Iron and biological production in the high-latitude North Atlantic

July 7 2009

Southampton scientists have demonstrated an unexpected role of iron in regulating biological production in the high-latitude North Atlantic. Their findings have important implications for our understanding of ocean-climate interactions.

Tiny plant-like organisms called phytoplankton dominate biological production in the sunlit surface waters of the world's oceans and, through the process of photosynthesis, sequester large amounts of atmospheric carbon dioxide. A proportion of the carbon is exported to the deep ocean, and because carbon dioxide is a greenhouse gas, this so-called 'biological carbon pump' helps prevent runaway global climate warming.

Iron is an essential micro nutrient for phytoplankton growth. In high-nutrient, low-chlorophyll (HNLC) oceanic regions, phytoplankton growth is limited by low iron availability. Classical HNLC regions, which account for about a third of the world's oceans, include the Southern Ocean and the subpolar North Pacific.

In contrast, it has been widely assumed that iron supply does not limit biological production of the high-latitude (>50 degrees N) North Atlantic Ocean. Here, winter cooling causes the sinking of nutrient-depleted surface waters and their replacement by deep nutrient-rich water. This winter 'overturning' replenishes surface water nutrients, and in the spring, when light intensities increase, a large phytoplankton bloom develops, leading to high rates of carbon export.

However, in many regions of the open North Atlantic, including the Iceland and Irminger Basins, residual amounts of nitrate persist into the summer period, after the spring bloom has ceased. This represents an inefficiency of the biological carbon pump that is potentially of global significance to the partitioning of carbon between the atmosphere and ocean.

Phytoplankton are grazed upon and some of the larger phytoplankton species such as diatoms with low grazing mortality are susceptible to silicate shortage. Traditionally, it has been believed that these factors, acting in concert, might be sufficient to terminate the spring bloom leaving some nitrate unused. However, there have been indications that phytoplankton might simply run out of iron before they are able to exploit any remaining other nutrients.

Now a team of scientists from the National Oceanography Centre, Southampton, have tested this 'iron limitation hypothesis' for the high-latitude North Atlantic Ocean. Their measurements were performed on a cruise aboard the RRS Discovery within the central Iceland Basin during the summer of 2007, and the findings are published this month in the scientific journal *Global Biogeochemical Cycles*.

The researchers found that the concentration of dissolved iron in surface waters was very low, as was biological production, despite the presence of residual nitrate. Experimental addition of iron to bottles containing seawater samples increased photosynthetic efficiency, chlorophyll concentrations, and growth of several types of phytoplankton, including the ubiquitous Emiliania huxleyi, a coccolithophore.

"These results, backed up by additional experiments, are extremely exciting," said team member Maria Nielsdottir: "They provide strong evidence that low iron availability limits summer biological production in the high-latitude North Atlantic. This has only previously been suspected, but helps explain why the spring phytoplankton bloom does not continue well into the summer and why residual amounts of nitrate remain unused."

The central Iceland Basin receives little iron input from continental sources or from atmospheric dust, and some iron is also lost through detrital sinking. Moreover, the new findings suggest that iron brought to the surface during winter overturning is insufficient to support maintenance of the phytoplankton bloom into the summer.

Nielsdottir, a research student at the University of Southampton's School of Ocean and Earth Science based at the National Oceanography Centre, said: "In effect, the high-latitude North Atlantic is a seasonal HNLC region, whereas classic, HNLC regions such as the Southern Ocean remain in this condition throughout the year."

The failure of the phytoplankton community to exploit residual nitrate remaining in the summer reduces the effectiveness of the biological carbon pump. "This is important," says Nielsdottir, "because the high-latitude North Atlantic is second only to the Southern Ocean in its potential to lower atmospheric carbon dioxide and un used nitrate in the surface highlight the potential for even higher CO2 drawdown, high levels of which are an important cause of global climate warming."

More information: Nielsdóttir, M. C., C. M. Moore, R. Sanders, D. J. Hinz, and E. P. Achterberg (2009), Iron limitation of the postbloom phytoplankton communities in the Iceland Basin, Global Biogeochem. Cycles, 23, GB3001 , doi:10.1029/2008GB003410.
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Source: National Oceanography Centre, Southampton