Synergies between the Sentinel Satellites and the use of Bio-optical and Flow cytometric measurements for tracing surface slicks along the Irish Western Shelf

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INTRODUCTION

- A challenge facing industry is the ability to distinguish maritime accidents from naturally occurring phenomena such as phytoplankton blooms and natural oil seeps [1].
- This project aims to link detection and monitoring of these natural and manmade surface slicks with satellite observations. Launch of the sentinel series of satellites provides opportunities for the fusion of *in situ* sampling with remote sensing. Products such as SAR roughness *(Sentinel 1)* and Ocean Colour *(Sentinel 3)* will be used.
- Sampling has been carried out across the western Irish coastal shelf on the *Celtic Explorer* last June (CE18009) and July (CE18010).

METHODS

- Conductivity Temperature and Depth (CTD) measurements are taken at sea *(Image 1)*.
- Flow cytometry *(Image 2)* and microscopic enumeration methods are used to identify pico/nano and phytoplankton species. This includes identification of Harmful Algal Bloom species (HAB's).
- For chlorophyll concentrations, seawater was filtered through 25 mm GF/F filter. The filters were frozen and analysed back on land.
- Baseline optical measurements of CDOM, FDOM and nutrients will be taken from surface waters. Absorption is obtained using Ocean Optics Spectrometers *(Image 3)*.
- Studies on the optical characteristics of CDOM formed from actively growing cultures of phytoplankton species such as *Emiliana huxleyi. (Image 4)*.
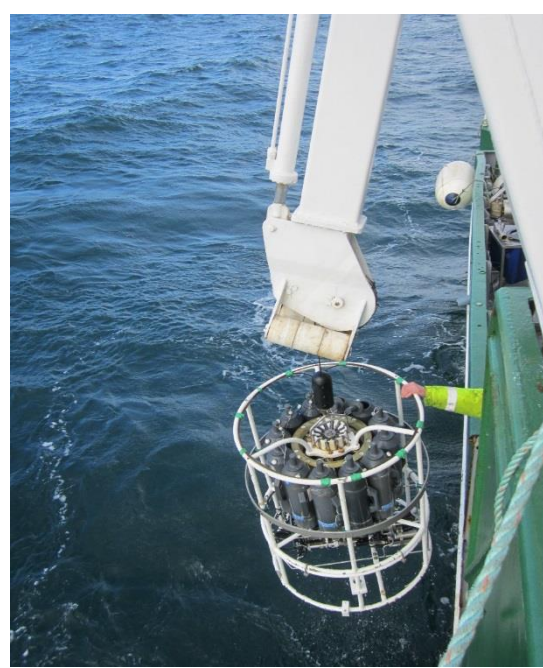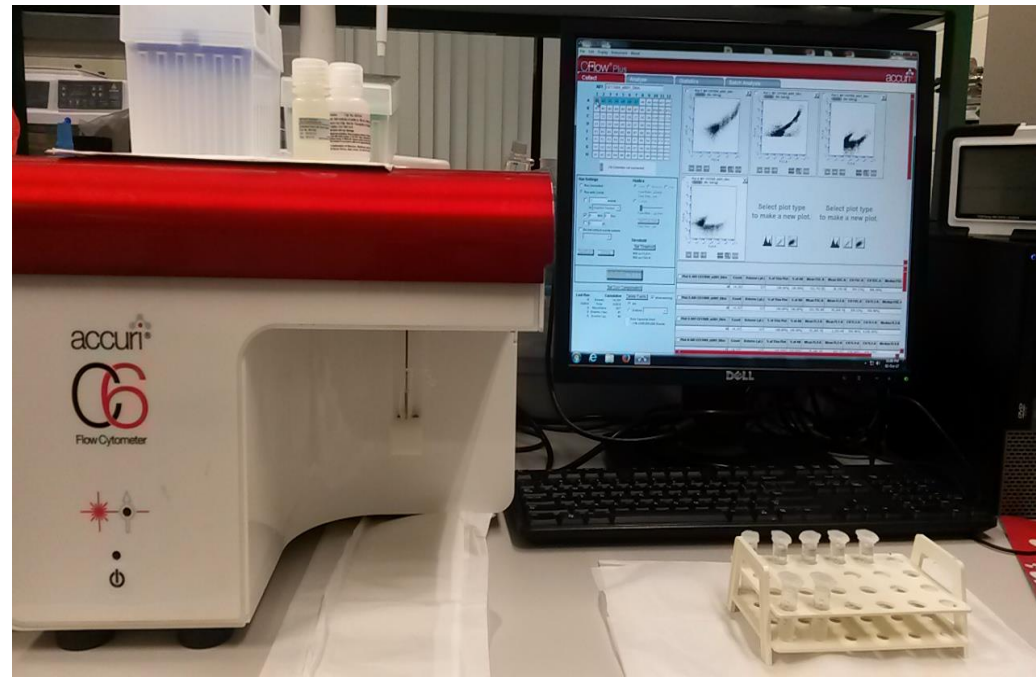

Image 1: Collecting seawater samples

Image 2: Phytoplankton abundance via BD Biosciences Accuri C6 Flow Cytometer
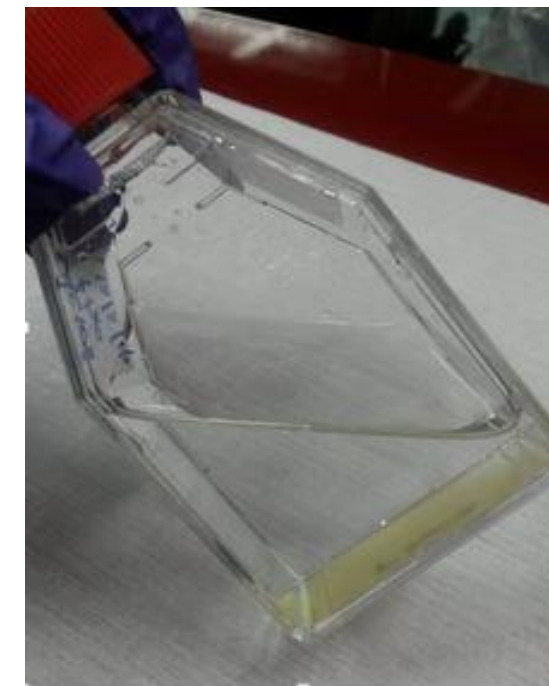

Image 3 : Running CDOM samples on spectrometer

Image 4: Culturing Coccolithophores

PRELIMINARY RESULTS & DISCUSSION

Satellite observations:

- The warm dry summer experienced during *WESPAS 2018* provided an unprecedented number of clear sky days for obtaining good satellite images of the ocean colour distribution over the North West European shelf. *[5]*
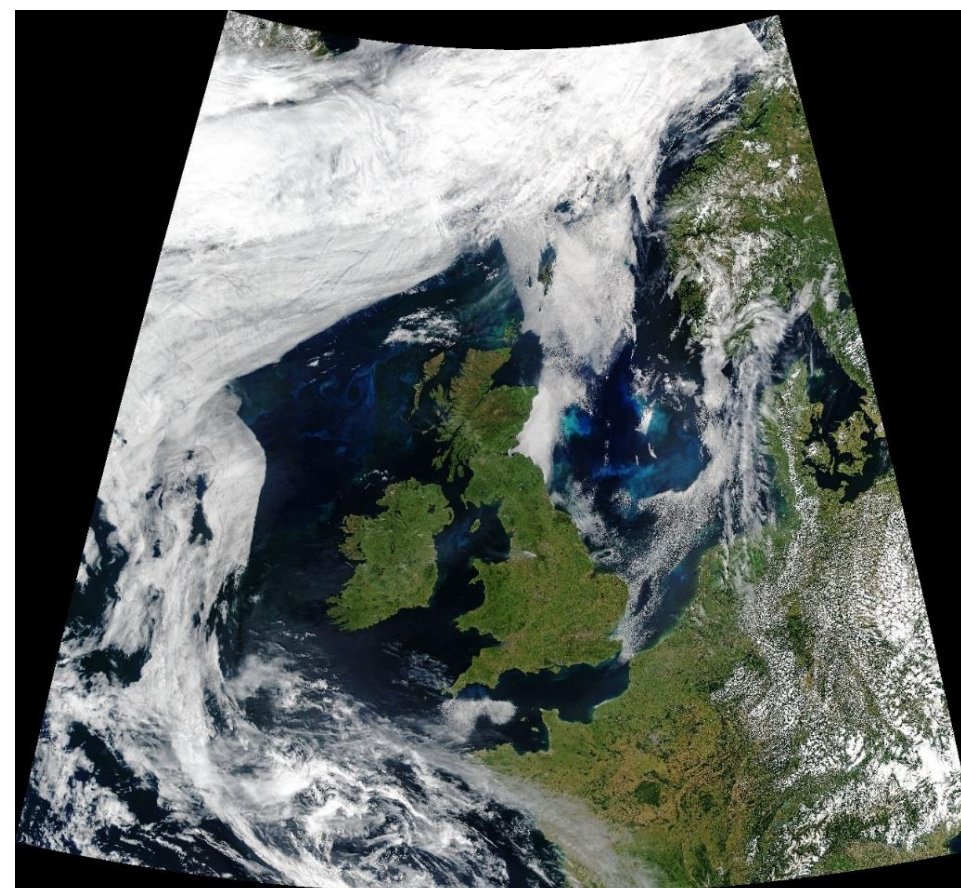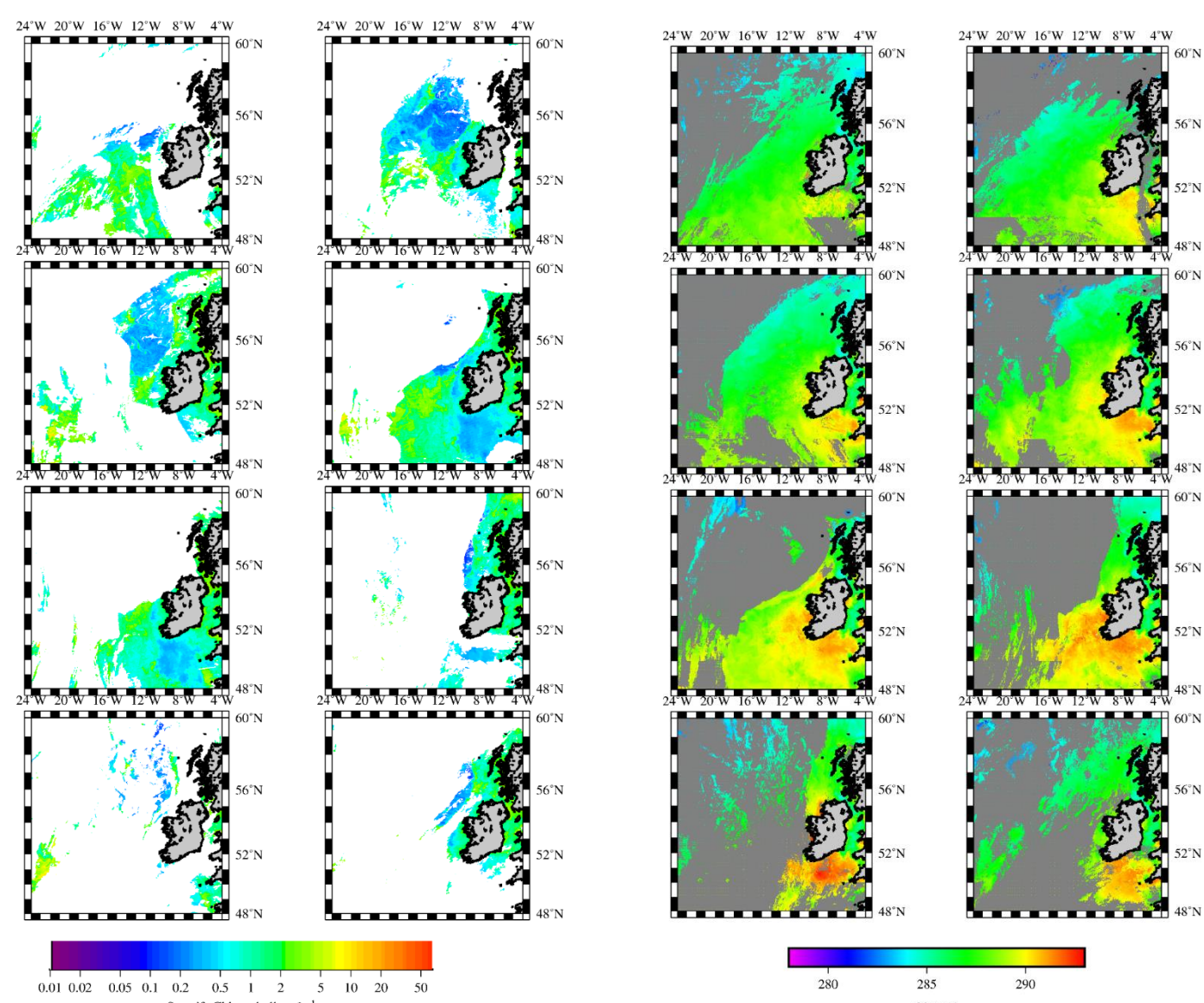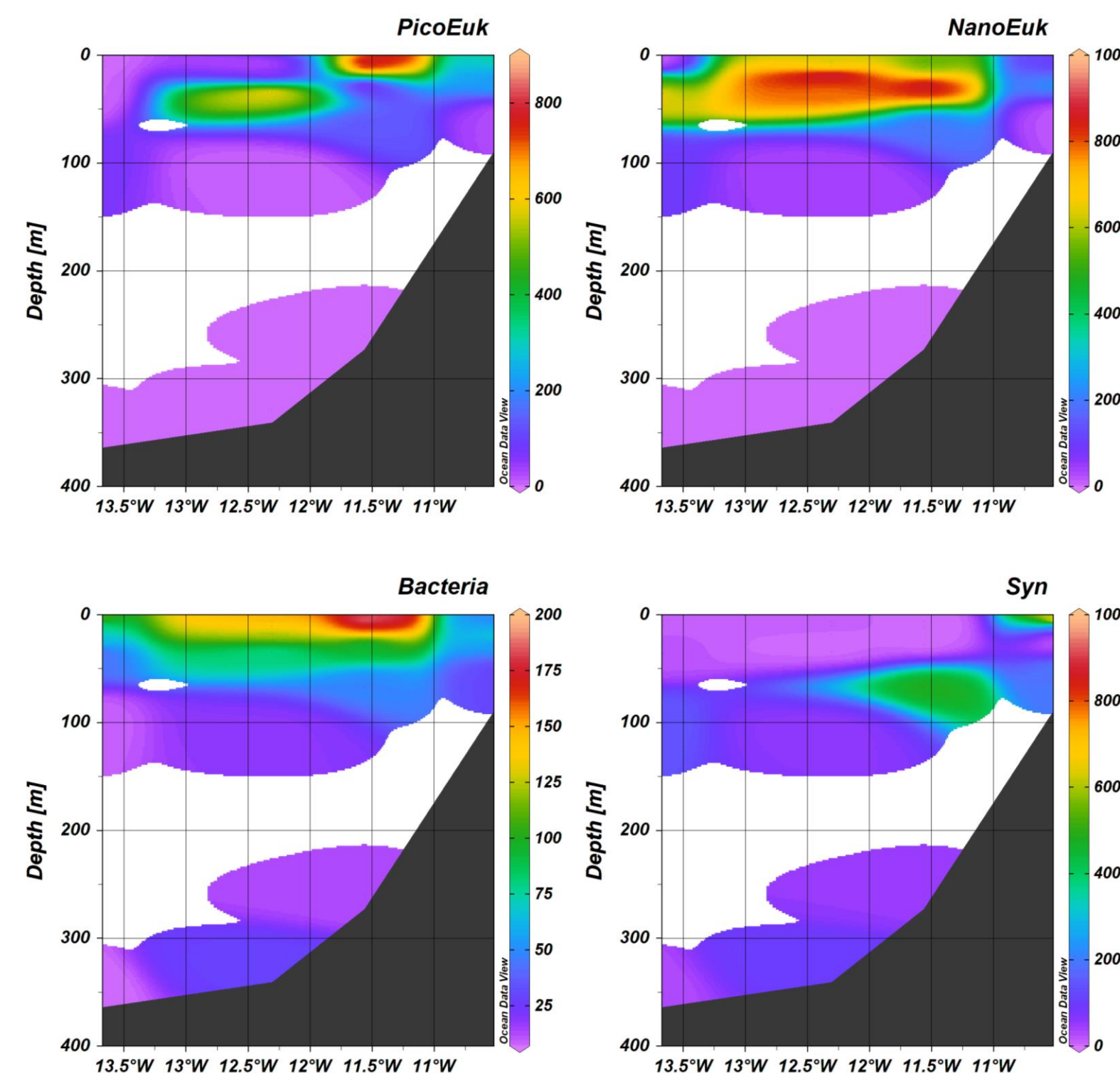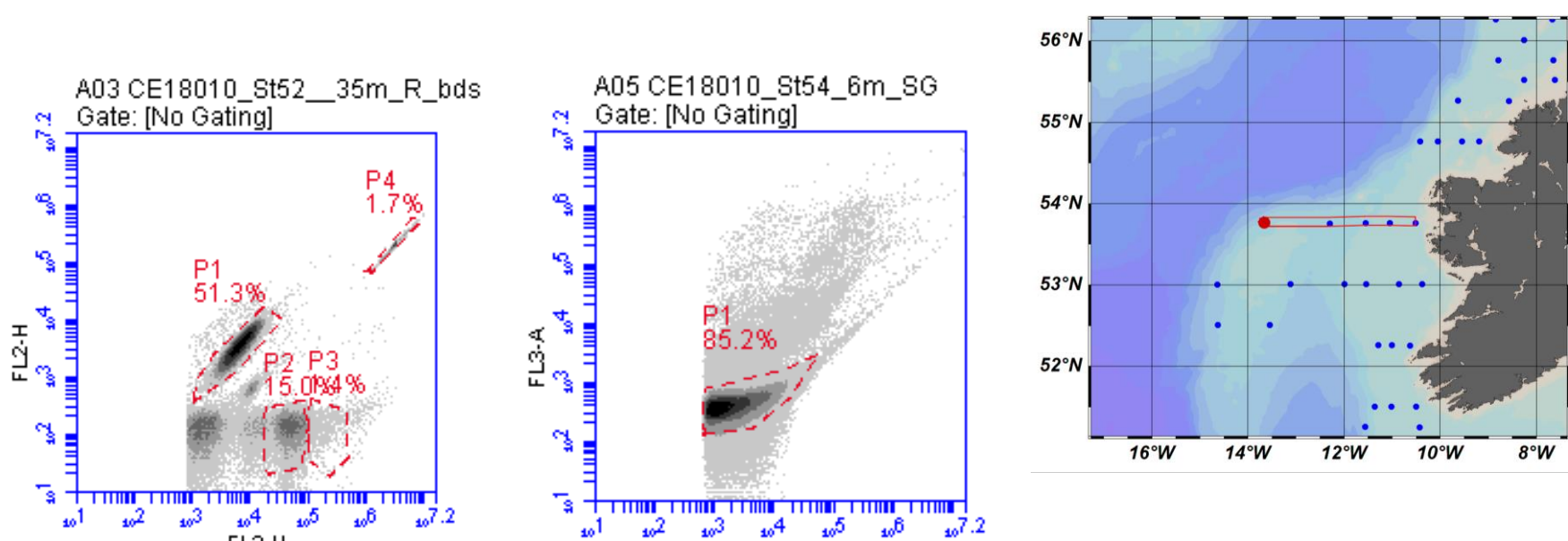

Image 5: Rare fair skies over Ireland & UK, 27TH June 2018 [5]

- The ocean colour images showed high chlorophyll levels along the shelf edge and porcupine mound with lower concentrations in the Celtic Sea. Below, an overview of the conditions during WESPAS, the satellite OC5Cl chlorophyll and SST from June 25 to July 2 (runs left to right, top to bottom). *[4]*

Bacteria, Pico and nanoplankton abundance:

- Unfiltered seawater samples collected directly from the CTD were run on an Accuri C6 flow cytometer while at sea according to *(Marie etal.,1997; Marie et al., 2014)* *[6]* Another sample is fixed with glutaraldehyde and then treated with the DNA Stain Syber Green to enumerate marine bacteria.

- Populations were determined using C6 software. *Synechoccus (P1), Picoeukaryotes (P2)* and *Nanoeukaryotes (P3).(As seen in Graph A03).* Bacterial cells were grouped along the curve. *(As seen in A05).*

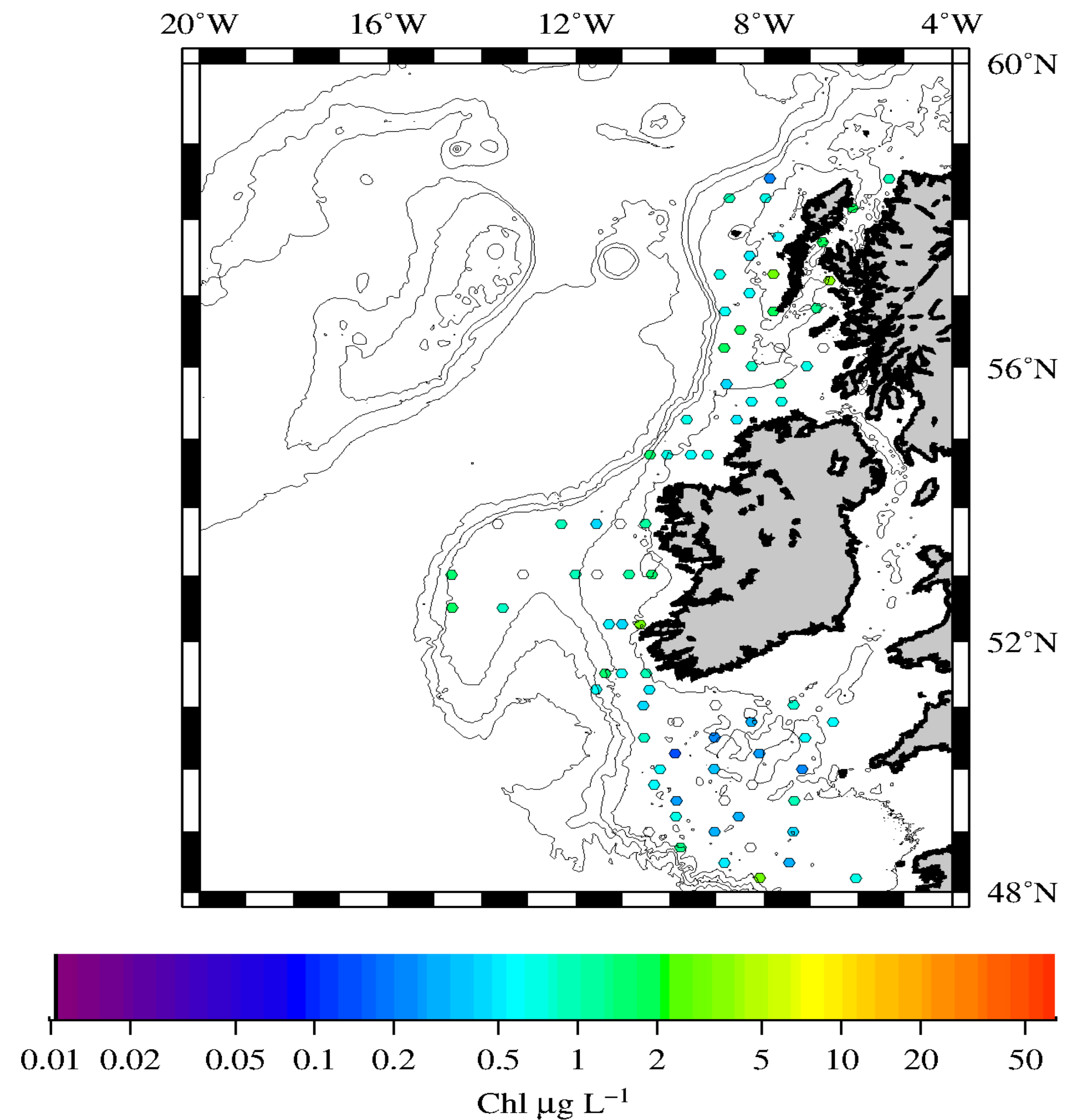- *Population counts were merged with CTD bottle data to create distribution maps in Ocean Data View.*

Sample area highlighted on the map in red. The numbers of Synechococcus (Syn), picoeukaryotes (PicoEuk), nanoeukaryotes (NanoEuk), and bacteria are shown in cellμL-1. In order to represent the bacterial populations they have been divided by 10³.

For this transect (Syn) reached its peak abundance near shore and 35m depth and decreased towards open ocean. (PicoEuk), (NanoEuk), and bacterial populations reached their peaks at Station 53 increasing as they moved further from the coast and decreased again as they moved towards the shelf.
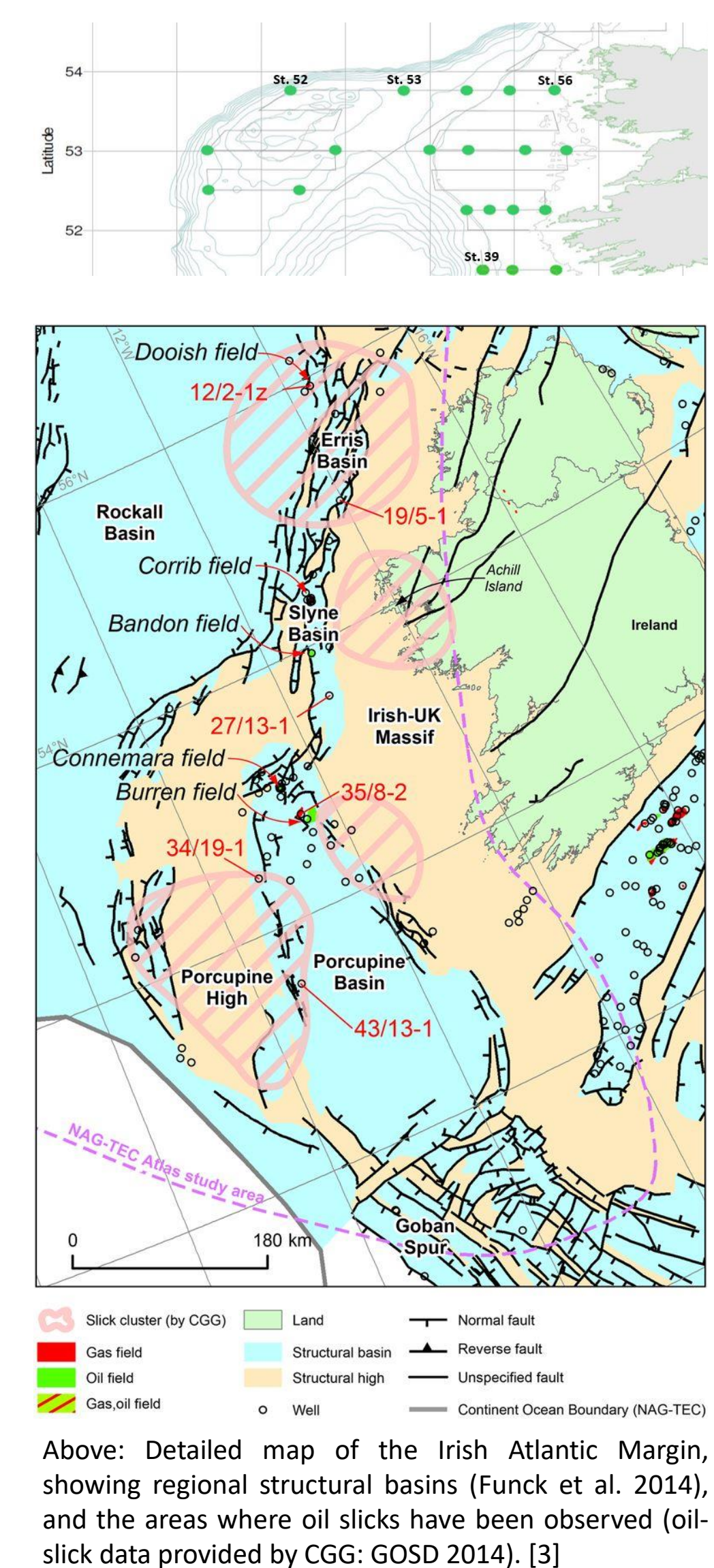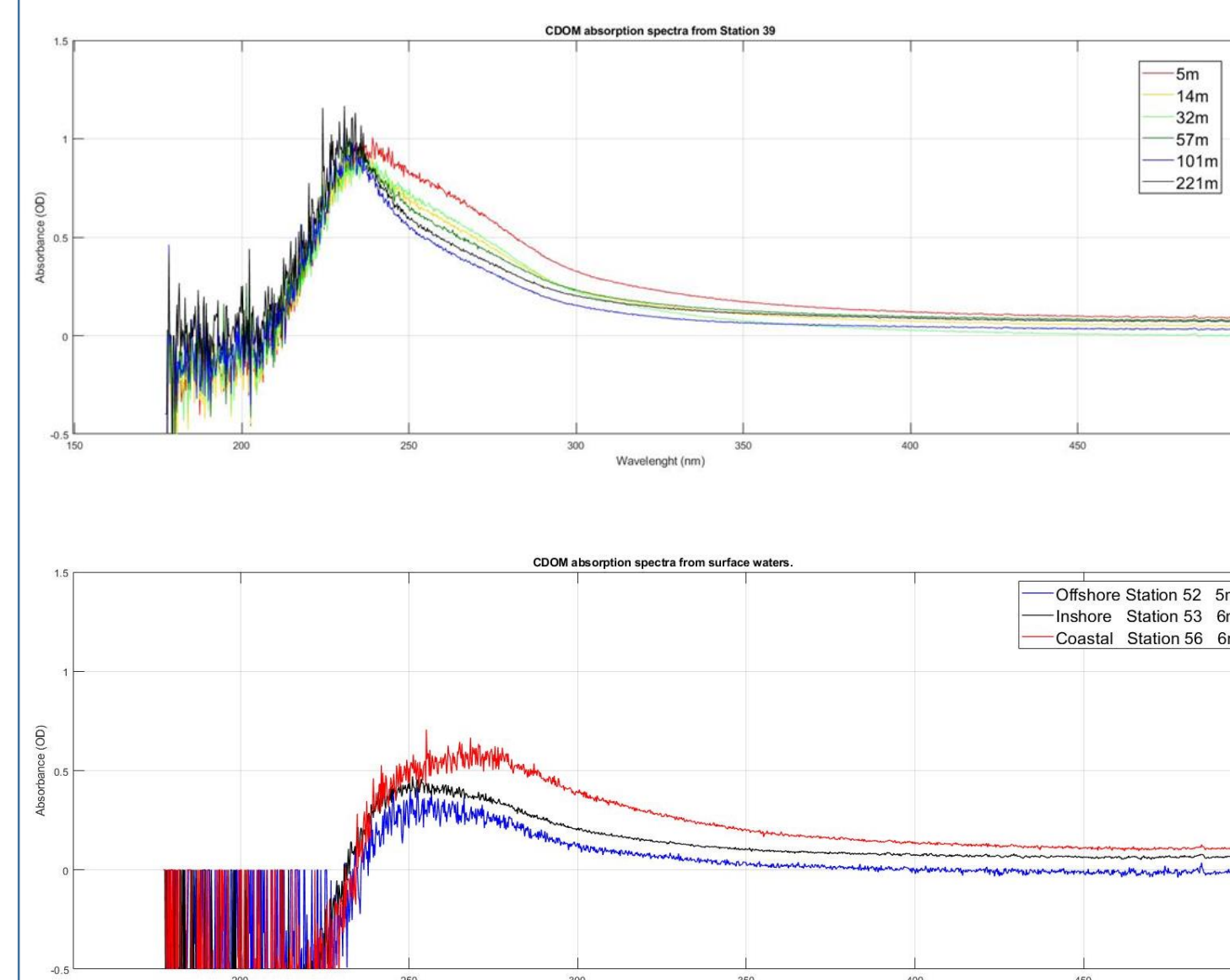
PRELIMINARY RESULTS & DISCUSSION

Chlorophyll concentration (5-6 m):

- The frozen filters were analysed in the laboratory for chlorophyll a (b & c) concentrations after extraction with 90% acetone using a Telfon grinder and subsequent measurement of the solution absorbance using an Ocean Optics Flame spectrophotometer with a low volume 10 cm pathlength cell and DT-mini light source. The concentration of chlorophyll a was calculated using the trichromatic equation of Jeffrey and Humphrey (1975). [2]
- Below: Near surface mixed layer chlorophyll measurements during *WESPAS*.

Chl $\mu g\ L^{-1}$

CDOM (5m - 424m):

- CDOM was collected from just below the surface waters, at regular intervals throughout the water column and just above the bottom. The first graph on the left represents the distribution of CDOM throughout the water column for Station 39, CE18009. This second graph to the left shows how CDOM concentration in surface waters decreases with distance from land in this transect. Stations marked in the map are corresponding to the graphs below.

FUTURE WORK

- Baseline studies of CDOM from phytoplankton and other natural sources along the west coast of Ireland.
- Concentrated sampling where oil slicks have been observed.[3]
- Satellite along with airborne hyperspectral observations of surface slicks along the Irish coast.
- Development of a Spectral library via 3D EEM fluorescence.

Above: Detailed map of the Irish Atlantic Margin, showing regional structural basins (Funck et al. 2014), and the areas where oil slicks have been observed (oil-slick data provided by CGG: GOSD 2014). [3]

ACKNOWLEDGEMENTS

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[3] Geert-Jan Vis Geological Society, London, Special Publications 2017;447:443-455

[4] Data from Copernicus, the European Unions Earth Observation and Monitoring Programme

[5] NASA Earth Observatory images by Joshua Stevens, using VIIRS and MODIS data.

[6] Marie, D., Partensky, F., Jacquet, S. and Vaulot, D., 1997. Enumeration and Cell Cycle Analysis of Natural Populations of Marine Picoplankton by Flow Cytometry Using the Nucleic Acid Stain SYBR Green I. Applied and Environmental Microbiology. Marie, D., Rigaut-Jalabert, F. and Vaulot, D., 2014. An improved protocol for flow cytometry analysis of phytoplankton cultures and natural samples. Cytometry Part A, 85(11): 962-968.