CONDITION OF EUROPEAN HAKE (*MERLUCCIUS MERLUCCIUS* L.) OFF THE BALEARIC ISLANDS: AN APPROACH OF PHASE TRANSITIONS OCCURRENCE IN THE POPULATION

M. Hidalgo [1] *, E. Massutí [2], B. Guijarro [2], P. Oliver [2], J. Moranta [2], L. Ciannelli [3], J. Josep Lloret [4]

[1] Institut Mediterrani d'Estudis Avançats (CSIC/UIB). Miquel Marquès 21, 07190 Esporles, Mallorca, Spain - manuel.hidalgo@uib.es

[2] Centre Oceanogràfic de Balears, Instituto Español de Oceanografía (COB-IEO). Apdo, 291, 07080 Palma de Mallorca, Spain

[3] College of Oceanic and Atmospheric Science, Oregon State University. 104 COAS Admin Bldg, Corvallis, OR 97331-5503, USA

[4] Institut de Ciències del Mar (CSIC). Passeig Joan de Borbó sn, 08039 Barcelona, Spain

Abstract

Population dynamic of the exploited demersal fish European hake (*Merluccius merluccius*. L.) off the Balearic Islands were explored in relation to the relative condition index (K_n) and mean length-at-age (ML). K_n was significantly correlated with hake population characteristics as recruitment, spawning stock biomass (*ssb*) or total biomass. Furthermore, ML also appeared to be significantly related to age-0 class abundance, but with a different relationship before and after 1995, driven by a stronger density-dependence effect of *ssb* for low values of ML. This suggests that changes or phase transitions in the population could be occurring, affecting the intraspecific relationships.

Keywords : Balear Islands, Demersal, Fisheries, Recruitment.

Fish condition is a measure of environmental and biological circumstances during previous periods. Condition indices are often used to represent the amount of energy stored within individual fish, although it is also relevant to estimate condition at the population level. Several morphometric and physiological indices used to be explored using individual observations. However, Mean Length-at-age (ML) can also be used as a proxy of the population condition when computation individual-level observations on weight and length are not readily accessible [1]. Condition of fish could reflect changes in the denso-dependent relationships and the population age structure. Inter-annual fluctuations of marine population can undergo abrupt changes which can be ecological, anthropogenic or climatologically driven [2]. This study aims to explore: 1) the effect of condition indices on the population abundance of European hake (*Merluccius merluccius* L.) (recruits abundance, *rec*, spawning stock biomass, *ssb*, and total biomass, *tb*) and, 2) explore the occurrence of possible phase transition in the population dynamic using ML as a proxy of condition of fish.

A total of 7447 individuals were sampled over the year from 1980 to 1992 (except 1987), estimating the relative condition index (K_n): K_n=100(W_{obs}/W_{est}), where W_{obs} is the observed weight and W_{est} the estimated weight. K_n was calculated for two groups, individuals lower that 30 cm (not maturing) and larger than 30 cm (maturing). ML at different ages was also calculated using yearly length distribution from 1980 to 2004. The outputs of the Virtual Population Analysis (VPA) were used in the analysis: *rec*, *ssb*, *tb* and number of individuals per age class [3]. Non-parametric Spearman correlations were used to compare K_n and hake population time series, being K_n index values ln transformed. However, as we got relatively longer time series for ML, we used a generalized additive model (GAM) to fit estimates of abundance at different age and ML. For studying the presence of changes in the time series, which may be indicative of phase transitions, changes in the condition as a threshold non-additive effect on ML throughout the time was explored, being the denso-dependency effect included trough *ssb*, also threshold by ML. The average per year of the ln transformed K_n (i<30 cm) index was significantly correlated with *rec* (r = 0.36, p<0.05), showing as well significant correlation with *ssb* and *tb* (lagged by one year) (r = 0.77 and r = 0.70 respectively, p<0.05) (Fig. 1a). Correlations with ln transformed K_n (i>30cm) were not significant (p>0.05). Although similar GAM approaches were followed for other ages, only results for age-0 are shown here. Figure 1b shows the different relationship between the covariate ML at age 0 (ML_0) and age 0 abundance (N_0), being 1995 the threshold in the relationship. Although higher N_0 is related to low ML_0 for the entire period, before 1995 around 15.5 cm ML_0 was linked to higher N_0, while after 1995 higher N_0 of small individuals were related to lower ML_0, around 14.5 cm. *Ssb* effect shows an increase of density dependence for low ML_0values (<15.8 cm).

The results show that the recruits condition and ML are related to the abundance. *Ssb* and *tb* of the previous year could also affect the condition of the offspring between 1980 and 1992. However, the different biological meaning of K_n and ML must be taken into account. While K_n reflects the energy allocated to the body, ML shows the mean size of an annual class which can have a positive or negative effect of the population, or being a reflection of the population state. Our results reveal that the density-dependence effect of *ssb* on $N_0$are mediated by ML_0. This suggests the occurrence of a possible phase transition in the population which must be explained within an ecological and fishery perspective (Hidalgo et al., in prep), because of the fishery-induced truncation of the age structured [4].

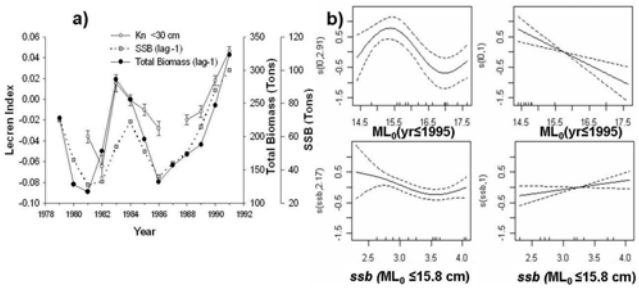

Fig. 1. a) Kn (i<30cm), tb and ssb time series from 1980 to 1992. b) Covariates effect of ML at age 0 (ML0) on the abundance of age-0 annual class (N0), under different period effect before and after 1995, and the density-dependent effect of ssb under different groups of ML0.

Acknowledgements - The IDEA project has been funded by the Spanish Ministry of Education and Science (Plan Nacional I+D+i 2000-2003, REN2002-04535-C02-02/MAR).

References

1 - Marshall,C.T., Needle,C.L., Yaragina,N.A., Ajiad,A.M. and Gusev,E. (2004) Deriving condition indices from standard fisheries databases and evaluating their sensitivity to variation in stored energy reserves. *Can. J. Fish. Aquat. Sci.* 61: 1900-1917.

2 - Duffy-Anderson,J.T., Bailey,K., Ciannelli,L., Cury,P., Belgrano,A. and Stenseth,N.C. (2005) Phase transitions in marine fish recruitment processes. *Ecol. Complex.* 2: 205-218.

3 - Guijarro, B., Hidalgo, M., Díaz, P., and Massutí, E. (2005). Stock assessment of hake (Merluccius merluccius) from the fishery off the geographical sub-area 05 (Balearic Island). working group on Assesment of Demersal Stock. Rome, Italy, pp. 16.

4 - Hsieh, C., Reiss, C. S. Hunter, J. R.., Beddington, J. R., May, R. M. and Sugihara, G. (2006). Fishing elevates variability in the abundance of exploited species. *Nature*, 443: 859-862.