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Physical oceanography conditions in the Gulf of Cádiz during ECOCADIZ - BOCADEVA 201407 cruises

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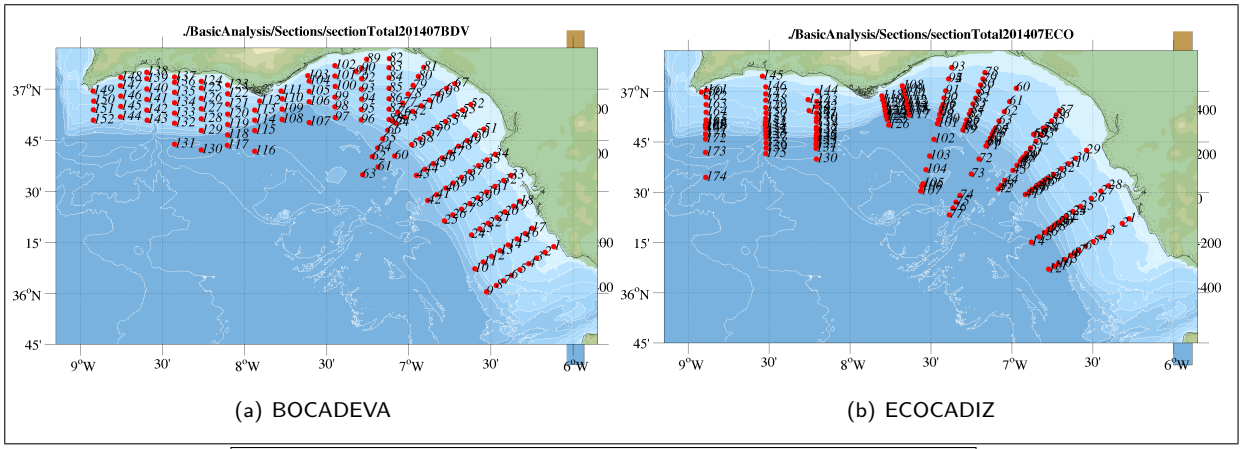
1 Setting

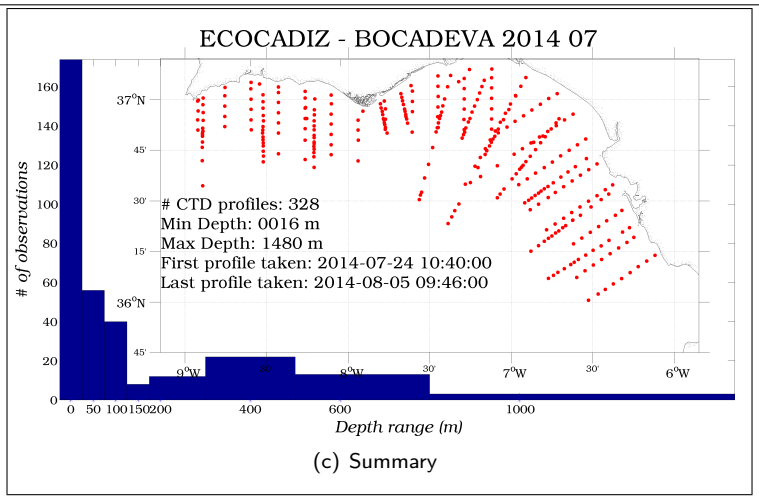
The contermporary and complementary ECOCADIZ 201407 and BOCADEVA 0714 cruises were conducten between July-August 2014. ECOCADIZ 201407 cruise was carried out onboard R/V Miguel Oliver between 24 July 2014 18:38 GMT and 5 August 2014 09:31 GMT whereas BOCADEVA0714 cruise was carried out onboard R/V Ramón Margalef between 24 July 2014 10:46 GMT and 30 July 2014 02:28 GMT. (Time stamps indicate deployments of the first and last CTD casts of each cruise.) Hydrographic sampling consisted of a particular observational grid of CTD profiles and ADCP transects.

For both R/V's the sampling design was build upon the realization of across-bathymetry hydrographic transects from the eastern part of the study area (close to the Strait of Gibraltar) westwards towards Cape St Vicente. Trabsects were separated less than 8 miles while maximum station distance was kept at less than 3 miles, at least over th continental shelf. Yet, due to unsteady wind conditions, this observational strategy avoided a fully-synoptic description of the oceanographic conditions.

A total of 328 full-depth CTD profiles were acquired from 10:40 UTC 24 July and 09:46 UTC 5 August 2014, 176 (including LADCP profiles) during ECOCADIZ and 152 during BOCADEVA. Depth range was 16-1480 m. The continental shelf was densely sampled with most of observations taken over grounds shallower than 200 m. During ECOCADIZ we used a SBE911+ system including dissolved oxygen, transmisivity, fluorescence and turbidity sensors attached to a Lowered-ADCP. In BOCADEVA we rather used a SBE25+ including dissolved oxygen, fluorescence and turbidity sensors. In both cases temperature, salinity and fluorescence were recorded underway, as well as current velocities velocities with a T-RDI 150 kHz OS ADCP. This document describes the data and characterizes oceanographic conditions at the time of the cruises based on these *in situ* and other remotely sensed data.



(a) BOCADEVA (b) ECOCADIZ



(c) Summary

Figure 1: CTD grid.

2 Ocean Wind

The wind time series at the RAYO ocean buoy (Puertos del Estado, fig. 2) illustrates how the cruise took place under a generally upwelling-favorable wind regime, onset from the beginning of July. Upwelling-favorable winds relaxed towards the 3rd week of july to increase again until the first week of August. During the first days of the cruise timespan winds were relatively weak, with peak velocities not exceeding 5 m/s. Starting in July 27 a vigorous westward wind burst occurred for three days, hence locally boosting coastal upwelling. After a brief calm perid, sustained northwesterlies peaked towards the last days of the cruise.

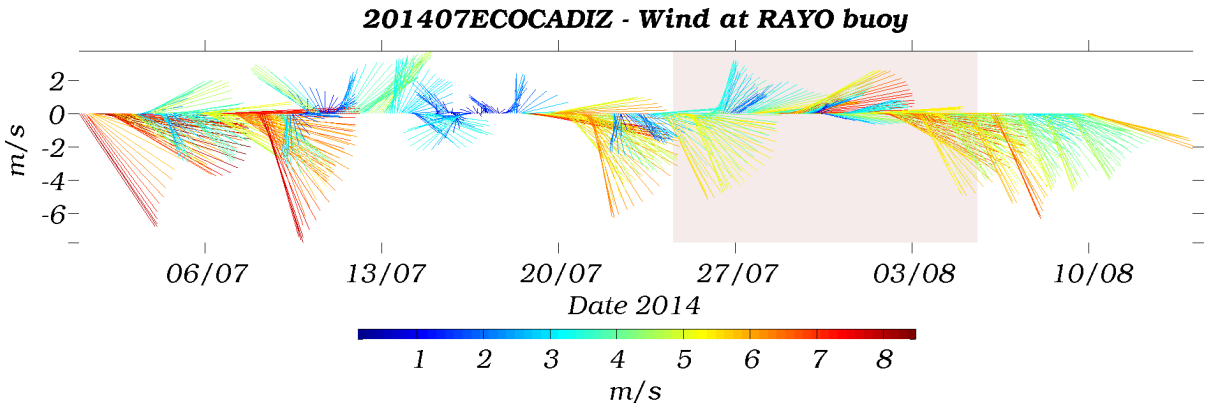
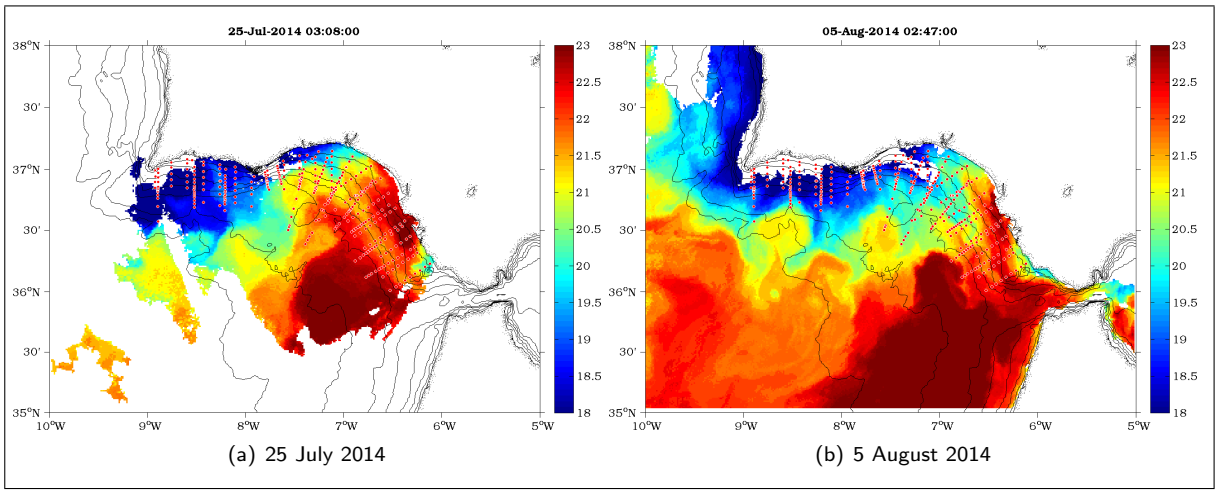


Figure 2: Subtinertial wind stick series at RAYO ocean Buoy (Deep-water Network, Puertos del Estado). Sticks align windward (oceanographic convention). A pink shade indicate the cruise period. Abscissa stand represent date 2014, ordinate wind speed (m/s). Positive to the north.

3 Satellite Ocean Sea Surface Temperature and Chl-a

The satellite SST/Chl-a images showed the wind effect on the surface distribution of water masses. During the first half of the cruise upwelling was strong particularly west of Cape St. Maria in the Portuguese EEZ. Cold water (¿ 21 °C) filaments were seen to stretch from this cape towards the Strait of Gibraltar. An inner component extends inshore past the mouth of Tinto-Odiel river. An offshore one is seen to spread between the 100-200 isobaths. The eastern Gulf of Cadiz was occuppied by warmer (¿ 23 °C) waters not only offshore but also inshore the 100 m isobath. This latter warm water pool was constrained by the upwelled filaments and the cold spot observed over the Trafalgar banks. The offshore warm pool seems to have an origin in southern latitudes.

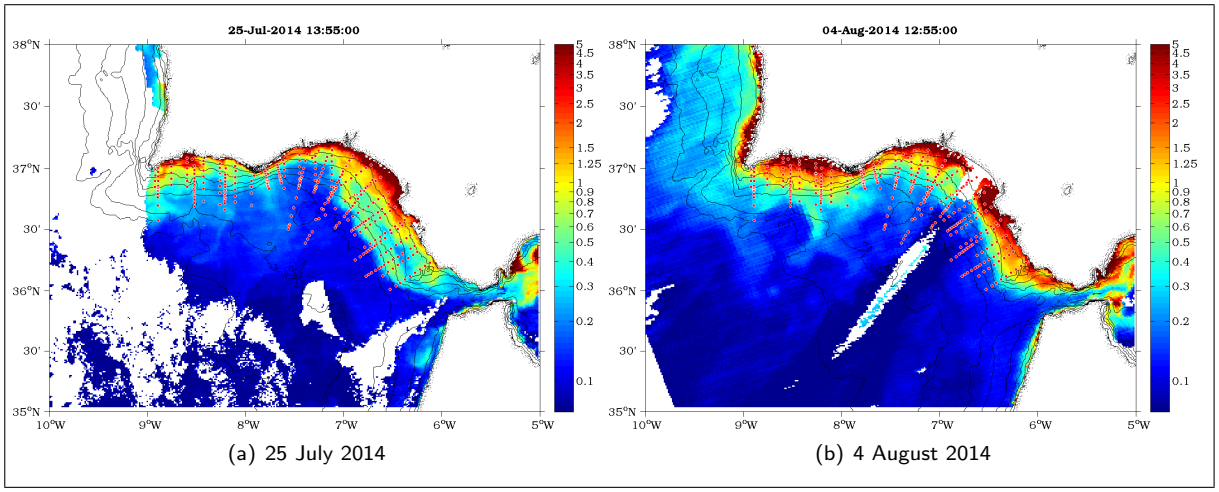


(a) 25 July 2014

(b) 5 August 2014

Figure 3: AVHRR Sea Surface Temperature (SST) images. Station grid and 20, 50, 100, 200, 500, 1000 m isobaths are also annotated.

Towards the end of the cruise the intensification of upwelling-favorable winds caused boosting and expansion of the coastal upwelling, particularly east of 7°W. A number of intensified upwelling filaments rooted west of Cape St. Maria stretched towards the Strait of Gibraltar. This caused the southward retreat of the offshore warm water pool, which was particularly evident SW of the cape.

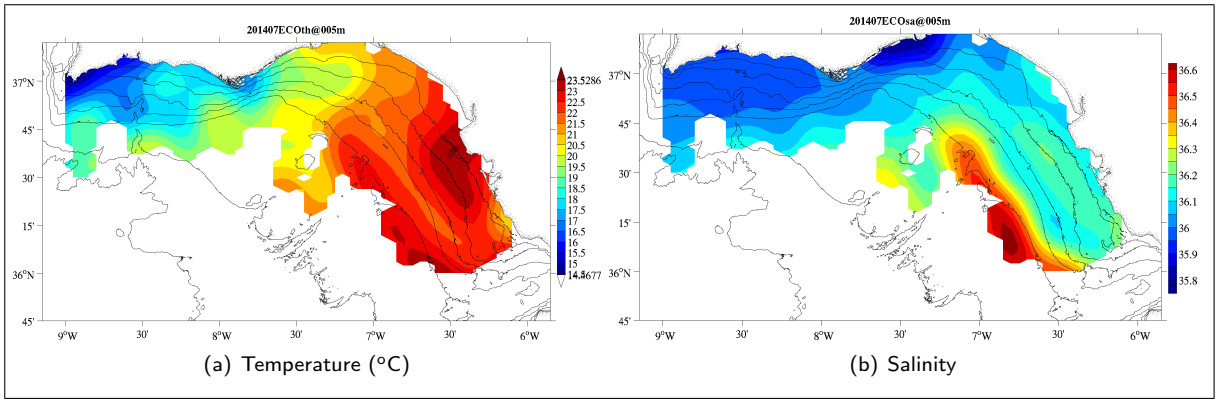


(a) 25 July 2014 (b) 4 August 2014

Figure 4: MODIS AQUA Sea Surface Chl-*a* concentration (mg m^3). Station grid and 20, 50, 100, 200, 500, 1000 m isobaths are also annotated.

4 In situ CTD data

The temperature distribution at 5 m from CTD observations accurately mimicks the satellite SST (fig. 5). This map shows that during the cruise the oceanographic conditions in the northern Gulf of Cadiz were dissimilar at both sides of Cape St. Maria. The 20.5 °C isotherm approximately run along the front separating freshly upwelled waters to the west and warmer pools to the east. However, as suggested by satellite imagery, a number of mesoscale filaments running parallel to the bathymetry seemed to disrupt the pattern. An inshore band extended past the Tinto-Odiel mouths approaching the Guadalquivir estuary. Another filament with near-surface temperatures below 21 °C was seen entering the Strait of Gibraltar between the 100-200 m isobats. In addition, an offshore projection of the cold coastal band occurred at about 7.5 °W.

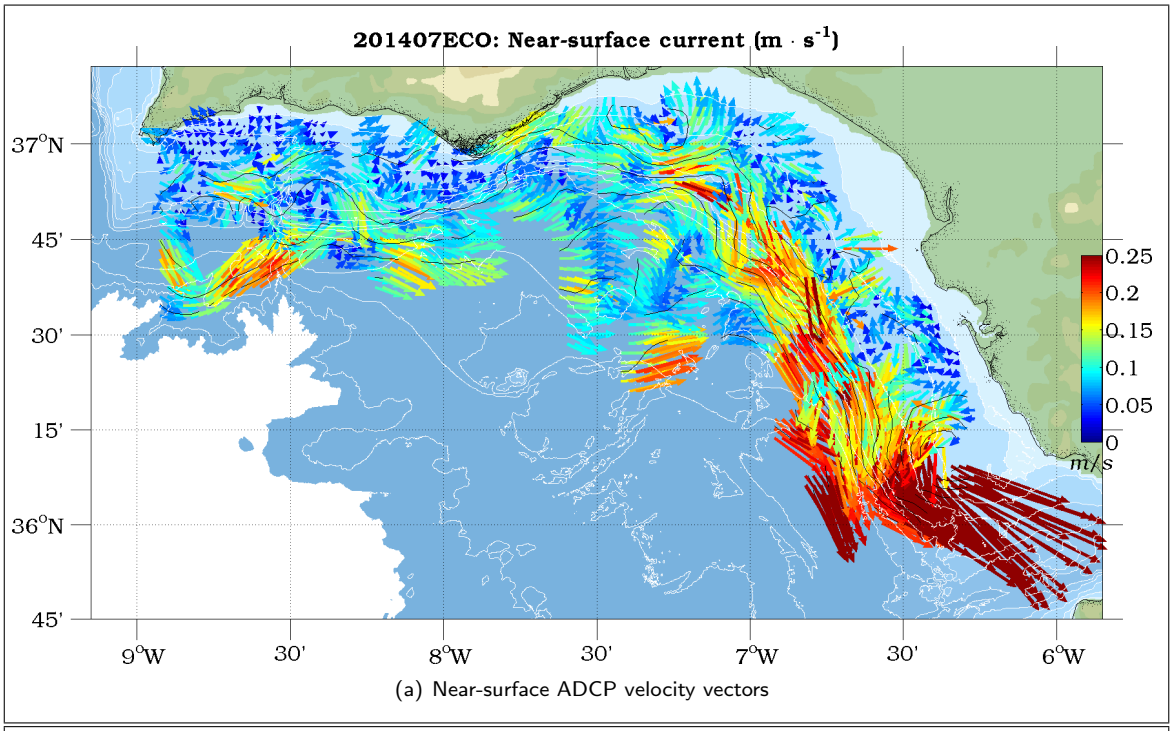


(a) Temperature (°C) (b) Salinity

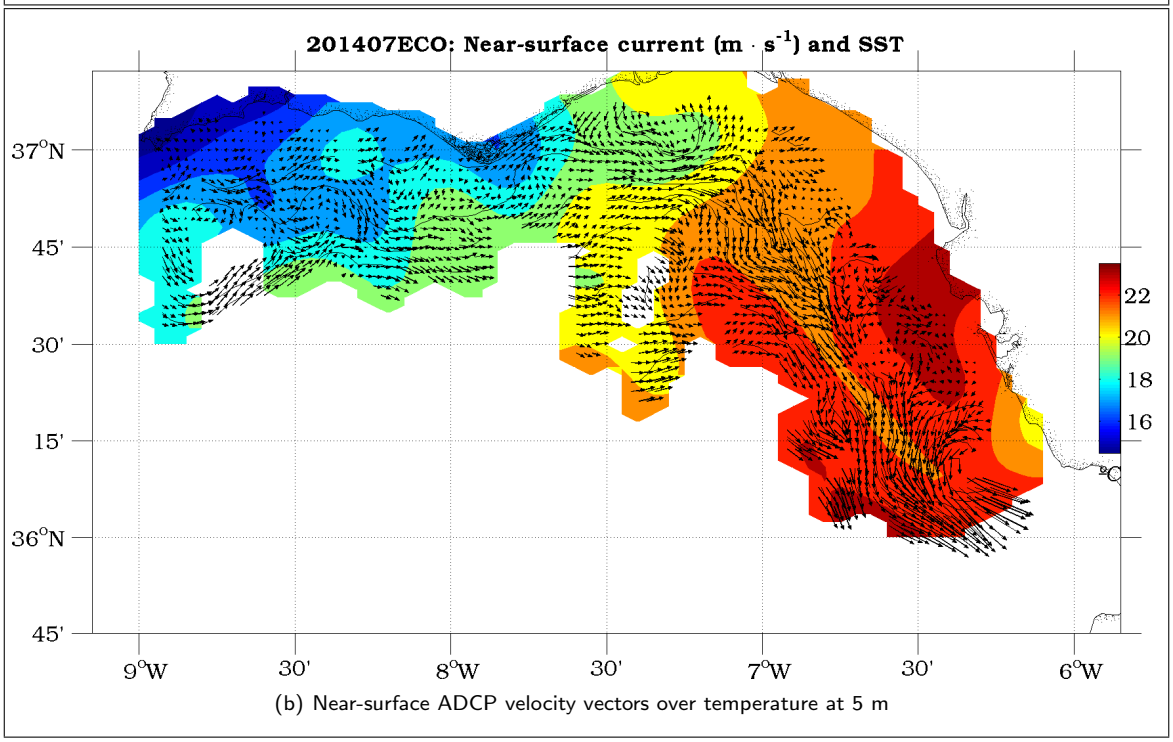
Figure 5: *In situ* horizontal fields at 5 m.

5 In situ ADCP data

The surface current pattern showed resemblance with the SST distribution. The disrupting effect of the Strait of Gibraltar was noted as velocity vectors aligned parallel to the bathymetry and exibited vigorous accelerations to attain values greater than 0.6 m/s towards the Mediterranean Basin to form the Atlantic Surface Jet. This component was formed both by relatively cold waters drained along the 100-200 m isobaths, and warmer offshore waters conveyed into the Strait to feed the Atlantic Jet.



(a) Near-surface ADCP velocity vectors



(b) Near-surface ADCP velocity vectors over temperature at 5 m

Figure 6: *In situ* Near-surface ADCP currents

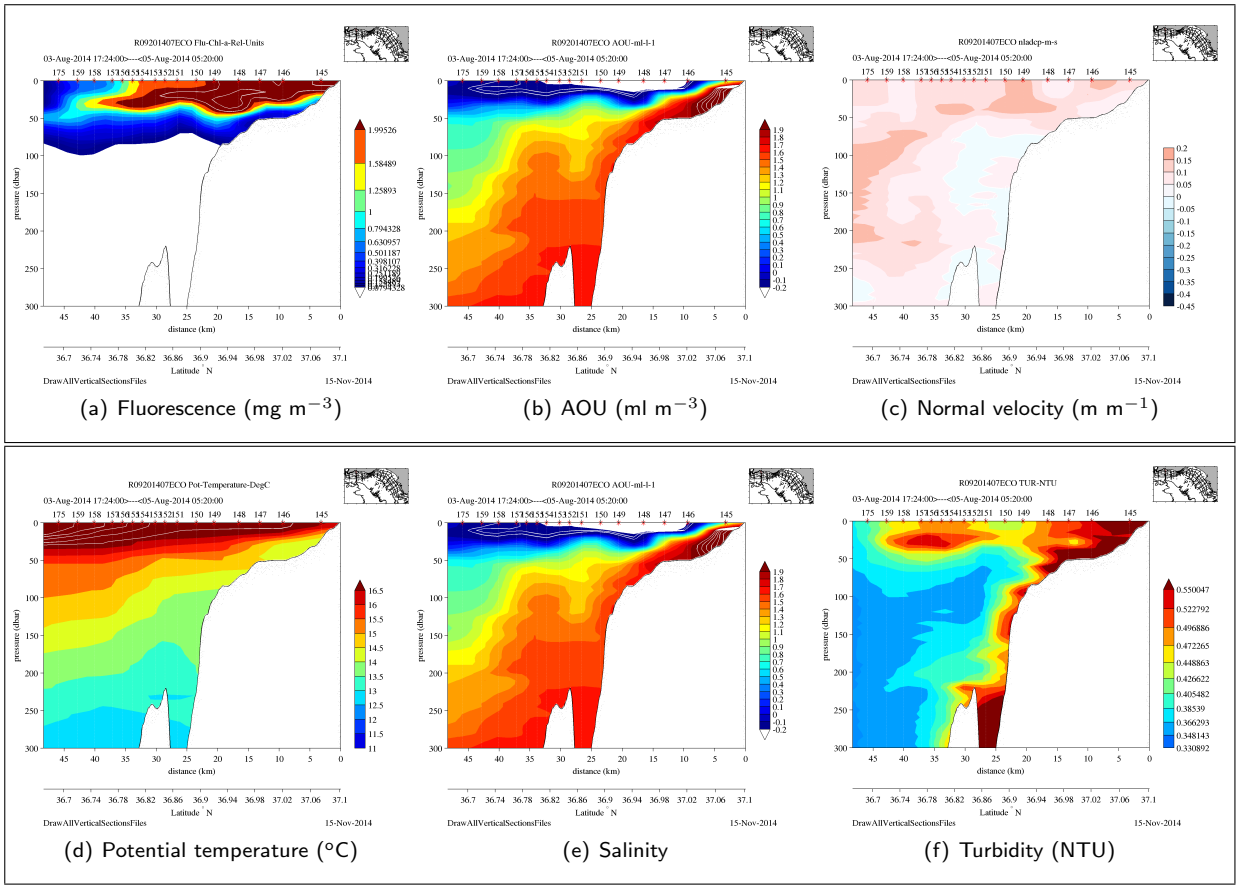
The Cape St. Maria upwelling filament was noted as near-surface velocities formed a coherent jet from the cape to the Strait of Gibraltar. Inshore, rather sluggish velocities were ubiquous, what suggests the retentive character of the inner shelf east of the cape.

Due to the strong intensity of the coastal upwelling and the relatively offshore location of the upwelling fornt, no coherent jet was observed in our data to the west of the cape. However, parts of this eastward circulation is inferred as some transects extended far beyond the continental shelf, such as for instance south of Cape St. Vicente. This jet advances towards the Strait of Gibraltar and it is hypothesized that part of the inflow in the Strait of Gibraltar must be partly composed of this water coming from the Portuguese upwelling.

Whereas the eastern shelf was split in two by the Cape St. Maria filament, the western shelf seemed relatively homogeneous. Smaller scale meanders did not split the upwelling zone west of Cape St. Maria. In both cases the circulation in the inshore part of the continental shelf was relatively tranquil, exhibing recirculatory patterns what led to favourable conditions for plankton retention.

6 Vertical cross sections

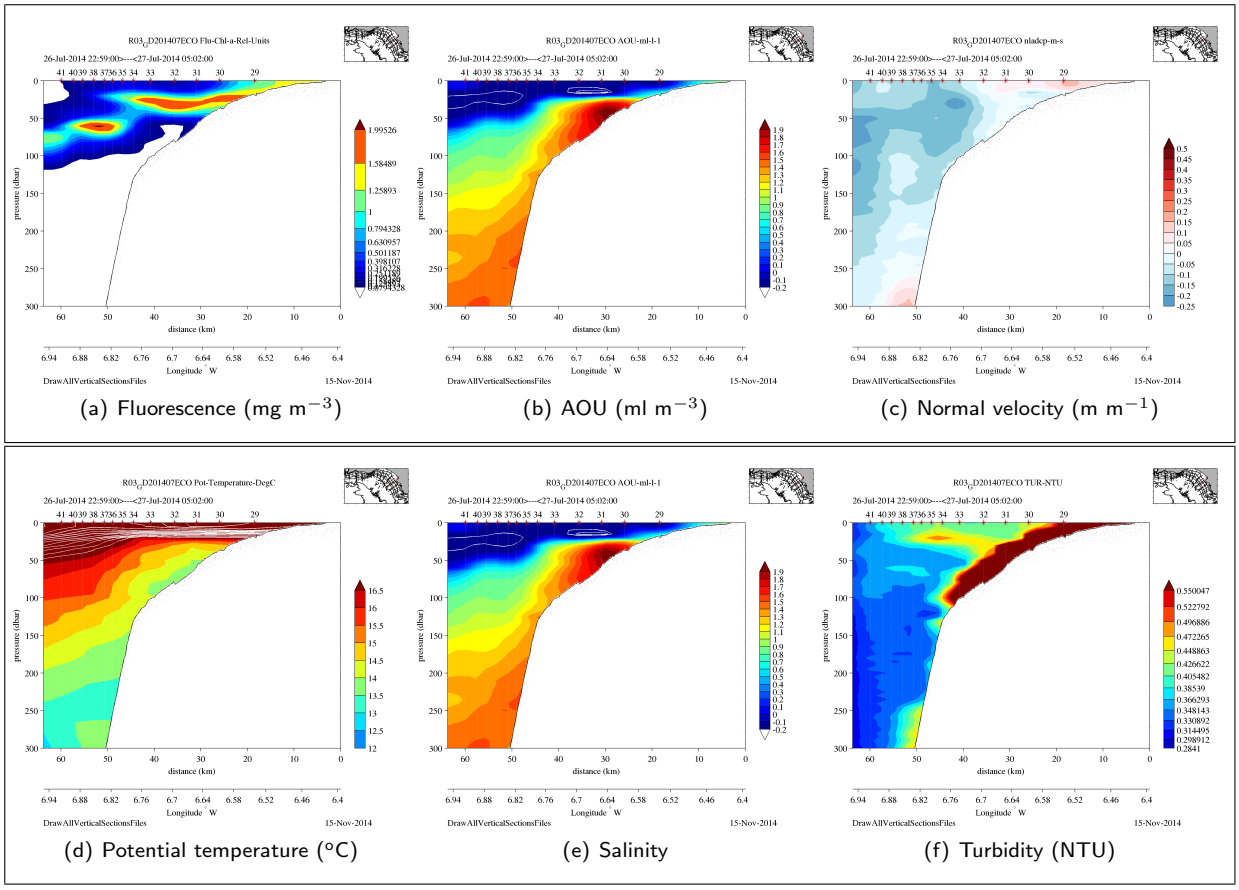
This picture can be observed along two sections conducted across each of the zones: one off the Guadalquivir river mouth (characteristic of the eastern shelf) and another off Portimao (characteristic of the western shelf). The chl-a fluorescence shows that the western shelf was actively being upwelled at the time of the cruise, as no DFM (deep fluorescence maxima) were noted. On the other hand, in the eastern part two different DFM were observed. A relatively weaker, inshore one was physically connected with the coast and shared features compatible with typical DFM of temperate oceans. A stronger, deeper offshore DFM was laid along the upwelling jet that conveyed the Cape St Maria upwelling, what suggest the connection with the Portuguese upwelling.



(a) Fluorescence (mg m^{-3}) (b) AOU (ml m^{-3}) (c) Normal velocity (m m^{-1})

(d) Potential temperature (°C) (e) Salinity (f) Turbidity (NTU)

Figure 7: ECOCADIZ 201407 section 09: off Portimao



(a) Fluorescence (mg m^{-3}) (b) AOU (ml m^{-3}) (c) Normal velocity (m m^{-1})

(d) Potential temperature (°C) (e) Salinity (f) Turbidity (NTU)

Figure 8: ECOCADIZ 201407 section 03: Off the Guadalquivir river mouth

Acknowledgements

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