Updated West Coast Rock Lobster Operating Models

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A number of recommendations pertaining to the assessment of West Coast rock lobster were made by the panel at the international workshop held in Dec 2010. The authors have taken these into account and updated all five operating models for the West Coast rock lobster resource. The following are items that have been checked and modified in the operating models and associated input data.

Data related

1. The F% values for all areas were checked for accuracy.
2. All percentage female and length-frequency data for which the corresponding sample size are low were identified and rules developed for excluding data for which the sample size is likely too small to provide meaningful information. See Johnston and Butterworth (2011).

Model structure

1. Fix female survivorship = 0.90 (same as for males)
2. Re-parameterise selectivity function:
    - Logistic function for males flat at large sizes. Fix selectivity at 90mm CL at 1.0.
    - Logistic function for females flat at large sizes, but add scaling parameter i.e. estimate asymptote.
    - The estimated trap sublegal selectivity (<75mm) estimated for A8 traps will be assumed for all other sublegal selectivity functions. (The A8 sublegal trap catch-at-length data are the ONLY sublegal catch-at-length data available for all gears and super-areas.)
    - Allow for decreasing selectivity at large sizes if needed for FIMS. Details are given later.

Estimation/minimization

1. An improved method of model fitting has been implemented to better ensure that the global minimum of the negative log-likelihood is found. This involves:
   - Fixing the selectivity functions and drawing the recruitment estimable parameters from a wide parameter space. This is done 5000 times. The –lnL is calculated for each draw, and the parameter vectors associated with the five lowest –lnL values out of 5000 random draws is kept.
   - Amoeba minimization is then initiated from each of these five parameter vectors, with all other estimable selectivity parameters now estimated.
   - The parameters associated with final "best fit" out of these five minimizations is the final set of best fit parameter values.

Note: The primary concern is to make sure models fit to CPUE trends! Fitting to CAL and F% data are secondary.

Selectivity-at-length functions

Trap and Hoopnet

The selectivity function (which depends on length) is assumed constant over time. Male and female selectivity are estimated separately as follows.

For trap and hoopnet males:

$$S_l^m = \frac{e^{-\mu^m l}}{1+e^{-\delta^m (l-l_*^m)}}.Q \qquad (1)$$

For trap and hoopnet females :

$$S_l^f = P\frac{e^{-\mu^f l}}{1+e^{-\delta^f (l-l_*^f)}}.Q \qquad (2)$$

where

for super-areas 3+4, 5+6, 7 and 8+ the μ value is fixed at zero which results in "flat" selectivity at larger sizes;

for super-area 1+2 hoops, the μ value is fixed at zero for males, but is allowed to be estimated for females as a very poor fit to female CAL data would otherwise result;

Q is a scaling parameter chosen so that male selectivity at 90mm =1; and

*P i*s a further scaling parameter which scales female relative to male selectivity at 90mm carapace length.

The estimable parameters are thus:

- $l_*^{m/f}$,
- $\delta^{m/f}$,
- *P* and
- μ^f for super-area 1+2 female hoopnet selectivity

The functions above for super-area 1+2, 3+4, 5+6 and 7 are used for the 75mm+ portion of the stock only, as no CAL data are available for sub-legal harvests. There are however sub-legal trap CAL data available for super-area 8. The trap selectivity estimated for super-area 8 for the <75mm portion of both the males and females are thus assumed to apply for the other super-areas for lobsters <75mm CL, as well as for the super-area 8 hoop <75mm CL lobsters. In order to link these sub-legal selectivity functions from super-area 8 to the selectivity functions estimated for the 75+mm lobsters in the other four areas, a scaling method is applied as follows:

$$S_l^{super-area} = \frac{S_{75}^{super-area}}{S_{75}^{A8,trap}} . S_l^{A8,trap} \quad \text{for } l \leq 75mm \tag{3}$$

For A7, the hoop selectivity functions are not estimated but set equal to those estimated for Area 8, due to insufficient hoop CAL and CPUE data for Area 7.

FIMS

Following workshop recommendations, the FIMS selectivity function is modeled to be somewhat more flexible and allow for more “finger-like” selectivity functions. The authors found though that the best form of selectivity function in order to fit the FIMS CAL data was more like a “table-top” function, and thus the following selectivity functions are used for both the FIMS males and females:

$$S_l^m = \frac{1}{1+e^{-\left(\delta^m(l-l_*^m)\right)}} \quad \text{for} \quad l < l^{m'} \tag{4}$$

$$S_l^m = \frac{e^{-\mu^m(l-l^{m'})}}{1+e^{-\left(\delta^m(l-l_*^m)\right)}} \quad \text{for} \quad l < l^{m'} \tag{5}$$

and similarly for females, and where

$$l^{m'} = 75mm$$

$$l^{f'} = 65mm$$

For A3+4 however, $l^{f'}$ is adjusted down to 62mm to improve the fit to FIMS female catch-at-length data, and for A5+6, $l^{m'}$ is adjusted down to 65mm to improve the fit to FIMS male catch-at-length data.

Results

Table 1 reports the model estimates of key parameters and quantities of biological interest for the operating models for each of the five super-areas, while Table 2 gives estimates of the selectivity parameter values.

Output statistics and quantities shown

B_{75} is the male+female biomass above 75mm carapace length

B_{75}^{m} is the male biomass above 75mm carapace length

Egg is the female egg production where egg production is a function of the female spawning biomass.

Figures 1a-e report the model fits to CPUE data and F% data (where data are available). Figures 2a-c report model fits to catch-at-length (CAL) data. Here values over a number of years have been averaged. Figures 3a-e show the estimated selectivity functions. The left hand plots show the male and female function on the same scale, and the right hand plots show the female functions only. Figures 4a-e show the recruitment, biomass and egg production trajectories. The left hand plots are for the 1920+ period (the models initiate the resource at unexploited equilibrium in 1910), and the right hand plots are for 1980+ only.

References

Johnston, S.J. and D.S. Butterworth. 2011. West coast rock lobster catch-at-length sample sizes. FISHERIES/2011/MAR/SWG-WCRL03.

Table 1: Comparative contributions to the –ln*L* value, sigma values, biomass and egg production estimates for all five super-areas.

Super-area	**A1+2**	**A3+4**	**A5+6**	**A7**	**A8+**
R_{1910} (millions)	44.1	306.7	312.0	60.7	607.4
R_{1920}/R_{1910}	3.92	0.762	1.150	1.165	0.107
R_{1950}/R_{1910}	0.001	0.076	0.016	0.243	0.041
R_{1970}/R_{1910}	0.045	0.105	0.111	0.362	0.082
R_{1975}/R_{1910}	0.008	0.147	0.139	0.233	0.175
R_{1980}/R_{1910}	0.032	0.033	0.043	0.107	0.158
R_{1985}/R_{1910}	0.034	0.148	0.053	0.265	0.485
R_{1990}/R_{1910}	0.001	0.043	0.041	0.113	0.374
R_{1995}/R_{1910}	0.017	0.165	0.038	0.025	0.400
R_{2000}/R_{1910}	0.045	0.006	0.062	0.317	0.533
R_{2003}/R_{1910}	0.005	0.209	0.079	0.071	0.313
Trap CPUE σ	-	0.524	0.339	0.469	0.177
Hoop CPUE σ	0.165	0.491	0.424	-	0.233
FIMS CPUE σ	-	1.652	1.107	0.772	0.274
Male Trap Size σ	-	0.217	0.150	0.239	0.310
Female Trap Size σ	-	0.230	0.239	0.219	0.451
Male Hoop Size σ	0.293	0.263	0.161	0.303	0.222
Female Hoop Size σ	0.964	0.253	0.212	0.780	0.373
Male FIMS Size σ	-	0.550	0.150	0.308	0.150
Female FIMS Size σ	-	1.791	0.150	0.285	0.150
Male Sublegal size σ	-	-	-	-	0.167
Female Sublegal size σ	-	-	-	-	0.232
Trap F% σ	-	0.150*	0.150*	0.150*	0.150*

Hoop F% σ	0.150*	0.150*	0.150*	0.150*	0.150*
FIMS F% σ	-	0.150*	0.150*	0.150*	0.150*
Total –*lnL*	-19.64	97.31	62.19	76.92	-62.67
B_{75}(1910) MT	56 090	160 740	203 878	98 900	242 311
B_{75}(2010) MT	1 064	4 322	3 711	3 475	14 437
$B_{75}(2010)/B_{75}(1910)$	0.019	0.027	0.018	0.035	0.060
$B_{75}(2010)/B_{75}(1996)$	0.807	1.164	0.974	0.366	0.790
B_{75}^{m}(1910) MT	39 386	142 271	183 018	89 744	210 670
B_{75}^{m}(2010) MT	425	3 990	3 230	1 941	13 640
$B_{75}^{m}(2010)/\ B_{75}^{m}\ (1910)$	0.011	0.028	0.018	0.022	0.065
$B_{75}^{m}(2010)/\ B_{75}^{m}(1996)$	1.821	1.773	1.669	0.341	0.886
$B_{75}^{m}(2010)/\ B_{75}^{m}(2006)$	1.160	1.037	1.132	0.824	0.988
Egg (2010)/Egg (1910)	0.025	0.057	0.040	0.156	0.225

*these result from hitting the lower bounded constraint of 0.150

Table 2: Estimated selectivity parameter values for each super-area. Values fixed or input are shown in bold.

			A1+2	A3+4	A5+6	A7	A8+
TRAP	Male	μ mm^{-1}	-	**0**	**0**	**0**	**0**
		l^* mm	-	0.87	14.91	50.78	79.83
		δ mm^{-1}	-	0.124	0.177	2.80	0.166
	Female	μ mm^{-1}	-	**0**	**0**	**0**	**0**
		l^* mm	-	0.00	100.55	87.94	127.67
		δ mm^{-1}	-	0.001	0.013	0.094	0.041
		P	-	0.432	0.286	0.273	0.261
HOOP	Male	μ mm^{-1}	**0**	**0**	**0**	**0***	**0**
		l^* mm	79.73	0.11	1.56	**2.808***	2.808
		δ mm^{-1}	0.18	0.170	0.173	**0.354***	0.354
	Female	μ mm^{-1}	0.062	**0**	**0**	**0***	**0**
		l^* mm	0.33	0.04	5.77	**41.65***	41.65
		δ mm^{-1}	0.27	0.001	0.001	**0.001***	0.001
		P	10.74	0.590	0.427	0.120	0.074
FIMS	Male	μ mm^{-1}	-	0.047	0.067	0.083	0.079
		l^* mm	-	52.57	55.57	61.39	62.28
		δ mm^{-1}	-	0.805	3.720	0.417	0.380
		l' mm	-	**75**	**65**	**75**	**75**
	Female	μ mm^{-1}	-	0.200	0.432	0.652	0.503
		l^* mm	-	26.10	44.99	58.32	56.57
		δ mm^{-1}	-	1.934	1.985	9.47	1.781
		l' mm	-	**62**	**65**	**65**	**65**
		P	-	1.220	1.842	4.169	1.160

*set equal to values for A8+

Figure 1a: Area 1+2 fit to CPUE and F%.

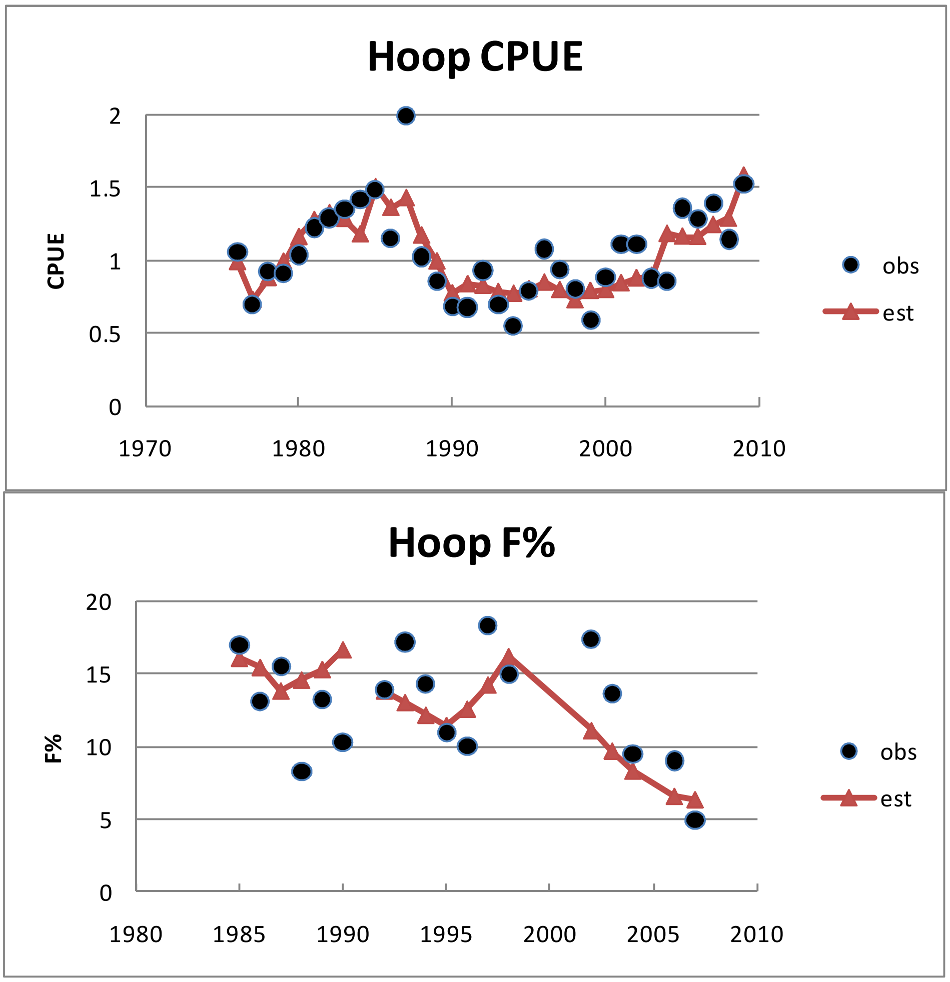


Figure 1b: Area 3+4 fit to CPUE and F%.

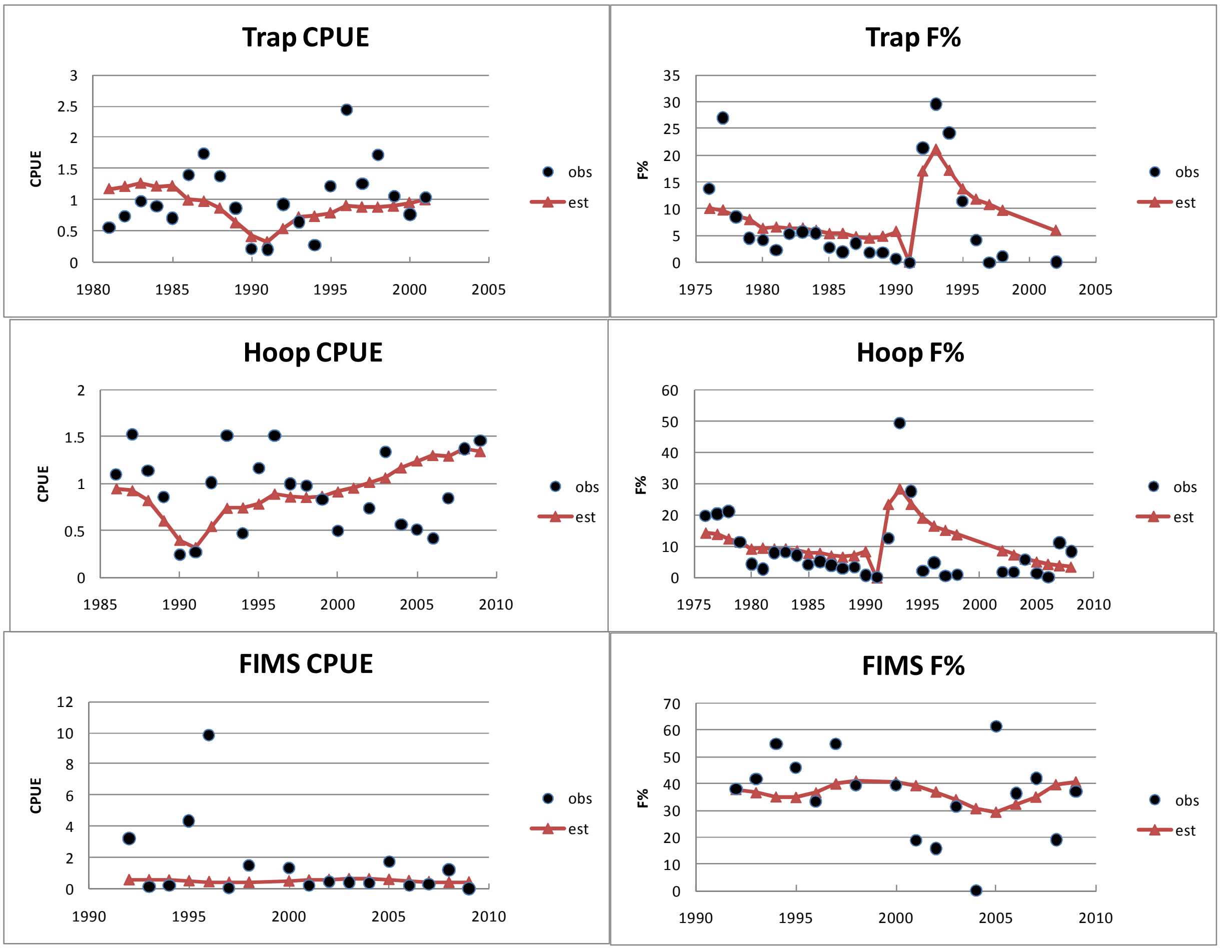


Figure 1c: Area 5+6 fit to CPUE and F%.

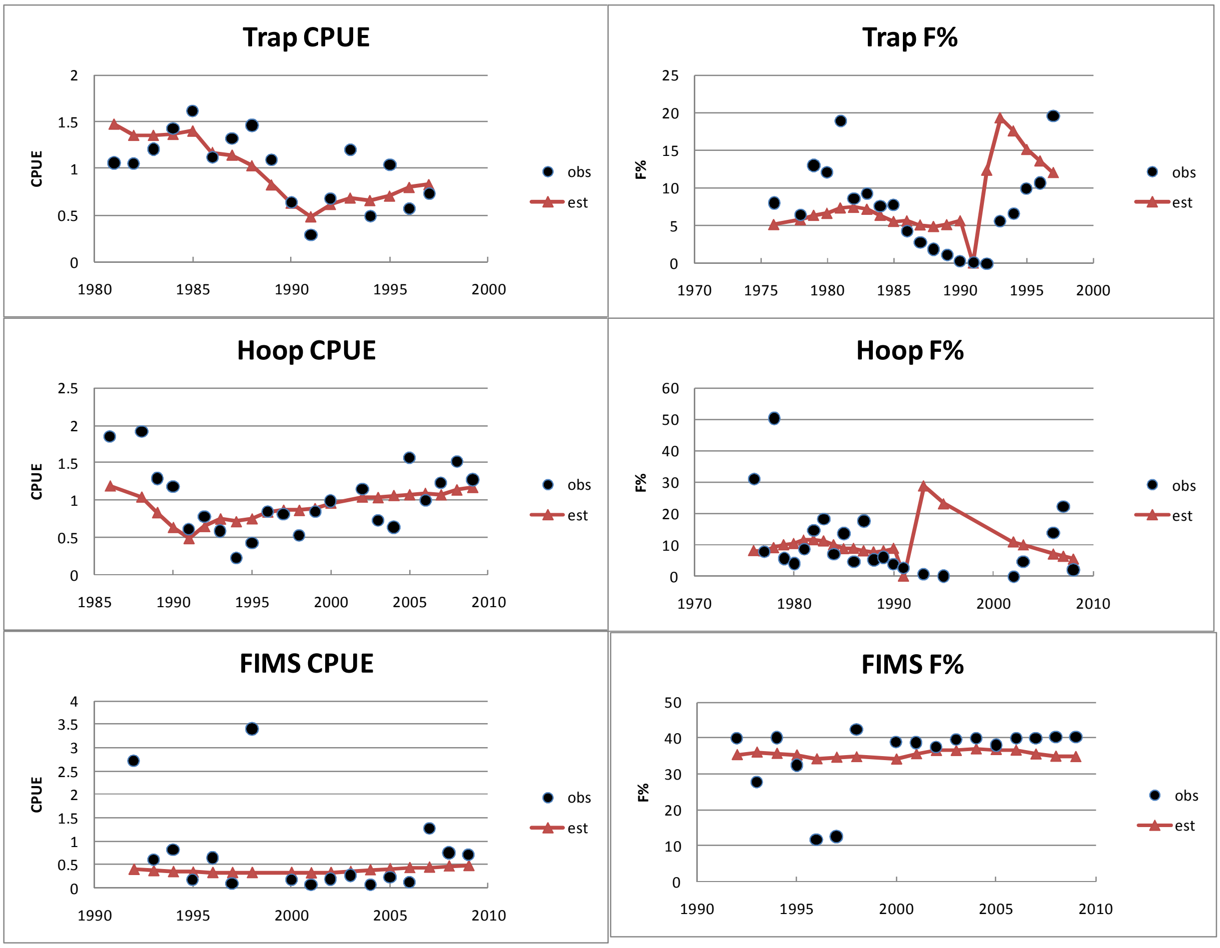


Figure 1d: Area 7 fit to CPUE and F%.

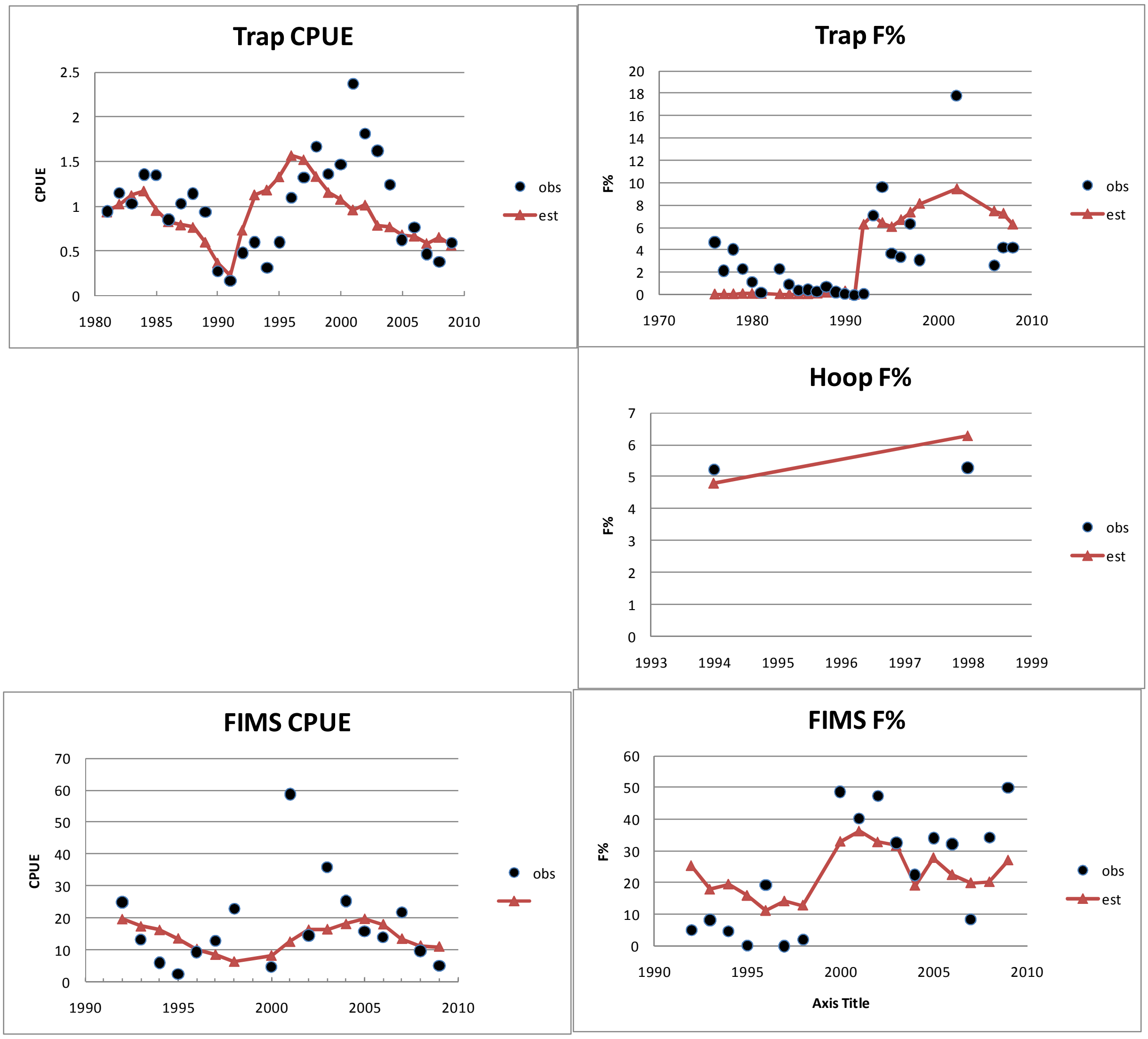


Figure 1e: Area 8+ fit to CPUE and F%.

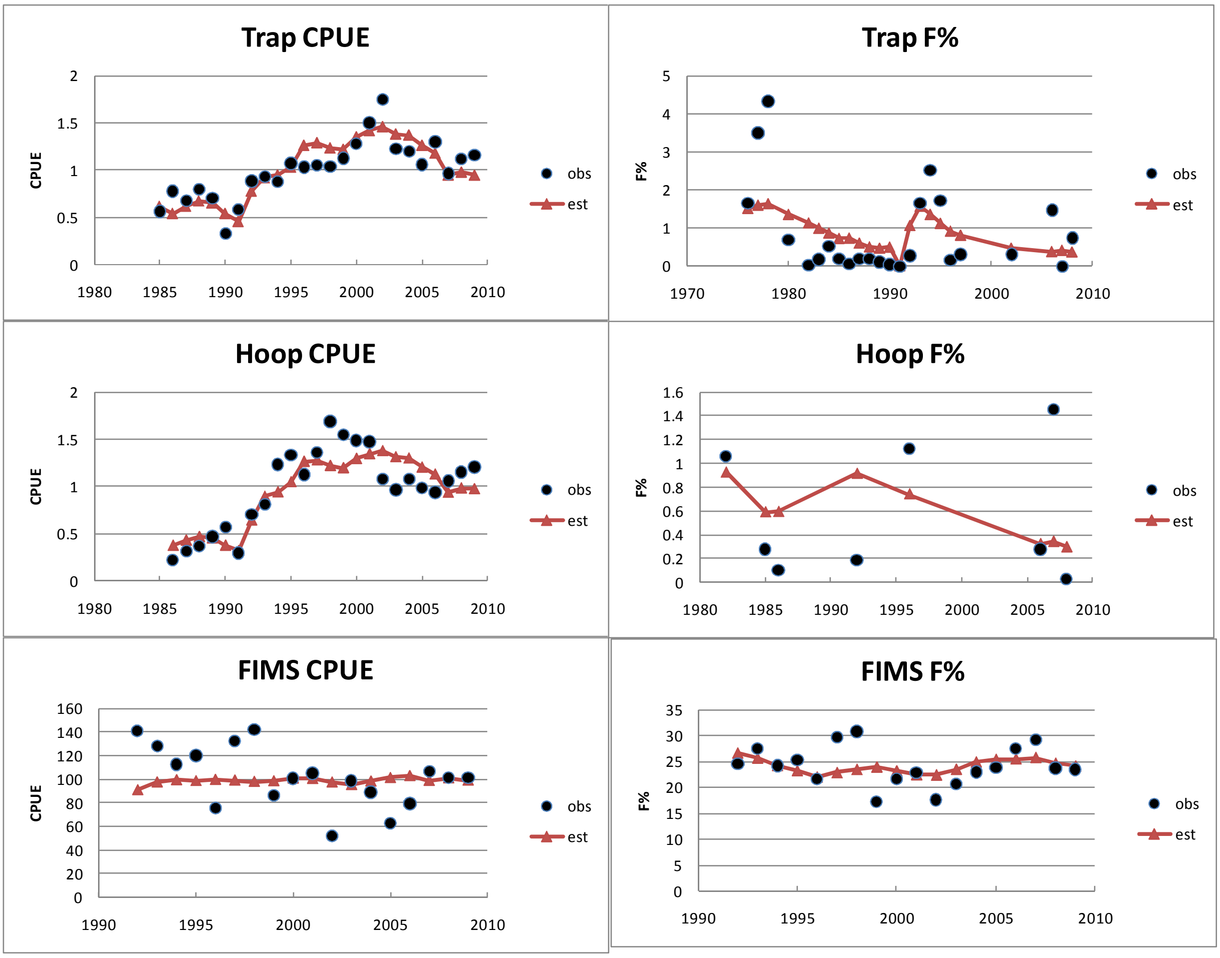
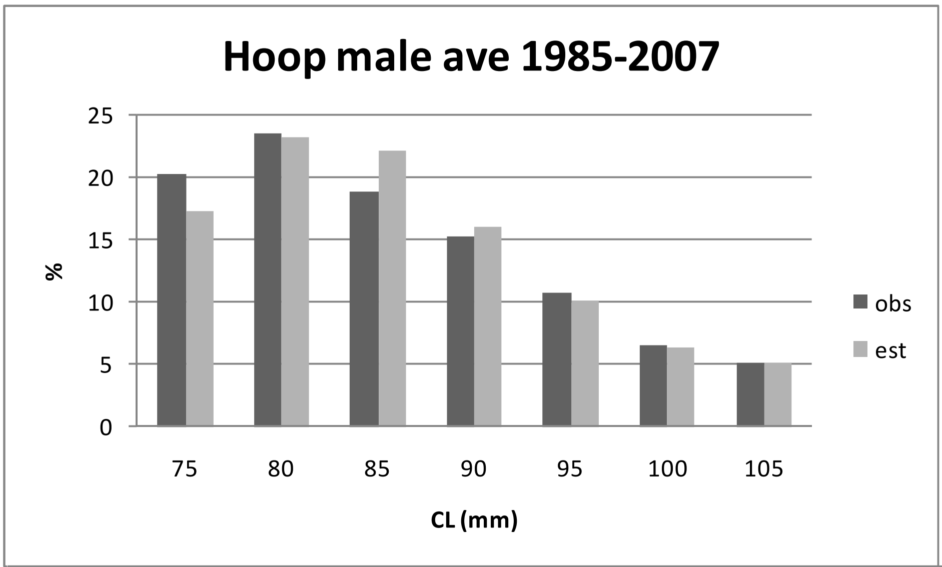


Figure 2a: Area 1+2 fits to CAL data – averages shown.



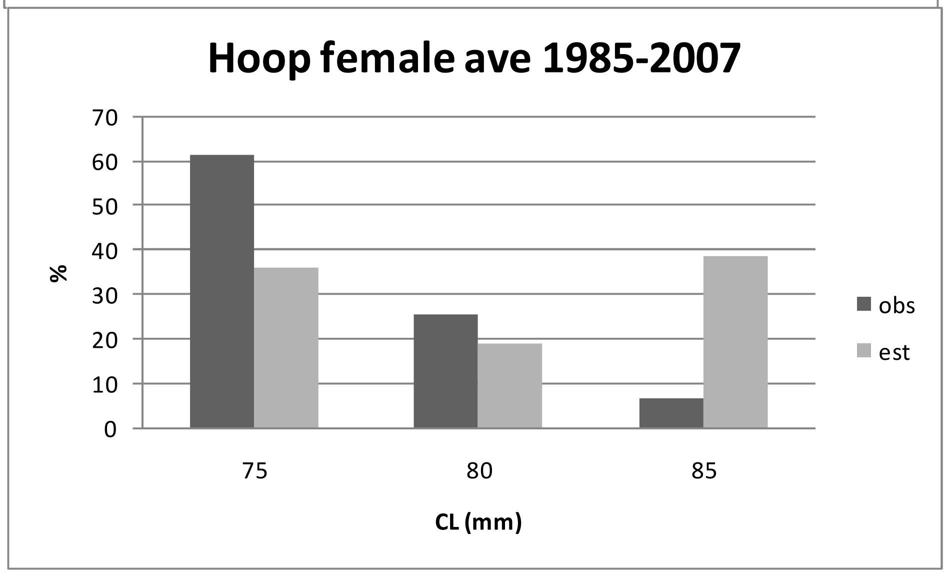


Figure 2b: Area 3+4 fits to CAL data – averages shown.

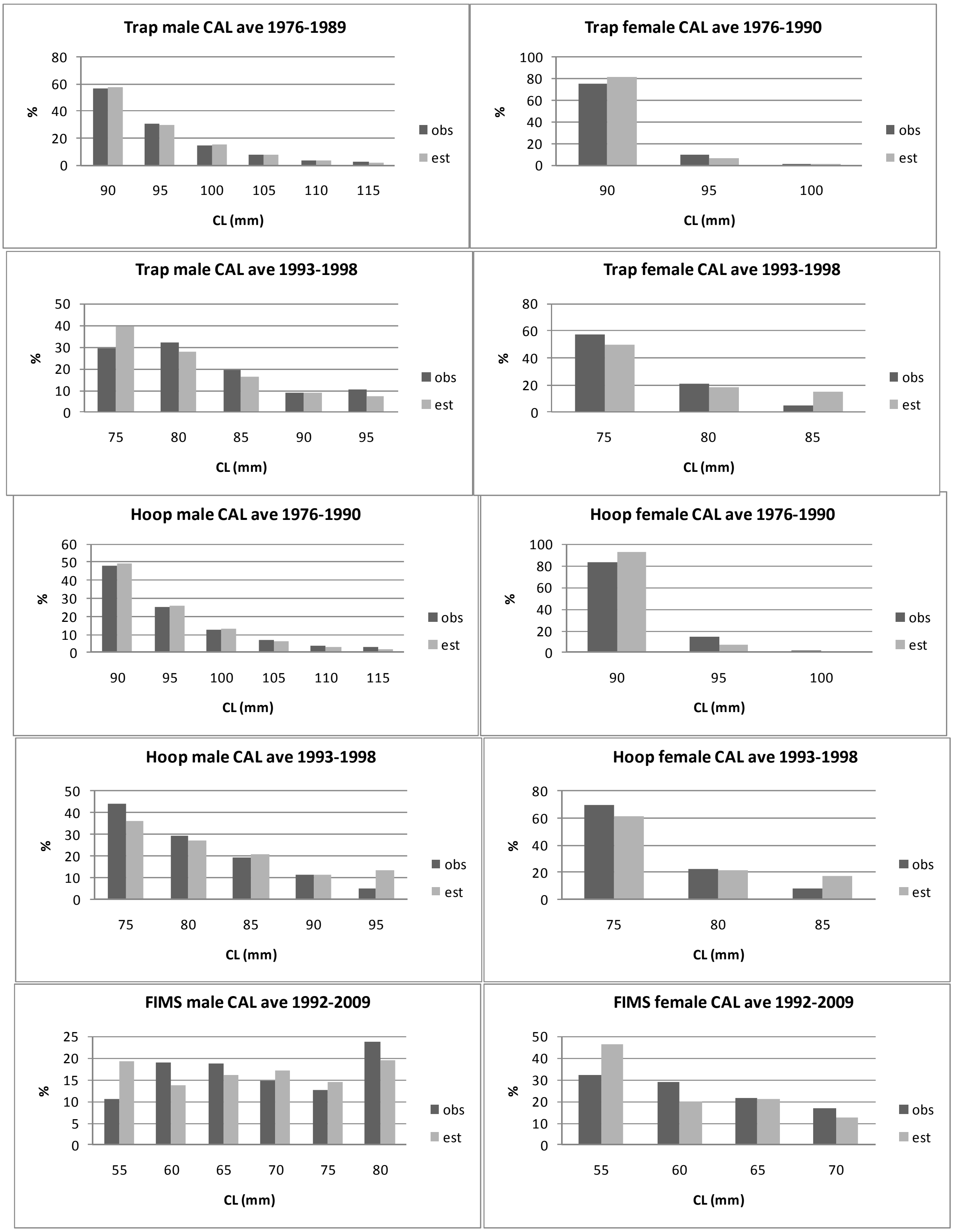


Figure 2c: Area 5+6 fits to CAL data – averages shown.

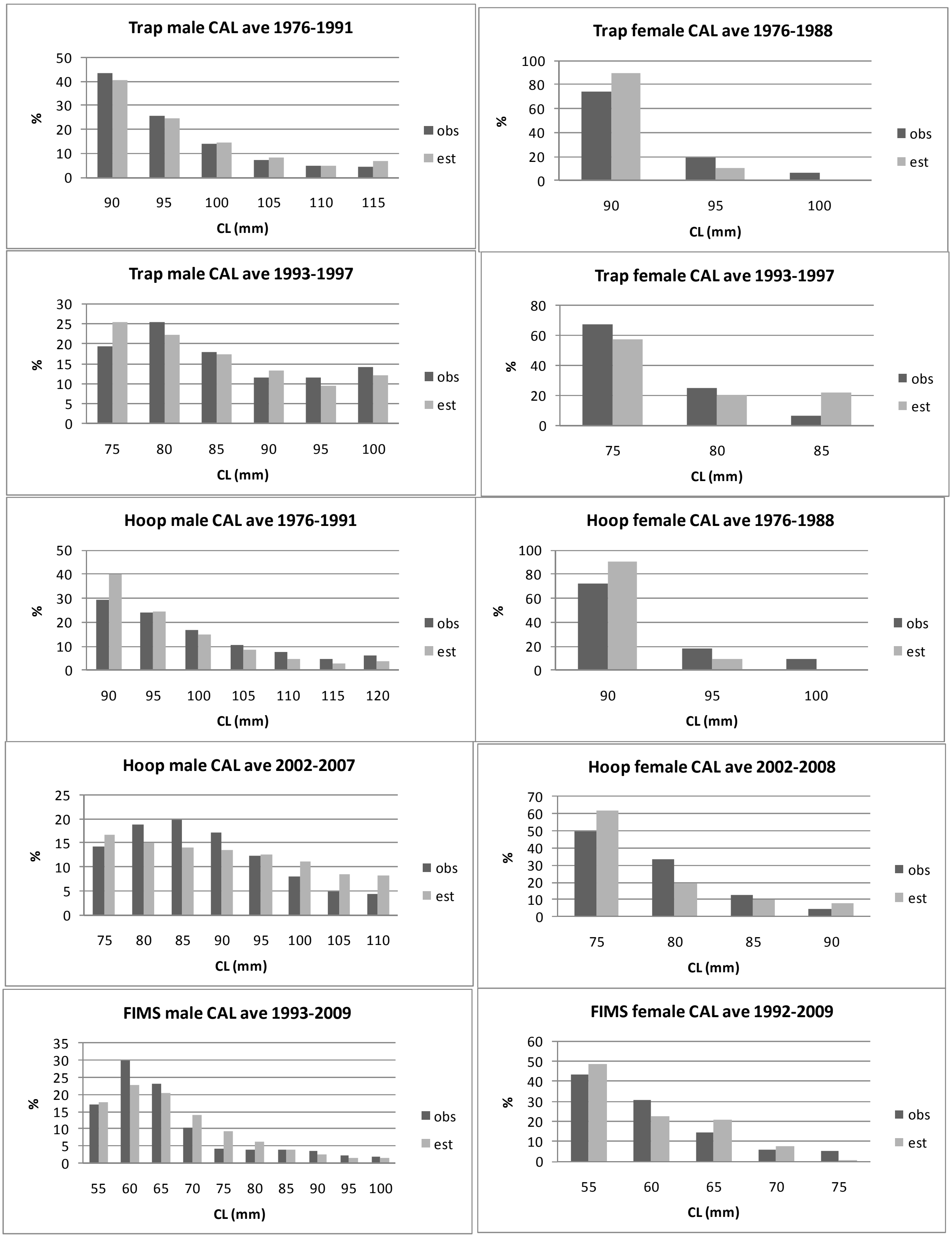


Figure 2d: Area 7 fits to CAL data – averages shown.

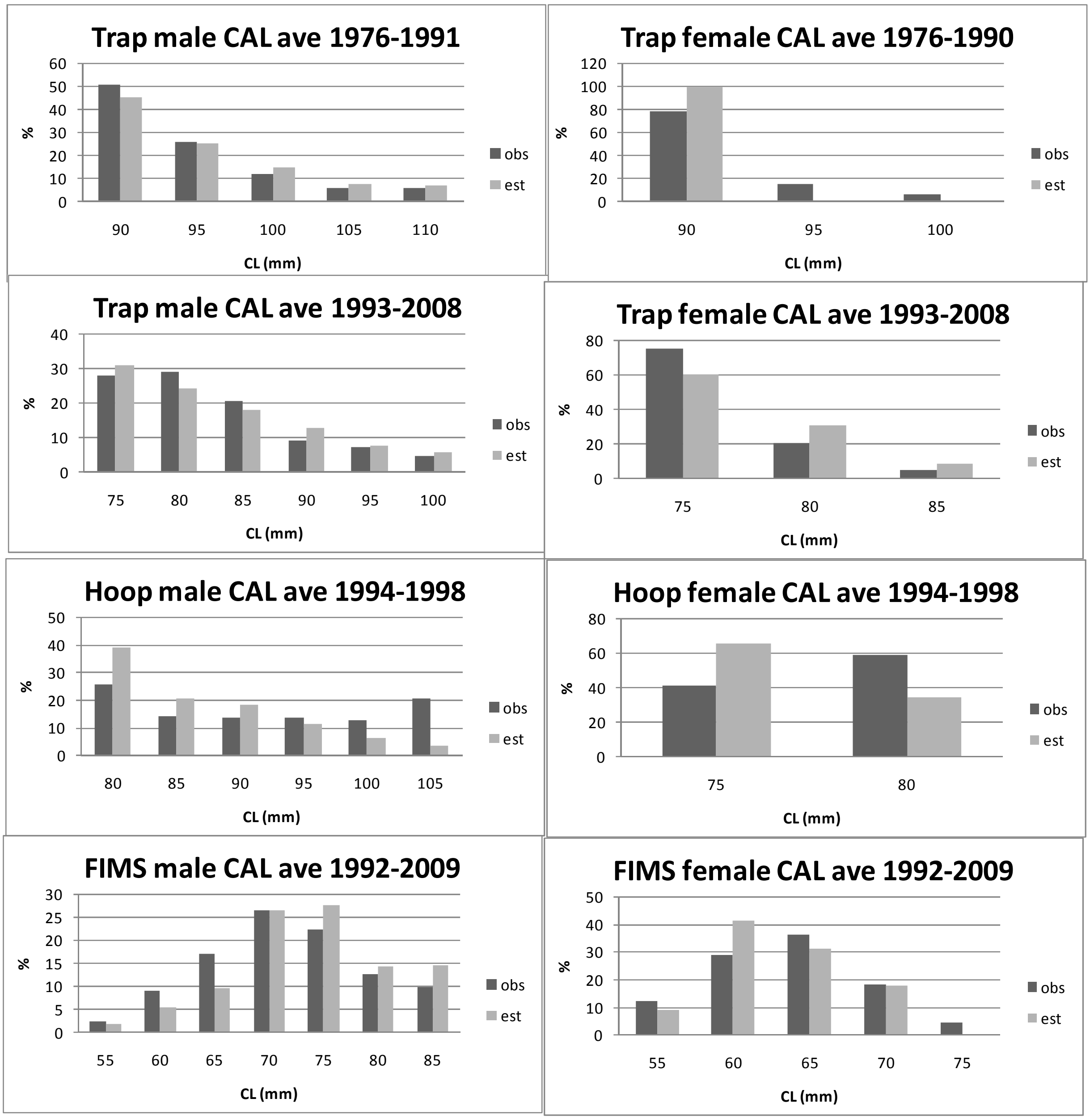


Figure 2e: Area 8+ fits to CAL data – averages shown.

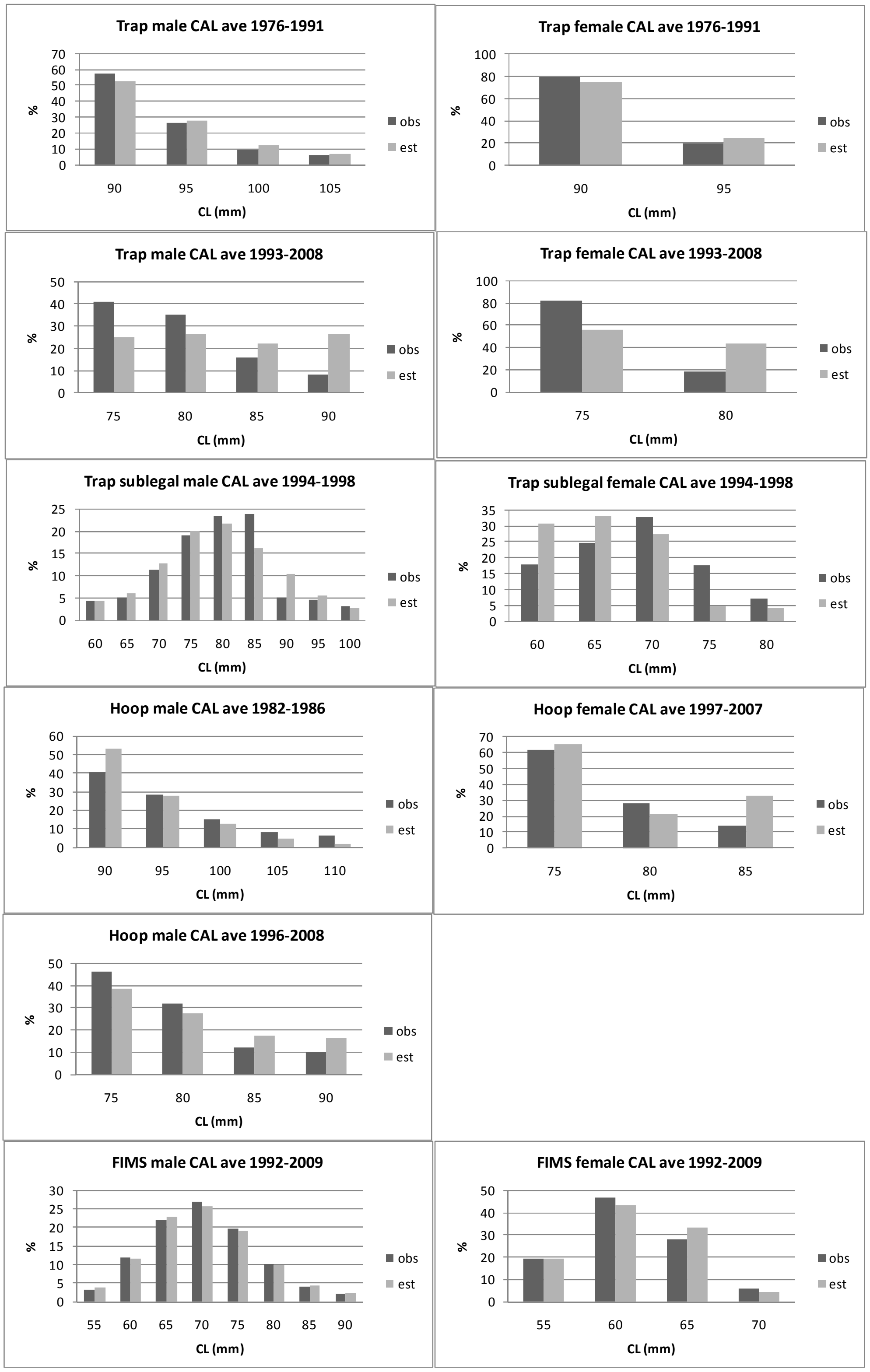
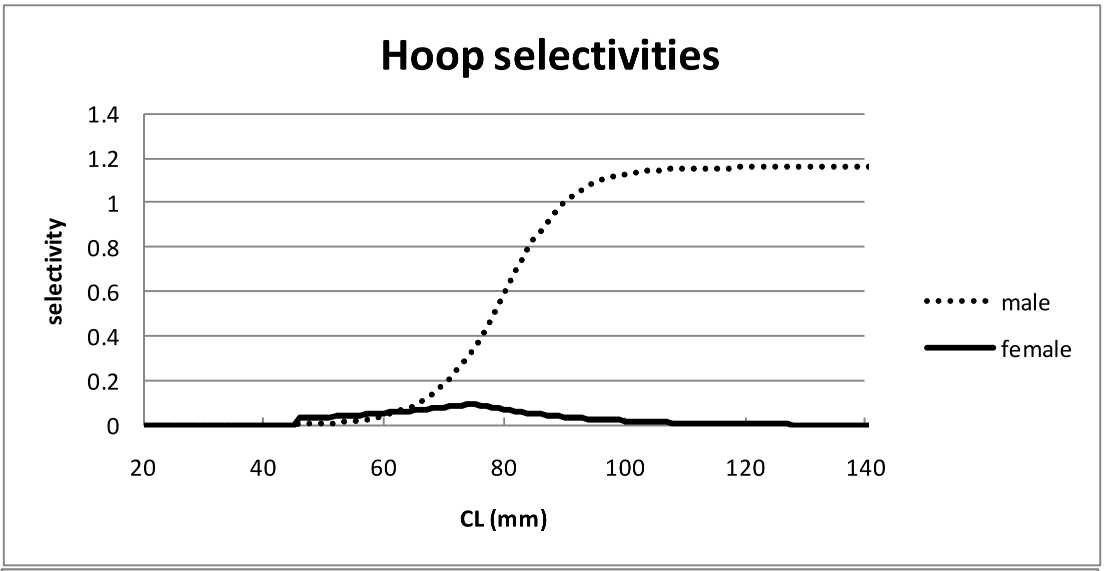


Figure 3a: Area 1+2 hoop selectivity functions. [Note the hoop sublegal selectivity function values are scaled to be equal to those estimated for Area 8.]



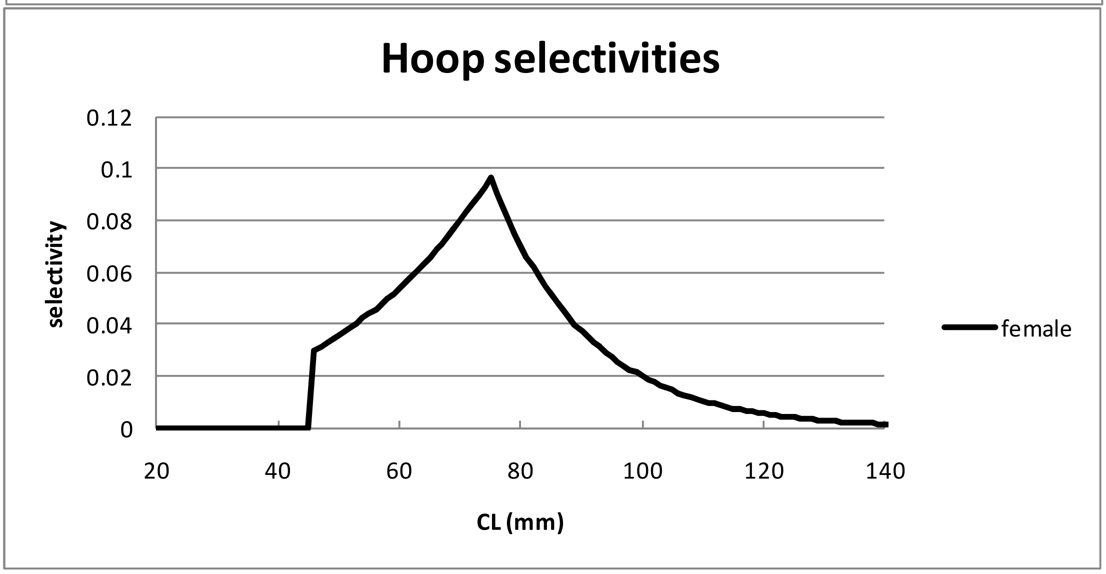


Figure 3b: Area 3+4 selectivity functions. [Note the hoop and trap sublegal selectivity function values are scaled to be equal to those estimated for Area 8.]

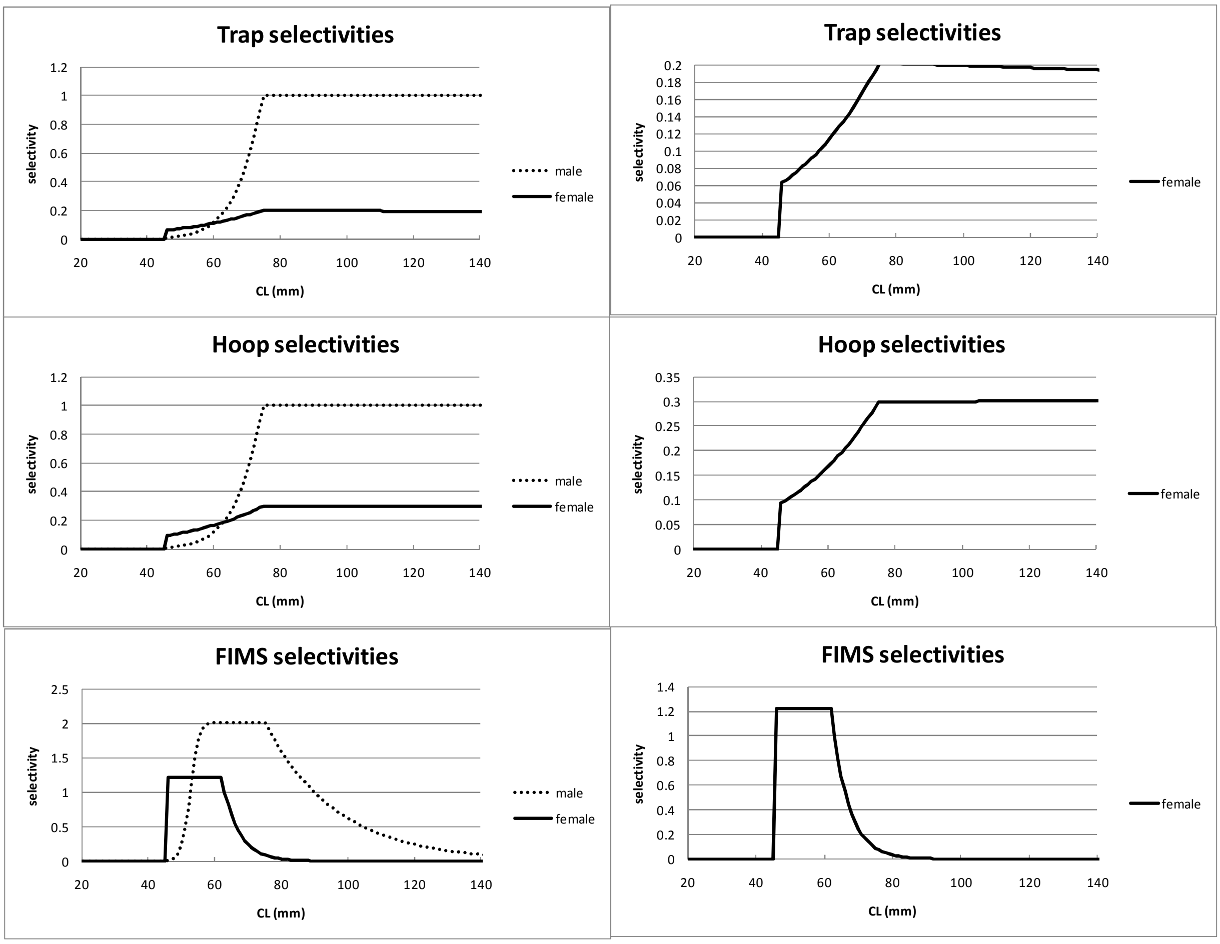


Figure 3c: Area 5+6 selectivity functions. [Note the hoop and trap sublegal selectivity function values are scaled to be equal to those estimated for Area 8.]

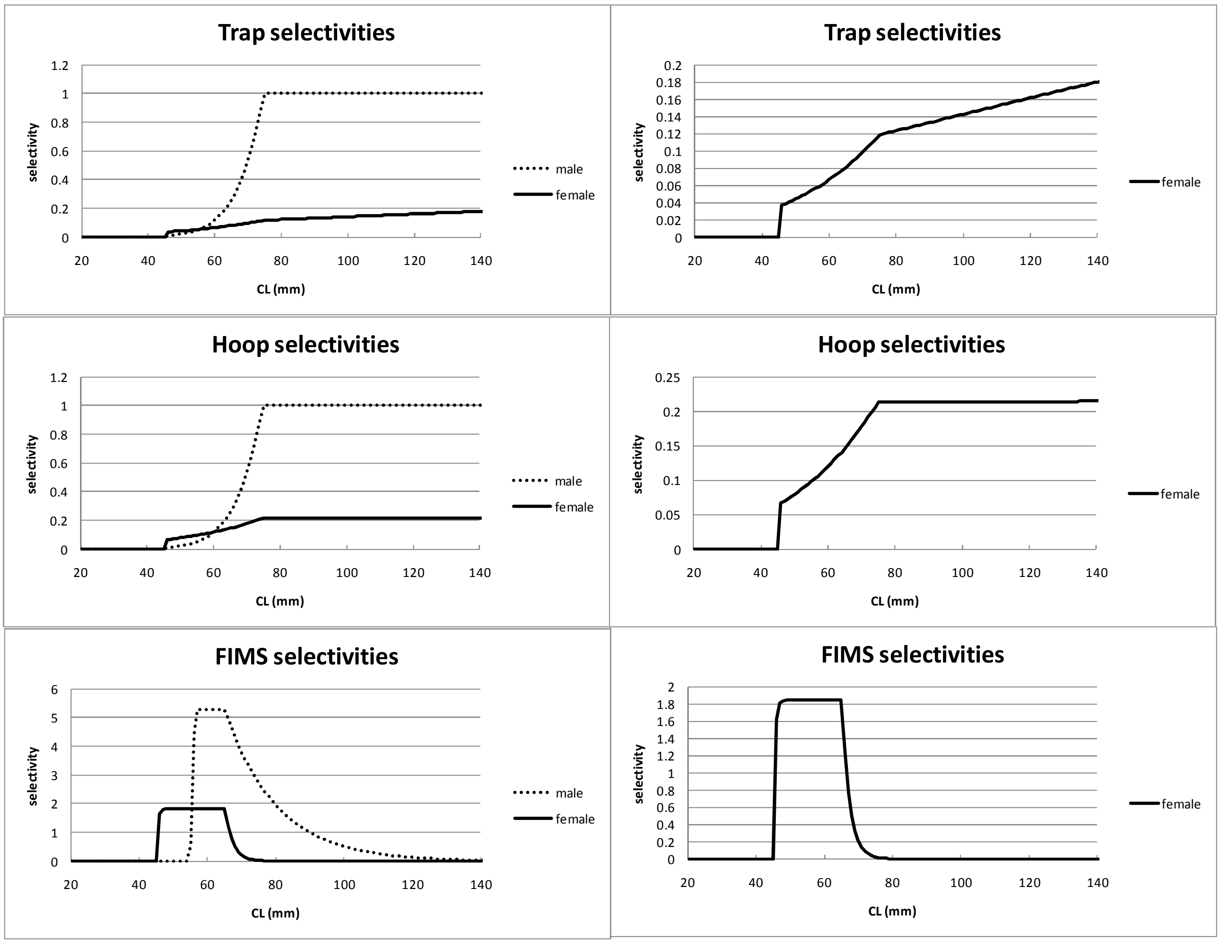


Figure 3d: Area 7 selectivity functions. [Note the hoop selectivity functions are not estimated but set equal to those estimated for Area 8, due to insufficient hoop CAL and CPUE data for Area 7, except for the female hoop scalar parameter which is estimated.]

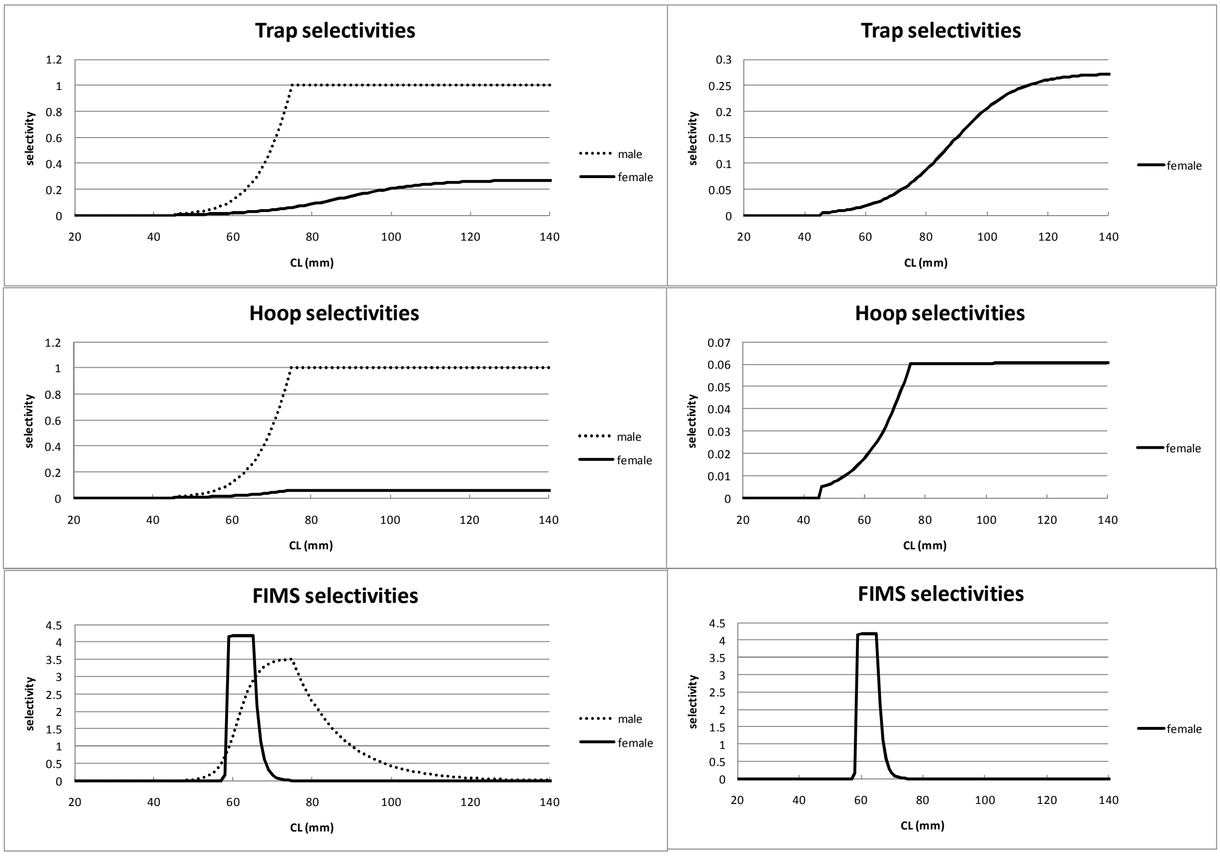


Figure 3e: Area 8+ selectivity functions.

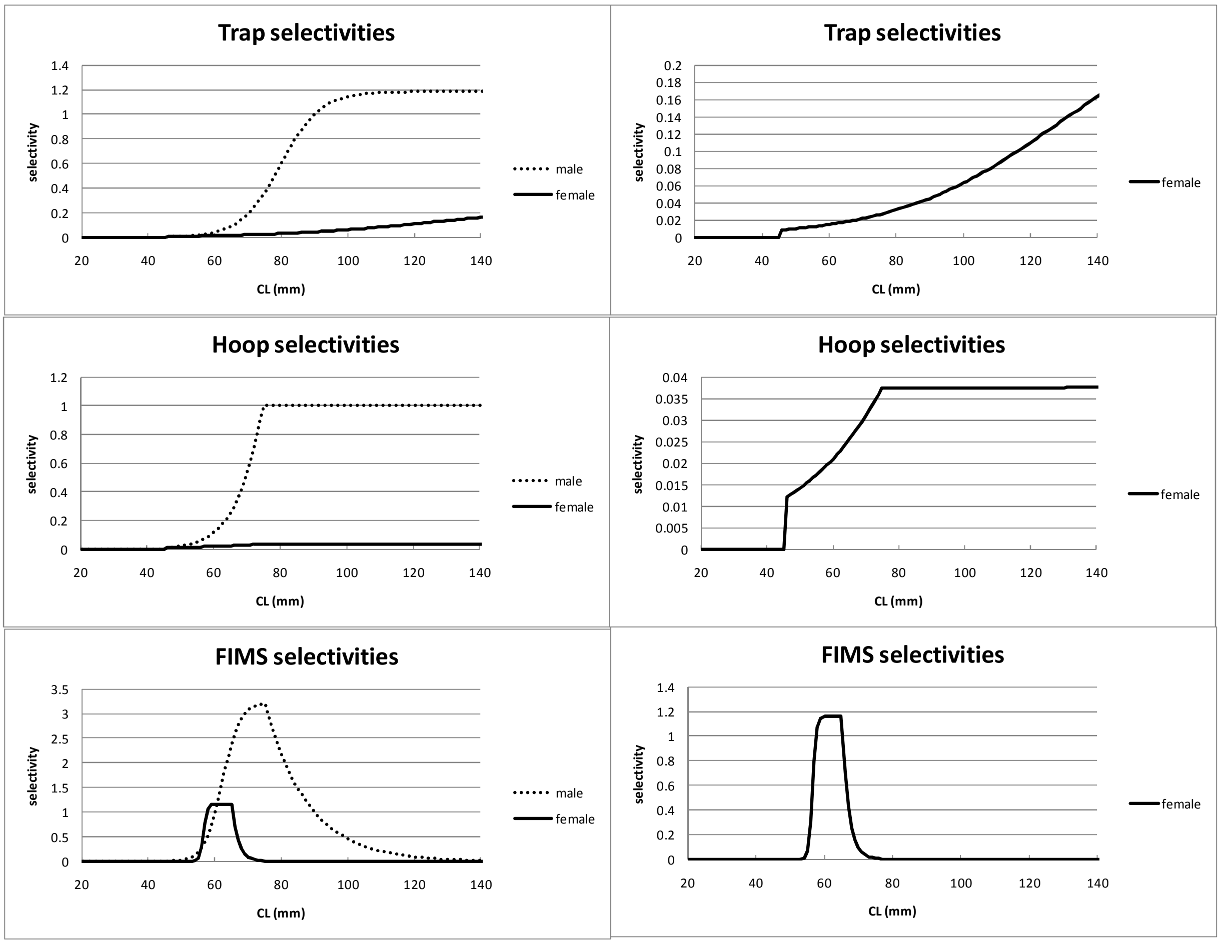


Figure 4a: Area 1+2 model Egg, B75 (m+f) and recruitment trajectories.

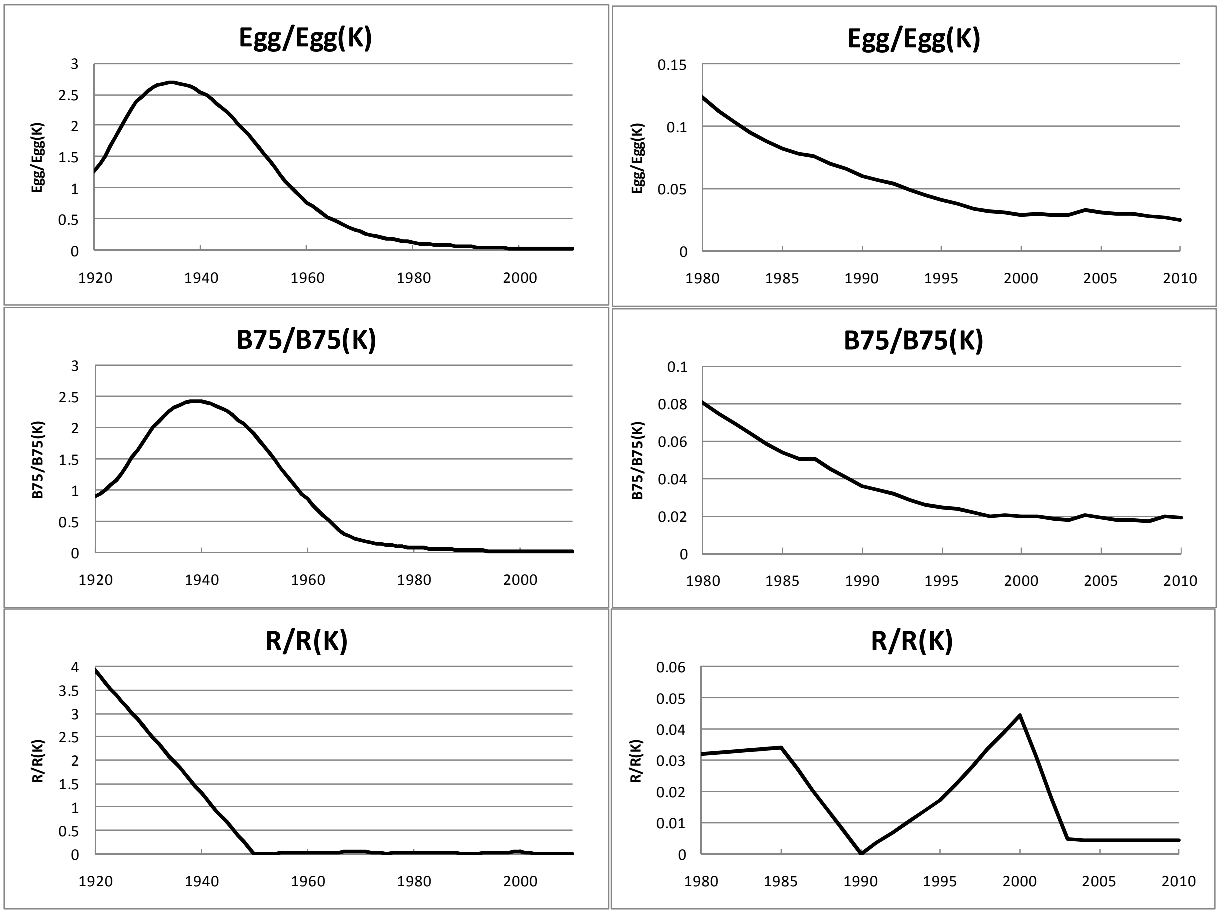


Figure 4b: Area 3+4 model Egg, B75 (m+f) and recruitment trajectories.

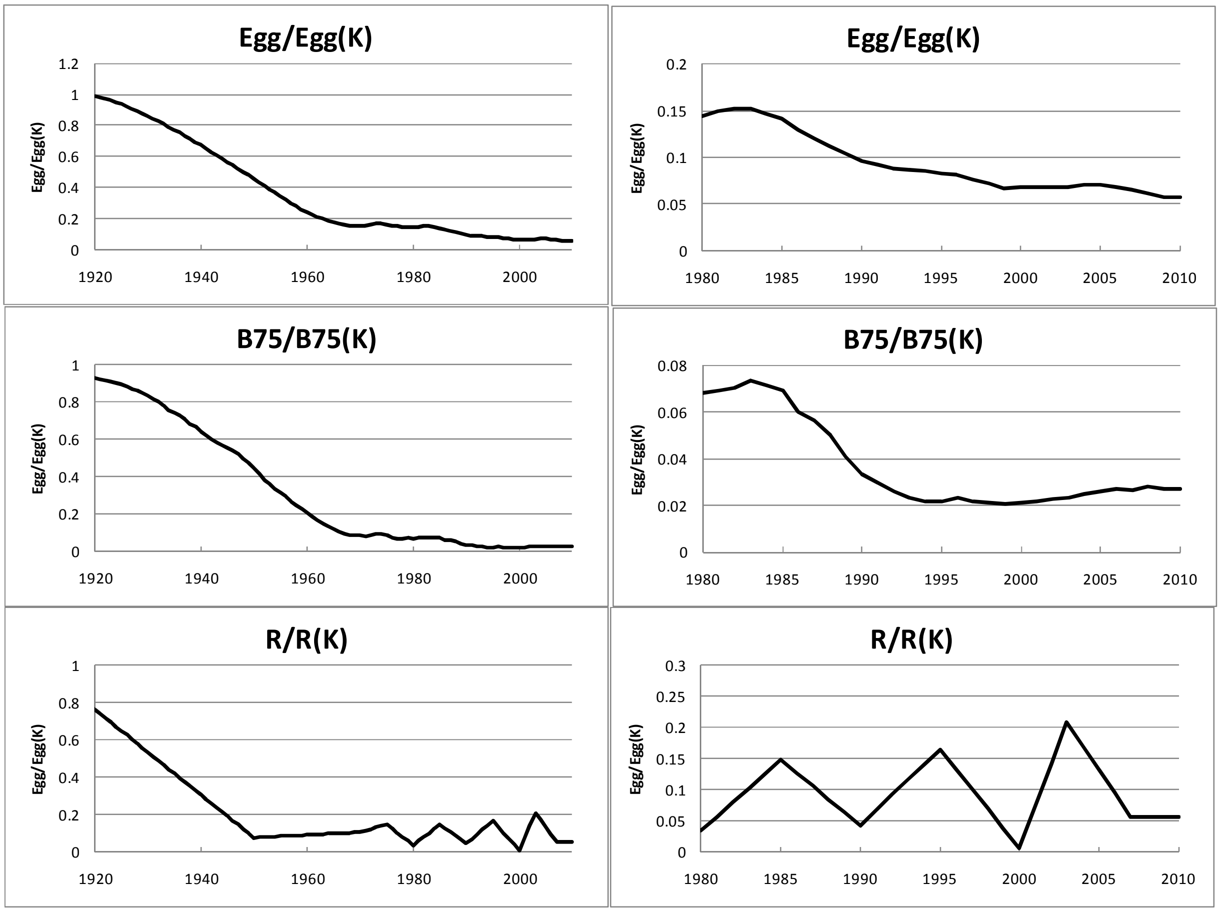


Figure 4c: Area 5+6 model Egg, B75 (m+f) and recruitment trajectories.

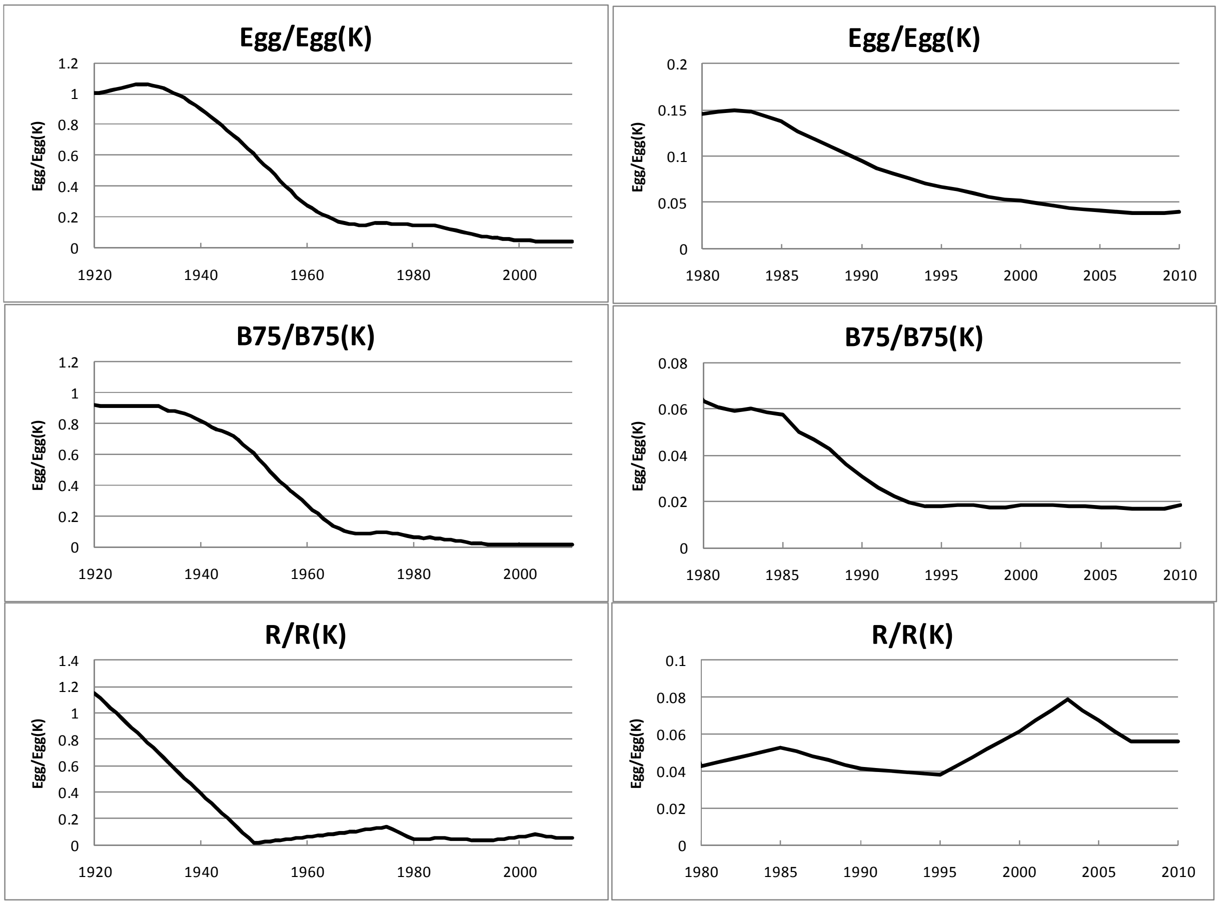


Figure 4d: Area 7 model Egg, B75 (m+f) and recruitment trajectories.

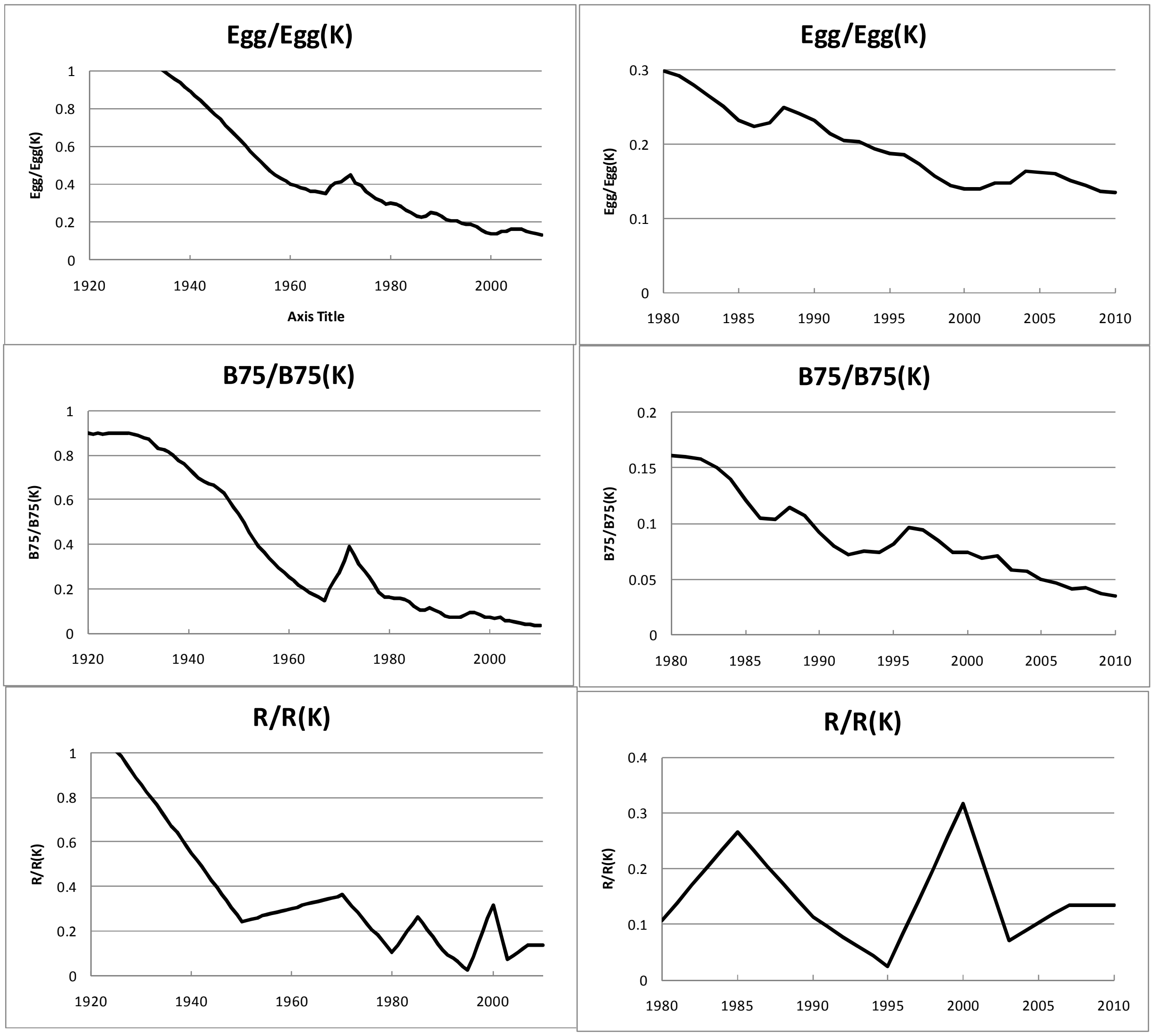


Figure 4e: Area 8+ model Egg, B75 (m+f) and recruitment trajectories.