



### SOLAS Spain

Isabel Cacho (UBarcelona) and Rafel Simó (CSIC) acted as local organisers for the SOLAS Open Science Conference in Barcelona, 16-19 November 2009. Over 250 scientists from 6 continents attended the conference. A public lecture event was also organised in collaboration with the CosmoCaixa Science Museum.

The ATOS Project (part of International Polar Year-Spain activities) team completed its field work in February 2009 with the second ATOS cruise to Antarctic waters. The team successfully sampled seawater, krill, iceberg ice, glacier ice, and aerosols. Currently ongoing analyses and data processing should provide insight into the role of ice melting in seawater biology and biogeochemistry, and the impacts of deposited atmospheric nutrients, metals and organic pollutants on the planktonic food web.

Extensive field studies aimed at assessing ocean carbon fluxes are being conducted by scientists from ICMAN-CSIC (Cadiz) in the Southwestern Iberian Peninsula, including the Gulf of Cadiz, Strait of Gibraltar and Alboran Sea areas. The IIM-CSIC group (Vigo) has measured air-sea CO<sub>2</sub> fluxes during the CAIBEX project led by Eric Desmond Barton (IIM-CSIC) and also within the FAMOSO project led by Mikel Latasa (IEO Gijón). The main objectives of these projects are the study of shelf-ocean exchanges in the Canaries – Iberian Large Marine Ecosystem and the fate of the Northwestern Mediterranean open sea spring bloom, respectively.

The ICMAN-CSIC (Cadiz) and IIM-CSIC (Vigo) groups have provided CO<sub>2</sub> data to the Carbon Dioxide Information Analysis Centre (CDIAC) on time-series and moorings and SOCAT databases. This group has also generated a data set representing the most complete oceanographic information available for the whole South Atlantic Iberian coast and one of the largest in the temperate Atlantic in terms of both spatial coverage and sampling frequency. The oceanographic and meteorological data can be checked in Prieto, L., Navarro, G., et al. (2009). Oceanographic and meteorological forcing of the pelagic ecosystem on the Gulf of Cadiz shelf (SW Iberian Peninsula). *Cont. Shelf Res.* 29: 2122-2137 doi:10.1016/j.csr.2009.08.007

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## Role of iron deficiency in production and remineralization of organic matter in the Arabian Sea

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The Arabian Sea contains the only major western-boundary upwelling system in the world's oceans. During summer, strong southwesterly winds bring up subsurface waters from depths of up to 200m off Somalia, Yemen and Oman. These waters, having high concentrations of macronutrients, especially nitrate and phosphate, are rapidly transported by filaments and plumes over 1,000 km offshore. Export of particulate organic matter (POM) produced by the resultant phytoplankton blooms and its remineralization below the mixed layer sustains the thickest (100/150-1200m) oxygen minimum zone (OMZ) in the ocean. Within a well-demarcated portion of the OMZ the dissolved oxygen concentration is very close to zero (suboxic, <1μM), allowing large-scale microbial conversion of nitrate to N<sub>2</sub> through denitrification and anaerobic ammonium oxidation. This zone is distinguished by very low levels of nitrous oxide (N<sub>2</sub>O), whereas intense accumulation of N<sub>2</sub>O occurs at its boundaries, making the Arabian Sea a globally significant source of this potent greenhouse gas. Surprisingly, unlike the OMZs of the Atlantic and the Pacific, the suboxic zone of the Arabian Sea is geographically separated from the high-productivity upwelling centres.

It has long been believed that the Arabian Sea receives large deposition of atmospheric dust, an important source of iron (Fe), a key micronutrient, such that primary production (PP) in the region is not Fe limited. Chlorophyll levels in surface waters are much lower than expected from the ambient nutrient levels, though, and this has been ascribed to intense grazing by zooplankton. However, evidence is now accumulating from both modelling (Wiggert et al., 2006) and observational

(Figures 1 and 2; Naqvi et al., 2010) studies for an important role of Fe in PP in the upwelling zones of the western Arabian Sea, as has been observed in other upwelling systems (e.g. off California and Peru – Hutchins and Bruland, 1998; Hutchins et al., 2002). Apparently, Fe supply through atmospheric dust deposition is highly variable in space and time. During the early part of the summer monsoon, such supply is generally adequate for healthy phytoplankton growth, but toward the end of this season, a significant part of the central Arabian Sea experiences the high-nitrate, low-chlorophyll (HNLC) condition presumably due to a lower dust deposition rate and phytoplankton uptake of Fe. Significantly, a large pulse of POM export from the surface occurs at this time, and this may be triggered by the onset of Fe deficiency.

Iron deficiency can also affect vertical POM flux in another way. The water upwelling in the western Arabian Sea is deficient in silicate relative to nitrate (Figure 2), a phenomenon further accentuated by the reported increase in the Si:N uptake ratio by diatoms in Fe-deficient waters (Hutchins and Bruland, 1998). This has two important effects: (a) POM is exported to greater depths; and (b) silicate is quickly consumed while sufficient nitrate remains in waters that advect to the central Arabian Sea. The latter results in a shift in phytoplankton community structure with increasing abundance of smaller autotrophs offshore (Garrison et al., 1998). As POM produced by small, non-diatomaceous phytoplankton may be degraded at shallower depths, one would expect the average depth of the remineralisation of sinking POM to shoal up with increasing distance from the coast. Such variability in the vertical scale of mineralisation can explain two anomalous

features of Arabian Sea biogeochemistry (Naqvi et al., 2010): (a) despite relatively invariable PP, vertical flux of POM to deep sea as measured by sediment traps shows a large onshore-offshore gradient; and (b) the most intense denitrification occurs offshore in the central Arabian Sea. It also has implications for millennial-scale changes in denitrification and N<sub>2</sub>O production (Suthhof et al., 2001): enhanced dust deposition could have led to a shift in POM remineralisation to deeper waters and consequently a relaxation of upper-ocean oxygen deficiency during glacial times.

References

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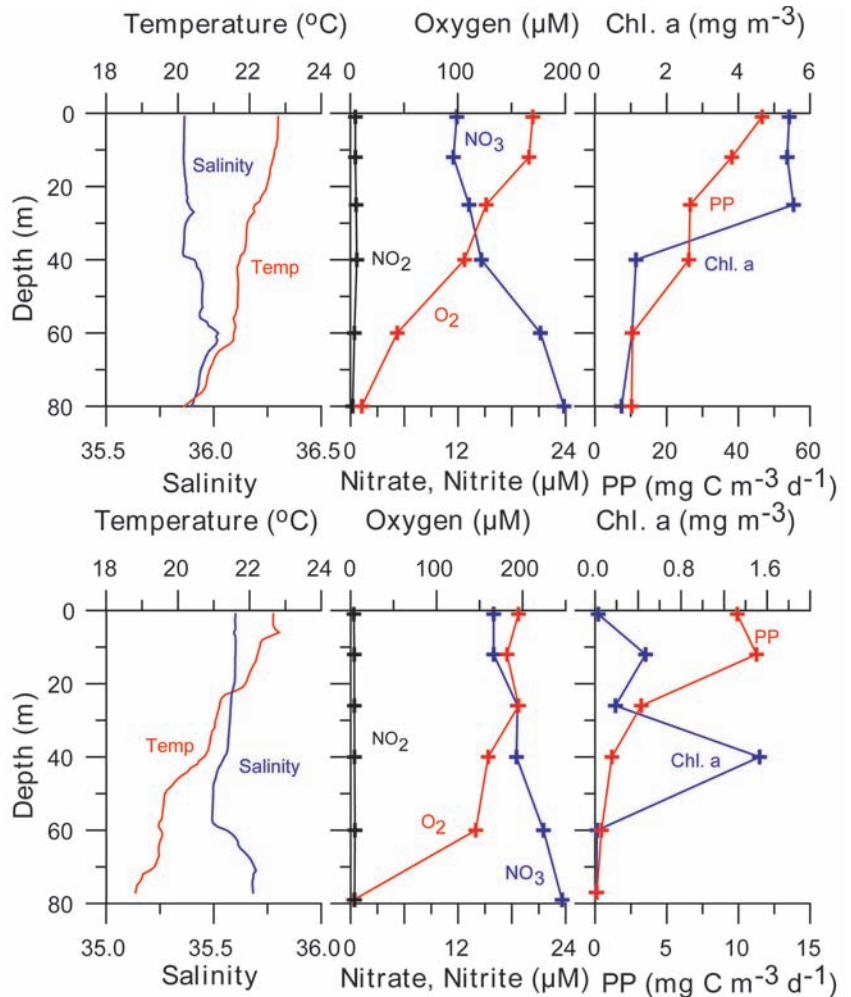
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> Figure 2 : Variations in SST, nitrate (including nitrite), silicate, surface chlorophyll a and chlorophyll a inventory along a coast-perpendicular line off Ras al Madrasah. Except at the first and the fifth stations, HNLC condition prevailed up to a distance of ~1,000 km off the coast.



▲ Figure 1 : Primary production (PP) and chlorophyll a along with ancillary data at two sites over the Omani shelf based on observations in September 2004: Sta. 7 (upper panel) off Ras al Hadd in the north, and Sta. 16 (lower panel) off Ras al Madrasah in the south. Both stations experienced intense upwelling as evident by low sea-surface temperature (SST) and high nitrate, but PP and chlorophyll were much lower at Sta. 16, presumably because of a factor of >6 lower dissolved Fe concentration.

