

More pieces of the shelf sea CO₂ flux jigsaw puzzle

Charlene Bargerón & David Hydes National Oceanography Centre, Southampton, U.K.



National Oceanography Centre, Southampton
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

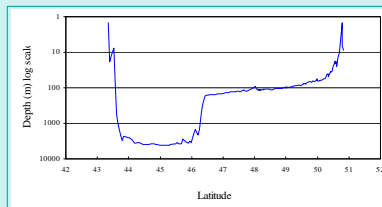
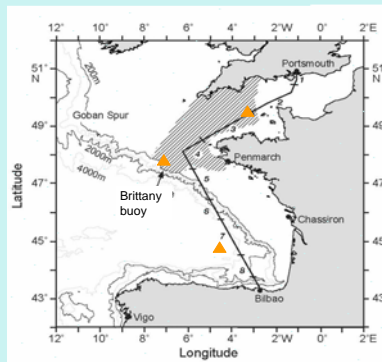
High latitude open shelf waters appear to be significant sinks for CO₂, but a need remains for data with the temporal and spatial resolution to calculate net annual fluxes. It is now possible to sample the NW European shelf-ocean region using a VOS, with a frequency that allows resolution of the annual sources and sinks of atmospheric CO₂ along the route.

Regional shelf-slope-ocean VOS track and system

The P&O VOS crosses regions of high temporal and spatial variability on the eastern margin of the North Atlantic that can be subdivided into well-mixed, tidal-frontal, shelf-slope and oceanic waters of the Bay of Biscay.

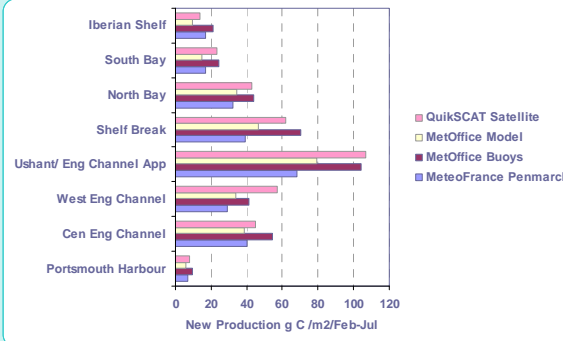
The area is well served with wind speed data sources allowing oxygen and CO₂ fluxes to be determined using the most appropriate local wind.

Our system includes a non-dispersive gas analyser with equilibrator system (Cooper et al., 1998) and oxygen Optode (Aanderaa), to measure xCO₂ and dissolved oxygen autonomously at a 30 sec frequency. Fluorescence and conductivity are measured at 1 Hz. Bulk seawater temperature is measured with a hull mounted sensor and radiometrically (ISAR).



The area is well served with wind speed data products; QuikSCAT scatterometer scatterometer (12-hourly), corrected ship's anemometer (1 sec), three regional MetOffice buoys (hourly) orange triangles in figure above, coastal station at Penmarch (3-hourly) and hourly Met Office numerical weather prediction model data. An analysis of the available wind speed sources is underway to determine the most appropriate source for calculation of oxygen and CO₂ fluxes.

Impact of wind speed data source on flux calculations



This is one of the buoys positioned along track providing hourly wind speed data.

In the figure above, oxygen fluxes were determined from discretely sampled monthly monthly oxygen observations (Winkler, 1888) using the Wanninkhof (1992) parameterisation with each of the wind speed sources listed. The positive fluxes during the period February to July, were summed to provide seasonal net net outgassing (SNO) (Keeling & Shertz, 1992), which closely approximates new new production for the period. Our previous study has shown (Bargerón et al. 2006) 2006) that the regions, shelf break, Ushant frontal region and western English Channel all show higher new production than could be calculated from a nutrient nutrient assimilation technique, i.e. winter nitrate multiplied by a Redfield ratio to to give carbon consumed. This is using the 2004 oxygen data.

In this further analysis, the regions - shelf break, Ushant and western Channel, are are distinguished by increases in new production when the satellite and buoy data data are used in the calculation. This is part of a wider analysis of the impact of of each of the wind speed sources. The ship's anemometer data will be included included when it has been corrected. The choice of wind speed data, especially in especially in the area around Brittany buoy, influences the new production estimate. estimate.

Regional oxygen anomaly

In the figure below, 5 min averaged data (from 30 sec data) is represented for each each of the eight regions for the year. The bubble free water supply from the ship's ship's sea chest provided the original data (Bargerón et al. 2006) and this is the first first of the Aanderaa Optode data. Peaks in oxygen anomaly can be seen in all all regions except the western English Channel around day 90 (early April). High High summer production can be seen in the shallow mixed regions of the English Channel Channel throughout the summer. The Optode is proving to be a reliable sensor that that when properly calibrated compares well with Winkler observations.

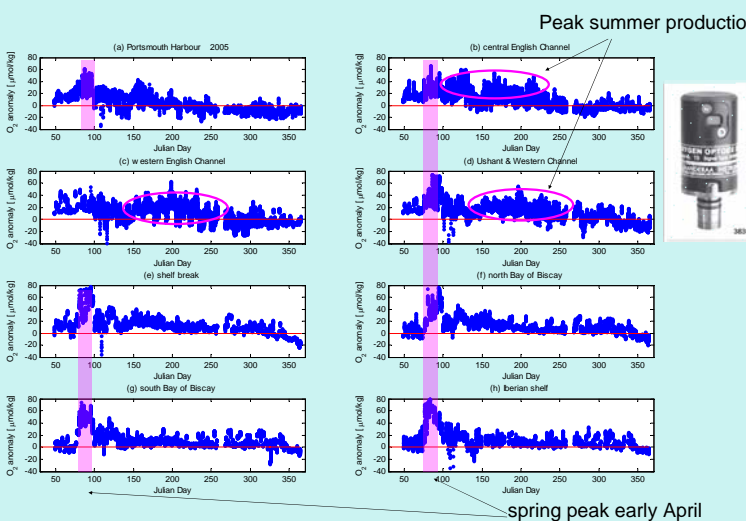


Fig. Five min oxygen anomaly (O₂ observed - O₂ solubility) over the eight regions during 2005.

2007 fCO₂

The CO₂ system (Cooper et al. 1998 and UEA built) is is now outputting data at 30 30 sec intervals. One of the the crossings from Bilbao to to Portsmouth is shown in in the figure here. The values values for the Bay of Biscay Biscay at > 360 < 380 are are similar to those found in in an earlier study (Borges & Frankignoulle, 2003, Frankignoulle & Borges, 2001). Each crossing takes takes 36 hours so there are are two crossings per week week which will allow annual fluxes to be be calculated for the regions.

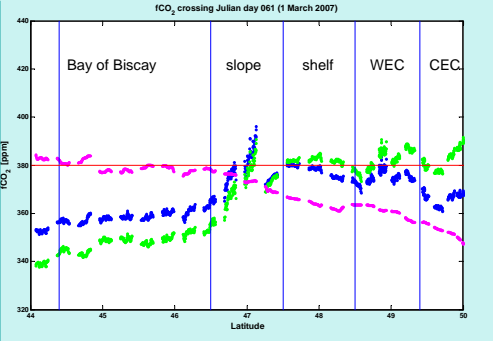


Fig. fCO₂ data from a recent crossing [blue] together with the same data normalised to 12.4 °C [green] and the value of fCO₂ at the observed temperature [magenta]. Temperature corrections from Takahashi et al. (2002). WEC is the western English Channel and CEC CEC is the central English Channel. Atmospheric CO₂ [red line].

Temperature traceability

Using two temperature sensors to calculate the change in CO₂ from temperature temperature differences between the equilibrator and bulk seawater can be be problematic. Unless the sensors are calibrated with a traceable standard to to determine their offset, differences in their readings are likely. We have a traceably traceably calibrated Seabird 38 platinum resistance thermometer that is being used used to calibrate the on-board equilibrator and hull sensors to ensure that the the temperature offset for 'back correction' (Takahashi et al. 1993) is known. We have have found that even 'famously accurate' sensors from 'well respected' suppliers suppliers have offsets outside the manufacturer's data sheets.

References:
C. P. Bargerón, D. J. Hydes, D. K. Woolf, B. A. Kelly-Gerrey, M. A. Qurban, 2006, *Estuarine, Coastal and Shelf Science* 69, 478.
T. Takahashi et al., 2002, *Deep-Sea Research: Part 2, Topical Studies in Oceanography* 49, 1601-1622.
L. W. Winkler, 1888, *Berichte der Deutschen Chemischen Gesellschaft* 21, 2843.
T. Takahashi, J. G. Orlowski, D. W. Coddard, D. W. Chipman, S. C. Sullivan, 1993, *Global Biogeochemical Cycles* 7, 843.
R. Wanninkhof, 1992, *Journal of Geophysical Research* 97, 7373, R. F. Keeling, S. R. Shertz, 1992, *Nature* 358, 723.

Acknowledgements:
There are many who have helped with the CO₂ system, but the following deserve a special mention: Dave Blomfield for help with the CO₂ system components, the engineers on the *Pride of Bilbao* for their help with the maintenance of the equipment, Are Olsen for help with the data reduction method and Jon Campbell and Andrew Yool for help with data management and processing and David Woolf for help with the wind analysis. A special thank you goes to P&O for their continuing help and support allowing access to the ship.