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Impact of phytoplankton phenology on anchovy recruitment in the Bay of Biscay

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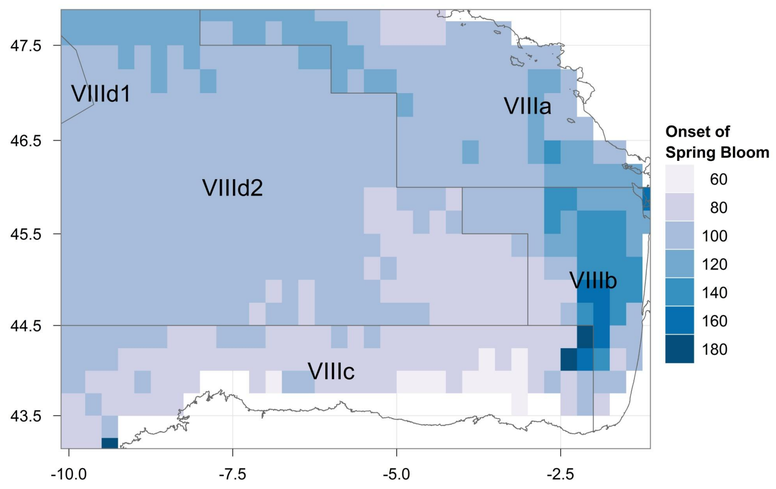
Anchovy fisheries experience great fluctuations in catches which seriously compromise their long term sustainability. The short life cycle of anchovy and external environmental factors, including human induced climate change, are usually invoked to explain the irregular dynamics observed in these species. In the Bay of Biscay, the spawning stock biomass of European anchovy (*Engraulis encrasicolus* L.) has remained at low levels during the last decade, resulting in a fisheries collapse which triggered a closure between 2005 and 2009.

Here, we take advantage of the availability of high quality data on both anchovy recruitment dynamics from stock assessment and long term, remotely sensed phytoplankton dynamics to analyze the impact of changes in phytoplankton phenology on the success of anchovy recruitment in the Bay of Biscay.

Data sources

Estimates of anchovy Recruitment (R) and Spawning Stock Biomass (SSB) were obtained from the two-stage biomass dynamic model employed by ICES (2010) to assess the status of the fishery. Median values were used to estimate a normalized index of larval survival as the ratio between recruitment and previous year standing stock biomass: R_t / SSB_{t-1}, following Platt et al. (2003).

We used SeaWiFS (Sept. 1997 - Dec. 2007) and Aqua MODIS (Jul. 2002 - Jun. 2010) data retrieved from the Ocean Color Web (Feldman and McClain, 2011) to study recent changes in the timing of seasonal peaks of biomass accumulation in the Bay of Biscay. We smoothed daily chlorophyll *a* time series and classified different seasonal peaks in spring and autumn/winter blooms attending to concurrent AVHRR sea surface temperature (Reynolds et al. 2007). Deviations from the mean timing of the spring bloom were retained for comparison with the index of larval survival.



The onset of the spring phytoplankton bloom shows a latitudinal gradient, occurring earlier in the southern Bay of Biscay. The special conditions in the inner part of the Bay alter this gradient locally, delaying the onset of the bloom. The map also shows ICES standard areas, which were employed as working units to group bloom dates.

Despite the short term nature of the data series studied, we found a spatially consistent relationship between anchovy recruitment and phytoplankton phenology along the Bay of Biscay continental shelf. The strength of the relationship is comparable, at least qualitatively, to those found with other environmental factors which are commonly suggested to play a role in anchovy dynamics.

In principle, these results suggest a potential role for Hjort-Cushing's match-mismatch hypothesis in regulating anchovy fisheries. Different mechanisms can explain the relationship found; including an indirect effect of earlier blooms in increasing earlier survival by increasing food availability, or just an association to earlier stratification which is known to trigger anchovy spawning.

Nevertheless, no clear mechanisms can be inferred from the data analyzed, although the promising relationship found, which might provide a guess of recruitment one year in advance, deserves further investigation.

References

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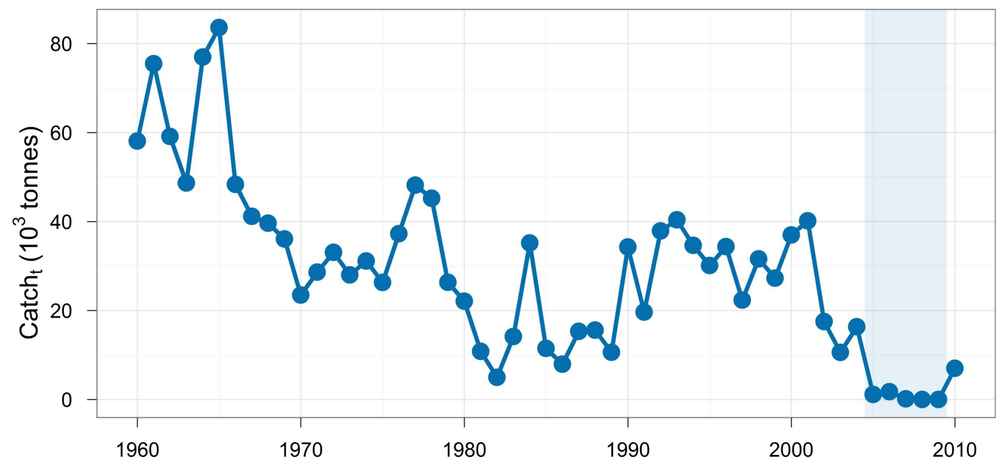
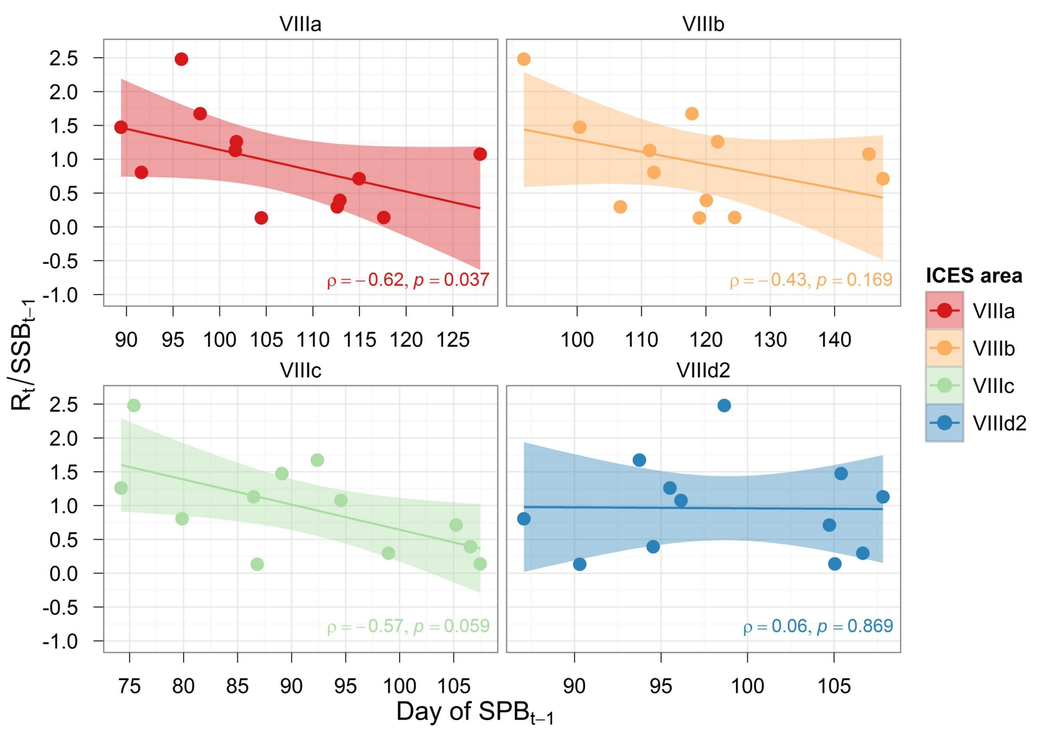
Reynolds, R.W. , T.M. Smith, C. Liu, D.B. Chelton, K.S. Casey, and M.G. Schlax. 2007. Daily high-resolution-blended analyses for sea surface temperature. *Journal of Climate* 20: 5473–5496.

Long-term trend of anchovy catches in the Bay of Biscay



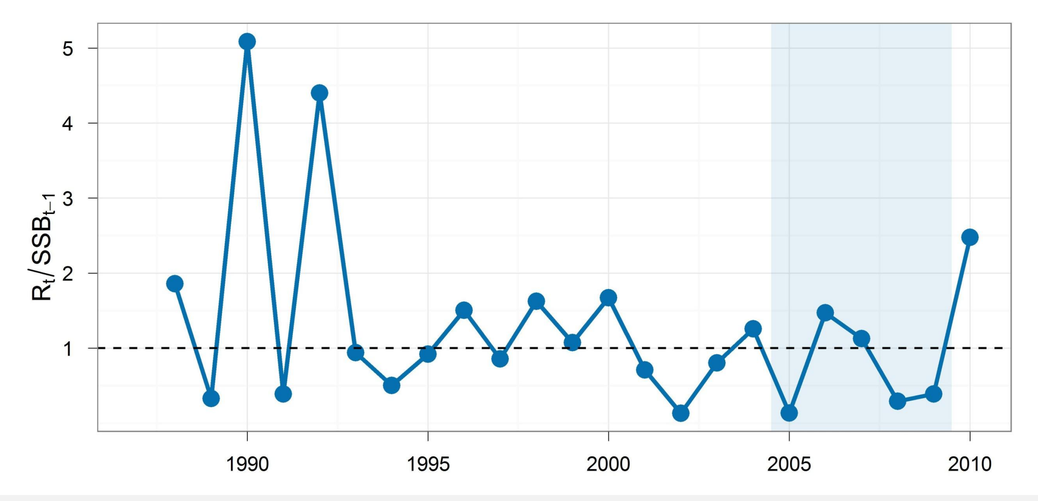
Anchovy catches in the Bay of Biscay between 1960 and 2010. Small scale Spanish and French purse seine fleets are responsible of most catches, which have declined since the mid 60's. There was a period of extraordinarily low catches in the mid 80's and a collapse during the last decade which ended with fisheries closure in July 2005. The fishery was reopened in 2010 but a low fishing quota was established.

Relationship between phytoplankton phenology and anchovy recruitment



The date of the spring phytoplankton bloom, as derived from ocean color remote sensing data, showed a negative relationship with European anchovy larval survival in the Bay of Biscay. The pattern was spatially consistent among the three ICES standard areas located in the continental shelf, but vanished in the pelagic domain. Each graph *above* includes, just for orientation, a linear relationship (with 95% confidence intervals), and Spearman rank correlation coefficients. Nevertheless, the short time span considered makes mandatory to remain cautious about statistical significance issues. The graph *bellow* presents the time evolution of the recruitment index between 1987 and 2010, highlighting the recruitment failure occurred during the last decade.

Changes in anchovy recruitment as reflected by the larval survival index



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