Shelf Sea Biogeochemistry Research Programme
WP1 (water column).

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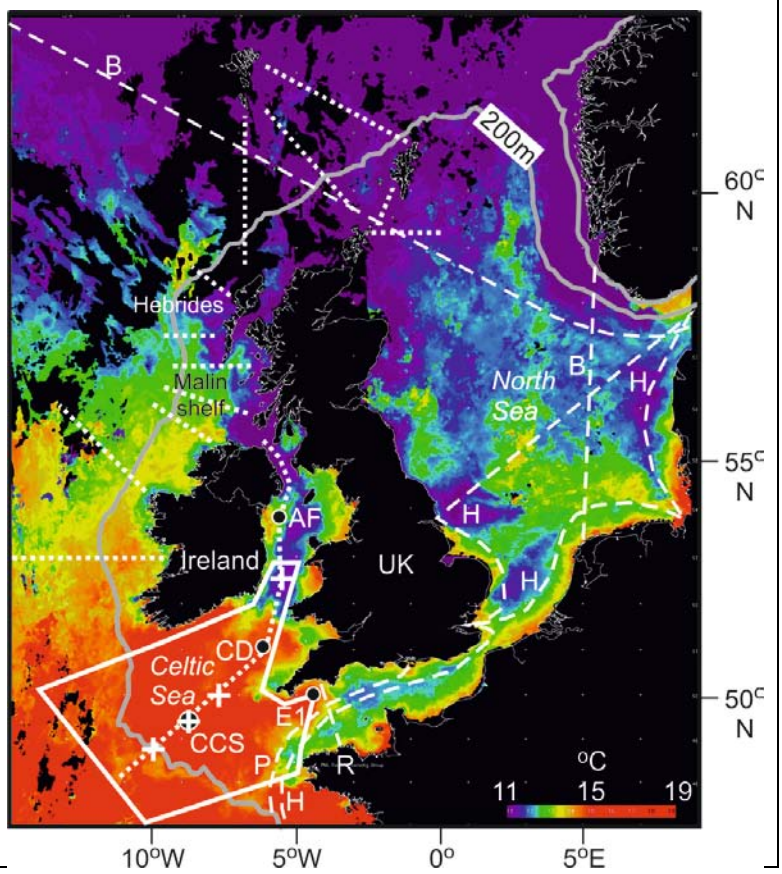
Overall Summary:
Although comprising only ca. 5% of the global ocean area, the shelf seas support 15-20% of global primary productivity and are a critical interface in the Earth System between the land and open-ocean. Consequently, processes in shelf seas play a crucial role in global biogeochemical cycles of nutrients, and these high productivity systems may have a significant influence on ocean CO_2 storage. The goals of this project are (1) to quantify the role of the NW European shelf seas in the global nutrient and carbon cycles, and (2) to understand the critical processes by which this role is sustained. Our programme will rely on a year-long whole NW European shelf sampling programme using vessels of opportunity (Objective 1) along with process studies on 4 cruises in the Celtic Sea (Objective 2). The whole shelf sampling programme will allow a synoptic assessment of the distribution and cycling of inorganic and organic carbon and nutrients, CO_2 and N_2O. We will estimate the air-sea fluxes of CO_2 and N_2O. We will quantify the biogeochemical exchanges between the shelf and open ocean through collaboration with the FASTNEt shelf edge physics programme. The process studies in the Celtic Sea will measure autotrophic and heterotrophic elemental uptake rates and their stoichiometric alterations, underpinning our understanding of the mechanisms by which the biogeochemical cycling of carbon, nitrogen, phosphorus and silicate in a shelf sea support any net flux of carbon to the deep ocean. This will allow identification of climate-sensitive drivers of the shelf sea system, and support the improvement of numerical models.

The region of shelf over which we will calculate the magnitude of the CSP. The image is a one week composite of summer SST. The grey 200m isobath is the shelf edge. Black dots show long-term moorings (E1-PML, AF-AFBI, CD-Cefas, CCS-deployed through this proposal). Process cruises cover the polygon (white solid line). White crosses indicate the 3 stratifying and 1 mixed process stations. Dotted lines are additional sampling opportunities for depth profiles (Marine Scotland, FASTNEt NOC, Marine Institute, AFBI). Dashed lines are ferry box routes (R-SBR, B-UoB, H-HZG, P-ULP). Daily surface samples through 2014 (not marked) will be covered by Cefas (central and S North Sea, English Channel, Celtic Sea), Marine Scotland (N North Sea, N and W Scotland), Marine Institute (W Ireland, Celtic Sea), AFBI (Irish and Celtic Seas).



Main Objectives:
Objective 1: *Estimate the size of the shelf pump over the whole NW European shelf, and its relationship to the global carbon cycle.*
We will achieve this in 2 ways. First, over 12 months we will collect observations of air-sea CO_2 fluxes, interpolate spatially and temporally and integrate over space and annually. This is analogous to work in the North Sea, but on a larger scale. Second, we will estimate concentrations

of C, N, P and Si in water flowing on and off the shelf and combine these with measurements of fluxes at atmospheric and sedimentary boundaries and via rivers (including collaborative work with the sediments workpackage of SSB). Coupled to estimates of transports across the shelf edge (the FASTNEt shelf edge physics programme and recent summaries) this will allow an observational estimate of the net off-shelf transport of C, N, P and Si. For C, accounting for any significant riverine or atmospheric influences, this should equal the net air-sea flux. Comparison of the C and N, P, Si fluxes will provide a provisional estimate of the relative importance of the solubility and biological components of the CSP. Observations will be made using pCO_2 systems and sampling opportunities aboard partner vessels and ferry boxes during their normal cruise schedules over the year 2014, along with measurements carried out from FASTNEt cruises and our own process-focused cruises.

Objective 2: *Determine the relative importance of external nutrient sources and internal biogeochemical cycling in maintaining the shelf pump.*
The stoichiometry of nutrients flowing on- and off-shelf at the shelf edge will provide an estimate of any on-shelf excess nutrient supply. During 4 process cruises, and using new and established moorings, we will further quantify the biogeochemical cycling by examining: (1) The uptake ratios of N, P, Si and C and the stoichiometry of organic matter produced by autotrophs; (2) How these ratios are modified within the foodweb above and below the thermocline and (with the SSB sediments workpackage) in the sediments; (3) The relative importance of microbial and zooplankton turnover of organic matter. The focus on biogeochemical processes under this Objective will also provide new descriptions of poorly understood or represented processes in numerical models through close collaboration with the SSB modelling workpackage.

Main hypotheses and outline of planned work:
H1: The NW European shelf is a net annual sink for atmospheric CO_2.
Work involves co-ordination of the multi-institute whole-shelf sampling campaign, analysis of the water samples, and integration/ interpolation of the datasets towards seasonal and monthly whole-shelf fields of inorganic nutrients, organic matter and CO_2 fluxes.
H2: The dominant source of new N and P to the shelf is the adjacent open ocean.
Data will be collected on shelf-ocean nutrient and carbon exchange from the whole-shelf sampling campaign and the process cruises. Winter physics and nitrate data will be used to assess shelf nutrient replenishment. Diapycnal supply of nutrients to the euphotic zone will be measured. Shelf edge particle transports and shelf sediment nutrient efflux will be included via the SSB sediments workpackage.
H3: Autotroph community structure and resource availability influence the stoichiometry of organic matter through increasing C:N:P:Si ratios under nutrient depleted conditions.
Process experiments in the Celtic Sea to quantify the uptake of inorganic C, N, P, Si by the autotrophs, the partitioning of organic matter into dissolved and particulate forms, and the phytoplankton community structure.
H4: Zooplankton ingestion of, and requirements for, organic substrates has significant effects on organic and inorganic C:N:P.
Experiments during process cruises, and work at station E1 in the western English Channel, to quantify the role zooplankton have on C:N:P, relate zooplankton productivity to C:N:P available in the autotrophs and quantify changes in organic matter C:N:P driven by zooplankton assimilation/ excretion/egestion.
H5: Remineralisation of POM and DOM creates a carbon-rich residual organic matter pool.
During the process cfruises in the Celtic Sea, determine the fate of organic material as processed by bacteria, including different mineralization rates of C, N, P and the contrasts in mineralization between particle sizes/ types/origin.