WD to the 2011 meeting of WGACEGG

Sardine maturity ogives

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Introduction

Maturity ogives and stock weights used in the sardine assessment are derived from spring acoustic data (end of spawning season and minimum of condition off Portugal) while the DEPM (peak spawning time) is used to tune SSB in the assessment model. Maturity and weights-at-age decline from the peak to the end of the spawning season and it is unclear if signals from the two phases of the spawning period are consistent. In case they arenát, this is expected to enlarge the discrepancy between observed and predicted SSB in the assessment and generally add noise to the assessment estimates. Given maturity and weight data are also available from the DEPM survey, with the advantage that maturity are microscopic stages observed at peak spawning time, their use in stock assessment in alternative to acoustic survey data should be evaluated.

Following a recommendation from WGANSA, this WD evaluates maturity and weights-at-age from DEPM and spring acoustic surveys, in particular:

1. Compares macroscopic and microscopic classifications of maturity in the DEPM surveys
2. Compares DEPM macroscopic and microscopic maturity ogives (by length and age)
3. Examines seasonal and annual changes in maturity
4. Compares mean female weight in DEPM with mean fish weight used in the assessment

Data and methods

1. Calculation of correspondence between macroscopic and microscopic stages

2. This comparison includes only data from the 2005 and 2008 Portuguese DEPM surveys since there is no histological data on macroscopic stage 1 (virgin) females in

the Spanish surveys and in the Portuguese surveys prior to 2005. Maturity-at-age 0 was assumed to be zero.

Macroscopic and microscopic maturity data was used to calculate the proportion of immature (virgin) and mature (adult) individuals by half-centimeter length class and by age-group. GLMs assuming a binomial error distribution and logit link function were fitted to the proportion of adult females by length class and type of maturity data (macro or micro stages) for each year. The initial model, considering the interaction between class and data type, was simplified by backward elimination of variables to minimize AIC.

3. This analysis was based on macroscopic data. The comparison between years included data from PT+SP DEPM surveys since 1997. A GLM was fitted to the proportion of adult females by length class using year as a factor variable. A ñquasibinomialò distribution was assumed to correct for overispersion. As before, the initial model considered interaction between class and year but in this case it was simplified by log-likelihood ratio tests (since AIC is not defined for ñquasiò models).

Yearly estimates of L50 from this model were compared with those from similar models fitted to the acoustic surveys (see WD Soares et al. 2011 to WGANSA).

Empirical proportions of adult females by age were calculated for the PT+SP DEPM surveys 2002-2008 (age data are not yet available for the 1997, 1999 and 2011 Portuguese surveys) and compared to maturity ogives used in the assessment (calculated from acoustic surveys data).

4. A simple graphical comparison of mean-weights-at-age calculated for the PT+SP DEPM surveys 2002-2008 (age data are not yet available for the 1997, 1999 and 2011 Portuguese surveys) and compared to estimates used in the assessment (calculated from acoustic surveys data). Weights are for females only in DEPM and for sexes combined in acoustic surveys.

Results

1. Figure 1 presents the global distribution of macroscopic stages within each oocyte stage in Spanish and Portuguese DEPM surveys.

2. Macroscopic and microscopic length maturity ogives were not significantly different (Table 1, Fig. 2). L50 calculated from the models with pooled macro and micro data was 10.7 cm (s.e.=0.17 cm) in 2005 and 12.9 cm (s.e.=0.16 cm) in 2008.

The GLM fitted to maturity-at-age in 2005 did not converge probably due to the very fast transition to maturity (Fig. 3). The 2008 model indicates that differences between macro and micro age maturity ogives were not significant ($p<0.001$). The difference beween years in the observed proportions of adult females is small and shows mainly at age 1.

3. Length-based maturity ogives could not be fitted to 1997 and 2011 DEPM data since almost all females sampled were adult (Fig.4). The GLM fitted to the proportion of adult females by length class in the DEPM surveys indicated significant differences between years from 1999 to 2008, in both the intercept and in the slope of the ogives ($p<0.001$, df=130). Over the years, L50 varied between 10.1 cm and 13.1 cm being always lower than L50 in corresponding acoustic surveys (Figure 5). The difference is minimal and likely non significant in 1999 (0.68 cm with extensive overlap in approximate confidence intervals) but is larger and probably significant in the remaining years (between 1.3 and 5.5 cm). Furthermore, the temporal variation between DEPM and acoustic L50s is not consistent.

Empirical age-based ogives for 2002-2008 show that maturation changes are most pronounced at age 1 with percentages between 47% to 100% in DEPM surveys (Table 2). Estimates from acoustic surveys are always lower and, as L50, vary differently between years.

Discussion

The broad comparison of macroscopic and microscopic stage data shows some misclassification of macro stages 1 since around 20% of ovaries with pre-yolked oocytes are classified in this stage in the Portuguese surveys. Afonso-Dias e tal. (2007) also found some misclassification of virgin and adult females. They report that 25% of macro stage 1 ovaries were in fact adults and 7% of macro stage 2 were virgin individuals in the beggining of the spawning season (November). Furthermore, in the late spawning season, a small percentage of the females classified macroscopically as post spawning were virgin (15%) and outside the spawning season the opposite happened. Nevertheless, the non-significant differences between macro and micro maturity ogives for 2005 and 2008 suggest that macro-micro misclassifications have a negligible impact on maturity ogives.

The macroscopic data from DEPM indicates that sardine maturity at length varies significantly between years with L50 shifting up or down more than 2 cm between consecutive years. Maturity ogives from spring acoustic surveys show extensive changes between years as well. The fact that wide year-to-year variations are observed in the peak spawning season indicates theyŷre not an artifact from sampling at the end of the spawning season but more likely reflect a demographic or ecological influence.

However, the comparison of L50s between the DEPM and acoustic surveys suggests the proportion of adult individuals in each length class is higher in the peak than in the end of the spawning season (i.e. L50 is lower). From the analysis of a longer period of data (although restricted to western Portugal) there is evidence that the proportion of maturing individuals varies over the spawning season in a dome shaped pattern with maximum values in December/January (Silva et al, WD WGACEGG 2011). Therefore, L50 varies with the spawning month in an inverted dome-shaped pattern: for example, point estimates of L_{50} for age 0/1 individuals of the 1986 cohort were 18.8, 13.8 and 15.6 cm in October, January and March, respectively.

The decline in the proportion of adult individuals from the peak to the end of the spawning season is most likely due to difficulty in separating virgin from post spawning individuals macroscopically. This difficulty is even larger for individuals of 14-16 cm that can be either virgin or adults. Since individuals in this range have a shorter spawning season that larger ones, most might have ended spawning in March-April, when the acoustic survey takes place.

It is also apparent that the DEPM and the acoustic surveys provide distinct signals about temporal variations in maturation, although the number of years available for comparisons is still limited (mainly in terms of age).

Besides extensive year-to-year variability, there is some evidence of long term trends in sardine maturation (Silva et al, WD WGACEGG 2011). L50 has increased from the 1940s to the 1970s, declined until the mid-1990s and fluctuated up to the present. Such variation is correlated with both an index of the population condition in the feeding season and SST.

Conclusions

- Macro and micro staging consistent at the peak of spawning

- There are large year-to-year changes in maturation at the peak of spawning. Few years to allow interpretation.

- Ogives calculated from DEPM and spring acoustic surveys do not show the same variation between years.

- Evidence of long-term changes in maturity-at-length correlated with changes in fish condition in the summer preceeding the spawning season.

- For assessment, the use of ogives from DEPM has some drawbacks: surveys are every three years so we need to assume something for the interim years, and this is not straightforward given the extensive year-to-year variations; something need to be assumed for the years prior to 1997 (could be ogives from commercial samples), not straightforward again, due also to the long term trend.

- For assessment the use of ogives from spring acoustic surveys has some drawbacks: SSB will be underestimated given the ogives are underestimates; they might be more variable since data are collected in the period that maturation probability is dropping fast and small shifts in the reproductive season may have a large effect;

Table 1: Models comparing macroscopic and microscopic length maturity ogives in 2005 and 2008; results of model selection tests.

Year	Step	Resid. Df	Resid. Dev	AIC	LRT	Pr(Chi)
2005	Full model	50	47.3	129.2		
	- class:ogive	51	49.1	129.0	1.8	0.19
	- ogive	52	51.5	129.4	2.4	0.12
	- class	53	538.8	616.8	489.8	<2e-16
2008	Full model	52	74.8	167.5		
	- class:ogive	53	74.9	165.6	0.1	0.76
	- ogive	54	76.2	165.0	1.4	0.24
	- class	55	686.6	773.3	610.4	<2e-16

Table 2: Proportions of adult females by age calculated from the DEPM and acoustic surveys (the latter are used for assessment) in corresponding surveys.

Year	Age	1	2	3	4
2002	N_DEPM	95	313	143	241
	N_assess	717	634	366	555
	Ogive DEPM	1.00	1.00	0.99	1.00
	Ogive assess	0.59	0.93	0.98	0.99
2005	N_DEPM	185	114	65	111
	N_assess	630	343	158	239
	Ogive DEPM	0.47	0.91	0.98	1.00
	Ogive assess	0.19	0.85	0.97	0.99
2008	N_DEPM	551	306	418	874
	N_assess	378	186	205	398
	Ogive DEPM	0.87	0.99	0.99	0.99
	Ogive assess	0.29	0.94	0.99	1.00

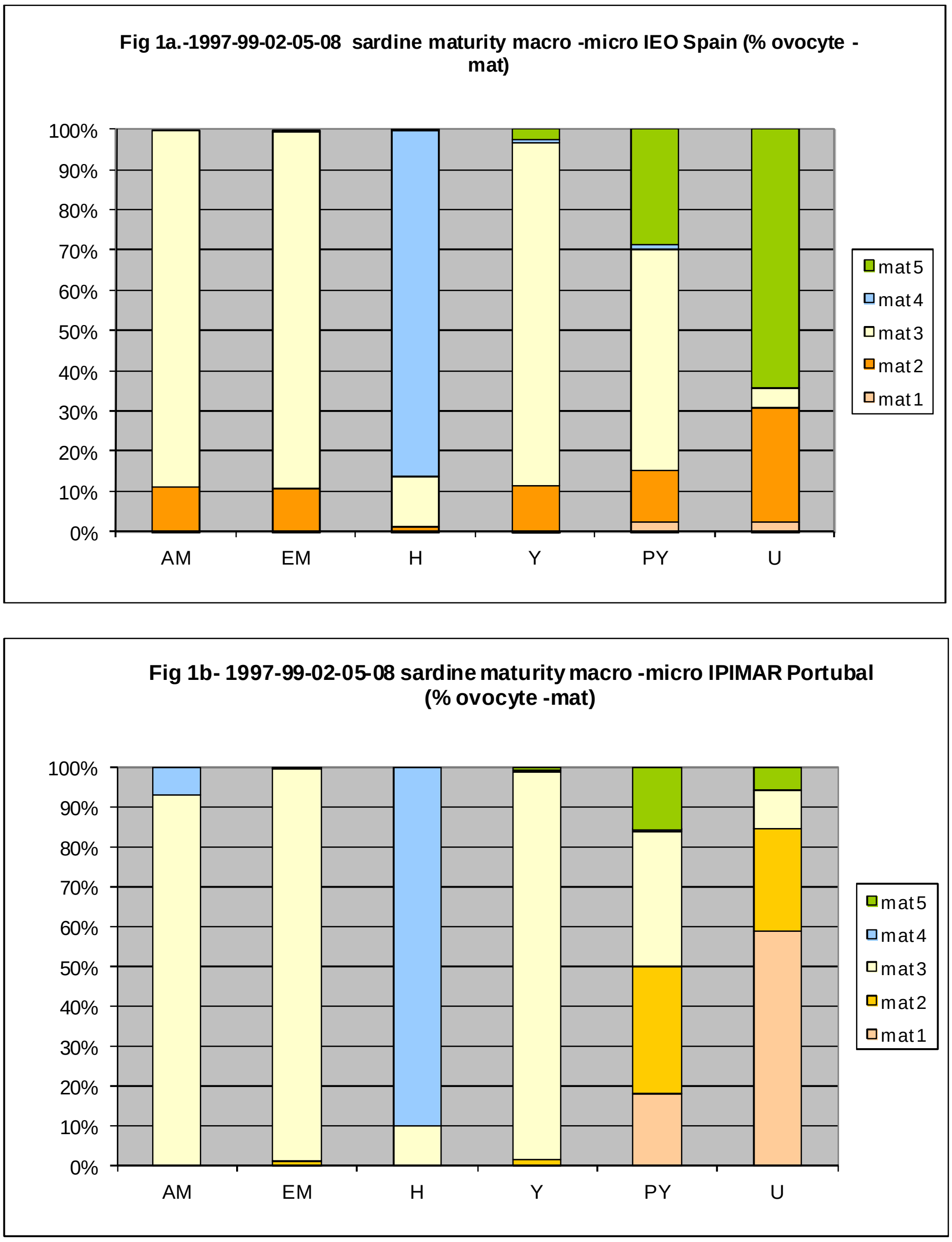

Figure 1: Distribution of macroscopic stages for each oocyte stage.

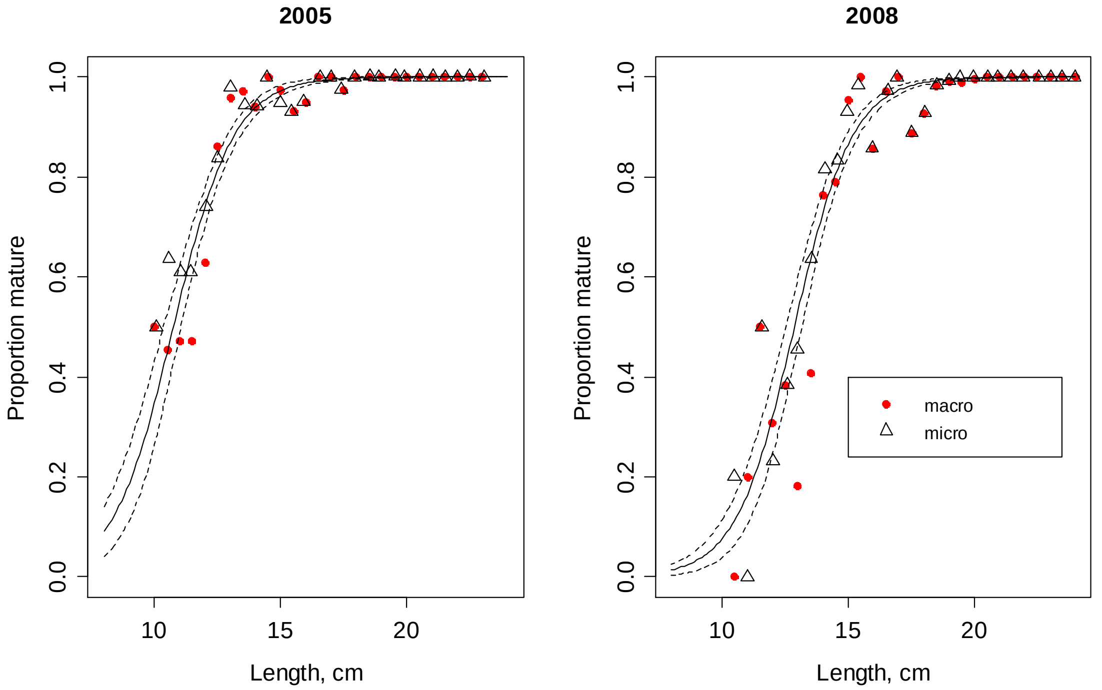

Figure 2: Length-based macro and micro maturity ogives for the 2005 and 2008 Portuguese DEPM surveys.

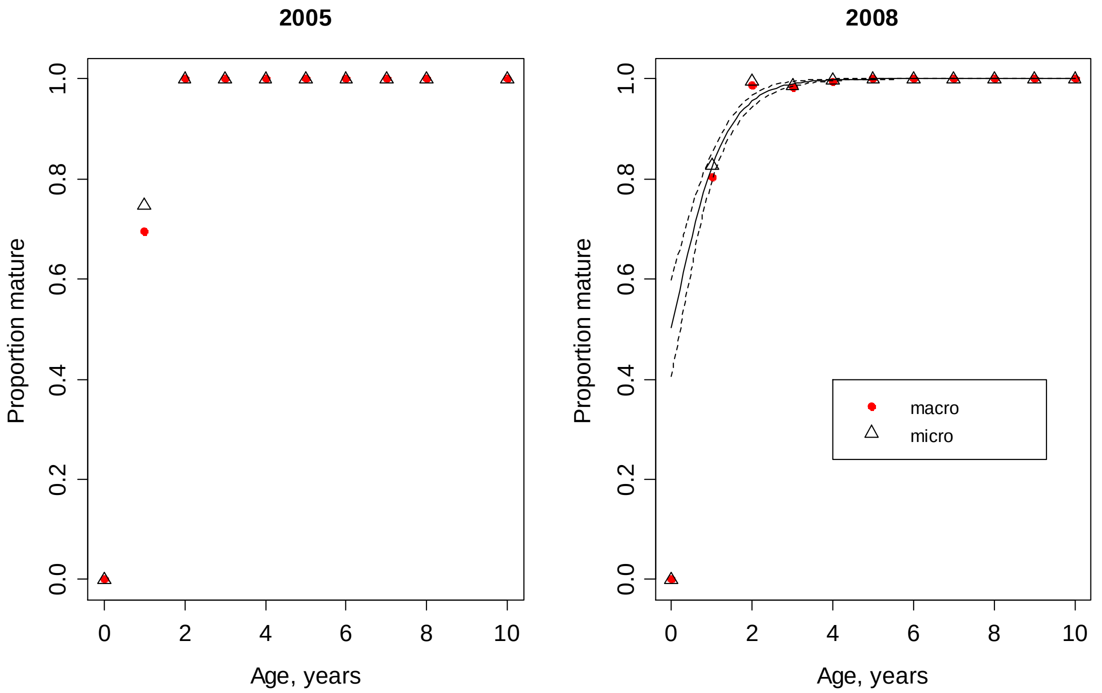

Figure 3: Age-based macro and micro maturity ogives for the 2005 and 2008 Portuguese DEPM surveys.

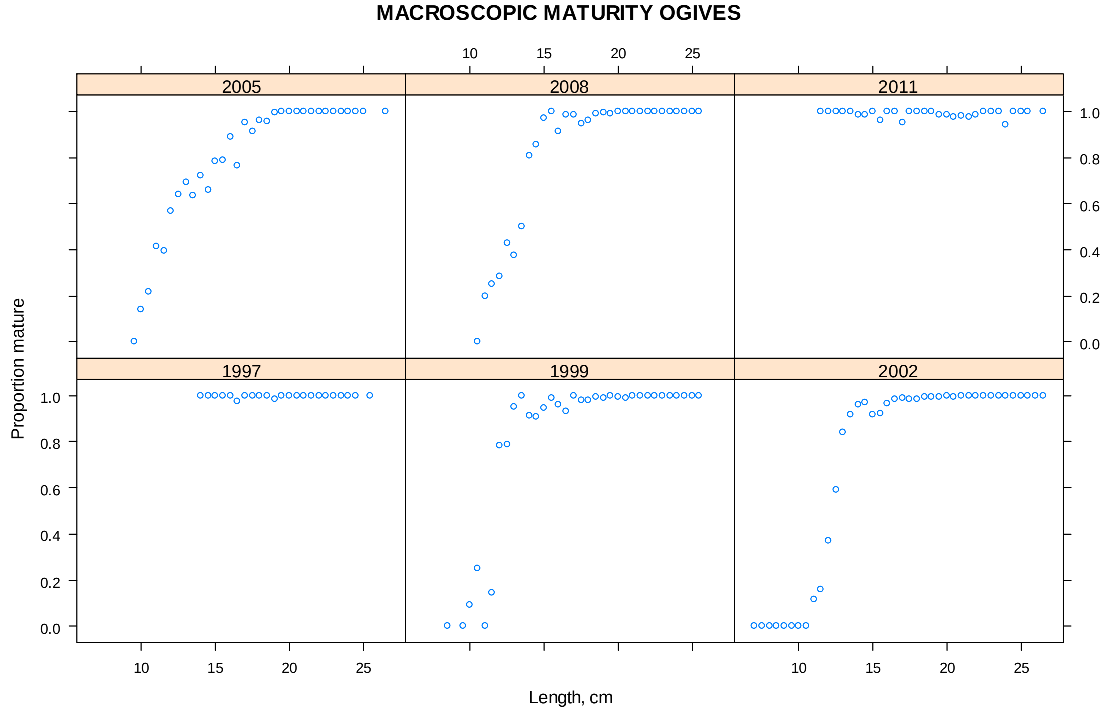

Figure 4: Proportion of adult females by length class in the DEPM surveys 1997-2011.

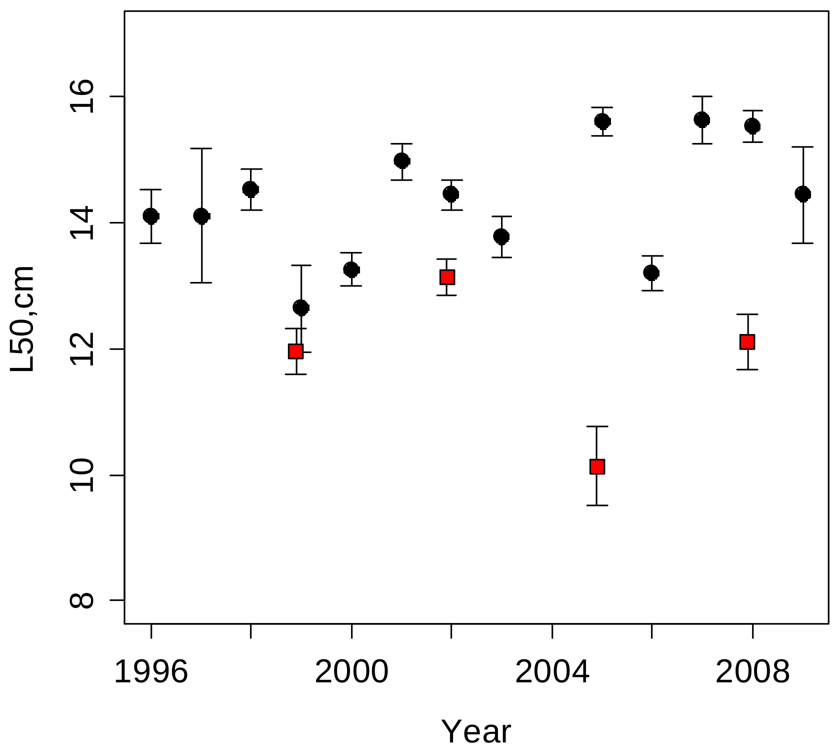

Figure 5: Estimates of L50 from acoustic (black circles) and DEPM (red) surveys.

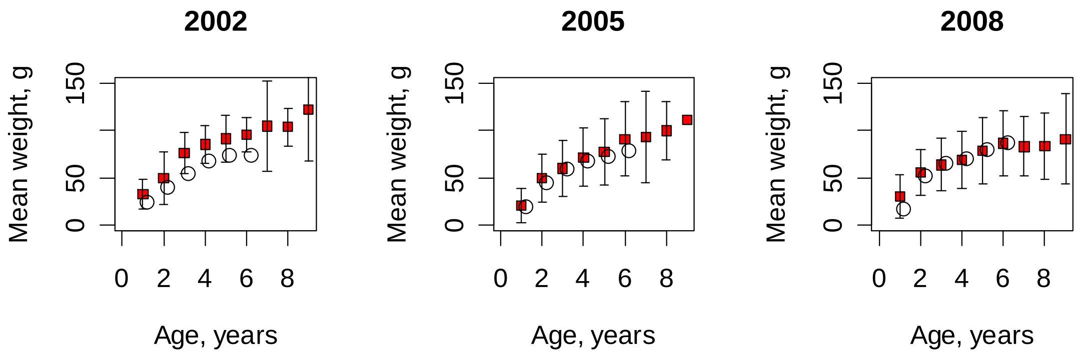

Figure 6: Mean weight-at-age of females in the DEPM surveys (red squares, bars are standard deviations) and in the acoustic surveys (white circles).