Theme 1:

Observations and synthesis to establish variability and trends of oceanic pH

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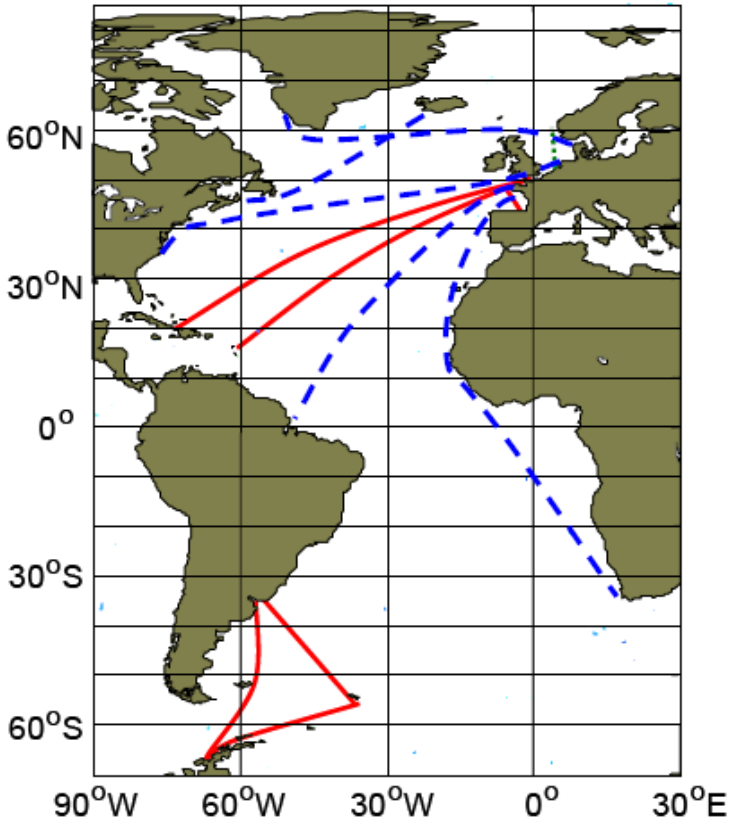
Theme 1: Summary

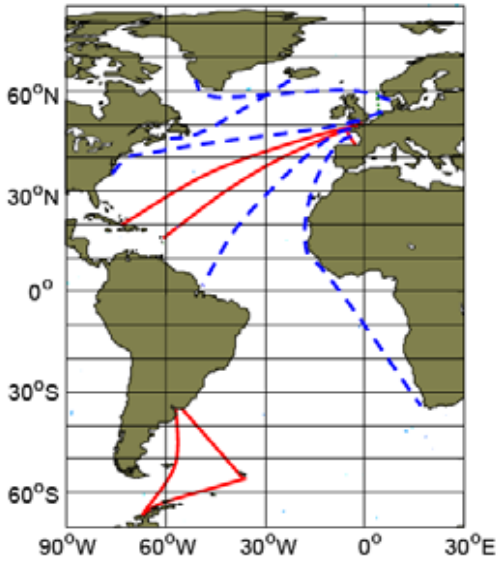
We will carry out a programme of **observations**, combined with analysis of past and ongoing time series, to determine the **magnitude of surface pH variations at seasonal up to decadal time scales**.

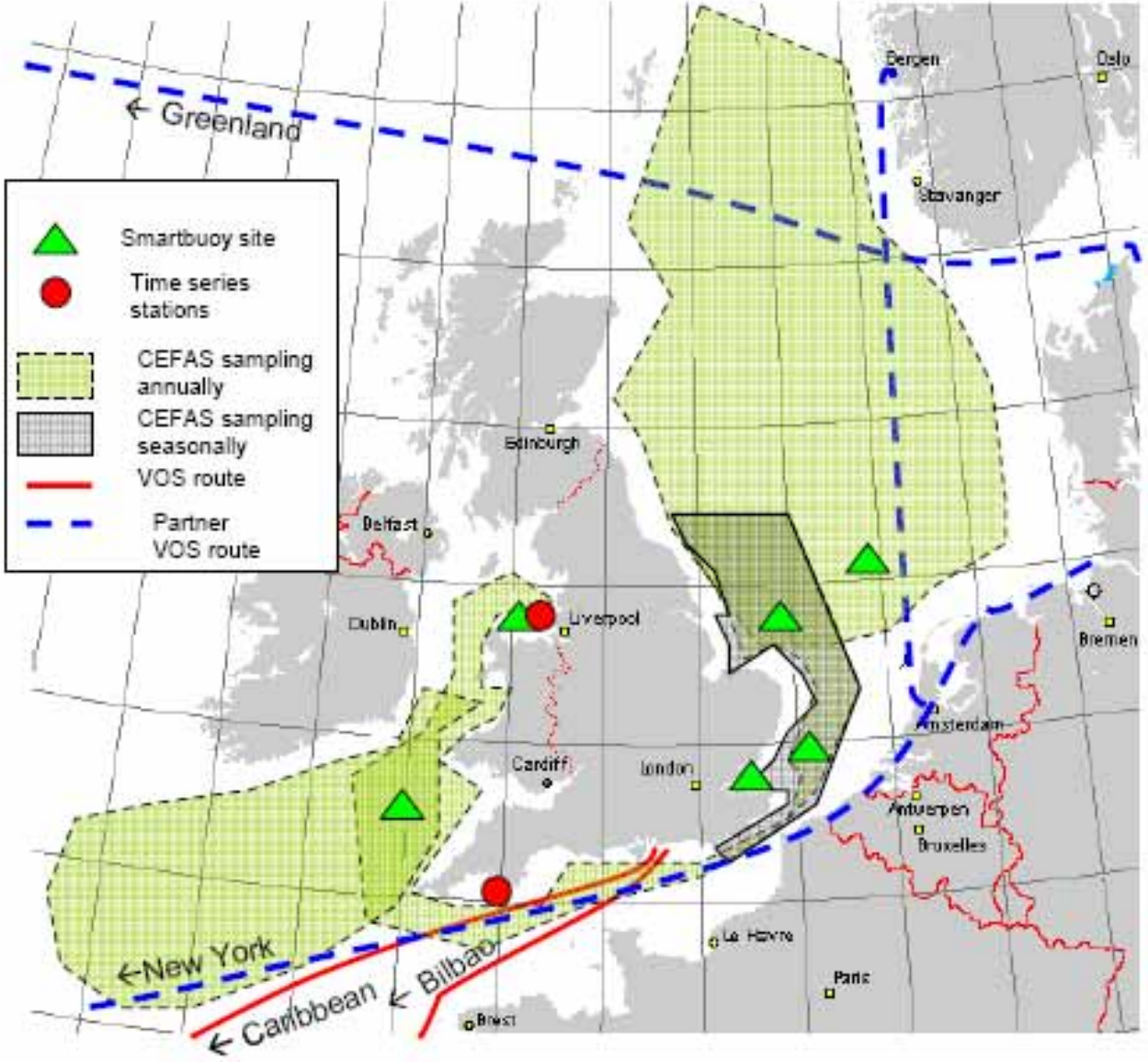
We will address the **North Atlantic, UK shelf and slope waters, and selected locations in the Southern Ocean and Nordic Seas**, using data from time series stations and volunteer observing ships (VOS), measuring **three parameters of the marine carbonate system**.

We will **integrate our observations** with previous and ongoing international efforts, contributing to the SOCAT data base, and to the internationally quality-controlled data relevant to ocean pH.



Theme 1: Location of observations





Theme 1: Aims and objectives

Aim 1.1

To quantify the **rate of progression of ocean acidification** in the Atlantic (including European shelf and slope), Southern and Arctic Oceans, including identification of **when / where $CaCO_3$ undersaturation** will occur first.

Aim 1.2

To quantify **spatial and seasonal variability** of carbonate system parameters in these areas.

Aim 1.3

To improve **quantification** of the rate of oceanic CO_2 uptake in these areas.

Funding beyond UKOARP is needed;

so far funding was from NERC, Defra, and the European Commission

Theme 1: Workpackages

WP1: Maintain/upgrade existing observations

- UK to Caribbean line
- North Sea to North-east Iberian shelf
- Western Channel Observatory (WCO) and Irish Sea coastal observatory (ISCO) – pending (requires further funding)
- *RRS James Clark Ross*

WP2: New observations

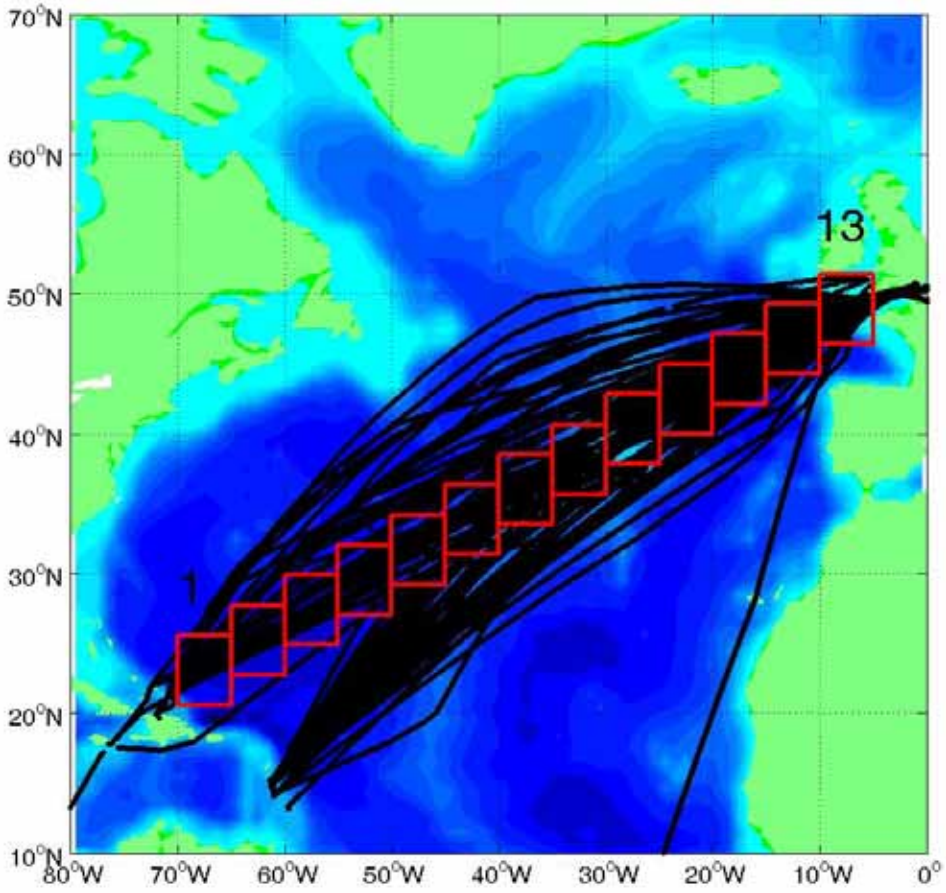
- in Ryder Bay at Rothera Base; by British Antarctic Survey
- *CEFAS Endeavour,* underway pCO_2 system
- *CEFAS Endevour,* regular DIC and TA sampling

WP3: Analysis of past and ongoing time series

- Interpretation of our own observations
- Contribution to the international effort on the ocean carbonate system
- Data archival and availablity

WP4: Management of the project

Estimated and ‘climatological’ change in sea surface pH



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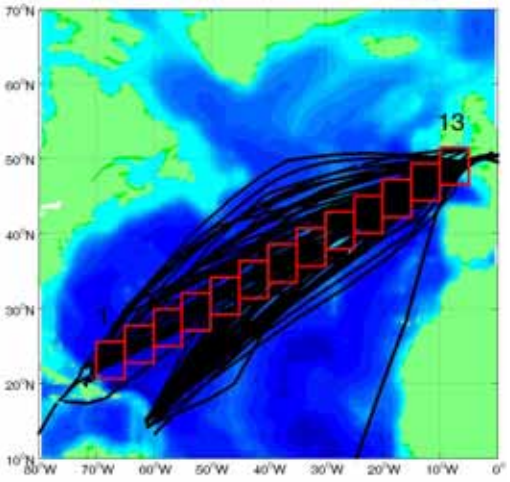
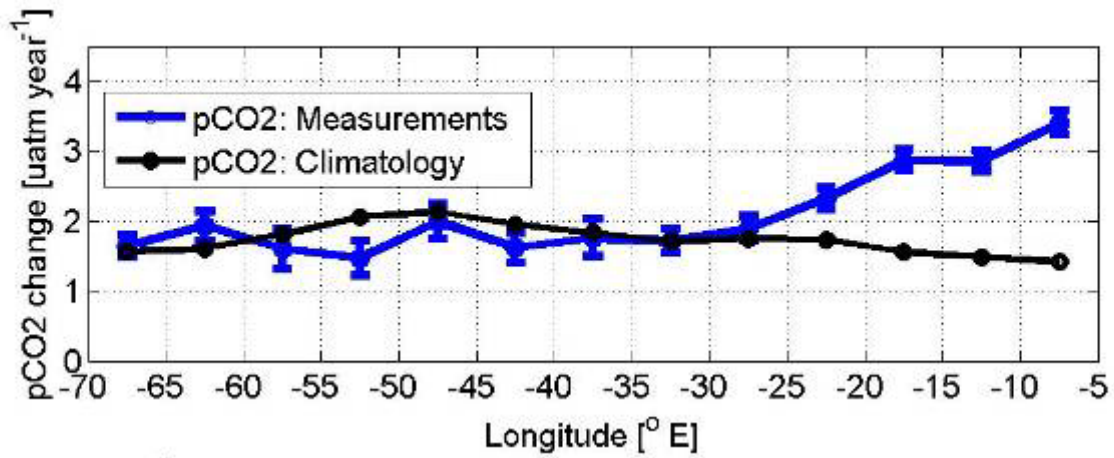
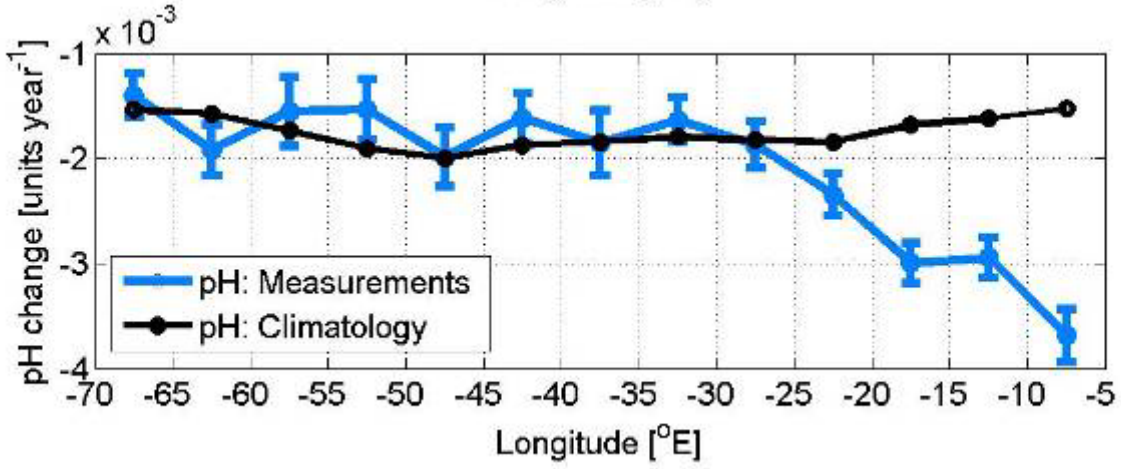


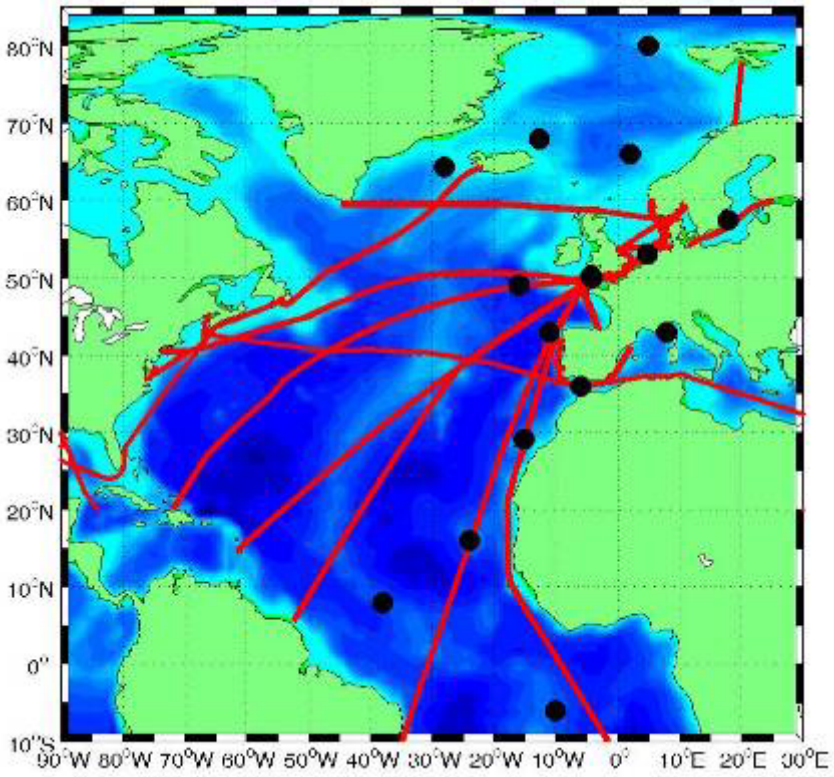


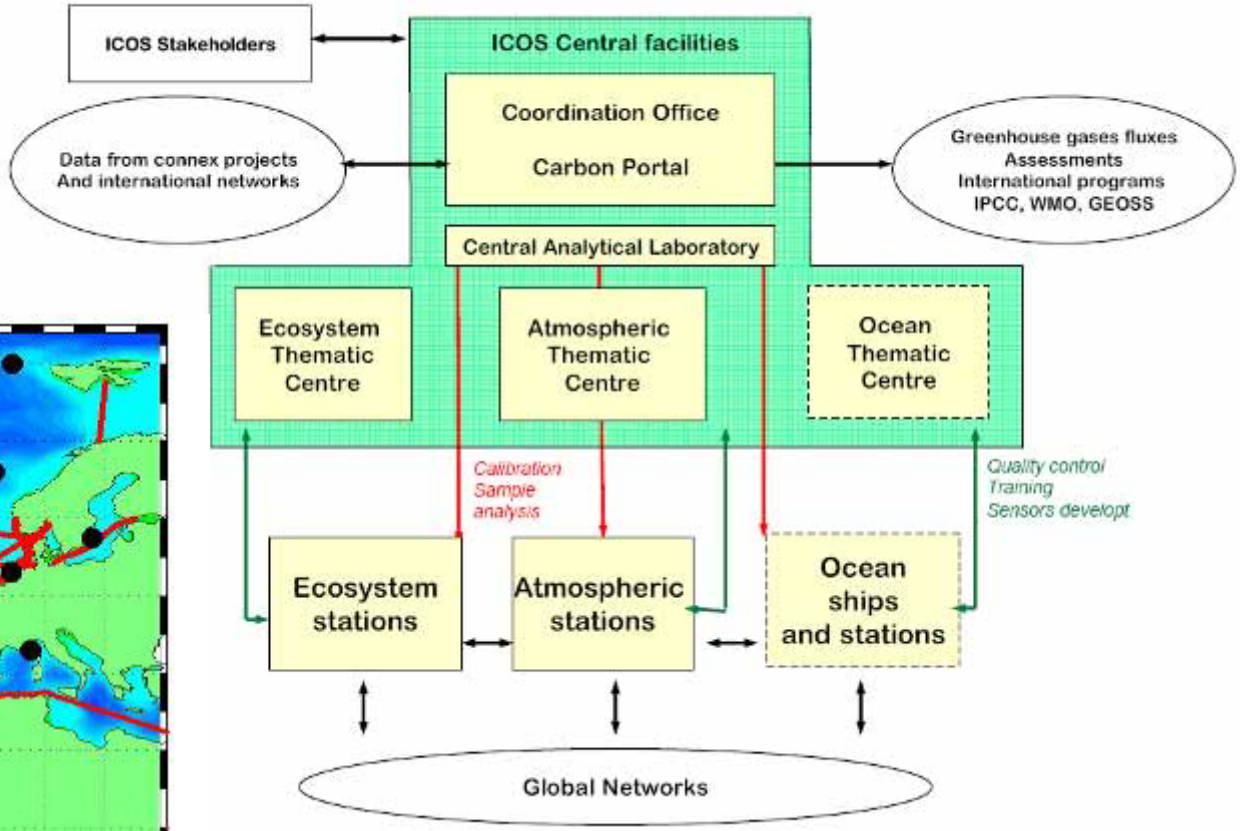


Schuster (2011) in preparation

integrated carbon observation system

A European infrastructure dedicated to high precision monitoring of greenhouse gas fluxes





EU-funded

Starting in 2011

Research Infrastructure for Carbon Cycle Observations

EU proposal submitted November 2010

Integrated non-CO_2 Greenhouse gas Observing System

EU proposal submitted November 2010

NOCS

National Oceanography Centre, Southampton

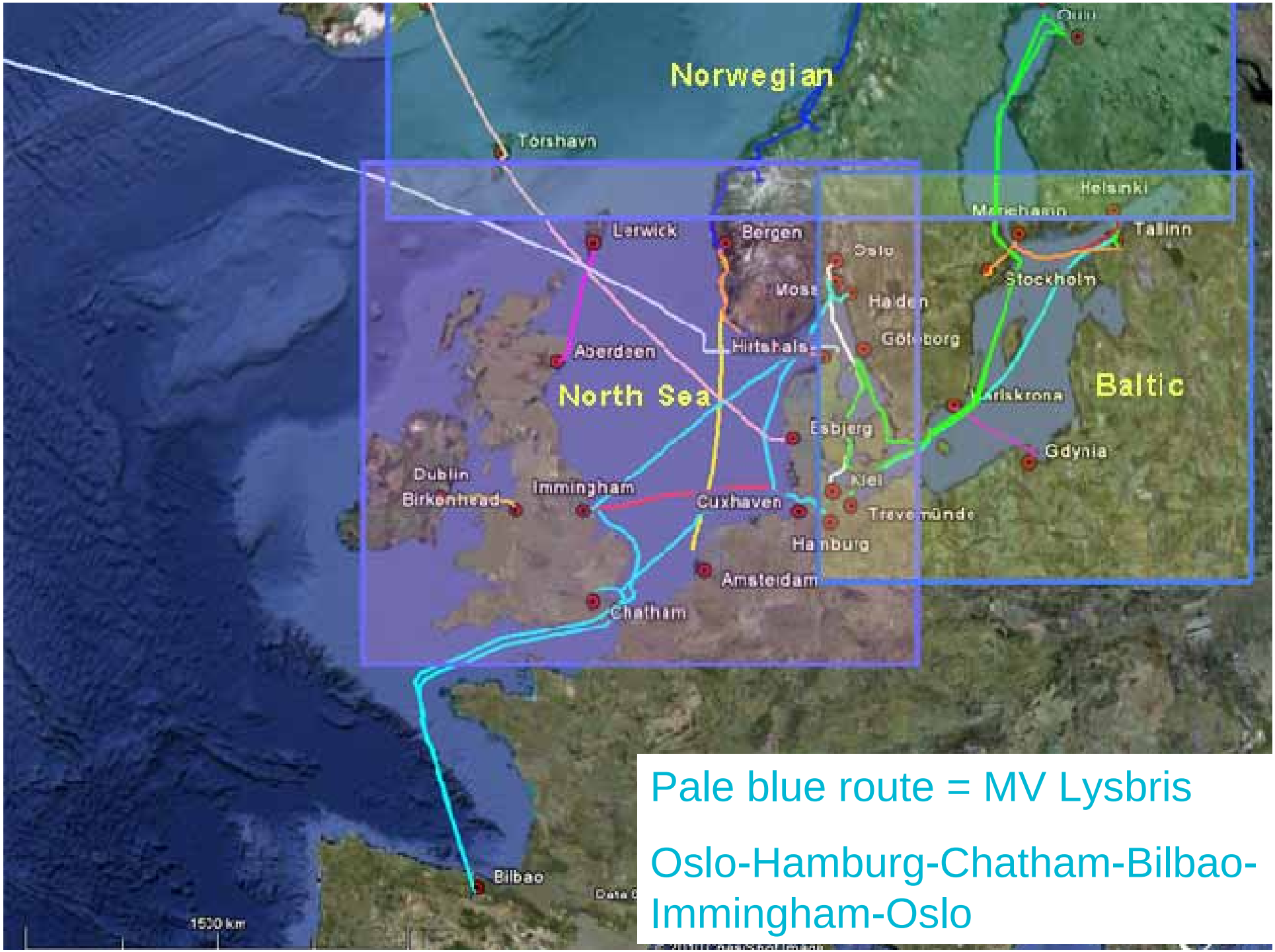
UNIVERSITY OF SOUTHAMPTON AND NATURAL ENVIRONMENT RESEARCH COUNCIL

NOCS working with HZK (GKSS)

News-print and containers

Vessel's Details

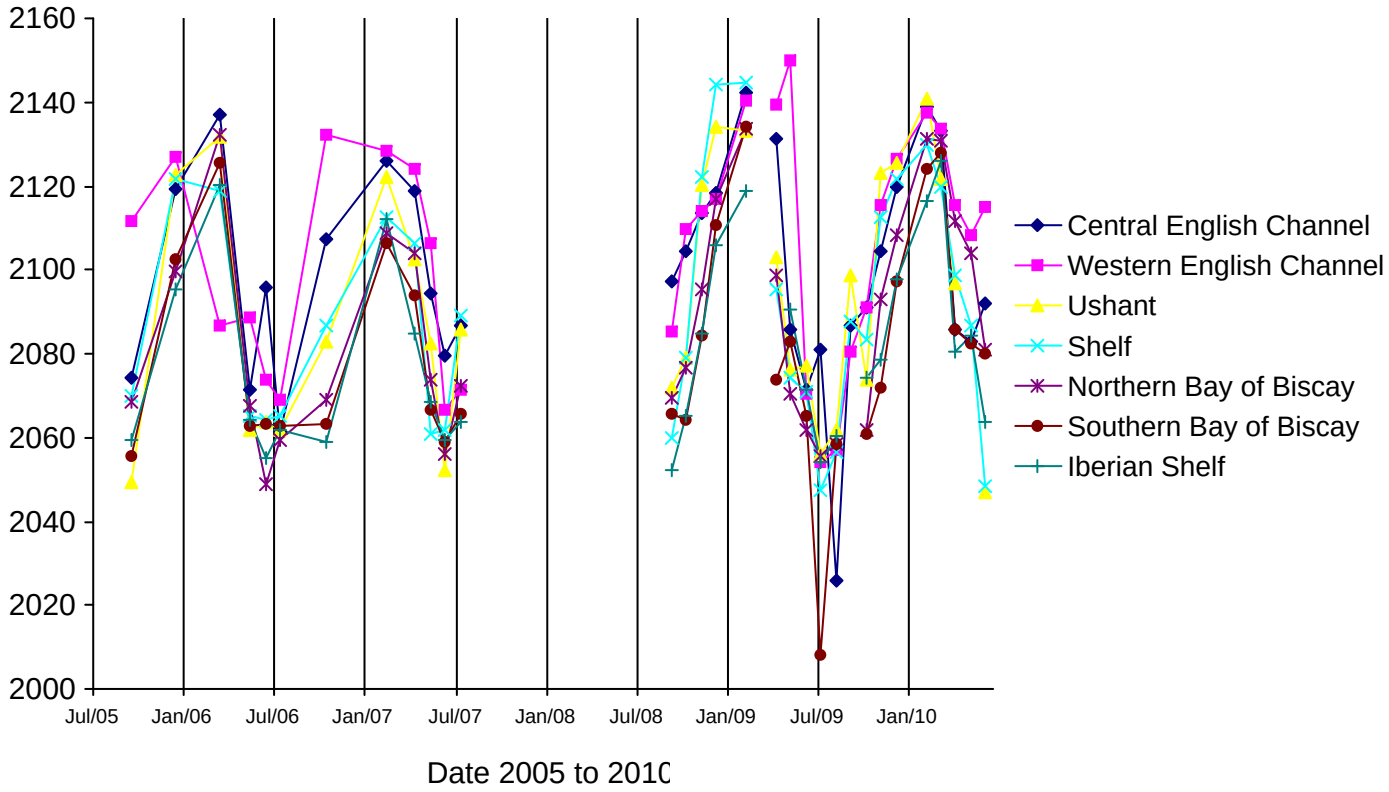
Ship Type: Cargo
Year Built: 1999
Length x Breadth: 129 m X 18 m
DeadWeight: 7500 t
Speed recorded (Max / Average): 16.1 / 13.1 knots
Flag: Norway [NO]
Call Sign: LJLN3
IMO: 9144263, **MMSI:** 259538000



Pale blue route = MV Lysbris

Oslo-Hamburg-Chatham-Bilbao-Immingham-Oslo

Continues Channel to Bilbao time series



Cross links with CEFAS

RWS-BCCR and Roscoff routes

Puts Area-B North Sea cruise into context

Equipment

4H-Jena Ferrybox - Temp, Cond , pH, Fluor-Chl-a, Turb, Nutrients (Nox, PO4, Si, NH4).

Electrode-pH now, **Colorimetric pH & Alk fall 2011**

pCO2 - Contros membrane device Jan 2011

PML - Dartcom equilibrator May 2011

Samples (alkalinity +)

ISCO controllable

water sampler

Collected

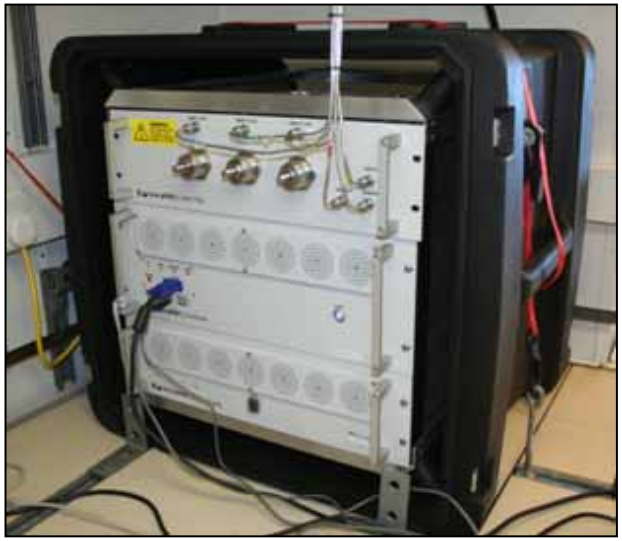
Chatham

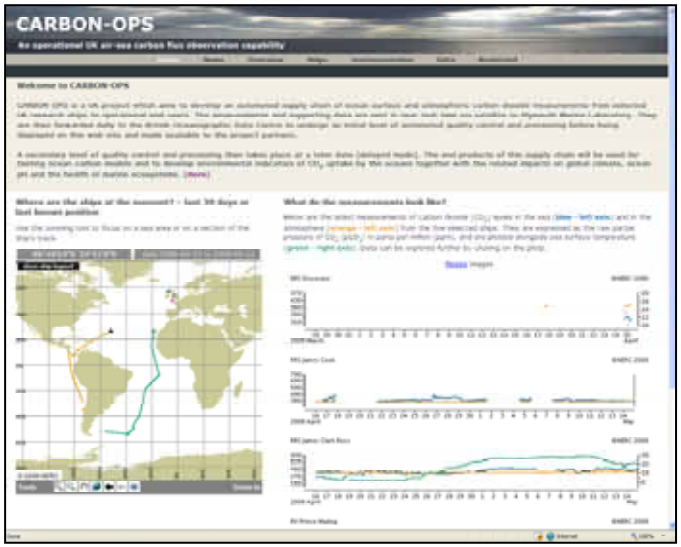
Hamburg +

PML

PML | Plymouth Marine Laboratory

PML *Live* pCO_2 autonomous monitoring





CARBON-OPS /DEFRApH projects (2006-2010)

- Installed on UK research fleet
- Near-real time data supply
- Web tracking (www.bodc.ac.uk/carbon-ops)


R/V Prince Madog


R/V Plymouth Quest


RRS James Cook

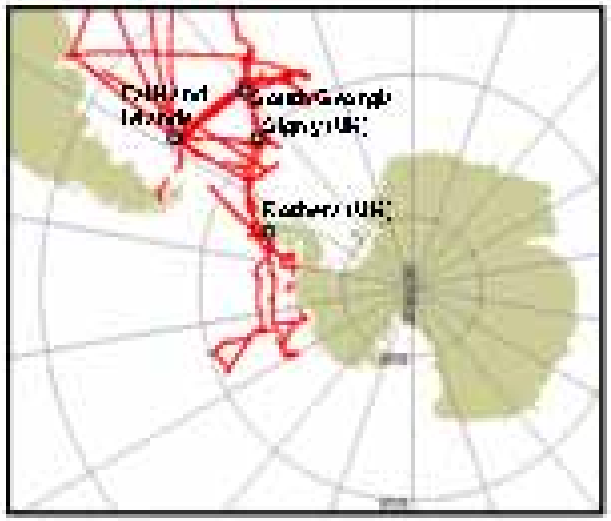

RRS James Clark Ross


RRS Discovery

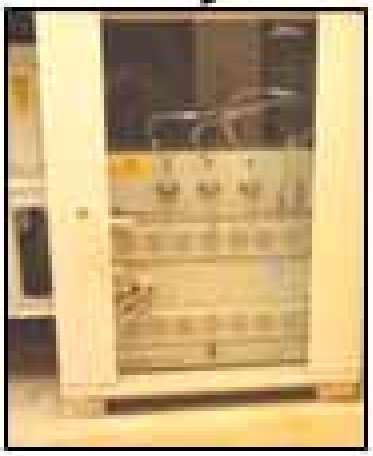
Southern Ocean Monitoring for Ocean Acidification (2010-2013)

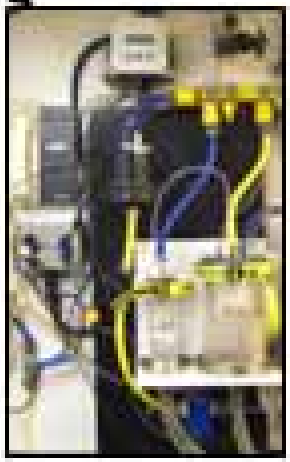
- Consortium funding for observations on *RRS James Clark Ross*:
  - NERC (UK Ocean Acidification Area A, WAGES)
  - EU FP7 CarboChange
- Measurements:
  - Surface ocean and atmosphere pCO_2
  - Surface water A_T and C_T bottle samples
- Analysis:
  - Characterisation of pH variability from observations
  - Rates of CO_2 accumulation and pH change in surface waters
  - Southern Ocean and UK Shelf Seas (results from DEFRApH work)

Sampling for pCO_2 on *RRS James Clark Ross*



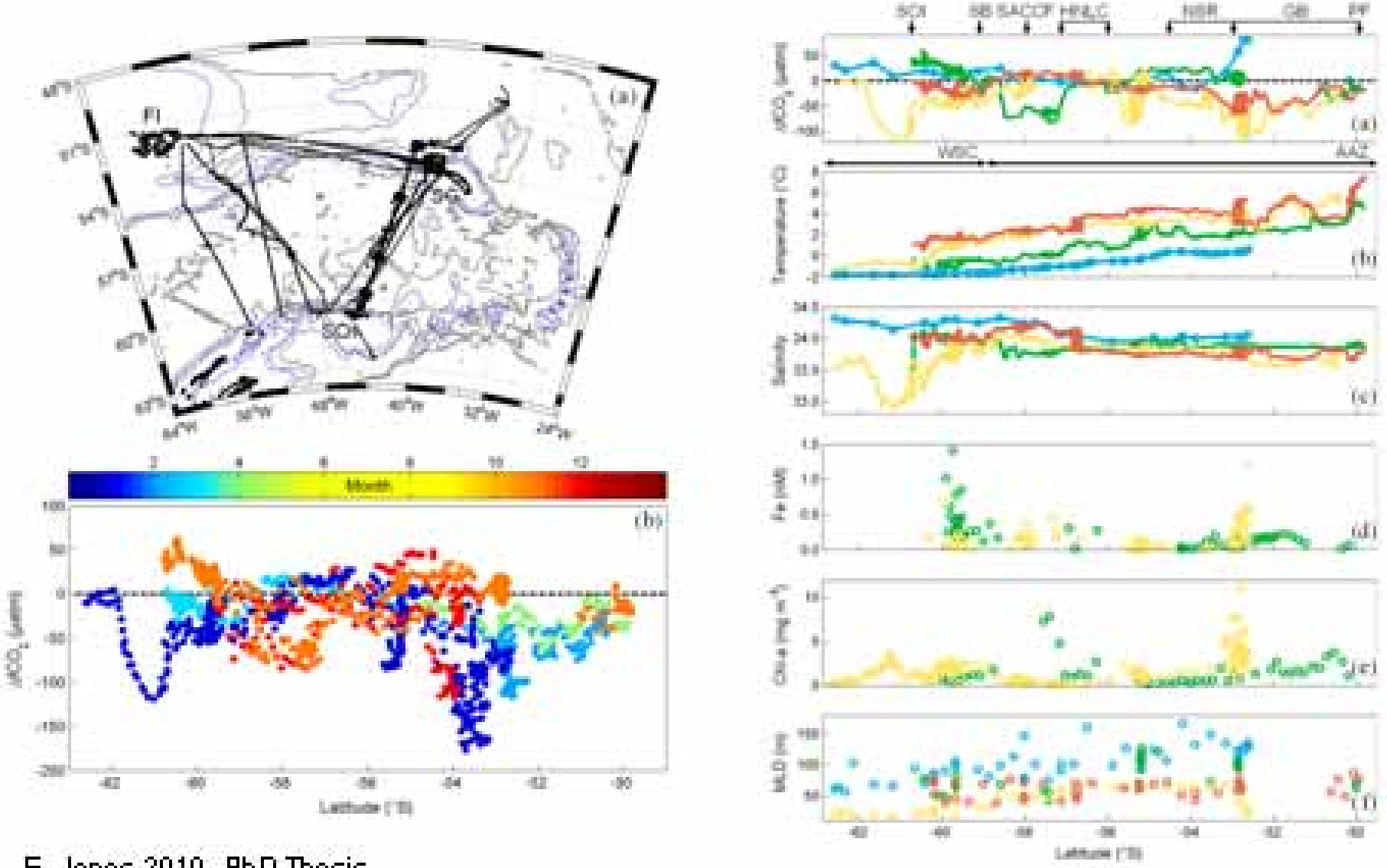
JCR sampling 2006-2010





- Automated measurements of surface ocean and atmospheric pCO_2 on all cruises
- Regular repeat routes between Antarctic bases
- OA work will extend time series until 2013 & add A_T

Southern Ocean: Scotia Sea 2006-2009

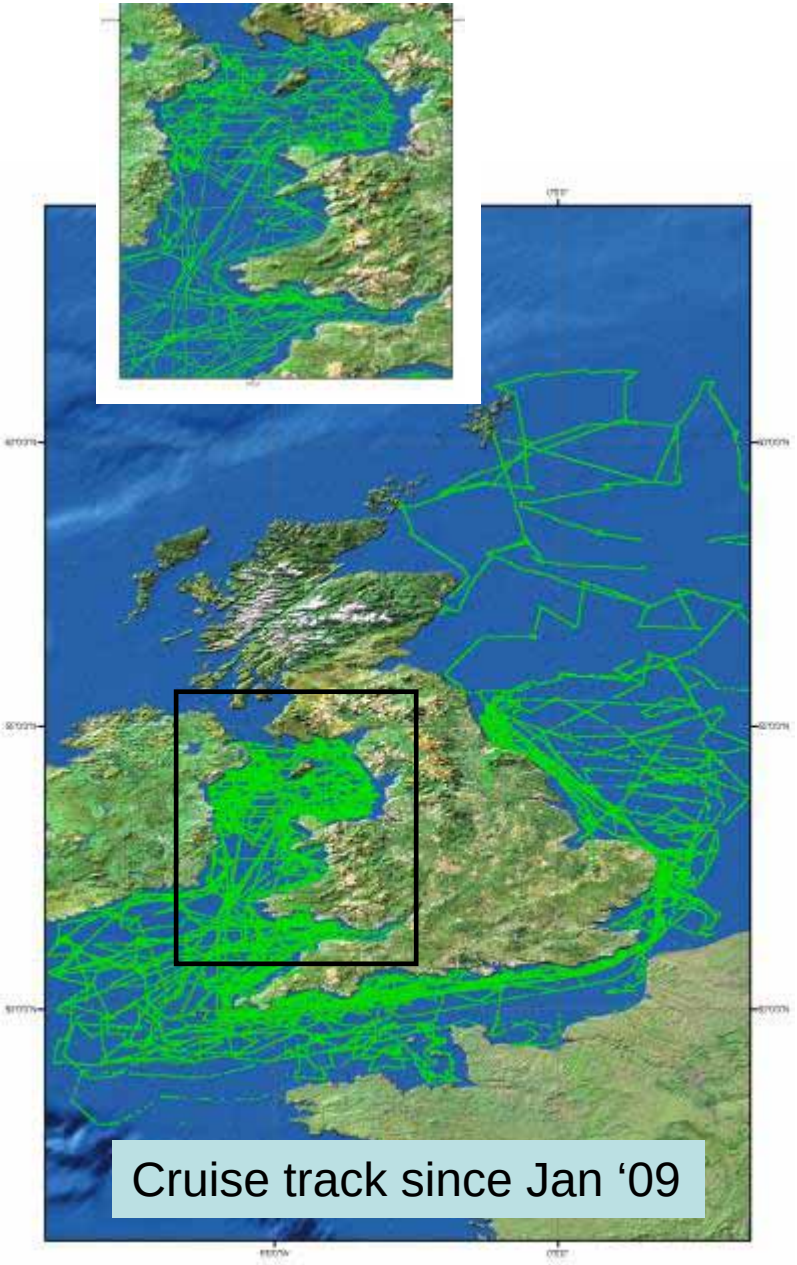


E. Jones 2010. PhD Thesis

CEFAS

Sampling from RV Endeavour

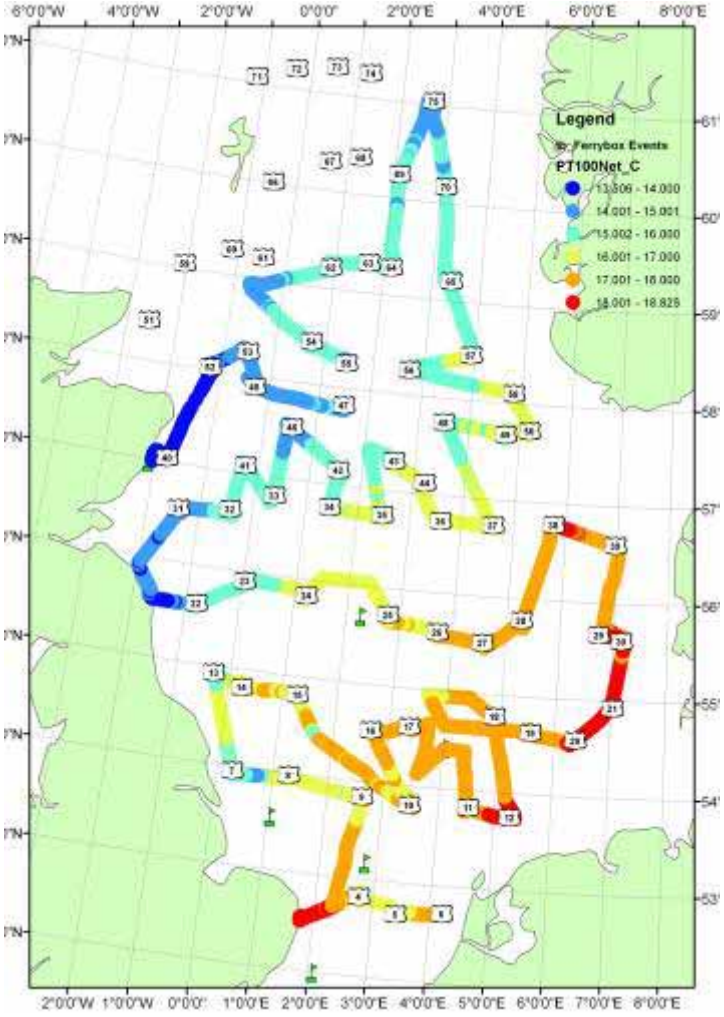
- Comprehensive coverage of UK shelf waters
- Make use of existing cruises



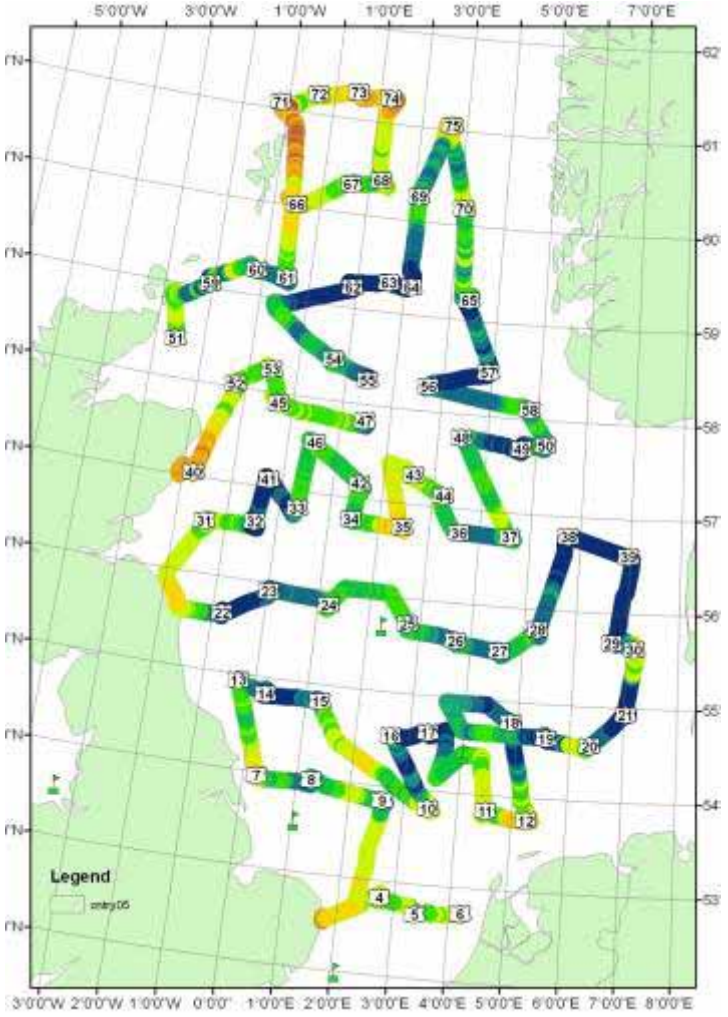
Existing underway sampling capability

- ‘Ferrybox’ since January 2009
- Augment with underway pCO_2 system second quarter of 2011
- Collect ~600 discrete samples per year for TA / DIC (analysis at central facility)

Example coverage during August



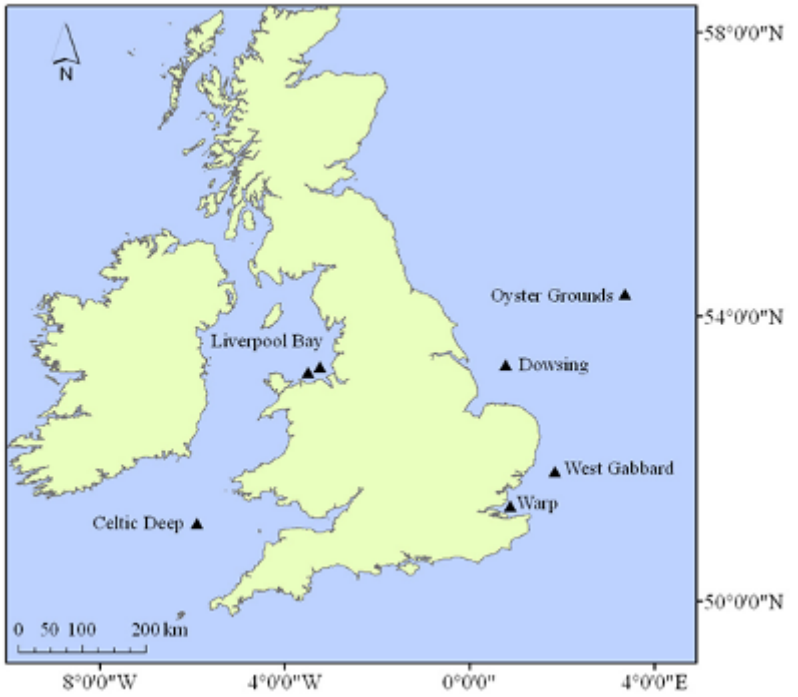
temperature



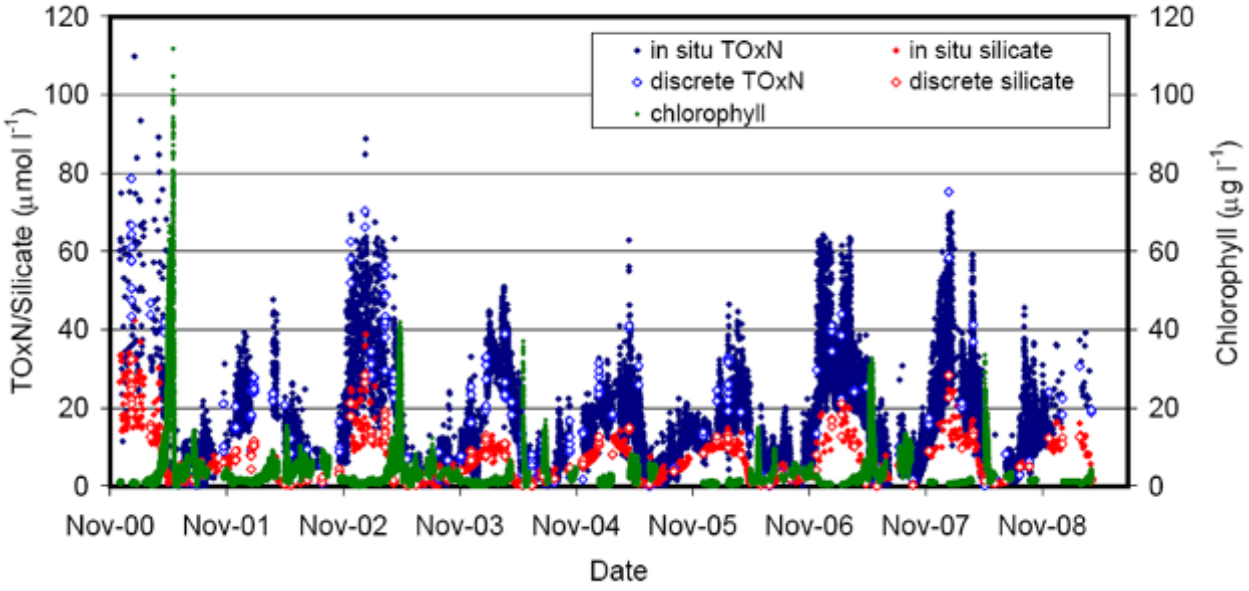
chlorophyll fluorescence

Sampling at SmartBuoy sites

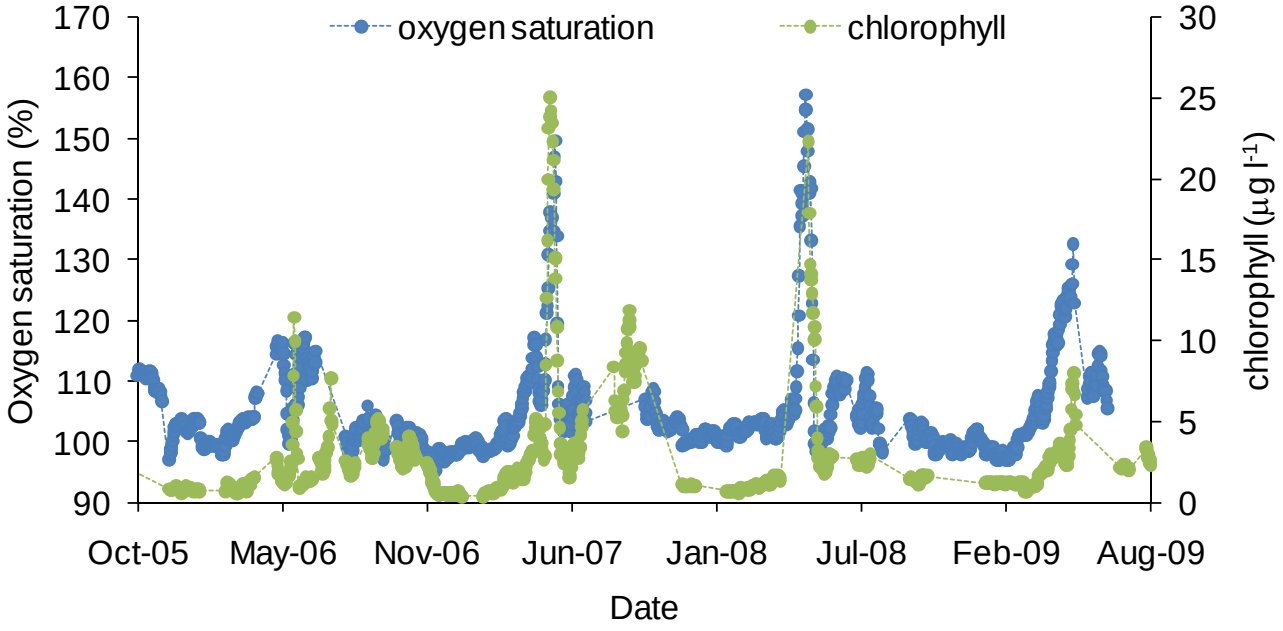
- Operational since Nov 2000 (Warp and Gabbard)
- High temporal resolution - compliment ship based measurements
- Collect discrete samples for TA/DIC ~ 9 times a year
- Sites well characterised (aid data interpretation)
- Potential PhD with UEA using in situ pCO_2 sensor



Variable	Sample frequency
Salinity Temperature Chlorophyll fluorescence Turbidity PAR irradiance Dissolved oxygen	1Hz in 2 x 10 min burst/hr Data acquisition and control via ESM-2
TOxN (total oxidisable nitrogen	Up to every two hours
Dissolved silicate	Up to daily
Phytoplankton counts and composition	Every 4 days



Thames SmartBuoy



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