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Effects of elevated CO_2 on phytoplankton community biomass and species composition from the Western English Channel

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Background

Supporting an estimated 10-15% of global ocean net annual primary production, coastal zones may be responsible for more than 40% of oceanic carbon sequestration (Muller-Karger, 2005). The surface ocean carbonate system is directly affected by increased atmospheric CO_2. The physiological response of phytoplankton to this changing environmental factor holds the potential to alter community composition, biomass and consequently primary production (Boyd & Doney, 2002).

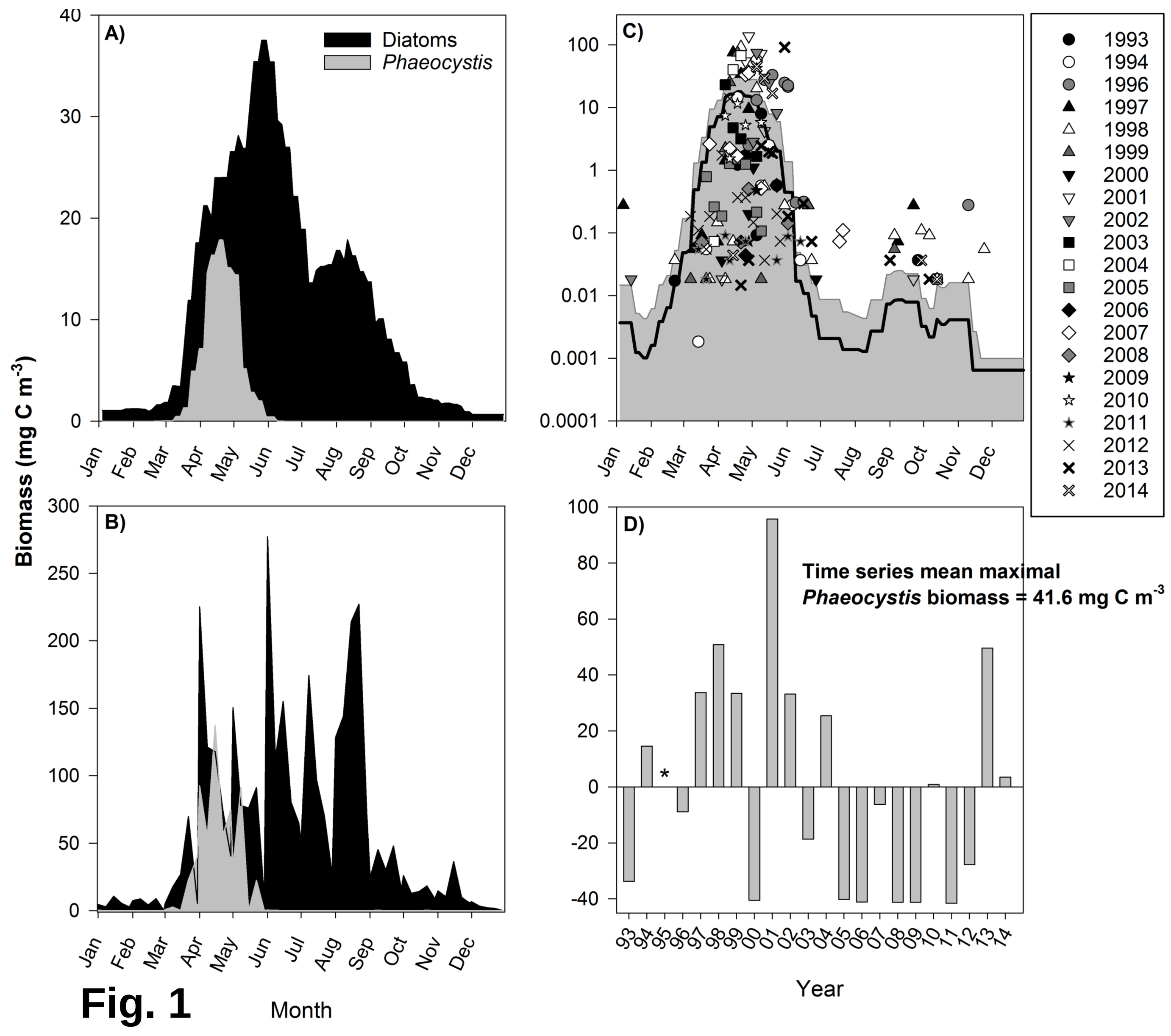


Fig. 1

Goal

To investigate the response in species composition and community biomass of a natural phytoplankton community to CO_2 enrichment during the spring bloom season.

Study site

Coastal station L4, situated within the Western English Channel Observatory. One of Europe's principal coastal time series stations including 22 years of phytoplankton community structure.

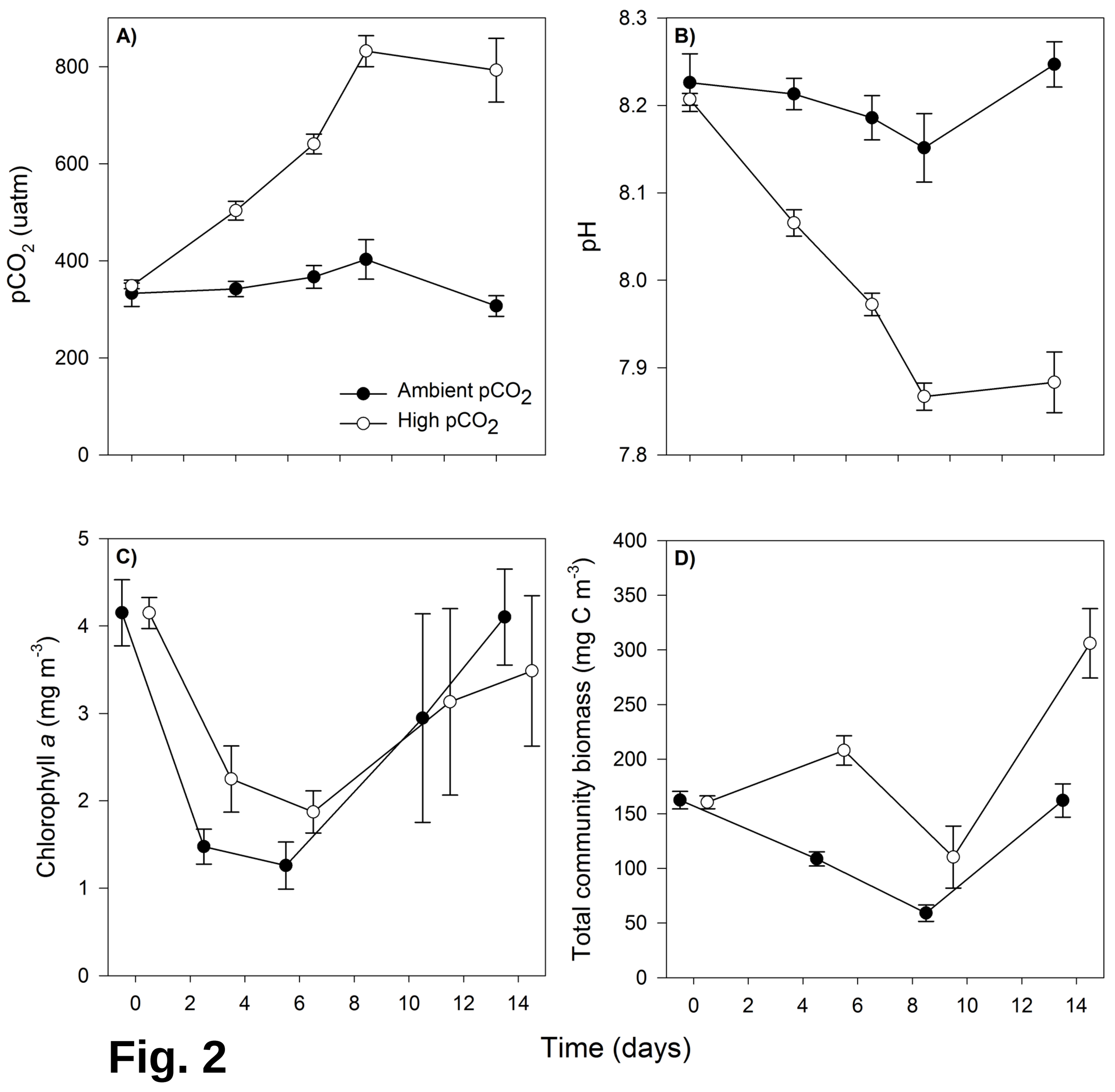
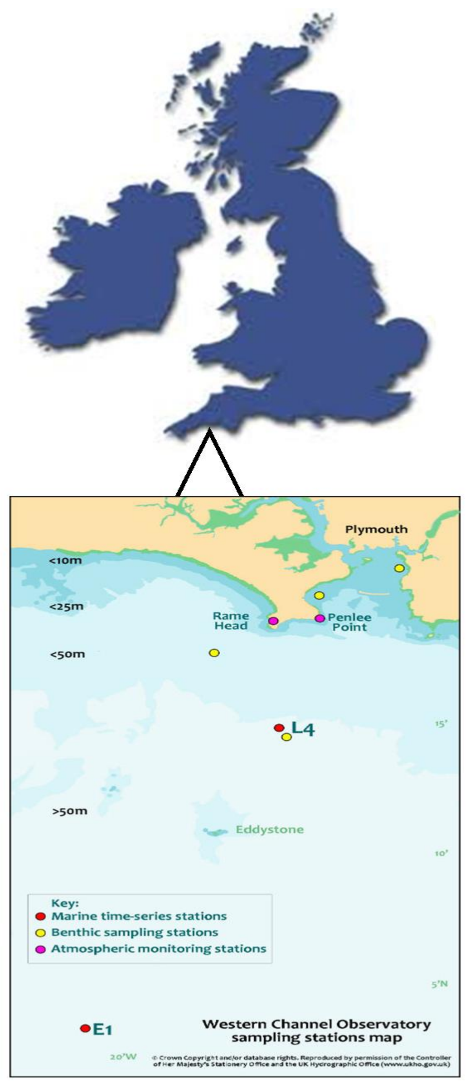


Fig. 2



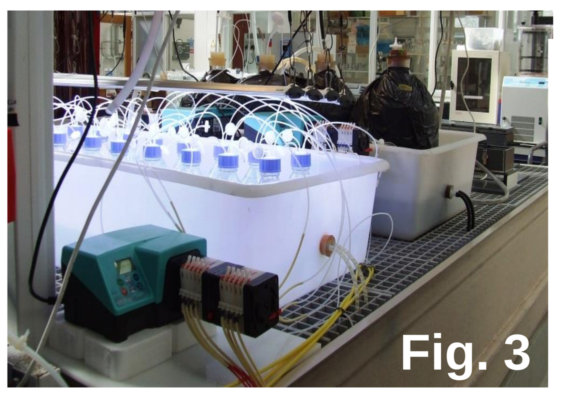


Fig. 3

L4 phytoplankton community time series

Drivers of the spring phytoplankton bloom formation at L4: Nitrate shows a negative relationship with chlorophyll *a* biomass while the relationship with silicate is positive, tracking temporal development of the diatom bloom. Evidence suggests that diatoms dominate *Phaeocystis* only when silicate concentrations are viable (Egge & Aksnes, 1992). At L4 however, irradiance has been shown to positively co-vary with *Phaeocystis* biomass. **Fig.1** shows the mean weekly biomass of diatoms and *Phaeocystis* between 1993-2014 **(A)** while **(B)** shows maximal values over this period. Both are major contributors to total community biomass in spring. **Fig. 1 (C)** shows seasonal trends of *Phaeocystis* at L4 by year (black line is weekly mean, grey area is standard deviation) and annual bloom period maxima above and below the time series mean maxima of ~40 mg C m^{-3} **(D)**.

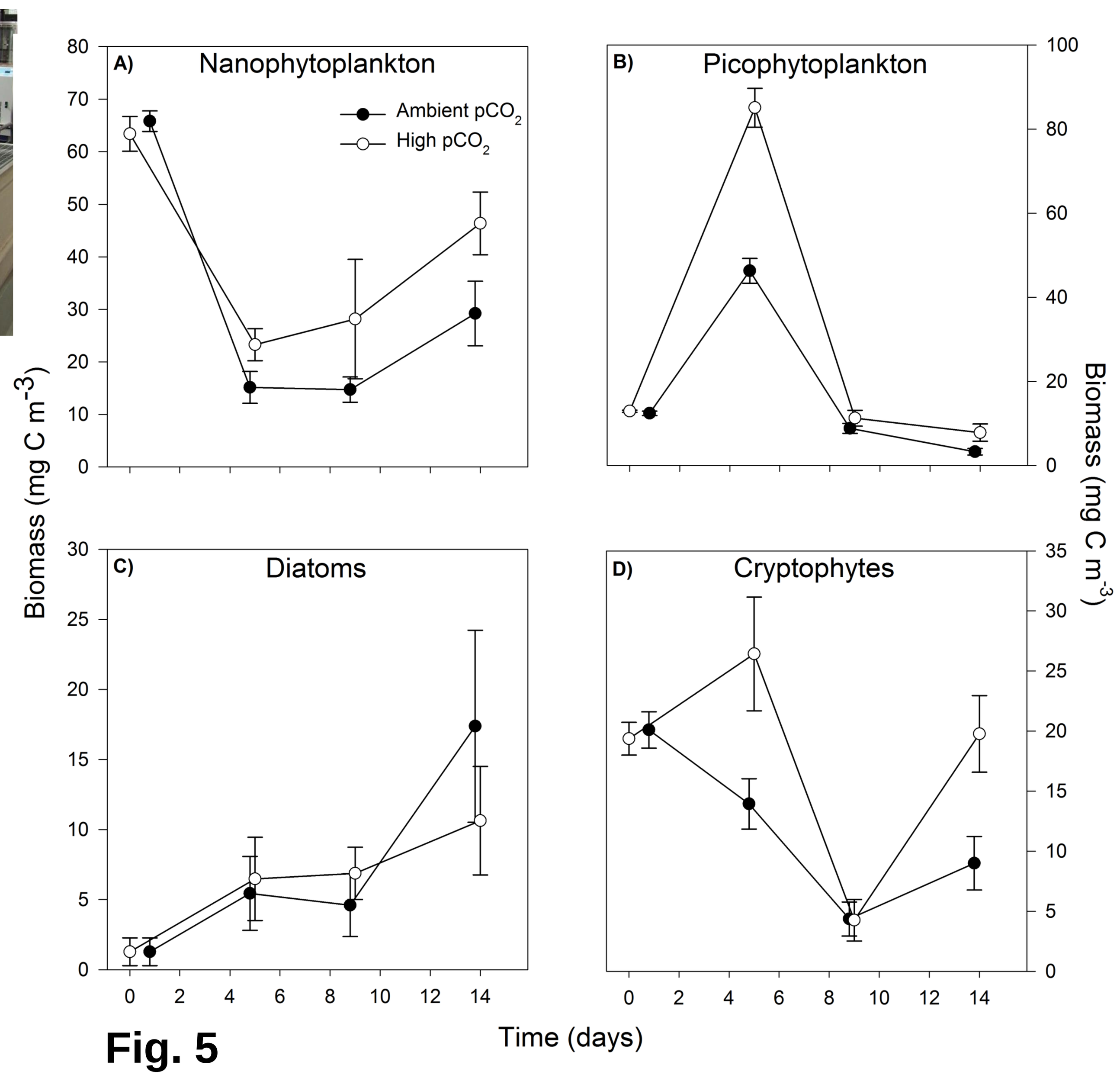


Fig. 5

Methods

- An intact phytoplankton community was sampled from 10m depth at L4 on 13th April 2015.
- 320L of seawater was collected for experimental media (0.2 and 0.1 µm sterile filtered).
- The community was incubated for 15 days in a semi-continuous batch culture system (n=8) (**Fig. 3**)
- The carbonate system of the media, not incubations, was adjusted to ~1,000 µatm (avoiding mechanical effects of bubbling that can impact sensitive species).(**Fig. 2. A & B**)
- Light, temperature and nutrient regime maintained at ~200 µmol photons m^{-2} s^{-1}, 11° C, 8µM N, 0.5 µM P.
- Phytoplankton community was analysed and enumerated by flow cytometry and FlowCAM.
- Cell bio-volume was calculated according to Kovala and Larrance, (1966). Biomass (mg carbon m^3) was estimated according to the equations of Menden-Deuer & Lessard, (2000).

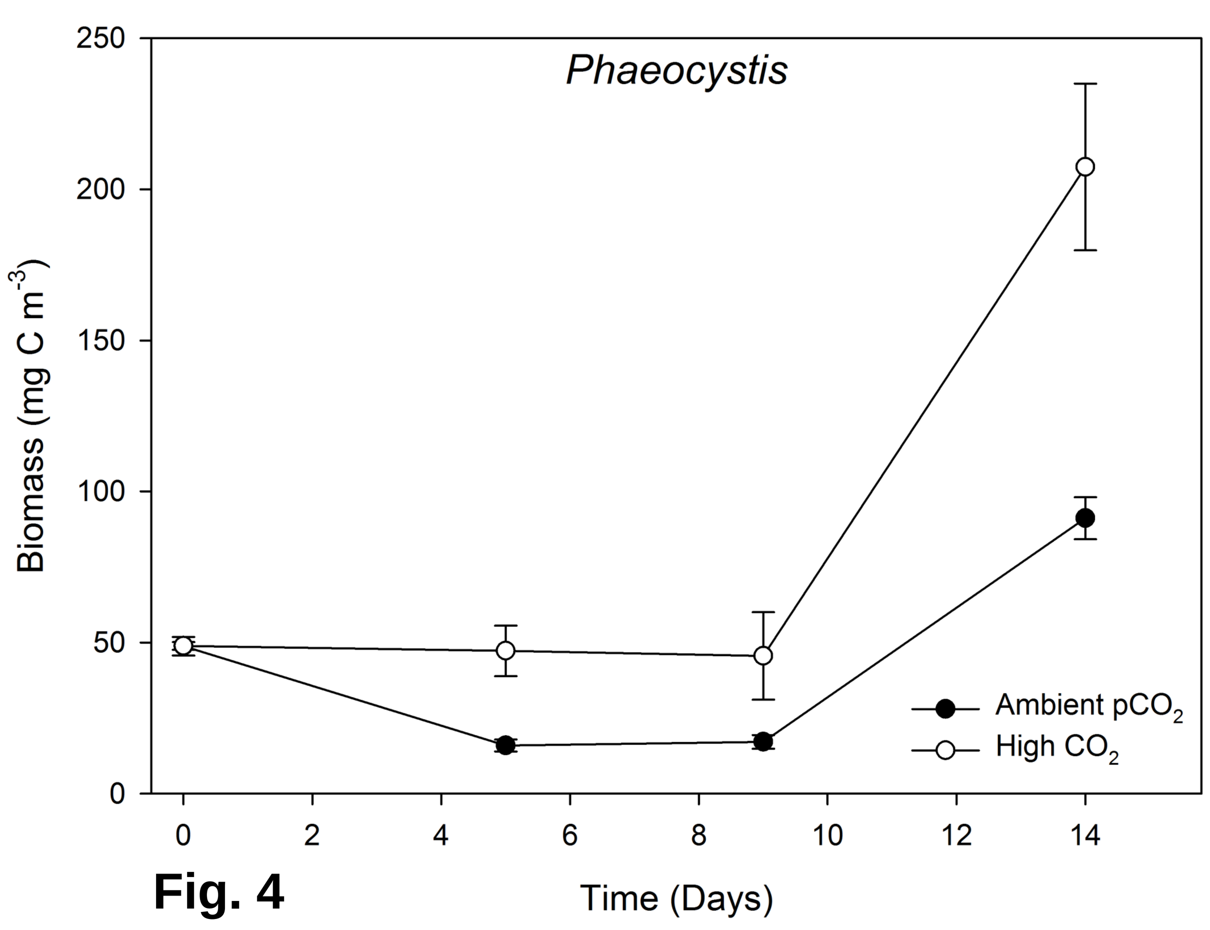


Fig. 4

Results & Conclusions

- Starting community biomass estimated at ~160 mg C m^{-3}: 40% nanophytoplankton, 30% *Phaeocystis*.
- Community biomass increased significantly to ~305 mg C m^{-3} (+90%) in high CO_2 treatment ($z = 3.536$, $p < 0.001$) (**Fig. 2. D**).
- Ambient CO_2 showed no net gain in community biomass.
- *Phaeocystis* exhibited greatest response in high CO_2 treatment:, significantly increased biomass >300% from 50 -
- ~200 mg C m^{-3}: contributing 70% of community biomass ($z = 3.219$, $p < 0.001$) (**Fig. 4**)
- More subtle response observed in other components of community (**Fig. 5. A, B & D**).
- Diatoms: only group to show decreased biomass at elevated CO_2 compared to control.(**Fig. 5. C**)
- Results suggest elevated CO_2 could favour sustained *Phaeocystis* populations over diatoms in late spring bloom period.
- At predicted 2100 atmospheric CO_2 concentrations, *Phaeocystis* may dominate the L4 spring phytoplankton bloom community structure, enhance CO_2 drawdown, but also cause an increase in noxious foam with possible consequences on fisheries and tourism.

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