REPORT OF ONGOING SOLAS ACTIVITIES IN SPAIN
March 2007

Prepared by Rafel Simó, February 28, 2007

Since 2006, the SOLAS Spain Committee is constituted by the following members:

Rafel Simó (co-ordinator, rsimo@icm.csic.es) – ICM-CSIC – *DMS, aerosols*
Javier Arístegui - ULPGC – *plankton metabolism*
Jordi Dachs - IIQAB-CSIC – *aerosols, pollutants, VOC*
Melchor González-Dávila - ULPGC – *air-sea exchange of CO_2*
Xosé-Ánxelu G. Morán - IEO – *food-web processes, N_2 fixation*

and Aida F. Ríos (IIM-CSIC) as President of the IGBP-Spain Committee
and Isabel Cacho (UB) as member of the SOLAS International Scientific Steering Committee

Spanish SOLAS at present has no direct (explicit) funding to carry out SOLAS science from national grants. However, because ocean-atmosphere interactions and Global Change are among the research priorities in the Spanish Research Plan, our community is very proactive in SOLAS-related research, and a number of activities at both national and international levels are being conducted. Here follows an updated compilation of SOLAS activities by research groups.

UNIVERSIDAD DE LAS PALMAS DE GRAN CANARIA

QUIMA-ULPGC group
Marine Chemistry

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ESTOC: EUROPEAN STATION FOR TIME SERIES IN THE OCEAN AT THE CANARY ISLANDS (SOLAS focus 3)

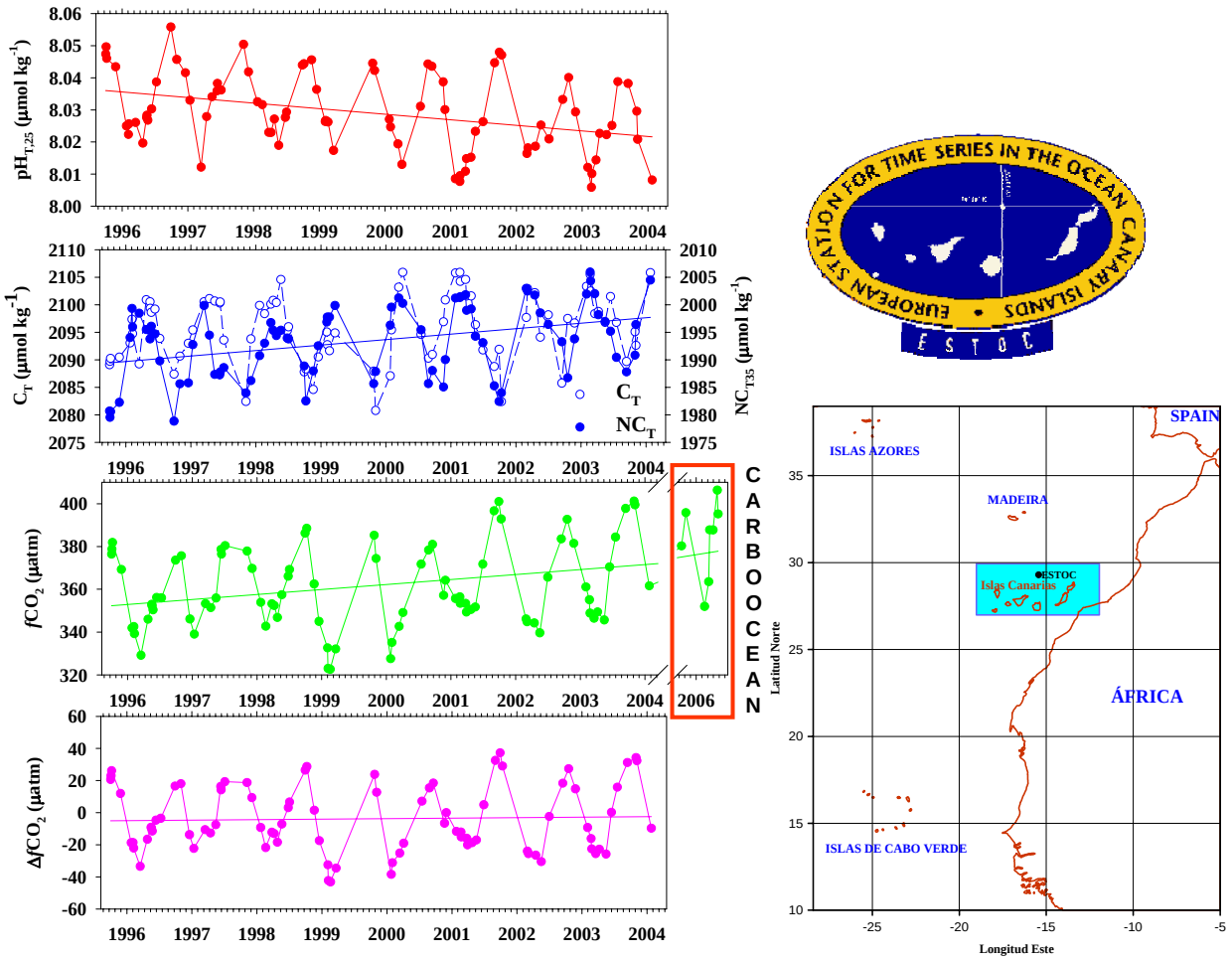
Time-series approach is the best procedure to detect long term trends and changes against the background of the interannual variability of biogeochemical processes and hydrodynamics. Since 1995, hydrographic properties, fCO_2, pHT, TA, and TC have been measured in surface waters on monthly cruises at the European Station for Time Series in the Ocean at the Canary Islands, ESTOC, located in the Northeast Atlantic subtropical gyre. Seasonal de-trended data of salinity-normalized TC (NTC) and experimental fCO_2 show upward trends of 0.99 ± 0.20 µmol kg-1 yr-1 and 1.55 ± 0.43 µatm yr-1, respectively, indicating a direct control in the TC concentration by the increased atmospheric CO_2 concentration. Our series of experimental pHT data confirm the acidification of surface waters in the East Atlantic Ocean with an inter-annual decrease of 0.0017 ± 0.0004 pH units yr-1. Future work is oriented to convert ESTOC in an operational station with continuous (daily resolution) subsurface data record.

Project CARBOOCEAN: SEA-SURFACE CO_2 AND O_2 (SOLAS focus 3)

Within the European project CARBOOCEAN the QUIMA group keeps working a new voluntary observing ship, monthly VOS-line from UK to Cape Town, which records surface SST, SSS, O_2, Chlorophyll and fCO_2. These data are integrated into an international observational effort aimed at measuring the variability of air-sea CO_2 fluxes in the Atlantic Ocean. This follows the internationally agreed strategy outlined by the IOC-SCOR Panel, Ocean carbon dioxide and IGBP, Global carbon cycle project Science Plan.

Project ICCABA: SEA SURFACE CO_2 (SOLAS focus 3)

As part of the Spanish MEC project ICCABA, a new VOS-line connecting weekly the Canary Islands and Italy is being established for a first CO_2 monitoring of the Western Mediterranean Sea.



Biological Oceanography group

Javier Arístegui (jaristegui@dbio.ulpgc.es)

Project RODA: OCEANIC EDDIES AND ATMOSPHERIC DEPOSITION IN THE CANARY CURRENT (SUBTROPICAL NORTHEAST ATLANTIC): MONITORING, BIOLOGICAL AND BIOGEOCHEMICAL EFFECTS, AND FLUXES TO THE OCEAN INTERIOR (SOLAS focus 1)

The main goal of this coordinated project is to study the joint effect of two mechanisms which we presume affect critically to the functioning of the pelagic marine ecosystems and to the vertical fluxes of nutrients and carbon to the ocean interior: the atmospheric deposition of organic matter, nutrients and mineral components on the sea surface, and the enhancement of vertical advective fluxes by counter-sense eddy-pairs. We aim to quantify the magnitude of these processes in the Canary Current (subtropical Northeast Atlantic), a region strongly influenced by mesoscale features and by intense eolic input events. On the one hand, our approach is innovative, since we don't know any similar focused-study in the literature. On the other hand, the results could be extrapolated to any oceanic region, since both mesoscale features and atmospheric deposition are two processes prevalent in most of the ocean, even in the remote central regions of the subtropical gyres. The project is being conducted through (i) the annual monitoring of atmospheric depositions (by the installation of high volume capture aerosol systems in the coast of Gran Canaria Island and onboard the R/V Hespérides), (ii) the annual monitoring of eddy generation and particle fluxes to the ocean interior (by the deployment of a mooring equipped with current meters, temperature sensors, and sediment traps), (iii) the performance of two oceanographic cruises with the Hespérides in the Canary Current region, (iv) carrying experimental work during the oceanographic cruises and near the coast.

INSTITUTO DE INVESTIGACIÓNS MARIÑAS - CSIC (VIGO)

IIM-CO_2 group

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AIR-SEA EXCHANGE OF CO_2 (SOLAS focus 3)

The national project **ECO** (Evolution of CO_2 in the Bay of Biscay) has finished recently. Some results are being published whereas other results still are being processed.

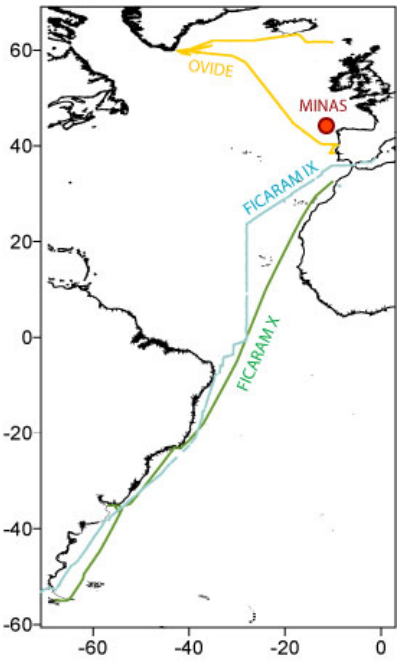
The group of IIM-CO_2 is partner in the European Integrated Project **CARBOOCEAN**. Their research activities are conducted within two Work Packages related with the objectives of SOLAS: Southern Ocean observations and procedures, and Atlantic observation system, VOS and time series.

Underway measurements of pCO_2 were collected during three oceanic cruises throughout 2006: FICARAM IX and FICARAM X on board BIO Las Palmas, and OVIDE 2006 on board

RV Maria S. Merian. During 2007, further two cruises will be performed: FICARAM XI and FICARAM XII. Furthermore, a CARIOCA buoy will be moored in the vicinity of 43ºN 11ºW.

SOLAS ACTIVITIES:

To resolve the seasonal and interannual variability of air-sea CO_2 exchange in the North Atlantic a good climatology of the surface pCO_2 is required. Within this context the IIM-CO_2 group has developed an autonomous pCO_2 measuring system (GASPAR) to record sea surface temperature, salinity, oxygen, fluorescence of Chl *a*, as well as atmospheric and oceanic pCO_2. We have been conducting air-sea CO_2 flux measurements over the entire Atlantic with our GASPAR instrument on board the BIO Las Palmas on its way to Antarctica from the Iberian Peninsula, and on board the R/V Maria S. Merian to track the xCO_2 in a section delimiting the outflows of deep waters in the North Atlantic (Ovide section).



The working plan of the IIM-CO_2 for the next future group involves the establishment of a long-term time series station off Cape Finisterre (43°N, 11°W): the Multidisciplinary Iberian North Atlantic Station (MINAS). The measurements of the CARIOCA buoy in this subduction region for North Atlantic Central waters should allow following the evolution of the penetration of anthropogenic CO_2 in the North Atlantic.

UNIVERSIDAD DE CÁDIZ

Physical Chemistry Department, School of Marine and Environmental Sciences

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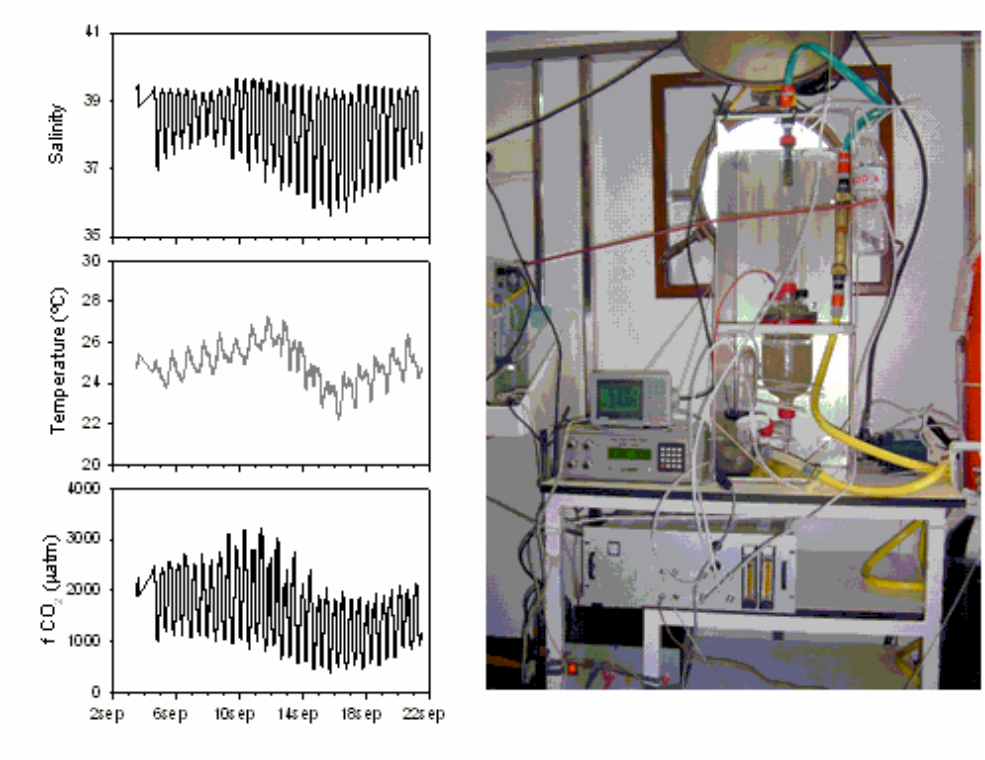
AIR-SEA EXCHANGE OF CO_2, CH_4 and N_2O (SOLAS focus 3)

One of the main activities of the group in the last years has been the characterization of gas exchange processes of greenhouse gases in coastal areas. Information of air-water fluxes of CO_2, CH_4 and N_2O has been obtained in shallow coastal systems (e.g., Bay of Cadiz, Guadalquivir estuary). These data show that these zones behave, during most of the year, as sources of these gases to the atmosphere.

At present, the study has been extended to the coastal area of the gulf of Cadiz, up to 20 miles off-shore. This work is part of the Spanish project " Emission zones of greenhouse gases to the atmosphere: Influence of coastal inputs and benthic metabolism". Besides a seasonal monitoring of the gas exchange with the atmosphere, a study of its coupling with continental inputs and benthic fluxes is being carried out.



Seasonal variability of salinity, temperature and CO_2 fugacity in Río San Pedro creek (Bay of Cadiz, SW Spain). (DelaPaz et al., subbmited to Mar. Chem.).

INSTITUTO DE CIENCIAS MARINAS DE ANDALUCÍA – CSIC (CÁDIZ)

Oceanography of Ecosystems group

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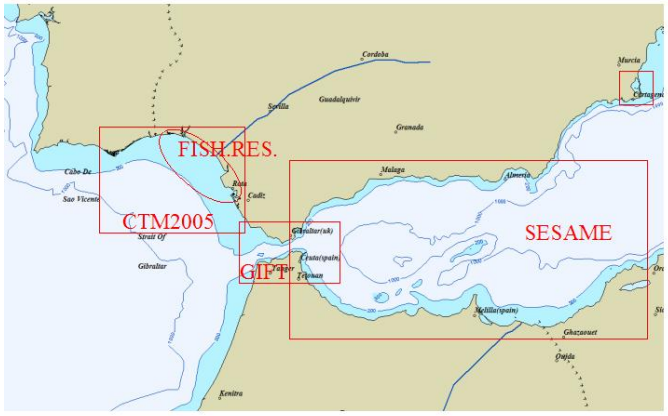
OCEAN CARBON FLUXES (SOLAS focus 3)

The group investigates the magnitude of Mediterranean carbon fluxes and Mediterranean/Atlantic carbon exchanges. Extensive field studies are being conducted in the Strait of Gibraltar and Gulf of Cadiz aimed at assessing the exchange of carbon between the

Mediterranean basin and the North Atlantic and also the biogeochemical cycles in the context of global change. The research will be extended until 2010, being funded by the European Commission within the 6th Frame Program trough Projects **CARBOOCEAN** and **SESAME**, and by the Spanish MEC.

The activity developed by the group is linked with the topics contained in the Joint SOLAS-IMBER Ocean Carbon Research. Monthly ocean pCO_2 and air-sea CO_2 fluxes have been obtained and calculated in the Gulf of Cádiz from 2003 to 2006 and fluctuations have been analysed in relation to the hydrodynamics of the area and the local patterns of primary production (Huertas et al 2005. Can J. Bot. 83:929-940, Huertas et al. 2006. Deep Sea Research II,53:1344-1362). At present, short-term extensive cruises are being performed seasonally in the basin and in the Strait of Gibraltar. In this latter spot, a permanent time series have been established (GIFT: Gibraltar Fixed Time series), which have allowed to calculate the fluxes of carbon associated to the two water bodies that meet in the strait, the Mediterranean outflow and the Atlantic inflow. All variables involved in the carbon cycle are being monitored.



Study region

UNIVERSIDAD DE VIGO

Biological Oceanography Group, School of Marine Sciences

Emilio Marañón (em@uvigo.es), Emilio Fernández (on leave), Pablo Serret (on leave), Eva Teira, Bea Mouriño, Cristina Sobrino, Patricia Estévez, Jose González, María Aranguren, Sandra Martínez, María Huete, Ana Fernández

Project CARPOS: NET METABOLIC BALANCE IN THE OLIGOTROPHIC OCEAN (SOLAS focus 1)

This project, funded by the Spanish MEC, has as its main goal to quantify the net metabolic carbon balance of microbial plankton in the central and marginal regions of the subtropical NE Atlantic, using a lagrangian approach. The 'Carpos' cruise, conducted in October-November 2006 (see Figure), allowed the simultaneous quantification of the metabolic

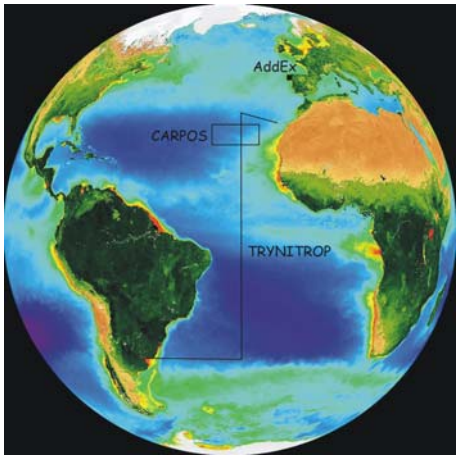
balance of the euphotic layer in vitro and in situ. It also provided the opportunity to quantify the effect of short-scale physical variability on primary production and to assess the role of bottle effects in determining the net metabolism (hence CO_2 exchange) of the microbial plankton community.

Project TRYNITROP: N_2 FIXATION (SOLAS focus 1)

This project, funded by the Spanish MEC, aims to determine which factors control the latitudinal distribution of the abundance and metabolic activity of the N_2-fixing cyanobacterium *Trichodesmium*. The project will provide experimental measurements of the rate of N_2 fixation, and subsequent release of dissolved organic nitrogen, in the tropical and subtropical Atlantic Ocean. It will also assess the longer term impact of N_2 fixation through the food web by measuring the distribution of ^{15}N in particulate organic matter within different size classes. Two 'Trynitrop' latitudinal transects from 35° N to 35° S (see Figure) on board BIO Hespérides are scheduled for November 2007 and April 2008.

Project ADDEX: ATMOSPHERIC INPUT OF NUTRIENTS (SOLAS focus 1)

This project, funded by the Galician government, stems from the tenet that land-use changes and alterations to the hydrological cycle may lead to changes in the quantity and quality of materials that are transported from land and the atmosphere to the surface of the ocean. Specifically, 'AddEx' looks at the effects of the addition of different organic and inorganic nutrients upon the structure and metabolic functioning of the microbial plankton community. It uses an experimental approach in which natural plankton assemblages, collected in coastal and shelf waters off NW Spain, are enclosed in microcosms and subjected to different combinations of organic and inorganic nutrient additions. 'AddEx' experiments will take place in four contrasting hydrographic settings during 2008.



INSTITUTO ESPAÑOL DE OCEANOGRAFÍA / UNIVERSIDAD DE OVIEDO

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PLANKTON-MEDIATED CARBON AND NITROGEN FLUXES IN THE OLIGOTROPHIC OCEAN (SOLAS foci 1 and 3)

This group is involved in the CARPOS project (see above), with the aim at explaining why in open-ocean oligotrophic environments respiration exceeds production, which makes these

regions apparently net sources of CO_2 to the atmosphere. Three mutually compatible hypotheses are being tested: 1) there is substantial transport of organic matter from the nearby African upwelling productive area, making the marginal eastern region a subsidized system whereas the central region would lie closer to metabolic balance, 2) episodic pulses of production associated to short-lived physical processes such as internal waves are missed unless high-frequency sampling programs are specifically conducted, and 3) high respiration rates are in part an artifact of long (24 h) incubations enhancing heterotrophic processes within bottle-confined microbial communities.

The group also takes part in the TRYNITROP project (see above).

INSTITUT MEDITERRANI D'ESTUDIS AVANÇATS – CSIC / UNIV ILLES BALEARS (MALLORCA)

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EFFECTS OF UVR AND NUTRIENT DEPOSITION ON C FLUXES (SOLAS focus 1)

The group examines the effects of ultraviolet radiation on primary production and phytoplankton survival (Llabrés and Agustí 2006), net metabolism of planktonic communities, and carbon fluxes. Also, the effects of atmospheric deposition of nutrients, metals and pollutants on phytoplankton growth and cell death, and carbon (DOC and CO_2) and O_2 fluxes, are investigated.

AIR-SEA EXCHANGE OF CO_2 AND VOC (SOLAS foci 2 and 3)

The group is measuring the exchange of organic carbon between the atmosphere and the ocean, which initial results reveal to be a major but overlooked component of the C flux between the ocean and atmosphere (Dachs et al. 2005). Other research topics are the role of planktonic metabolism just below the ocean skin in controlling the variability of the CO2 and VOC fluxes (Calleja et al. 2005), and the role of organic matter in modulating the rate of gas exchange at the air-sea interface.

These goals are approached by participation in several national (COCA; ICEPOS; RODA; ATOS), and European projects (**THRESHOLDS**), and by conducting cruises in the Mediterranean Sea, the subtropical Atlantic Ocean, and the Artic and the Antarctica within the Spanish contribution to the **IPY** (project ATOS).

INSTITUT DE CIÈNCIES DEL MAR – CSIC / INSTITUCIÓ CATALANA DE RECERCA I ESTUDIS AVANÇATS (BARCELONA)

Group of Oceanic Biogeochemistry and Global Change

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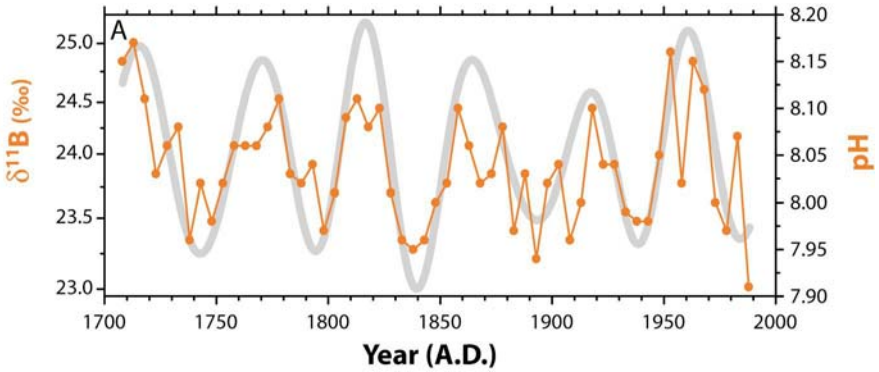
Project ROMIAT: EFFECTS AND RESPONSE OF MARINE ORGANISMS TO THE IMMINENT ACIDIFICATION OF THE OCEANS: A MULTI-TEMPORAL STUDY (SOLAS focus 3)

With this project, recently funded by the Spanish Ministry of Education and Science, we aim to assess some of the effects of the progressive acidification on marine ecosystems, from three different perspectives: First, we will simulate the future by means of the manipulation of pH in aquaria to assess the effects of acidification in selected corals from the Mediterranean Sea. Second, we will set up a methodology to analyse boron isotopes in carbonates, which we will use as a proxy for seawater pH. With this technique, and similar to a previous reconstruction that we produced during a post-doctoral stage in Australia (see figure below), we will learn how seawater pH has changed during the last hundreds of years in another key marine environment. This will help us establish analogues for the future and delimit which are the levels of pH that marine organisms can tolerate. Third, we will analyse multiple proxies in a marine sediment core from the Eastern Equatorial Pacific to assess some of the biogeochemical processes and feedbacks that regulated past marine productivity and phytoplankton composition over glacial to interglacial times, and their linkage with global climate changes.



Left: Drilling a Porites *coral. Record of Flinders Reef (Coral Sea) coral $\delta^{11}B$ (boron isotopic composition) as a proxy for seawater pH covering the last 300 years showing a cyclical pattern of ~50 yr periodicity (adapted from Pelejero, Calvo et al., Science 2005).*

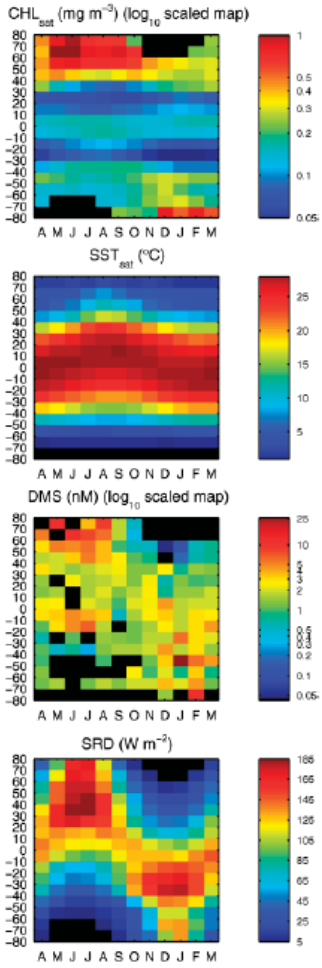
BIOLOGICAL AND BIOGEOCHEMICAL CONTROLS ON SULFUR EMISSION FROM THE OCEAN (SOLAS focus 1)

The group studies the biotic and abiotic factors that control the oceanic emission of DMS at multiple temporal and spatial scales, from diel cycles to annual series, and from individual microbes through plankton community experiments to regional and global distributions. Research tools include molecular biology techniques for microbial diversity (Vila-Costa et al.

2006), single-cell biogeochemistry methods (Vila-Costa et al. Science 2006), “grazing dilution” experiments, a time series sampling station in the coastal NW Mediterranean, open-sea lagrangian studies, and satellite / ocean climatology data analyses. Emphasis is given to the phylogeny of sulfur-transforming microbes, the role of dimethylated sulfur in food-web S fluxes, and the physico-chemical forces driving DMS dynamics.

These goals are approached through the participation in national and US projects, and by cruises to the Mediterranean, the North Atlantic, and the Artic and the Antarctica within the Spanish contribution to the **IPY** (project ATOS)

GLOBAL OBSERVATION AND MODELING OF BIOGENIC SULFUR, AEROSOLS AND CLOUDS (SOLAS focus 1)



The hypothesis that oceanic plankton influence climate through the production and emission of the cloud precursor DMS is addressed by numerical analyses of the data obtained with new-generation satellite sensors for global observation. These data include surface temperature, Chla, wind speeds, and the optical properties of aerosols and clouds. In combination with diagnostic models of global DMS distribution and mechanistic atmospheric models, these data shall provide novel insights into global DMS dynamics, its atmospheric (cloud-related) effects and its responses to climate forces (Vallina and Simó, Science 2007). This research is funded by the Spanish MEC through the project MIMOSA.

Monthby latitude plots of climatological global distributions of satellite-derived chl-a concentrations, satellite-derived sea surface temperature, surface DMS concentrations, and the solar radiation dose in the mixed layer. All variables are monthly averaged by 10º latitude bands (from Vallina and Simó, Science 2007).

INSTITUT D'INVESTIGACIONS QUÍMIQUES I AMBIENTALS – CSIC (BARCELONA)

Group of Water-Air-Soil Exchanges Measurement and Modeling

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CONTINENT-ATMOSPHERE-OCEAN TRANSPORT OF NATURAL AEROSOLS, VOLATILE CARBON, AND POLLUTANTS (SOLAS foci 1 and 2)

The research of the group at the Dept. of Environmental Chemistry has the objective to understand and quantify the processes of exchange of organic compounds between the atmosphere and the surface ocean. A first line of research deals with the measurement of diffusive air-water and dry atmospheric deposition fluxes of total organic carbon. This work is important since diffusive fluxes of OC are unknown, even thought they could play an important role on the marine carbon cycle. The second line of research has the objective to understand the fate of organic pollutants such as PAHs, PCB and PBDE in the surface ocean in terms of sink to the deep ocean, importance of atmospheric inputs as an entry route to aquatic food webs, etc. The approach is by combining field studies from oceanographic ships with modeling. Some of the recent key contributions are: i) determination of the importance of the biological pump as a sequestration of atmospherically transported persistent organic pollutants in the global oceans (Dachs et al. 2002, Jurado et al 2005), ii) Modeling of the cycle of individual organic compounds in the surface ocean as a function of their physical-chemical properties (Jaward et al. 2004, Jurado et al. 2006), iii) Study of the influence of the surface microlayer on the atmospheric deposition of aerosol and PAHs, iv) Quantifications of diffusive air-water fluxes of organic carbon to/from the NE Atlantic ocean, v) Observations and modeling of aerosol formation and transport over the global ocean, by use of satellite data and atmospheric chemistry models.

The group research is funded by the Spanish MEC and European projects (**THRESHOLDS**), and study regions include the Mediterranean, the subtropical Atlantic, and the Antarctica and the Artic as part of the Spanish contribution to the **IPY**.