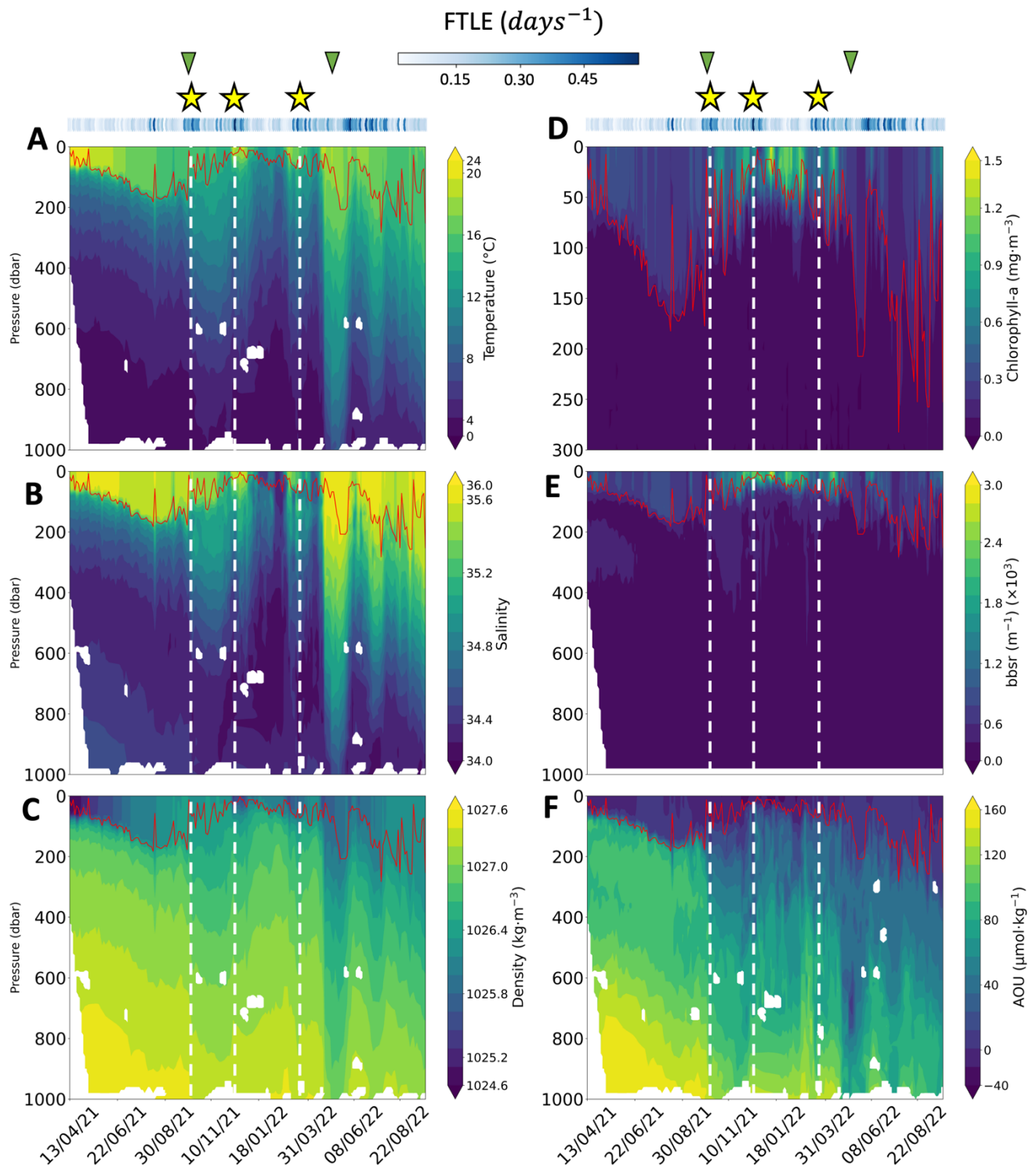
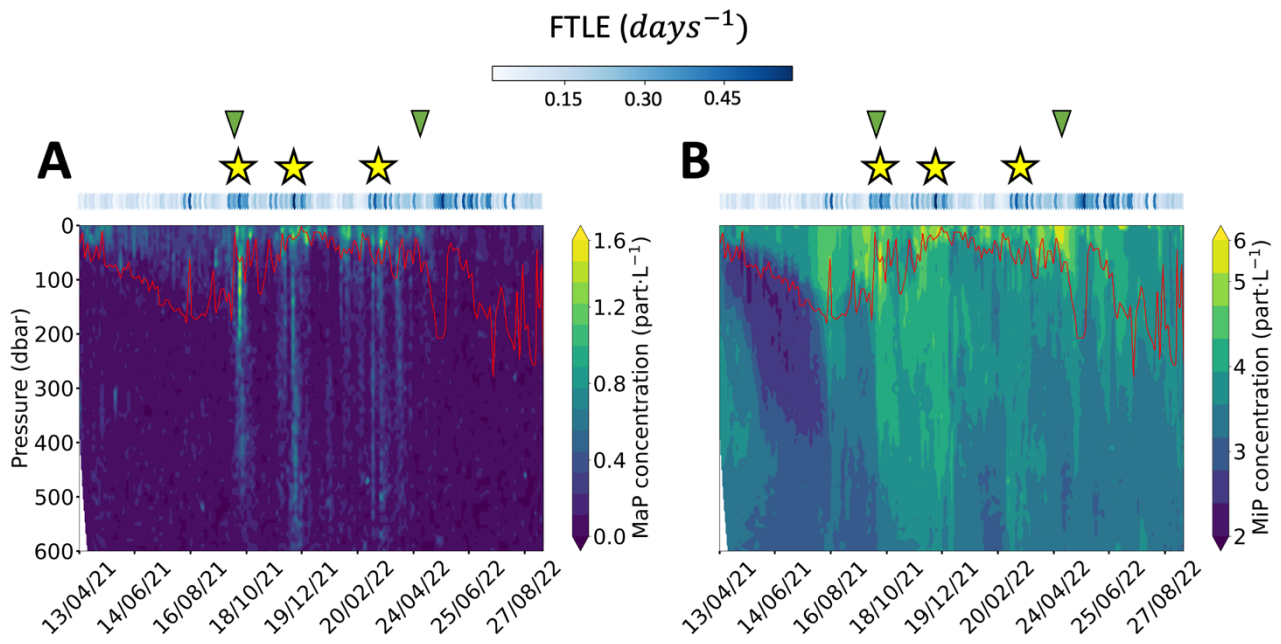


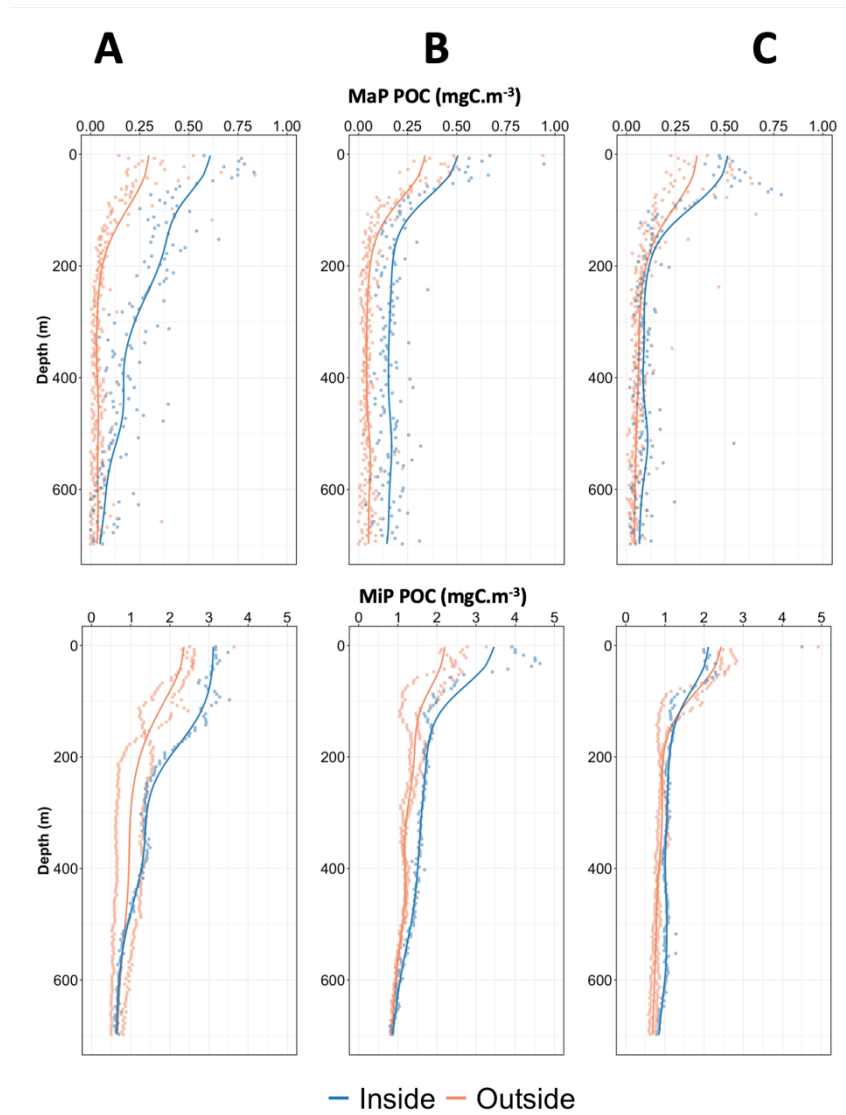
**Figure 1:** (A) Float trajectory (thick gray line) during its entire deployment from April 2021 to September 2022 in the South-East Atlantic Ocean. Orange arrows indicate the direction of the float trajectory. Stars highlight export features described in our study (1 to 3 in panels B, C and D). Yellow dots indicate Eddy Subduction Pump (ESP) events (defined as in Llort et al., 2018). Shaded gray dots indicate profiles during which no export features were detected. The background map is the bathymetry of the study zone. (B), (C) and (D) panels show ADT field snapshots with the float trajectory (thick black line) during each export feature. Cyclones and anticyclones are associated with blue and red colors, respectively. Diamonds show eddies centroid. Thick solid lines correspond to eddies maximum speed. Thin solid lines correspond to ADT isolines. Dashed lines to eddies outer limit definition.



**Figure 2: Hydrographic and biogeochemical properties as a function of time and depth along the float trajectory (1.5 years, from April 2021 to September 2022). The panels show (A) temperature, (B) salinity, (C) potential density, (D) chlorophyll-a concentration, (E) log<sub>10</sub> of 700 nm optical backscatter bbsr, (F) Apparent Oxygen Utilization (AOU). The red solid line in each panel shows the mixed layer depth (MLD). The white dashed lines and the yellow stars show the location of intense exports of particles. The green triangles indicate the start and the end of the production period. Blue dots on top of the panel show the mean five days backward FTLE ( $\text{days}^{-1}$ ) for each profile location.**



**Figure 3: Particles spatio-temporal distribution.** The panels show, (A) MaP (Macrometric Particles  $0.6 < \text{ESD} < 16 \text{ mm}$ ) concentrations, (B) MiP (Micrometric Particles  $0.1 < \text{ESD} < 0.5 \text{ mm}$ ) concentrations. Both concentrations were log transformed. Red solid line represents the MLD. Yellow stars show the location of intense exports of particles. Green triangles give the start and the end of the production period. Blue dots on top of the panels show five days backward FTLE ( $\text{days}^{-1}$ ) for each profile location.



**Figure 4: Comparison of MiP POC (top panels) and MaP POC (bottom panels) in the water column both outside and inside each export feature. The panels show, (A) the first export feature (01-10-2021 – 17/10/2021), (B) the second one (01-12-2021 – 19-12-2021) and (C) the last one (01/03/2022 – 28/03/2022). The dots on the graph represent the data averaged over 5-meter bins. The solid lines are a moving average of the 5-meter bins data. The orange signal corresponds to the average of profiles recorded one month prior to and after each feature (outside), while the blue signal corresponds to the average profiles recorded during each feature (inside).**

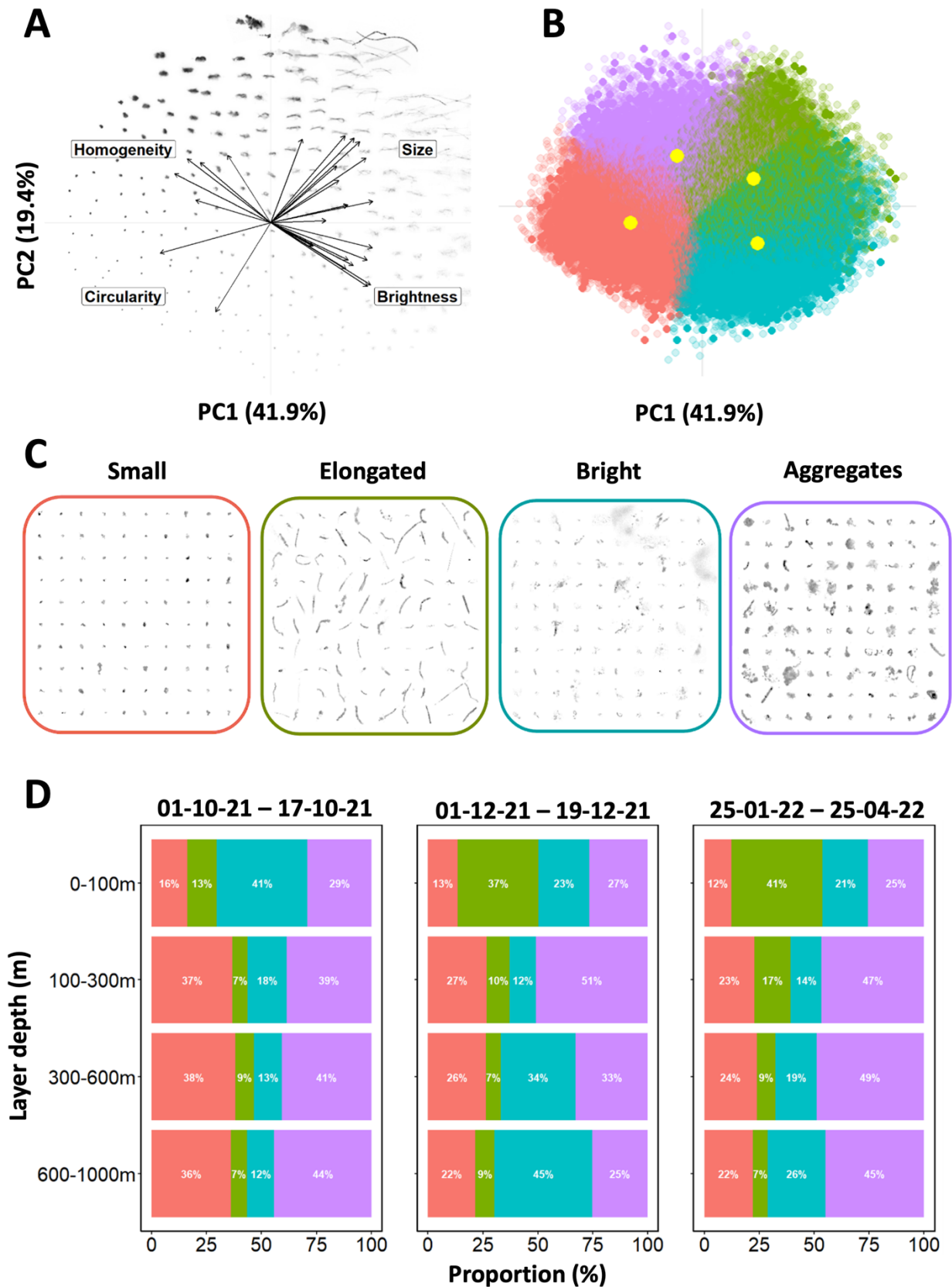
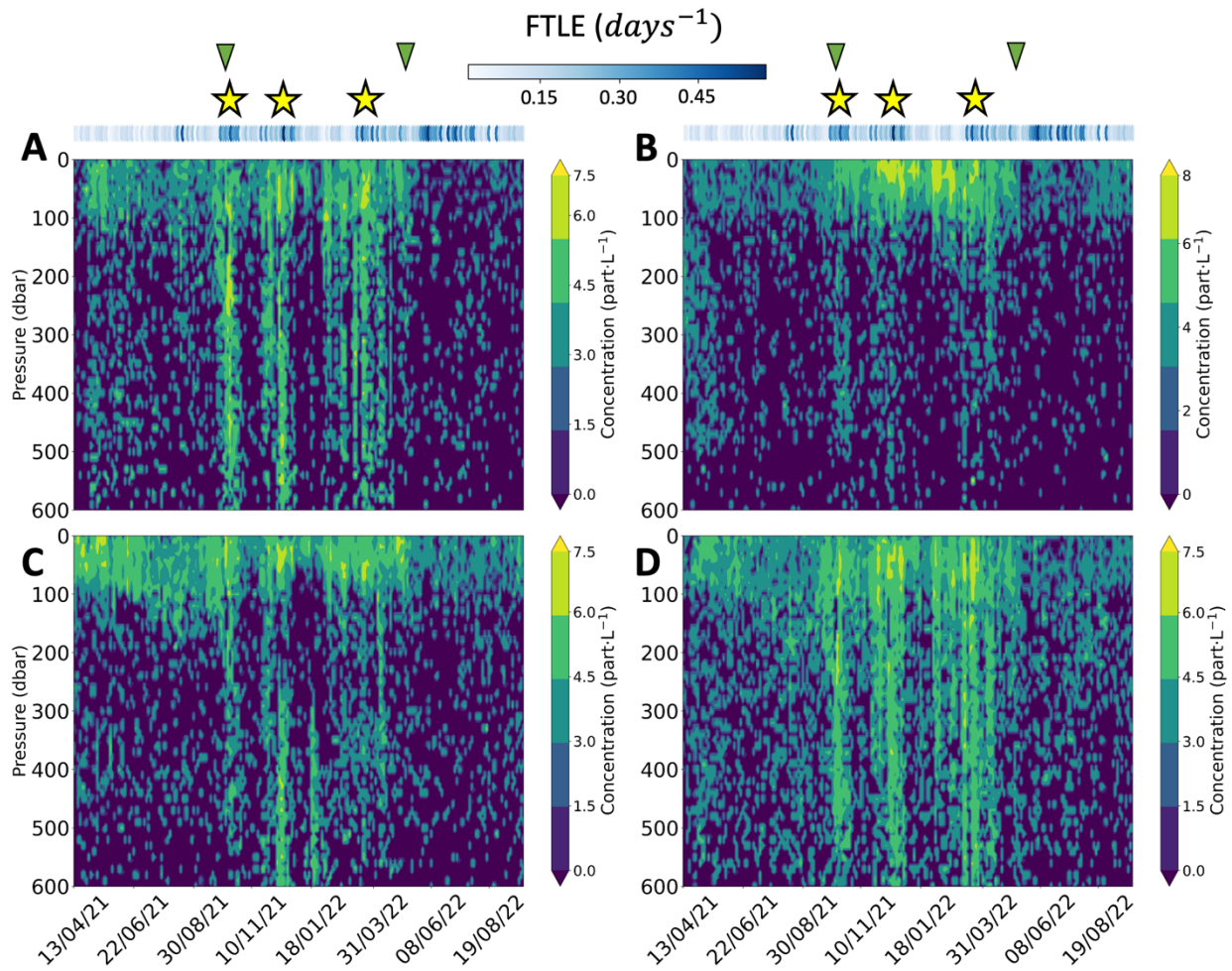


Figure 5: Results of PCA/K-means clustering on morphological traits of particles. Panels show, (A) the distribution of particle images in the morphospace built by PCA, (B) the K-means clustering classification where each point represents an image, and each cluster is colored independently. The yellow dots represent the center of each cluster. The most transparent dots represent images not retained in the analysis, (C) Representative subset of each morphotype and (D) the proportion (%) of each group according to depth layers during the three export features observed in the morphotypes spatio-temporal distribution. The color code is the same for (B), (C) and (D).





**Figure 6: Morphotypes spatio-temporal distribution of exclusive members.** The panels show log transformed concentrations ( $\text{part.L}^{-1}$ ) of (A) Small, (B) Elongated, (C) Bright and (D) Aggregates morphotypes. Yellow stars and green triangles have the same meaning as in the Figure 2.

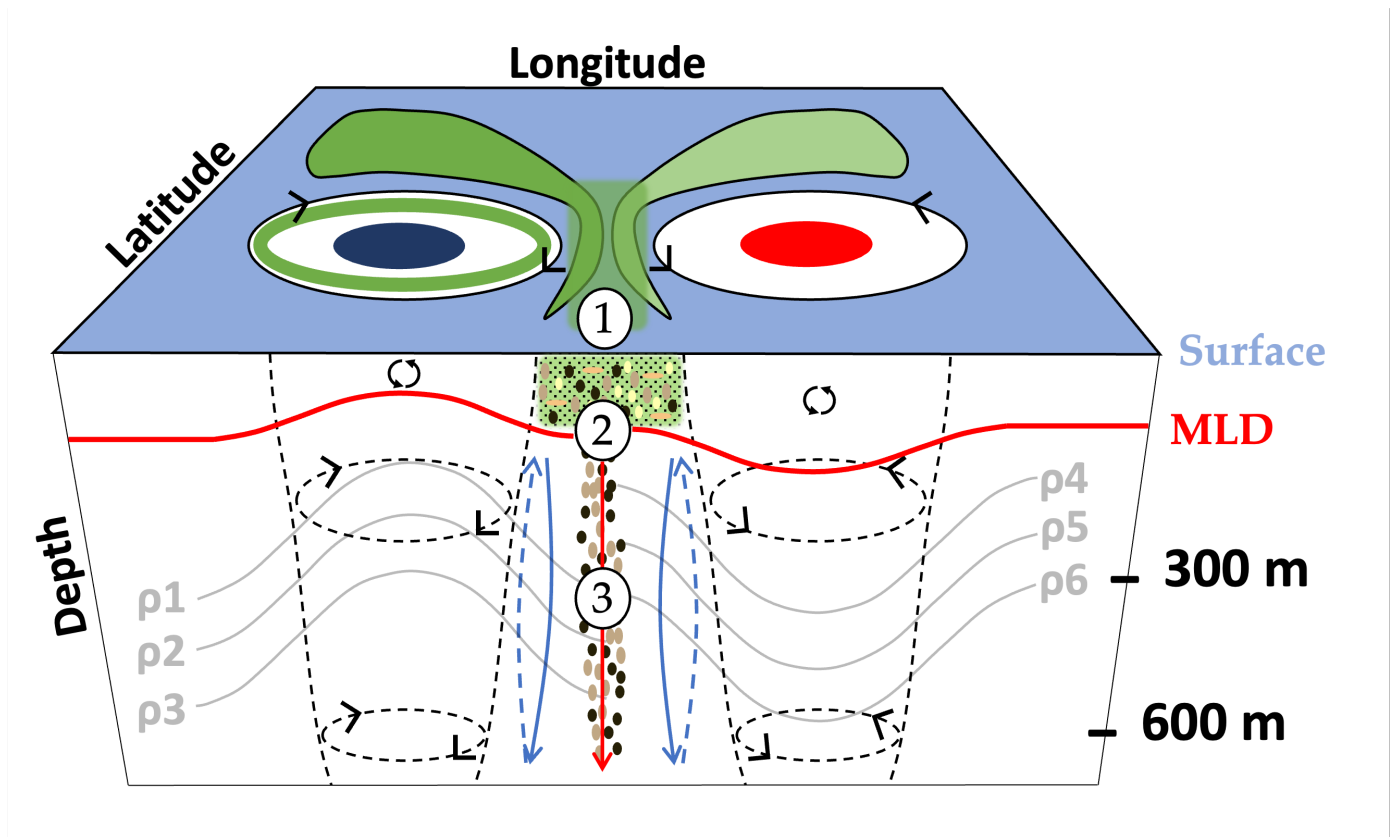


Figure 7: Schematic view of the proposed mechanism for the deep observed accumulation of particulate carbon in the mesoscale context of the study. (1) Aggregation and coagulation of surface organic matter (green shapes around eddies), facilitated by eddy trapping or stirring. The green circle in the cyclone represents the accumulation of POM at its periphery (resulting from the divergence of the water masses) (2) Influence of the Gravitational Carbon Pump (represented by the red vertical arrow) that transporting selected marine snow types with sufficient downward speed beneath the Mixed Layer Depth (MLD). (3) Coupling with a frontogenesis mechanism inducing enhanced physical vertical speeds (represented by blue arrows), particularly below the MLD and in interface zones between mesoscale structures. The coupling between (1), (2) and (3) can lead to the transport of particles down to significant depths (600 meters in our study). Black arrows in the MLD represent the physical mixing.

## Supplementary figures

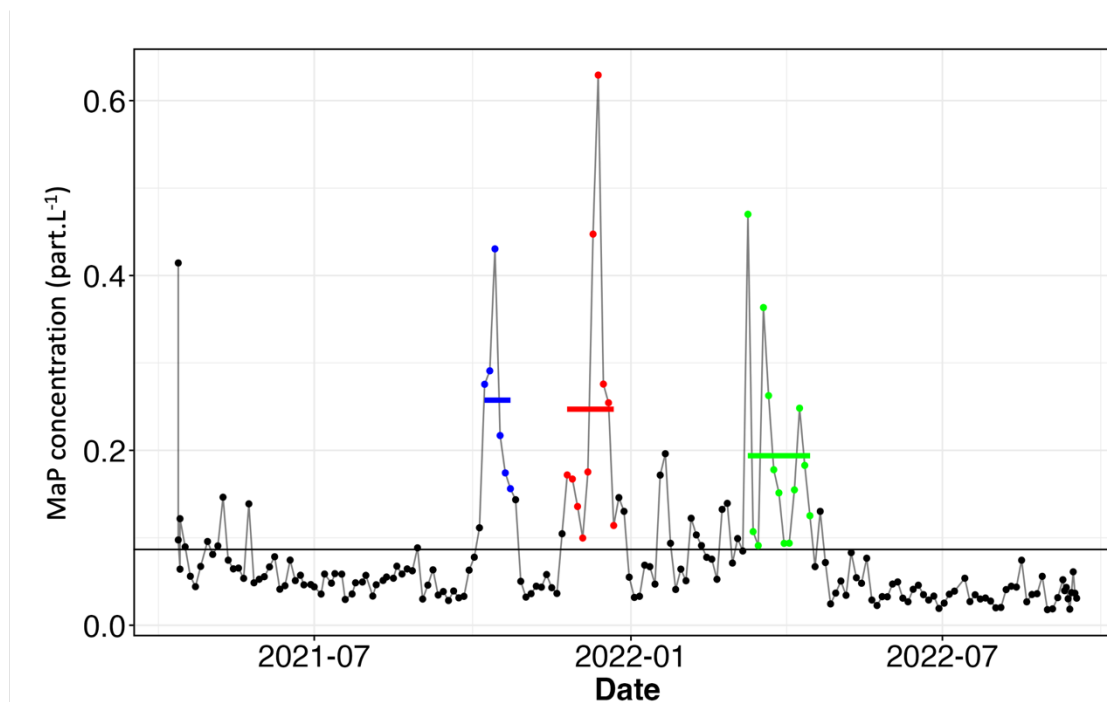
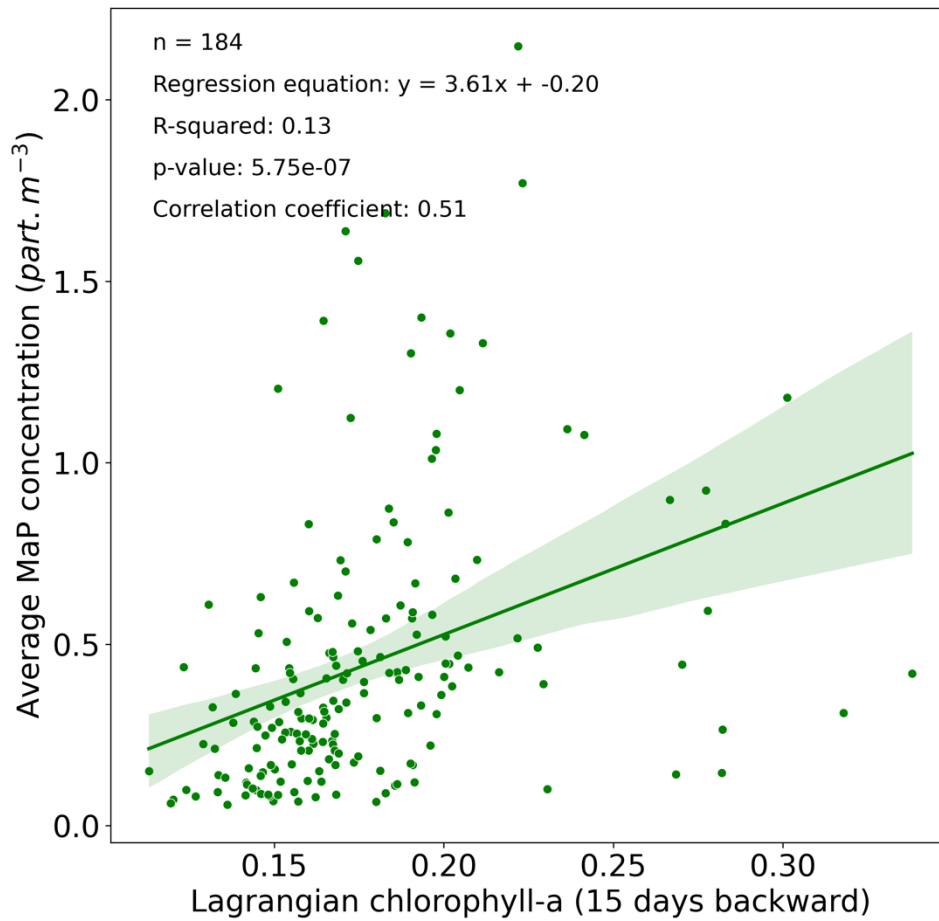
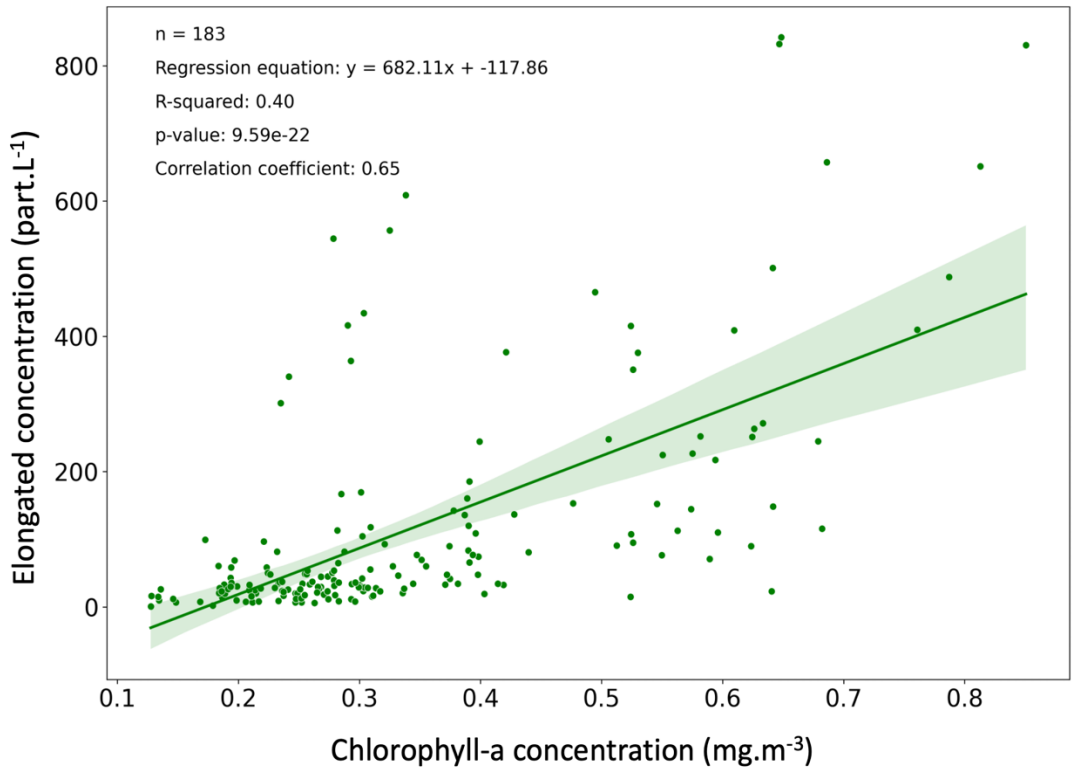


Figure S1: Evolution of MaP concentration averaged between 150- and 600-meters depth. Three features were detected using the STARS method. Each dot represents a profile and the blue, red and green ones correspond to the first, second and third feature respectively. The horizontal black line is the MaP concentration mean over the entire deployment. The blue, red and green lines are the mean concentration of each corresponding feature.

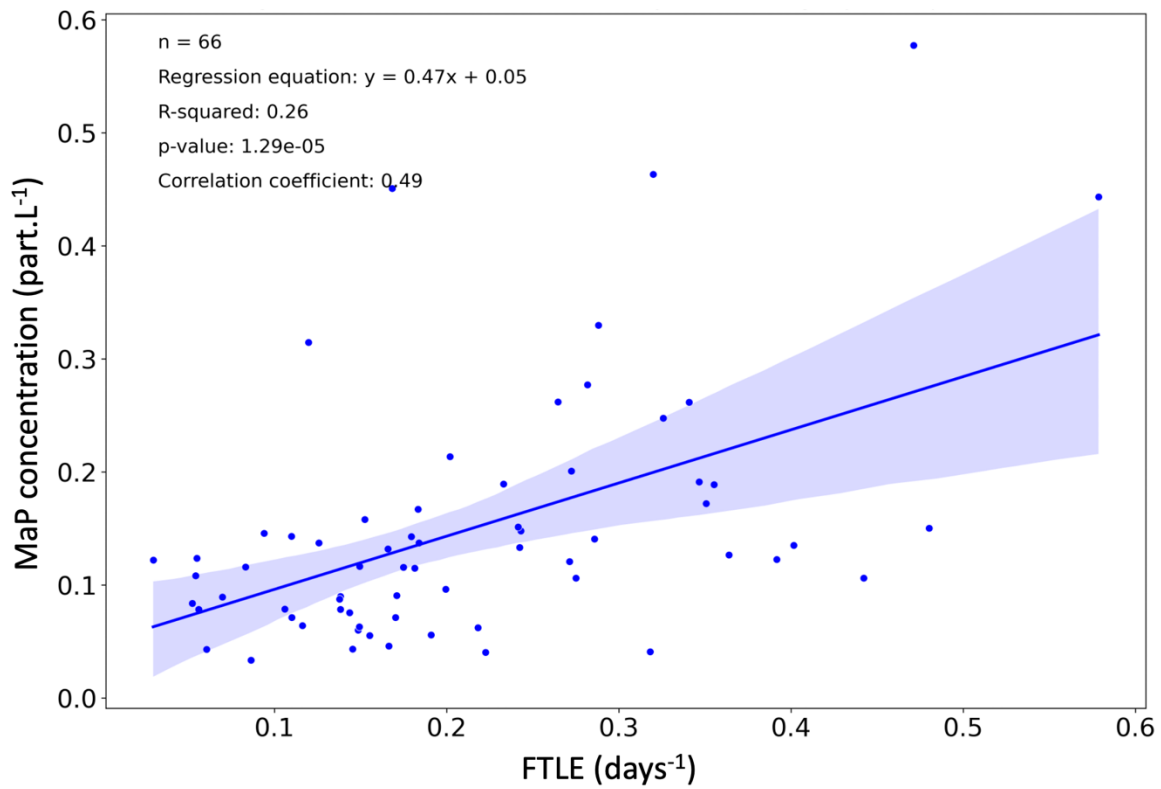




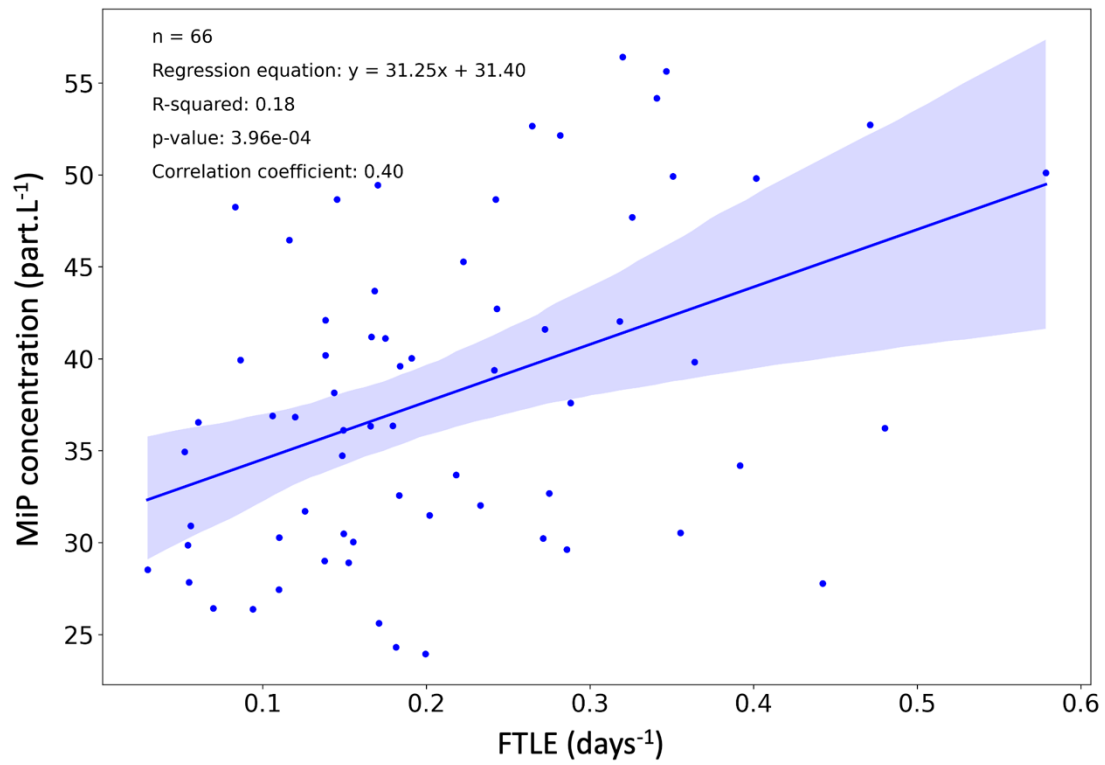
**Figure S2: Spearman correlation between averaged MaP concentration and Lagrangian chlorophyll-a (15 days backward) in the upper 100 meters of the water column. The green dots represent the mean of each profile ( $n = 183$ ). The green line represents the linear regression between both variables. The green shaded area represents the regression confidence interval (95<sup>th</sup> percentile).**



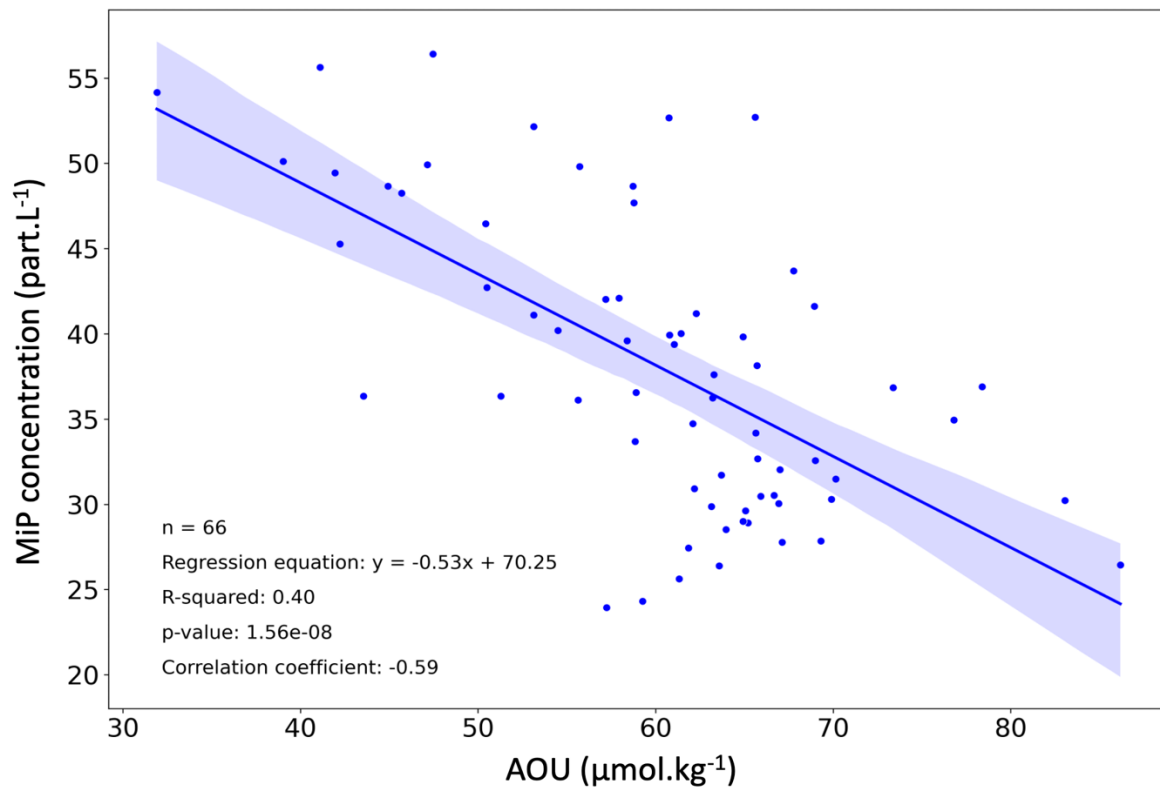
**Figure S3: Spearman correlation between averaged elongated morphotype concentration and chlorophyll-a concentration in the upper 100 meters of the water column. The green dots represent the mean of each profile (n = 183). The green line represents the linear regression between both variables. The green shaded area represents the regression confidence interval (95<sup>th</sup> percentile).**



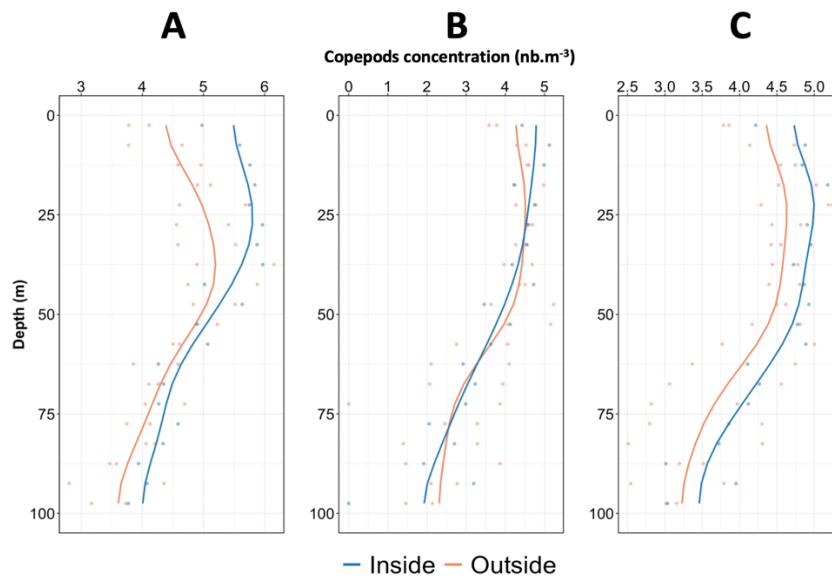
**Figure S4: Spearman correlation between averaged MaP concentration and Lagrangian FTLE (5 days backward) between 100- and 1000-meters depth and during the productive period (from 05/10/2021 to 23/04/2022). The blue dots represent the mean of each profile (n = 66). The blue line represents the linear regression between both variables. The blue shaded area represents the regression confidence interval (95<sup>th</sup> percentile).**



**Figure S5: Spearman correlation between averaged MiP concentration and Lagrangian FTLE (5 days backward) between 100- and 1000-meters depth and during the productive period (from 05/10/2021 to 23/04/2022). The blue dots represent the mean of each profile (n = 66). The blue line represents the linear regression between both variables. The blue shaded area represents the regression confidence interval (95<sup>th</sup> percentile).**



**Figure S6: Spearman correlation between averaged MiP concentration and Apparent Oxygen Utilization (AOU) between 100- and 1000-meters depth and during the productive period (from 05/10/2021 to 23/04/2022). The blue dots represent the mean of each profile (n = 66). The blue line represents the linear regression between both variables. The blue shaded area represents the regression confidence interval (95<sup>th</sup> percentile).**



**Figure S7: Comparison of Copepods concentration in the water column both outside and inside each export feature. The panels show, (A) the first export feature (01-10-2021 – 17/10/2021), (B) the second one (01-12-2021 – 19-12-2021) and (C) the last one (01/03/2022 – 28/03/2022). The dots on the graph represent the data averaged over 5-meter bins. The solid lines are a moving average of the 5-meter bins data. The orange signal corresponds to the average of profiles recorded one month prior to and after each feature (outside), while the blue signal corresponds to the average profiles recorded during each feature (inside).**