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Spatio-temporal changes in the distribution of phytopigments and phytoplanktonic groups at the Porcupine Abyssal Plain (PAP) site

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ABSTRACT

We have made a comprehensive study of pigment distributions and microscopically determined phytoplankton abundances within the Porcupine Abyssal Plain (PAP) location in the North Atlantic to better understand phytoplankton variability, and make some suggestions regarding the composition of the material falling to the sea bed and its impacts on benthic organisms such as *Amperima rosea*. The area has been the focus of many studies of ocean fluxes and benthic communities over recent years, but little attention has been given to the spatio-temporal variability in the surface waters. Dawn casts over a 12-day period at the PAP mooring site (48.83°N 16.5°W) revealed the presence of only one species, the diatom *Actinocyclus exiguus,* at bloom concentrations for just 5 days. Smaller populations of other diatoms and the dinoflagellates *Gymnodinium* and *Gyrodinium* were also present at this time. Following this 5-day interval, a mixed population of small–sized dinoflagellates, prymnesiophytes, prasinophytes, chrysophytes and cyanobacteria occurred. It is clear from concomitant CTD/bottle surveys that rapid changes in phytoplankton community structure at a fixed time series position do not necessarily reflect a degradation or manifestation of one particular species but rather represent the movement of eddies and other water masses within very short timescales. These cause substantial variability in the species class and size fraction that may explain the variability in carbon export that has been seen at the PAP site. We also make some suggestions on the variable composition of the material falling to the seabed and its impact on benthic organisms such as *Amperima rosea*.

1. Introduction

Knowledge of phytoplankton community structure and succession is fundamental to our understanding of the ocean's uptake of increased atmospheric anthropogenic carbon dioxide and carbon export, the impacts of ocean acidification and ultimately the effect of climate change. Moreover, phytoplankton are the base of the oceanic food chain and, when they die and the organic material falls to the sea floor, also provide a vital link to deep ocean organisms (Witbaard et al., 2001). In particular, the distribution and fate of the carotenoid zeaxanthin has been shown to be important for the sexual chemistry of deep-sea holothurians (Wigham et al., 2003).

Traditionally, chlorophyll-a has been used as a marker pigment for estimating phytoplankton biomass (Jeffrey and Mantoura, 1997). More recently, the development of High-Performance Liquid Chromatography (HPLC) techniques has led to the separation and quantification of up to 50 additional chloropigments and carotenoids in marine phytoplankton. Many of these pigments have strong chemotaxonomic associations, which can be used as markers of phytoplankton community composition. For example, fucoxanthin is the main photosynthetic pigment for diatoms (Wright and Jeffrey, 1987) although it is also found in many strains of haptophyta (Zapta et al., 2004). Peridinin is the primary photosynthetic pigment in autotrophic dinoflagellates (Gibb et al., 2001), whereas 19'-hexanoyloxyfucoxanthin is the marker for prymnesiophytes including coccolithophores and *phaeocystis* ssp. (Bjørnland and Liaaen–Jensen, 1989) and 19'-butanoyloxyfucoxanthin for chrysophytes (Barlow et al., 1993). In addition, phytoplankton have a number of accessory photoprotective pigments such as diadinoxanthin which is found in a number of algal divisions and classes and alloxanthin which is primarily associated with cryptophytes (Jeffrey and Mantoura, 1997).

The PAP site in the North Atlantic (Fig. 1) has been a focus for studies of carbon cycling and export measurements since 1989 (Billett et al., 1983; Lampitt et al., 2010) and long-term moored sediment traps have shown strong regional and seasonal variations in downward particle flux at depths of 1000, 3000 and 4700 m (Fabiano et al., 2001). These variations have been attributed to changes in upper ocean biogeochemistry and phytoplankton community, but little attention has been paid to spatial-temporal variability in the surface water transport.

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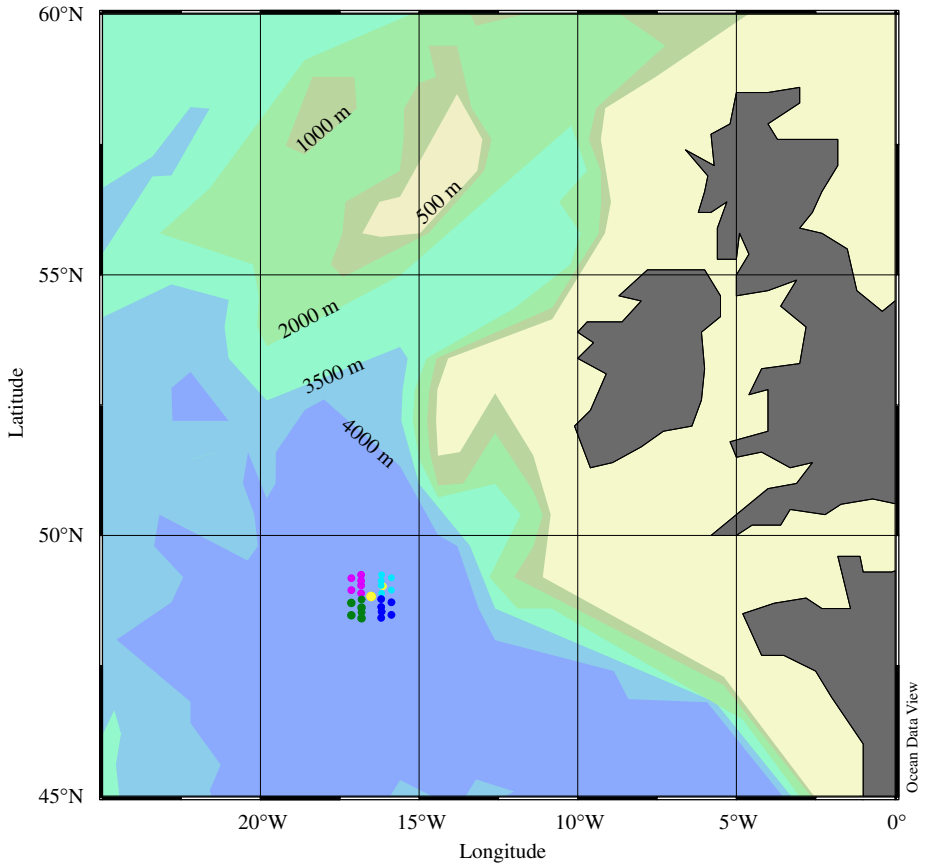

Fig. 1. Map showing the location of the PAP site (yellow) and the four outer quadrant sections: NW – magenta, SW – green, NE – pale blue, SE – dark blue.

The site lies in the centre of the North Atlantic Drift Province as determined by Longhurst (1998) with the major phytoplankton bloom occurring in the spring, followed by the formation of a deep chlorophyll maximum. Lying south of the main stream of the North Atlantic Current the site receives flows coming from west and northwest of the region as well as from the south (Hartman et al., 2010). It is also subject to a number of intermittent cyclonic and anticyclonic eddies. It is the complex flow and interaction of water bodies, together with their inherent temporal differences that, we believe, results in the variability seen at the site. Without an understanding of these natural seasonal and interannual changes it is difficult to accurately discern the effects of climate change.

To this end, a comprehensive study of pigment distributions and microscopically determined phytoplankton abundances around the PAP region was made in June/July 2006 by combining 12 days of fixed dawn measurements at one central location with separate one-day multi-CTD/bottle sections in four quadrants surrounding this central site. In this way we were able to develop a better understanding of variations that occurred at the central site and go some way to explaining why there are such interannual differences in the 15-year time series (Lampitt et al., 2010; Billett et al., 2010).

2. Methodology

The central dawn CTD casts at 48.83°N, 16.5°W were made at approximately 4.00 am from Julian Day 177-188 (June 26–July 7, 2006) with one exception on Jday 179 when the cast was taken slightly to the northeast at 49.03°N, 16.14°W. The high-resolution quadrant sections were made on Jdays 183-186, commencing with the northeast quadrant on Jday 183, the southeast quadrant on Jday 184, the northwest quadrant on Jday 185 and the southwest quadrant on Jday 186 (see Fig. 1). A total of 24 CTD dips, six in each quadrant were made during these sections.

2.1. Phytoplankton pigments

Samples for HPLC analysis were collected at up to 12 different depths on the dawn casts, selected according to light level and presence of deep chlorophyll maximum and at six fixed depths (5, 20, 40, 60, 80, 100 m) on the quadrant sections. Various recorded volumes of water (1000–6000 ml) were filtered through Whatman GF/F filters which were then immediately frozen with liquid nitrogen and stored in a -80 °C freezer prior to analysis at NOCS. The frozen filters were extracted with 2 to 3 ml of 100% methanol using 30-second sonication and stored in a fridge for approximately 12 hours to complete the extraction. The samples were centrifuged for 10 minutes at 2000 r.p.m and then for a further 10 minutes at 10000 r.p.m after which 1 ml of the supernatant was transferred to an HPLC vial and placed in the cooling rack of the analytical instrument. A Thermo-Finigan HPLC Spectra System 3 fitted with a P2000 gradient pump, vacuum degasser, AS3000 autosampler, UV6000 diode-array detector, FL3000 fluorescence detector, SN4000 system controller and Chromquest 4.0 software was used for the analysis. The method was that described by Gibb et al. (2001) using a Hypersil 10 × 0.46 cm column, with two solvents: 70% methanol/30% 1 M ammonium acetate buffer and 100% methanol. The peaks were identified from their retention time and compared with those of pure standards obtained from DHI, Denmark. The pigments measured were chlorophyll-a, chlorophyll-c2 and -c3, peridinin, 19'-butanoyloxyfucoxanthin,