Vertical fluxes of microplastics and other anthropogenic particles measured using moored sediment traps in two Arctic glacial fjords (Svalbard archipelago)

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INTRODUCTION

- MPs have been reported in deep Arctic sediments and in the water column, however the mechanisms driving MPs vertical transport are still unclear and little is known about MPs sinking dynamics and export to the seafloor.

- The magnitude of microplastics (MPs) sinking flux and its temporal variability is crucial to understand the global fate of MPs in the ocean.

- Within the JPI-Oceans FACTS project we started measuring MPs vertical fluxes along the water column in the Fram Strait and in two Arctic glacial fjords (**Kongsfjorden** and Krossfjorden) located in the Svalbard archipelago.

SCIENCE ADVANCES | RESEARCH ARTICLE

WATER POLLUTION

The Arctic Ocean as a dead end for floating plastics in the North Atlantic branch of the Thermohaline Circulation

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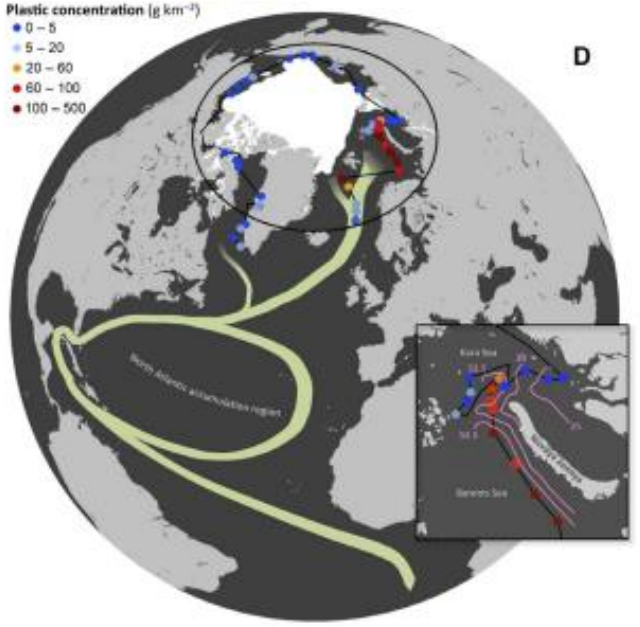


STUDY AREA

- **Kongsfjorden (MDI)**

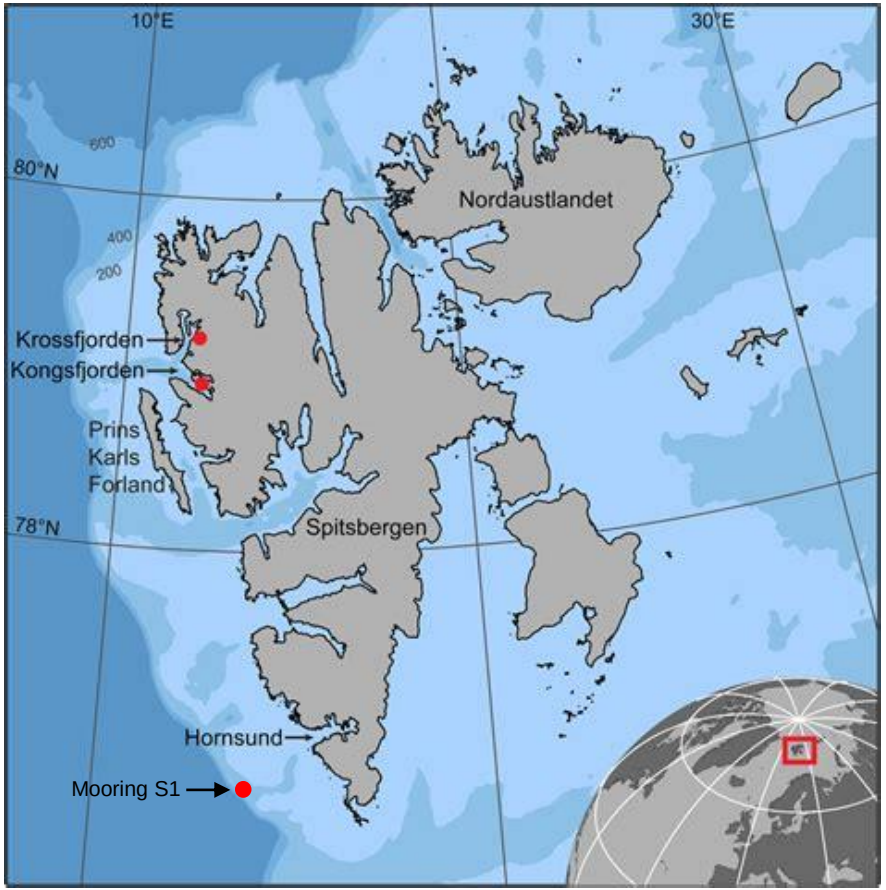
A MPs dedicated time-series sediment trap with 12 receiving cups was placed at 61 m depth on September 2021. The interval of this trap rotation was set at ~30 days allowing the study of monthly and seasonal variations in MPs deposition rates. Samples were retrieved in September 2022 and the trap was re-deployed.

- **Krossfjorden (KIM)**

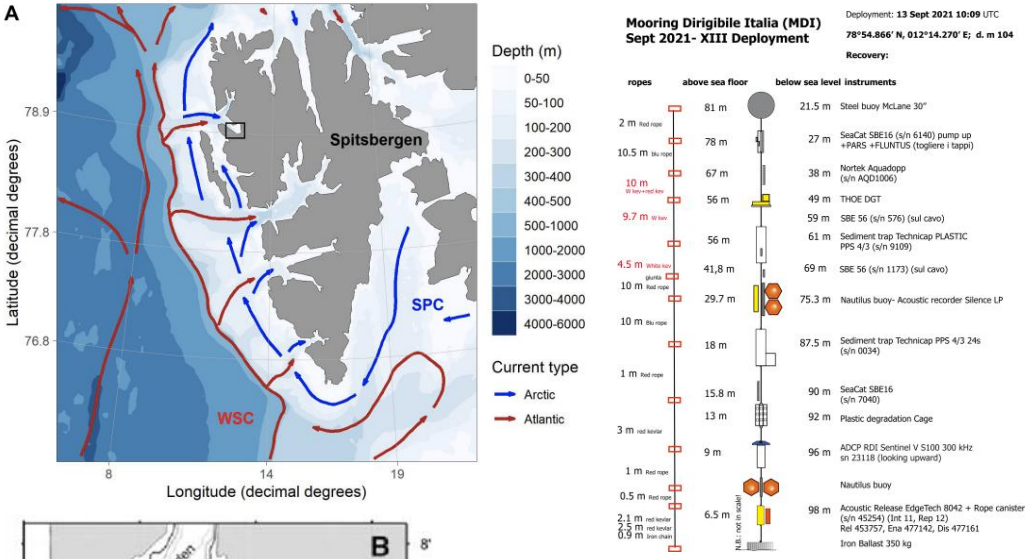
A single-cup sediment trap dedicated to microplastics was deployed in 2020 at 110 m below sea level. The sediment trap was retrieved in 2021 and not re-deployed.

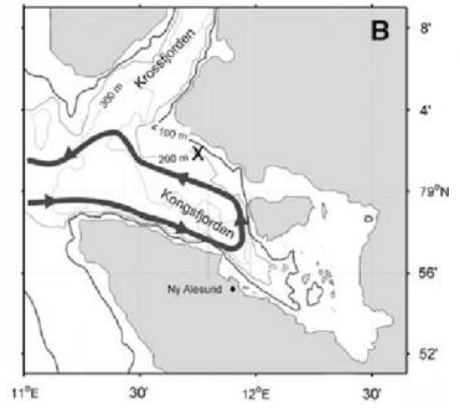
- **Fram Strait (S1)**

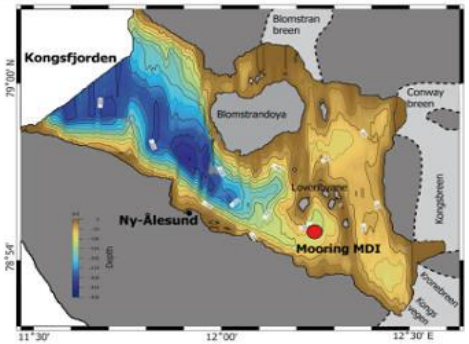
A single-cup sediment trap dedicated to microplastics was deployed in 2021 but the sample was lost during retrieval. The MPs trap was re-deployed in 2022.



STUDY AREA







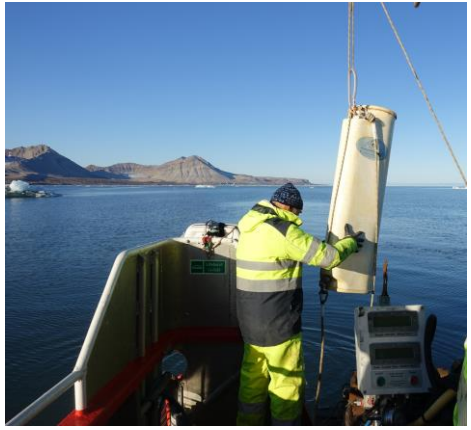
Kongsfjorden is an Arctic fjord located in the Svalbard archipelago. The fjord is directly influenced by several tidewater glaciers and by an inflow of warm and saline Atlantic Water. It represents the ideal location to study interactions between fjord waters and tidal glaciers (marine vs. subglacial sediment supply).

The mooring **Dirigibile Italia (MDI)** was installed in 2010 in the inner part of the fjord at a depth of 105 m with the aim of studying intensity and composition of particles fallout, while monitoring the main physical properties of the water column (glacier melting, coastal runoff, Atlantic waters intrusion, local bottom waters).

The mooring is serviced annually. The data are downloaded during maintenance and uploaded to the Italian Artic Data Center (IADC). A 12-year time series of data for climate purposes is available (T, S, currents (ADCP), turbidity, DO, CO_2).

SAMPLING

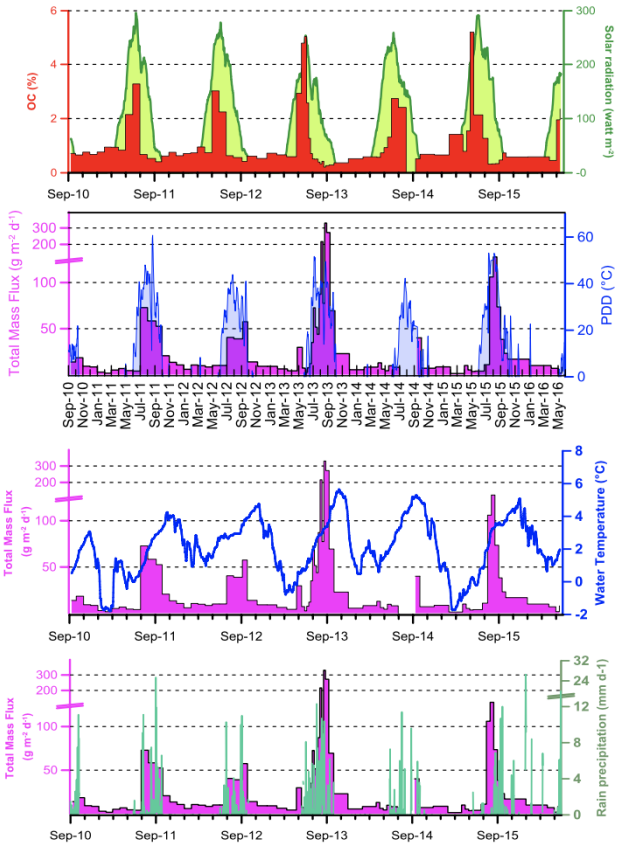
Technicap PPS 4/3
0.05 m^2 collection area
12 receiving cups
Sampling interval: 1 month



High seasonality in sediment fluxes (7-330 g m^{-2} d^{-1}).

a) *Autochthonous sources* (vertical flux of marine organic matter, peak in late May-June).

b) *Allochthonous sources* (lateral advection of terrestrial particles in Jul-Aug by meltwater run-off, glacial and subglacial drainage, submarine melting and calving, surface run-off. **Most abundant**

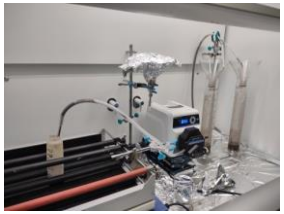


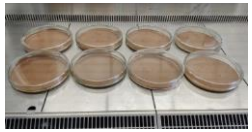
Samples were stored frozen

SAMPLE PROCESSING

Samples

Homogenization and splitting in 2 aliquots + dry weight (freeze drying)





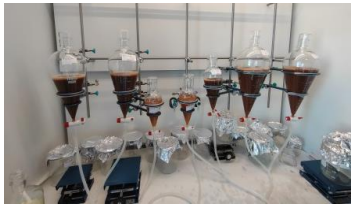
MF aliquot

Visual counting
+
ATR µFTIR

MP aliquot

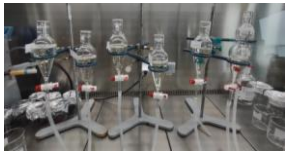
Pre-oxidation (H_2O_2 10%)

Density separation ($ZnCl_2$)



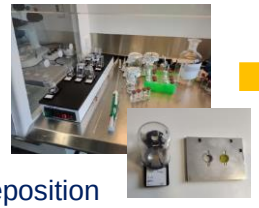
SDS digestion

Fenton reaction



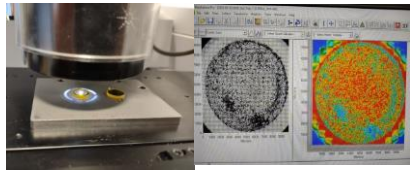
Evaporation

2nd density separation (ZnCl)

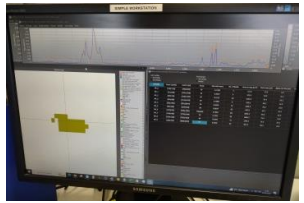


Deposition

FPA-µFTIR analysis



Data analysis



CONTAMINATION

Full laboratory procedural blanks were performed using «clean» sand (density separation + burned for 5 hrs at 500 °C).

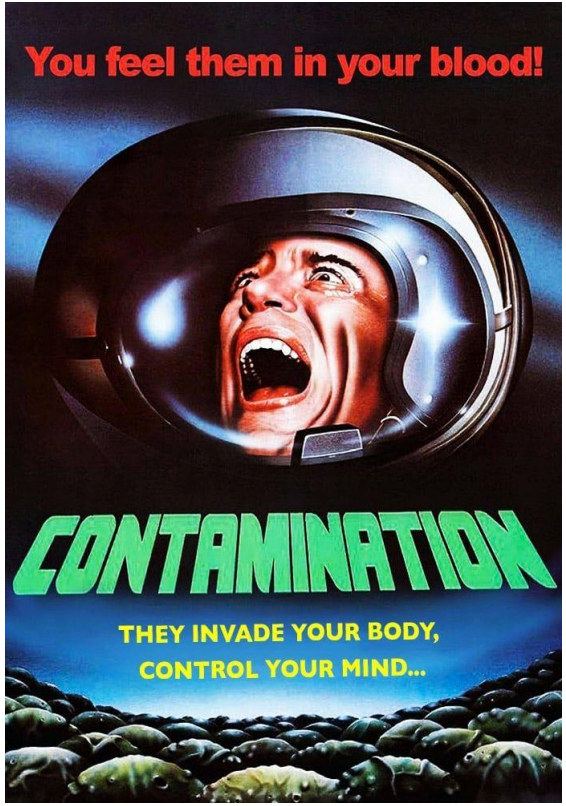
Blank samples underwent exactly the same procedure used for sediment samples (i.e. splitting in 2 aliquots for MP and MF quantification).

RESULTS:

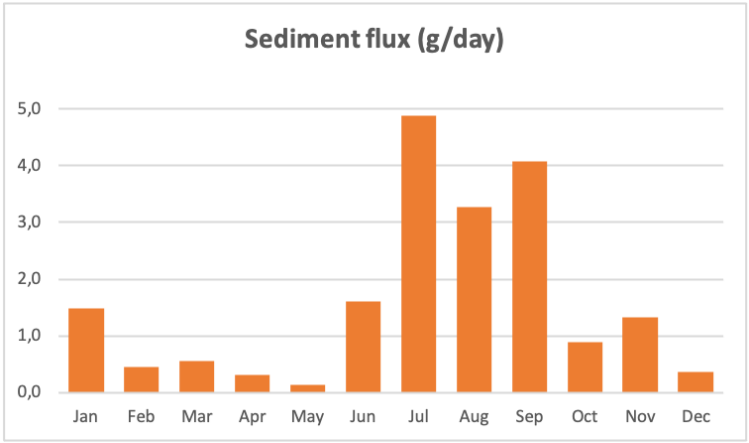
MPs contamination level: 36.6 ± 1.5 MPs/sample
PEST (62.1%), PE (20.7%) + PA, PU, PS, PVC, PVOH (3.4%)

MFs contamination level: 14.1 ± 3.3 MFs/sample

The following results are not yet blank-corrected!

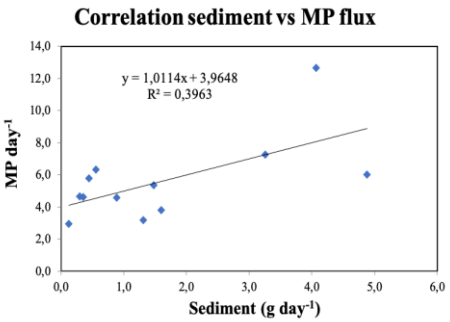


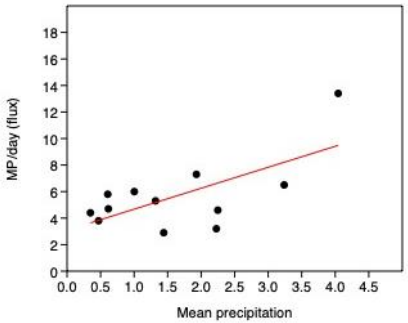
RESULTS



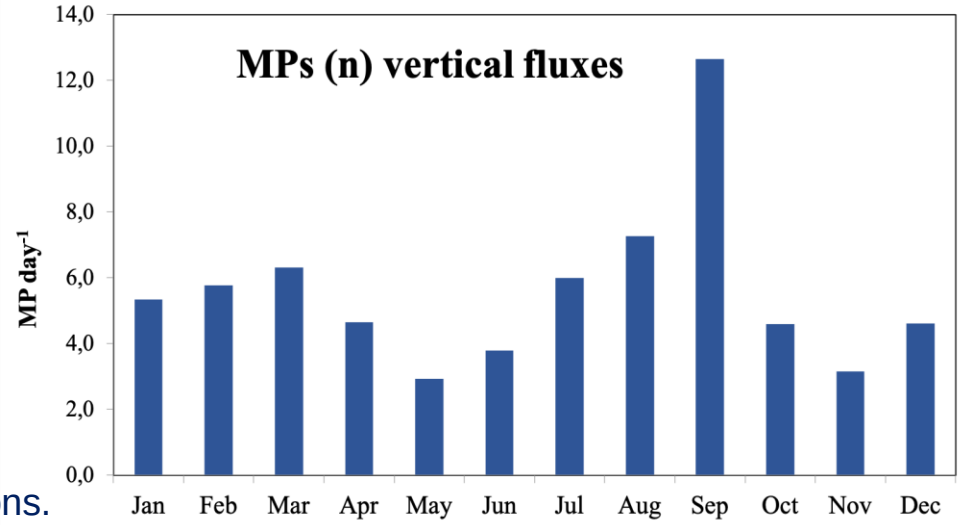
- Sediment flux is higher in Jul-Sep due to glacier melting by solar radiation, air temperature, higher rain precipitation/run off and Atlantic water intrusion

- 1887 MPs were counted (total mass 246 µg)
- Mean: 157.3 ± 45.6 MPs/sample
- Annual mean flux: 5.6 ± 2.6 MP day^{-1} (0.7 ± 0.4 µg day^{-1})
- Highest MP deposition in Sept (12.6 vs 2.9 MP day^{-1} in May).

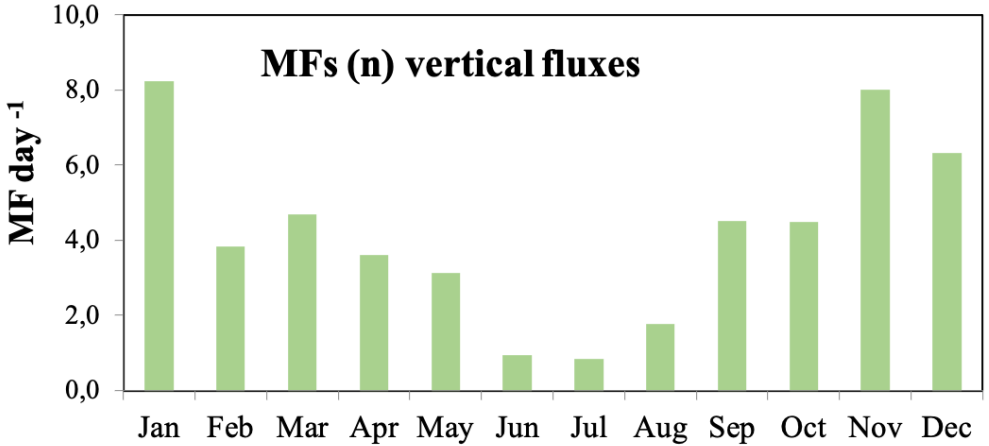




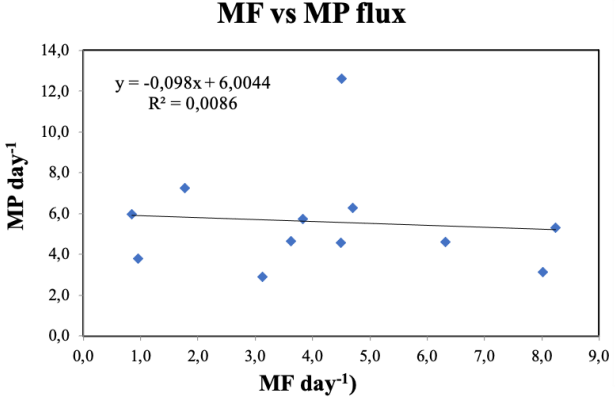
Positive relation with sediment flux and with precipations.

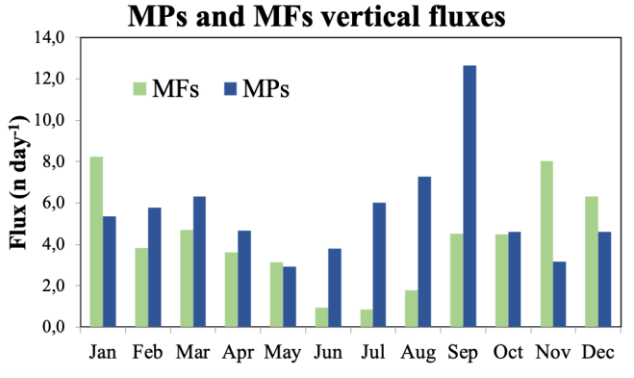


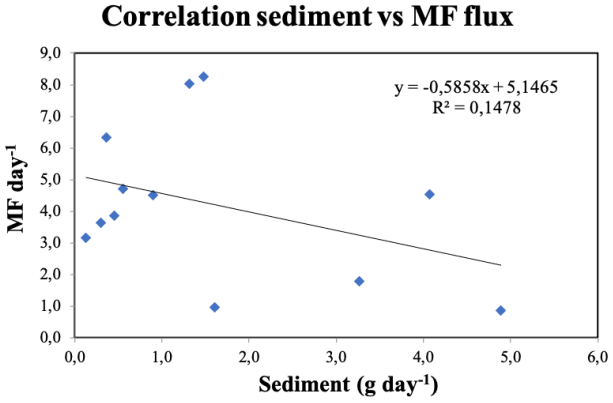
MICROFIBERS



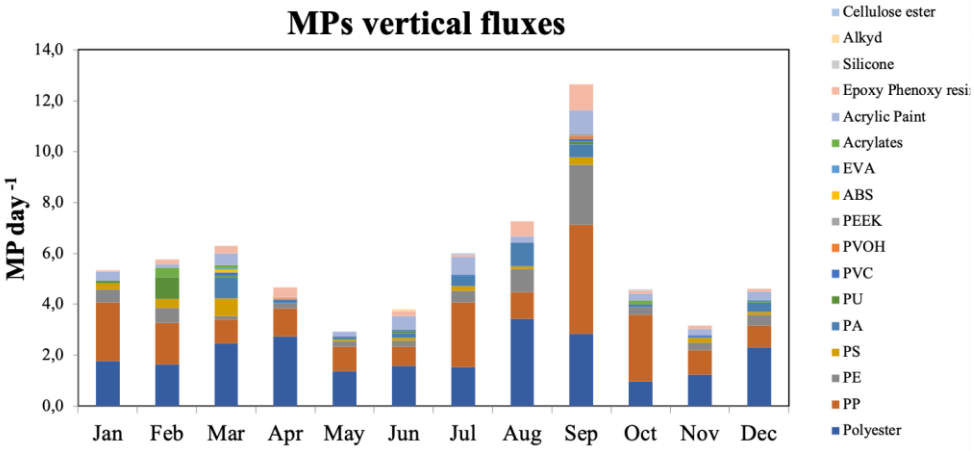
- 1481 MFs were counted
- Mean 123.4 ± 75.8 fibers/sample.
- Annual mean flux of 4.2 ± 2.4 MF day^{-1}
- Highest input in winter (8.2 MF day^{-1} vs 0.8 MF day^{-1} in end of spring/summer).
- No correlation with MPs flux
- Weak negative relation with sediment flux
- MPs and MFs could have different sources.

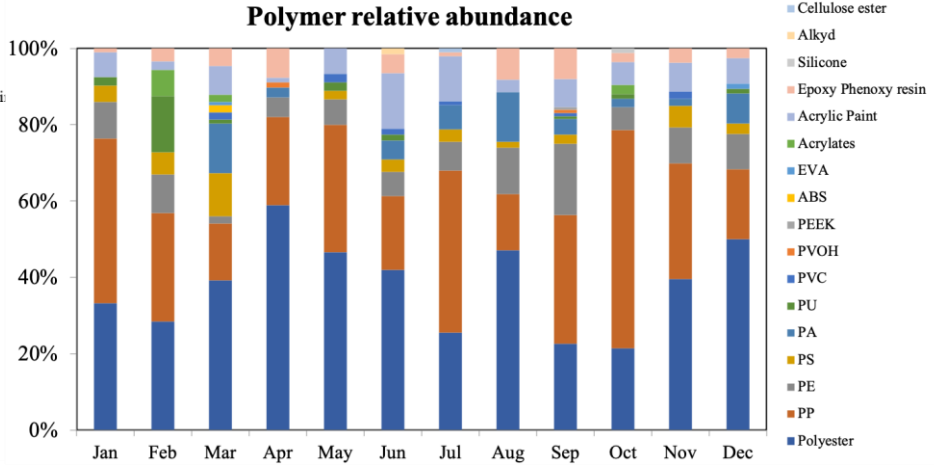






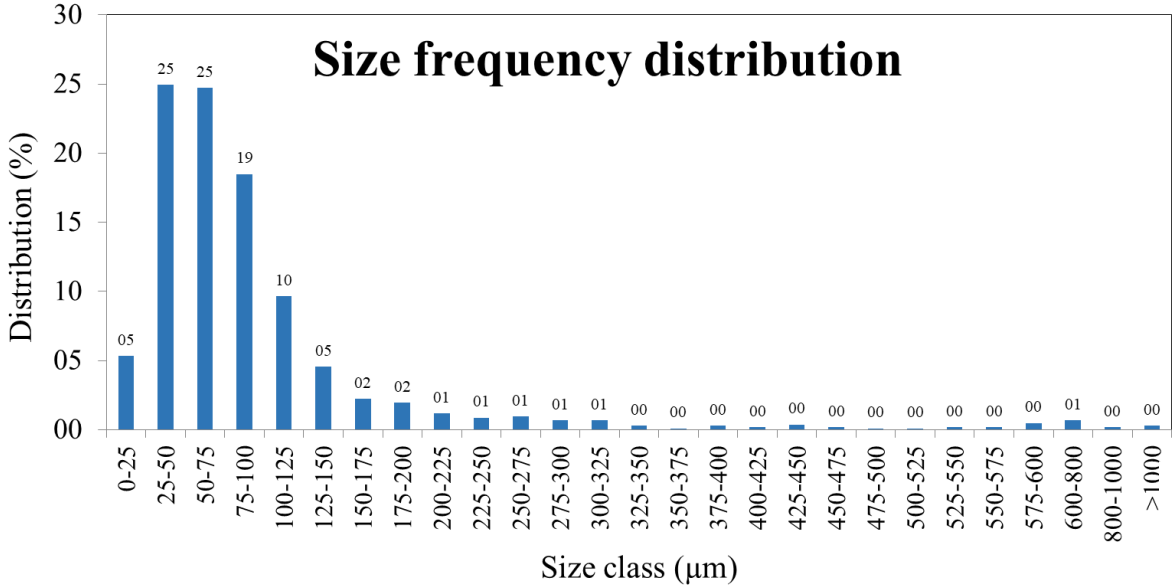
POLYMER COMPOSITION





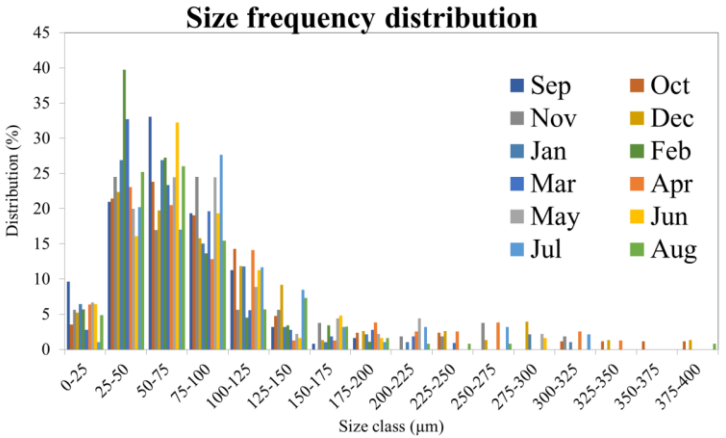
- 17 different polymers were detected.
- Most common polymers: PEST (36.8%), PP (29.6%), PE (9.1%), PA (5.4%), and PS (3.6%).
- Less frequent: PU, PVC, PVOH, PEEK, ABS, EVA, Acrylates, Acrylic Paints, Epoxy Phenoxy resin, Silicon
- Contamination from the sediment trap and from the mooring line?
  Trap body: GRP, Carousel: PETP, Bottles: PE/PP, Ropes: Kevlar+PEST, Baffle: Nylon
- **No correction has been applied yet**, but if these polymers were coming from sampling contamination that contamination would be constant and the seasonal trend would still be there…

SIZE DISTRIBUTION



- 90% of MPs < 150 µm
- 75% of MPs < 100 µm

Missing particles < 25 µm (close to limit of detection = poor spectral quality)



CONCLUSIONS

WORK IN PROGRESS – Sampling is still on-going (time-series)

- These (preliminary) results shed new light on the temporal variability of MPs vertical fluxes in the Arctic region, providing crucial information about the mechanisms behind MPs export and removal from the sea surface to the seafloor.
- Results still need to be blank-corrected and microfibers still need to be analyzed by µFTIR (there might be a lot of cellulose fibers!).
- FPA-FTIR processing also includes synthetic microfibers.
- Contamination by the sediment trap and by the mooring line can be a major issue (basically highlighting how difficult it is to avoid plastics!).
- Similar samples are also being collected in the Mediterranean Sea.
- Ideally, MP concentrations in sediment traps should be compared with MP concentrations in the sediments underneath.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Thank you!