Pronounced seasonal and spatial variability in determinants of phytoplankton biomass dynamics along a near-offshore gradient in the southern North Sea

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Marine phytoplankton biomass dynamics are affected by eutrophication, ocean warming, and ocean acidification. These changing abiotic conditions may impact phytoplankton biomass and its spatiotemporal dynamics. In this study, we used a nutrient–phytoplankton–zooplankton model to quantify the relative importance of bottom-up and top-down determinants on phytoplankton biomass dynamics in the Belgian Part of the North Sea. Using four years (2014 – 2017) of monthly observations at nine locations of nutrients, solar irradiance, sea surface temperature, chlorophyll-a and zooplankton biomass, we disentangled the monthly, seasonal and yearly variation in phytoplankton biomass dynamics. To quantify how the relative importance of determinants changed along a near–offshore gradient, the analysis was performed for three spatial regions, i.e. nearshore region (< 10 km to the coastline), midshore region (10 – 30 km), and offshore region (> 30 km). We found that from year 2014 to 2017, phytoplankton biomass dynamics ranged from 1.4 to 23.1 mg Chla m^{-3}. Phytoplankton biomass dynamics follow a general seasonal cycle as in other temperate regional seas, with a distinct spring bloom (5.3 – 23.1 mg Chla m^{-3}) and a modest autumn bloom (2.9 – 5.4 mg Chla m^{-3}). This seasonal pattern was most expressed in the nearshore region. The relative contribution of factors determining phytoplankton biomass dynamics varied spatially and temporally. Throughout a calendar year, solar irradiance and zooplankton grazing were the most influential determinants in all regions, i.e. explained 38% – 65% of the variation in the offshore region, 45% – 71% in the midshore region, and 56% – 77% in the nearshore region. In the near- and midshore regions, nutrients are most limiting the phytoplankton production in the month following the spring bloom (44% – 55%). Nutrients are a determinant throughout the year in the offshore region (27% – 62%). During winter, sea surface temperature is a determinant in all regions (15% – 17%). The findings of this study contribute to a better mechanistic understanding of the spatiotemporal dynamics of phytoplankton biomass in the southern North Sea. The parameterized causal relationships allow estimating how the base of the southern North Sea food web will change under future climate change and/or blue economy activities that affect one or more determinants of the phytoplankton biomass dynamics.

Keywords: Primary production; Ecosystem model; Phytoplankton biomass dynamics; Environmental conditions