Geophysical Research Abstracts
Vol. 13, EGU2011-5462, 2011
EGU General Assembly 2011

Changing ocean temperature and phytoplankton community size structure

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The size structure of the phytoplankton community is important both in determining the structure of higher trophic levels in the food web but also in terms of the strength of the biological pump, as it has often been demonstrated that phytoplankton size is an important factor controlling sinking rate. It is, therefore, important to understand the factors influencing community size structure. Dominance of small phytoplankton cells in warm waters has often been demonstrated but this is usually interpreted as being a result of reduced nutrient availability due to increased stratification in warmer ocean regions and not a temperature effect. Here, using results collected on the circumnavigating global Galathea 3 expedition in 2006-7 as well as a cruise carried out in the northern North Atlantic in August 2008, a direct relationship between temperature and phytoplankton community size structure is demonstrated. Fractionated chlorophyll determinations from stations > 400 m over the entire route (temperature range from <0o to >30o C) demonstrate a very significant (P<0.0005) relationship between the percentage of the total chlorophyll in the sample retained on a 10 (and 50) μm filter and temperature. When water temperatures are > 20o C, there are no stations where more than about. 30% of the chlorophyll is retained on a 10 μm filter. However, the relationship between community size structure and temperature is not confined to stations where the water temperature is highest. When the data are separated into 4 different temperature groups: (1) -2-6 oC; (2) 6-14 oC; (3) 14-22 oC og (4) > 22 oC, the greatest dominance of large cells is seen in group 1 and the importance of large cells in the community gradually decreases from groups 1 to 3. There is not a significant difference in community size structure between groups 3 and 4. There is also a significant relationship between community size structure and DIN (P = 0.034) and phosphate (P=0.031) concentrations but the relationship was much weaker than size structure vs. temperature. Furthermore, when the data were divided into two halves, with the highest and lowest DIN and phosphate concentrations, respectively, then the slopes of the lines for the DIN groups vs. temperature and two phosphate groups vs. temperature were not significantly different from one another. This is interpreted as an being indication that it is not nutrient availability that is driving the relationship between community size and temperature as we would expect if nutrients were driving the relationship that the response would be greatest at the lowest nutrient concentrations. The study also demonstrates a significant relationship between mesozooplankton production, primary production, and export production (calculated after Laws et al. 2000) and phytoplankton community size structure. In addition, the weighted average of d15N i the seston is strongly correlated with both primary and export production. In the northern North Atlantic, where the seasonal data coverage is best, a relationship is also noted between both primary and export production and phytoplankton community size structure as well as between export production and the flux of CO2 from the atmosphere to the surface ocean.

Reference

Laws, E.A., Falkowski, P.G., Smith Jr., W.O., Ducklow, H., McCarthy, J.J., 2000. Temperature effects on export production in the open ocean. Global Biogeochemical Cycles. 14, 1231-1246.