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Shift in phytoplankton size structure and trophic status of the upwelling system Ría de Vigo (NW Iberia) due to mussel farming

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Summary

Size fractioned chlorophyll *a* (chl *a*), primary production (PP) and net community production (NCP) were examined in the Ría de Vigo by comparing data obtained inside a mussel farming area (raft station, RaS) and at a reference station (ReS), outside the farming area. During upwelling integrated PP was high at ReS (1.05 ± 0.45 g C m^{-2} d^{-1}), when microphytoplankton (> 20μm) dominated both biomass (68 ± 16 % of chl *a*) and carbon fixation (74 ± 14% of PP). However, nanophytoplankton (20-2 μm) and picophytoplankton (< 2 μm) became more relevant during winter, when integrated PP significantly decreased (0.24 ± 0.03 g C m^{-2} d^{-1}). The water column was always autotrophic at ReS. In contrast, we observed a decrease in integrated chl *a* (by 33%) at RaS that did not affect picophytoplankton, indicating that small phytoplankton is not a suitable food for mussels. However, the decrease in PP affected the three fractions up to 63 %, which we attribute not only to the decrease in chl *a,* but also to a decrease in light below the rafts. Phytoplankton consumption and the lower irradiance also caused the decrease in NCP at RaS, yet remained autotrophic.

Introduction

Net community production (NCP) provides an estimate of the fraction of total PP that is not remineralised within the microbial community in the photic layer and thus it would potentially be exportable outside the microbial planktonic system (Eppley and Peterson 1979) by settling into the aphotic layer or by transfer to higher trophic levels such as mussels. Highly productive ecosystems often have a distinctly autotrophic metabolism, with large phytoplankton preponderance and the development of an herbivorous food chain associated with important export processes (Legendre and Rassoulzadegan 1996). Asses to what extent intensive mussel aquaculture may alter the size distribution of PP, and modify the metabolic balance in the Ría de Vigo, is essential to unravel the complex trophic interactions that probably exist between microbial plankton community and mussel, its most important consumer in the Ría (Tenore and Gonzalez 1975).

Material and Methods

The study was conducted under four different oceanographic seasons (autumn, winter, spring and summer), characteristic of the Ría de Vigo. At both stations water samples for analysis of size fractioned chl *a*, PP and NCP were collected at 5 depths using a CTD SBE 9/11 (Sea-Bird) fitted to an oceanographic rosette equipped with 12 Niskin bottles. Size fractioned chl *a* concentration was determined by sequentially filtering 250 ml of water thought 20 μm (microphytoplankton), 2 μm (nanophytoplankton) and 0.2 μm (picophytoplankton) pore size polycarbonate filters. Chl *a* concentrations were evaluated after measuring the fluorescence of

the pigment extracts using a Turner Desings fluorometer calibrated with pure chl *a* (Sigma). Size fractioned PP was measured using the ^{14}C method and measurements of oxygen production and respiration were obtained with light / dark incubations and subsequent Winkler oxygen analysis. In both cases, 24 h *in situ* incubations were performed.

Results and Discussion

The favorable upwelling conditions recorded in autumn led to maximum values of GPP (226 ± 68 mmol O_2 m^{-2} d^{-1}) and NCP (186 ± 67 mmol O_2 m^{-2} d^{-1}) at ReS (Fig. 1A). On the contrary, minimum values of GPP (47 ± 19 mmol O_2 m^{-2} d^{-1}) and NCP (43 ± 22 mmol O_2 m^{-2} d^{-1}) occurred during winter mixing (Fig. 1A). NCP was always positive for the four sampling periods, pointing to the prevalence of autotrophy in the microbial plankton community.

Our results also show that mussel farming influenced the metabolic balance of the microbial plankton community (Fig. 1B). This influence took place basically through the decrease in GPP due to the consumption of primary producers and the reduced irradiance field. However, mussel culture did not affect community respiration (CR), probably because microbial respiration primarily occurs in the heterotrophic picoplankton fraction (bacteria) that were not consumed by mussels (Froján et al. 2014). This contrasting effect of mussel activity on GPP and CR, provoked a declined of NCP at RaS. Even so planktonic microbial community remained autotrophic at RaS, dismissing a potential mussel food limitation under current environmental conditions.

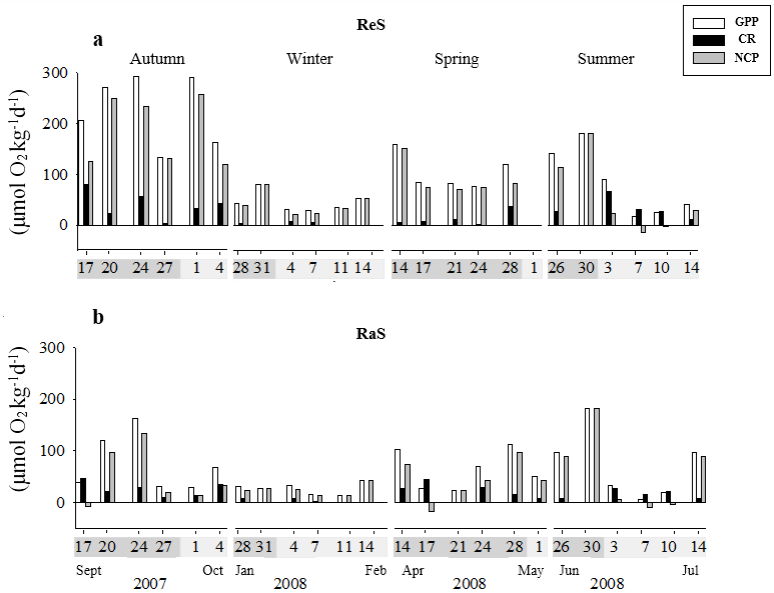

Figure 1. Gross primary production (GPP), net community production (NCP) and community respiration (CR) integrated in the upper 12 m of the water column at (a) reference station (ReS) and (b) raft station (RaS).

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