Biological variability of the European Anchovy (*Engraulis encrasicolus*) year classes during 2000-2009 in the Bay of Biscay

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OBJECTIVE

The main objective of this study is to analyze the inter-annual variability of some biological traits of the Bay of Biscay anchovy between 2000 and 2009. We explore the changes in the mean length-at-age, sex-ratio indices, gonadal development in the spawning season and condition status of individual year classes of this species. Also, we investigate the potential density-dependent relationship between stock size and growth (in terms of length-at-age). Finally we discuss the variability of the growth in relationship with the environmental conditions.

MATERIAL & METHODS

Biological samples were collected from commercial landings, acoustic and trawl surveys in the Bay of Biscay between 2000-2010 (13,836 specimens were sampled), for the spawning period season . These are used to describe temporal trends and variation in the maturation pattern, sex-ratio indices, condition factor and growth.

Data analysis:
Sex-ratio: % of females per year class. **Maturity stages**: analysis of the monthly evolution of the percentages of active stages (III-IV-V stage) of combined sexes during 2000-2010 and analysis of percentages of mature (II to VI stage) and immature (I stage) individuals for each year class during the spawning season, following ICES (2008) scale. For the purpose of monthly evolution of active stage, only those based on a minimum of 30 individuals were considered. **Condition Factor**: (CF=Wt/L3* 100) as mean of the CF for all anchovies and for anchovies in active stages for each year class during spawning season. **Growth** was analyzed in terms of length-at-age by year class during the spawning season. The criterion used to age estimation was that agreed in the 2002 and 2009 anchovy ageing workshop (Uriarte et al. 2002; ICES, 2009). **Density-dependent growth**: the annual survey abundance indices by age class (ICES, 2010) were correlated with the mean lengths at age

Meteorological and hydrological data: Local environmental factors that may drive the spawning and recruitment of the anchovy are the water temperature and the turbulence in the water column. Data on Sea Surface Temperature representative for the area from the NOAA Optimum Interpolation SST (Reynolds et. al., 2002) and also the local wind from a meteorological station in Santander in the southern Bay of Biscay (43°30'N, 3°47'W), were analysed.
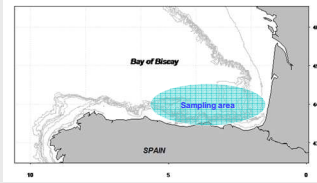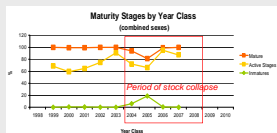
RESULTS & DISCUSSION

### BIOLOGICAL VARIABILITY

Sex-ratio
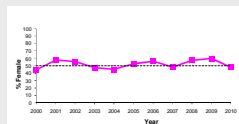
Similar interannual values in sex ratio close to 1:1, without no clear trend was found. Values between 44.3% (CV= 0.05) in female in 2000 and 59.5% (CV= 0.03) in 2009.

Maturity Stages

The proportion of mature fish **declined** from values of 100% in 2003 to minima of 80% in 2005. Concurrent with this shift was a change in the mean length-at-age by sampling year for ages 1 and 2. Both age groups depict a decrease in mean length to 2004 and 2005 year class (see growth fig.).

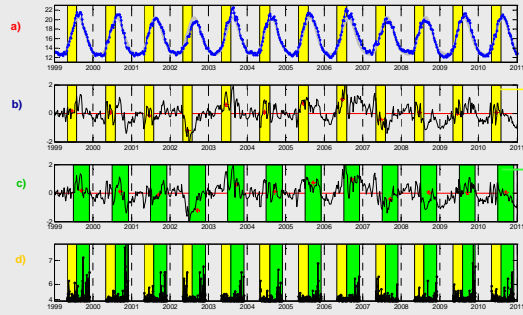#### Spawning Period
(Monthly % of active stages by year)
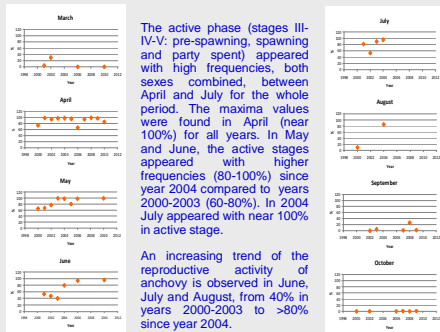
The active phase (stages III-IV-V: pre-spawning, spawning and party spent) appeared with high frequencies, both sexes combined, between April and July for the whole period. The maxima values were found in April (near 100%) for all years. In May and June, the active stages appeared with higher frequencies (80-100%) since year 2004 compared to years 2000-2003 (60-80%). In 2004 July appeared with near 100% in active stage.

An increasing trend of the reproductive activity of anchovy in June, July and August, from 40% in years 2000-2003 to >80% since year 2004.

Condition Factor (CF)

The mean CF were significantly **different** between year classes (P < 0.001), showing a maximum value in 2001 year class and minima values from 2004 to 2007 year classes. From 2004 to 2007 the CF were 10% lower than in 2001.

Growth
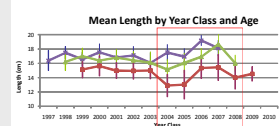
The mean length (ML) between year classes were significantly **different** (P < 0.001). ML at age decreased from 2003 to 2005. Anchovies originating from the 2004 and 2005 year classes were the smallest. The ML at age 3 from the 2006 and 2007 year classes were the biggest.

Density-dependent growth

No significant correlations between mean length (ML) of age and population abundance index at age from surveys were found.

These results do not support the hypothesis of density-dependent growth. Thus, the scarcely abundant cohorts of 2004 and 2005 showed very low ML at ages 1 and 2. The high abundant cohorts of 1998-2000 showed large ML at age.
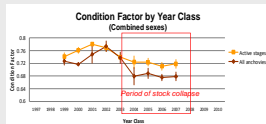
ENVIRONMENTAL FACTORS

Years of major failure of recruitment (2004 and 2005) and with the anchovy smallest length of these year classes, do neither present outstanding anomalies in the properties of the upper ocean during the relevant periods for anchovy. The only common feature is a short return to wintry conditions after a relative calm period, thus delaying the onset of the spring.
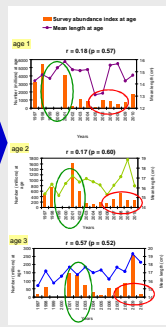
a) Weekly SST at the southern Bay of Biscay over imposed to the mean seasonal cycle (1981-2010 gray) from 1990. Yellow shadowed is the April-June period (spawning peak of anchovy) and green shadowed is June-October (first season of growth and recruitment). **b)** Anomaly of SST in the spawning period. **c)** Anomaly of in the recruitment period. **d)** Local turbulence induced by wind (as wind speed cubed, labeled as Beaufort scale).

CONCLUSIONS

These results seem to point to a change in the biological parameters during the decline of the Bay of Biscay anchovy population:

• The **abundances** decrease from 2001 to 2007 year classes (ICES, 2010). The scarcely abundant 2004 and 2005 cohorts is that showed ones of the lowest mean lengths at ages 1 & 2. The 2006 & 2007 year classes showed the largest mean length at age 3.

• The proportion of **mature and active stage** was lowest in the years 2004 and 2005, coinciding with the lowest abundance and with the minimum length of these year classes.

• The **condition factor** was most lower since the decline of the anchovy population (year classes 2004 to 2007).

• It is observed an increasing trend of the **reproductive activity** of anchovy in June, July and August, since 2004 compared to 2001 & 2002 where this activity was concentrated in April.

• No evidence of **density-dependent growth** was found.

•The decline in growth seems to be related neither with **temperature** nor with **endogenous factors** (i.e. individual age). Hence, for anchovies originating from the 2004 & 2005 year classes it could by hypothesized that a later-born and/or food limited could be factors driving the observed low growth rates.

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ICES, 2008. Report of the Workshop on Small Pelagics (*Sardina pilchardus, Engraulis encrasicolus*) maturity stages (WKSPMAT). ICES CM 2008/ACOM-40; **ICES, 2009**. Report of the Working Group on Age reading of European anchovy (WKARA). ICES CM 2009/ACOM:43; **ICES, 2010**. Report of the Working Group on Anchovy and Sardine (WGANSA). ICES CM 2010-ACOM:16; **Reynolds, R. W. , N. A. Rayner, T. M. Smith, D. C. Stokes, and W. Q. Wang. 2002.** An improved in situ and satellite SST analysis for climate. J.Clim. 15 (13), 1609-1625; 2002; **Uriarte, A., M. Blanco, O.Cendrero, P. Grellier, M. Millán, A. Morais, I. Rico. 2002**. Report of the Workshop on anchovy otoliths from subarea VIII and division IXa. Annex to PELASSES report EU study Project -EC DG XIV Contract nº99/010 and Working Document to the ICES Working Group on the assessment of Mackerel, Horse Mackerel, Sardine and Anchovy. Copenhagen, 10-19 September 2002.