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MSE Mackerel

Density dependent growth of mackerel

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Background

Density dependence not only in recruitment but also in growth, maturity and natural mortality are important to consider in MSE and when aiming for biological reference point estimates (see e.g. Lorenzen (2016) for an overview). Currently only DD in recruitment is considered for mackerel.

Here we try to find good, simple and pragmatic models for DD in growth which can be used in MSE for mackerel.

Analysis

We used data from ICES (2019) on weight-at-age and total stock biomass (TB). Because there are errors in both data series (both process and observation errors) it was judged prudent to apply a functional regression approach. The CV of the two variables were assumed identical.

The density dependent function was assumed to be a simple linear one between weight-at-age in the stock and TB:

$$\text{Weight (age, y)} = \text{alfa(age)} * \text{TB(y)} + \text{beta(age)},$$

Where y is year, TB total stock biomass, and alfa and beta regression parameters specific for each age group. The functional regression is taken as the mean parameter estimate from two regressions, one as given in the formula above and another one where TB is regressed against weight-at-age.

Table 1 gives parameters by age group as well significance level of correlation. Age 0, 1 and 2 did not show a relationship to TB and are probably more linked to stock numbers of the cohorts as they are distributed in the sea in areas quite far from the adult individuals. This issue was not pursued here where we want to keep complexity low. Age 3 weight is far from significantly correlated to TB and the parameters obtained are clearly driven by noise rather than signal in the data. An alternative approach is suggested where the parameter alfa is fixed to that for age 4 and the beta parameter is found by maximum likelihood (see parameters at the bottom of Table 1).

Table 1. *Mackerel. Estimated parameters for density dependent growth (weight-at-age in the stock). TB is measured in million tonnes and weight in kg.*

Age	alfa	beta	CV	P value of slope different from 0
0	-	-	-	-
1	-	-	-	-
2	-	-	-	-
3	-0.0726	0.5490	0.099	0.4639
4	-0.0317	0.4280	0.073	0.0037
5	-0.0308	0.4711	0.066	0.0001
6	-0.0341	0.5254	0.069	0.0000
7	-0.0337	0.5558	0.062	0.0000
8	-0.0311	0.5776	0.057	0.0000
9	-0.0319	0.6061	0.052	0.0000
10	-0.0326	0.6347	0.054	0.0000
11	-0.0377	0.6856	0.058	0.0006
12	-0.0338	0.7054	0.050	0.0001
Alternative run for age 3 where parameter alfa is fixed to the one for age 4				
3	-0.0317	0.3794	0.167	-

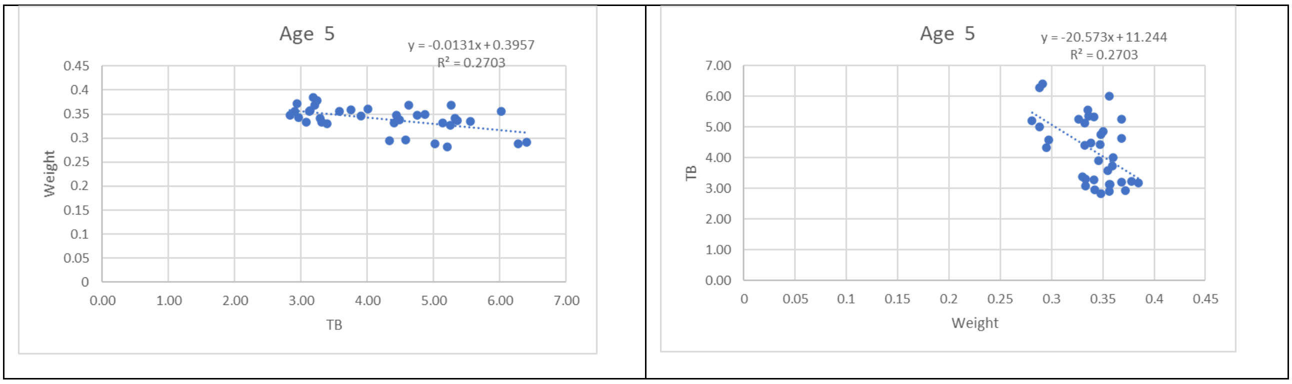

Figure 1. *Mackerel. Relationship between weight-at-age for age 5 and stock total biomass. Left panel weight vs TB and right panel TB vs weight. The functional regression is taken as the mean parameter estimate from these two regressions.*

Catch-weight-at-age is different from stock-weight-at-age because of the selectivity of the fishing gear and the fisheries targeting specific parts of the stock. We suggest a simple relationship is to obtain catch-weight-at-age from stock-weight-at-age. Based on the historic relationship from 1980-2018, obtain catch-weight-at-age by multiplying stock-weight-at-age by the ratios in Table 2.

Table 2. *Mackerel. The ratio between catch-weight-at-age and stock-weight-at-age as a mean of most recent 5 years, 2014-2018.*

Age	Ration between weight in the catch and weight in the stock. Mean 2014-2018
1	2.20
2	1.30
3	1.27
4	1.26
5	1.23
6	1.22
7	1.21

8	1.17
9	1.15
10	1.11
11	1.13
12	1.09

Discussion

The TB used is from ICES 2019 assessment and assumes that the MSE is based on this assessment. However, if the misreporting-corrected assessment is the correct one and the MSE is based on this assessment, the density dependent factors should instead be based on TB from the misreporting-corrected assessment.

The alfa parameters are quite similar between age groups except for age 3, the only age group for which the density dependence is not significant (and far from being so). Thus, an alternative approach might be to estimate one common alfa parameter for all ages. The results of such an analysis are not expected however to be very different from those in Table 1 if the alternative set of parameters for age 3 (bottom row of Table 1) is used, and probably not worth the while.

ICES (2017) used this equation for weight-at-age in the stock:

$\log(sWya) = \alpha + \delta age + \beta \times N1 + gamma \times SSB$,

where the catch weight in year y for mackerel of age a (sWya) is related to N1, the size of the cohort at age 1, and SSB in the same year y. They used a similar equation for weight-at-age in the catch. Our approach is simpler, and we tend to prefer a simple method due to the low signal to noise in the basic data. We also prefer our approach of a functional regression that takes account of uncertainties in the independent variable, TB.

References

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