Seasonal changes in chlorophyll a concentrations, phytoplankton biomass and primary production in the Baltic Sea based on monitoring and glider data

Joanna Paczkowska [1, 2], Chiara Monforte [1], Louise Biddle[1], Bastien Y. Queste [1, 2]

(1) Voice of the Ocean Foundation, Skeppet Arans Vag 19, 42671 Vastra Frolunda, Sweden

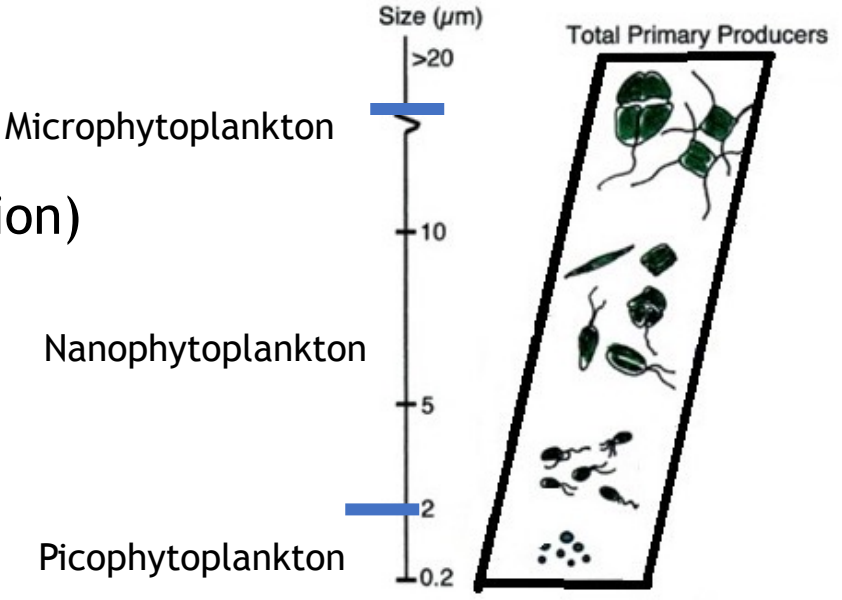
(2) Department of Marine Sciences, University of Gothenburg, Gothenburg, Sweden

Voice of the Ocean

GÖTEBORGS UNIVERSITET

Introduction

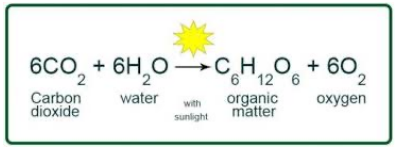
Size (Groups)



- Small cells – warm and nutrient-poor conditions (stratified condition)
- Larger cells – cold and nutrient-rich conditions

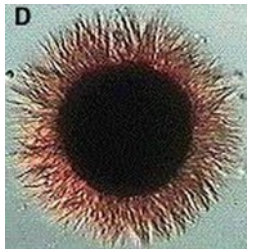
Nutritional strategy of phytoplankton

- Autotrophs



- Mixotrophs (combining photosynthesis and heterotrophy) *Mesodinium rubrum*

Vertical Movements



- Flagellate phytoplankton
- *Mesodinium rubrum* (hair-like structure)

1. Chlorophyll *a* Concentration (Chl *a*, mg m^{-3})

2. Total Phytoplankton Biomass (C, µg C l^{-1})

Particulate backscattering coefficient (bbp), a proxy for particulate organic carbon (POC, carbon incorporated in living organisms e.g., phytoplankton, heterotrophic bacteria and nanoflagellates, detritus) from which phytoplankton biomass.

3. Carbon to Chlorophyll *a* ratio (C: Chl *a*)

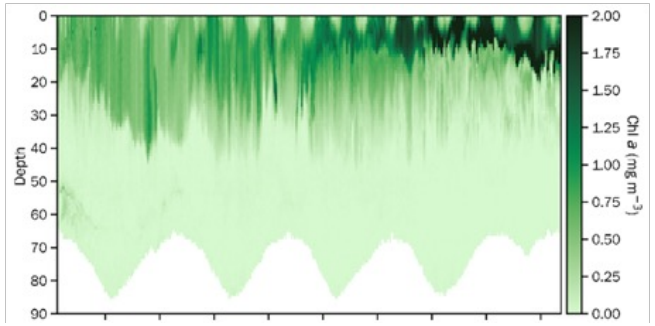
Light ↓ Carbon **Chl *a*** ↑

Light ↑ Carbon **Chl *a*** ↓

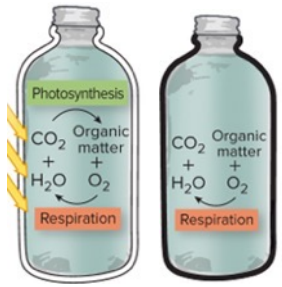
Nutrients ↓ Carbon **Chl *a*** ↓

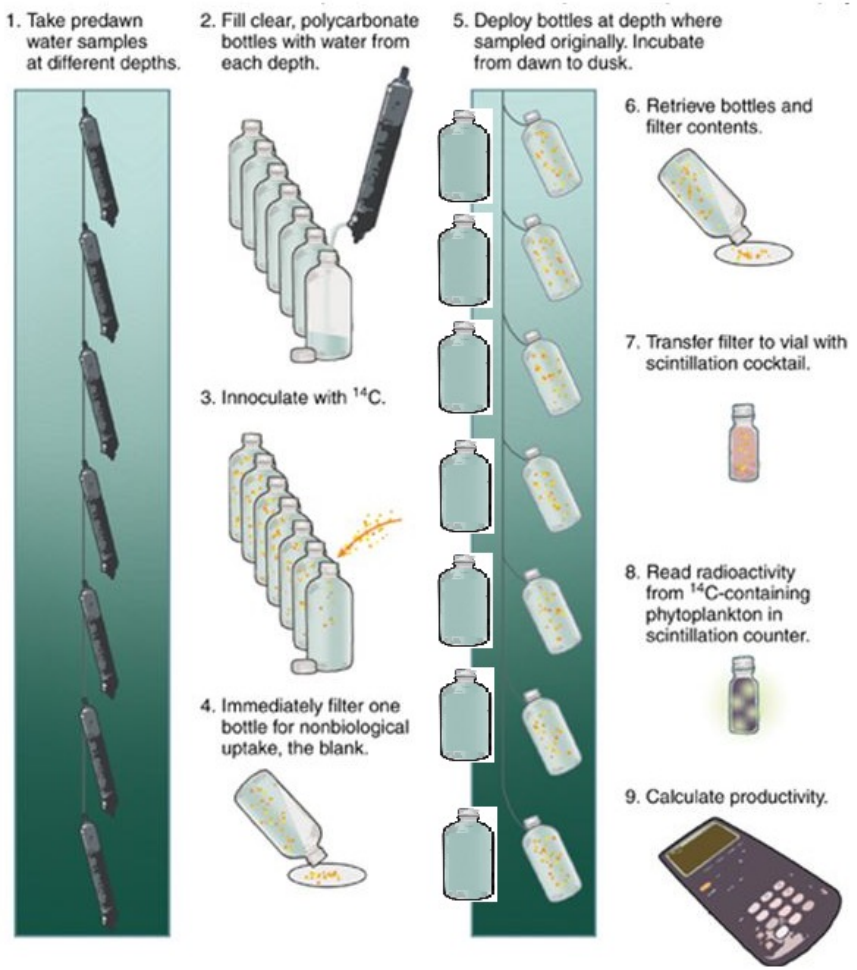
C: Chl *a* ↓ Winter

C: Chl *a* ↑ Summer



4. Primary Production



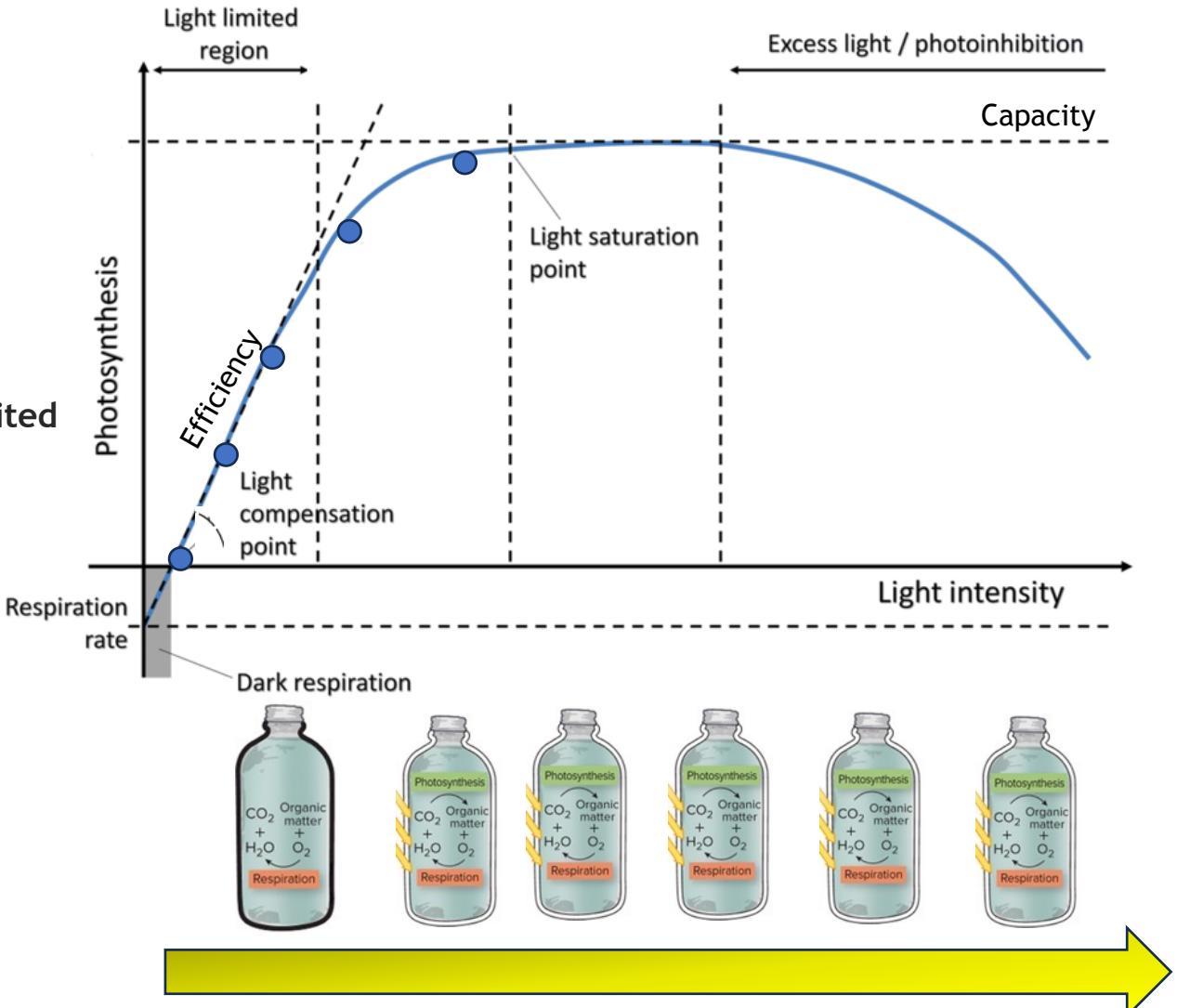


P^B_{max}

The maximum photosynthetic rate

α^B

The light limited slope



Primary Production Model (Platt et al., 1980)

$$PP_{\text{int}} = P^{B}_{max} \times \left(1 - e^{\alpha^{B} I_{0}^{m} / P^{B}_{max}}\right) \times \text{Chl } a$$

- **PP_{int}**: Integrated primary production (mg C m^{-2} d^{-1})
- **P^{B}_{max}**: The light-saturated maximum rates of the *P-E* curve normalized to chlorophyll *a* concentration
- **α^{B}** : The light-limited slope of the *P-E* curve normalized to chlorophyll *a* concentration
- **I_o^m**: Photosynthethic Activer Radiation (PAR) at depth
- **Chl *a***: Chlorophyll *a* concentration at depth

- Vertically Generalized Production Model (VGPM, Behrenfeld and Falkowski, 1997),
- Carbon-based Productivity Model (CbPM,Behrenfeld et al., 2005)

Phytoplankton Succession

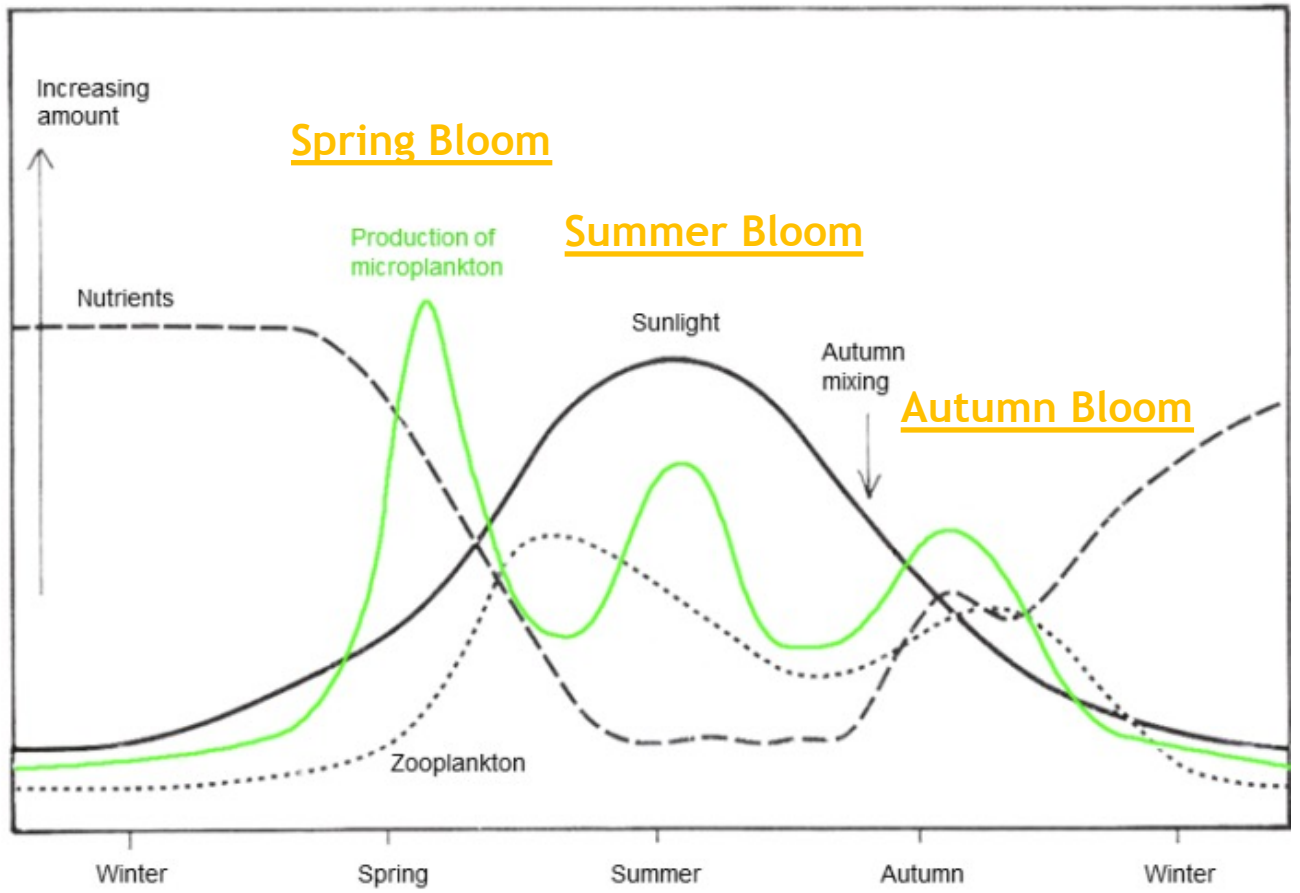


Fig. 1. Picture adapted from Rosenberg 1982 and Hällfors & Niemi 1986.

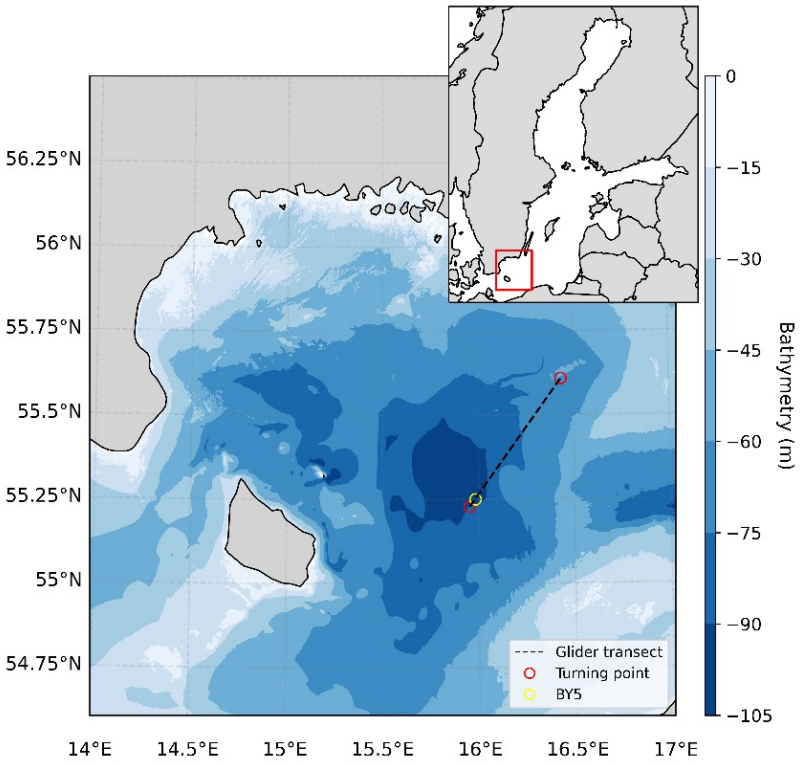
Summer Bloom

1. **Produce toxins**
2. **Eutrophication**
3. **Contribute to oxygen depletion**

Methods

- 3rd March 2021 and 15th February 2022

Study Area



- **<u>Swedish Oceanographic Data Centre (SHARK) (0-10 m)</u>**

1. Inorganic nutrients (Nitrate+Nitrite)

2. Chlorophyll *a* concentration (Chl *a*) ★
3. Phytoplankton Biomass (pico-, nano- and microphytoplankton) ★
4. Photosynthetic parameters: light-saturated maximum rates (P^B_{max}) and light-limited slope (α^B)
5. Primary Production ★

- **<u>Voice of the Ocean (VOTO) (0-10 m, water column)</u>**

1. Salinity, temperature, and depth → Mixed layer depth (MLD)
2. Photosynthetically Active Radiation (PAR) → Euphotic zone
3. Particulate Backscatter (700 nm), as a proxy of POC ★

4. Chlorophyll *a* concentration ★
5. Primary Production Model ★

Is it possible to use gliders to study phytoplankton dynamics in the Baltic Sea and support the Swedish National Monitoring Program?

Results

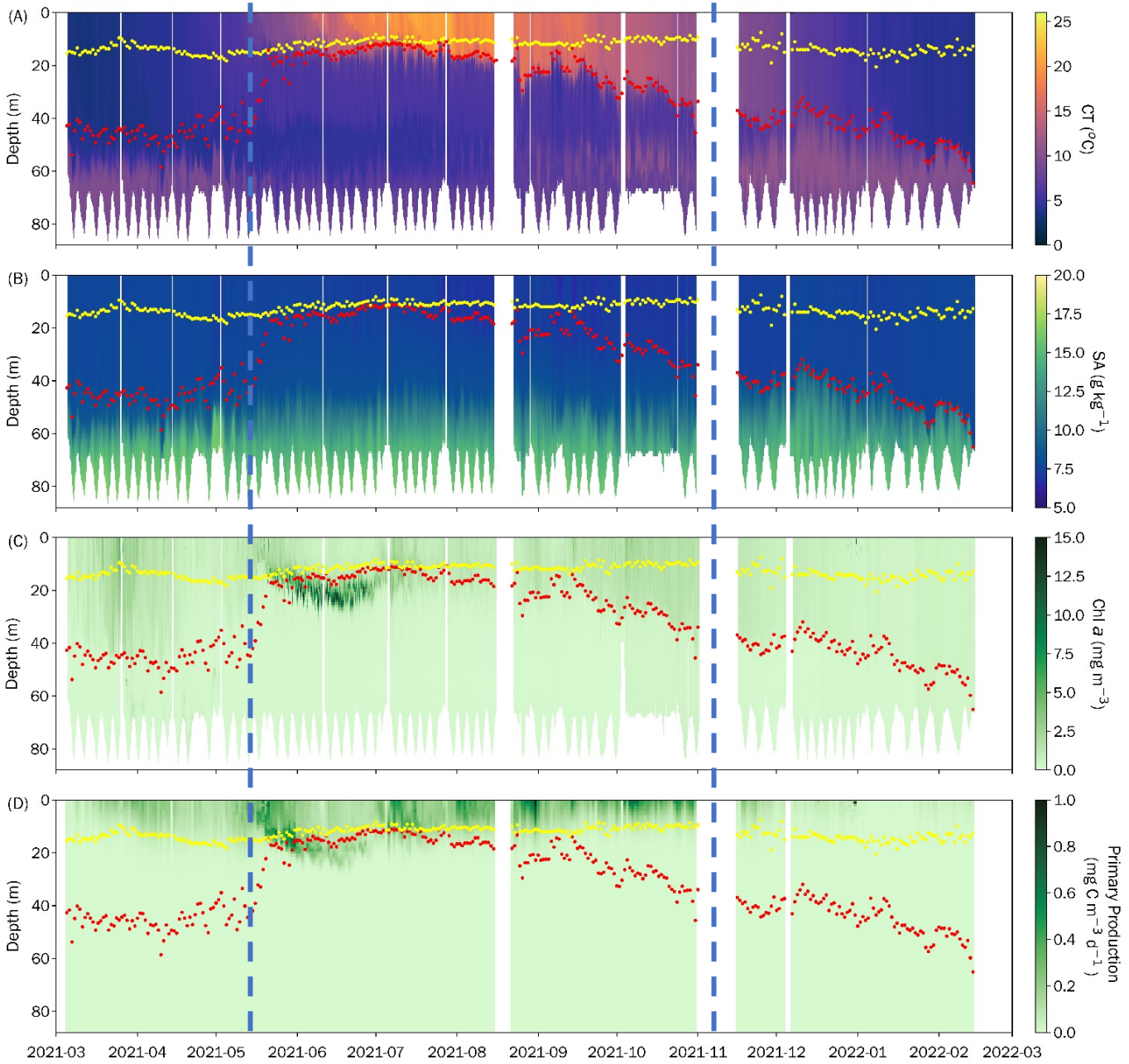
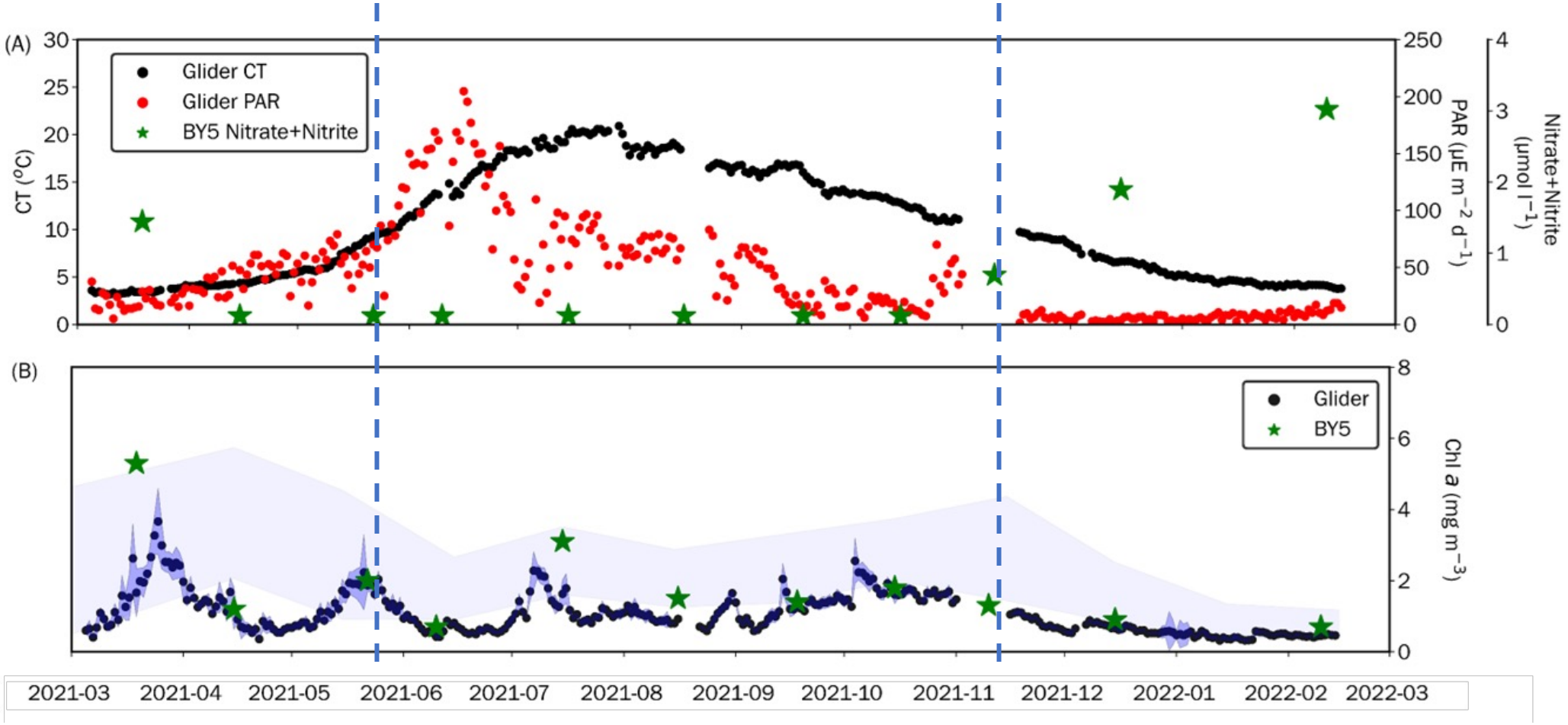


Fig. 2. Vertical variations of conservative temperature (CT) (A), absolute salinity (SA) (B), chlorophyll *a* concentration (Chl *a*) (C) and primary production (D) collected by the glider during the study period (2021/2022). The red and yellow dots represent the mixed layer depths (MLD) and euphotic depths, respectively.



Inorganic Nutrients	High	Low	High
Temp	Low	High	Low
Light	Middle	High	Low

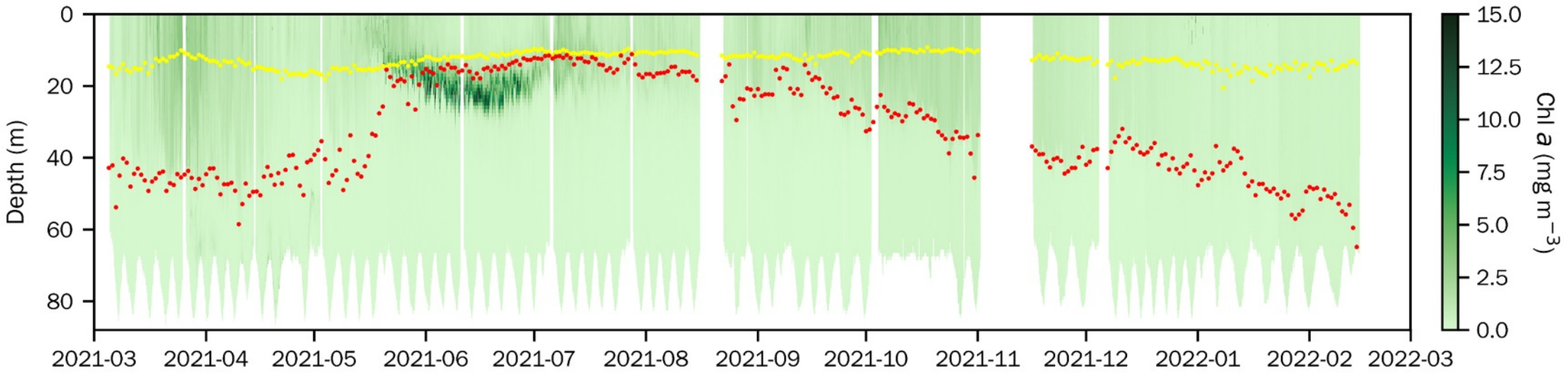
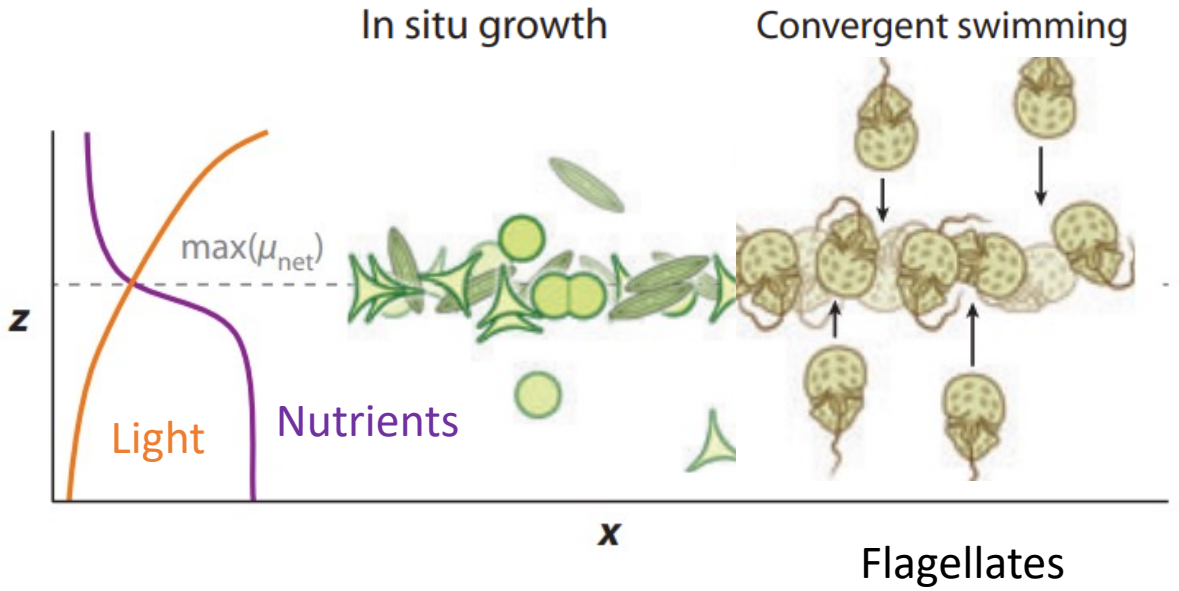


Fig.3. Vertical variations of chlorophyll *a* concentration (Chl *a*) collected by the glider during the study period (2021/2022). The red and yellow dots represent the mixed layer depths (MLD) and euphotic depths, respectively.



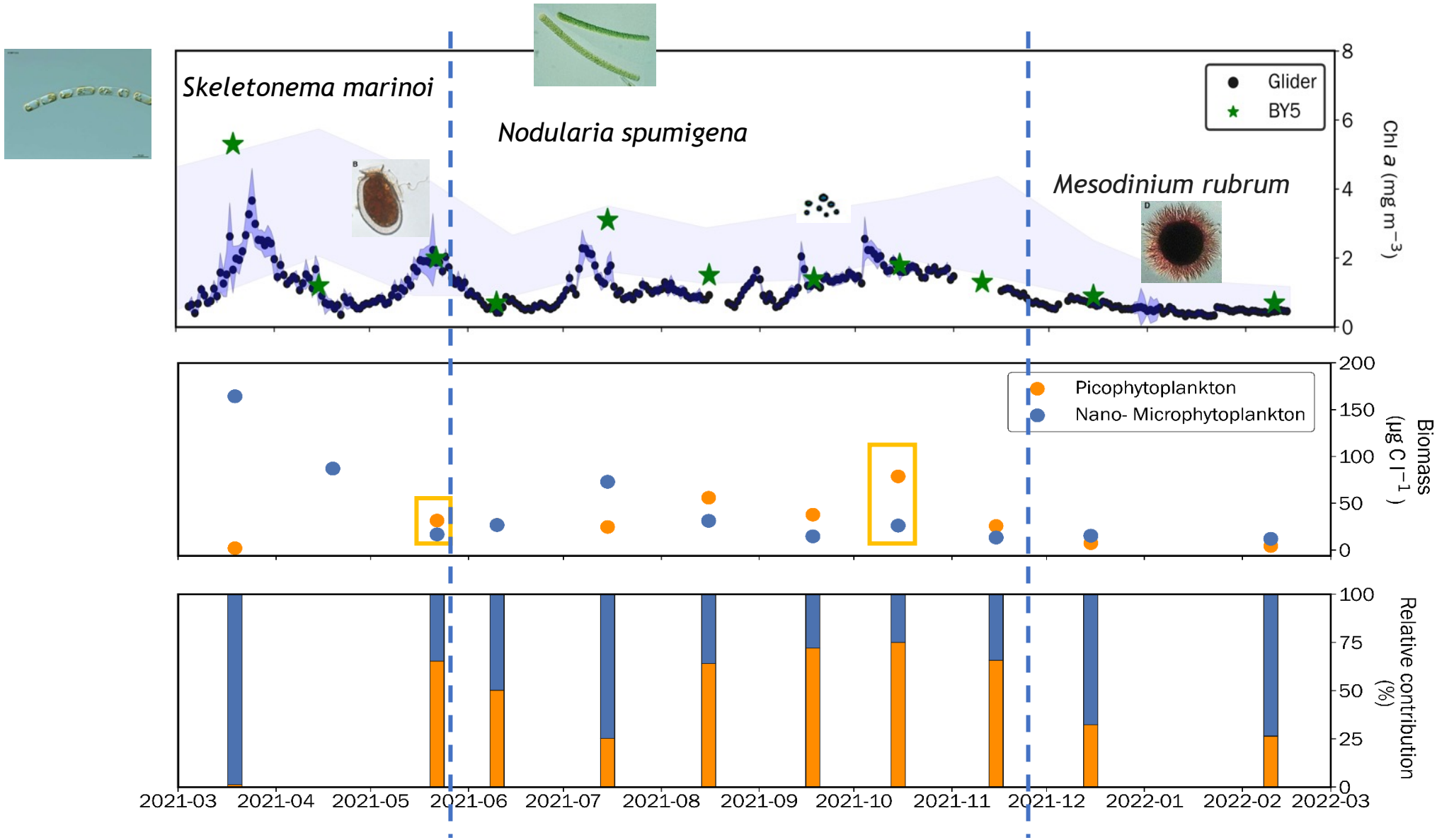


Fig. 4. Daily variations of surface chlorophyll *a* concentration (Chl *a*), pico- and nano-, microphytoplankton biomass and their relative contribution collected at BY5 station and by the glider during the study period (2021/2022). Light blue shaded area corresponds to the monthly average monitoring Chl *a* ± standard deviation.

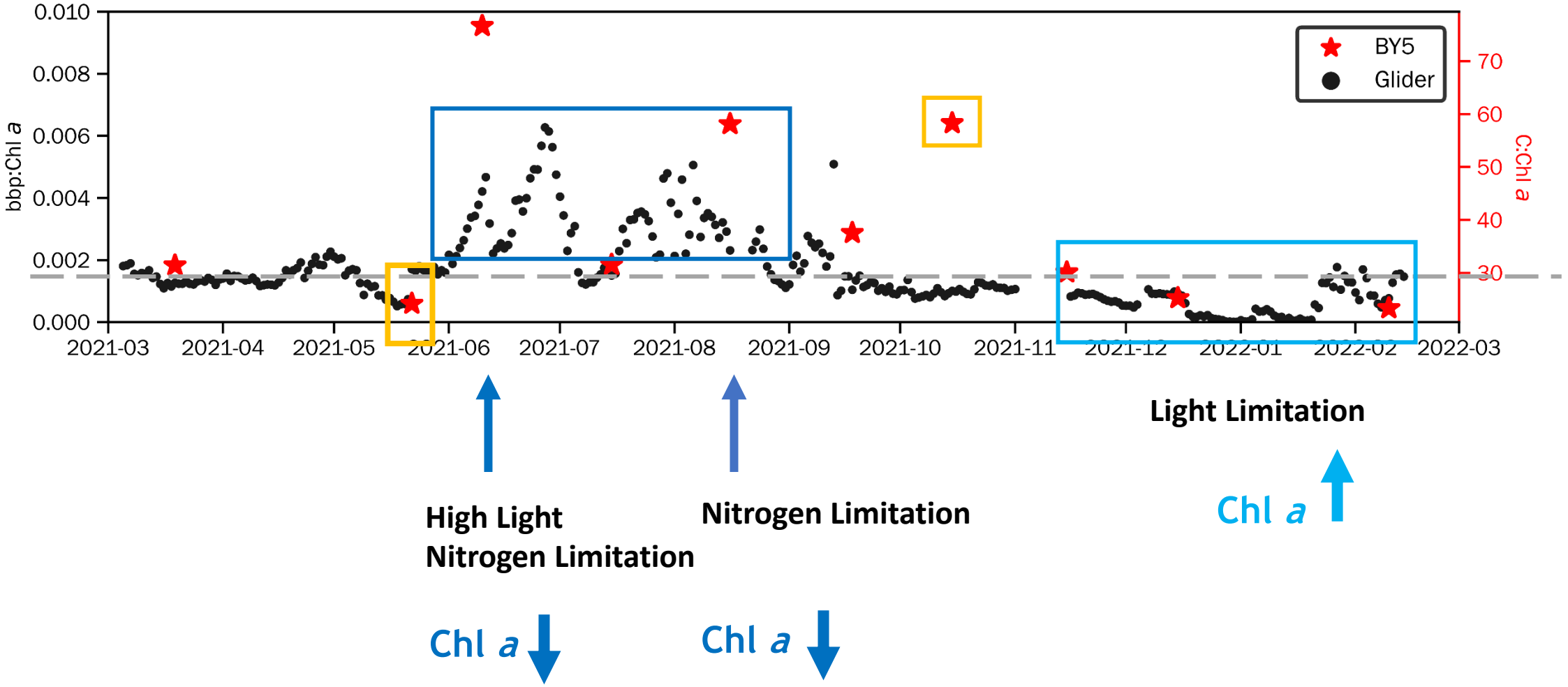


Fig. 5. Daily variations of C:Chl *a* ratio and bbp:Chl a ratio collected at BY5 station and by the glider during the study period (2021/2022).

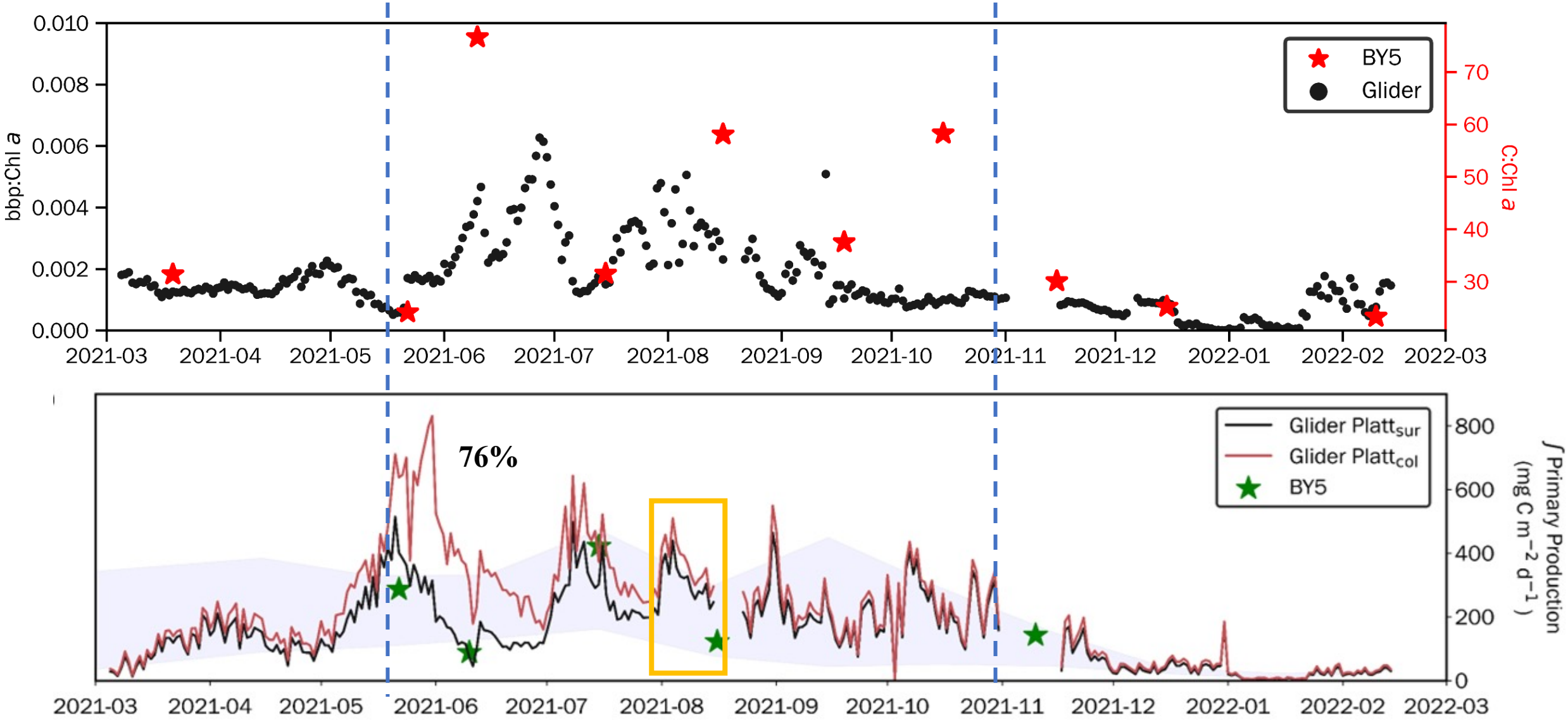


Fig. 6. Daily variations of bbp:Chl a and C:Chla ratio (A) and primary production (B) collected at BY5 station and estimated using the glider data during the study period (2021/2022).

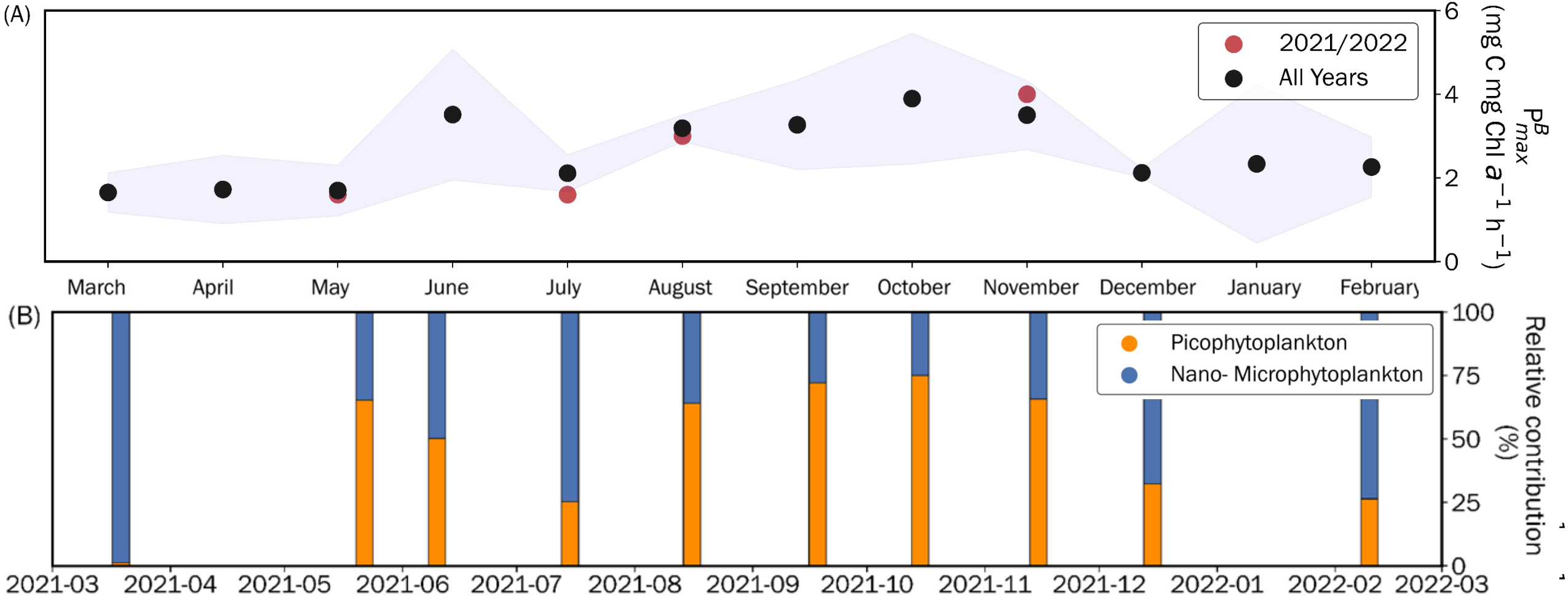


Fig. 7. Monthly variations of photosynthetic parameters: P^B_{max} collected at BY5 station during the study period (2021/2022) and the monitoring program (All Years) (A) and the relative contribution of pico- and nano-, microphytoplankton to the total phytoplankton biomass (B). Light blue shaded area corresponds to the monthly average monitoring photosynthetic parameter ± standard deviation.

Conclusion:

- Gliders can fill the gap in Chlorophyll *a* and Primary Production measurements
- Deep Chlorophyll Maximum → Integrated Primary Production (up to 76% during the summer)
- Uncouple between Chlorophyll *a* concentration, Phytoplankton Biomass and Primary Production
- Picophytoplankton play a significant role in phytoplankton dynamics and primary production

Future work:

- Total Phytoplankton Biomass
- Explore other proxy from glider data to explain phytoplankton productivity (oxygen diel method)
- Expand the scope of this work to the other VOTO observatories