The red harmful plague in times of climate change: Blooms of the cyanobacterium *Planktothrix rubescens* triggered by stratification dynamics and irradiance

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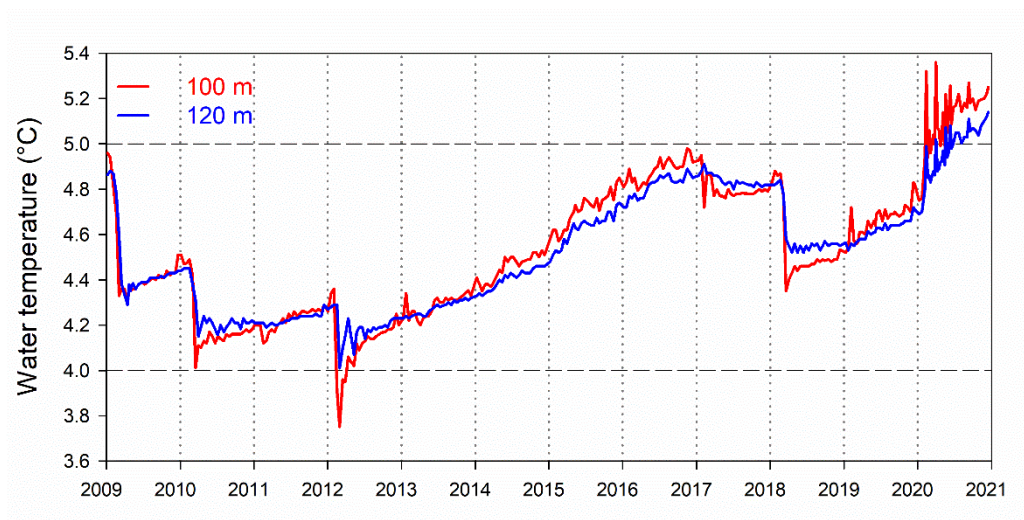
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Supplementary Figure S1: Hypolimnetic water temperatures for two selected depths (100 m, 120 m) in Lake Zurich (z_{max} = 135 m), Switzerland, during January 2009 to December 2020. Measurements were done on a biweekly basis (weekly during spring, in total 320 samplings). A YSI 6600 (YSI 6600 V2 since 2014) multiparameter probe was used for the determination of water temperature (°C). Note the cooling effect of the deep water turnover in 2012, and the continuous increase in water temperature during the period of 2014 to 2017. That period was characterized by a consecutive series of incomplete winter mixing. A sudden temperature increase to values above 5 °C was recorded in winter 2019 / 2020 after intensive storms (see Figure 2). Temperature profiles for the entire water column and depths of winter mixing are shown in Figure 1.
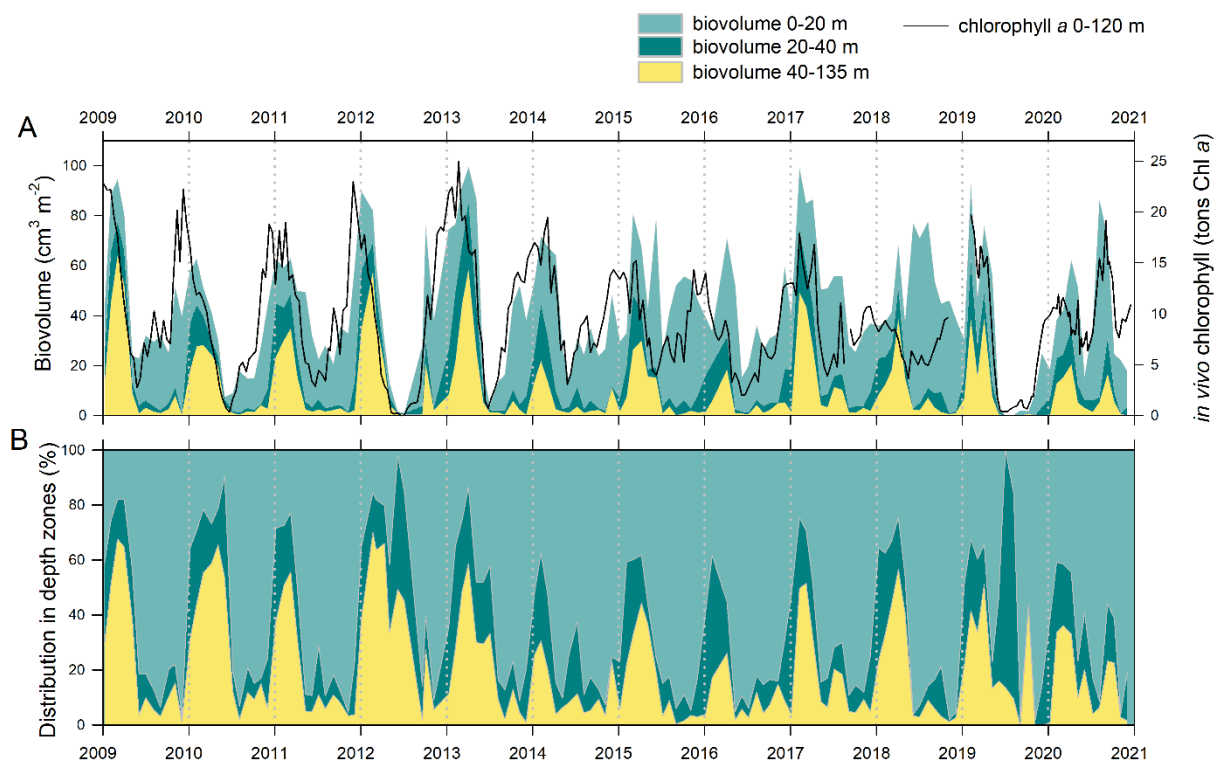
Supplementary Figure S2: (**A**) Comparison of depth-integrated total amounts of *Planktothrix rubescens* specific *in vivo* chlorophyll *a* (tons Chl *a*) with total amounts of *P. rubescens* based on biovolumes (cm^3 m^{-2}) during the investigation period (2009 to 2020). *In vivo* Chl *a* concentrations (µg Chl *a* L^{-1}) were determined weekly / biweekly (*n* = 320) with a bbe FluoroProbe (Moldaenke, Germany) in 1 m steps between 0 m and 120 m. Chl *a* concentrations were multiplied with the adequate lake volumes in 1 m steps, and integrated over the entire water column. Biovolumes of *P. rubescens* populations (mm^3 L^{-1}) were determined monthly (*n* = 144) and are based on microscopic counts and filament length measurements in Lugol's iodine fixed samples. Cumulative biovolumes (cm^3 m^{-2}) of *P. rubescens* for the entire water column were computed for the depth layers 0 – 20 m, 20 – 40 m and 40 – 135 m (for details see Material and Methods). (**B**) Biovolume data for three depth zones as in (**A**) but as percentages of the total biovolume.
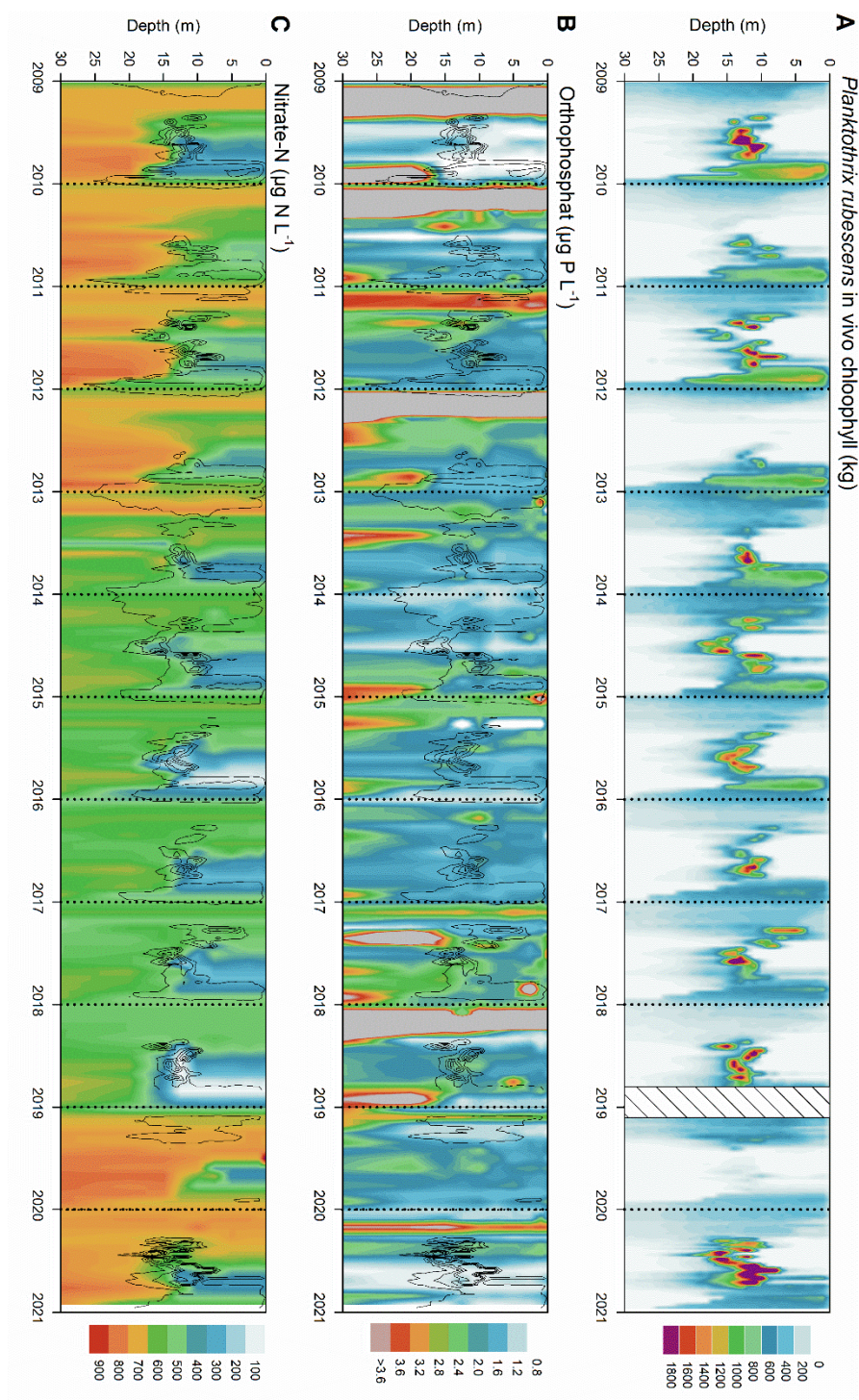
Supplementary Figure S3: Trends (2009-2020) in *Planktothrix rubescens* in vivo chlorophyll values, orthophosphate concentrations and nitrate concentrations in Lake Zurich (Switzerland) for the first 30 m of the water column. (**A**) *In vivo* chlorophyll *a* concentration (µg Chl *a* L^{-1}) of the cyanobacterium *P. rubescens* based on weekly / biweekly profiles (*n* = 320) of parameters, measured with multi-parameter probes and interpolated in 1 m steps between 0 to 30 m depth. White striped area: no measurements from November 2018 to January 2019. (**B**) Concentrations of orthophosphate (µg P L^{-1}) and (**C**) nitrate nitrogen (µg N L^{-1}) with black isoline indicating the center of the *P. rubescens* population. Panels (**B-C**) are based on monthly analyses (*n* = 144) of 10 sampling depths between 0 m to 30 m.