaged over years.

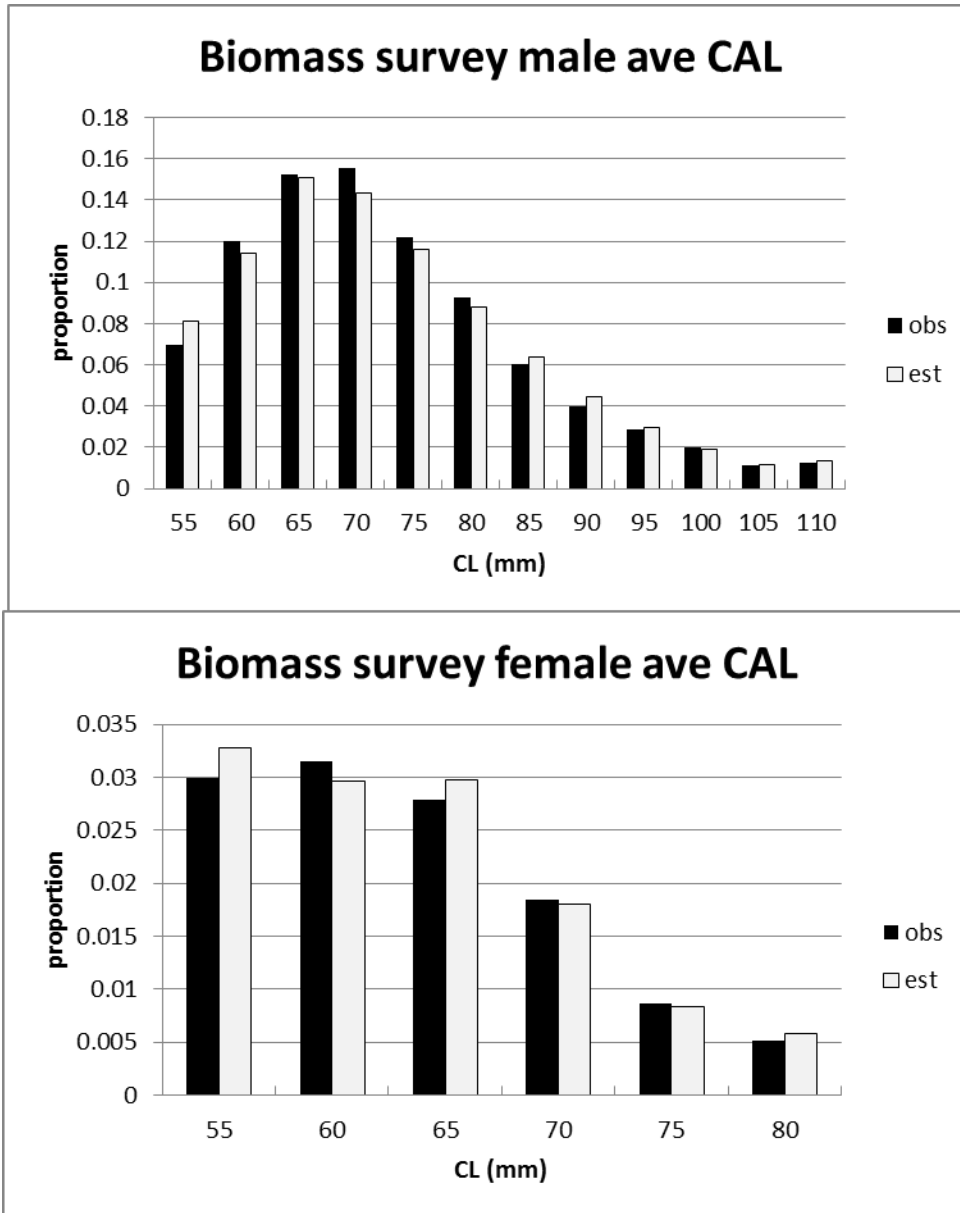


Figure 1e: Inaccessible standardised commercial longline CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

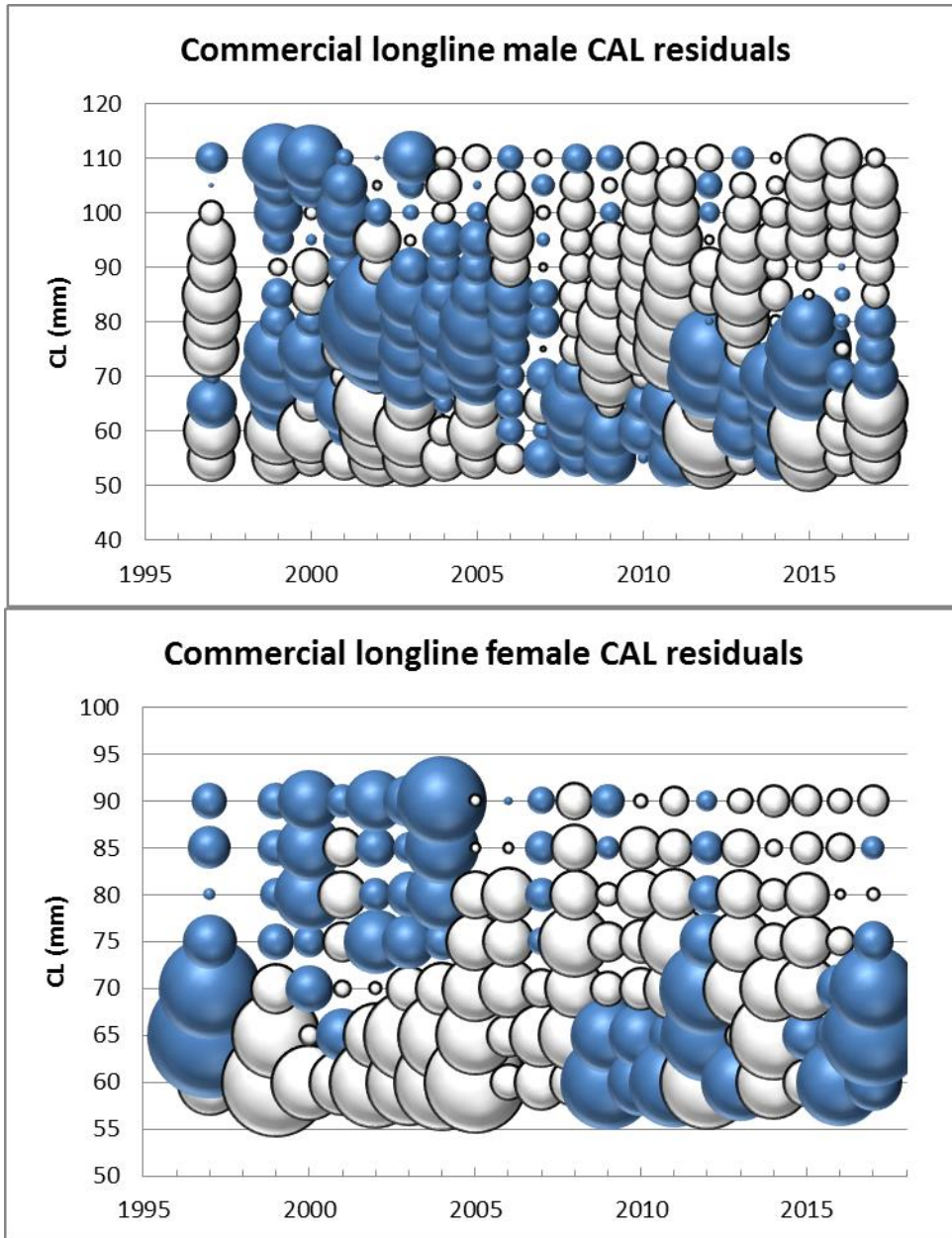


Figure 1f: Inaccessible standardised biomass survey Leg1 CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

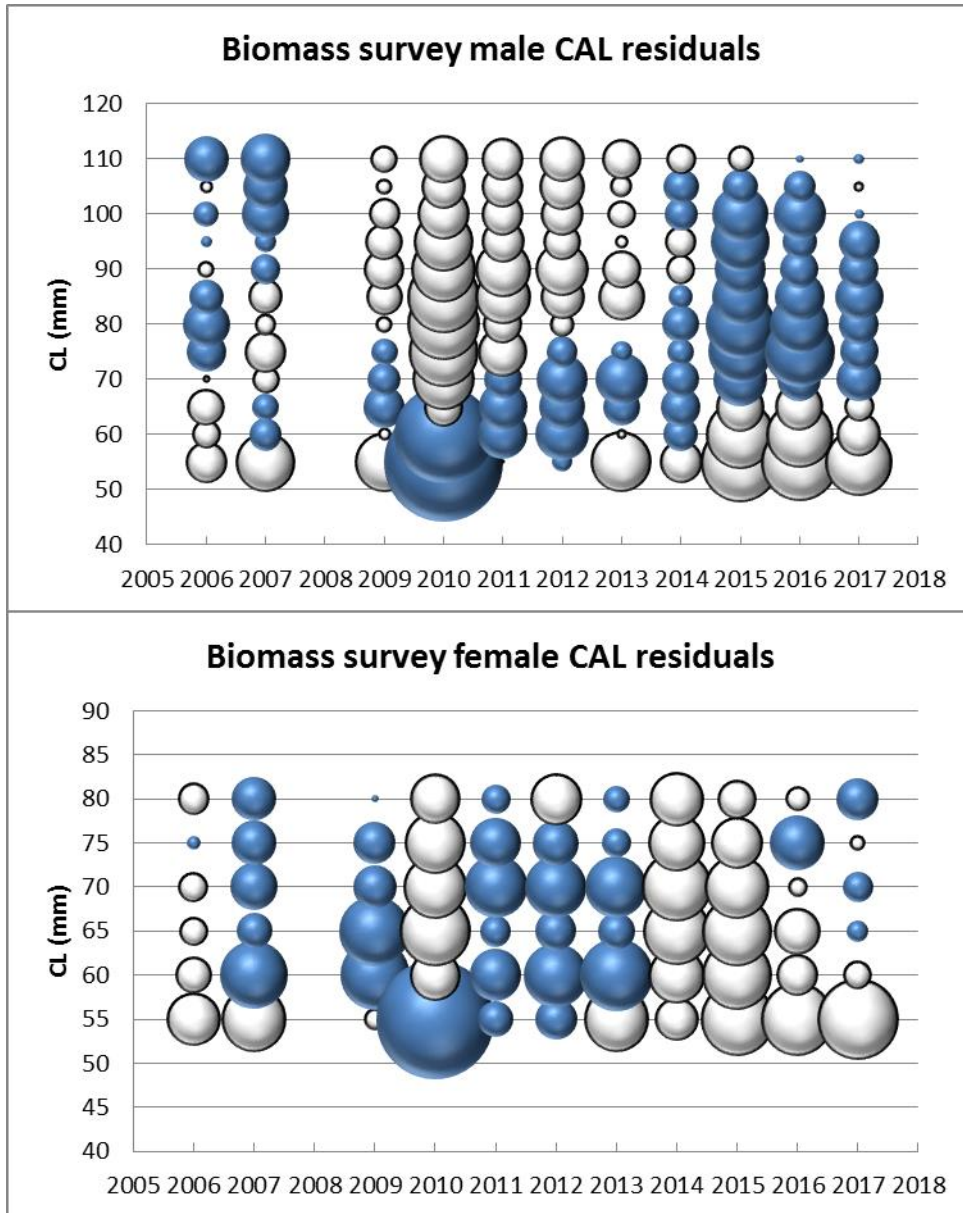


Figure 2a: Gough 2018 assessment results.

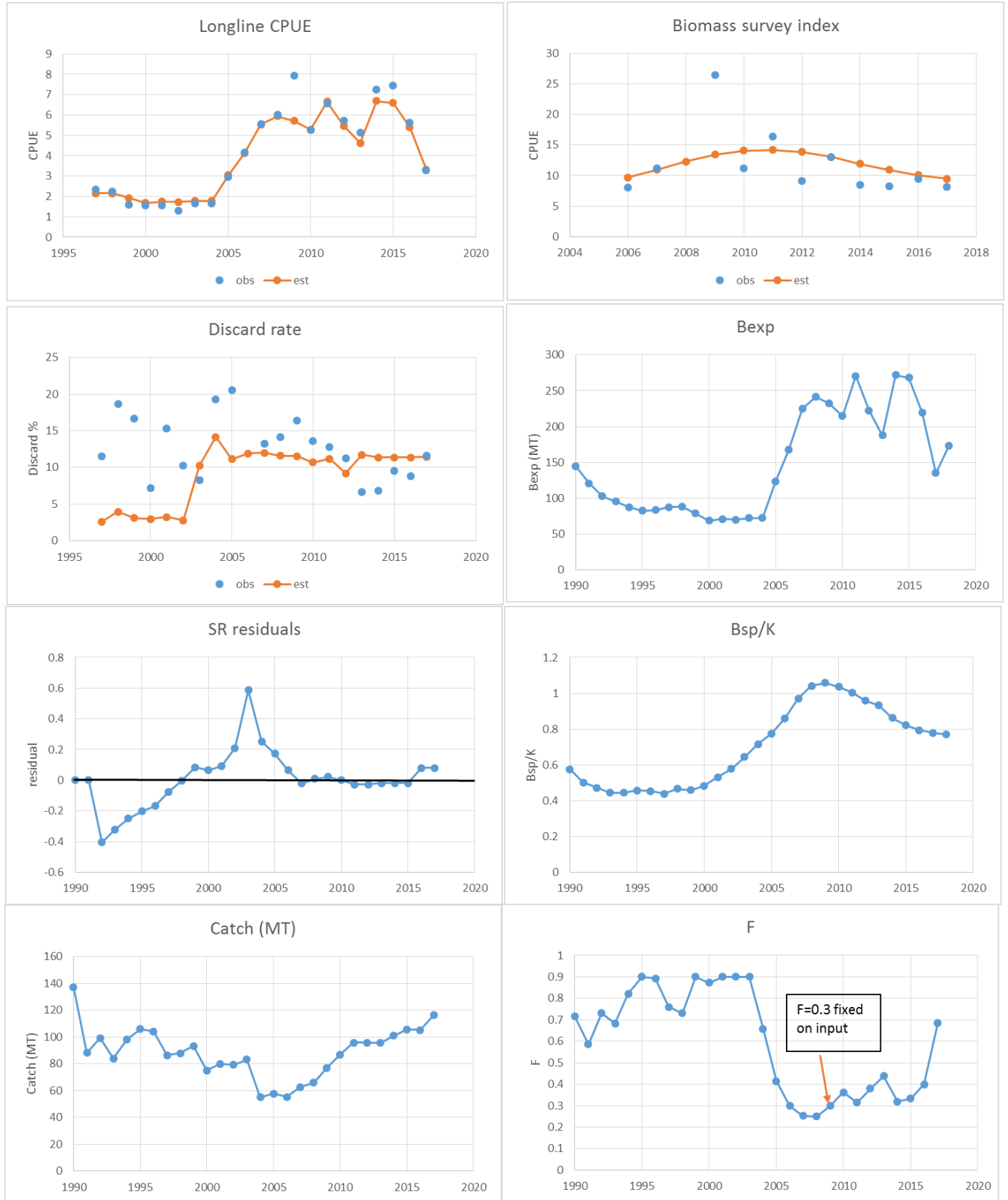


Figure 2bi: Gough selectivity functions.

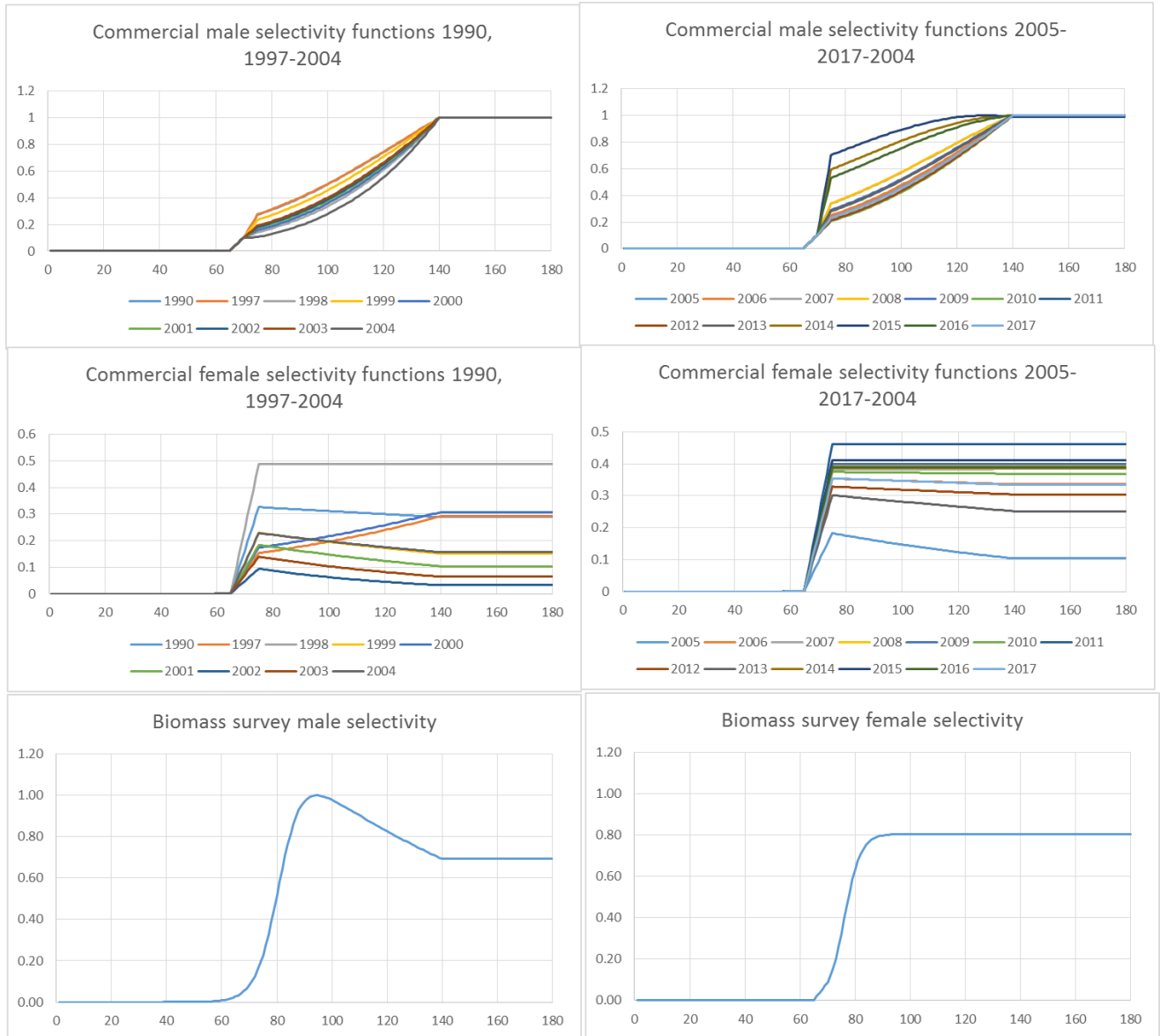


Figure 2bii: Gough estimated  $\mu$  residuals (used for selectivity function variability).

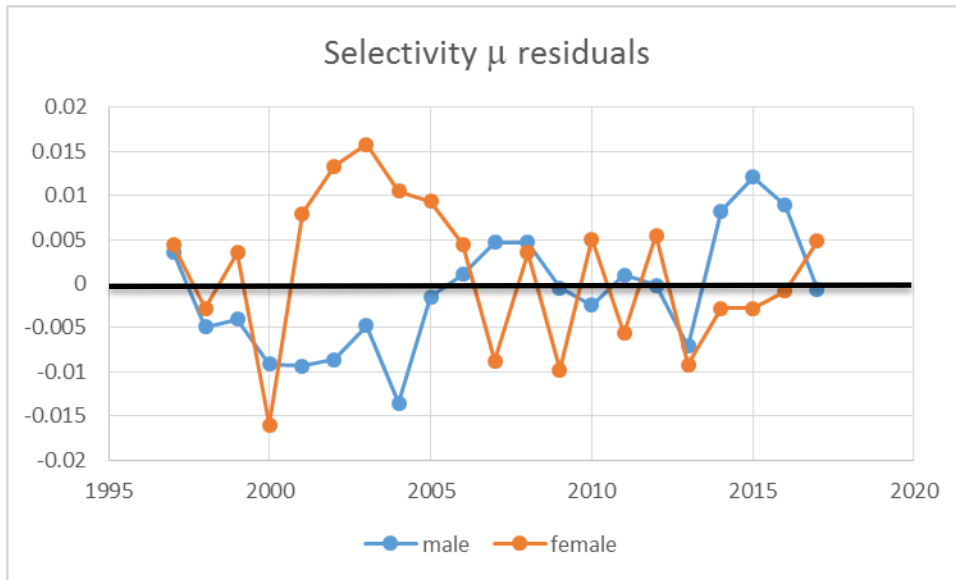


Figure 2c: Gough commercial longline CAL fits averaged over years.

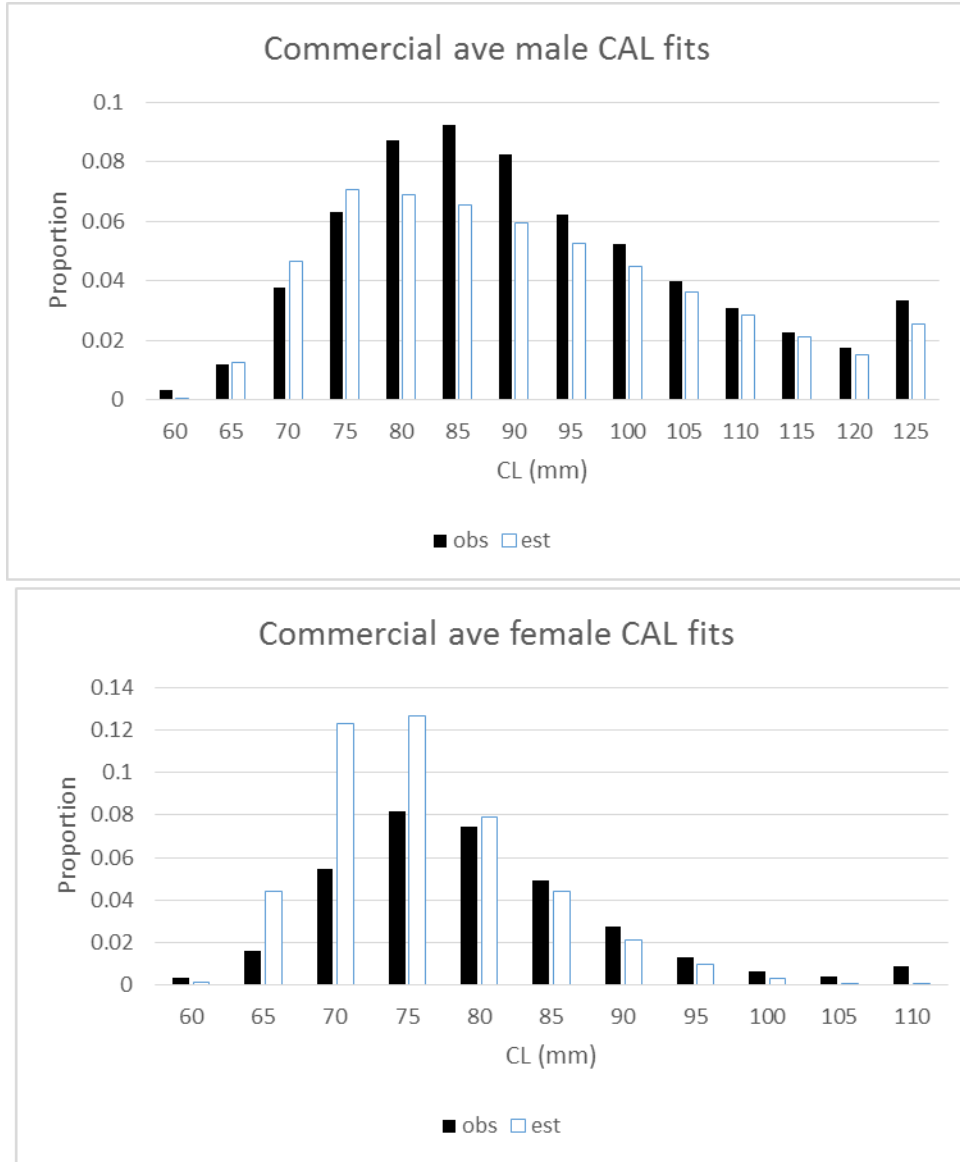


Figure 2d: Gough biomass survey Leg1 CAL fits averaged over years.

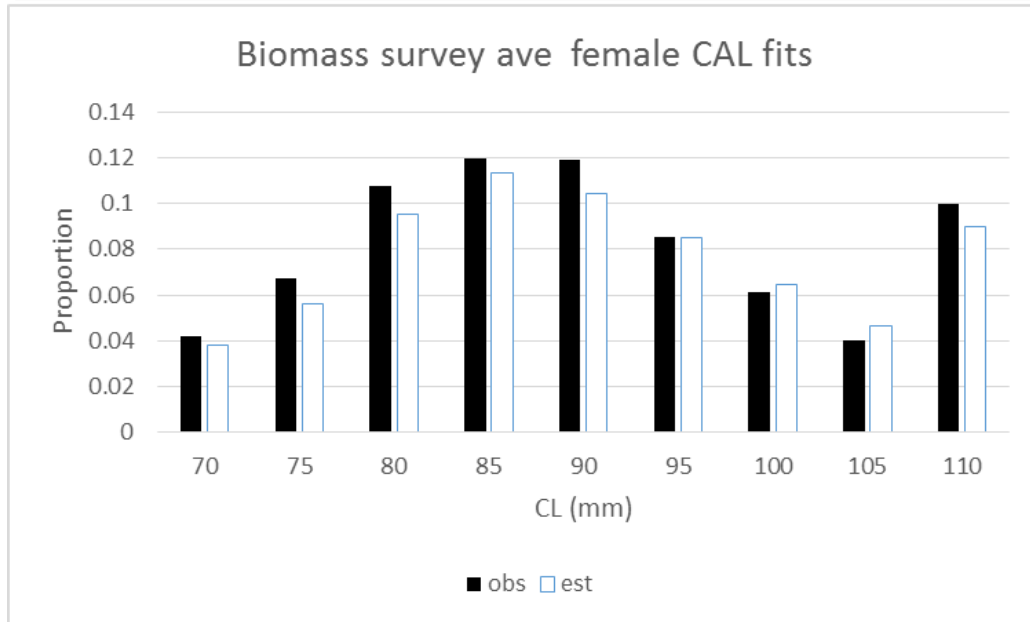
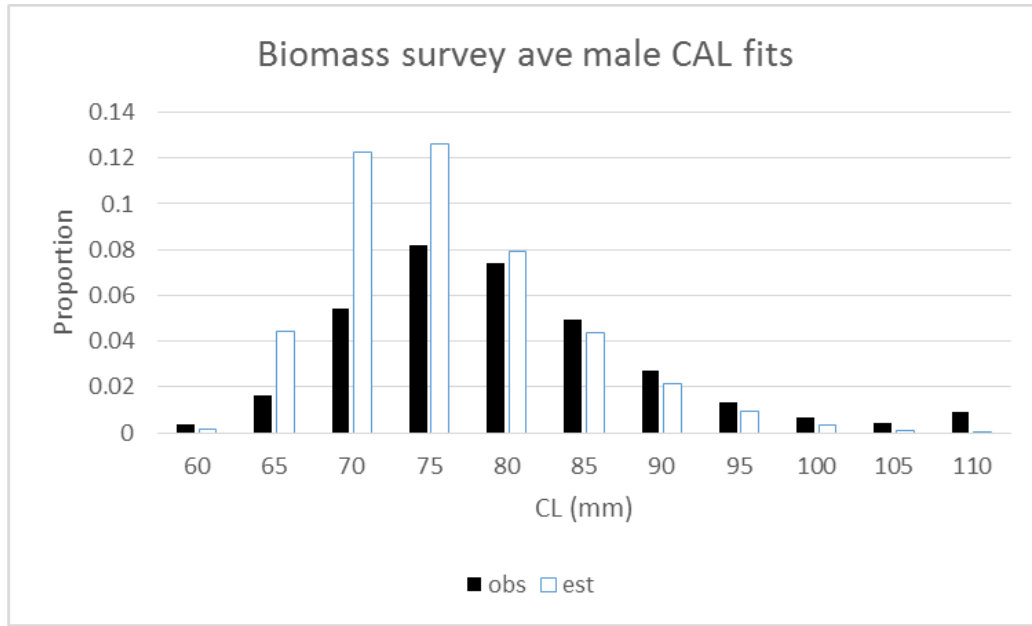


Figure 2e: Gough standardised commercial longline CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

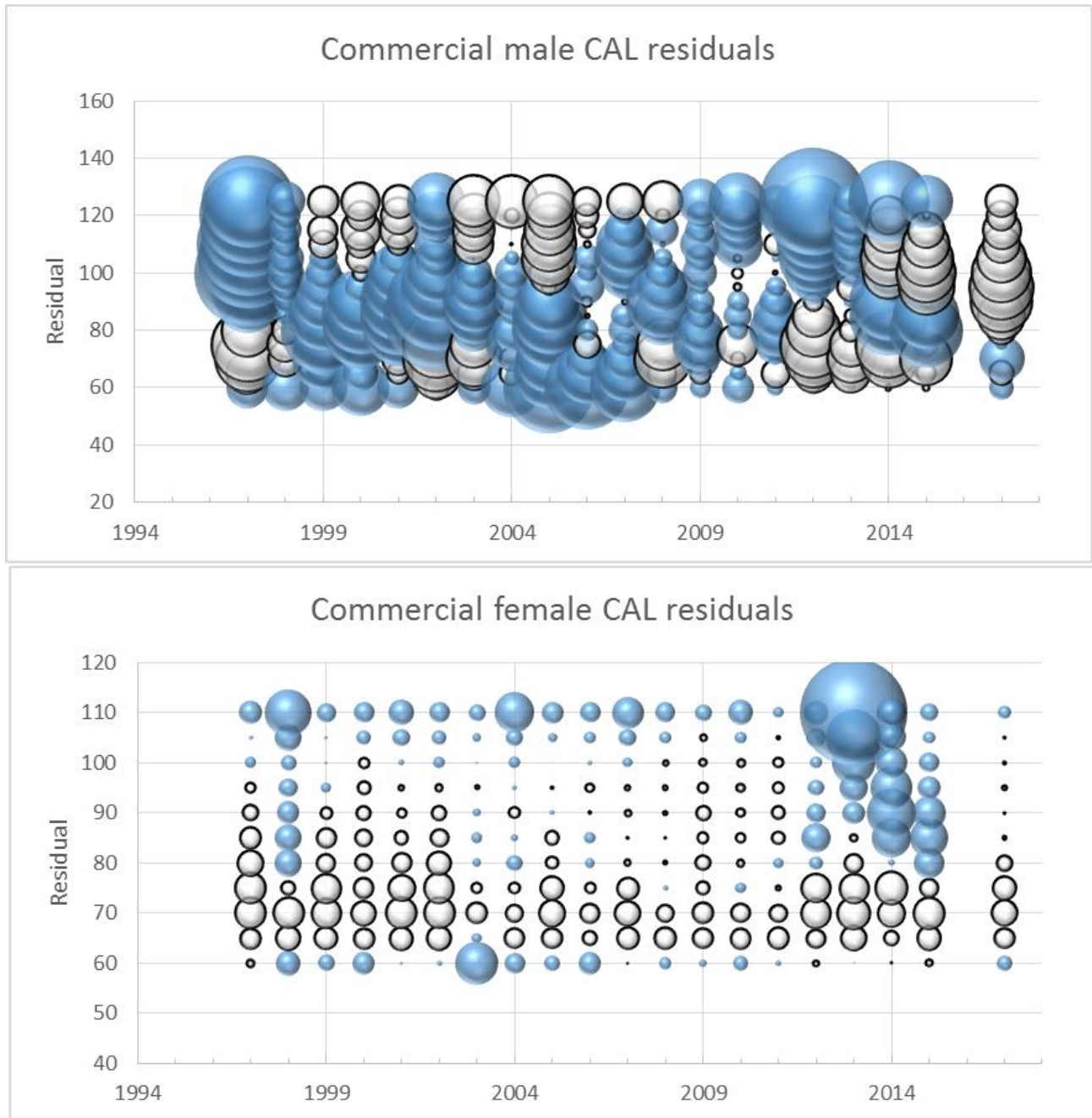


Figure 2f: Gough standardised biomass survey Leg1 CAL residuals. The dark bubbles reflect positive and the light bubbles negative residuals, with the bubble radii proportional to the magnitudes of the residuals.

