Changes in the length-weight relationship in Northern Stock of European hake (*Merluccius merluccius*).

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Contents

Background

Information on length-weight relationships (LWR) for commercially exploited species is essential for the assessment of marine resources. However, commonly the analyses of LWR do not consider the intrinsic differences that could have individuals caught from different areas or years. The variability in the LWR could affect their estimations and the utility of this data in computing fisheries biomass.

In addition, for the northern stock of the European hake, (*Merluccius merluccius*), fishers in the ICES areas VI and VII warned that the mean LWR of individuals has decreased in the recent years. Biological data is not reported to the group and a fixed LWR is used in the assessment.

Within this context, we investigated the LWR for the European hake, northern stock, from 2003 to 2018 assessing difference among areas and years.

Sampling

Sampling length-weight measurements of European hake individuals collected from the Atlantic waters were taken from historical records collected during 2003-2018. Total length (TL) was measured to the nearest 0.1 cm and total weight (Wt) was measured to the nearest 1 g. AZTI provided 30990 samples from the commercial fleet, while the IEO provided 15213 from both fisheries and research surveys. In all cases, fish were processed fresh and sexed. Frozen samples were not considered in this study. However, it worth to be mentioned, that most of the data of the weight measurements provided by the IEO of commercial fisheries was gutted and for this reason excluded by most of the analysis.

Length-weight relationships

All analyses were conducted using the R statistical software R Core Team (2018) and in particular, the length-weight relationship parameters were computed using the Fisheries Stock Assessment (FSA) package Ogle (2017). First, a linear regression was performed (model 1) as presented in equation 2, where Wt is total weight, TL is total length, α is the regression intercept, and β is the regression slope.

$$\log_{10}(Wt) = \log_{10}(\alpha) + \beta \log_{10}(TL) \tag{1}$$

As mentioned before, several factors could influence the LWR. For this reason an error term e_i normally distributed was included in the equation 2. This error could be associated to annual (model 2) or spatial (model 3) variations at the level of fish individuals population. In order to account for differences with respect to length, temporal and spatial effects and interaction terms were added to the basic model (model 1). This allowed us to model LWR, including factors separately or as interactions to test if the relationship between length and weight (i.e. slopes) was statistically different across areas, seasons and years.

Models were fitted using the following terms as fixed factors: log10TL (continuous), divisions (VI, VII, VIII, Unknown) and year (2003-2018).

Model selection was performed using the Akaike Information Criterion (AIC). The final selected model was the one with the lowest AIC value.

Results and discussion

Descriptive results

From 2003, 2200 individuals on average were collected each year. Only in the 2014 a lower number of fishes was available (1636). The ICES divisions where fishes were caught were the VI, VIIbchjk,VIIIabd. These were grouped in three zones such as VI, VII and VIII.

In particular, the VIII was the area with more caught individuals (29010), followed by the VII with 8346, the VI with only 103 individuals and all sampled in the 2011 (Figure 1). It worth to be mentioned that, for 8744 individuals, the sampling area was unknown.

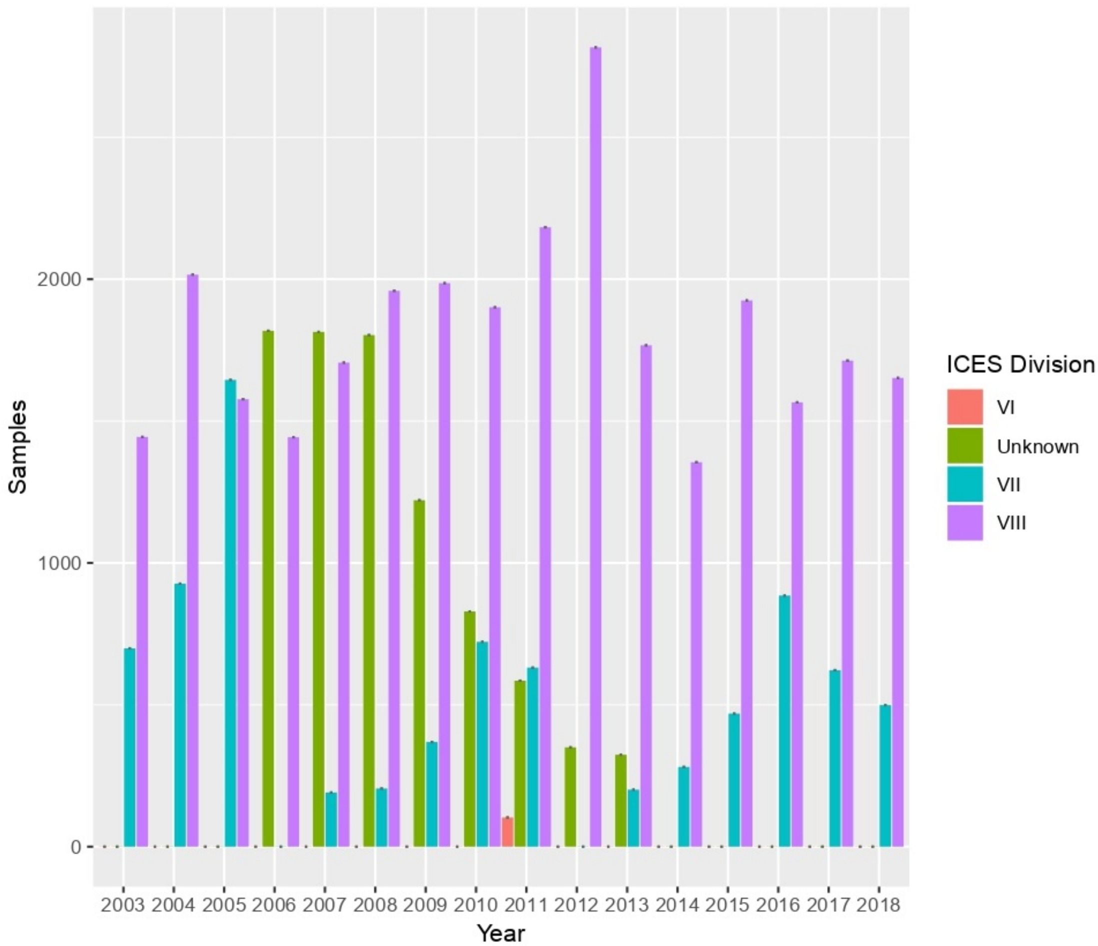

Figure 1: Samples by year and ICES Division.

If we examine the length frequency (with a length interval data of 10 cm) we can see that both, in number of individuals and in proportion, the majority of the population is between 30-40 cm (Figure 2).

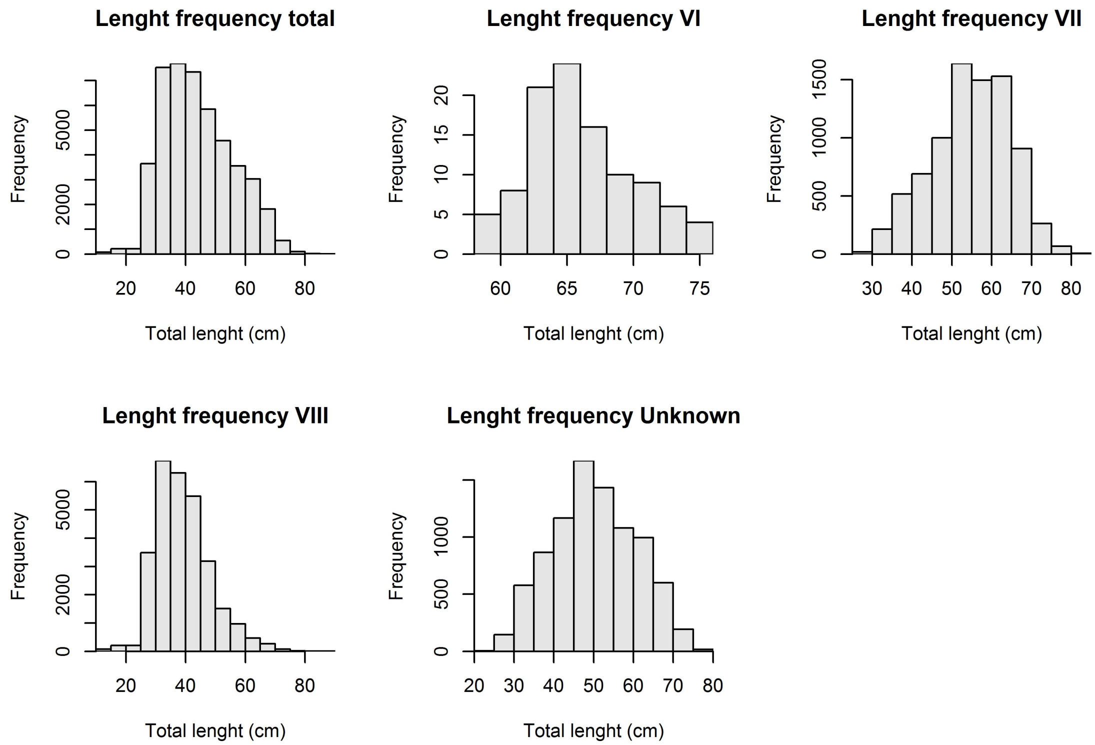

Figure 2: Histograms length frequency for all data and by ICES Division.

Length-weight relationships.

Log10 transformed weight (gutted weights) significantly predicted lengths. The model exhibits a good fit to the transformed data (R^2 0.99) with the possible exception of few individuals (Figure 3). The estimates for α and β for the basic model was:

$$\log_{10}(Wt) = \log_{10} -2.13 + +2.95 \log_{10}(TL) \tag{2}$$

with a variation of α between -2.15 (2.5 %) and -2.15 (97.5 %), and β between 2.95 (2.5 %) and 2.96 (97.5 %) (all on the transformed scale).

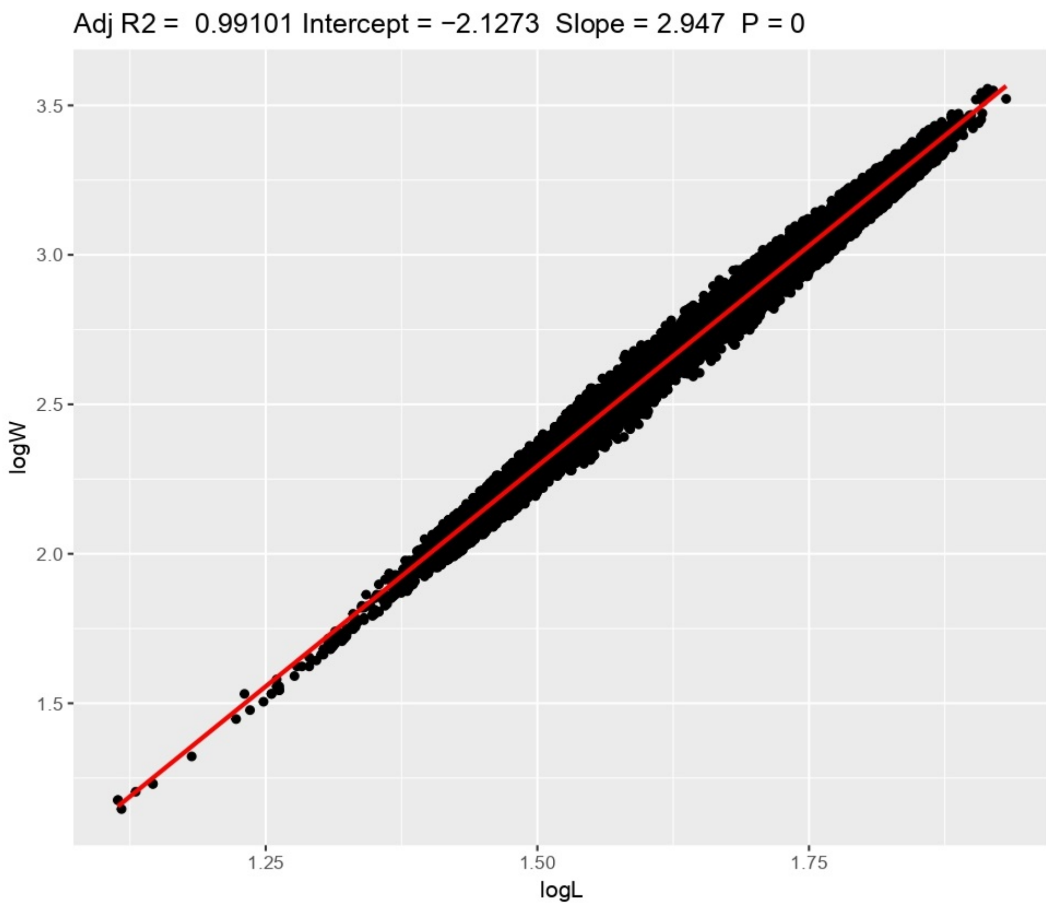

Figure 3: Length-weight relationship of the European hake from 2003-2018 with all data (gutted weights).

Testing spatio-temporal variations.

The model with the inclusion of the year as factor reveled that the year had a significant effect on the LWR. Because the studied years have statistically different slopes and intercepts, there is a variable difference between the log-transformed weights of the collected individuals in 2003-2018 regardless of the log-transformed lengths (Figure 4).

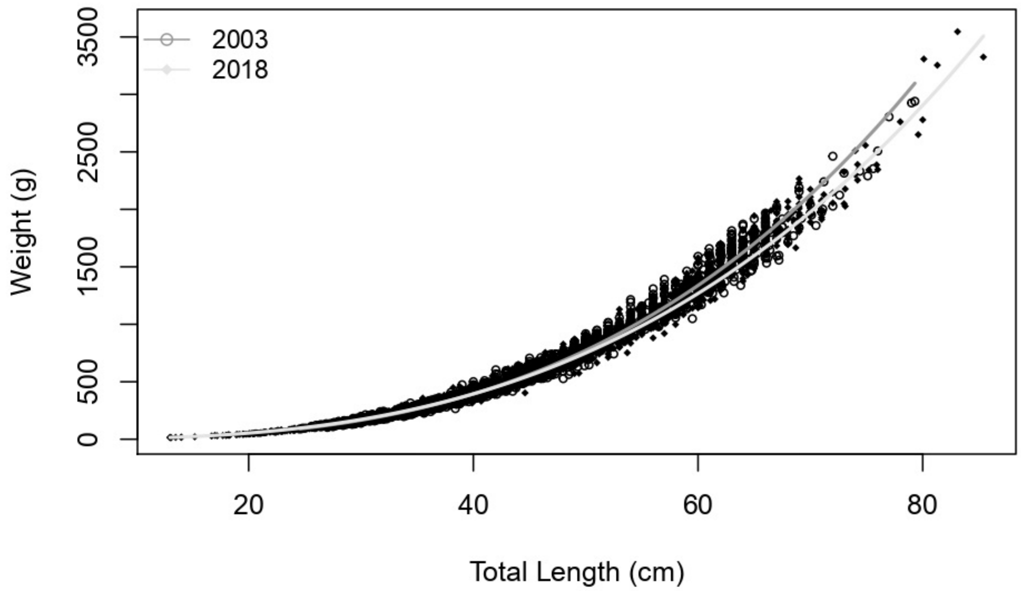

Figure 4: Length-weight relationship (gutted weights) of the European hake from 2003-2018 with the year factor.

Also the area showed a significant effect on the LWR, but particularly the difference was between the VI and the VII and VIII (Figure 5). However, it worth to be mentioned that data from the VI were present only for one year of the time series. The AIC of this model was -187230.5, while the one of the model with only the year was -188100.3. The model with the year is better.

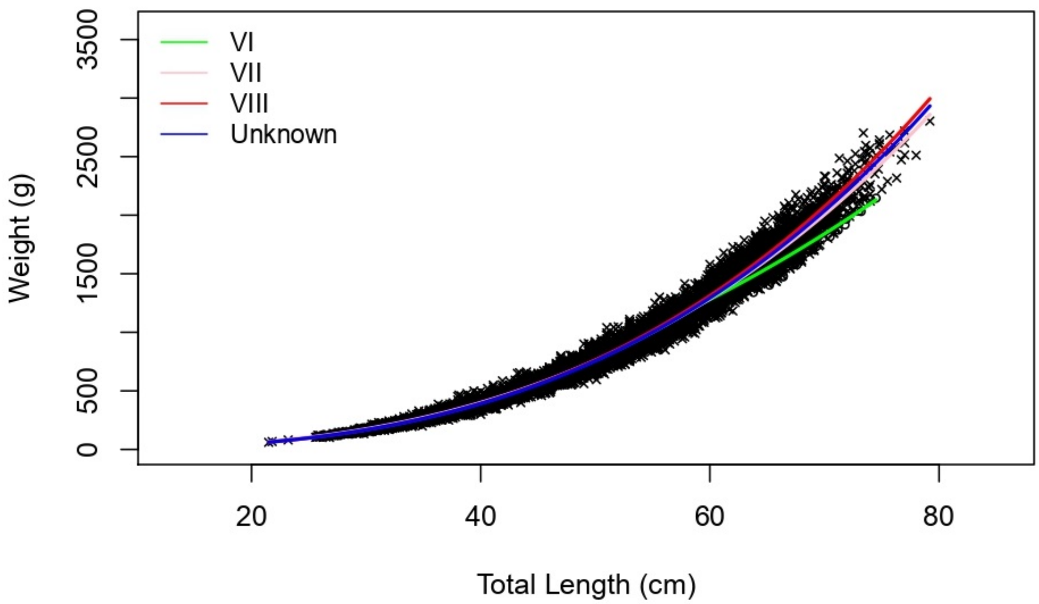

Figure 5: Length-weight relationship (gutted weights) of the European hake from 2003-2018 with the ICES division factor.

Assessment Results Comparison

As the difference between areas VII and VIII was not too big, and the input data for the stock assessment model require the use of total weights (not gutted), we run a separated analysis using only AZTI data that has total weights for the VIII area.

The model with the AZTI data (total weights) used for compute yearly LW parameters showed that there was a change in 2011 (Figures 6 and 7).

Year	a	b
2003	0.0086	2.93
2004	0.0038	3.16
2005	0.0053	3.06
2006	0.0056	3.05
2007	0.0071	2.99
2008	0.0046	3.10
2009	0.0068	3.00
2010	0.0057	3.04
2011	0.0078	2.96
2012	0.0081	2.95
2013	0.0099	2.89
2014	0.0072	2.98
2015	0.0079	2.95
2016	0.0117	2.85
2017	0.0078	2.95
2018	0.0095	2.91

Figure 6: Length-weight parameters computed with 2003-2018 data for VIII ICES area.

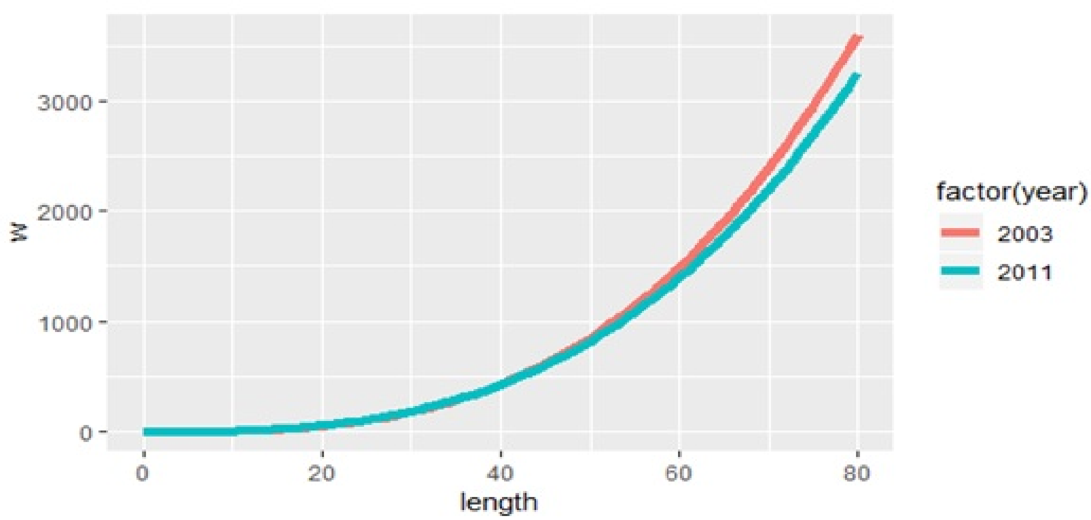

Figure 7: Length-weight parameters computed with 2003-2018 data for VIII ICES area.

92 The LW parameters commonly used in the SS3 until now was equal to α and 0.00513

and β 3.074.

As SS3 allows to add these parameters in temporal groups we used two different blocks:
(1) 1978-2010 α 0.00512 and β 3.07
(2) 2011:2017 α 0.00840 and β 2.94

Using the new computed LW parameters there was a decrease of the 7% in the SSB with respect to the assessment in 2017 performed with traditional parameters, and an increase in 8% in the F (Figure 8).

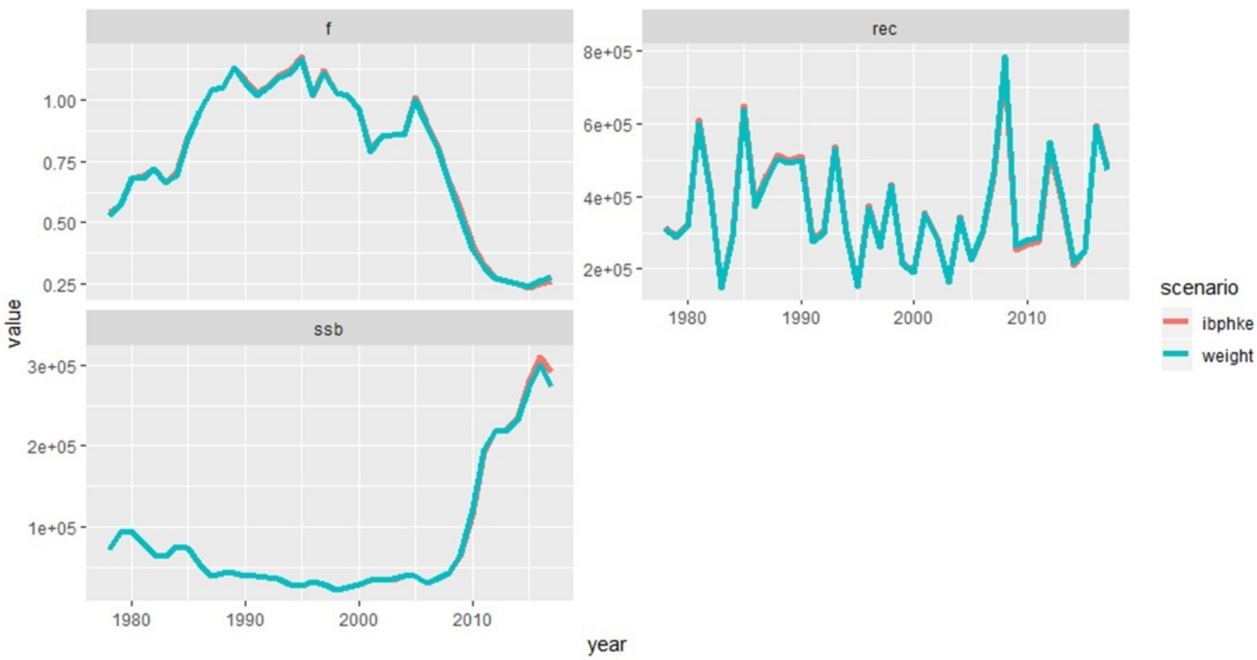

Figure 8: SS3 results using the new LW parameters.

For biological reference points there was slight changes (Figure 9).

Fishing mortality	wg19		Variation in weight	
	With Btrigger	No Btrigger	With Btrigger	No Btrigger
Fmsy	0.28	0.27	0.28	0.28
Flow	0.17	0.17	0.17	0.18
Fupp	0.41	0.39	0.43	0.42

Figure 9: Biological reference points comparison between the assessment of 2017 performed with traditional LW parameters and the new one.

Conclusions

Based on this preliminary analysis the introduction of the new LW parameters could vary the final assessment and advice. Further analysis need to be performed to explore additional data and specifically to apply the computed LWR to compile raw data that are used in the assessment.

References

Ogle, D. (2017). Fsa: Fisheries stock analysis. r package versión 0.4. 12.

R Core Team (2018). *R: A Language and Environment for Statistical Computing.* R Foundation for Statistical Computing, Vienna, Austria.