Influence of Particle Sinking Velocities on Carbon Flux Attenuation and Export Efficiency

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ABSTRACT

Particle sinking velocity is an important determinant of carbon transport and sequestration to the deep-sea. It is however technically challenging to measure in situ particle sinking velocities. Recently, methods based on the radioactive pairs, (^{234}Th-^{238}U and ^{210}Po-^{210}Pb) were developed to estimate average sinking velocity (ASV), along the classical carbon export flux estimates. The influence of ASVs on key metrics of the biological carbon pump such as (i) the particle export efficiency (defined as the proportion of PP being exported below the surface ocean) (ii) carbon export fluxes and attenuation, still remain uncertain and need to be further evaluated.
ASVs are calculated in five biogeochemically contrasting sites: high latitude (Irminger Basin; Scotia Sea), temperate (PAP site) and oligotrophic (BATS, Equator) North Atlantic. ASVs are also calculated for different bloom stages (bloom - post bloom) in the North Atlantic and at the start of the bloom in two contrasting sites in the Southern Ocean (Scotia Sea).
A systematic increase of ASVs with depth, inversely correlated to carbon flux attenuation, is detected. We assess whether the increase in ASV with depth is correlated with either temperature or community structure (phytoplankton and/or zooplankton). Evidences of ASV correlation with carbon export efficiency are detected, but they vary strongly with season and location, e.g. very distinct relationships are found for the results from Scotia Sea, likely driven by zooplankton abundance.

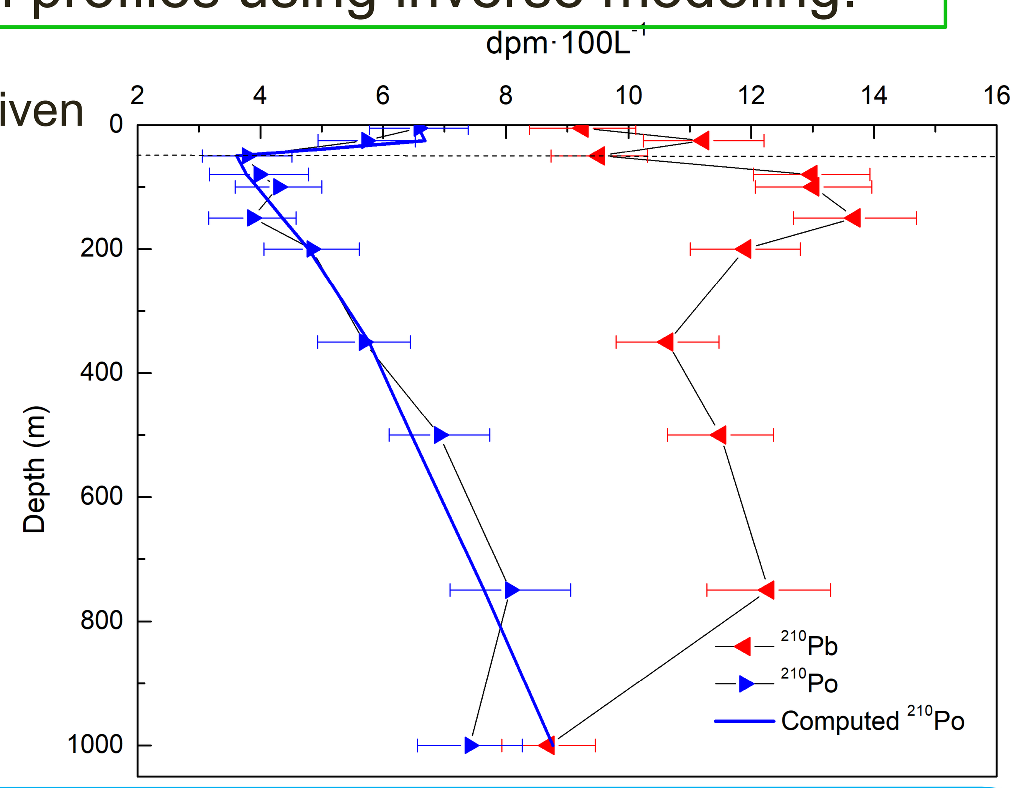
Calculation of average sinking velocity (ASV)

We compute ^{210}Po depth profiles using inverse modeling.

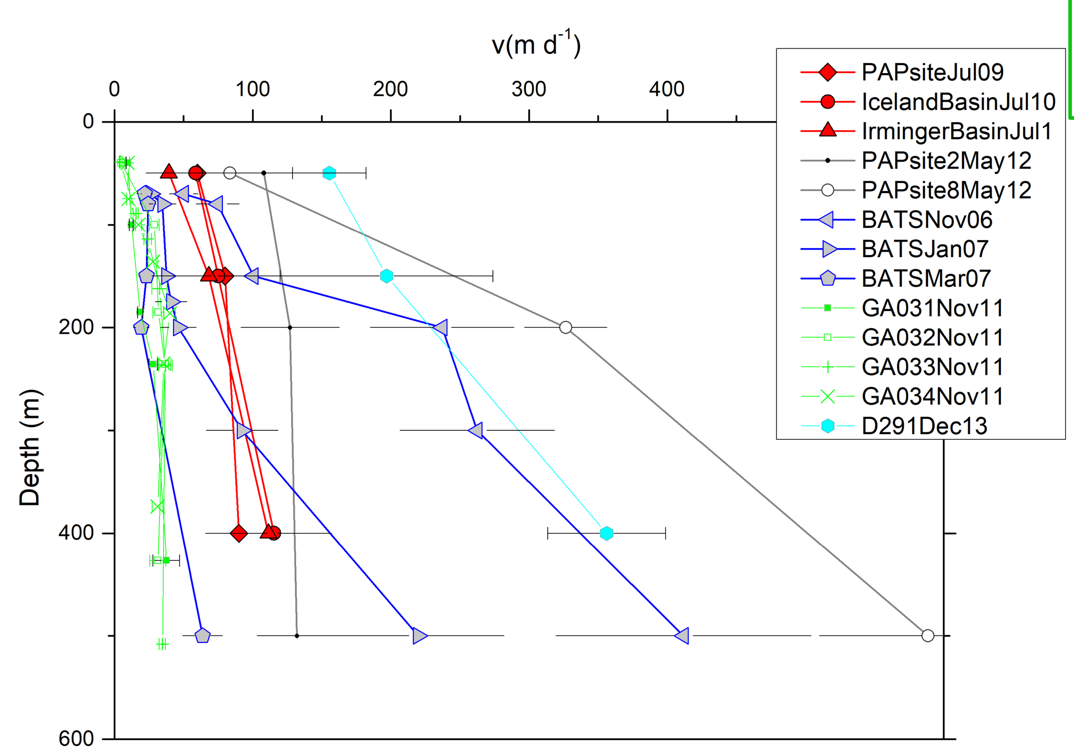
It depends on sinking velocity, given that:

$$P_{^{210}Po} = a^{particle}_{^{210}Po} v(z)$$

From the computed ^{210}Po profile it is calcualted the average sinking velocity (ASV). **It represents the AVS of all the particles, slow and/or fast that conform POC flux.**



Increase of ASV with depth



Systematic increase of ASV in depth →Flux attenuation

SV increases in depth due to:

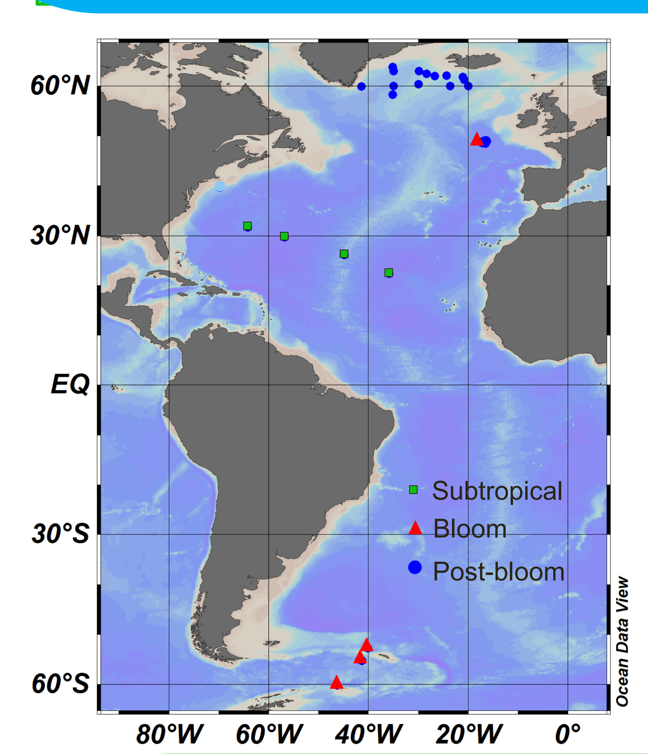
⇒ Aggregation increases particle size and density

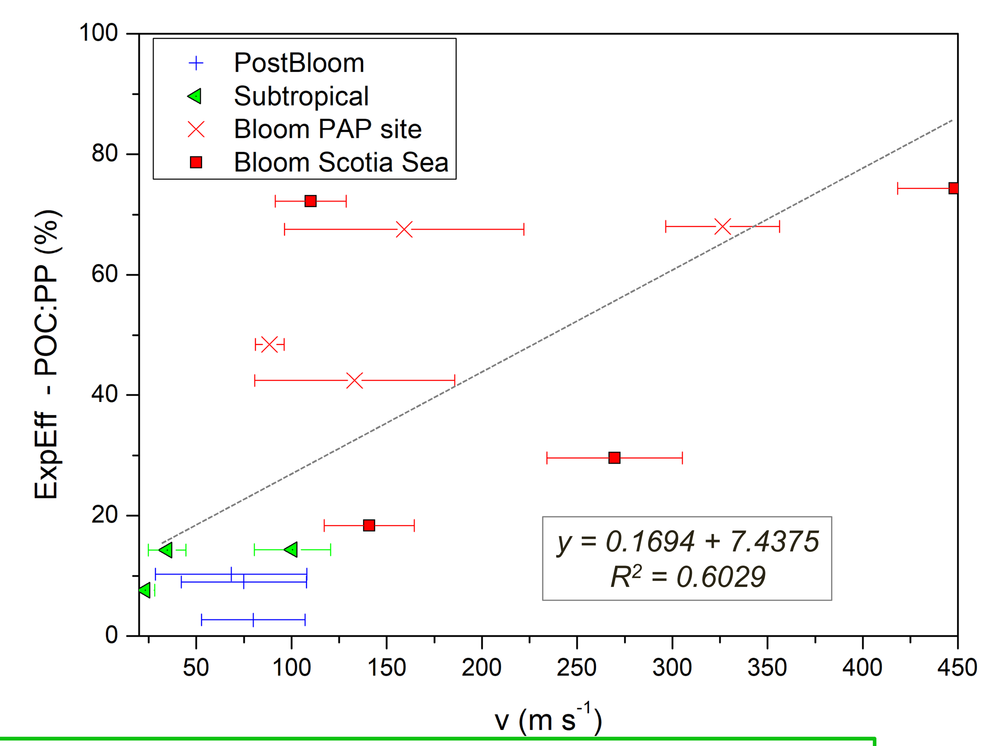
⇒ Remineralization of the POC → increases particle density

⇒ Faster remineralization of slower particles POC

Highest gradients of ASV are found in subtropical scenarios. Might be affected by NSS

Global impact of sinking velocity in Exp Eff. Ecosystem contribution

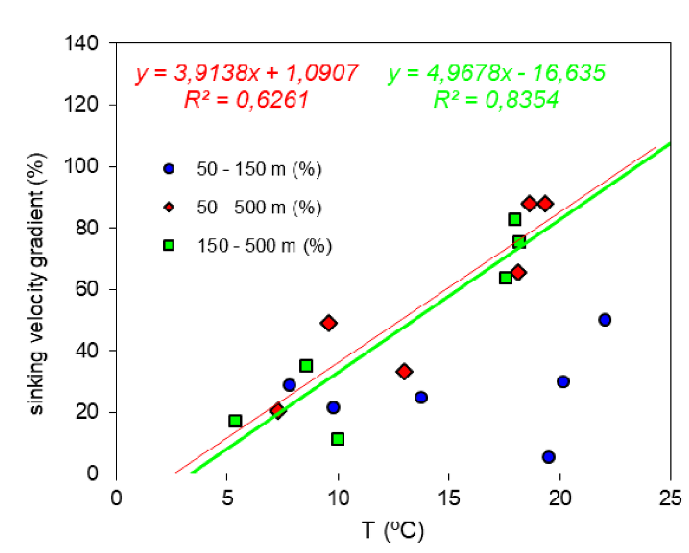




ExpEff is globally correlated to ASV

- *Blooms* provide **the highest ExpEff** and the highest **particle ASV** → During blooms aggregates are formed, ASV increases and sinks efficiently
- *Out of the Bloom* **ASV is lower than 100 m s^{-1}** → Slow sinking particles contribute significantly to POC flux and **Exp Eff** decreases

Increase of ASV in depth is not constant. Temperature and ecosystem



Remineralization mechanisms *out of the Bloom* (i.e. no aggregation)

⇒ From 150 to 500 m ASV gradient is **strongly correlated to T**. → bacterial degradation

⇒ From 50 to 150 m ASV gradient is **not correlated** to T. → bacterial degradation + zooplankton

CONCLUSIONS

- **Export Efficiency and average sinking velociy are globaly correlated. Faster particles provide higher Export Efficiency**
- **It is found a consistent increase of average sinking velocity with depth**
- **Contrasted gradients are found. Unlike the increase below 150 m, in shallow depths the velocity increase does not depend on temperature, suggesting zooplankton repackaging.**

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