Supplementary information

A - Physical description of the study area

1 - Satellite images

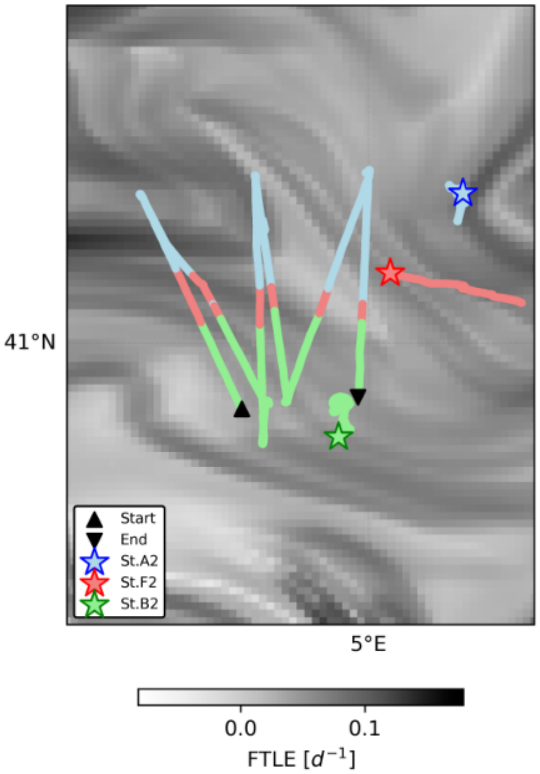

Fig. A1. "Before SWOT" satellite characterization of the frontal region. Resulting map of the cross-front transect regions from the GMM method, colored as in Fig. 2, overlaid on DUACS 2023 FTLEs [d^{-1}]. At the scale of the front identified during BioSWOT-Med (~10 km), DUACS Lagrangian products lack sufficient resolution to effectively identify it, while it is clearly possible with the FLTE product including SWOT data (Fig. 2b,c). The three stations are also shown (star positions indicate the beginning of stations).

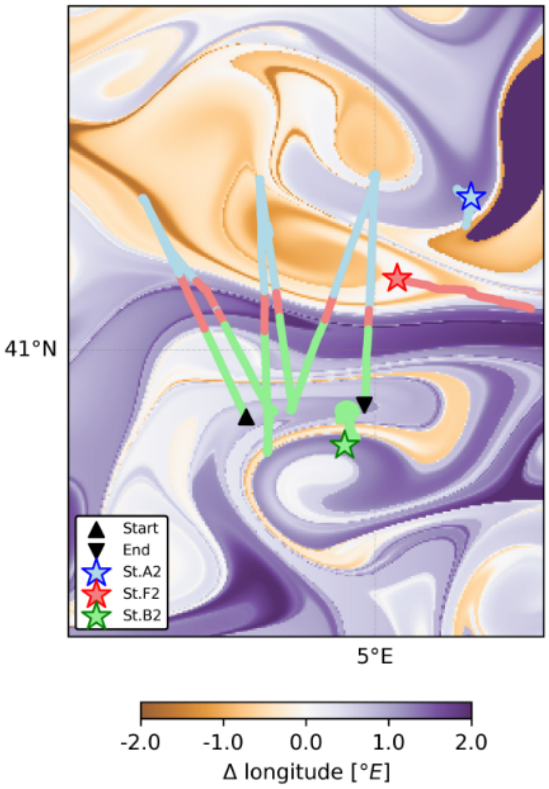

Fig. A2. Satellite characterization of the frontal region. Resulting map of the cross-front transect regions from the GMM method, colored according to the salinity criterion and stations (Fig. 2), overlaid on SWOT backward-advected longitude [°E], for 15 days starting from April 29 (first day of the cross-front transect). A positive value indicates eastward transport of the fluid (purple), while a negative value represents westward transport (orange). The three stations are also shown (star positions indicate the beginning of stations). The red section of the cross-front transect (F) aligns well with the frontal region highlighted by the advected longitude in purple. Note that the F2 station appears in the orange region on this map due to the temporal dynamics of the front. This reflects the difference between the period of the cross-transect (April 29–30), represented by this map, and the period when the stations were sampled (May 5, 6, and 7), during which the front had shifted slightly northward (see Fig. A3).

2 - Drifter data for front tracking

Drifters are Lagrangian oceanographic instruments freely advected by sea currents, designed to float at a specific depth and regularly transmitting their GPS position, therefore giving a direct measurement of passive transport driven by ocean dynamics.

During BioSWOT-Med, surface drifters drogued within the 1 m depth[1,2] were deployed within distinct water masses, identified through satellite products and TSG transects, in order to provide guidance for the adaptive sampling strategy of the cruise. Here we focus on the drifters deployed within the front, therefore supporting the localization of region F and station F2, and consequently the sampling of the surrounding water masses.

Figure A3 highlights the presence of the front by following the advection of drifters deployed in April 23-26, (first experimental phase, 5 westermost drifters). During the cross-front transect (29-30 April) and stations A2 (7 May), F2 (6 May) and B2 (5 May) we released additional drifters to track the water mass advection path and keep the vessel on target (second experimental phase, 7 easternmost drifters).

The surface drifters deployed along the front in the two experimental phases, have been selected to characterize the sea current speed which shows local peaks up to 70 cm/s, and an average speed of 30 cm/s (Fig. A3) with flow convergence and strain rate up to $-f$ and $2f$ respectively, where f is the local Coriolis parameter. There is a general continuity and agreement of the drifter trajectories deployed in the two phases, covering continuous areas, providing also information on the scale of the frontal structure.

(1) Davis RE. Drifter observations of coastal surface currents during CODE: The method and descriptive view. Journal of Geophysical Research: Oceans. 1985 May 20;90(C3):4741-55. https://doi.org/10.1029/JC090iC03p04741.

(2) Novelli G, Guigand CM, Cousin C, Ryan EH, Laxague NJ, Dai H, Haus BK, Özgökmen TM. A biodegradable surface drifter for ocean sampling on a massive scale. Journal of Atmospheric and Oceanic Technology. 2017 Nov;34(11):2509-32. https://doi.org/10.1175/JTECH-D-17-0055.1.

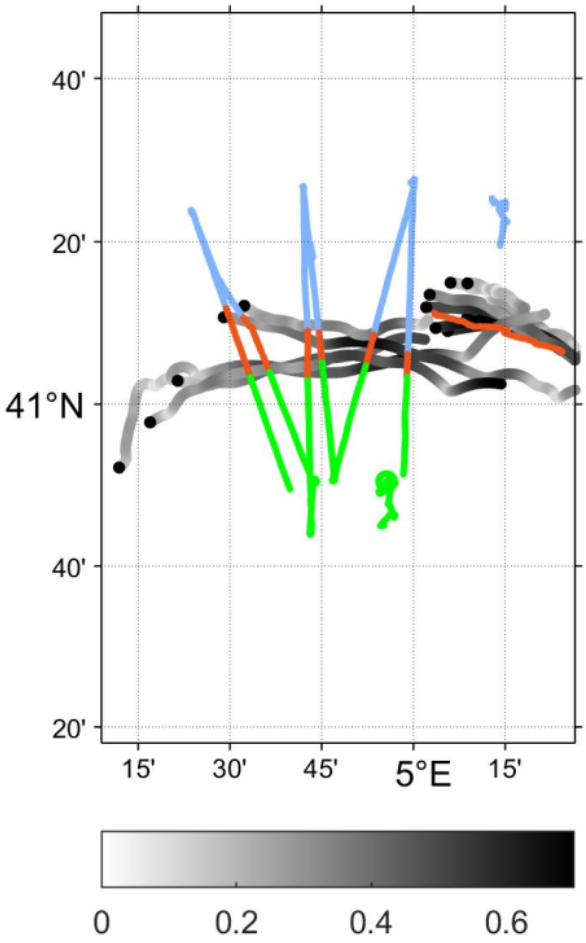

Fig. A3. *In situ* characterization of the frontal region. Surface drifter trajectories deployed along the front, for the period April 23 - May 7, 2023. Black dots indicate deployment positions, while the gray colorbar indicates the speed (m/s) of drifters advected by the front. Superimposed are the cross-front transects and water mass stations colored as in Fig. 2.

B - Phytoplankton community

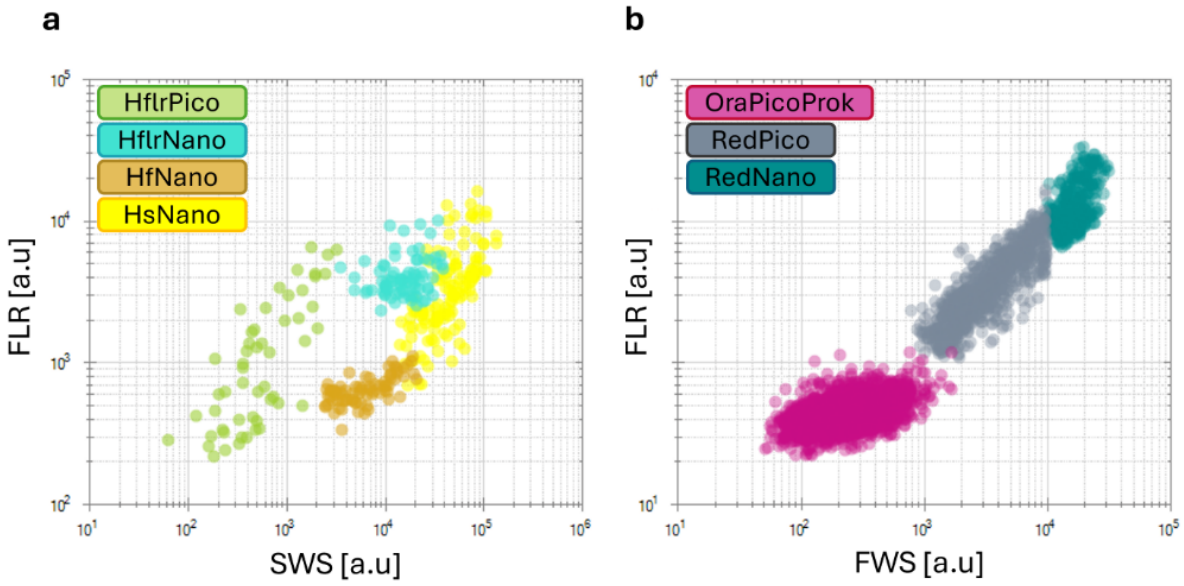

Fig. B1. Cytograms of the seven phytoplankton groups identified by flow cytometry during BioSWOT-Med. These groups were distinguished through an analysis of various cytograms combining four key signals: fluorescence (red and orange) and scattering (forward and sideward) [arbitrary units, a.u]. Here, two examples of cytograms are presented. In both cases, the y-axis represents the total red fluorescence (FLR) signal recorded for each cell. The x-axis of **a** represents the total sideward scatter signal (SWS), while in **b** it corresponds to the forward scatter signal (FWS).

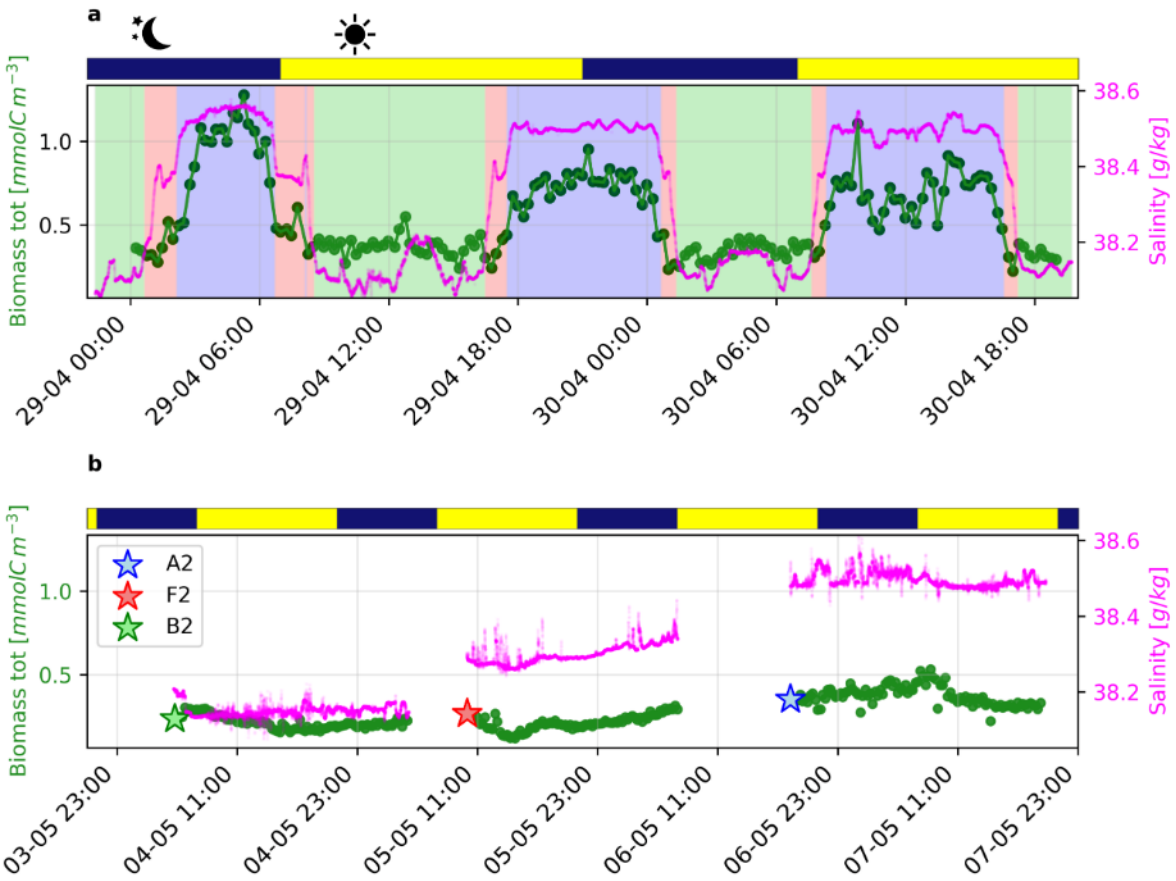

Fig. B2. Time series of total cytometric biomass (green) and absolute salinity (pink). **a** Cross-front transect. The background color gradient represents the three regions (A in blue, F in red and B in green) identified based on the salinity criterion (Fig. 2). Note the salinity signature, characterized by a short-lived plateau around 38.4 g/kg within F. **b** Station A2, F2, B2 (star positions indicate the beginning of stations). The color bar above panels (a) and (b) indicates the diurnal cycle, with daytime shown in yellow and nighttime in blue.

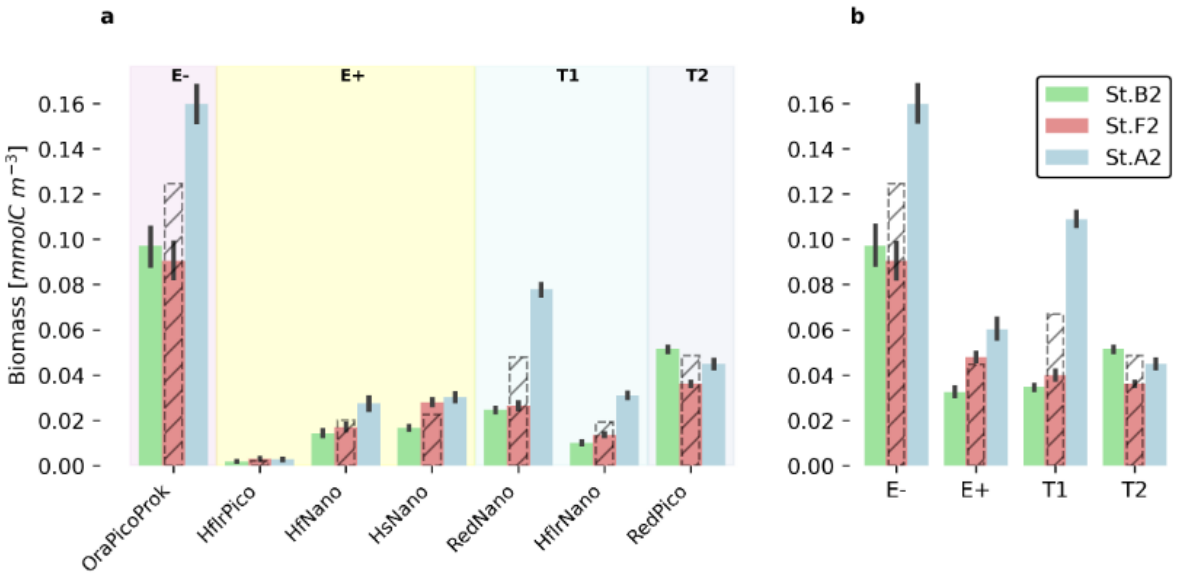

Fig. B3. Phytoplankton biomass. **a** Mean biomass of each cytometric phytoplankton group in A2, F2, and B2. **b** Mean biomass of transient (T) and edge (E) groups in A2, F2, and B2. The grey hatched bars represent the biomass resulting from a conservative mixing of A2 and B2 biomass. This was calculated using the salinity-based mixing ratio (α) within F2: $\alpha = \frac{S_{F2} - S_{B2}}{S_{A2} - S_{B2}}$; where S is the mean salinity within stations A2, F2 and B2. α is equal to 0.44, indicating a nearly 1:1 mixing. When the hatched bar is higher than the F2 bar, it indicates a lower observed biomass than would have resulted from conservative mixing. This suggests that E−, T1, T2 are negatively affected by frontal conditions (due to e.g., increased grazing or subduction/dilution). Conversely, E+ are close to mixed A2/B2 biomass. Overall, our results indicate that E+ taxa are the “winners” at the front; not by reaching biomass maxima, but by not being disadvantaged by frontal conditions.

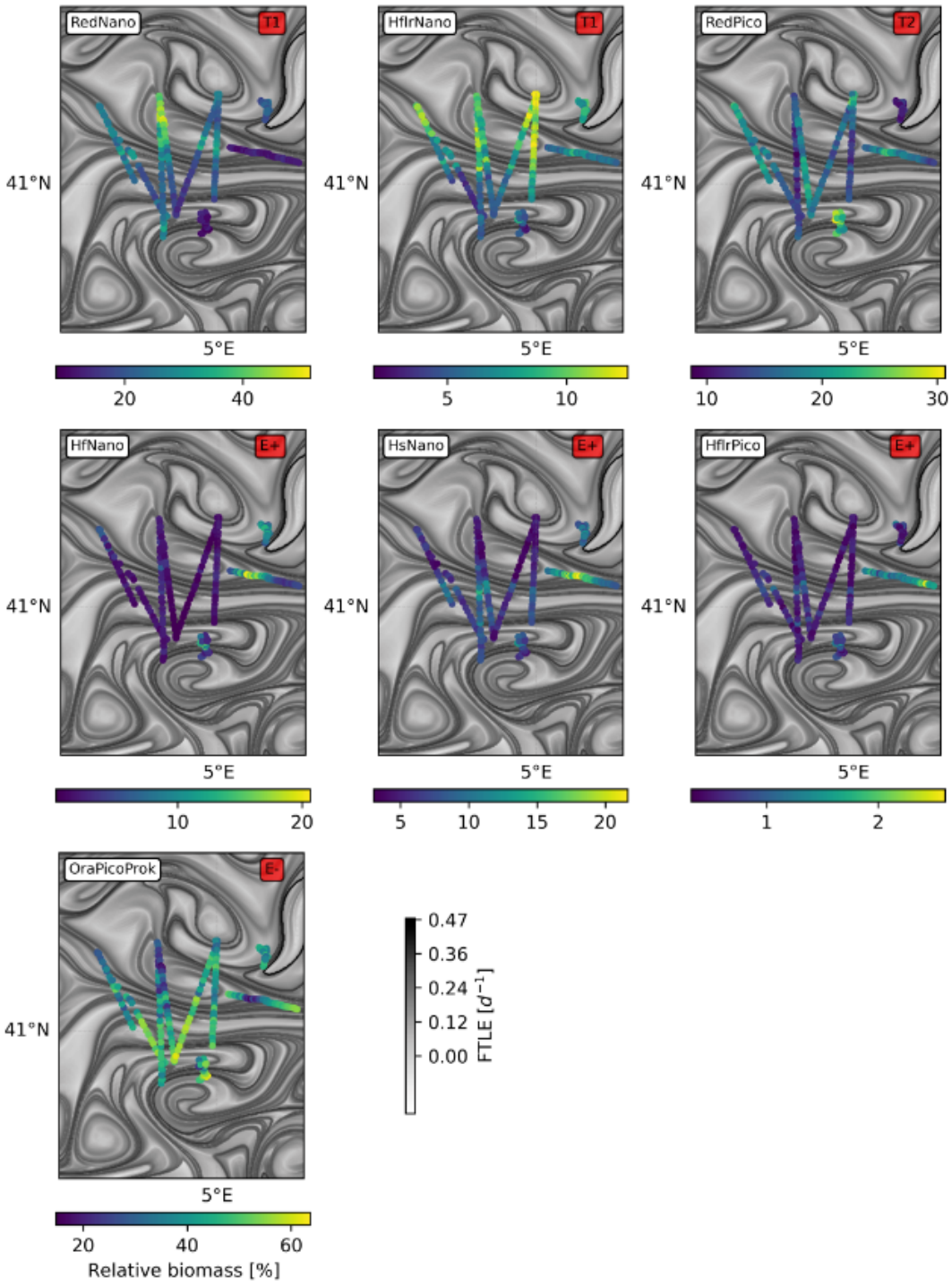

Fig. B4. Phytoplankton community distribution. Biomass percentages along the cross-front transect and at stations of each phytoplankton group, overlaid on SWOT FTLEs [d-¹] on April 29. The red box indicates the type of phytoplankton (E+, E-, T1 or T2) relative to the precedent analysis (cf. Fig. 3 and B3).