

## Changes in anchovy maturity assumptions over time

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*Changes in the estimation of anchovy maturity over time are explained, with broad agreement and overlap between the knife-edge maturity-at-age assumed for Operating Models used to develop OMP-14 and the annual maturity-at-length ogives used in Operating Models to develop OMP-18rev.*

*Keywords: anchovy, maturity, survey bias*

A few SWG-PEL TTG members have spent time analysing past and present methods of estimating anchovy maturity. Three main points from those discussions which may pertain to signing-off on OMP-18rev are listed below. Further consideration of, for example, the impact of using macroscopic instead of histological ageing will be addressed during the development of Operating Models for the next OMP.

### Time-invariant maturity ogive used for OMP-18 was incorrect

- The maturity-at-length ogive used in the 2015 and 2016 anchovy assessments (Figure A.1 of de Moor 2016) was incorrect.
- Correctly weighting the 4 sets (1985 and 1986, male and female) of proportions (not numbers) mature by length, i.e.  $p_l^{mature} = \frac{\sum_i p_{i,l}^{mature} \times N_{i,l}^{total}}{\sum_i N_{i,l}^{total}}$ , and fitting using sum of squares (as per de Moor 2016) results in a  $L_{50}$  of 8.94cm ( $\delta = 0.319$ ), lower than the 10.61cm ( $\delta = 0.661$ ) of de Moor (2016).

### Changes in November survey bias used in the baseline OM for OMP-18 to OMP-18rev is due to the inclusion of an informative prior for this bias and the previous use of an incorrect ogive, not due to changing from time-invariant to annual maturity ogives

- The baseline OM used to tune OMP-18 (which incorporated a time-invariant maturity-at-length ogive with  $L_{50} = 10.61\text{cm}$ ) had a median  $k_N^A$  of 0.63 with a 90% probability interval of [0.51,0.77].
- The updated OM, using the same (incorrect) time-invariant maturity-at-length ogive estimated  $k_N^A = 0.68$  at the joint posterior mode.
- Updating that OM further to incorporate an informative prior on  $\ln(k_N^A)$  estimated  $k_N^A = 0.76$  at the joint posterior mode.
- Had a time-invariant maturity-at-length ogive with a  $L_{50} = 8.94\text{cm}$  and  $\delta = 0.319$  been used, instead of  $L_{50} = 10.61\text{cm}$  and  $\delta = 0.661$ , the November survey bias would have been estimated to be 0.89 at the joint posterior mode. This  $k_N^A = 0.89$  is the same value estimated at the joint posterior mode when the annual maturity ogives are used (de Moor 2020, 2021).

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- Thus the change reported between rows 2 and 3 of Table 1 of de Moor (2021) was not due to a change from time-invariant to annual maturity ogives, but due to the previous use of a maturity ogive that has been estimated incorrectly, compared to new (and correct) estimation methods.
- The absolute biomass estimated by de Moor (2016) is thus positively biased because of the use of a lower  $k_N^A$  than would apply given a corrected different maturity ogive.

#### Differences in maturity assumptions between OMP-14 and OMP-18rev

- OMP-14 was developed using an Operating Model (OM) conditioned on data up to 2011 (de Moor and Butterworth 2012, 2013).
- That OM assumed (i) all anchovy matured at age 1, (ii) November survey observations represented 1+ biomass, and (iii) no length-frequency data were used to condition the model. The model was conditioned on proportion-of-age-1 anchovy in the November surveys, which was estimated by fitting modelled length distributions of age 1 and 2+ anchovy to the survey length distributions (de Moor *et al.* 2013).
- The November survey bias for that baseline model was 1.04 with 90%ile [0.85,1.27].
- OMP-18rev has been developed using an OM conditioned on data up to 2019 (de Moor 2020).
- That OM assumed (i) anchovy mature according to a maturity-at-length ogive which has a different  $L_{50,y}$  for each year, based on annual data, (ii) November survey observations represent 0+ biomass, and (iii) length-frequency data from commercial catches and November surveys are used to condition the model.
- The  $L_{50,y}$ 's ranged from 8.0cm to 9.8cm with an average of approximately 8.7cm.
- The assessment of de Moor (2020) estimates the length at age 1 in November to be approximately 9.5cm, with the 90%ile ranging from 7-7.5cm to 11.5-12cm.
- Thus there seems to be some broad agreement and overlap between the knife-edge maturity-at-age assumption assumed in the OM underlying OMP-14 and the maturity-at-length assumptions in the OMs underlying OMP-18rev.
- The November survey bias for the baseline OM for OMP-18rev is 0.89 with 90%ile [0.75, 1.01].

Changes in assumptions about anchovy maturity should therefore not bias comparisons between the risk of OMP-14 and OMP-18rev.

Based on these comparisons, it is likely that the qualitative impact of using histological instead of macroscopic ageing (Melo (1992) suggests the latter over-estimates the length at 50% maturity by approximately 1cm) would result in a higher value estimated for November survey bias and thus a lower absolute anchovy biomass.

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