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Nutrient consumption and chain tuning in diatoms exposed to storm-like turbulence

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Current information on the response of phytoplankton to turbulence is linked to cell size and nutrient availability. Diatoms are considered to be favored by mixing as dissolved nutrients are more easily accessible for non-motile cells. We investigated how diatoms exploit microscale turbulence under nutrient repletion and depletion conditions. Here, we show that the chain-forming diatom *Chaetoceros decipiens*, continues to take up phosphorus and carbon even when silicon is depleted during turbulence. Our findings indicate that upon silica depletion, during turbulence, chain spectra of *C. decipiens* remained unchanged. We show here that longer chains are maintained during turbulence upon silica depletion whereas under still conditions, shorter chains are enriched. We interpret this as a sign of good physiological state leading to a delay of culture senescence. Our results show that *C. decipiens* senses and responds to turbulence both in nutrient repletion and depletion. This response is noteworthy due to the small size of the species. The coupling between turbulence and biological response that we depict here may have significant ecological implications. Considering the predicted increase of storms in Northern latitudes this response might modify community structure and succession. Our results partly corroborate Margalef's mandala and provide additional explanations for that conceptualization.

Diatoms are unicellular, non-flagellated algae surrounded by a characteristic siliceous exoskeleton called the frustule. This class of algae displays one of the highest species richness in phytoplankton with ca. 14,000 described species[1] and a growing evidence for the existence of cryptic species[2,3]. Diatoms' ecological[4–6] and, lately, also biotechnological[7–9] importance is undeniable. Life forms and their concurrent life and cell cycles in diatoms are highly diversified and in several cases rather peculiar[10–12]; at mitosis daughter cells of chain forming species can either separate completely or elongate the chain. Chain formation and the junction mode between two adjacent cells are species-specific features[13–17] and in some cases, e.g., in many *Chaetoceros* species, the elongation of the chain or its splitting is prepared before cell division by changing the shape of the connecting spines[18–20], and can be easily monitored looking at that trait.

Diatoms, especially the chain forming ones, are considered to optimally thrive in turbulent environments. The unifying explanation for this is that turbulence may compensate for their lack of self-propelling organs favoring their encounter with dissolved nutrients and their persistence in the euphotic zone[21]. Chain formation as well has been interpreted as a mechanism to heighten the same processes, but a convincing proof and the possible mechanisms behind it, are still elusive (see refs 22–24 for a discussion). It is worth remembering that diatom cell sizes are much smaller than the Kolmogorov scale as well as Batchelor scale in some cases, below which viscosity rules the flow regime. Current knowledge about turbulence response in phytoplankton is strictly correlated to cell size and nutrient availability; e.g. the giant diatom *Coscinodiscus* benefits from turbulence in phosphorus limiting condition compared to the smaller *Thalassiosira pseudonana*[25]. Barton and coworkers[26], in a model study concluded that in nutrient replete condition, turbulence does not significantly affect the community structure.

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