The contribution of primary production to export flux in the ultraoligotrophic eastern Mediterranean Sea

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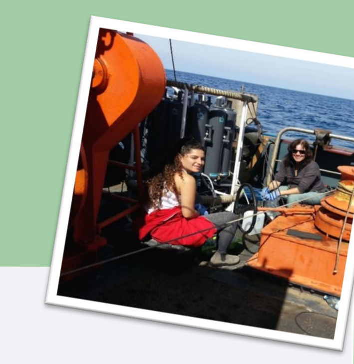


Introduction

The Levantine basin in the eastern Mediterranean Sea (EMS) is one of the most oligotrophic basins of the world characterized by very low dissolved inorganic nutrient concentrations and subsequent low primary productivity.

Carbon is transported through the oceans by the solubility pump and the biological pump, in which CO_2 is converted to organic carbon (by primary producers and subsequent consumers). The resulting biomass can subsequently be grazed and recycled (regenerated) in the upper water layer or exported from the euphotic zone to the bottom of the ocean where it may then be stored or remineralized (Fig.1).

Observations and modelling suggest that predominant carbon in the EMS is exported as dissolved organic carbon (~80%), while the particulate flux represents only ~10% of the total export. Yet, there are few actual studies examining the vertical flux of carbon in the EMS and how much of the primary production is recycled or exported to depth.

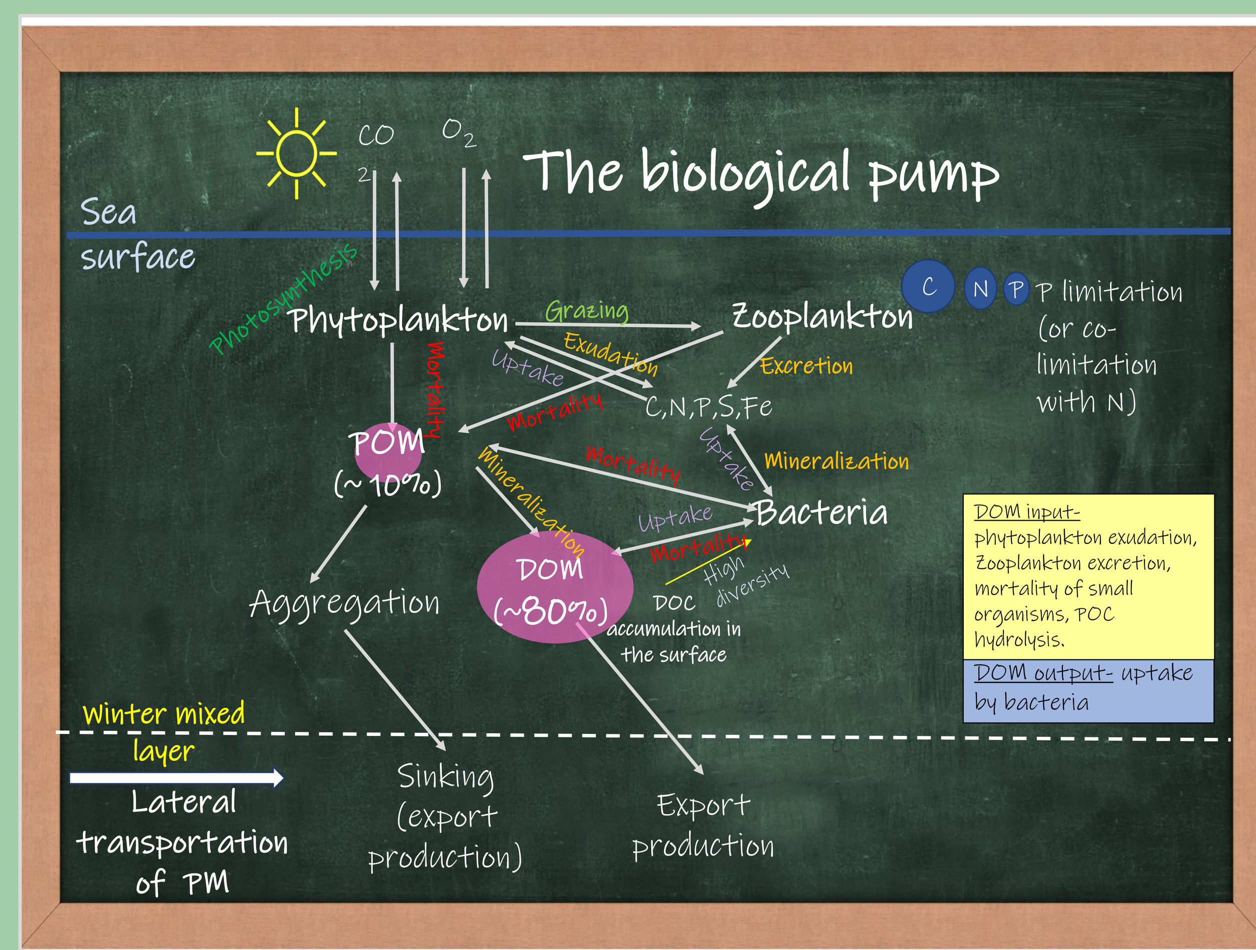
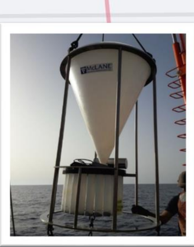


Figure 1. Conceptual diagram of the biological pump based on the biogeochemical model presented in Alekseenko et al. (2014).

Rational of working in the EMS

Investigation of ocean carbon recycling and export is crucial since the ocean plays critical roles in global carbon cycling and mitigates climate change. Increasing temperatures are predicted to slow oceanic circulation, stabilize thermal stratification and reduce nutrient supply and subsequent production and export. The EMS is one of the most impacted regions with increasing seawater temperatures. Thus, the Mediterranean Sea is a good model system to investigate the effects of global warming on oligotrophic marine systems and the production and subsequent export of carbon via the biological pump.

Objective: To examine the contribution of primary producers to the export flux in EMS.



Methods

The first moored deep station was deployed in Nov 2016 at 1500 m water depth, ~50 km offshore Haifa (H05), Israel (Fig.2). It is equipped with three McLane automated traps (180,280, 1,300m) and two single bottle cylindrical sediment traps (810 and 1490 m).

Multiple parameters were collected and analyzed :

- particulate and dissolved organic matter(DOC/N & POC/N/P –bulk)
- biomass and cell counts (FCM)
- bacterial production (BP)
- chlorophyll a.
- primary production (PP)

In this work, I am focusing on the primary and bacterial communities and their contribution to the POC.

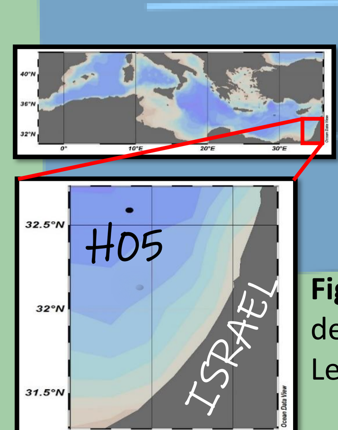


Figure 2. Location of DeepLev deep mooring station H05 in the Levantine basin, EMS.

Biomass in the water column

- Primary producers and bacteria are less than 20% from the total biomass in the upper 180m (Fig. 3).
- Primary producers have low contribution to the total POC in the upper water column (less than ~ 10%).
- Their low contribution to the POC in the upper 180m combine with relatively shallow MLD (i.e stratification) indicates that there is probably recycling of POC in the upper 180m.
- Most of the biomass is comprised from picoeukaryotes which has a very slow sinking rate (3m -d) which increase the possibility of recycling in the upper water column.

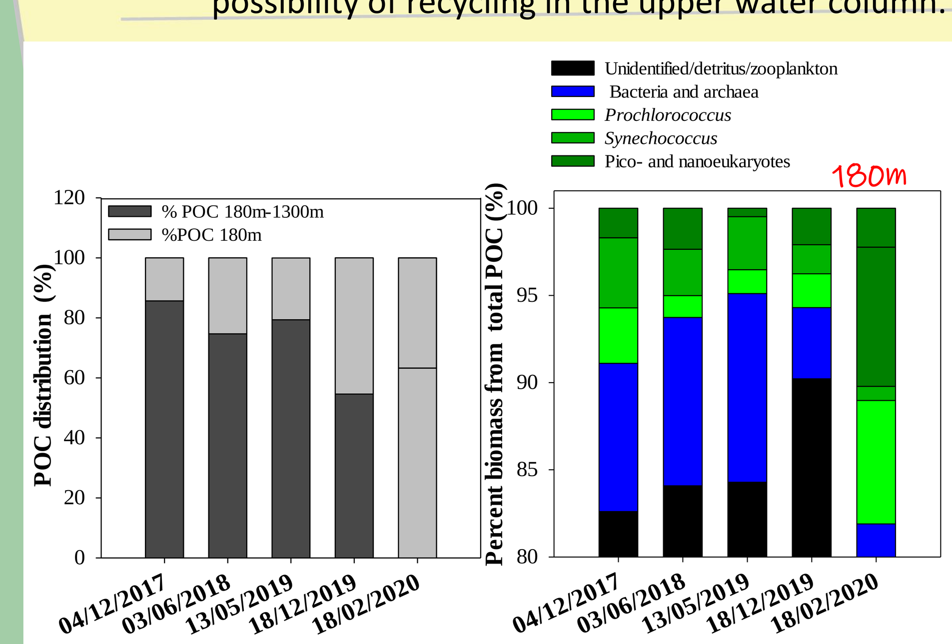


Figure 3. The contribution of group-specific biomass in the water column to the integrated POC in the upper 180m of the water column . The left Panel represents POC distribution (%) in the upper 180m and below 180-1300m in the water column.

Potential and actual export

- To estimate ratios of new or export production (EP) to total PP in the ocean (potential EP) we incorporated the equation NPP**ef ratio* (Laws et al. 2011).
- The carbon fixed by PP from 0-180 m, was significantly higher by fold of ~46 ($p<0.01$) and ~13.7 ($p>0.05$) than the organic carbon flux to the sediment during stratified and mixed periods, respectively (Fig.5a).
- Expected carbon export during mixed and stratified periods was higher(Fig.5b).
- Lower carbon concentration in the sediment traps (actual carbon export) during mixing (Fig.5b).

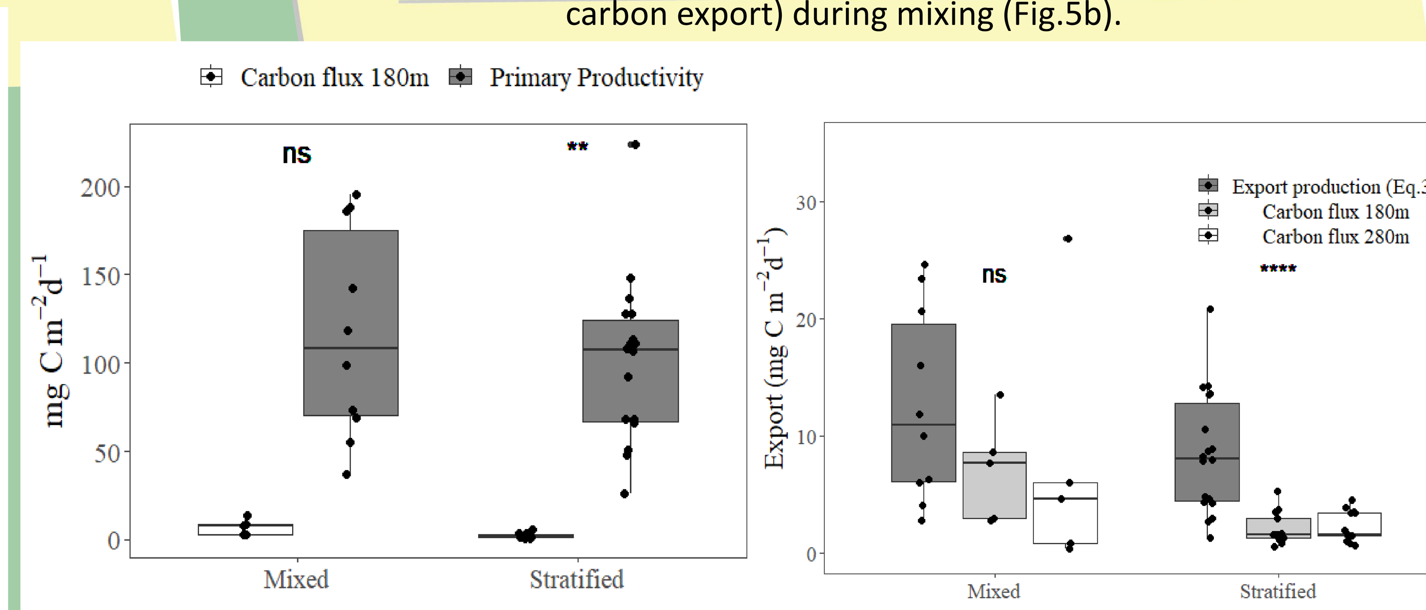


Figure 4. Comparison of the integrated primary productivity from 180m and the carbon flux calculated from the sediment traps at 180m during the stratified and mixed periods(left) and the difference between the calculated potential export (Eq.3 Laws et al. 2011) and carbon flux from sediment traps at 180m and 280m during stratified and mixed periods(right).

PP contribution to sinking PM in the Sediment traps

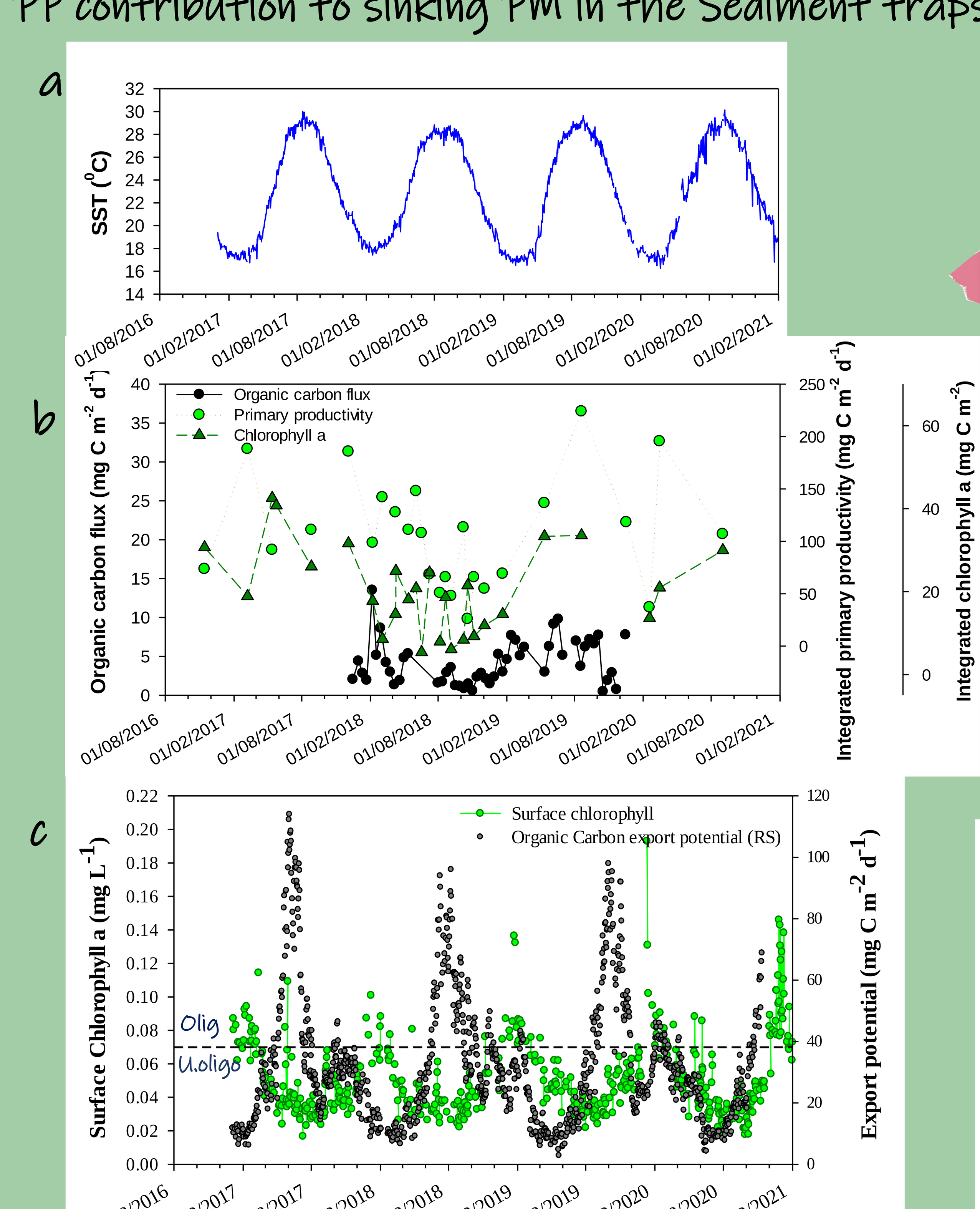


Figure 5. Temporal changes in satellite derived sea surface temperature (a), integrated PP, sediment trap total organic carbon mass flux in the upper 180m (b), potential carbon export and chlorophyll a concentration (c).

- Potential EP(calculated from modeled integrated PP) high trend corresponded with SST trend (Fig.5a) while smaller trend follows surface chlorophyll (Fig.5c).
- POC flux (180m)(Fig.5b) don't follow the seasonal changes in chlorophyll concentration (in contrast to the potential export dynamics).
- Low POC concentration (> 20 mg C m-2 d-1) compared to the potential (up to 114 mg C m-2 d-1).

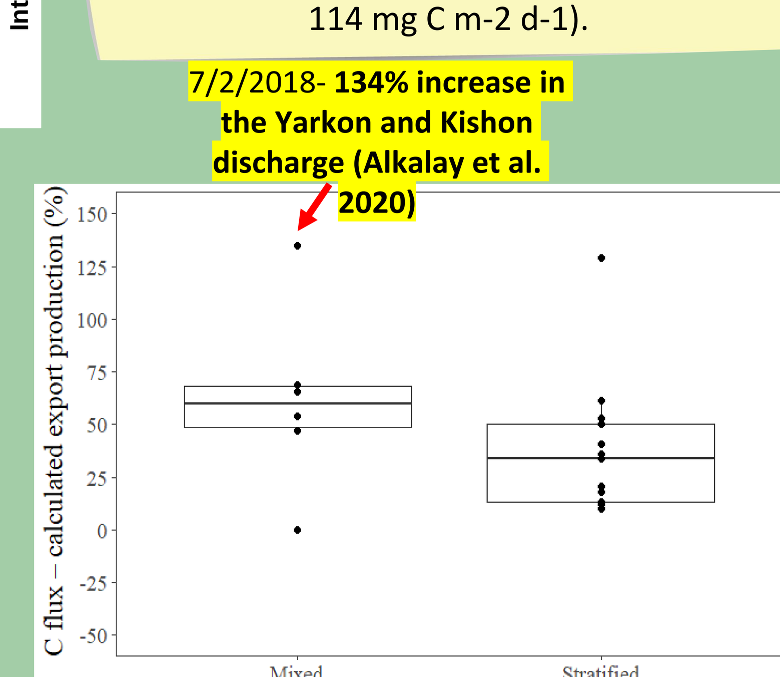


Figure 6. Δ (%) between carbon flux from the sediment trap and calculated export production (Eq.3 Laws et al. 2011) at 180m during stratified and mixed periods (the delta presents the potential export that reached to the sediment trap).

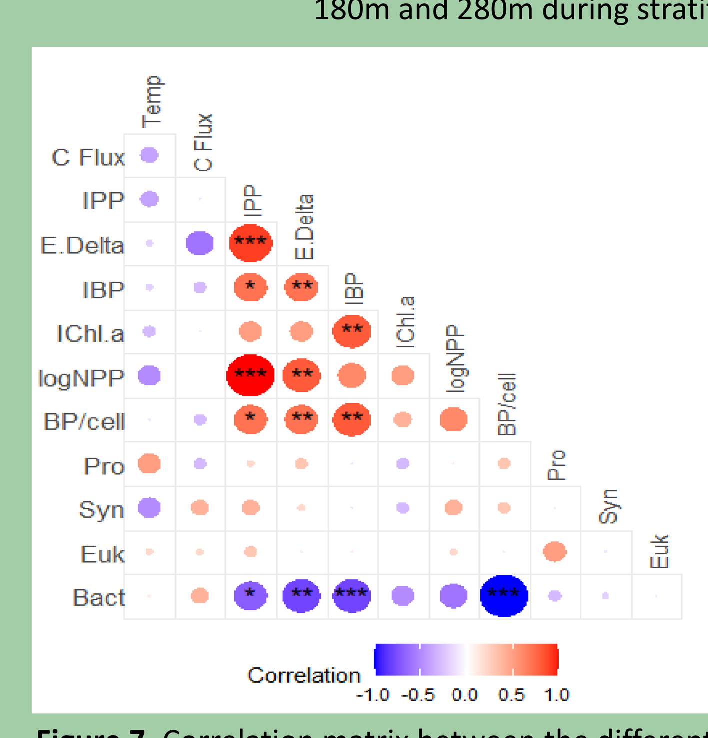


Figure 7. Correlation matrix between the different parameters (p value, *= 0.05, **=0.01, ***=0.001).

- The Export delta (E.Delta) is the fraction of carbon that didn't reach the sediment trap (180m)(Fig.7).
- The E.Delta was highly correlated with IBP and BP/cell.

- The delta was between 25% -75%.
- In some cases, carbon flux exceeds the potential export which results in delta higher from 100% (129%, 134%).
- During stratified periods 35% of the potential export reached to the sediment trap compared to the 60% during mixing.

Summary

- **Primary producers contribution to the POC is minor (~10%) while heterotrophic bacteria is higher, especially during stratified periods.**
- **POC flux concentration was low compared to the potential and it doesn't follow the seasonal changes in chlorophyll concentration(Fig .5).**
- **During stratified periods most of the POC is recycled in the upper 180m (70%), thus contributing to the dissolved fraction rather than the particulate (Fig.6).**
- **Supported by the Strong link between BP to the POC that didn't sink to 180m (E.Delta)(Fig.7)**
- **During mixing, 60 % of the organic carbon is exported (enhanced coupling between PP and export of organic matter??).**

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