frontiers in Marine Science

EDITORIAL
published: 09 March 2022
doi: 10.3389/fmars.2022.869618

Editorial: Phytoplankton Dynamics Under Climate Change

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Keywords: climate change, phytoplankton dynamics, CO_2, biodiversity, harmful algal blooms

Editorial on the Research Topic

Phytoplankton Dynamics Under Climate Change

Phytoplankton plays an important role in ocean processes, and is well-known to have an enormous positive impact on climate change or more specifically on global warming, by reducing atmospheric CO_2 levels through the sinking of produced organic and inorganic matter to the deep ocean (Falkowski, 2012; Beardall and Raven, 2013). However, climate change, with consequences of elevated seawater temperatures and decreased pH levels (Beardall and Raven, 2013), influences phytoplankton dynamics, changing phytoplankton composition, geography and biomass in the oceans (Falkowski and Oliver, 2007; Boyd et al., 2015; Jonkers et al., 2019). Temperature increases could also drive temporal shifts in the onset of the regular annual blooms, their composition, duration and amplitude as well as mismatches in timing between trophic levels (Hinder et al., 2012; Mikaelyan et al., 2015).

The overall impact of increased temperature on phytoplankton is not easy to assess due to variable and complex repercussions. For example, increasing temperatures can lead to more stratified waters, especially in summer months, and prevent nutrient replenishment at the ocean surface. The warming of surface waters can result in lower phytoplankton production, particularly concerning at low latitudes (Boyd et al., 2015; Basu and Mackey, 2018). Contrary, the increase in temperature may also lead to higher growth rates of phytoplankton with increased CO_2 uptake rates from the atmosphere at high latitudes (Beaugrand et al., 2012; Boyd et al., 2015; Krumhardt et al., 2017). Extreme weather is forecasted to increase under climate change scenarios, which will result in a higher frequency of high wind and rain events. This increase in strong winds and high rainfall can influence phytoplankton biomass positively due to increased mixing and nutrient loading in particular in coastal systems (Wetz and Paerl, 2008). Reduced frequency of cold winters and unusual types of phytoplankton succession have also been reported in some regions (Mikaelyan et al., 2018). Changing weather patterns, and nutrient imbalances are thought to be driving shifts in phytoplankton community such as a decrease in the ratio of dinoflagellate to diatom abundance at high latitudes (Hinder et al., 2012).

This Research Topic on "*Phytoplankton Dynamics Under Climate Change*" aims to cover recent investigations performed in the field and laboratory to elucidate long-term impacts of climate change/global warming on phytoplankton species composition and abundance.

In this Research Topic, a total of six papers were published, related to the impacts of climate change on phytoplankton dynamics. Two papers are focused on Antarctic waters, a region not only important for the global CO_2 ocean sequestration but also amongst the most impacted by the recent warming events (Bolinesi et al.; Ferreira et al.). The first paper reported high chlorophyll

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Edited and reviewed by:
Angel Borja,
Technological Center Expert in Marine and Food Innovation (AZTI), Spain

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Specialty section:
This article was submitted to Marine Ecosystem Ecology, a section of the journal Frontiers in Marine Science

Received: *04 February 2022*
Accepted: *15 February 2022*
Published: *09 March 2022*

Citation:
Eker-Develi E, Kideys AE, Mikaelyan A, Devlin MJ and Newton A (2022) Editorial: Phytoplankton Dynamics Under Climate Change. Front. Mar. Sci. 9:869618. doi: 10.3389/fmars.2022.869618

a biomass in Terra Nova Bay and the south-central Ross Sea contrasting with the high nutrient low chlorophyll *a* nature of the off-shore waters during summer (Bolinesi et al.). These authors underlined importance of appropriate sampling scales in understanding alternative pathways for primary production for different sub-systems. The second paper, critically reviewing the studies performed in the northern Antarctic Peninsula reveals five main gaps to ascertain the impacts of climate change on phytoplankton (Ferreira et al.). They have also remarked the short- and long-term scenarios for phytoplankton communities notably the increase of small flagellates at the expense of diatoms and their shattering consequences for the ecosystem. The third paper is a long-term study performed in a subtropical region, the Tasman Sea coast of Australia, denoted decreased abundance of a cool-affinity diatom species, *Asterionellopsis glacialis* from 1931–1932 to 2009–2019 and increased abundance of a warm-affinity diatom species, *Leptocylindrus danicus,* simultaneous with an $\sim$1.8°C increase in water temperature in the same period (Ajani et al.). The fourth paper is related to the impact of a once in 100-year flood on phytoplankton community in Moreton Bay, Australia (Clementson et al.). This unprecedented flood resulted in very low salinity values and very high turbidity of the seawater in the bay. In spite of reduced light intensity, phytoplankton responded rapidly (1–2 weeks) to the increased nutrients provided by the flood and micro-phytoplankton composed of mainly diatoms dominated in the region. However, in the subsequent weeks the influence of the flood disappeared and the community composition changed to nano- and pico-plankton in all areas of the Bay indicating fast but short-lived effects of the flood (Clementson et al.). The fifth paper deals with changes in dinoflagellate assemblages in the west Iberian upwelling region, Portugal during 1994–2001 (Danchenko et al.). Results of the investigation revealed that potentially harmful dinoflagellate species such as *Dinophysis acuminata*, *D. acuta*, *D. caudata*, *Prorocentrum* spp., and *Gonyaulax* spp. generally developed during the late stage of regional upwelling season in summer-autumn months, but also following relaxation of shorter upwelling events outside of the main upwelling season, often in spring. At the same time, in the study, similar communities of harmful algal bloom species (*Dinophysis* spp., *Lingulodinium polyedra*) were favored by weaker upwelling during the main upwelling season and warmer water in late summer and autumn; it was reported that climatic trends toward weakening of summer upwelling may increase likelihood of their development (Danchenko et al.).

In the last paper, ecoevolutionary interactions between a coccolithophore (*Emiliania huxleyi*), and a diatom (*Chaetoceros affinis*) were investigated under increased CO_2 concentrations growing alone, or competing with one another in co-occurrence (Listmann et al.). Among nine initial genotypes from each of the species, one remained as a result of highly reproducible genotype sorting treatments. Community response to climate change was depicted by a shift in the dominance of *C. affinis* to *E. huxleyi* as a result of strong evolutionary selection (Listmann et al.).

These results manifest clear consequences of climate change on primary producers in the oceans and it is evident that marine ecosystems will go on to be exposed severe effects of global warming in the future. Finally, the Guest Editors would like to sincerely thank all the authors for their valuable contributions and all the reviewers for their efforts.

AUTHOR CONTRIBUTIONS

EE-D: conceptualization, writing, original draft, and review. AK: writing, conceptualization, validation, and review. AM, MD, and AN: writing, review, and editing. All authors contributed to the article and approved the submitted version.

ACKNOWLEDGMENTS

The authors acknowledge the Frontiers in Marine Science Submissions Team Manager Talitha Gray for her offer to be guest editor of this special topic. We also thank Dr. Angel Borja for his valuable comments.

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