Mapping nutrient distributions over the Atlantic Ocean

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Large-scale distributions of two important nutrient pools - dissolved organic nitrogen and dissolved organic phosphorus (DON and DOP) have been systematically mapped for the first time over the Atlantic Ocean in a study led by Dr Sinhue Torres-Valdes of the National Oceanography Centre, Southampton. The findings have important implications for understanding nitrogen and phosphorus biogeochemical cycles and the biological carbon pump in the Atlantic Ocean.

Tiny marine plants called phytoplankton living in the sunlit surface waters of the oceans produce organic matter through the process of photosynthesis, thereby drawing carbon dioxide down from the atmosphere. Much of this organic matter is recycled, but some of it - the so-called export production - sinks as 'marine snow' to the deep ocean. This is also known as the biological carbon pump, and it helps to significantly reduce the CO_2 released by the burning of fossil fuels (oil, gas and coal), that would otherwise accumulate in the atmosphere.

In addition to light, phytoplankton growth requires nutrients for growth. However, inorganic nutrients are in short supply in vast areas of the oceans known as oligotrophic regions or oligotrophic oceans. This means that phytoplankton must get the nutrients from somewhere else and therefore "understanding the sources and distribution of nutrients is of major interest to oceanographers," says Torres-Valdes. The new study involved scientists based at the National Oceanography Centre, Southampton and the University of Liverpool.

The scientists studied the distributions of dissolved organic nutrients during eight research cruises in the Atlantic between spring 2000 and autumn 2005. Six of these cruises sampled north-south transects between 50 degrees N and 50 degrees S, while the other two sampled east-west transects at 24 and 36 degrees N. In this way, they were able systematically to cover large tracts of the Atlantic Ocean.

"This big effort combines observations and a modelling study in order to understand the role dissolved organic nutrients play in export production" said Torres-Valdes: "The large scale distributions revealed very interesting things: First, nutrient pools in surface waters are dominated by dissolved organic nutrients, making up typically more that 75% of the total nutrient pools in the upper 100 metres of the oligotrophic Atlantic Ocean. Second, patterns emerged showing differences exist between the extensive oligotrophic North and South Atlantic subtropical gyres. DON and DOP concentrations are lower in the North Atlantic. These differences are more striking in the case of DOP, which is very low in the North Atlantic subtropical gyre."

This is important because export production over the nutrient poor, or 'oligotrophic' subtropical gyres is thought to account for up to half of global oceanic carbon export. The patterns observed probably reflect differences in how dissolved organic nutrients are recycled, with DON being mostly refractory. DOP seems more easily taken up by organisms than DON. In the North Atlantic subtropical gyre, DOP may actually provide the extra phosphorus required by microbes that 'fix' nitrogen.

The researchers also used a computer model to study the effect of cycling and transport on export production. The modelling work shows that both DON and DOP are important. While DON contributes up to 40% of the particulate nitrogen export, DOP contributes up to 70% of the modelled particulate phosphorus export. This also shows that DOP is more easily used by microbes than DON.

The observations and model results are consistent with the hypothesis that DON and DOP are important for sustaining export production in surface layers of oligotrophic gyres. Specifically, these dissolved organic nutrients are produced as a result of enhanced primary production over upwelling regions - the tropical Atlantic more or less along the equator, off the Northwest African Coast and the North Atlantic subpolar gyre. These nutrients are then distributed by the ocean circulation, with a very important eddy component, and are then used and recycled as they are transported.

"It's very likely that this situation also applies to many nutrient-poor marine systems, including other subtropical gyres, the Mediterranean Sea, and summer, stratified shelf seas", said Torres-Valdes.

More information: Torres-Valdes, S. et al. Distribution of dissolved organic nutrients and their effect on export production over the Atlantic Ocean. *Global Biogeochemical Cycles* 23 (3 November 2009). doi:10.1029/2008GB003389

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