Control of tHe structure of marine phytoplAnkton cOmmunities by turbulence and nutrient supply dynamicS (CHAOS)

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ABSTRACT

In order to investigate the role of turbulence mixing on structuring marine phytoplankton communities, the CHAOS project included a multidisciplinary approach involving specifically designed field observations supported by remote sensing, database analyses, and modeling and laboratory chemostat experiments. Field observations carried out in the outer part of Ría de Vigo in summer 2013 showed that, as a result of increased mixing levels, nitrate diffusive input into the euphotic layer was approximately 4-fold higher during spring tides. This nitrate supply could contribute to explain the continuous dominance of large-sized phytoplankton during the upwelling favorable season. Simultaneous estimates of nitrate diffusive fluxes, derived from microturbulence observations, and picoplankton abundance collected in more than 100 stations, spanning widely different hydrographic regimes, showed that the contribution of eukaryotes to picoautotrophic biomass increases with nutrient supply, whereas that of picocyanobacteria shows the opposite trend. These findings were supported by laboratory and modeling chemostat experiments that reproduced the competitive dynamics between picoeukaryote and picocyanobacteria as a function of changing nutrient supply. The results derived from this project confirm that turbulence and mixing control the availability of light and nutrients, which in turn determine the structure of marine phytoplankton communities.

INTRODUCTION

Phytoplankton growth is limited by light and nutrients, and the availability of both resources is strongly dependent on the mixing conditions of the water column. Thus, turbulence and mixing have been frequently invoked in model formulation to explain the behavior of individual phytoplankton cells or collective functional groups. Based upon his observations in Ría de Vigo (NW Spain), Margalef [1978] proposed a simplified bottom-up control model to explains how mixing and nutrient concentration control the composition of marine phytoplankton communities. Due to the difficulties of measuring turbulence in the field, previous attempts to verify this model have applied different proxies for nutrient supply, and very often used interchangeably the terms mixing and stratification. Moreover, because the mandala was conceived before the discovery of smaller phytoplankton groups (picoplankton <2 µm), it describes only the succession of vegetative phases of microplankton. In the framework of the CHAOS project, by using a multidisciplinary approach, we investigated the role of turbulence and mixing on structuring marine phytoplankton communities.

MATERIAL AND METHODS

The CHAOS project (IP: Beatriz Mouriño, CTM2012-30680) used a multidisciplinary approach including specifically designed field observations supported by remote sensing, database analyses, and modeling and laboratory chemostat experiments.

RESULTS AND DISCUSION

The two cruises carried out in August 2013 in the outer part of Ría de Vigo sampled different tidal and upwelling conditions, covering a transitional period from relaxation-stratification (CHAOS1, spring tides) to upwelling (CHAOS2, neap tides). As a result of increased mixing levels [*Fernández-Castro et al., in preparation*], the averaged nitrate diffusive flux computed during spring tides was almost four times higher than during neap tides [*Villamaña et al., submitted*]. This nutrient supply could represent an important fertilizing mechanism to explain the continuous dominance of large-sized phytoplankton during the upwelling favorable season.

In order to investigate the influence of ocean mixing and nutrient supply dynamics on picophytoplankton community composition in the context of Margalef's Mandala [*Margalef*, 1978], we compiled simultaneous estimates of nitrate diffusive fluxes, derived from microturbulence observations, and picophytoplankton abundance collected in more than 100 stations in the tropical and subtropical Atlantic and Pacific ocean, the Mediterranean Sea and the Galician upwelling system (NW Spain). In agreement with Margalef's model, our results show different responses of picophytoplankton groups to nitrate supply (probably reflecting differences in nutrient uptake abilities), and that the ratio of prokaryotic to picoeukaryotic photoautotrophic biomass decreases with increasing nitrate supply. These findings were supported by laboratory and modeling chemostat experiments that reproduced the competitive dynamics between picoeukaryote and picocyanobacteria as a function of changing nutrient supply [*Otero-Ferrer et al., in preparation*]. The role of nutrient supply in oligotrophic regions is made evident only when nitrate fluxes, and not just concentrations, are considered. Accurate estimates of nutrient supply are crucial to discern the role of environmental factors. The results from this project confirm that turbulence and mixing control the availability of light and nutrients, which in turn determine the structure of marine phytoplankton communities.

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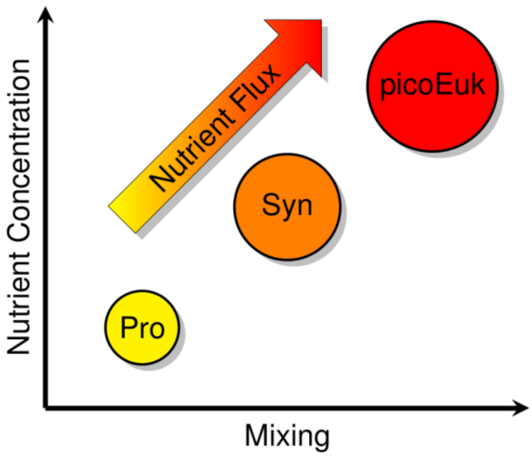

Fig. 1. Schematic showing the dominance of *Prochlorococcus* (Pro), *Synechococcus* (Syn) and picoeukaryotes (picoEuk) versus turbulent mixing, nutrient concentration and vertical flux of nutrients through turbulent diffusion. Adapted from Mouriño-Carballido et al. [2016].

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