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SNOMS: SWIRE NOCS Ocean Monitoring System
Diary of the system development and installation
on the MV *Pacific Celebes* in 2006 and 2007

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2007

The Swire Group and the National Oceanography Centre, University of Southampton working together to examine the role of the oceans in limiting the build up of carbon dioxide in the atmosphere

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ABSTRACT <p>The SNOMS project brings together the resources of the United Kingdom's National Oceanographic Centre, Southampton (one of the world's leading centres for marine research) and The Swire Group (a major multinational corporation) to make a significant contribution towards improving our understanding of the role of the oceans in controlling concentration of carbon dioxide in the atmosphere and hence the worlds climate.</p> <p>The Swire Group Charitable Trust funded the design, assembly and installation of a scientific data collection system on their ship the MV <i>Pacific Celebes</i>. The system is now providing data from areas where no or little data exists particularly in the Indian Ocean, Red Sea and Mediterranean. It links with and connects on-going observations in the Atlantic. Data from the system supports projects both at NOC and elsewhere including the IOCPP (International Ocean Carbon Coordination Project).</p> <p>This report provides an illustrated diary of the progress of the project between signing of the contract between the Swire Group and NOC in March 2006 and the installation of the working system on the MV <i>Pacific Celebes</i> in June 2007.</p> <p>A new type of system for monitoring the partial pressure of CO₂ at the sea surface had to be developed which could run autonomously of NOC with only periodic servicing by the ship's crew. This was done by designing a simple tank system to contain temperature, conductivity and dissolved oxygen sensors built by Aanderaa and the new CO₂ device the "ProCO₂" developed by ProOceanus in Canada. This would be used with the ProOceanus total gas Pressure device the GTD.</p> <p>The system was assembled and tested at NOC before its first sea trial on the P&O ferry MV <i>Pride of Bilbao</i> in November 2006. Modifications were made after this trial. A longer trial was carried out on the <i>Pride of Bilbao</i> from February to April 2007. The system was shipped to Singapore in May 2007, and installation was completed in Jakarta on 4 June 2007.</p>	
KEYWORDS carbon dioxide, equipment, installation, measurement, long term observation, monitoring, MV <i>Pacific Celebes</i> , MV <i>Pride of Bilbao</i> , Ships of Opportunity, SNOMS	
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Diary of the system development and installation on the MV Pacific Celebes in 2006 and 2007

2006

March

A contract signed between NOC and the Swire Group for the development of an OceanBox system for the scientific study of ocean concentrations of carbon dioxide, making use of a China Navigation Company ship as a scientific platform. The acronym SNOMS was chosen representing **Swire NOCS Ocean Monitoring System**.

Procurement and assembly of the SNOMS system

March & April

Final specification of the instruments to be used was completed and an order was placed with ProOceanus in Canada for instruments to measure total dissolved gas pressure and the dissolved concentration of carbon dioxide. The instruments for measuring conductivity, temperature and concentration of dissolved oxygen were ordered from Aanderaa in Norway.

May

A conversation with John Grace from Edinburgh University alerted David to the existence of the Vaisala GMP343 sensor for atmospheric CO₂. The design of the SNOMS system was extended so that atmospheric concentrations of CO₂ could be monitored using this device. The GMP343 is used along with sensors for air temperature, pressure and humidity.

June

David Hydes and Jon Campbell visited to Singapore to see the MV Pacific Celebes (then called the Indotrans Celebes) to arrange the installation of the Ocean Box later in year. David and Jon worked with Francis Cheung the technical manager for the Pacific Celebes and the ship's engineers to work out the optimum position for the equipment and to arrange the necessary fitting out and cables runs.



Group photograph on the bridge wing of the Celebes of David and Jon with the Ship's Captain, Chief Engineer and Technical Manager, from left to right David, Valeri, Jon, Norman and Francis.

July

David worked with Peter Stephenson at NOC on a design for flow through tank that would house all the sensing devices, and that could be opened easily for cleaning. A number of possible manufacturers were contacted to discuss a final design

July & August

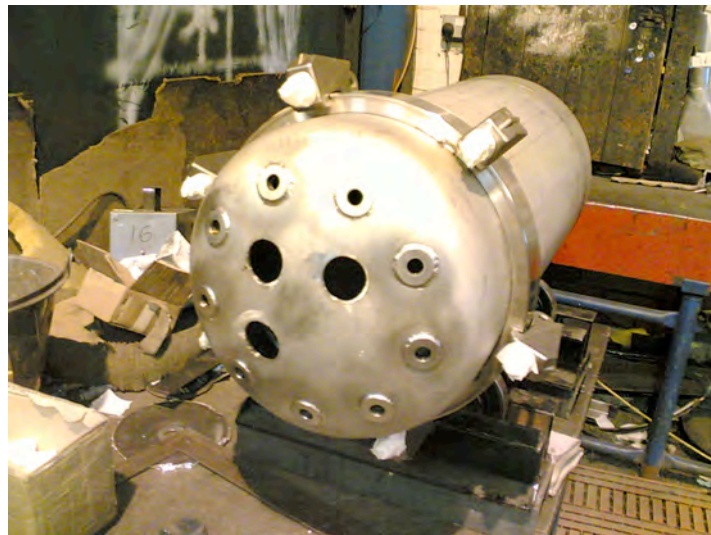
The instruments to be used in the system from Aanderaa in Norway, ProOceanus in Canada and Vaisala in Finland were delivered to NOC.

August

The final design of the water flow through system to hold the instruments was completed and an order was placed with Abbfab Services, Bolton UK.

September

Work on tank was well underway at Abbfab Services



The SNOMS tank on the work bench at Abbfab on 19 September 2007



The SNOMS tank nearing completion at Abbfab services 21 September 2007

October

The SNOMS tank arrived at NOC and was pressure tested with the external fittings that would be used in the full SNOMS OceanBox system on the Pacific Celebes.



The SNOMS tank under leak testing at NOC

Tests of the system at NOC and on the *Pride of Bilbao* in 2006

October

Calibration of the Aanderaa sensors in-situ on the SNOMS tank was carried out working with the NOC Calibration Facility.



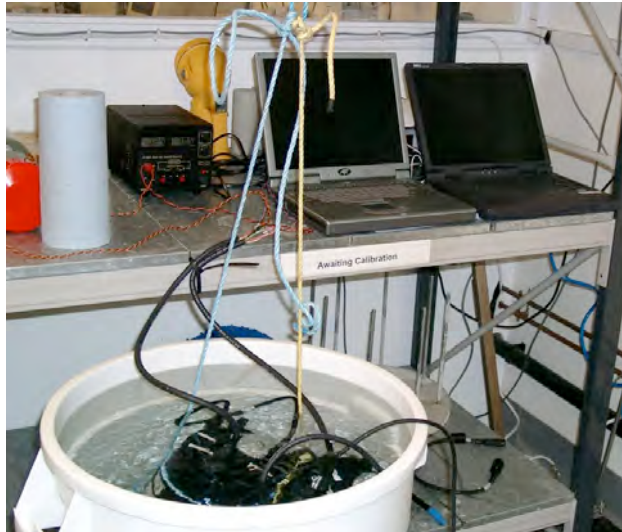
The Aanderaa sensors for temperature, conductivity and dissolved oxygen newly fitted into the lid of the SNOMS tank



Dave Childs collects a sample to of the seawater being pumped through the tank so he can measure its salinity to compare with the output from the Aanderaa sensors

October

Laboratory tests of the performance of the two ProOceanus ProCO₂ units were carried out.



The two ProCO₂ units were suspended in a large tubs of continuously aerated seawater and the output logged over several days, for number of tests.

November

The plan in June had been to fit out the Celebes in Singapore in the autumn. The delayed design and delivery of the tank prevented this ambitious plan happening and encouraged a more detailed set of evaluations to be carried out.

On 23 November the first field tests of the SNOMS OceanBox were done on the P&O ferry the MV Pride of Bilbao. [NOC has been working with P&O and the Pride of Bilbao since 2002.] David Hydes sailed with the system to collect an extensive set of calibration samples during the 3 day round trip between Portsmouth and Bilbao back to Portsmouth.



SNOMS OceanBox tank and electronic cabinet in the forward pump room of the P&O Pride of Bilbao 23 November 2006



The ProOceanus ProCO₂ unit being lowered into the SNOMS tank prior to the test cruise on the Pride of Bilbao.

December

At this stage fitting out of the Celebes had been seen as being in Houston in January. The results from the tests on the Pride of Bilbao indicated that some modification might improve the system. The enclosed design of the ProCO₂ unit's manifold made it difficult to be sure how clean the surfaces of the exchange membrane were. In discussion with Bruce Johnston of ProOceanus an idea for more open design was developed. The unit used on the Pride of Bilbao was then returned to Halifax for it to be modified. It was therefore decided to delay fitting out of the Celebes until after a test of at least two months duration had been conducted on the Pride of Bilbao. This was considered necessary to check the stability of the sensors and how effectively they could be maintained in a clean condition. The date of fitting out was now moved to May when the Celebes would return to Singapore after being refitted in Thailand.

December

David Hydes and Charlie Bargeron attended the 2nd CarboOcean Annual Science meeting on Gran Canaria, and presented a poster that showed some of the results from the trial of the OceanBox tank on the Pride of Bilbao in November. The poster is attached as an Appendix to this report

2007

Tests on the Pride of Bilbao in 2007

February

2/2/07 The SNOMS OceanBox tank and electronics control unit were fitted in the P&O Ferries MV Pride of Bilbao along with the standard FerryBox system. The GTD was not fitted at this stage as corrosion round the membrane retaining plate was found when the plenum chamber was removed. The GTD was shipped to Canada for repair.

On 5/2/07 the Pride of Bilbao sailed on first crossing after refit.

23/2/07 the system was cleaned for the first time (due to logistics problems including the weather severely delaying the ship's arrival in Portsmouth). The SNOMS tank was found to be very muddy (see photograph below). The levels of sediment collecting in the FerryBox units was higher than seen at any time in the proceeding four years due to

stirring up of bottom sediments by the very stormy condition experienced in 2007 up to mid April. The mud did not attach to surfaces and cleaned off easily.



Before cleaning photograph showing the high levels of sediment contamination experienced in 2007

March

Comparison of the data from the ProCO₂ SNOMS system and the equilibrator CO₂ system showed that the two data sets agreed well immediately after cleaning. On 9/3/07 before the system was cleaned the amount of respiration taking place in the mud in the tank was looked at by turning off the flow through the tank. Turning the flow off for 30 minutes resulted in an xCO₂ increase from 600 to 1200 ppm and a decrease in oxygen from 290 to 210 micro mole/L.

The system stopped receiving data from the ProCO₂ during these tests. It didn't prove possible to diagnose the fault on board Pride of Bilbao. On 23/3/07 ProCO₂ and SNOMS logger were removed from ship for tests at NOC. The fault was found to be a loose connection and chip inside the ProCO₂.



Interior of OceanBox tank after cleaning. Tank contains the ProOceanus ProCO₂ and GTD units. The Seabird 38 thermometer(used for comparison with the Aanderaa 4050 thermometers in the lid of the tank) can be seen at "5 o'clock".

On 30 March the complete SNOMS system with the ProCO2 unit and the repaired GTD were refitted in the tank. In addition a high accuracy Sea Bird 38 thermometer was also set up in the tank - see photograph pervious page.

April

The complete SNOMS system then run well until the day it was removed from the ship on 20/4/07. The system was cleaned on April 5, 11 & 17th. The GTD was found to settle fast after cleaning and refilling the tank if efforts were made to remove the air bubble that got trapped on the interface when the tank was filled. For work on the Celebes where conditions were expected to be cleaner, it was decided that the GTD should be mounted with the interface at the top (a) So bubbles would not be trapped and (b) so that it could be cleaned without the need to remove it from the tank. On 20/4/07 a blanking plug in the base of the tank began to leak and the crew turned off the system. On 20/4/07 the system is removed from the Pride of Bilbao as planned. It was returned to NOC to be cleaned and checked ready for shipping to Singapore in May.



The SNOMS OceanBox tank being winched out of the engine room of the P&O Pride of Bilbao

April

David Hydes and Charlene Bargeron attended the meeting on Surface Ocean CO2 Variability and Vulnerabilities, April 11-14 2007 hosted by IOC/UNESCO, Paris. A report of the meeting can be found at -

<http://ioc.unesco.org/ioccp/LatestNews.htm#Article1>

A poster was presented which introduced the work than underway on the Pride of Bilbao. This poster is attached as an Appendix to this report.

May

MV Pacific Celebes was dry docked and refitted in Thailand



The newly repainted bow of the MV Pacific Celebes before the ship left dry dock in Thailand



Stern of the Pacific Celebes showing her single screw

Installation of the SNOMS system on the MV Pacific Celebes in Singapore and Jakarta

18 May

549 kg of equipment was shipped from NOC to Singapore to meet the Pacific Celebes on its arrival



The SNOMS OceanBox Tank on its pallet prior to wrapping and shipping



Gear and bottle crates on their pallet already wrapped ready for labelling

27 May

David Hydes and Jon Campbell fly from Heathrow.

28 May

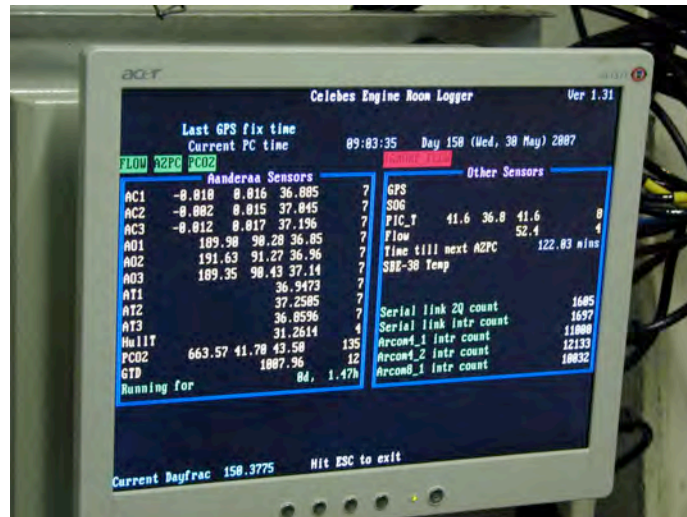
David and Jon arrived Singapore 17:15 local time, and sign on Pacific Celebes. Location of equipment is checked out – all gear appears to have arrived in good condition.

29 May

All fittings and cabling installed on ship checked out Equipment moved down into machinery space or the fitter's workshop. OceanBox tank and electronics cabinet installed in machinery space adjacent to seawater purifier ejector pump

30 May

Rahmon starts work on the Monkey Island frame. Electrical power wired into Machinery space electronics cabinet. Sensors fitted in the OceanBox tank.



First view of machinery space electronics control box data screen

31 May

Completion of installation of OceanBox tank and electronics unit in machinery space First down load of test data. Frame delivered to Monkey Island. Finishing delayed by rain

June 1

Ejector pump which provides seawater supply turned on for first time. It provides a flow >30 litres per minute and there are no significant leaks. Data from Ocean Box tank starts to be recorded. Work on the Monkey Island is completed. Stevenson Screen containing the Met sensors installed and the Iridium GPS box mounted.



Rahmon and Roberto putting the final touches to the Monkey Island frame built by Rahmon



Roberto, Rahmon, Luis and Luis' assistant. The fitting & wiring team



Stevenson Screen and Iridium GPS box on the frame on the Monkey Island

June 2

Bridge GPS checks out OK. First Iridium message sent. Photo call on bridge and Monkey Island



Jon shows Tony, Chris and Francis the contents of the Stevenson screen

Adjustments made to system

Work on training manual and system description underway and first footage for training video shot.

Pacific Celebes sails from Singapore for Jakarta



Sunset off Singapore 2 June 2007

June 3

Data and system checking continues

First versions of the training manual and videos for cleaning the OceanBox tank and the collection of samples completed.

The training manual containing job descriptions and risk assessments is available as NOC Internal Document No. 9 as PDF file from the University of Southampton E-print service (<http://eprints.soton.ac.uk>)



The tools of the trade for cleaning the OceanBox tank

June 4

Pacific Celebes docks in Jakarta

Engineers trained in cleaning and sampling procedures

Final versions of system descriptions and training videos prepared

Tidy up and prepare box for shipping



Team photo of the OceanBox maintenance and sampling squad with their coach



A demonstration of how to use the pipette when preserving the alkalinity and Total CO₂ sample that will be collected each day the ship is underway.

June 5

The SNOMS system and documentation was finished and handed over to the ship.



The SNOMS tank and electronics box in the machinery space on the Pacific Celebes

June 6

David Hydes and Jon Campbell left Jakarta on 6 June.

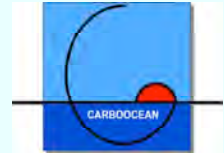
June 10

Chief Engineer (Chris Wilson) e-mailed to say the Pacific Celebes had sailed from Jakarta at 18:00 local time and that the ship had entered clean water and the system was restarted 12:24 GMT.

Appendix

Poster

Presented at 2nd CarboOcean Annual Meeting, Gran Canaria, 4-8, December 2006

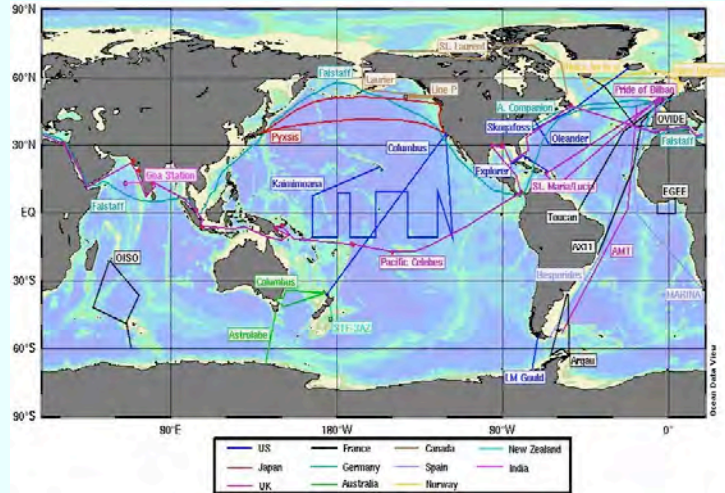


David Hydes (djh@noc.soton.ac.uk)

2nd Annual Meeting Gran Canaria 2006

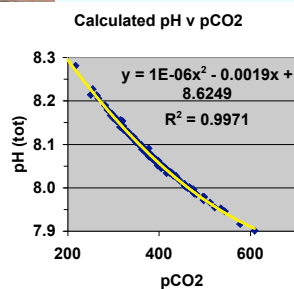
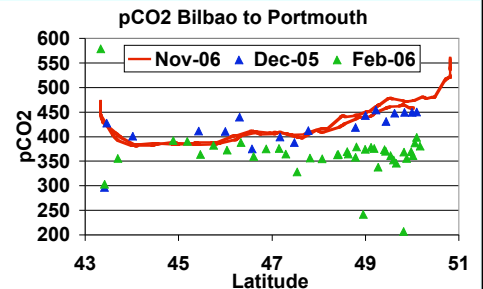
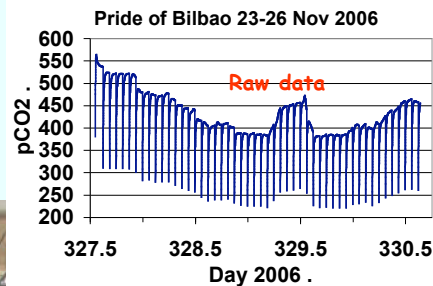
NOC Southampton and the China Navigation Company, Hong Kong (part of the Swire Group) are fitting a pCO₂ measurement system to the MV Pacific Celebes. It is a robust system that can be maintained by the crew who will also collect calibration samples. Water from the sea-chest is pumped through a tank containing Pro-Oceanus CO₂-Pro and GTD (total dissolved gas pressure) instruments, on the lid of the tank are 3 each of Aanderaa conductivity, temperature and dissolved oxygen (optode) sensors. Data will be logged in the engine room and mated with GPS and data from Vaisala atmospheric pCO₂, humidity and air temperature sensors at bridge level. Data will be transmitted to NOC every 4 hours using an Iridium link. At NOC it will automatically transferred to a public web page.

IOCCP Underway VOS Map

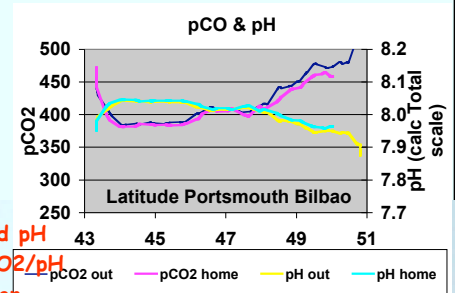


The Celebes operates on a global route taking 160 days to visit. Singapore, Jakarta, New Guinea, Samoa, Tahiti, Panama Canal, Houston, Camden, Halifax, Suez Canal, Jeddah, Mundra, Mumbai, Chennai, Singapore.

Testing the system
23-26 Nov 2006



ProOceanus compared to earlier pCO₂ from TA & TCO₂ measurements



Measured pCO₂ and pH estimated from pCO₂/pH relationship based on measured TA & TCO₂ in this area



Many thanks to many - particularly the Swire Group, P&O, Jon Campbell, Charlene Bergeron, Angus Roberts, Anastasia Charalambopoulou

Appendix

Poster

Presented at :Surface Ocean CO₂ Variability and Vulnerabilities, IOC/UNESCO meeting Paris, April 11-14, 2007

FINE AND GLOBAL SCALE MEASUREMENTS OF CO₂ AND O₂ WORK IN PROGRESS

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 Charlie Bargeron (cpb103@noc.soton.ac.uk)



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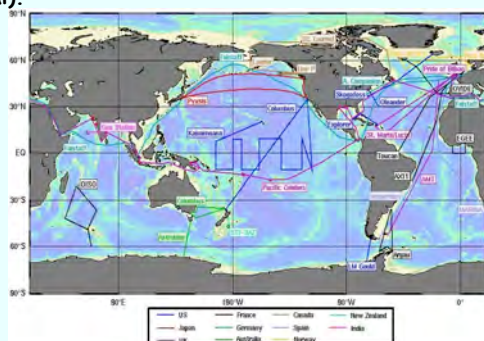
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

Grateful thanks are due to many, particularly Swire Shipping and P&O Ferries; NERC studentship (cpb), NERC-BICEP, EU FerryBox & CarbOcean, Jon Campbell and Mark Hartman; Anastasia, Angus, Cynthia, Holly, Navjit,

VOS measurements are made on a shelf sea to ocean route between Portsmouth and Bilbao:- pCO₂ ("Cooper et al." equilibrator system), dissolved oxygen, fluorescence, temperature and salinity. Regular monthly discrete sampling of nutrients, alkalinity TCO₂ and chlorophyll, is carried out.

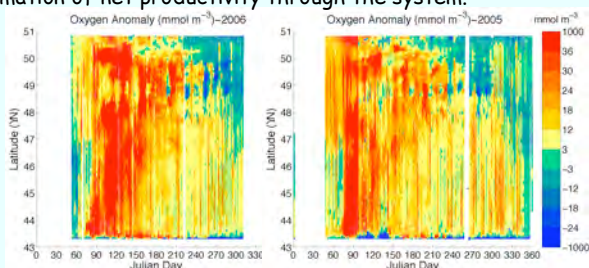


In 2007, with funding from Swire Shipping (Hong Kong), we are going global - fitting a pCO₂ system on a 160 day route (Singapore, Panama Canal, Houston, Halifax, Suez Canal, Mumbai).

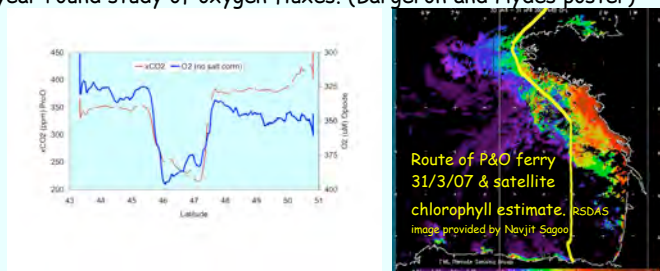


The design has to be robust and serviceable by the ships crew. It uses a Pro-Oceanus CO₂-Pro and GTD (total dissolved gas pressure) instruments, in a tank with Aanderaa conductivity, temperature and dissolved oxygen (optode) sensors - GPS, Vaisala atmospheric pCO₂, humidity and temperature sensors will be at bridge level. Data will be transmitted to NOC every four hours using an Iridium link.

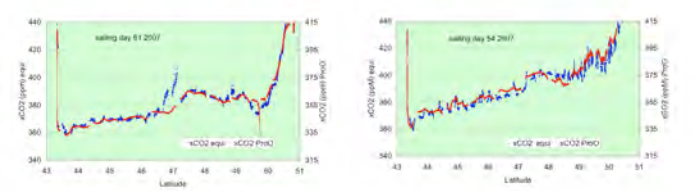
There is a high data repeat rate (four hours to three days) enabling short time scale events to be observed. Bargeron et al., (2006, Est Coast Mar. Sci 69, 478-490) demonstrated the value of oxygen anomaly measurements with calculations of gas exchange for the estimation of net productivity through the system.



In 2005, the system was extended to include measurements of dissolved oxygen using the Aanderaa Optode. The plots above show the calculated oxygen anomaly determined in 2005 and 2006. This data is being used to extend the work of Bargeron et al., 2006 to year round study of oxygen fluxes. (Bargeron and Hydes poster)



The detail achievable using the optode in conjunction with the CO₂-Pro is shown in the plot above - data from 31 March 2007.



In February we began testing the Swire system (below left) against an equilibrator based system (below right). The xCO₂ data track well but there is an offset. We are working on resolving this.

