LIFE-TRAITS OF EUROPEAN HAKE IN IBERIAN ATLANTIC WATERS

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INTRODUCTION

European hake (*Merluccius merluccius*) is a resource of great commercial importance in Iberian Atlantic waters. Despite of the recovery plan implemented in 2006 and the Multiannual management plan for Western Waters, the fishing mortality is still above the one corresponding to the maximum sustainable yield (F_{msy}) [2].

Understanding biological processes underlying stock dynamics and providing updated information about life-traits is essential for efficient assessment and management of marine resources.

OBJECTIVES

1. Study of the annual variability of the size at first maturity (L_{50}) with respect to environmental and biological factors.
2. Estimate biological parameters such as size at first maturity and the relative condition factor (K_n) for European hake.

LIFE-TRAITS

Size at first maturity **(L_{50}).** The size at first maturity is the length at which 50% of individuals reach sexual maturity. This is estimated by fitting the data to a logistic model: $y = 1/(1 + exp(a + b * x))$, where y is the proportion of mature individuals, x is the total length (cm) and a and b are parameters to be estimated.

Relative condition factor **(K_n)** Indicator of the body condition of the fish, which is obtained as the relationship between the total weight (W) and the total weight expected for a fish of the same size: $K_n = W/(a * T^b)$, where T is the total length, and a and b are the linear regression coefficients.

MATERIAL AND METHODS

Individual's weight and length distribution as well as macroscopic maturity stage of the hake were obtained from samplings of the commercial fleet that operates in Iberian Atlantic waters (ICES subdivisions 27.8.c and 27.9.a), for the period between 1982 and 2019. In addition, data on environmental variables such as sea surface temperature (SST), the North Atlantic Oscillation (NAO) and the Atlantic Multidecadal Oscillation (AMO), were extracted from open-access databases.

L_{50} and K_n are estimated for each year between 1982 and 2019 and for each sex (male and female). It should be noted that lack of information on some biological traits have prevented estimation of these life history traits for some years. These missing values have been replaced by moving averages. In addittion, prior to the study of the temporal variability of L_{50}, outliers of both the response variable and the explicatives ones were removed to avoid possible biases in the analysis.

The variability of the L_{50} for each sex was modeled with Generalized Additive Models (GAMs) [1] considering as explanatory variables, environmental factors (AMO, NAO, and SST) and biological variables (biomass, spawning biomass at length and K_n).

Each model was adjusted using the Gaussian distribution, the "*cr*" as the smoothing base and the restricted maximum likelihood estimation method (REML). The number of nodes was limited to avoid overfitting and to obtain a robust and reliable model. The variable selection was performed using the backward method. All the GAMs were adjusted using the *mgcv package* [4] in R [3] .

ANNUAL VARIATION OF L_{50} :

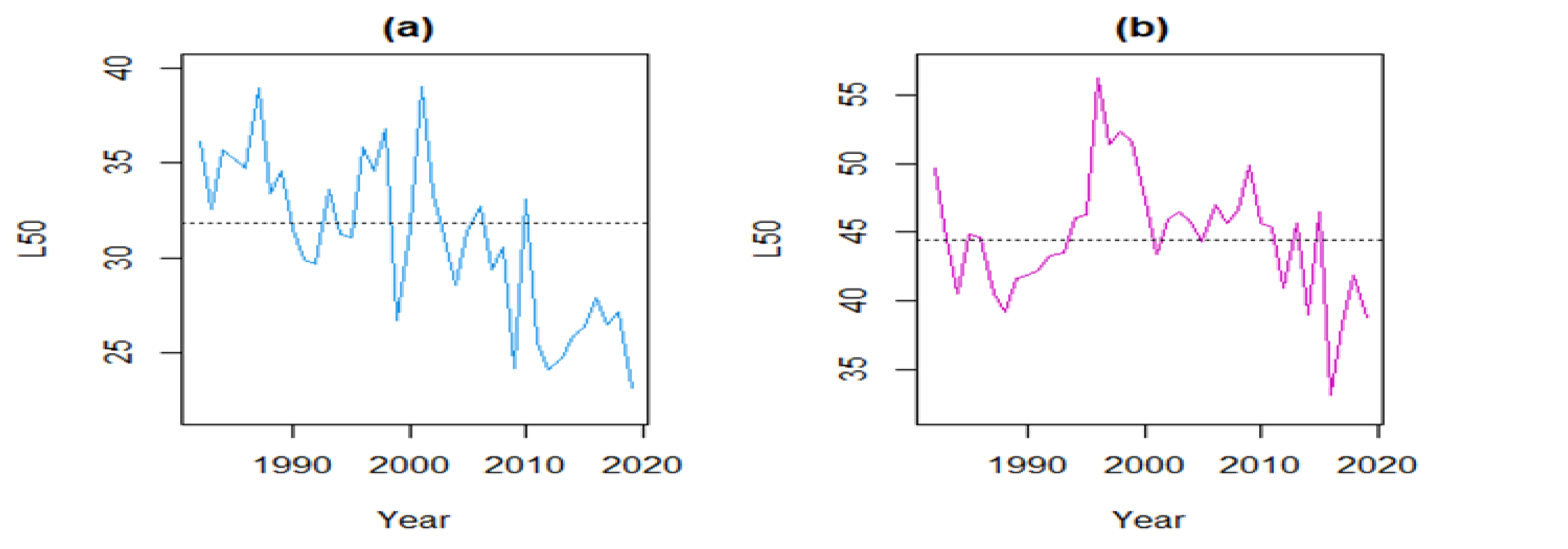

Figure 1: Annual variation of size at first maturity for (a) males and (b) females.

VARIATION OF L_{50} WITH RESPECT ENVIRONMENTAL AND BIOLOGICAL FACTORS:

	FEMALE	MALE
YEAR	⌢	-
ENVIRONMENTAL		
AMO		
NAO	+	
SST		
BIOLOGICAL		
K_n		
SBL	+	
BIO	⌣	

Figure 2: Summary table of the GAMs results of the European hake for each sex. The decreasing or negative (-) relationship is indicated in red, increasing or positive relationship (+) in green and dome relationships (⌣ or ⌢) in yellow.

CONCLUSIONS

The results of this study point to a **temporal trend towards decreasing size at first maturity**. The variability of size at first maturity for each sex is mainly influenced by the time variable. In addition, changes in size at first maturity for females are influenced by variations in density where decreasing biomass and spawning biomass in length cause an increase in this life history trait. Adding, it is also influenced by the environmental variable NAO, where higher values of this variable imply an increase in size at first maturity.

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