OCB 2018

Constraining Biological Rates governing the North Atlantic Annual Cycle in Phytoplankton Biomass

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1-Motivation

- Interactions between phytoplankton and their grazers have been hypothesized to be a major ecological factor governing annual dynamics of phytoplankton biomass accumulation, including when the North Atlantic spring bloom initiates.
- During the four field campaigns of the **N**orth **A**tlantic **A**erosols and **M**arine **E**cosystem **S**tudy **(NAAMES)** conducted in November 2015, May 2016, September 2017, and March 2018, we measured phytoplankton growth and grazer-induced mortality rates in a total of 145 two-point dilution experiments.
- Concurrent measurements of physical, chemical, and biological properties provided an environmental context for the rate measurements.

2- Mesoscale physical complexity of NAAMES region

- Due to its latitudinal extent from the Gulf Stream to the subpolar, NAAMES sampling region in the Western North Atlantic (38-48 W, 40-55 N) was physically variable and characterized by a complex mesoscale eddy field (Fig. 1), the spatial variability of which cannot be fully captured based on geography only.

- Although the four campaigns were conducted during different seasons, some stations sampled at different seasons overlapped in their physical and chemical properties (Fig. 2).

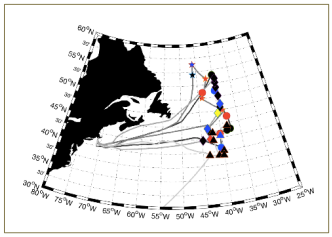

Fig. 1-Location of stations sampled during NAAMES four cruises (1= circles, 2= stars, 3= diamonds, 4= triangles) as well as associated eddy features (blue = cyclone, red= anticyclone). Stations that were not located within an eddy are marked in black. Map courtesy of P. Gaube, APL- UW).

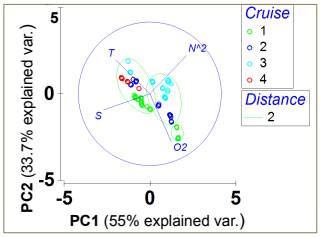

Fig. 2- Principal Component Analysis of upper water column physical and chemical characteristics, including temperature (T), salinity (S) buoyancy frequency (N2), and oxygen (O2) CTD data averaged over 5-100 m.

3- Overall dominance of pico/nano-phytoplankton

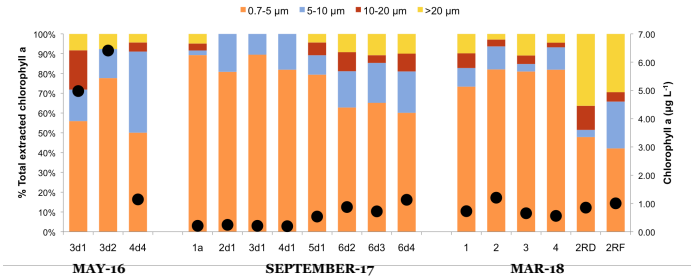

Fig. 3- Surface chlorophyll concentration (black dots) and size distribution during 3 of the 4 NAAMES campaigns show that most of the biomass was contributed by cells <20 µm, even when total chlorophyll concentration was high (NAAMES II). At stations, diatoms were surprisingly rare, even during the spring bloom.

4- Seasonal pattern at large spatial scale

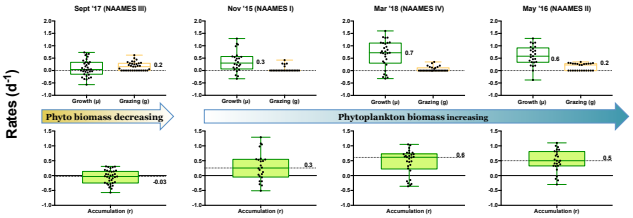

Fig. 4- Upper panels: Rates of phyoplankton growth (μ, green open boxes, grazer-induced mortality (g, orange open boxes), and **lower panels:** phytoplankton biomass accumulation (r, green solid boxes) measured during the 4 NAAMES campaigns. Rates were obtained from experiments that were performed using surface (~ 5m) seawater incubated at 4-5 different light levels obtained by shade-screening deck-board incubators. Minimum to maximum boxplots. Horizontal bars on box represent median values. Accumulations rates also account for viral losses (data not shown).

5- Accumulation variability at local scale

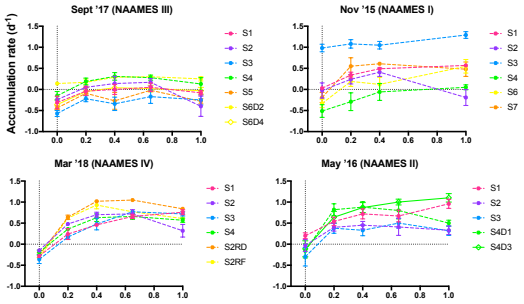

Fig. 5- Accumulation rates as a function of incubation light, each fraction of light representing a percentage of the light received by an unscreened incubator. Error bars represent one standard deviation from duplicate experiments.

6- Mixed signals of grazing in the mixed layer

The observed **dependence of grazing rates on collection depths within the mixed layer** have implications for our ability to integrate process rates over the integral mixed layer from surface and/or satellite data, and impinge on our understanding of carbon pathways.

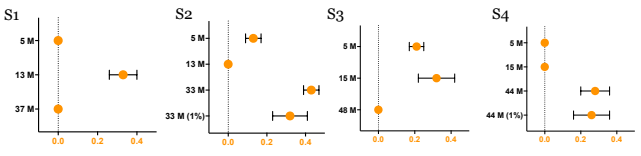

Fig. 6- Microzooplankton grazing rates estimated from dilution experiments performed at 4 stations during NAAMES IV with source water collected at **3 different depths within the mixed layer** and incubated at 20% surface irradiance. Error bars represent one standard deviation from duplicate measurements. Incubations performed with water collected at a depth corresponding to 1% surface irradiance were also incubated separately at their native light level. Resulting rates are presented when different from zero.

7- Conclusion

These data imply a prolonged growth period and a relatively shorter period of net biomass loss. Consequently seasonal biogeochemical fluxes and the transfer of matter and energy through the North Atlantic food web may be quite prolonged rather than defined by short 'bloom' events.

8- Acknowledgements

We thank Captains A. Lund and D. Bergeron and the crew of the R/V Atlantis for their excellent operation of the ship. We are grateful for the outstanding teams of the NAAMES campaigns at sea, in the air and on land and leadership of the chief scientist Mike Behrenfeld. Thanks to the many helping hands, including Sean Anderson, Caitlin Russell. This work was largely supported by NASA NAAMES project (award # NNX15AL2G), and in part by the National Science Foundation EPSCoR Cooperative Agreement (award #EPS-1004057).

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