The cycling of organic carbon in the Irish marine environment and at 'cold seep' features

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Project Outline

The aim of this project is to combine recent advances in molecular ecology and analytical techniques to study (i) the cycling of natural and anthropogenic carbon in Ireland's marine environmnent and (ii) chemical and biological processes at cold seeps in Irish waters. There will be a particular emphasis on the the degradation of a marine sedimentary hydrocarbon - ranging from natural allochtonous and autochtonous organic matter and natural hydrocarbons (methane) at cold seeps, to anthropogenic pollutants such as polyaromatic hydrocarbons and oil-related aliphatic hydrocarbons. This project shall utilise next generation 454 metagenomic sequencing and other molecular biological techniques coupled with advanced analytical techniques such gas chromatography-isotope ratio mass spectrometry (GC-irMS) and 1- and 2D nuclear magnetic resonance (NMR) to characterise the source and fate of aforementioned organic compounds in the marine environment and the microbial communities associated with and involved in their degradation.

Current site locations

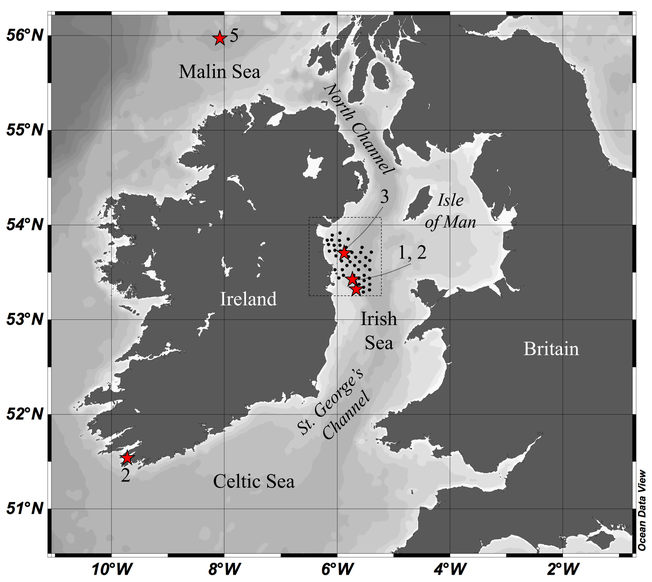

Figure 1: Map of current site locations

★ Cold seep sites – Codling Fault Zone carbonate mounds (1), Dunmanus Bay pockmark field (2), Irish Sea mudbelt pockmarks (3), Lambay Deep mud diapir (4), Malin Sea pockmarks (5). Surface sediment samples and up to 6 metre cores taken

Western Irish Sea mudbelt – high resolution surface sediment samples and regional sediment cores taken

Cold seeps in Irish waters

A number of natural hydrocarbon "cold seep" features have been discovered in recent years in Irish waters. These include pockmarks, which are seabed depressions of diverse size and morphology, mud diapirs (seabed doming expressions) and methane-derived authigenic carbonates mounds (Fig. 1). This project aims to assess the seepage activity of these sites and investigate the unique microbial communities mediating formation and degradation processes at these sites.

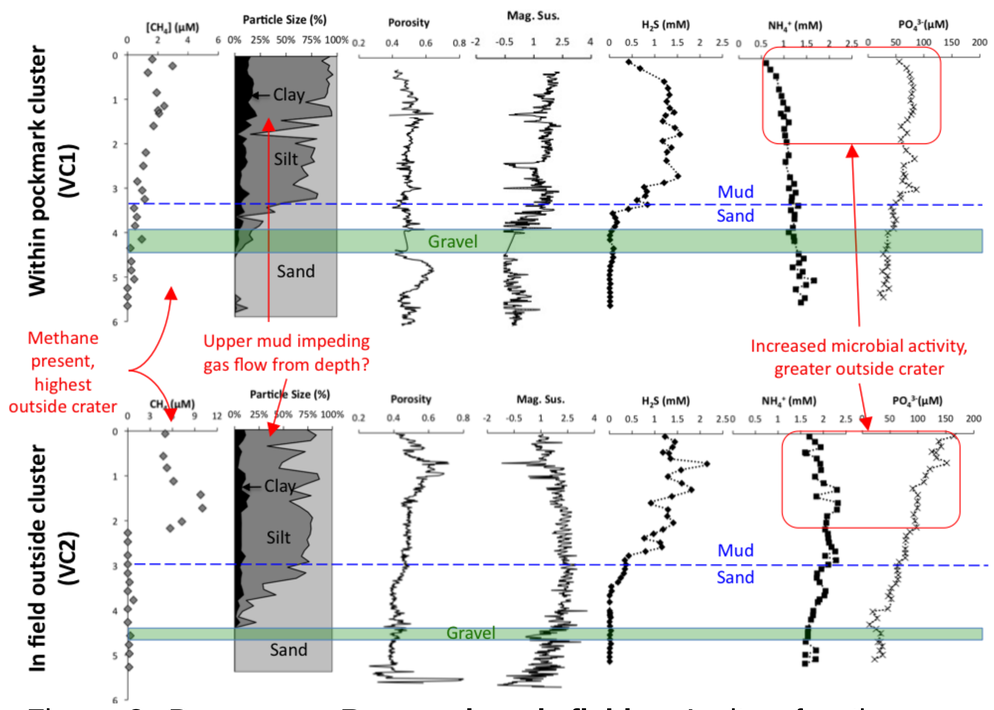

Figure 2: **Dunmanus Bay pockmark field** – A site of active seepage and increased microbial activity in gassy sediment strata within field.

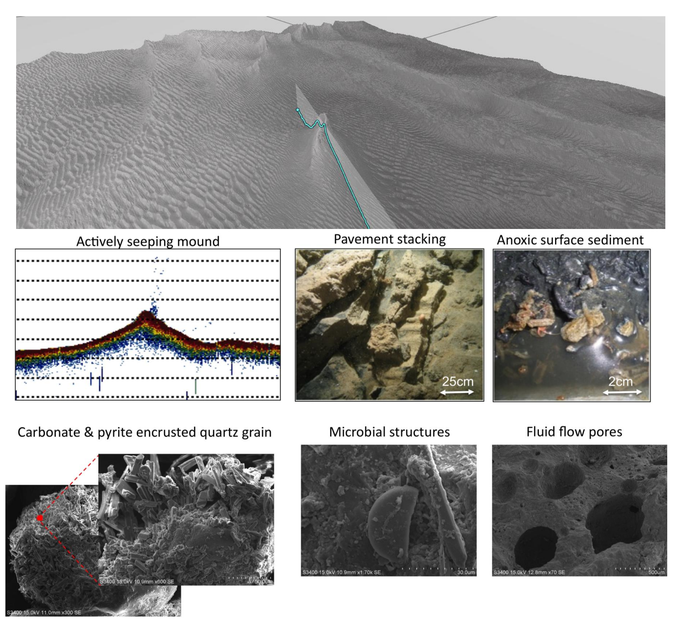

Figure 3: **Codling Fault MDAC mounds** – A site of active hydrocarbon seepage and unique associated microbial diversity. Methane is precipitated as $CaCO_3$ over geolgical timescales to form dramatic seabed features. This process is mediated by unique microbial consortia.

Cycling of Natural and anthropogenic organic carbon in the Irish marine environment

The western Irish Sea mudbelt is a site of anthropogenic and natural organic matter deposition. The transport and fate of total organic carbon (Fig. 4C), anthropogenic hydrocarbons (polyaromatic hydrocarbons, Fig. 4D) and terrestrial organic matter (plant hydrocarbons, Fig. 4E) is controlled by the distinct hydrographic and depositional regime in the Irish Sea (Fig. 4A & B). Benthic microbial community diversity is varied across the region (Fig. 5) and likely controlled by a variety of factors i.e. water depth, grain size and TOC. Using 454 metagenomic sequencing and multivariate statistical analysis of bulk (e.g. Fig. 6) and molecular parameters we wish to elucidate the primary controls on the fate of organic compound classes and to characterise the microbial communities engaged in the degradation of these compounds.

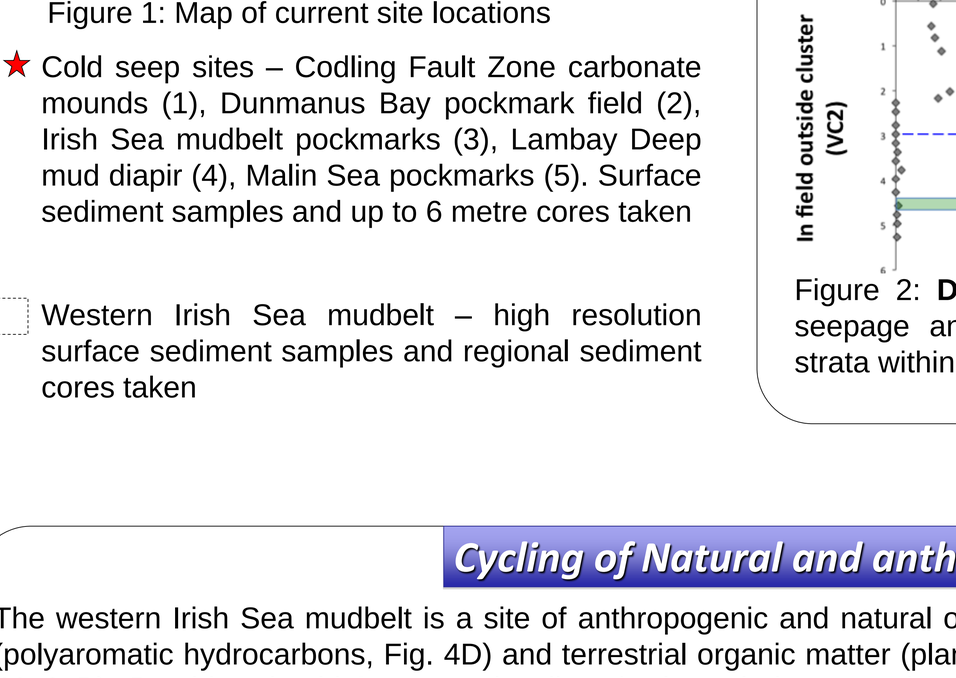

Figure 4: Distribution of grain size (A), mud (B), total organic carbon (C), polyaromatic hydrocarbons (D) and terrestrial plant alkanes (E) in western Irish Sea surface sediments

Figure 5: Denaturing gradient gel electrophoresis (DGGE) of bacterial community diversity across surface sediments in the Irish Sea mudbelt

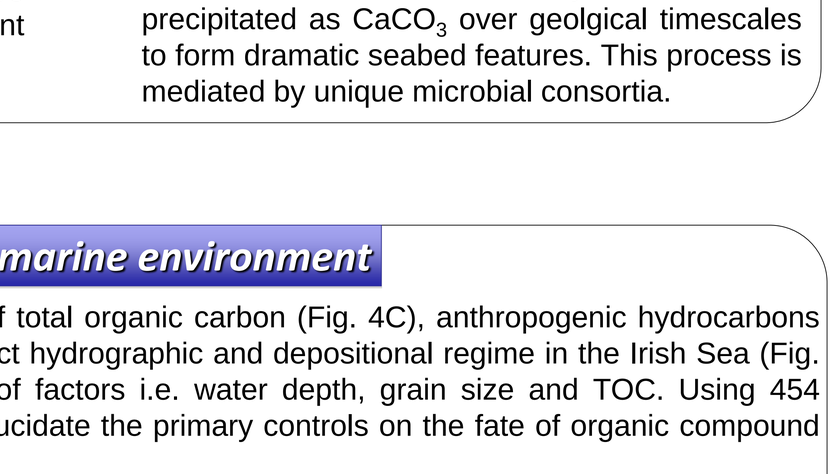

Figure 6: Principal component analysis of bulk physical and chemical parameters in western Irish Sea surface sediments