Primary production of surface and subsurface phytoplankton communities across the Atlantic Ocean

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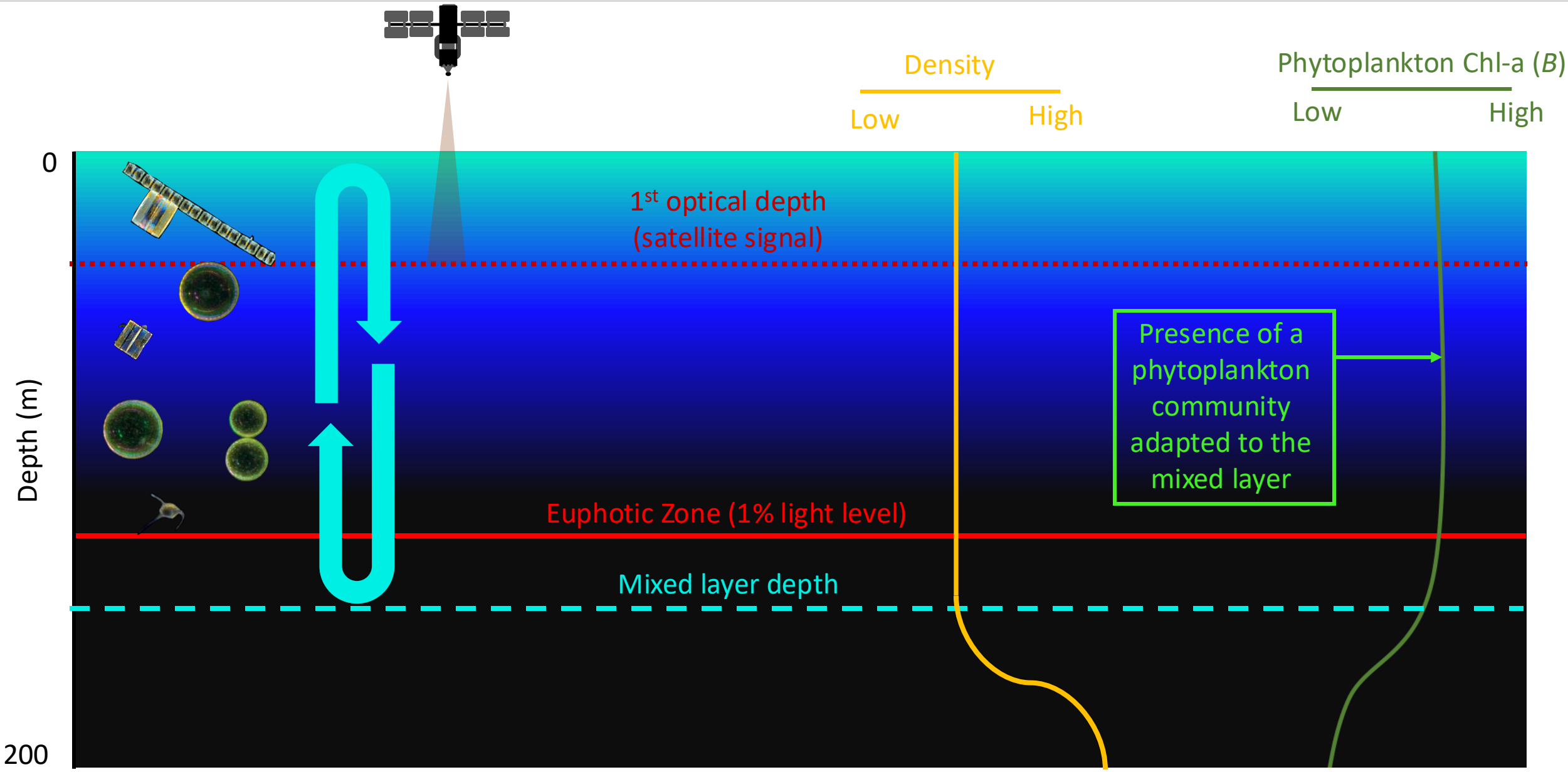
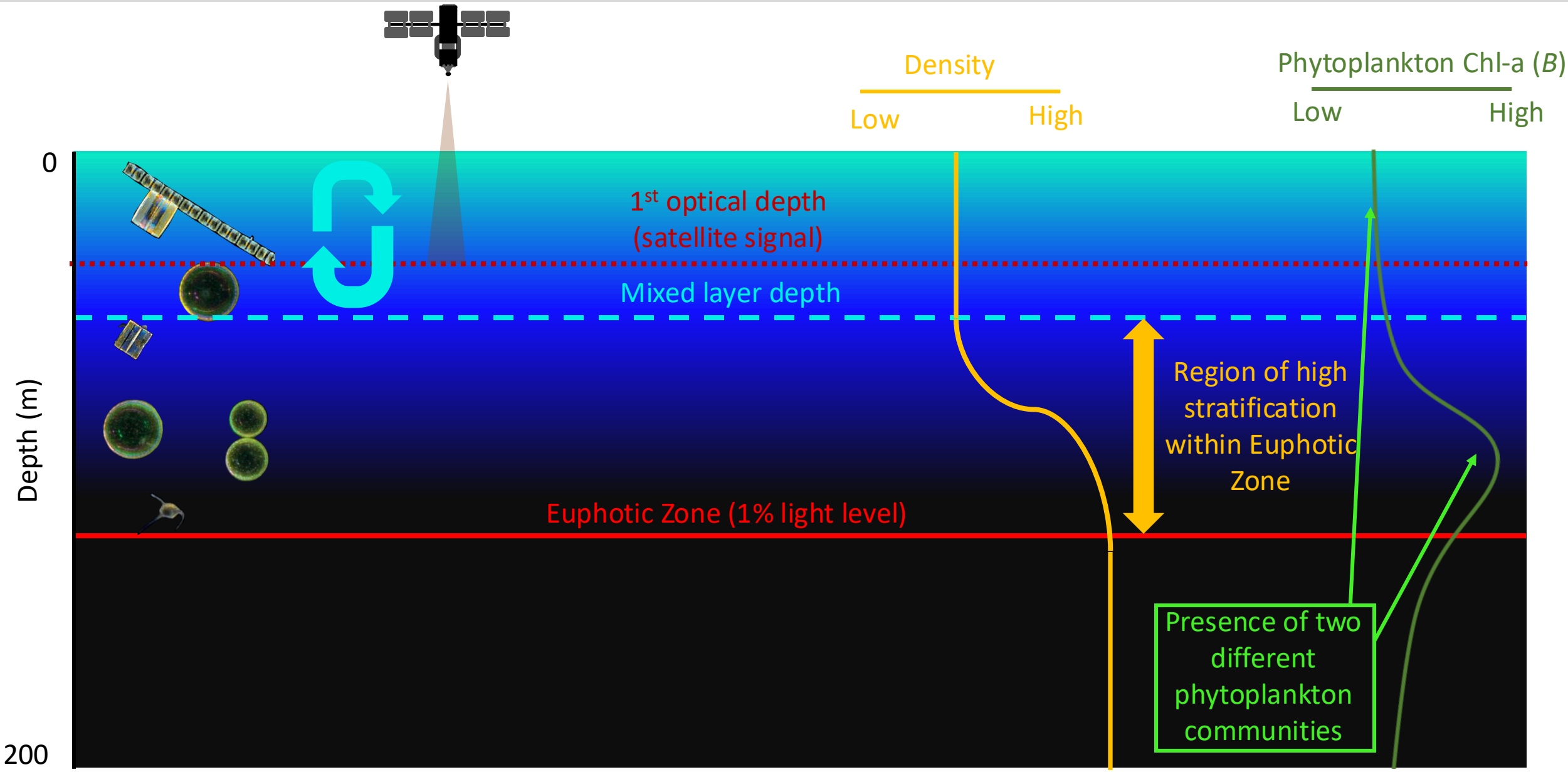
Future Leaders Fellowships

University of Exeter



Phytoplankton community = a group of species that occur together in space and time

Begon et al. (1990) Ecology: Individuals, populations, and communities. Blackwell Science Inc.



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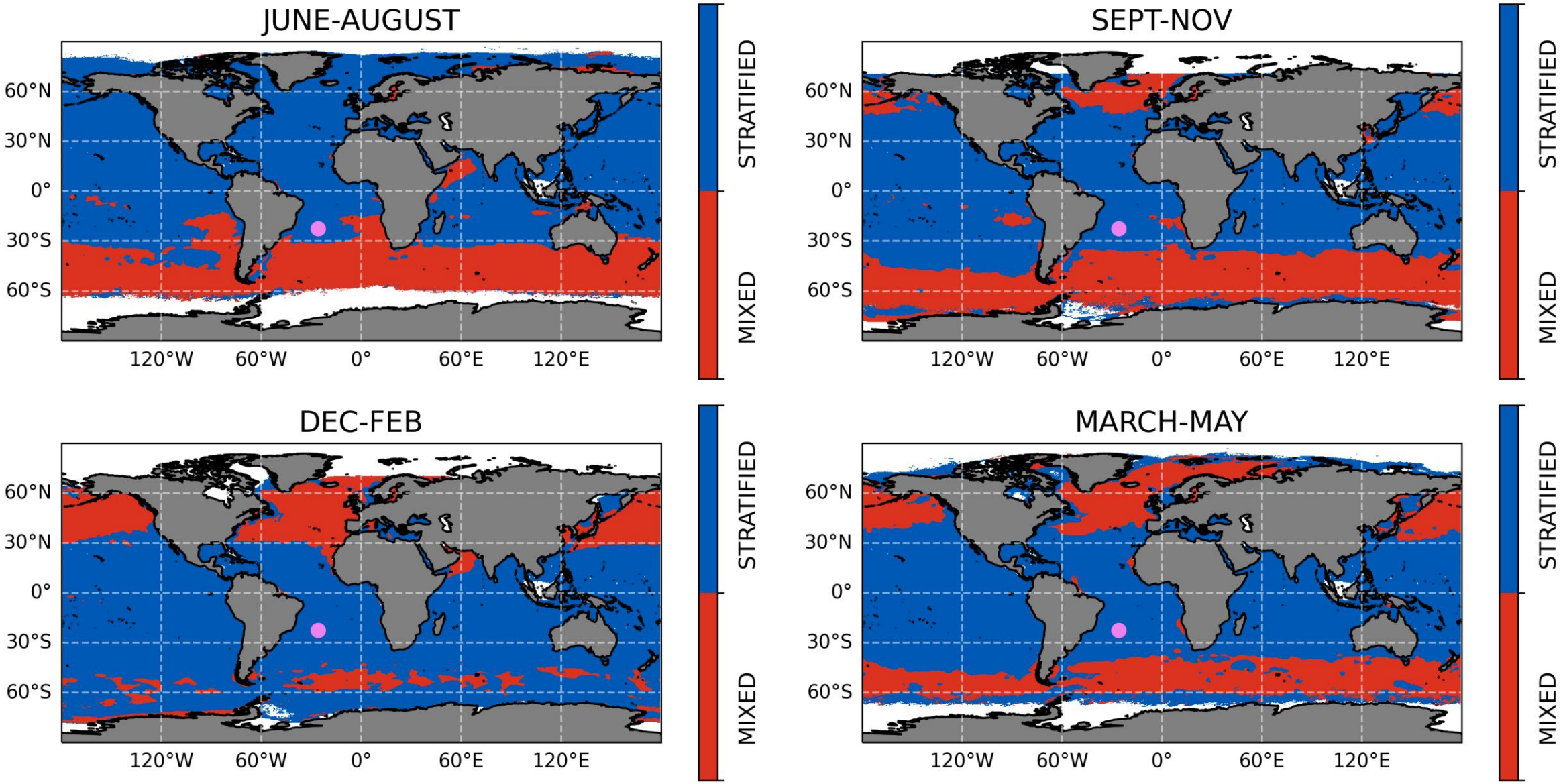
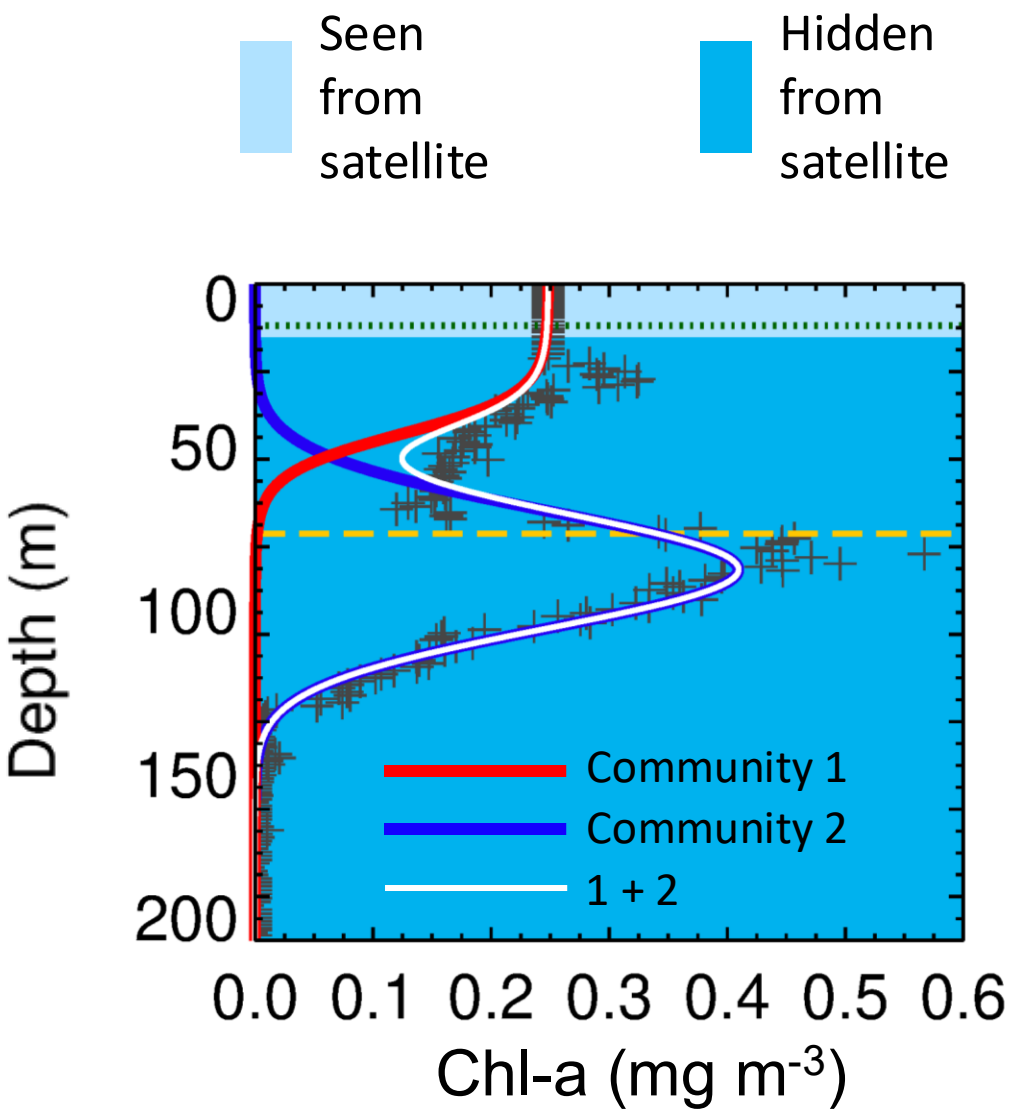

JUNE-AUGUST
SEPT-NOV
DEC-FEB
MARCH-MAY
60°N
30°N
0°
30°S
60°S
120°W
60°W
0°
60°E
120°E
STRATIFIED
MIXED



Research Questions

1. Is the photophysiology of these two communities different?

2. What is the contribution of these two communities to primary production?

3. How does this differ to the contribution to Chl-a concentration and phytoplankton carbon?

Brewin et al. (2022) JGR - Oceans https://doi.org/10.1029/2021JC018195

Available light model of primary production

$$P = \int_{t=0}^{D} \int_{z=0}^{\propto} B(z) P_m^B(z) \left(1 - \exp\left(-\frac{\alpha^B(z) I(z,t)}{P_m^B(z)}\right)\right) dz dt$$

Platt et al. (1980) J. Mar. Res.

P_m^B Assimilation number of the light saturation curve (mg C (mg B)$^{-1}$ h^{-1})

α^B Initial slope of the light saturation curve (mg C (mg B)$^{-1}$ h^{-1} (µmol quanta m^{-2} s^{-1})$^{-1}$)

B Chl-a concentration (mg m^{-3})

I Light (µmol quanta m^{-2} s^{-1}) (PAR)

D Daylength (h)

t time

z depth

Available light model of primary production for two communities

$$P = \int_{t=0}^{D} \int_{z=0}^{\propto} \sum_{i=1}^{2} B_i(z)\, P_{m,i}^{B}(z) \left(1 - \exp\left(- \frac{\alpha_i^B(z) I(z,t)}{P_{m,i}^{B}(z)} \right) \right) dz dt$$

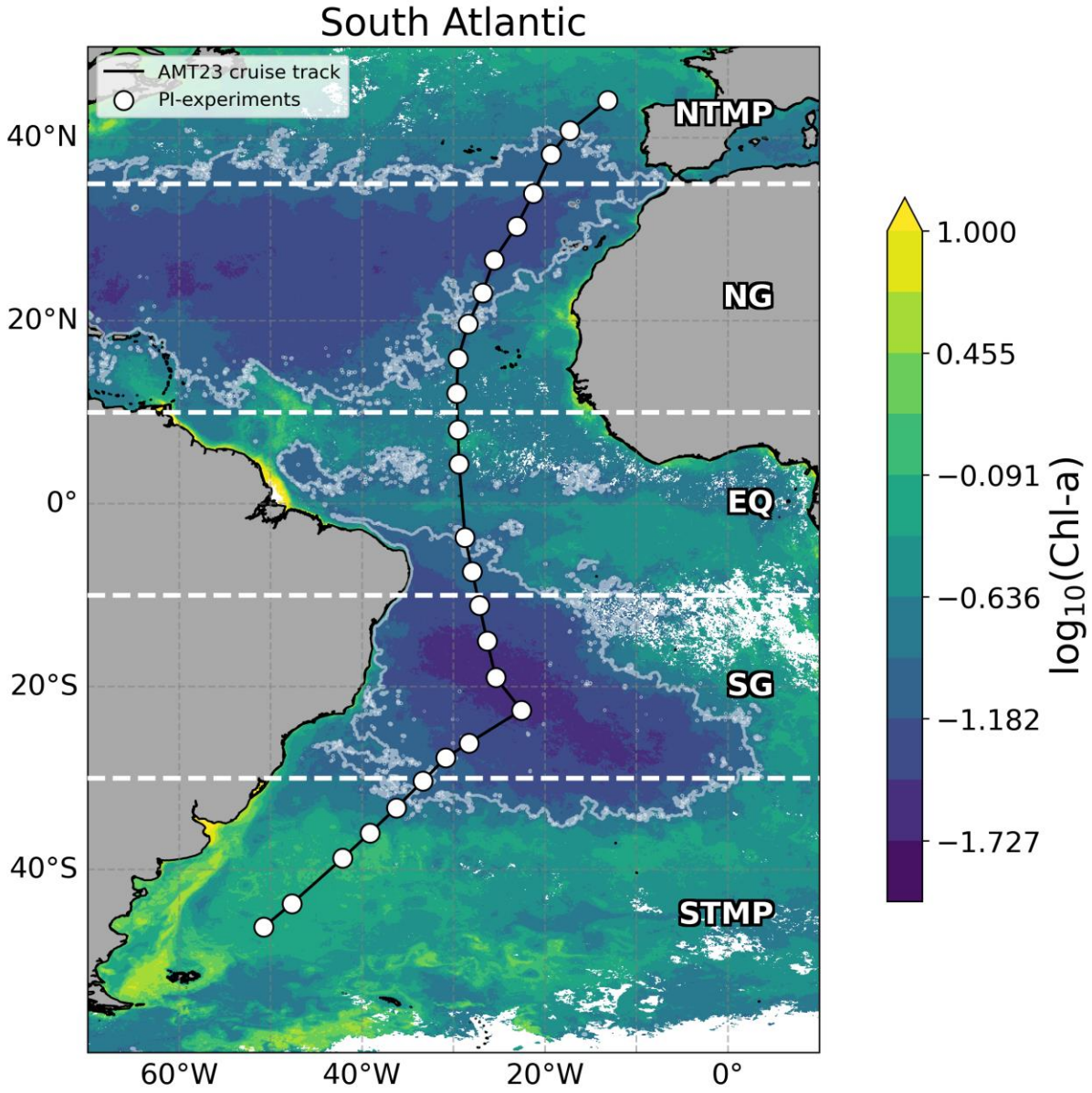
$P_{m,i}^{B}$ Assimilation number of the light saturation curve (mg C (mg B)$^{-1}$ h^{-1})

α_i^B Initial slope of the light saturation curve (mg C (mg B)$^{-1}$ h^{-1} (µmol quanta m^{-2} s^{-1})$^{-1}$)

B_i Chl-a concentration (mg m^{-3})

Specific to community 1 and 2, where i = either 1 or 2.

Study Region



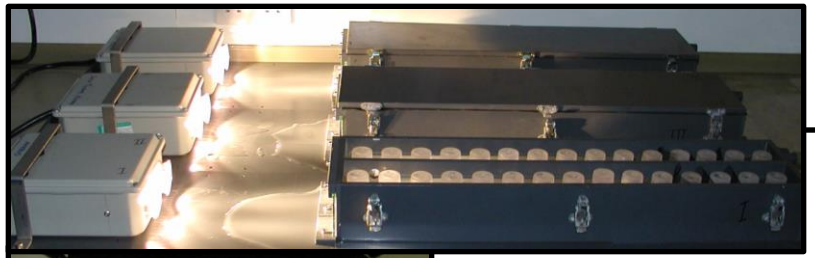
Atlantic Meridional Transect 23 (October 2013)

Discrete (local noon) sampling of surface (Community 1) and subsurface (at DCM) water (Community 2)

Discrete measurements of PI-experiments ($P^B_{m,i}$ and α^B_i), HPLC pigments, phytoplankton absorption (a_{ph}), with CTD profiles of physics + Chl-a (B), particle beam attenuation (c_p) and PAR

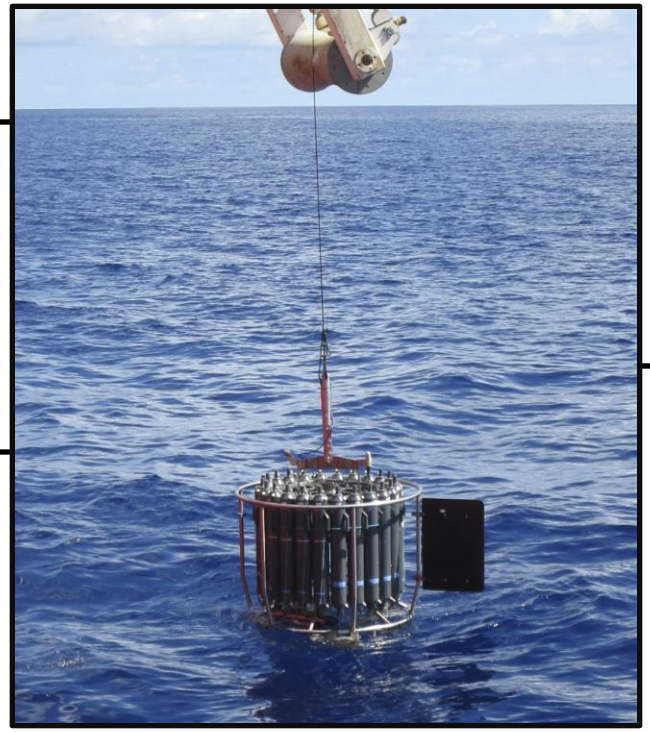
Additional (independent pre-dawn stations) on-deck incubations

Daily, depth-integrated primary production



$P^B_{m,i}$, α^B_i, Chl-a

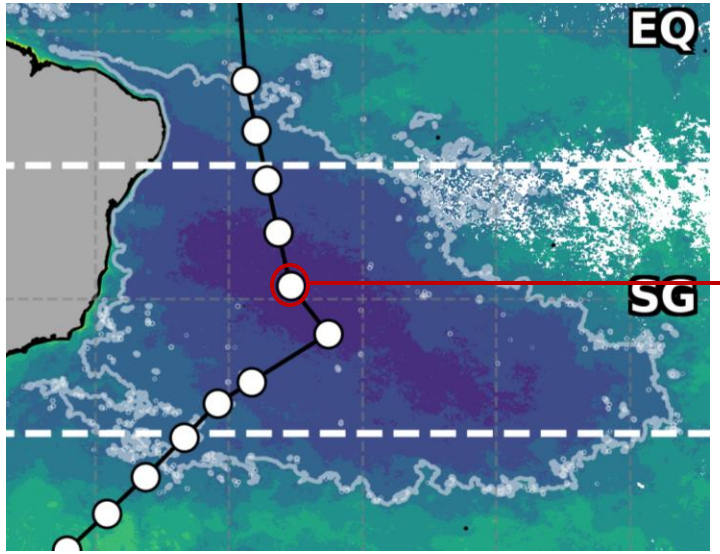
HPLC (Chl-a, PSC, PPC), $a_{ph}(\lambda)$



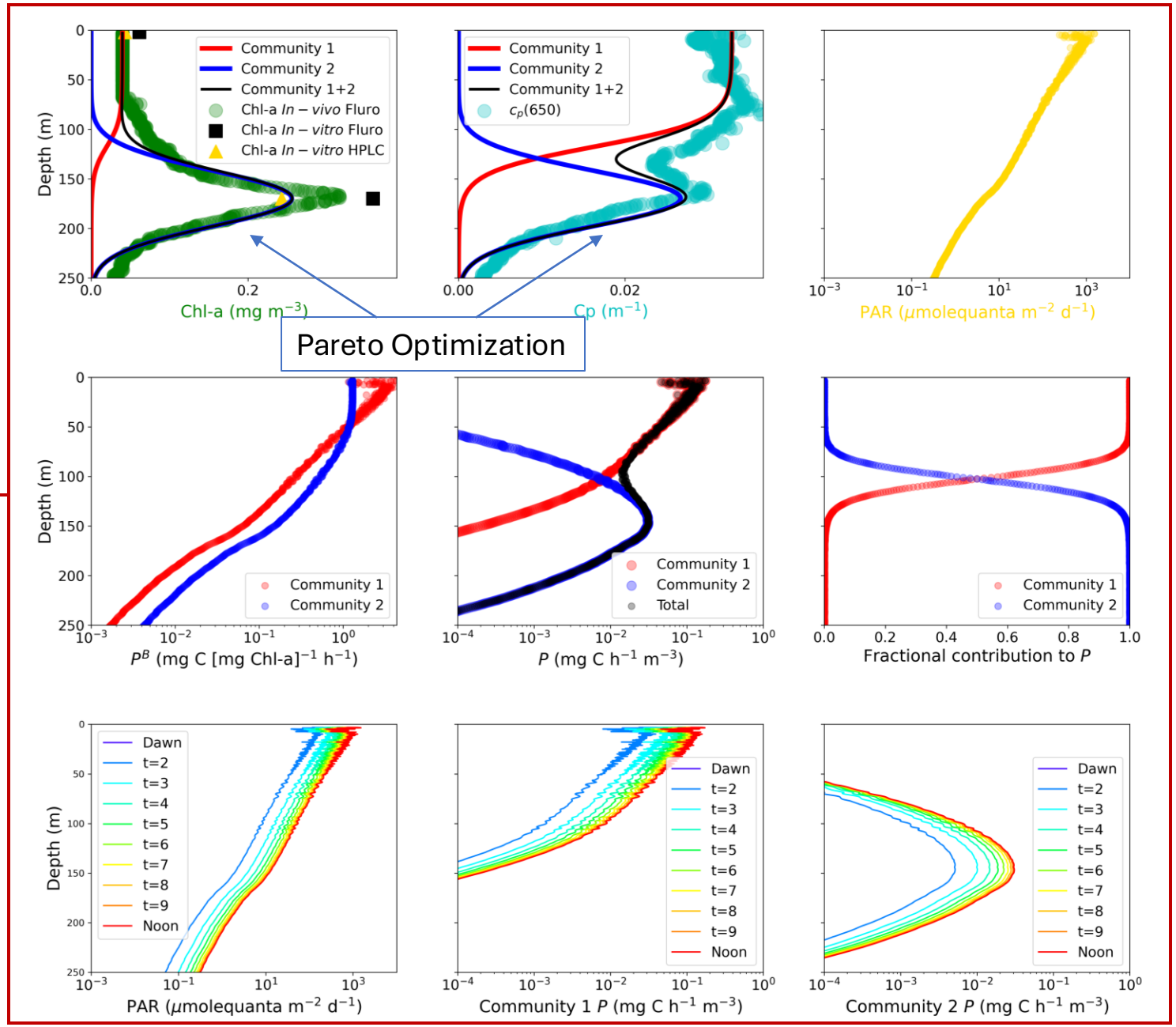
Water (surf and DCM); CTD (T, S, PAR (noon), Chl-a, $c_p(650)$

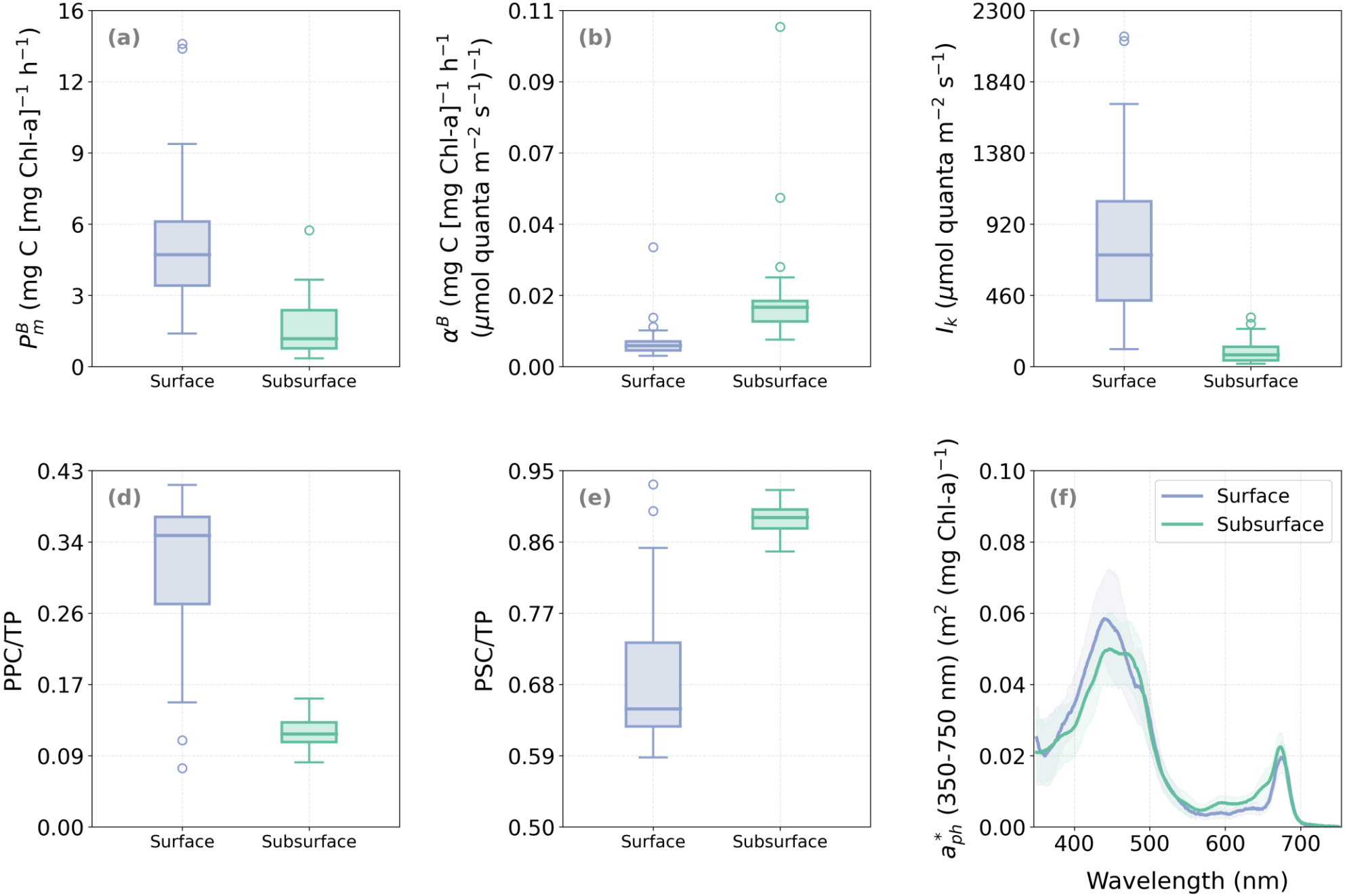
Depth-integrated primary production for two communities

$$P = \int_{t=0}^{D} \int_{z=0}^{\infty} \sum_{i=1}^{2} B_i(z)\, P_{m,i}^{B}(z) \left(1 - \exp\left(-\frac{\alpha_i^B(z) I(z,t)}{P_{m,i}^{B}(z)}\right)\right) dz dt$$

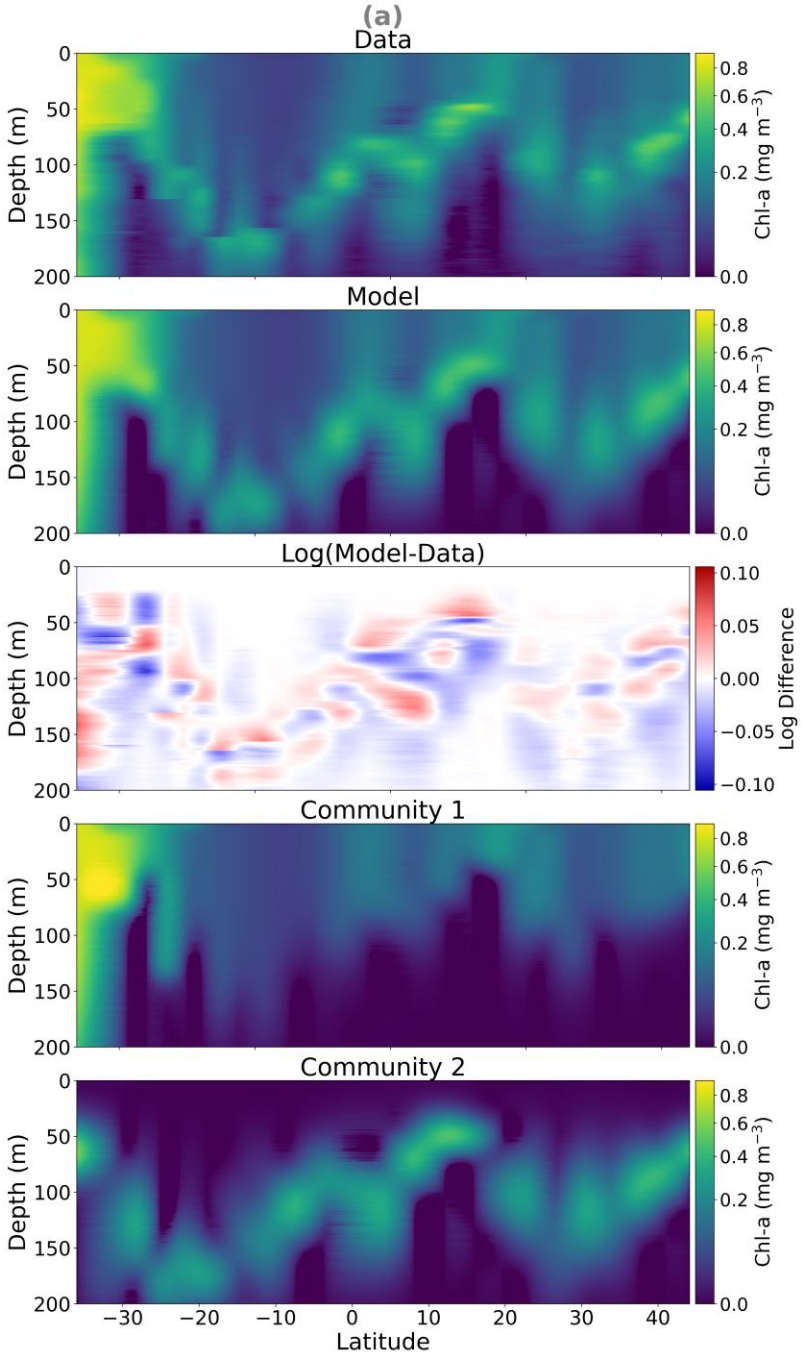


Repeated for each station!

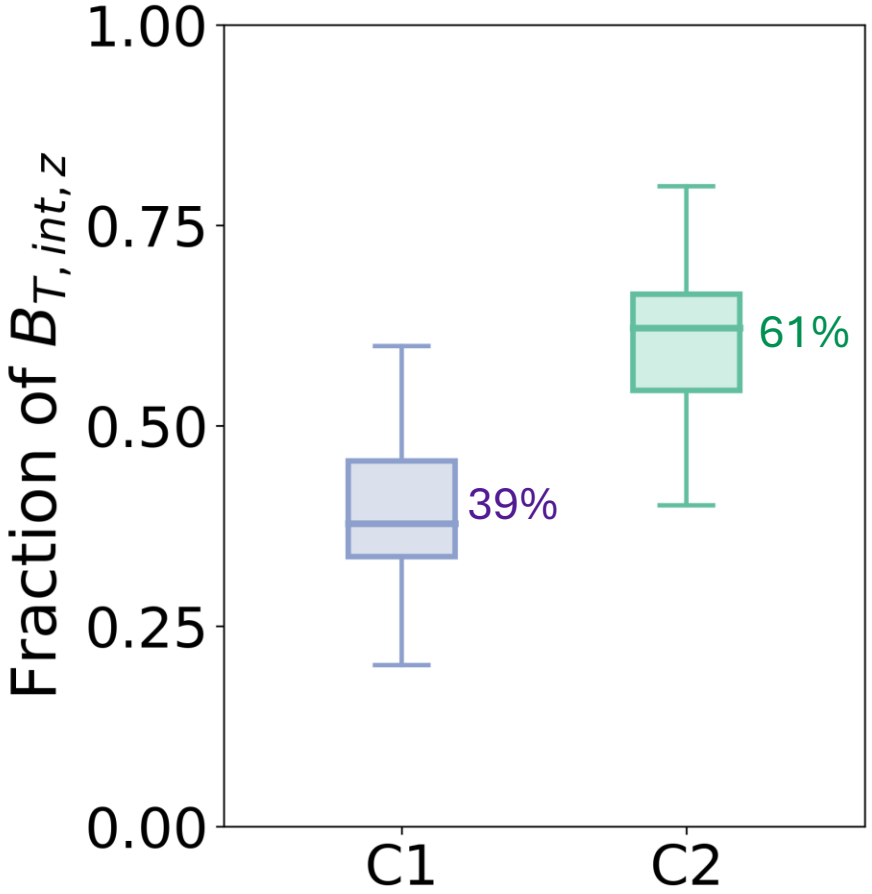




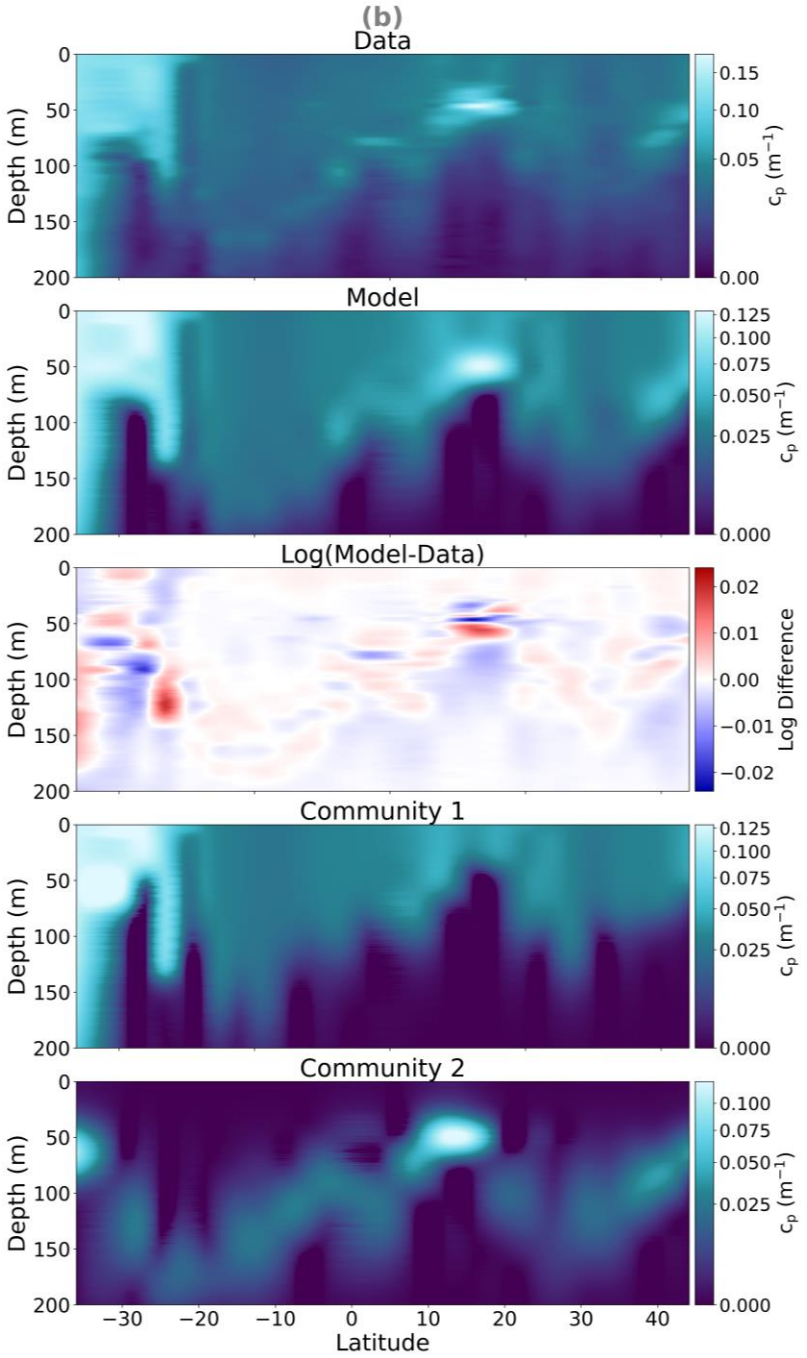
Two communities have different photo-physiology

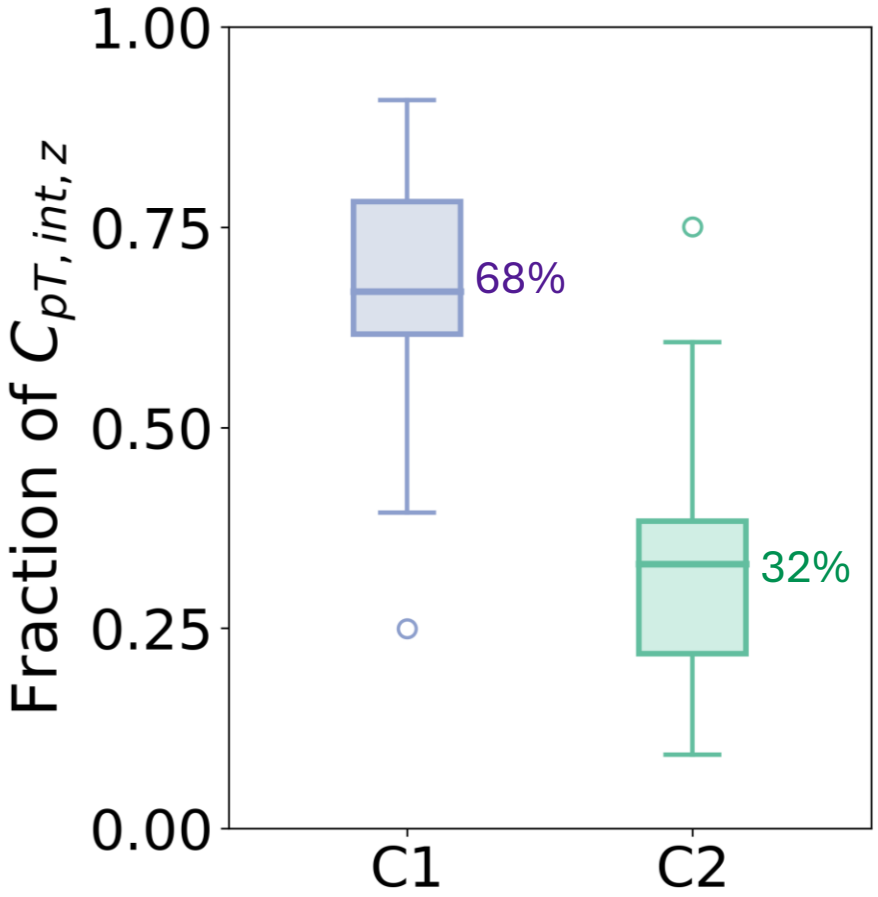


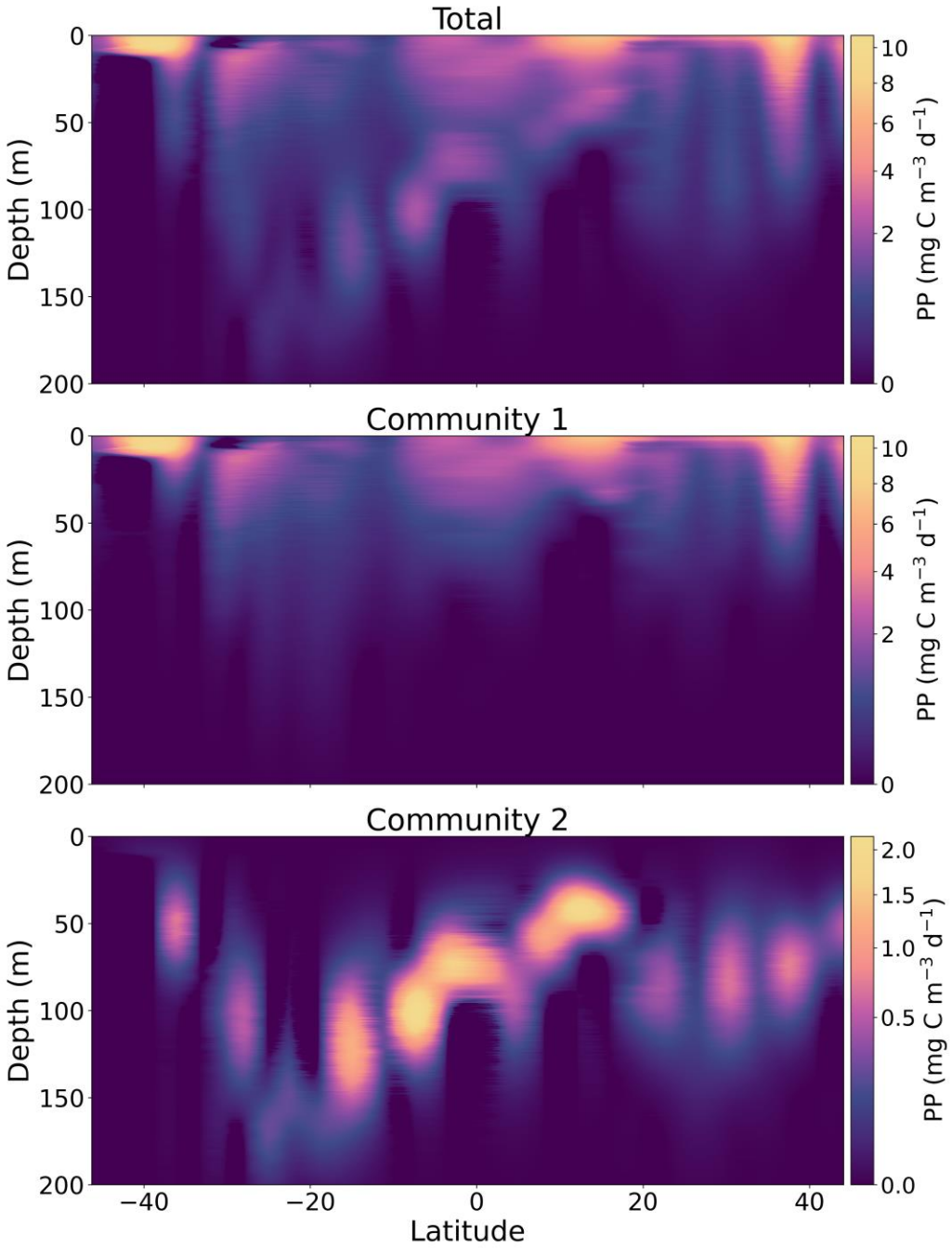
Chl-a concentration (B)



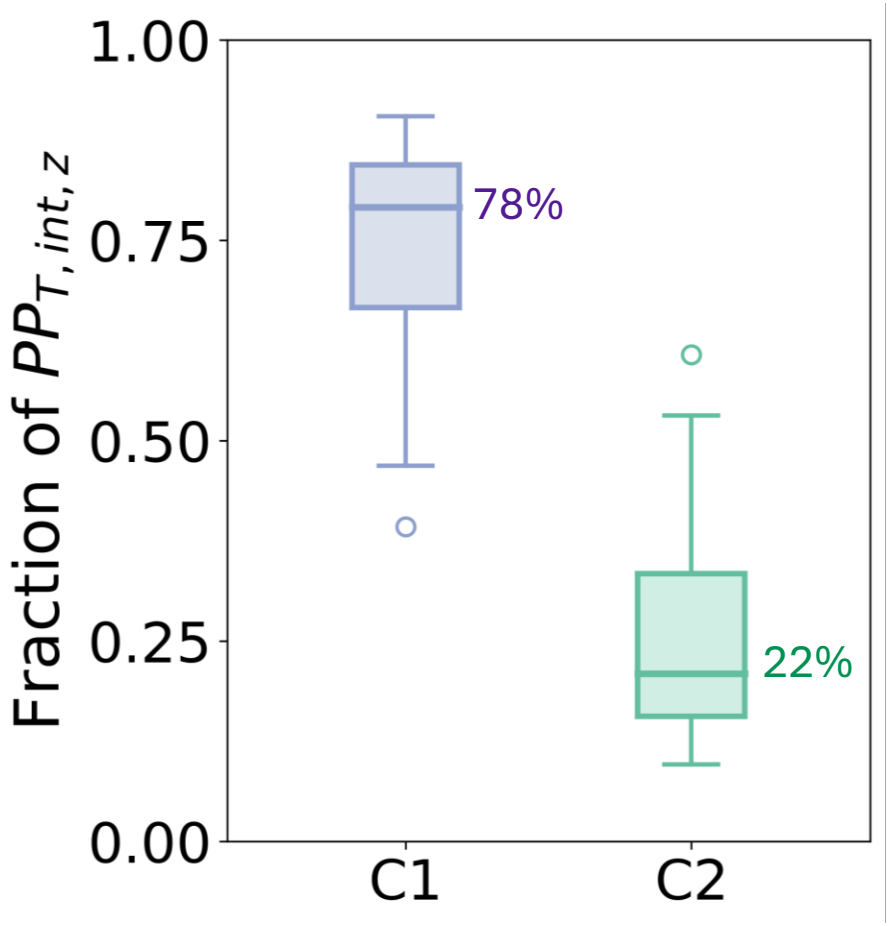
Particulate Beam attenuation (C_p)

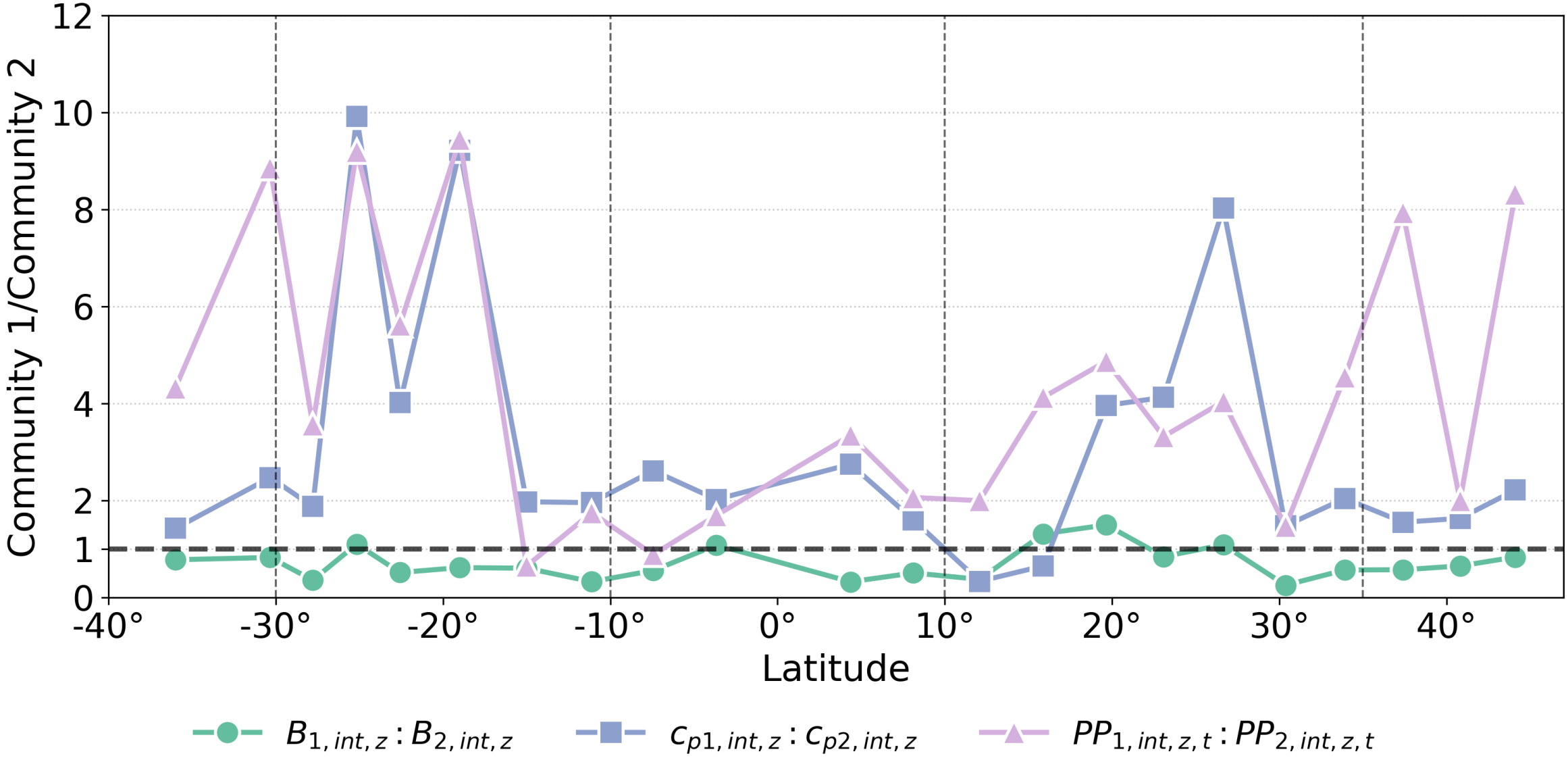






Primary Production




Community 1/Community 2
12
10
8
6
4
2
1
0
-40°
-30°
-20°
-10°
0°
10°
20°
30°
40°
Latitude
$B_{1,int,z} : B_{2,int,z}$
$c_{p1,int,z} : c_{p2,int,z}$
$PP_{1,int,z,t} : PP_{2,int,z,t}$

nature communications

Article

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Global declines in net primary production in the ocean color era

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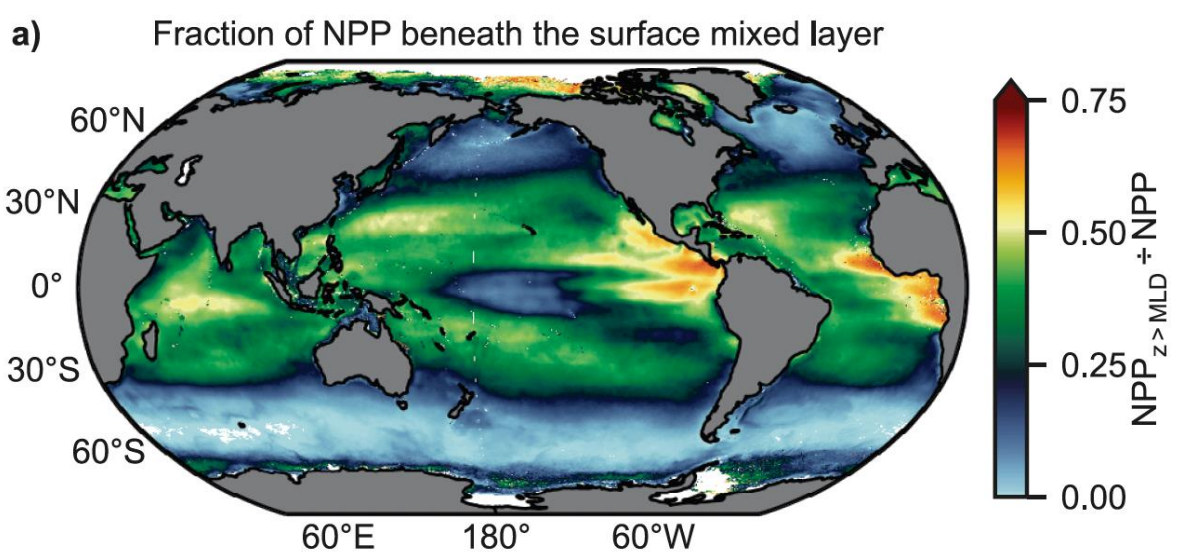

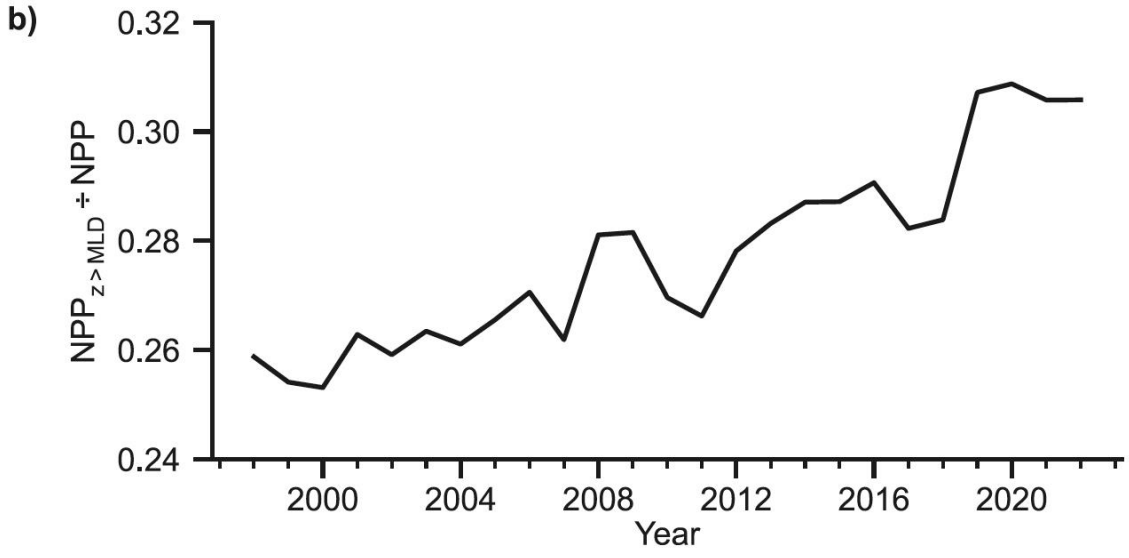

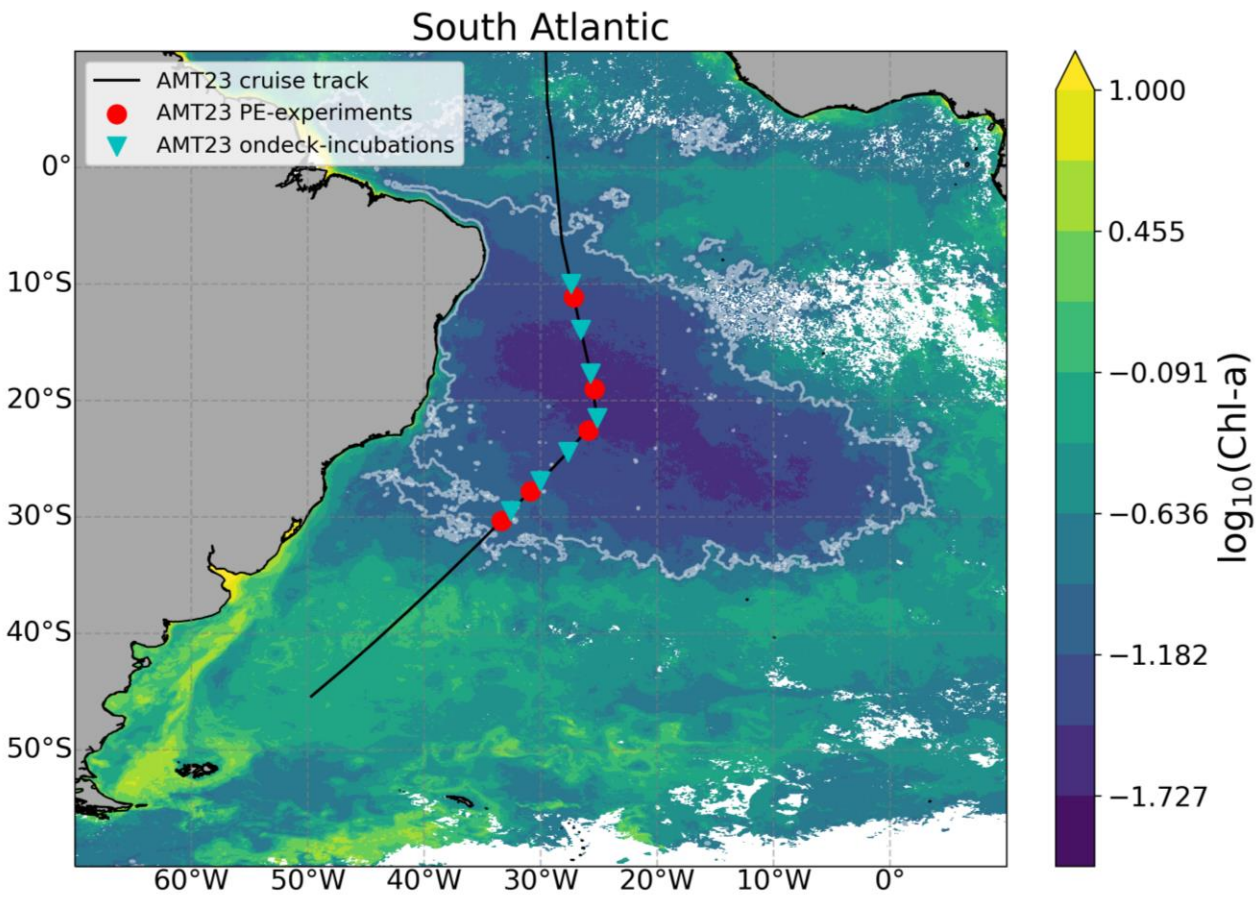

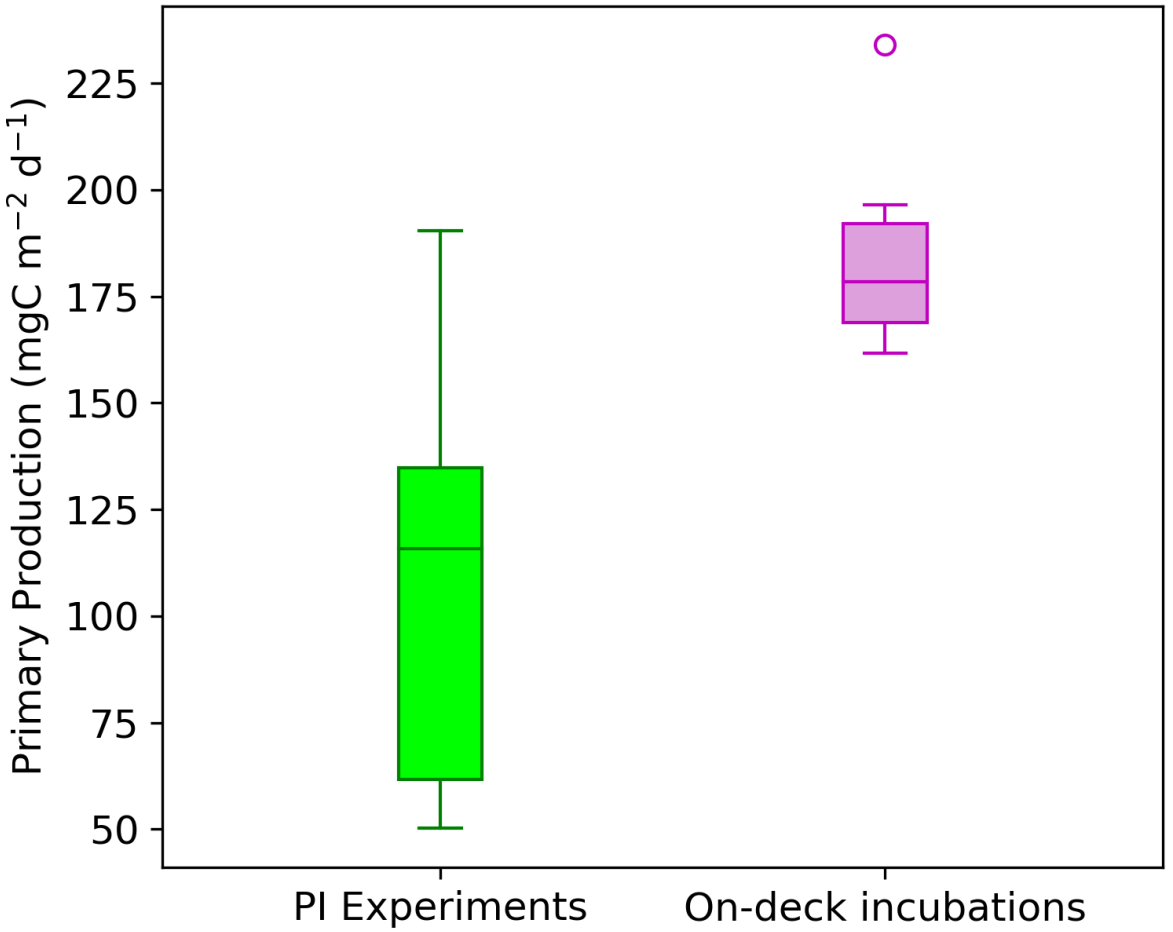

Computations of total integrated primary production in South Atlantic gyre from PI experiments reasonable for oligotrophic waters, but lower then estimates from on-deck incubations.

- *Research question 1 "Is the photophysiology of these two communities different?"* Yes, the two communities have different photosynthetic rates, pigment composition, and differences in spectral optical properties.

- *Research question 2 "In the Atlantic what is the contribution of these two communities to primary production?"* Community 1 (surface mixed layer) contributes around 78% to integrated primary production, Community 2 (DCM) contributes around 22%.

- *Research question 3 "How the contribution of these two communities to primary production differ to the contribution to Chl-a concentration and phytoplankton carbon?"* Similar for $c_p(650)$ (a proxy for phytoplankton carbon, 68% community 1, 32% Community 2) but very different for Chl-a concentration (39% community 1, 61% Community 2).

- *Implications?* Although contributing only around 22% to integrated primary production overall, this is higher in the trophic, and Community 2 (DCM) is permanently below the mixed layer. Hence the primary production by Community 2 could contribute a lot to new production (Bouman et al. 2020 https://doi.org/10.1098/rsta.2019.0351).