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The 2008 North Atlantic Spring Bloom Experiment: Bloom Evolution at the Patch Scale

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A novel system consisting of a heavily instrumented Lagrangian mixed-layer float, mobile gliders, ship-based measurements and remote sensing characterized initiation of the 2008 North Atlantic spring bloom and the subsequent evolution and demise of an O(10 km) scale diatom-rich, high-chlorophyll patch. Autonomous platforms collected measurements in a quasi-Lagrangian frame, beginning before bloom initiation and extending well past the patch's demise. The float followed water parcels, cycling within the mixed layer, while gliders repeatedly surveyed the volume surrounding the drifting float to characterize patch-scale bloom evolution. Lagrangian sampling provided a patch-following frame that helped differentiate temporal evolution from advective effects.

Onset of stratification driven by slumping of existing horizontal density gradients initiated the bloom, with surface warming playing a role later in the evolution. Diatoms dominated the phytoplankton community within the blooming patch, while the community outside was comprised of picoeukaryots, protists and heterotrophic bacteria. The two communities possessed distinct optical signatures which could be quantified by the ratio of chlorophyll fluorescence to particulate optical backscatter. This pair of optical measurements, common to all of the platforms, thus allowed observations to be classified as being 'inside' or 'outside' the patch. The patch strained and advected around an anticyclonic eddy. Within the patch, the bloom ended with the depletion of silicate, at which time sediment traps and optical measurements observed diatom cysting, aggregation and sinking out of the euphotic zone. Sinking aggregates produced large spikes in optical backscatter, beam attenuation and fluorescence that indicated a sinking rate of 75 m$\cdot$day^{-1} and a carbon flux of approximately 4.4 – 5.6 g$\cdot$m^{-2} at 200 m. Budgets of nitrate, dissolved oxygen and particulate organic carbon (POC) following the patch were used to estimate net community production (NCP) and apparent POC export. Net community production was 805 mmol C$\cdot$m^{-2} during the main bloom, with apparent POC export of 564 mmol C$\cdot$m^{-2} and 282 mmol C$\cdot$m^{-2} lost due to net respiration (70%) and apparent export (30%) on the day following bloom termination. Thus, POC export of roughly 70% NCP occurred steadily throughout the main bloom, while respiration, rather than sinking, drove the rapid drop in POC at bloom termination. Numerical simulations were used to investigate both the processes governing stratification onset and subsequent bloom evolution, where one-dimensional models were able to describe the observations to within error. Tuning to fit the extensive biogeochemical measurements placed strong constraints on model parameters, demonstrating the utility of such data sets for guiding numerical investigations.