

## Corrected Reference Case for the South African hake resource

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### Summary

An error in the way the sex-disaggregated catch-at-length data were taken into account in the likelihood in the September RC is corrected. This makes little difference to recruitment estimates and abundance trends, but in terms of the spawning biomass at MSY, *M. paradoxus* is estimated to be seven percentage points lower and *M. capensis* three points higher than in September.

### Corrected Reference Case

Rademeyer and Butterworth (2016) presented results for an updated RC of the South African hake resource (from here onwards referred to as the “September RC”). The September RC included taking account of new/updated data as well as making some modifications to the survey selectivities compared to the May RC (Rademeyer and Butterworth, 2016b). The September RC however, handled the sex-disaggregated catch-at-length data incorrectly (we thank M. Bergh for drawing attention to this), and this error is corrected here. The following changes have consequently been made to the September RC:

- 1) In the September RC, the catches-at-length proportions for the juveniles (<21cm), males and females were computed so that they sum to 1 for each gender (“juveniles” being treated as a further “gender” throughout this document). This is incorrect, as information about the relative gender proportion is lost, and hence particularly the information about recent recruitment strength. Instead, the corrected Reference Case now computes the CAL proportions to be used in the negative log-likelihood computations as:

$$p_{y,l}^g = \frac{C_{y,l}^g}{\sum_{g'} \sum_{l'} C_{y,l'}^{g'}} \quad (1)$$

Where

$p_{y,l}^g$  is the proportion of fish of length  $l$  and gender  $g$  in year  $y$ , and

$C_{y,l}^g$  is the number of fish caught of length  $l$  and gender  $g$  in year  $y$ .

- 2) Using step 1) above results in some of the proportions to be very small for all lengths for a particular gender, such as males *M. paradoxus* in the west coast longline catches or juveniles *M. paradoxus* in the south coast surveys for examples. To deal with these small numbers, the “sqrt(p)” method is used to compute the contribution of the CAL data to the negative of the log-likelihood function instead of the Punt-Kennedy method used in the September RC:

$$-\ln L^{CAL} = \sum_y \sum_l \left[ \ln(\sigma_{len}^g) + \left( \sqrt{p_{y,l}^{i,g}} - \sqrt{\hat{p}_{y,l}^{i,g}} \right)^2 / 2(\sigma_{len}^g)^2 \right] \quad (2)$$

This formulation mimics a multinomial form for the error distribution by forcing a near-equivalent variance-mean relationship for the error distributions.

- 3) In the September RC, the standard deviation associated with the proportion at length data is estimated for all genders together. Here, the standard deviation is more appropriately computed for each gender separately:

$$\hat{\sigma}_{len}^g = \sqrt{\sum_y \sum_l \left( \sqrt{p_{y,l}^g} - \sqrt{\hat{p}_{y,l}^g} \right)^2 / \sum_y \sum_l 1} \quad (3)$$

- 4) Use of the sqrt(p) formulation has the advantage that the CAL data do not need to be grouped into minus and plus groups.

## Results and Discussion

Results for the September and these corrected “November RC” results are compared in Table 1, with the spawning biomass trajectories plotted in Figure 1 and stock-recruitment curves, recruitment and recruitment residuals trajectories in Figure 2.

The survey and commercial selectivities-at-length are shown in Figures 3 and 4 for the November RC.

The fit to the CPUE and survey data are compared for the two RCs in Figure 5 and 6 respectively. The fit to the commercial sex-aggregated and sex-disaggregated CAL data are plotted in Figures 7 and 8, while the fit to the survey CAL data are plotted in Figure 9.

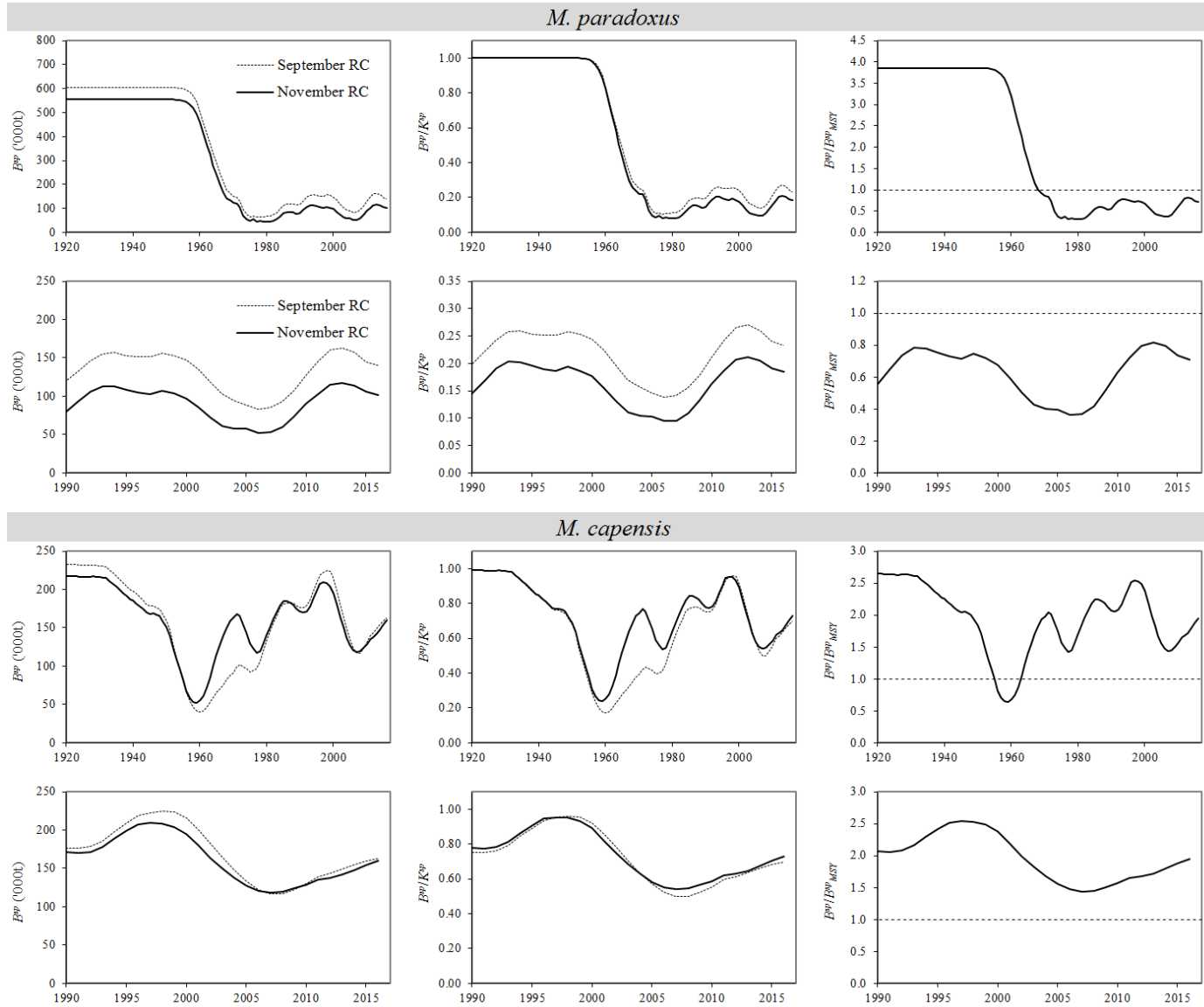
Broadly speaking the fits of the November RC to all data types seem adequate and differ little from those for the September RC. The correction makes little difference to the estimates of recent recruitment (see Figure 2). Spawning biomass trends are very similar, though in absolute terms both species are currently somewhat lower than for the September RC (see Table 1 and Figure 1). The estimated stock–recruitment relationships change slightly, which affects estimates of MSY-related quantities (Table 1 and Figure 2). In terms of the spawning biomass at MSY, *M. paradoxus* is estimated to be seven percentage points lower and *M. capensis* three points higher than for the September RC (Table 1 and Figure 1).

## REFERENCES

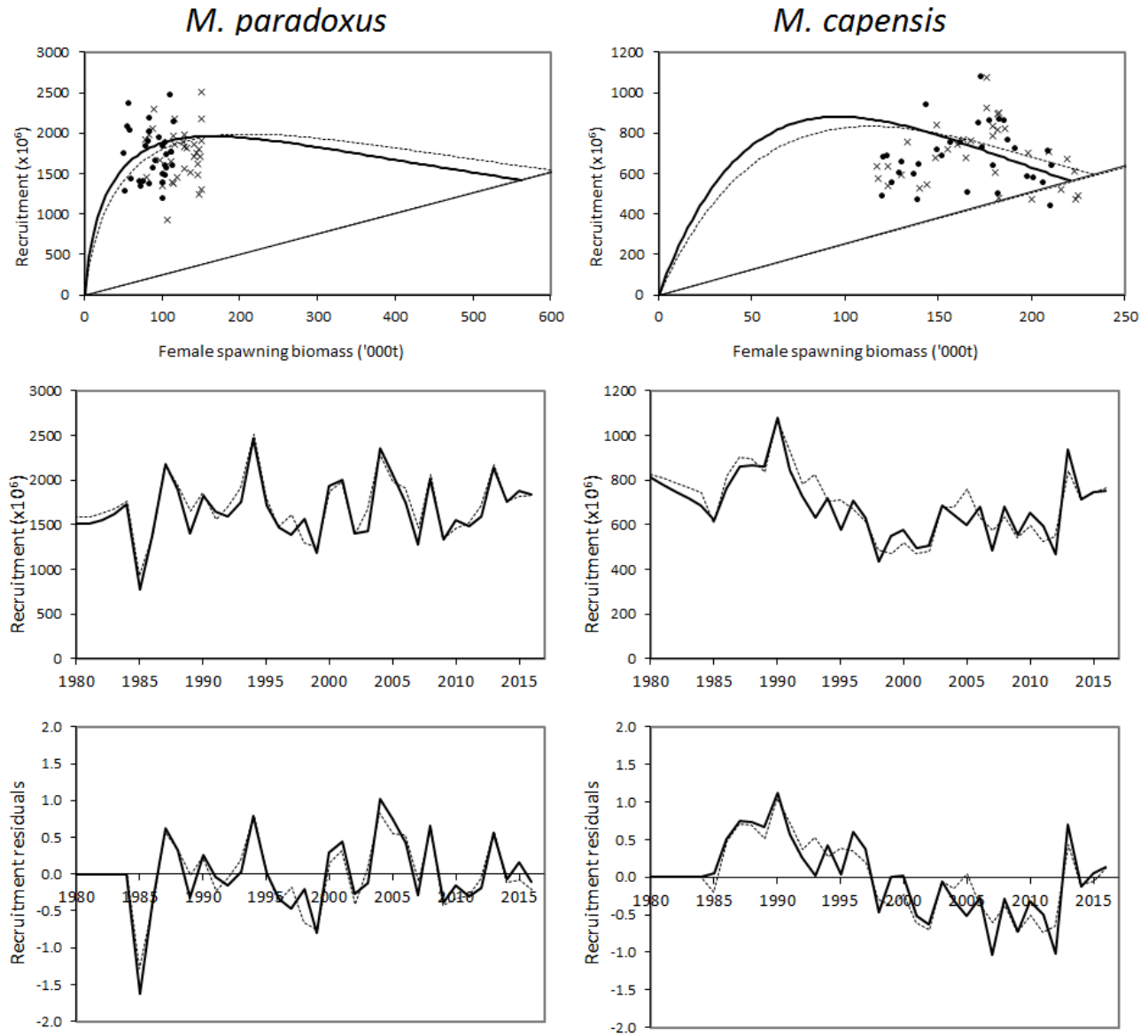
Rademeyer RA and Butterworth DS. 2016. A further update of the Reference Case assessment and related projections for the South African hake resource. FISHERIES/2016/SEPT/SWG-DEM/75.

**Table 1:** Estimates of management quantities for the September and November RCs.

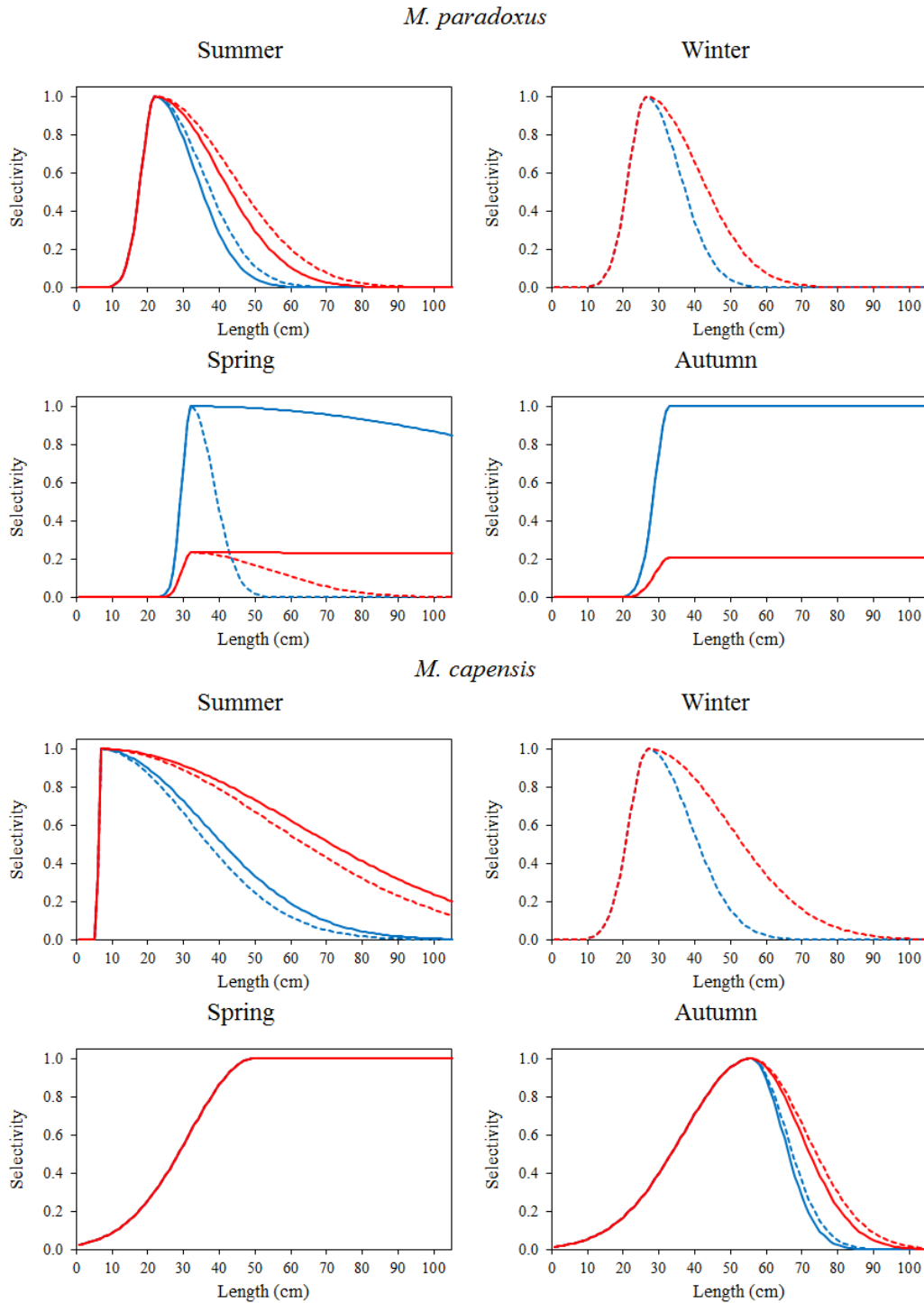
	September RC	November RC	
<i>M. paradoxus</i>	$K^{SP}$	604	554
	$B^{SP}_{MSY}$	166	144
	$B^{SP}_{2016}$	129	102
	$B^{SP}_{2016}/K^{SP}$	0.21	0.18
	$B^{SP}_{2016}/B^{SP}_{MSY}$	0.78	0.71
	MSY	117	119
<i>M. capensis</i>	$K^{SP}$	234	219
	$B^{SP}_{MSY}$	95	82
	$B^{SP}_{2016}$	164	160
	$B^{SP}_{2016}/K^{SP}$	0.70	0.73
	$B^{SP}_{2016}/B^{SP}_{MSY}$	1.73	1.95
	MSY	65	75



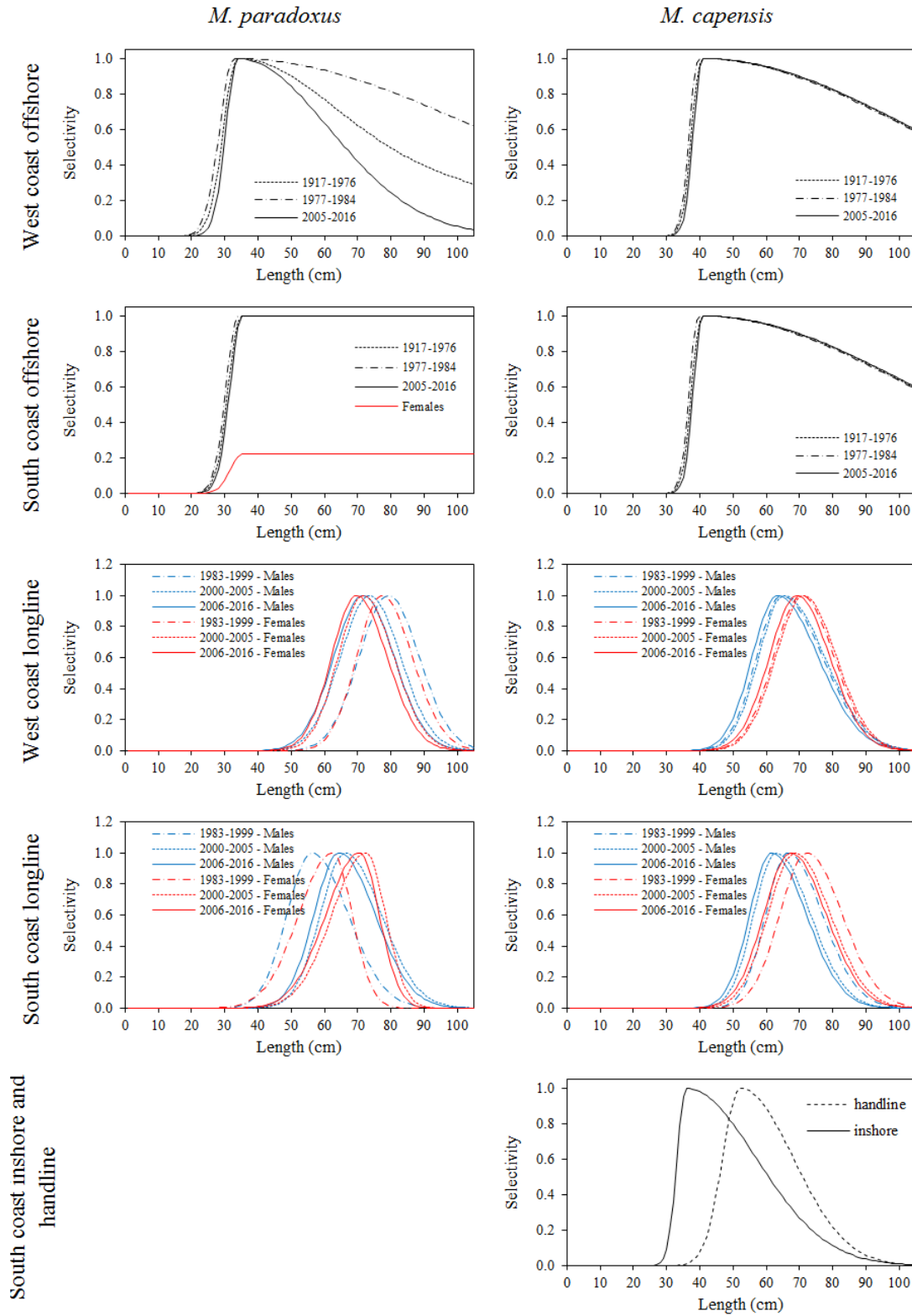
**Figure 1:** Spawning biomass trajectories (in absolute terms, and relative to pre-exploitation level and to  $B_{MSY}$ ) for the September and November RCs. For each species, the second row repeats the first row but with a different range of years.



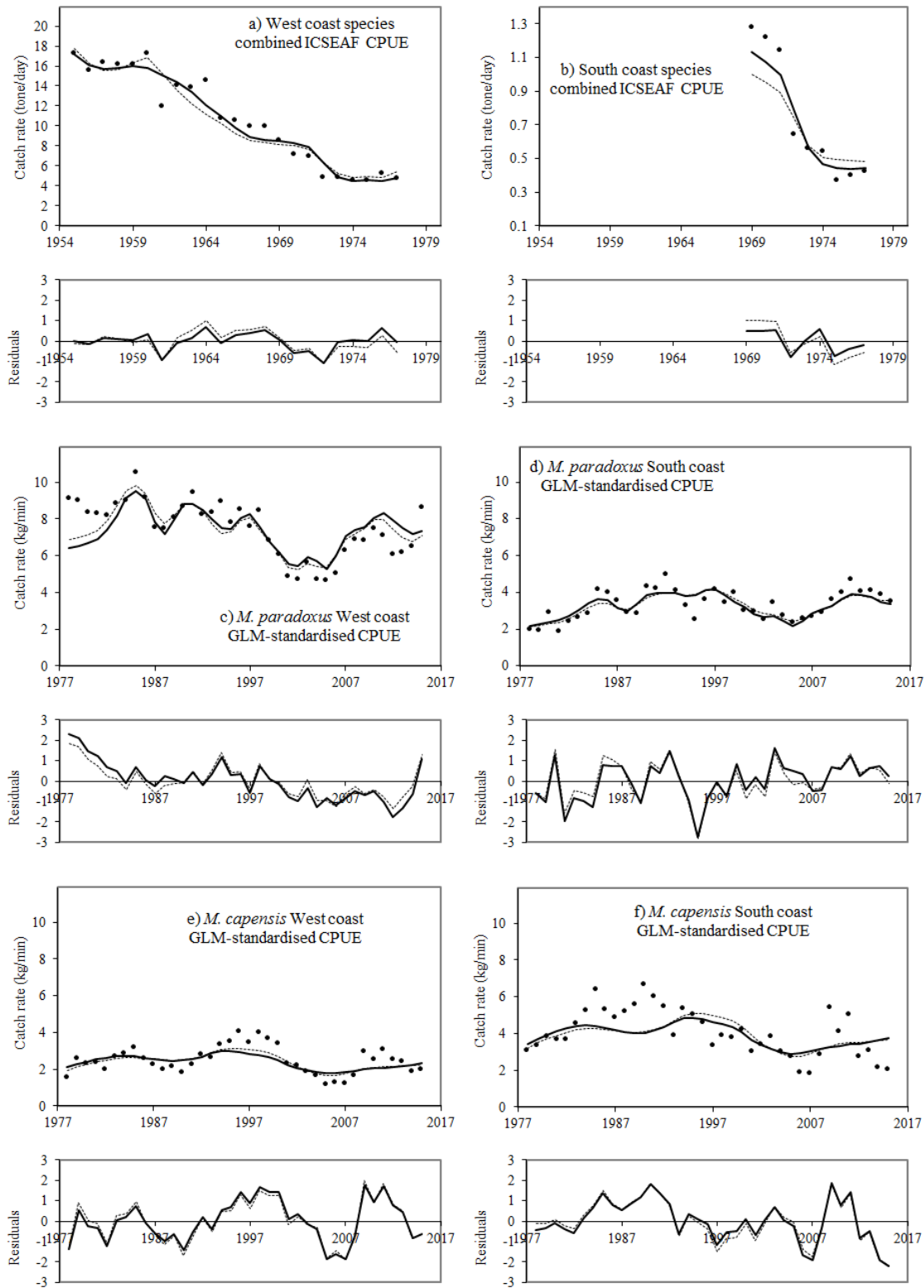
**Figure 2:** Stock-recruitment curves, recruitment and recruitment residuals for the September and November RCs.



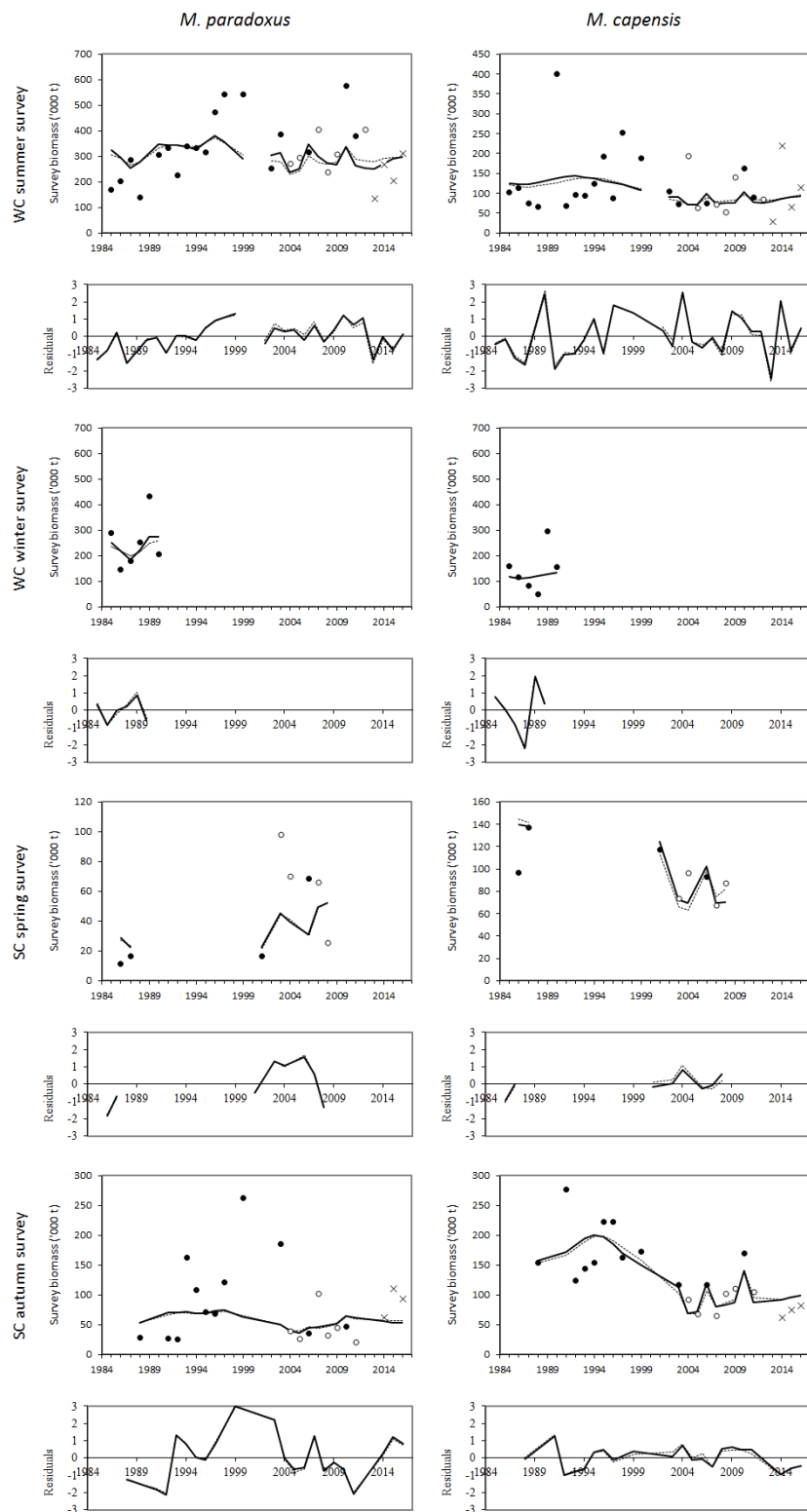
**Figure 3:** Survey selectivities-at-length for the November RC. Black curves for sex-combined, blue curves for males, red curves for females, dashed curves for old gear and full curves for new gear.



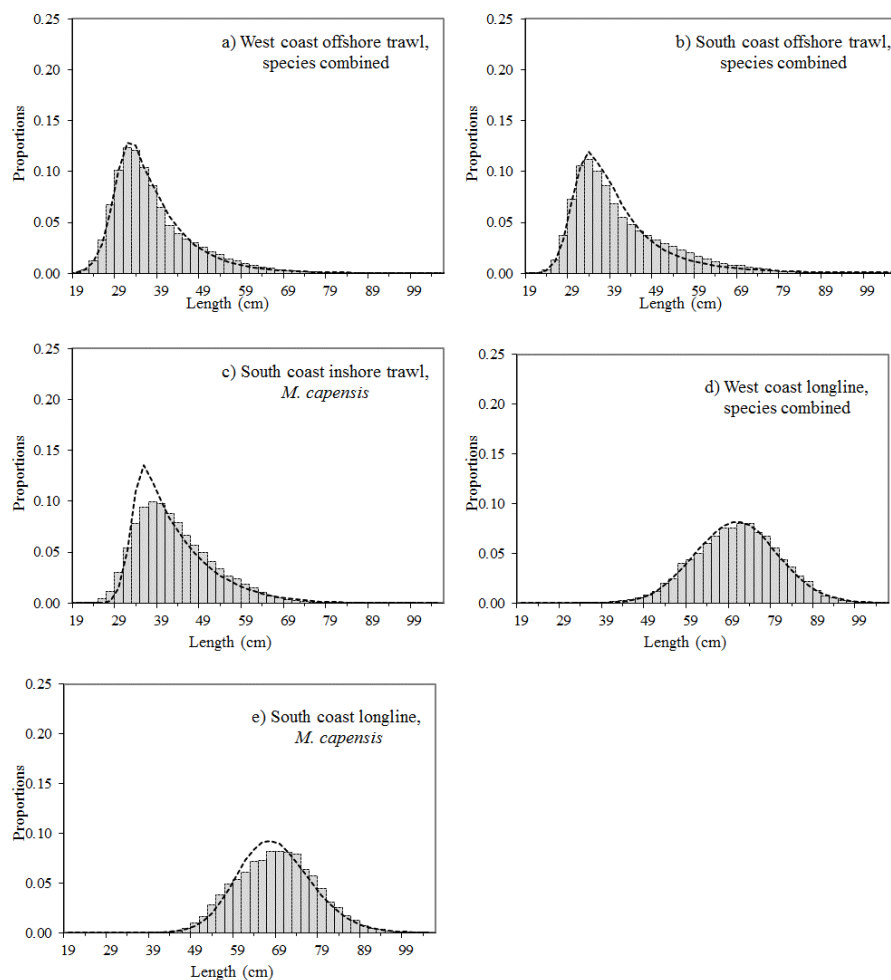
**Figure 4:** Commercial selectivities-at-length for the November RC (black curves for sex-aggregated, blue curves for males and red curves for females).



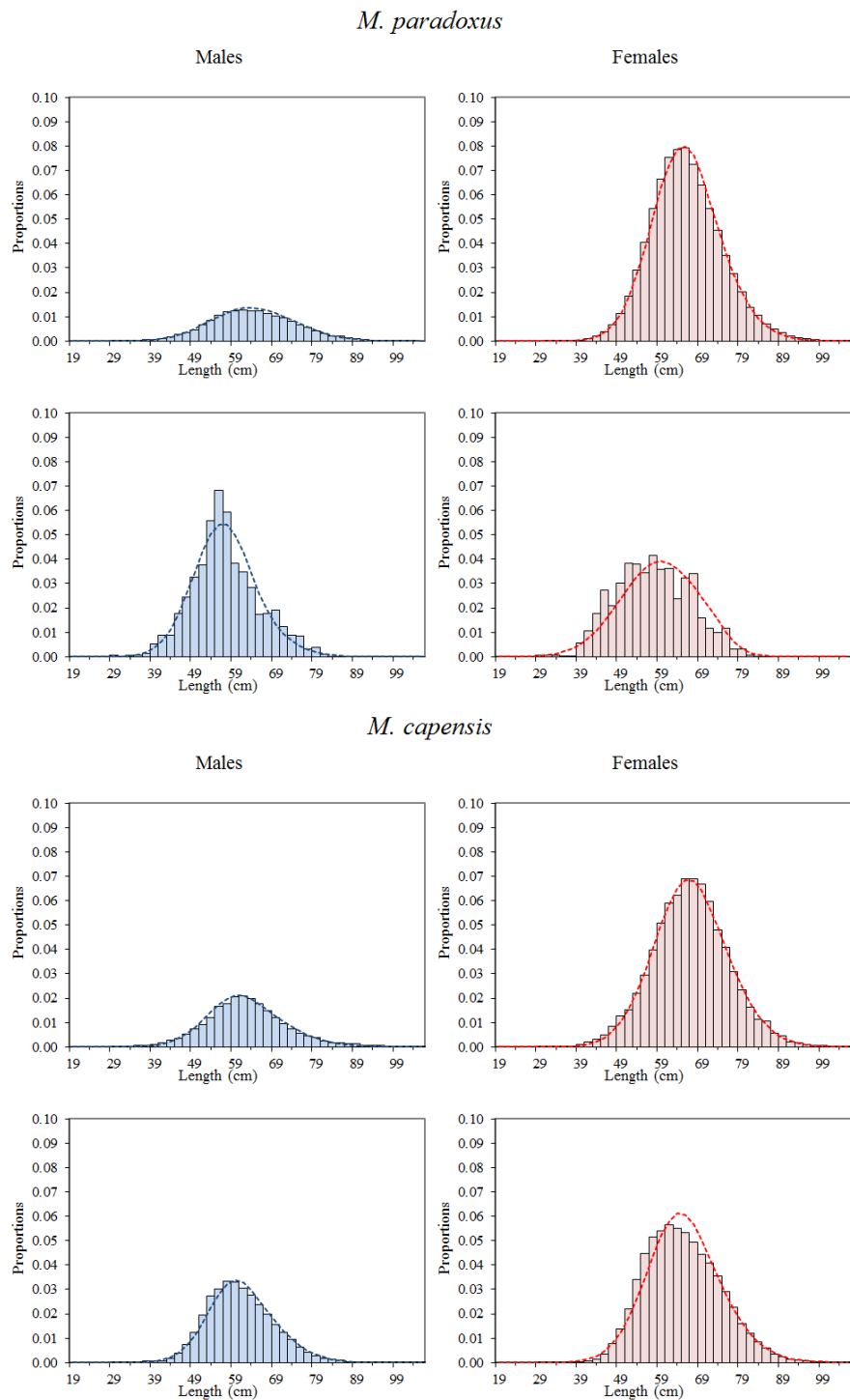
**Figure 5:** Fits to the CPUE series, with standardized residuals, for the September (dashed lines) and November (full lines) RCs.



**Figure 6:** Fits to the survey series for the September (dashed lines) and November (full lines) RCs. The full circles show the surveys conducted by the *Africana* old gear (adjusted by the *Africana* old/new gear calibration ratio), the open circles by the *Africana* new gear and crosses by industry vessels.



**Figure 7:** Fits to the commercial sex-aggregated catches-at-length averaged over years for the November RC.



**Figure 8:** Fits to the commercial sex-disaggregated catches-at-length averaged over years for the November RC.

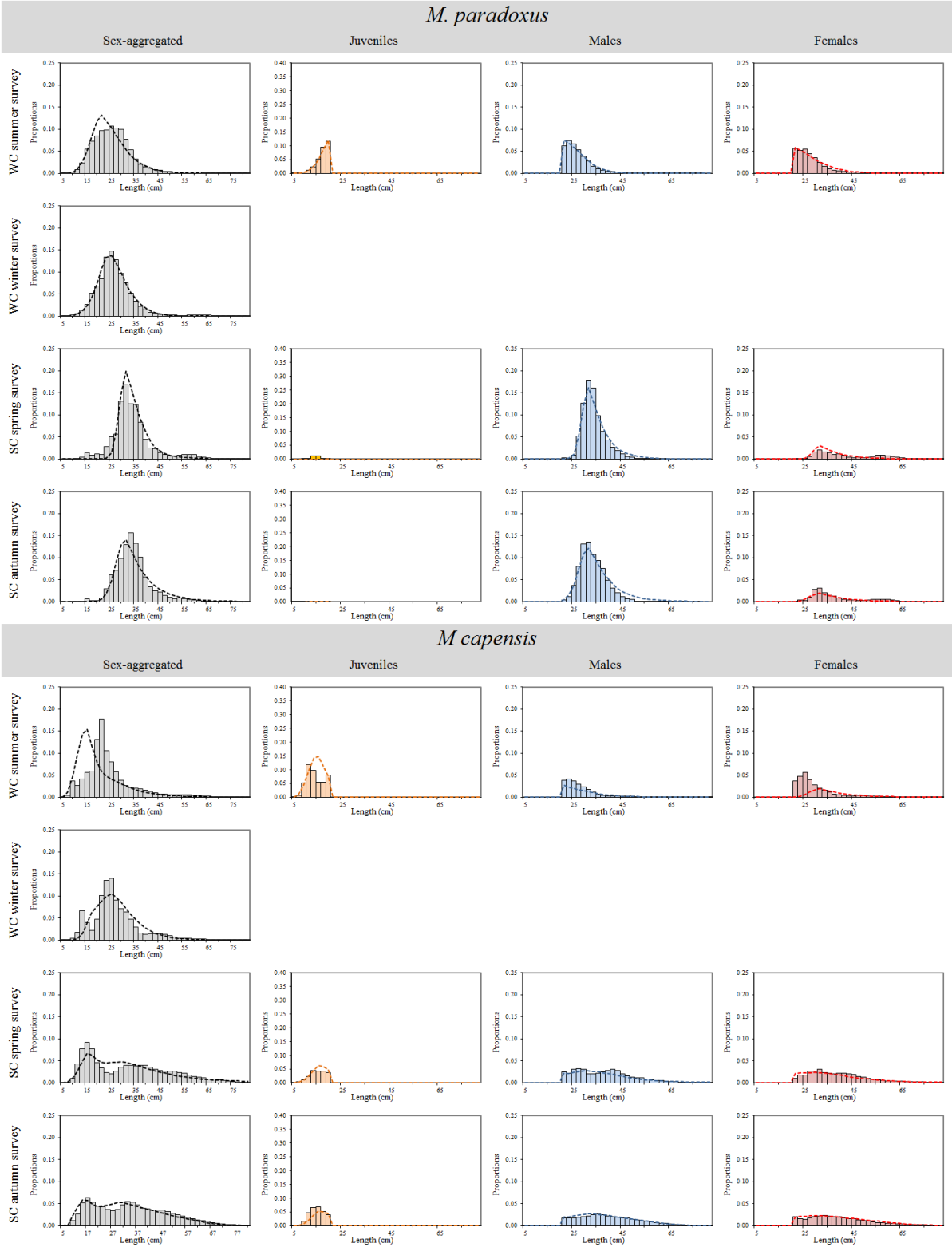


Figure 9: Fits to the survey sex-aggregated and sex-disaggregated catches-at-length averaged over years for the November RC.