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Autonomous Studies of Coupled Physical-Biogeochemical Processes-Lessons from NAB08 and Prospects for the Future

Craig Lee (1), Eric D'Asaro (1), and Mary Jane Perry (2)

(1) University of Washington, Applied Physics Laboratory, Seattle, United States (craig@apl.washington.edu), (2) University of Maine, School of Marine Sciences, Maine, USA

Motivated by the increasing application of autonomous sensors to physical, biological and biogeochemical investigations at the submesoscale, we examine techniques developed during the 2008 North Atlantic Bloom Experiment (NAB08), review successes, failures, and lessons learned, and offer perspectives on how these approaches might evolve in response to near-term shifts in scientific goals and technological advances. NAB08 exploited the persistence of autonomous platforms coupled with the extensive capabilities of a ship-based sampling program to investigate the patch-scale physics, biogeochemistry and community dynamics of a spring phytoplankton bloom. Autonomous platforms (Seagliders following a heavily-instrumented Lagrangian float) collected measurements in a quasi-Lagrangian frame, beginning before bloom initiation and extending well past its demise. This system of autonomous instruments resolved variability at the patch scale while also providing the persistence needed to follow bloom evolution. Biological and biogeochemical measurements were conducted from R/V Knorr during the bloom. An aggressive protocol for sensor calibration and proxy building bridged the ship-based and autonomous efforts, leveraging the intensive but sparse ship-based measurements onto the much more numerous autonomous observations. The combination of sampling in the patch-following frame, persistent, autonomous surveys and focused, aggressive calibration and proxy building produced robust, quantitative estimates of physical and biogeochemical processes. For example, 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. Sensor networks require proper intercalibration to support quantitative use of the measurements, but calibration efforts become increasingly difficult as the number of independent sensors grows. NAB08 offers a suitable model for modest networks, but alternative approaches will be required for larger arrays.