Progress made on updating the SCRL assessment

S.J. Johnston

Three models have been identified by the SWG for the SCRL assessment update. These relate to the areal splits, and are:

Model 1: A1, A2, A3 (as in recent years)

Model 2: A1E, A1W, A2, A3 (i.e. 4 areas)

Model 3: A1E, A1E, A2+3

In this report I have concentrated on updating Model 1 first.

Updated data

Updated input data include:

1. Catches by area to include the 2010 season (FISHERIES/2012/APR/SWG-SCRL/07 provides details)
2. CPUE by area (1977-2010) (FISHERIES/2012/APR/SWG-SCRL/09 provides details)
3. Catch-at-length data (scientific) (1995-2010) (FISHERIES/2012/SPR/SWG-SCRL/08 provides details). These data are sex- and area-specific.
4. It was also decided to use catch-at-length data derived from the pack-category data (see FISHERIES/2012.JAN.SWG/SCRL/03 for details). It was decided to use data for seasons 1990-1997 and 2006-2010 as part of the likelihood (model comparisons for other years could be provided for comparative purposes). Note that the pack-category CAL data are for both sexes and all areas combined.
5. Somatic growth parameters: FISHERIES/2011/OCT/SWG/SCRL/10 provided estimates of L_∞ and ρ. Mike Bergh pers. comm. provided further updates for these values. These are reported in Table 1 below:

Area	L_∞ values	
	Males	Females
1	105.6	95.9
2	116.3	106.4
3	119.2	109.3
1E	89.3	79.5
1E	110.7	100.9
2+3*	117.75	107.85
ρ (all areas)	0.098	

*average of A2 and A3

Updated model assumptions and parameters

Stock recruit residuals: estimated for 1997-2003

Recruitment split between areas (λ's) 1973-2003

Time-varying selectivity (when used): 1995-2010

Pack-category data inclusion to likelihood (treated similarly to "scientific" catch-at-length data):

The following term is added to the negative log-likelihood:

$$-\ell \mathrm{n}\, L^{\mathrm{PAC}} = \sum_{y}\sum_{l}\left[\ln\left(\sigma_{len}/\sqrt{p_{y,l}}\right) + p_{y,l}\left(\ln p_{y,l} - \ln \hat{p}_{y,l}\right)^2 / 2\left(\sigma_{len}\right)^2\right] \quad (1)$$

where

$p_{y,l}$ is the observed proportion of pack category lobsters (by number) in length group *l* in the catch in year *y*, and

σ_{len} is the standard deviation associated with the length-at-age data, which is estimated in the fitting procedure by:

$$\hat{\sigma}_{len} = \sqrt{\sum_{y}\sum_{l} p_{y,l}\left(\ln p_{y,l} - \ln \hat{p}_{y,l}\right)^2 / \sum_{y}\sum_{l} 1} \quad (2)$$

Selectivity function

There are two options explored:

1) No time varying selectivity (No TVS)
2) Selectivity is allowed to vary over time (TVS)

The selectivity function (which depends on length) is allowed to vary over the time period for which catch-at-age data are available (1994-2005). To effect this, the form of the selectivity function is generalised to:

$$S_{y,l}^{m/f,A} = \frac{1}{1+e^{-\ln 19\left(l-\left(l_{50}^{m/f,A}+\delta_{y}^{m/f,A}\right)\right)/\Delta^{m/f,A}}} \quad (3)$$

The estimable parameters are thus:

- $l_{50}^{m/f,A}$ (the expected length at 50% selectivity, when $\delta_{y}^{m/f,A}$ = 0), and
- $\Delta^{m/f,A}$ and for *y* = 1995-2010 Note:
- the expected length at 95% selectivity ($l_{95}^{m/f,A}$, when $\delta_{y}^{m/f,A}$ = 0) is given by $l_{50}^{m/f,A} + \Delta^{m/f,A}$, and

- $\delta_y^{m/f,A}$ for pre-1995 and 2010+ = 0.

An extra term is added to the likelihood function in order to smooth the extent of change in the selectivity, as follows:

$$-\ln L \rightarrow -\ln L + \sum_{m/f}\sum_{A}\sum_{y=1995}^{y=2010}\left(\frac{\delta_y^{m/f,A}}{\sigma_{sel}}\right)^2 \quad (4)$$

where the σ_{sel} is input (a value of 0.75 was found to provide reasonable performance).

An issue to be taken into account is that for equation (1), if $\delta_y^{m/f,A}$ decreases, this means that selectivity is increasing on younger lobsters; however given that the model fitting procedure assumes that:

$$\hat{CPUE}_y = q\sum_l w_l S_{l,a} N_{l,a} e^{-M/2} \quad (5)$$

this situation seems implausible, in that an enhanced CPUE would result even if there was not any increase in abundance.

Presumably enhanced catches of younger animals are achieved by spatially redistributing effort on a scale finer than captured by the GLM standardisation of the CPUE. A standard method to adjust for this, while maintaining a constant catchability coefficient *q*, is to renormalise the selectivity function in some way:

$$S_{y,l}^{m/f,A} \rightarrow S_{y,l}^{*,m/f,A} = S_{y,l}^{m/f,A} / X_y^{m/f,A} \quad (6)$$

where here as a simple initial approach we have chosen:

$$X_y^{m/f,A} = \sum_{l_1^{m/f,A}}^{l_2^{m/f,A}} \frac{S_{y,l}^{m/f,A}}{l_2^{m/f,A} - l_1^{m/f,A} + 1} \quad (7)$$

i.e., normalising selectivity by its average over a certain length range, so that now if $\delta_y^{m/f,A}$ decreases, the $S_{y,l}^{*,m/f,A}$ will decrease for large *l* to compensate for the effort spread to locations where younger animals are found associated with the increase for smaller *l*.

The values of $l_1^{m/f,A}$ and $l_2^{m/f,A}$ are fixed at the following values after examining the length frequency distributions, to ensure that the ranges associated with these *l* values cover the greater part of these distributions.

m/f	*A*	$l_1^{m/f,A}$	$l_2^{m/f,A}$
m	**1**	65mm	90mm
f	**1**	65mm	90mm
m	**2**	65mm	90mm
f	**2**	65mm	90mm
m	**3**	55mm	90mm
f	**3**	55mm	90mm

Two alternate selectivity functional forms are modeled for Area 3.

It was decided that a year-independent second selectivity function, with the shape of a normal distribution would be modeled as the "second" selectivity function for Area 3.

Thus the selectivity for Area 3 is defined as follows:

$$S_{y,l}^{m/f,3} = (1-\lambda)S1_{y,l}^{m/f,3} + \lambda S2_l^{m/f,3} \qquad (8)$$

where

$S1_{y,l}^{m/f,3}$ is the original selectivity function (as used for other Areas)

$S2_l^{m/f,3} = e^{-\left(l-l_{m/f}^*\right)^2/\omega^2}$ (the second normal-shaped selectivity function) (9)

Note that we now estimate the following further parameters: l_m^*, l_f^*, ω and λ.

This formulation is thus time-invariant (λ constant over time), but allows for a different male and female *S*2 selectivity function to be estimated for Area 3.

Results

Figure 1 compares the pack category data for each year with the "scientific" catch-at-length data for each area where these have been combined over both sexes. Figures 2-5 report Model 2012b output– model with TVS – old type of selectivity function i.e. no μ values.

Figure 2 shows the fit to CPUE data.

Figure 3a shows the residuals of the scientific CAL data to fits to the data. Figure 3b shows the fits for the pack-category data.

Figure 4 shows the selectivity functions for males and females and all three areas – these are the functions estimated for the first year. Figure 5 shows the selectivity "delta" values – which allow for the selectivity functions shown in Figure 4 to change over time.

Figures 3a and b show that even with TVS there remain serious systematic trends in CAL residuals. It thus seems that the selectivity models used (equations 3, 8 and 9) are not sufficiently flexible. Experimentation has thus commenced generalising equation 3 to allow for the right hand limb of the selectivity curve to be reduced (or increased) depending on the estimated value of μ. Thus

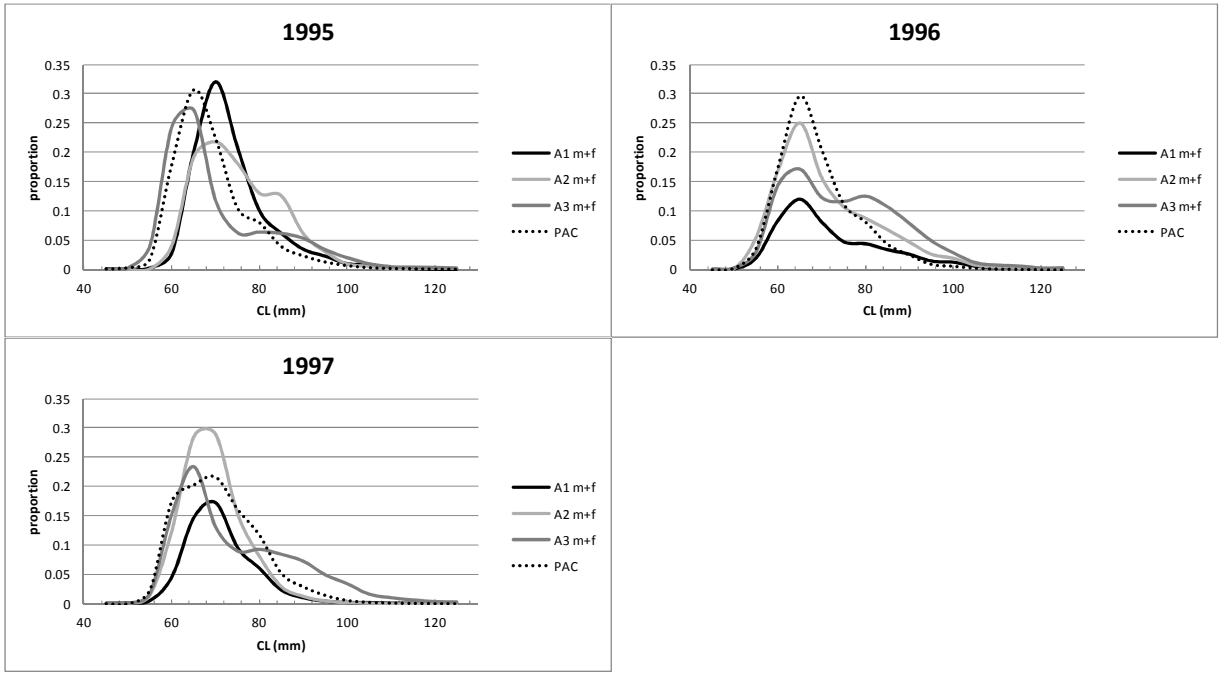
$$S_{y,l}^{m/f,A} = \frac{e^{-\mu l}}{1+e^{-\ln 19(l-(l_{50}^{m/f,A}+\delta_y^{m/f,A}))/\Delta^{m/f,A}}} \qquad (10)$$

In the TVS version, allow for first only the μ to vary over time, then perhaps both the μ and δ values to vary over time.

Table 1: Summary table of Models run so far. All these results are for the scenario of an Area 1, Area 2 and Area 3 (as previously). Models included all data include latest 2010/11 data from Jean.

	Model	CAL data included in –lnL	-ln (CPUE)	-ln (SCI CAL)	-ln (PAC CAL)	B_{11}^{sp} / K^{sp}	$B_{11}^{\exp} / K_{1973}^{\exp}$
With TVS 2011 results (MARAM model)	Model 2011	SCI CAL	-131.81	-99.79	-	0.29 (2009/K)	0.28 (2009/K)
Model 2012 updated with new data No TVS; old selectivity	Model 2012a	SCI*1.0+ PAC*1.0	-91.64	-97.88	51.52	0.26	0.31
Model 2012 updated with new data TVS; old selectivity	Model 2012b	SCI*1.0+ PAC*1.0	-92.99	-122.85	51.43	0.27	0.31
Model 2012d but fix *h*=0.99		SCI*1.0+ PAC*1.0	-73.23	-161.90	31.80		

Figure 1: Comparison between Scientific CAL data (combined across sexes here, but kept separate for each area), and the PAC category CAL data (sexes and areas combined).



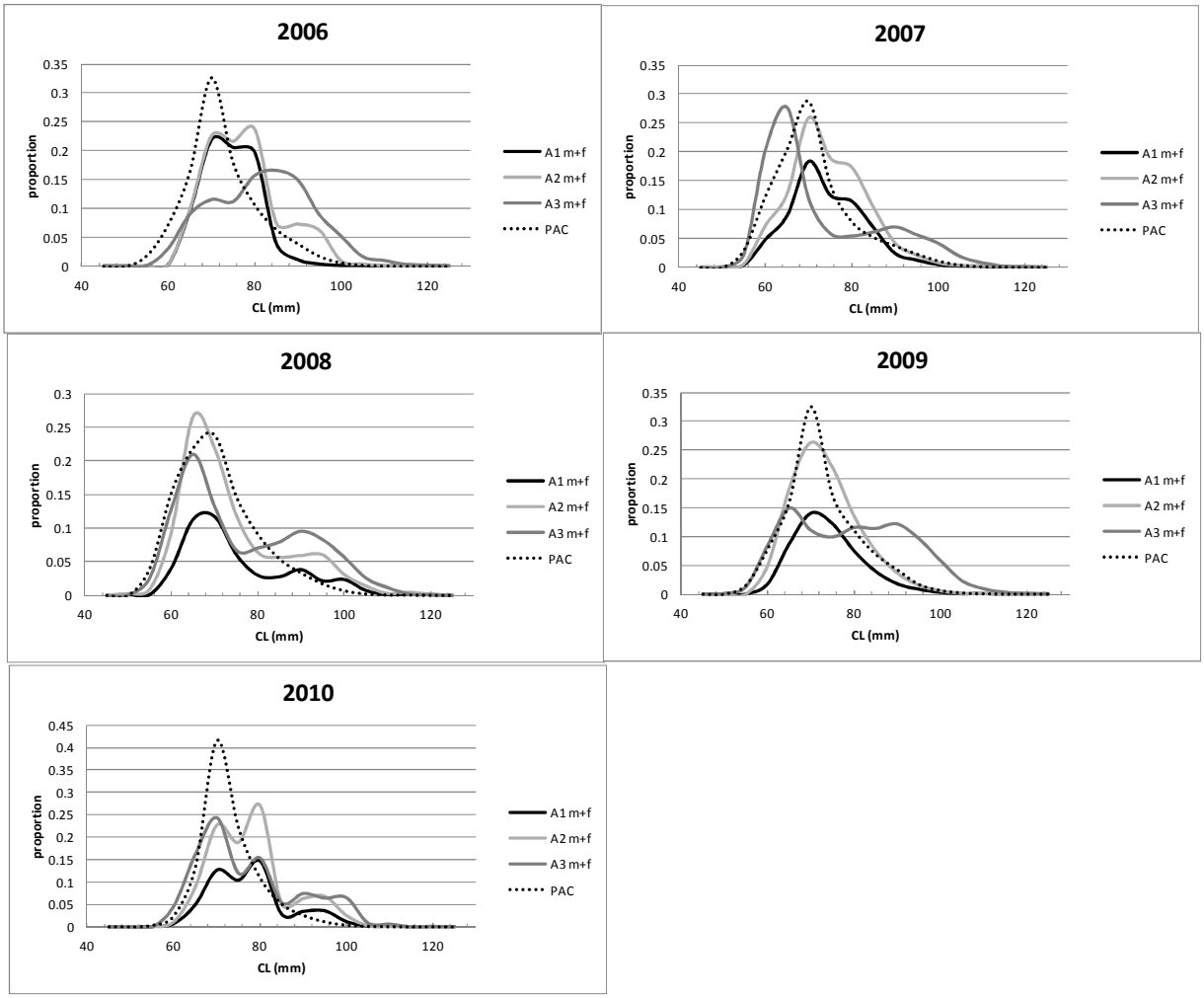
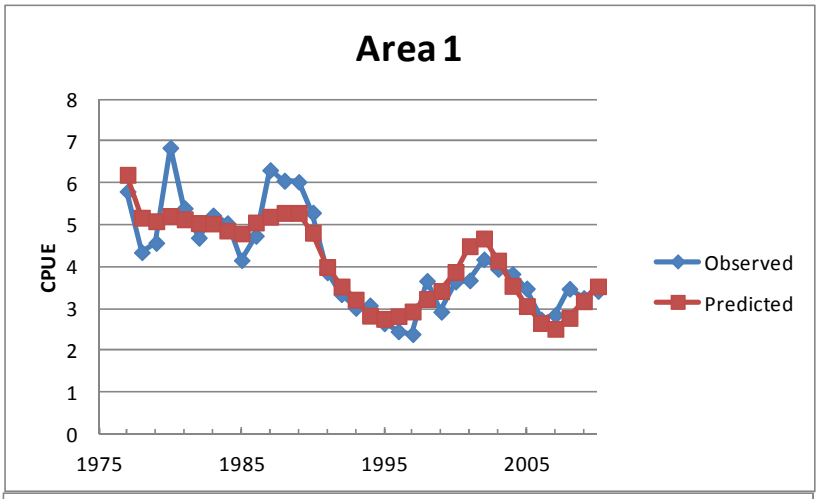
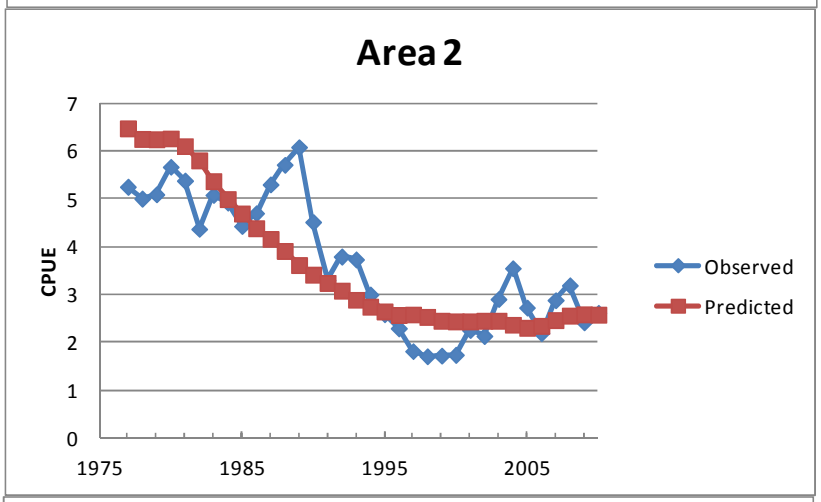

2006
2007
2008
2009
2010
proportion
CL (mm)
A1 m+f
A2 m+f
A3 m+f
PAC

Figure 2: Model 2012b CPUE fits





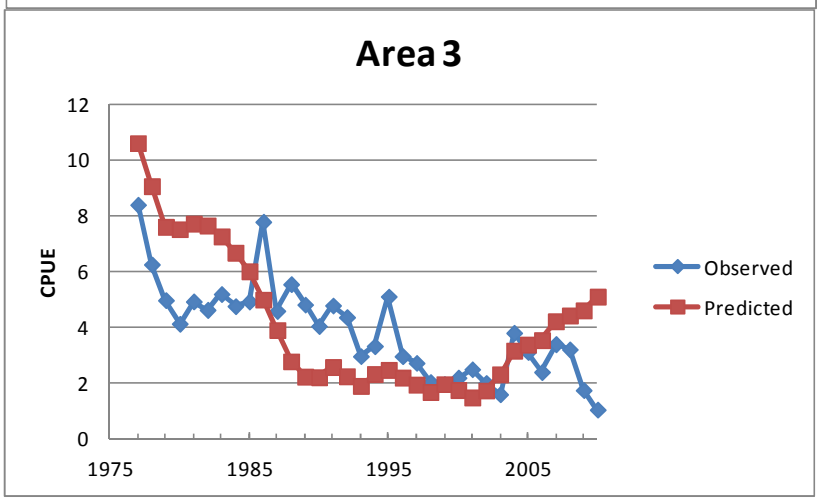


Figure 3a: Residuals of the Scientific CAL fits to data: (white means model estimate is larger than observed!)

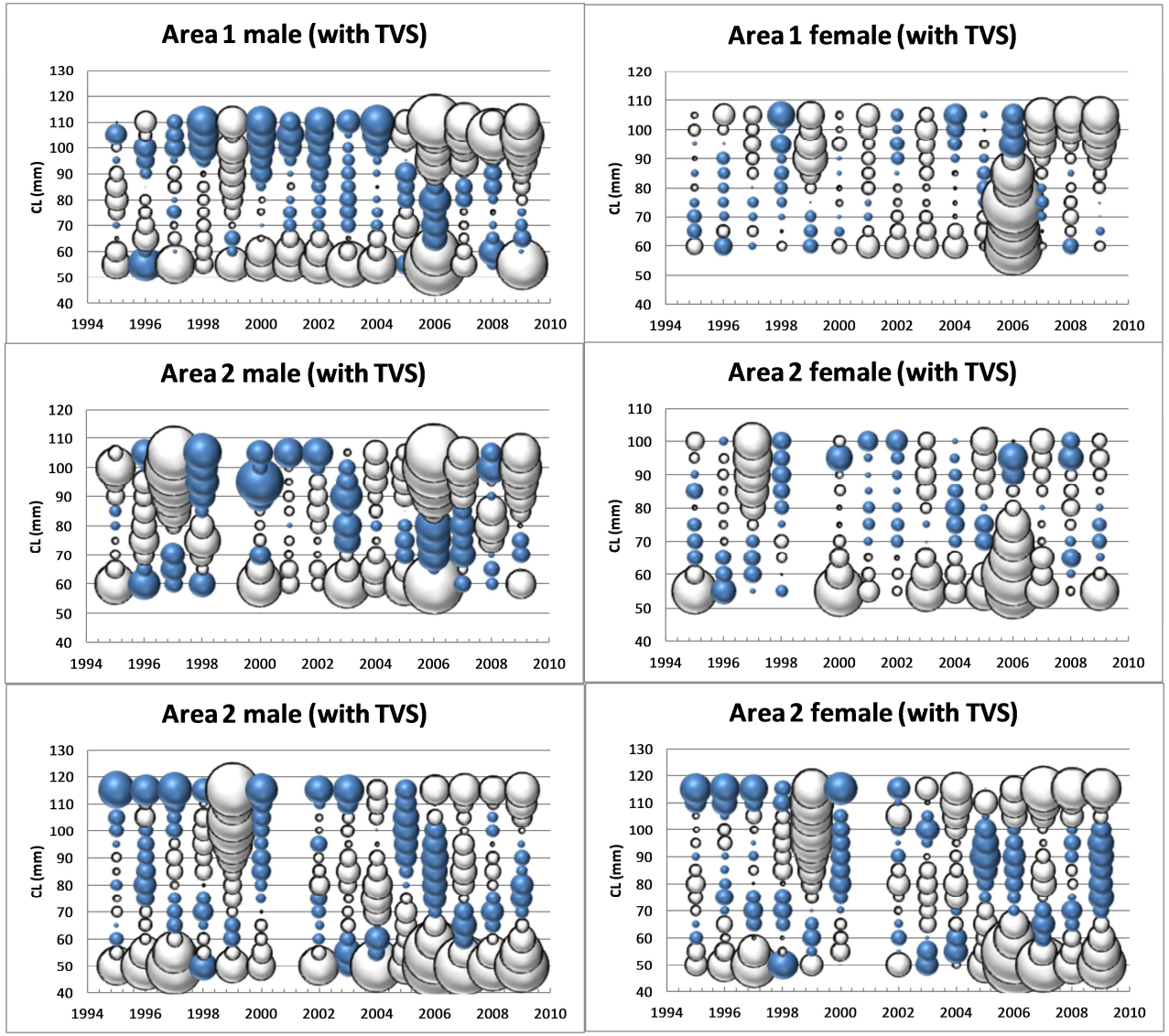


Figure 3b: Fits to pack-category data.

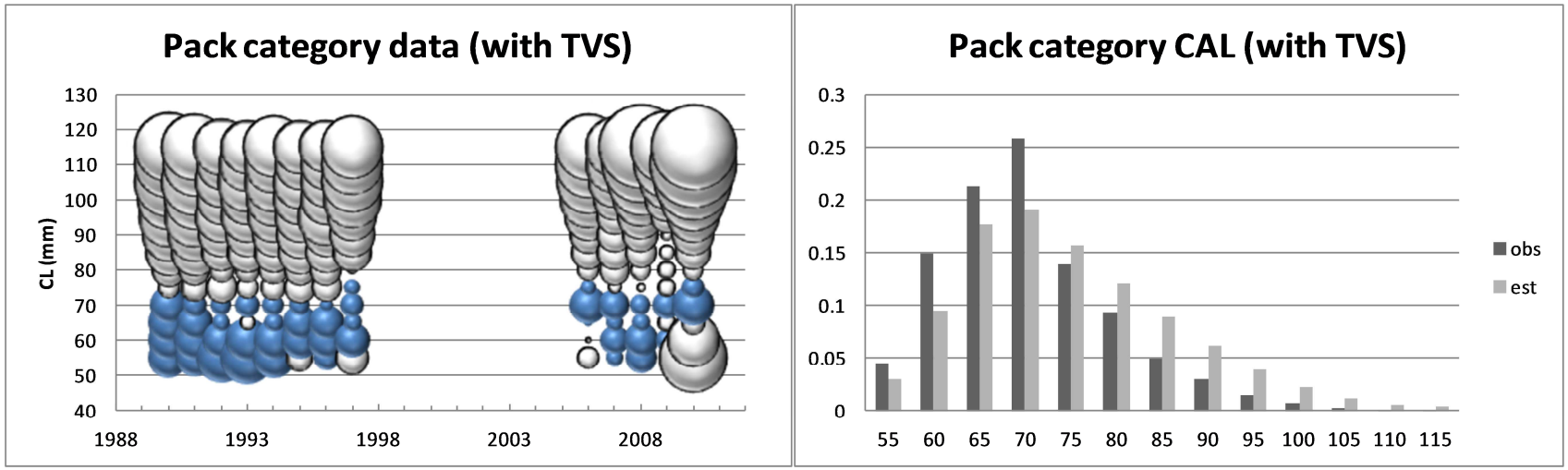
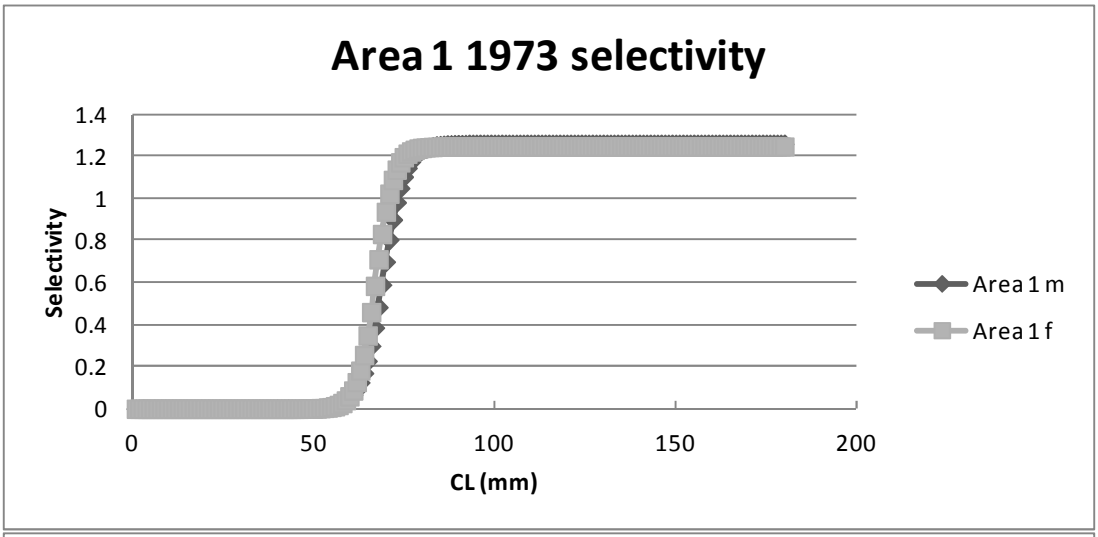
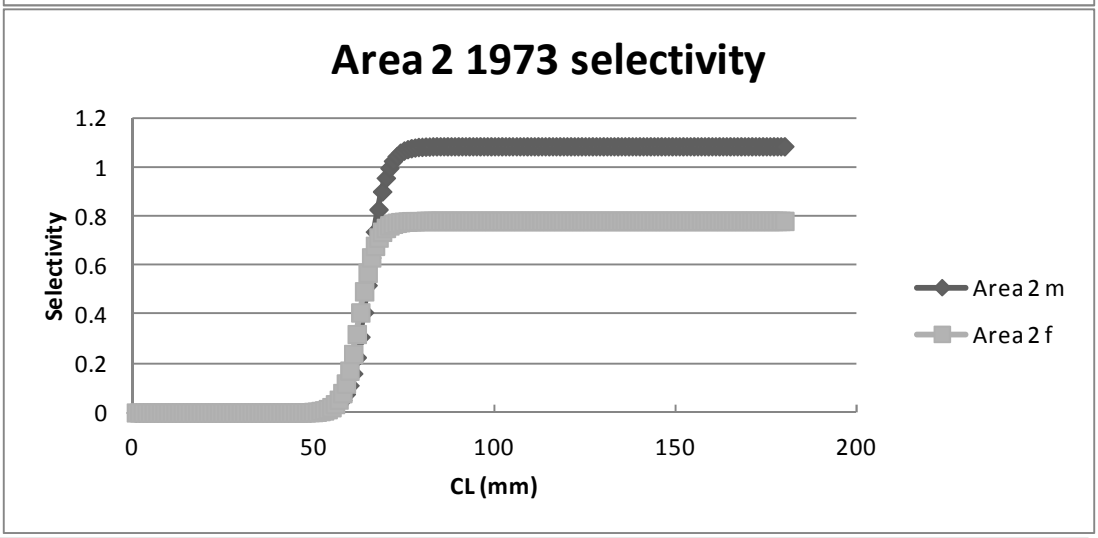


Figure 4: Selectivity functions for first year (1973)





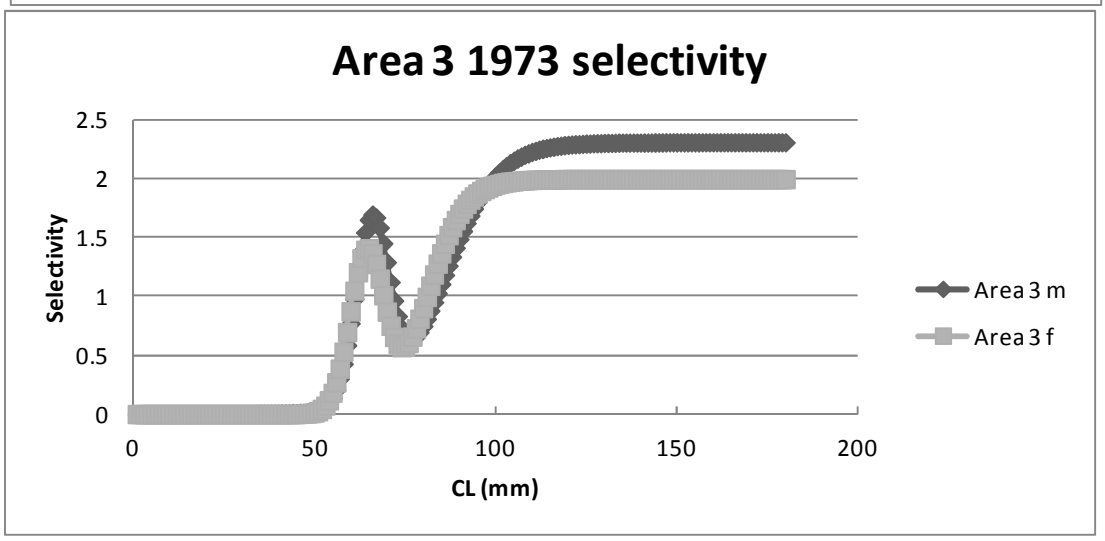


Figure 5: Selectivity “deltas” (print out error thus no values for 2009 and 2010 for Area 2 and 3)