



Temporal variability of the spawning season for the southern component of the Northeast Atlantic Mackerel (*Scomber scombrus*) (1990-2010)

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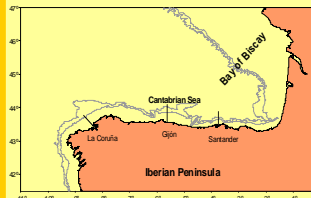
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INTRODUCTION

Southern component of the Northeast Atlantic mackerel population migrates towards the southern spawning area (Cantabrian Sea) at the end of winter. An analysis of the fishery indicates a forward shift in the timing of the migration since 2000 (Punzón and Villamor, 2009). Such a shift causes that spawning in the Southern component has occurred earlier in the last decade compared to the previous. Other variables as changes in spawning peaks may be also associated to these changes in the migratory pattern. This work analyses the spawning seasonality of mackerel and its inter-annual variations in the period 1990-2010, studying reproductive characteristics. The impact of environmental conditions on these changes are also investigated.

MATERIAL & METHODS

Spawning seasonality was determined from the analysis of the monthly evolution of the percentages of mature individuals (active stages of female fish ≥ 30 cm length), mean gonadosomatic index [GSI somatic = Gonad weight x 100 / (Total weight-gonad weight)] and monthly eggs abundance in North Spanish coast (Cantabrian Sea, VILLIC ICES Division) along several years (1990-2010), to compare the changes in the spawning peaks between the two last decades.



Biological samples from mackerel commercial landings and acoustic, eggs and trawl surveys, have been regularly collected from the area since 1990s (a total 13,728 specimens were sampled), and are used to describe temporal trends and variation in the maturation pattern of the southern mackerel component, following Walsh et al. (1990) scale. For the purpose of monthly evolution of active stage, only those based on a minimum of 30 individuals were considered.

Southern mackerel **histological samples** for fecundity estimation are traditionally collected in February-May during triennial Annual Egg Production Method (AEPM) surveys. Fecundity has to be estimated in the previous period to the spawning. Hyaline eggs are the principal spawning marker, and its presence is recorded

Eggs sampling: Since 1990s, eggs have been sampled monthly from two cross-shelf transects in the Cantabrian Sea (off Coruña and Santander Spanish ports) in order to study temporal variations for fish egg abundances. By other hand, mackerel Daily egg production in the Southern area has been estimated from Triennial Mackerel eggs surveys applying the Annual Egg Production Method since 1995.

Meteorological and hydrological data: as a major environmental factor that may drive the behavior of the mackerel is the water temperature (in particular the start of the spring warming), there are explored the Sea Surface Temperature representative for the area from the NOAA Optimum Interpolation SST (Reynolds et al., 2002) and also the heat content from a fixed hydrographical northwards from Santander in the southern Bay of Biscay (43°42'N, 3°47'W).

RESULTS & DISCUSSION

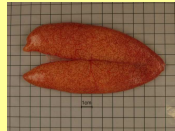
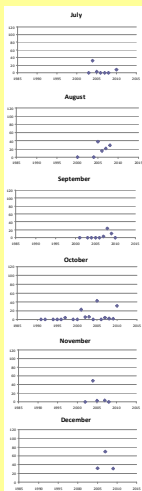
SPAWNING PERIOD 1990-2010

Mackerel ovary development. Macroscopic observations

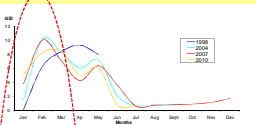
The active phase, i. e., pre-spawning, spawning and partly spent (III-IV-V stages in Walsh scale), appeared with higher frequencies between January and June for the whole period. The reproductive activity decreased drastically in the second part of the year.

In the 1990's and beginning of 2000's, maximum values were found in February to May (>90%). However, at the end of the last decade (2005 to 2010) the highest values (almost 100%) were observed earlier on the year, from January to March.

Mackerel reproductive activity in January increases from a 40% in 2000 to a 100% in 2010. However the opposite is observed in June. A decreasing trend in the activity was observed in April and May during the 2000s.

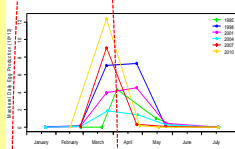


Mean Gonadosomatic Index (Females)



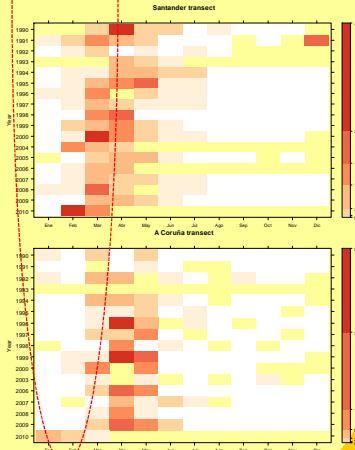
There was a shift in GSI maximum values. While in 1995 maximum values of GSI were reached in April, during the last decade (2004, 2007 and 2010) this GSI maximum values shifted to February-March

Daily Egg Production



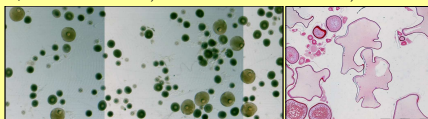
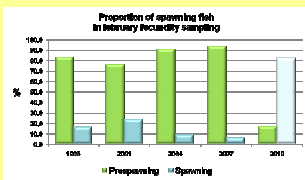
In the period 1995-2004 daily egg production has mainly been restricted in March and April, peaking in April, from 1995 to 2004. However, in 2007 and 2010, the highest mackerel daily production was moved to March with little production in the months after

Monthly egg abundance



Mackerel ovary development. Histological observations

During the Triennial AEPM surveys in Southern mackerel has been traditionally sampled for fecundity in February. But it has been difficult to find enough samples for fecundity estimation in 2010 because spawning markers (hyaline eggs) were present in more than the 80 percent of samples.



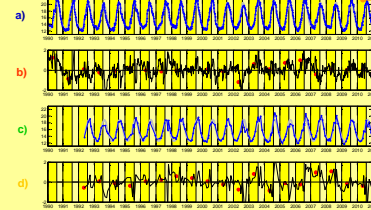
Hyaline eggs in whole mount (a) and histology (b)

In Santander transect showed a higher mackerel egg monthly densities mainly in March - April in the 90's decade, but in the late 2000's higher densities were mostly in February - March.

In A Coruña transect no showed a clear pattern along time series, although in 2010, there was a maximum abundance in January-February.

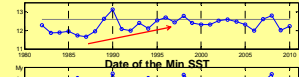
ENVIRONMENTAL FACTORS

Seasonal changes in SST



Higher temperatures in winter-spring are noted in the 00's respect to the 90's. Some years in the 00's show an advancement of the spring.

Min SST reached during winter



Defining the onset of the spring is a more subtle task that depends on the shape of the warming period. The minimum SST (minSST) achieved in winter time defines the properties of the mixed layer that will be under the seasonal thermocline year-round. The minSST increased from the mid 80's to the mid 90's about half a degree and then remained quite stable (despite some anomalies). The date at which the minSST is achieved is a proxy for the onset of the spring and it varies widely from early February to early April but, interestingly, there is a period of early onsets of spring from 2001 to 2006 that broke in 2007 and 2008, years with an extremely warm winter.

All in all it can be said that during the 00's the winter tended to be warmer and the spring tended to start earlier.

CONCLUSIONS

These results seem to point to a change in the pattern of mackerel spawning migration to the Southern Area:

- Mackerel have been started its reproductive activity one month earlier in the southern area since 2000.
- Santander transects showed a maximum egg abundance peak in March-May in the 90's, while in the 2000's the peak tend to be earlier (February-March). This tendency has not been observed in a Coruña transect (except in 2010), probably due to the east-west mackerel migration in the Cantabrian Sea (Villamor et al., 1997; Punzón et al., 2004).
- Egg surveys recording show that highest densities of eggs were gradually appeared earlier, from April (1995) to March-April (1998-2004) and finally they have been recorded in March (2007-2010).
- Egg abundance has very probably been underestimated since 2007, as Egg surveys didn't sampling the Cantabrian Sea in February.
- During the 00's, Mackerel has coming earlier to the Southern spawning area and it can also be seen that mackerel ovaries are developing earlier in the year, and these facts are very likely related to an advancement of spring in this decade.
- The advancement of the mackerel spawning migration to the Southern area has been confirmed (Punzón and Villamor, 2009).
- Having into account previous conclusions, changes have to be done in the design of the egg surveys to adjust sampling period to these advancement of the spawning activity of mackerel in the southern area. These changes will avoid the underestimation of SSB, improving mackerel resources management.

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