1.- Motivation

• Red shrimp (Aristeus antennatus) fished around Mallorca (Balearic Islands) is mainly caught in two different fishing grounds: Siller (north) and Cabrera (south).
• During winter, the boats from Palma harbour fish in Cabrera and the boats from Siller harbour in Siller.
• During summer, the boats from both harbours fish in Siller.
• Why the fishing fleet from Palma harbour migrates every summer from Cabrera to Siller fishing ground?

2.- Available Data

Red shrimp CPUE data:
• Daily times series of the landings from the bottom trawl obtained from the official sales bills between 2000 and 2010 (both years included).
• No data from Cabrera is available from summer time.
• The red shrimp landings were transformed into monthly averaged CPUE time series, having only into account the adult individuals (carapace length ≥ 35mm), main target of the fishing fleet.

Satellite Images:
• We have estimated the relative vorticity from the daily Sea Surface Height (SSH) satellite images (http://www.avos.arms.coastspace.com) as:

\[ \zeta = \frac{\Delta u}{\Delta y} \]

(1)

After computing the daily vorticity fields, we took the absolute value and computed the spatial average in the dashed rectangle represented in the figure from the right. Finally, the vorticity time series were monthly averaged.

Mooring data:
• A mooring was installed near each fishing ground. We have only used data from the mooring of the zone star in the figure.
• The mooring, placed around 900m depth, had:
  - 4 CTDs (SeaBird 683, 500, 700 and 900m, dt = 10 minutes).
  - 2 current meters Nortek Aquadopp (500 and 900m, dt = 30 minutes).
  - 1 sediment trap (30 meters above the bottom, dt = 30 days).

3.- Results

Correlations Vorticity Vs A. antennatus CPUE and suggested mechanism.

• An increase in vorticity generally causes a decrease in the CPUEs, although a decrease in vorticity does not cause an increase in CPUEs (negative correlation).

Explanation of the suggested mechanism.
• An increase in the absolute value of the surface vorticity is commonly caused by an eddy.
• During 2010, at least three eddies produced some footprint in the instruments deployed in the mooring line.

The two panels from above from the figure from right is a 240-low-pass filtered speed series of 500 and 900 m in depth for the whole recorded period. The two panels from above are the corresponding progressive vector diagrams. Different colors coincide temporally with the speed time series. Enclosed areas represent moments when an eddy is present in the zone.
• The eddy number 3 was clearly reflected in the currents registered at 500 and 900 m depth by:
  - A significant vorticity increase at both depths (spikes of 25 cm/s at 900 m depth).
  - Change of the current direction: clockwise at 500 m and a down-slope gyre at 900 m.
• This eddy reached the bottom, and the recorded gyres and vorticity increases could easily have caused the material reappearance, hypothesis supported by time index measurements.

The increase in the total flux mass (TPM) the increase of the acoustic backscattering due recorded by the moored sediment trap at the ing the episode coinciding with the speed vorticity time of the eddy.
• The correlation has increased up to 0.48.
• The vorticity and the adult CPUEs from the fishing ground of Cabrera to Siller fishing ground are positively correlated.

4.- Conclusion

A reasonable grid negative correlation was found between the monthly CPUE of the adult A. antennatus and the mean-surface vorticity.

Suggested mechanism:
• Eddies causing the vorticity events may reach the bottom, increasing the velocities.
• This effect would trigger the sediment resuspension and increase the bottom water turbidity.
• Such a change in the water conditions would force adult A. antennatus to move away from the fishing ground, probably downwards, to greater depths.

The correlation found with other demersal species are consistent with the proposed mechanism:
• The desopod crustacean C. longispina, the crested serpent- eel and the benthic species showed a significant positive correlation. These two species are closely connected to the bottom, as reflected by their feeding behavior and biological characteristics.
• C. longispina, with more mobility, feeds on the mesopelagic prey with the occurred occurrence of the bottom feeding activity and swimming in the adult phase.
• M. poutassou, P. biaculeatus, the two benthic-pelagic talgois with greater capacity of movement of the bottom, are expected to be less affected by bottom water turbidity.

The answer to the motivation question why the fishing fleet from Palma harbour migrates every summer from Cabrera to Siller fishing ground? is perhaps obvious:
• They follow the highest abundance of large red shrimp females in Siller.
• According to previous works, the juvenile episodes are much more intense off north- ern Mallorca during the winter time (October to March) than in summer.
• So, the absence of large adult aggregations in Siller during the rest of the year (out of summer), probably related to the particular dynamics of the species could be re- flected in a decrease in the availability of the red shrimp in fishing exploitation during these months when eddy episodes are more frequent in this area.

5.- Future Work

As a future work, we will be able to estimate the time evolution of the vorticity in the Balearic Sea, throughout climatic models, we would be able to investigate how this changes could affect to the red-shrimp CPUEs.

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Influence of the hydrodynamic conditions on the accessibility of Aristeus antennatus and other demersal species to the deep water trawl fishery off the Balearic Islands (western Mediterranean)

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Winter 0.2

Summer 0.3

Spring 0.4

autumn

|Vorticity| (x10−5 s−1)

−10 −8 −6 −4 −2 0 2 4 6 8 10

−0.6

−0.4

−0.2

0

0.2

0.4

0.6

Lag (months)

Correlation coefficientb