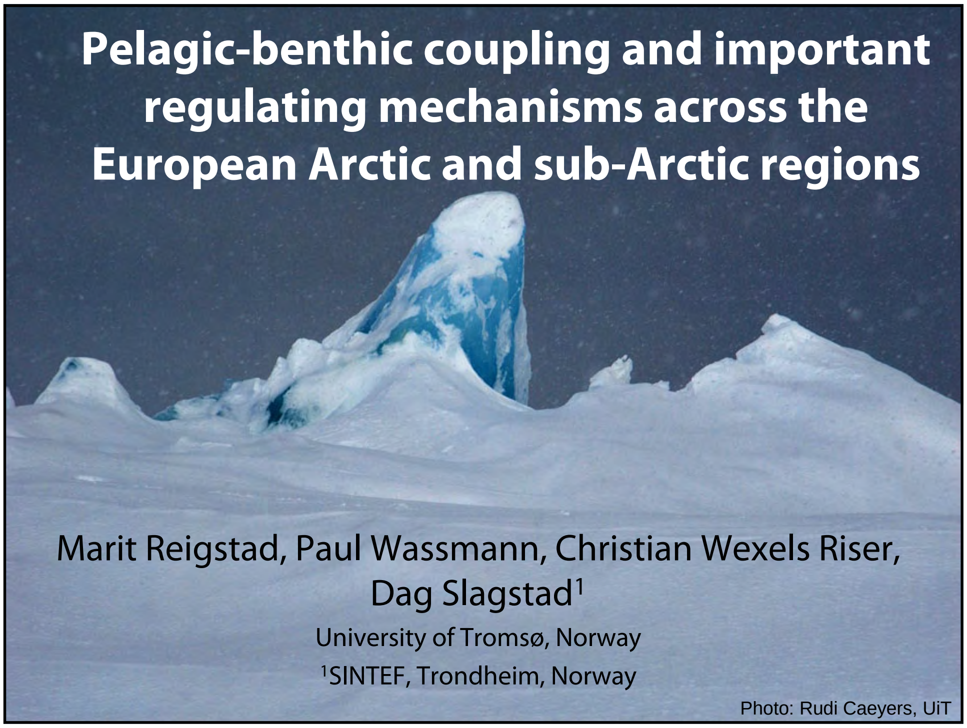


Pelagic-benthic coupling and important regulating mechanisms across the European Arctic and sub-Arctic regions

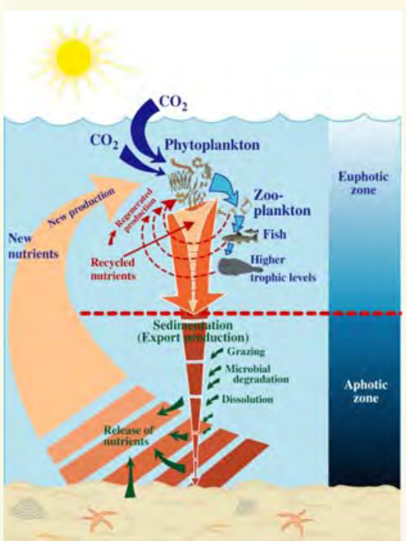
Marit Reigstad, Paul Wassmann, Christian Wexels Riser, Dag Slagstad[1]

University of Tromsø, Norway

[1]SINTEF, Trondheim, Norway

Photo: Rudi Caeyers, UiT

What is pelagic-benthic coupling?

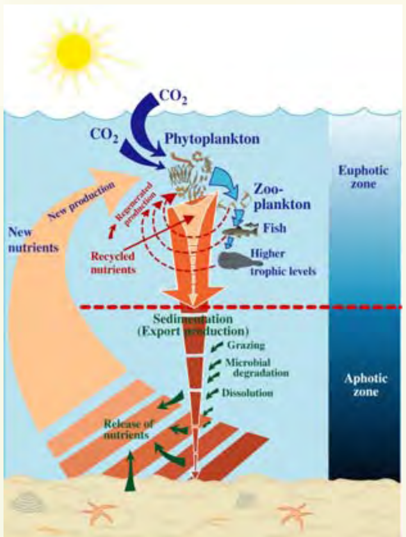


Supply of material from upper productive zone to deeper waters and seafloor

- ~sedimentation
- ~vertical export
- ~vertical flux
- ~downward flux

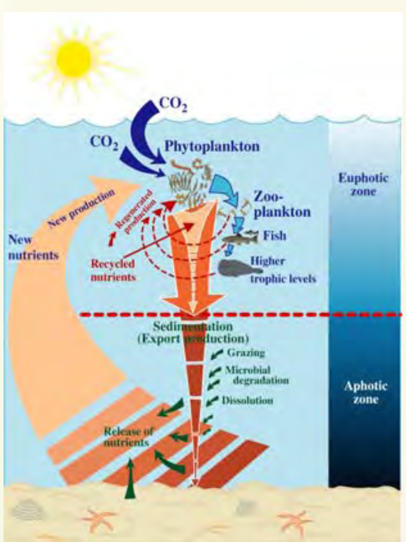
- ~benthic-pelagic coupling

Why is that of interest?



- Matters for the ecosystem (and fishermen) if the pelagic or benthic organisms get the food
- It transports carbon away from the upper watermasses (carbon sink)
- If we want to model the carbon cycle – vertical carbon export is a significant process
- We cannot project changes in ecosystem or carbon cycling if we do not understand underlaying mechanisms

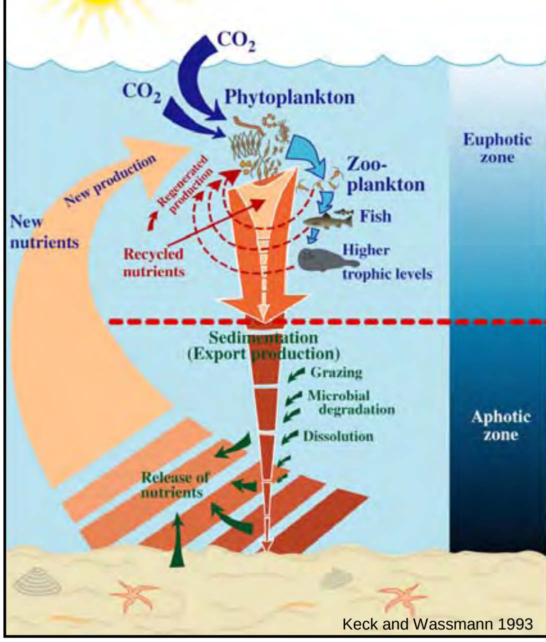
What regulates pelagic-benthic coupling?



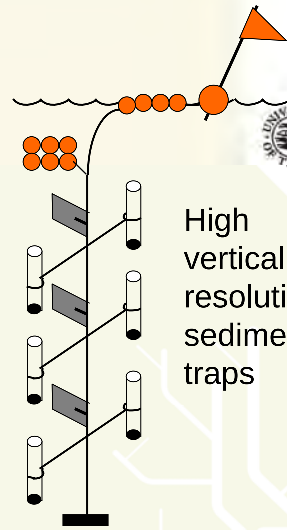
REGULATED BY

- **Primary production** (new production)
- **Composition** of primary producers (sinking ability)
- **Grazers** (herbivores)
- **Remineralisation** rate (bacteria, microbial foodweb)
- **Physical processes** (mixing, advection)
- **Active biological transport** (vertical migration)
- **Depth** (sinking time from production to sea floor)

How do we measure vertical export

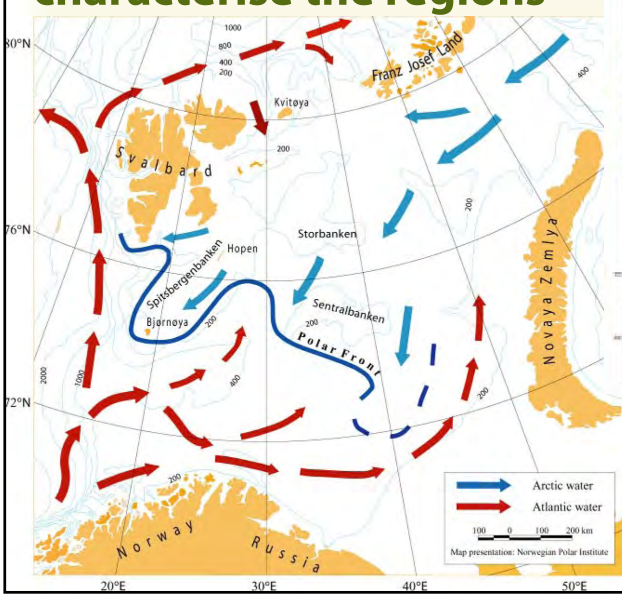


Keck and Wassmann 1993

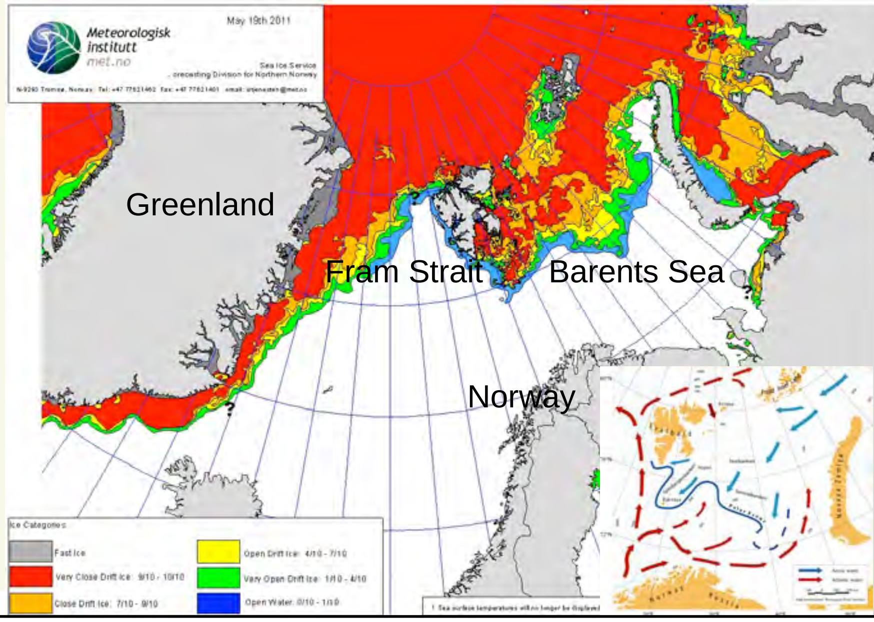


High vertical resolution sediment traps

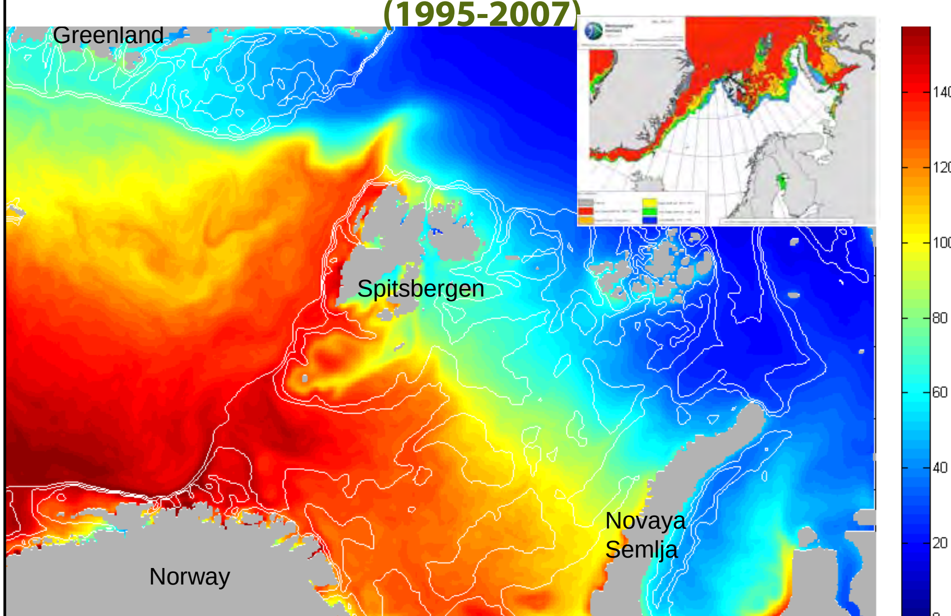
Atlantic and Arctic currents characterise the regions



Ice map from European Arctic, May 19, 2011

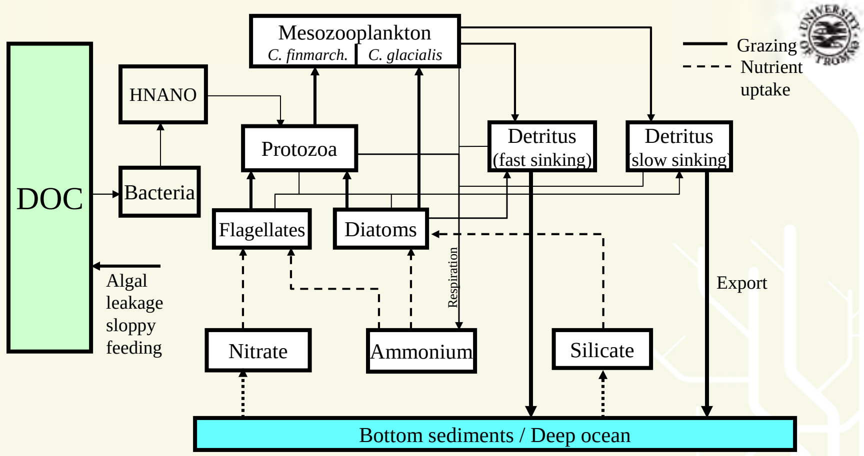


Average annual simulated gross primary production (1995-2007)



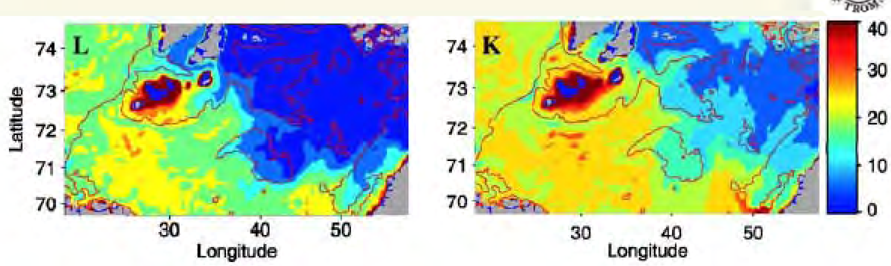
Reigstad et al. (2011) Prog. Oceanogr.

SINMOD Ecosystem model



Wassmann, Slagstad et al. 2006

Simulated annual vertical POC export at 50 m depth in the Barents sea 1998 and 1999

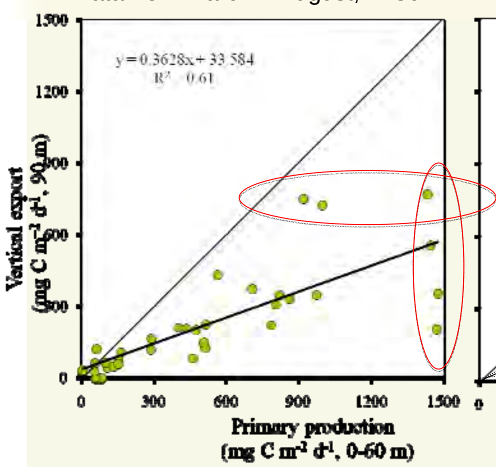


Higher vertical export in the Atlantic region where primary production is higher, but rates too low compared to measurements: Challenge to get the processes right

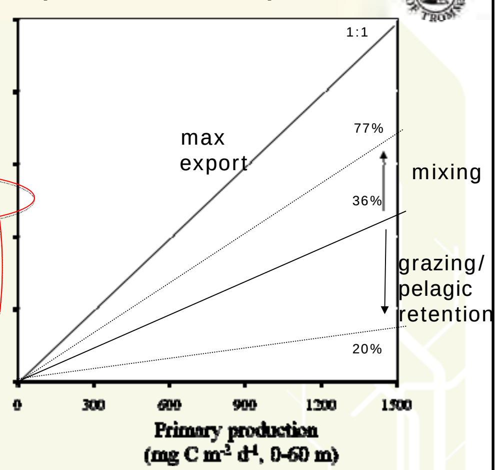
HOW IS VERTICAL EXPORT RELATED TO PRIMARY PRODUCTION

Daily primary production and vertical export ratios in the Barents Sea (shelf)

Data from March – August, n=36

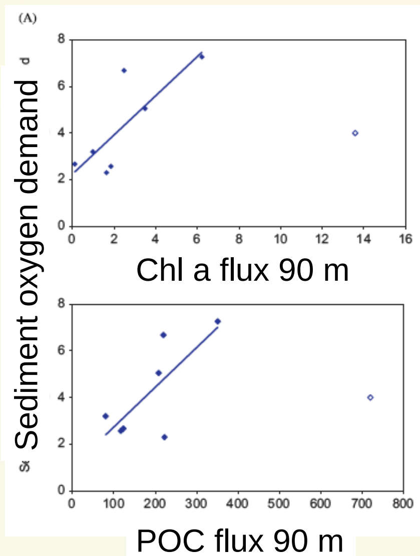


Export depends on attenuation exposed to **top-down** or **bottom-up** effects



Reigstad et al. 2008

Sediment oxygen demand at >200 m and vertical Chl a and POC flux at 90 m depth



Strong correlations between sediment oxygen demand and Chl a and POC export at 90 m depth

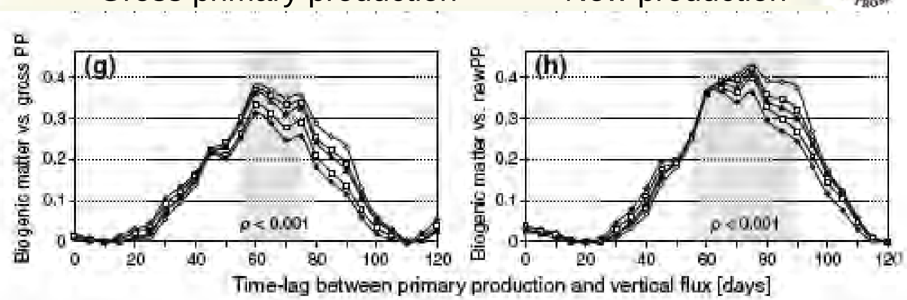
Tight pelagic-benthic coupling during the pre- to post bloom period in the Barents Sea

Renaud et al. (2008) DSR II

Central Fram Strait (Hausgarten): Time lag between primary production and vertical flux

Gross primary production

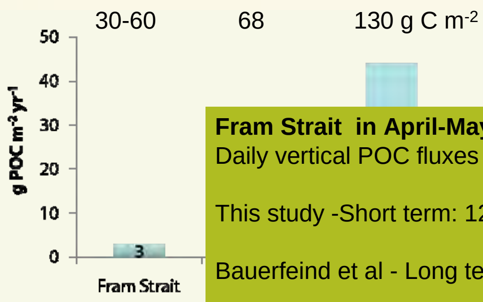
New production



Forest et al. 2010

Annual vertical carbon export in the Fram Strait vs the northern Barents Sea

Annual primary production model simulations



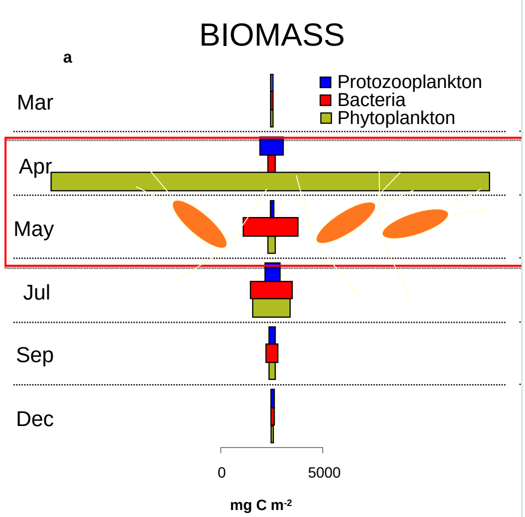
Fram Strait in April-May
Daily vertical POC fluxes 200-250 m:

This study -Short term: 12 (6-20) mg C m^{-2} d^{-1}

Bauerfeind et al - Long term: 6-12 mg C m^{-2} d^{-1}

Annual POC export:
Fram Strait: Bauerfeind et al. (2005, 2009) J Mar Syst., Deep Sea Res I
Barents Sea: Reigstad et al. (2008) Deep Sea Res II
Gross PP simulation; Slagstad and Ellingsen

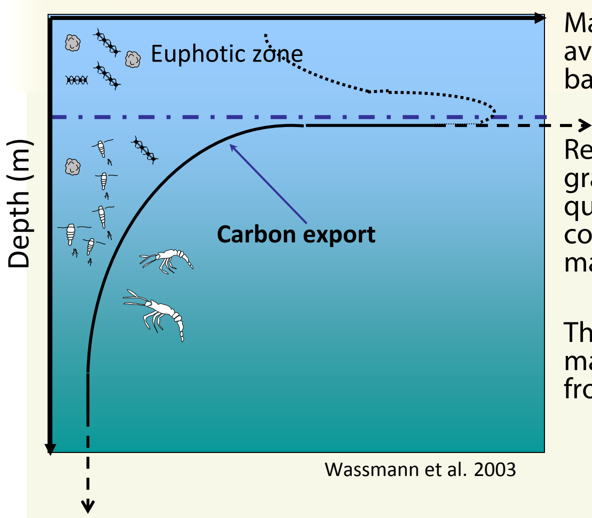
First seasonal study of the auto- and heterotroph dynamics in Kongsfjord, Svalbard 2006



Iversen & Seuthe (2010), Seuthe et al.(2010) Polar Biology

NEED TO LOOK AT BOTH PELAGIC PROCESSES AND THE VERTICAL FLUX PROFILE AND COMPOSITION TO UNDERSTAND MECHANISMS

Conceptual sceme of vertical export processes:



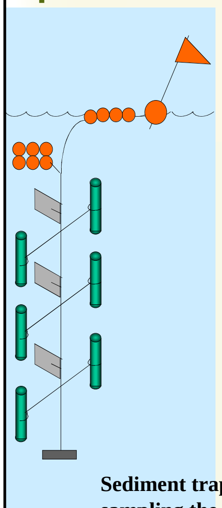
Wassmann et al. 2003

Max amount of material available for export at the base of the euphotic zone

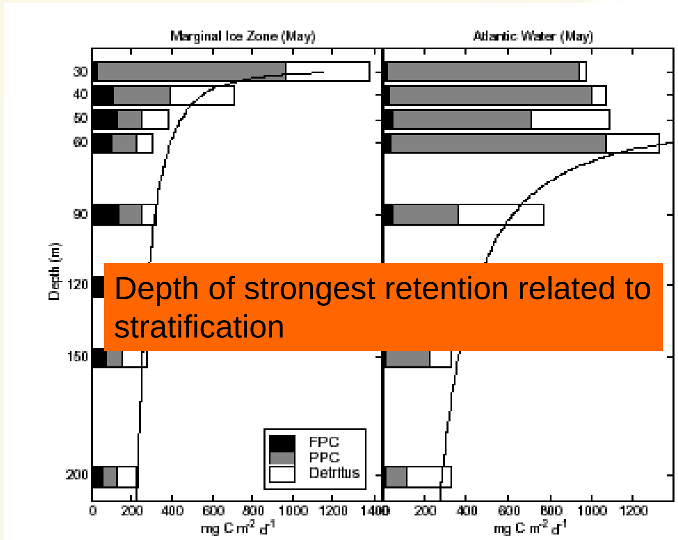
Remineralisation and grazing will reduce the quantity and change composition of sinking material

Their vertical distribution matters, and can be seen from vertical flux profiles

Sediment traps: High vertical resolution on sinking particles reveal depth specific flux reduction



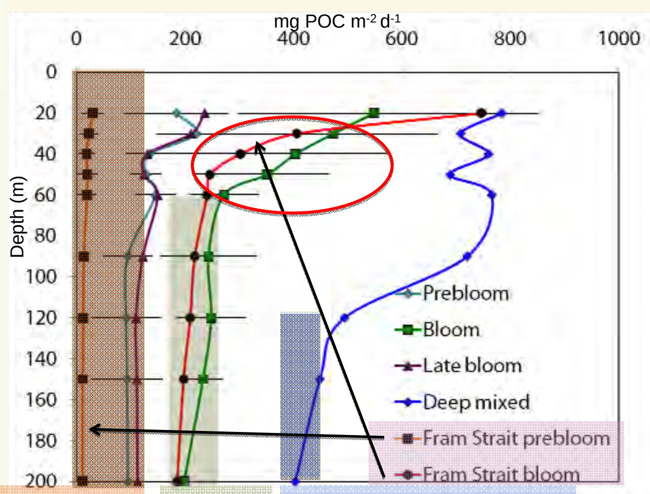
Sediment traps sampling the upper 200 m

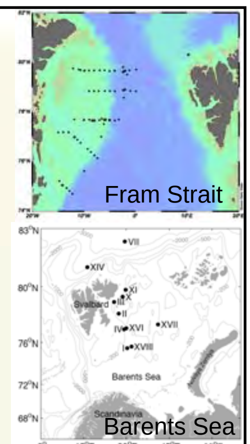


Depth of strongest retention related to stratification

Wassmann et al. 2003

Vertical carbon export profiles (n=21): Bloom conditions and attenuation





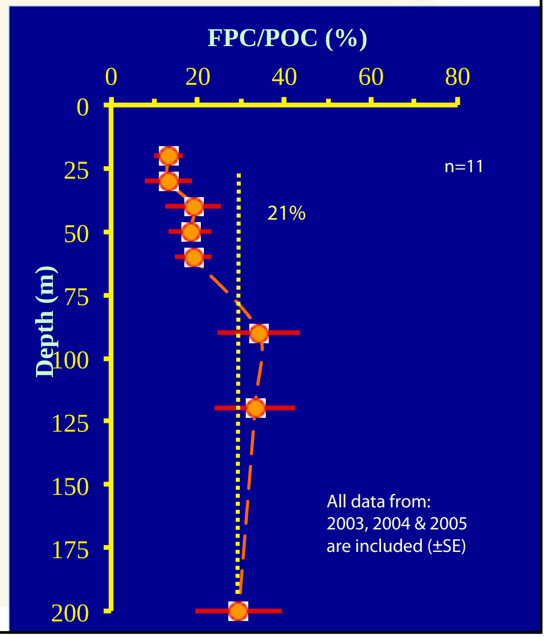
Pre- (n=8+3) & Late (n=1) bloom

Bloom (n=2+6)

Mixing short- circuited the retention >30 m

How large proportion of the total POC export is made up by zooplankton FP?

The relative importance of faecal pellet vary in time and space!!!



BUT DO ALL PRODUCED FAECAL PELLETS SINK

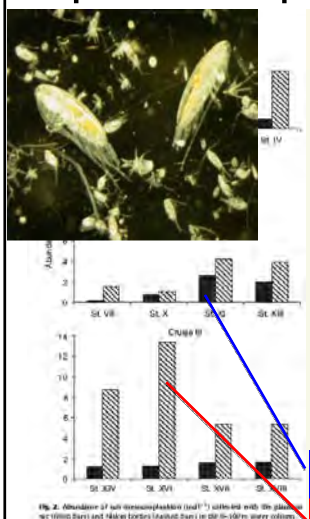
And what is the success factor?

SIZE MATTERS, but is not enough to ensure successful export

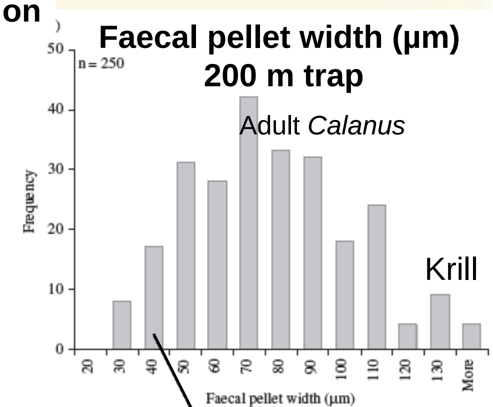
FP from small species and stages are not exported to depth

Wexels Riser et al. 2008

Zooplankton composition



Pasternak et al. 2008



Large copepods

Small copepods

Small: Correspond to stage CIII/IV of Calanus glacialis/ finmarcicus

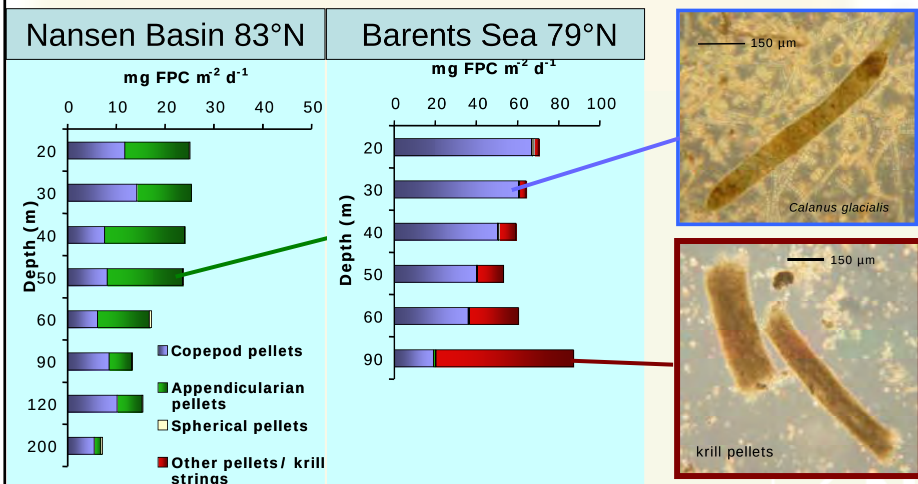
Spatial variability in FP retention in the central Barents Sea during May

	Prod.	Sed.	Ret.
May			
Atlantic Water	104	4	96
Polar Front region	43	27	37
Arctic Water	62	32	48

Prod. = FPC production (mg FPC m^{-2} d^{-1})
Sed. = FPC sedimentation (mg m^{-2} d^{-1})
Ret. = FP retention (%)

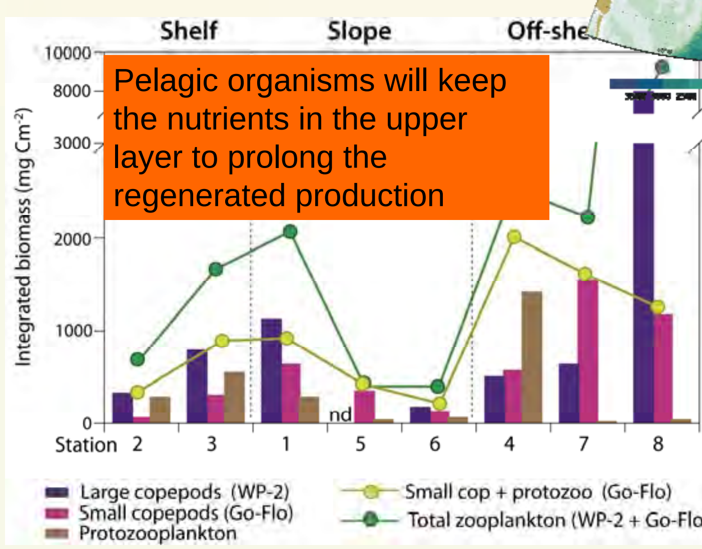
Wexels Riser et al. 2002

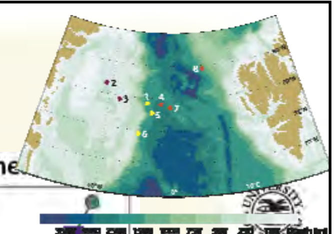
So who are the main contributor to the FPC export??



Wexels Riser et al. 2008

Zooplankton community
Combined datasets (Go-Flo + WP-2)





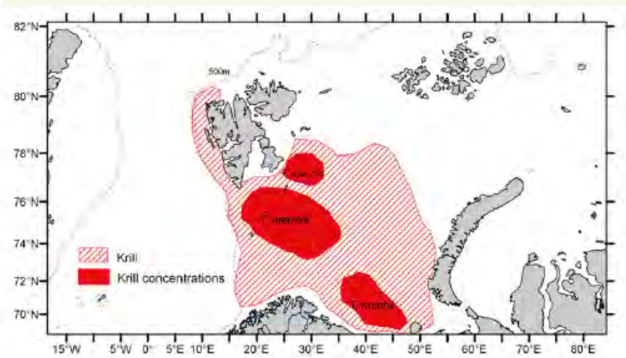
Pelagic organisms will keep the nutrients in the upper layer to prolong the regenerated production

September 2006 and 2007

Svensen et al. (in rev). Prog. Oceanogr.

Krill distribution:

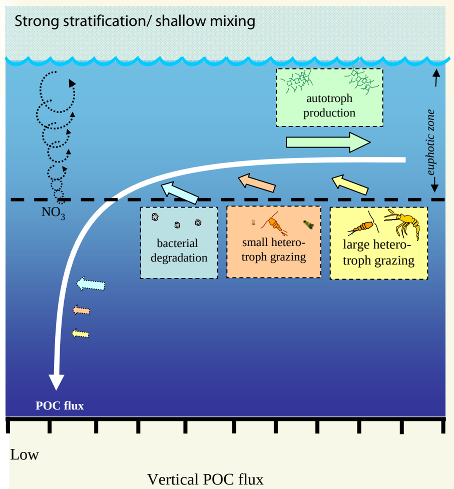
Fast sinking faecal pellets
Active vertical migration
Consumption and export of *Phaeocystis* (that otherwise do not sink)



Eriksen and Dalpadado (2011) Polar Biol.

RETENTION MECHANISMS AND THE IMPORANCE OF TIME/ SINKING SPEED

Carbon cycling and vertical particle export regulation: The role of microbial processes and organisms



What is the relative importance of remineralising microbes and larger zooplankton for degradation and retention:

Fast sinking faecal pellets as model particle

www.conflux.arctosresearch.net

Research question:

Who contribute to retention of faecal pellet?

- Microbial community (Bacteria + plankton < 180 µm)
- Microbial community + *mesozooplankton (Calanus)*

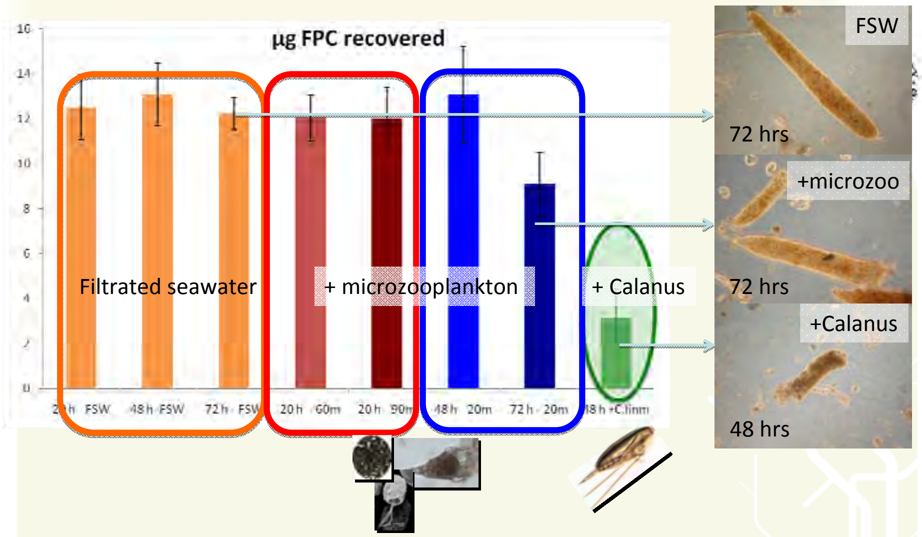
Faecal Pellets | **< 180 µm fraction Microbial community** | ***Calanus finmarchicus***

 **+**   **?**

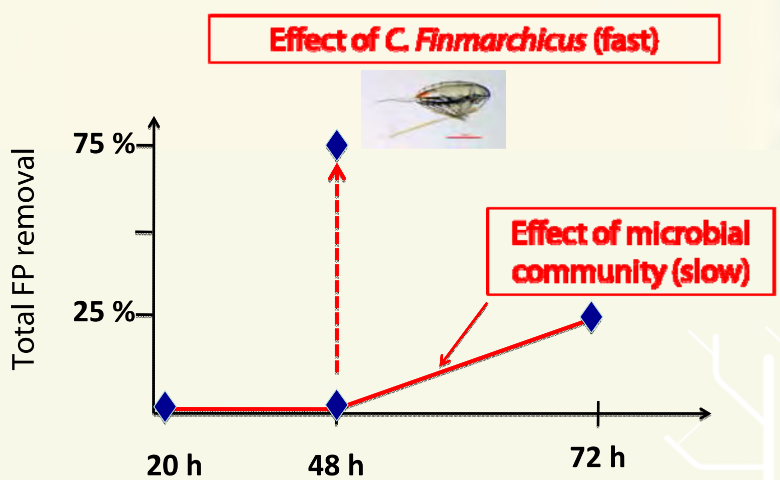
 **+**    **?**

Svensen, Wexels Riser and Reigstad, to be submitted

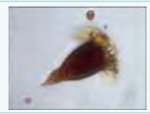
Experiment to identify actors degrading FP



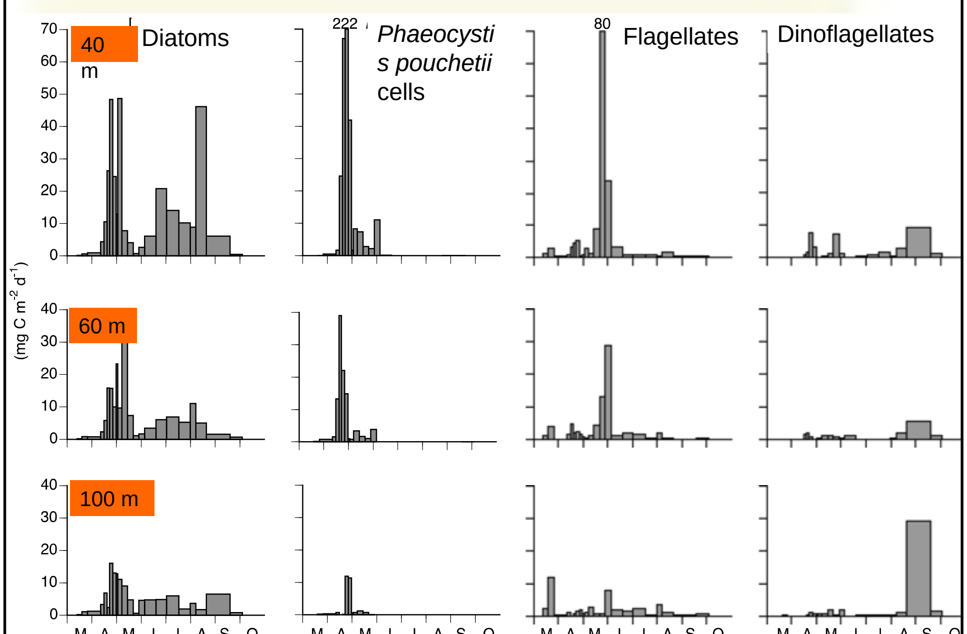
Summary faecal pellet degradation



Downward flux of faecal pellets in the upper 100 m: Summary and ecological relevance

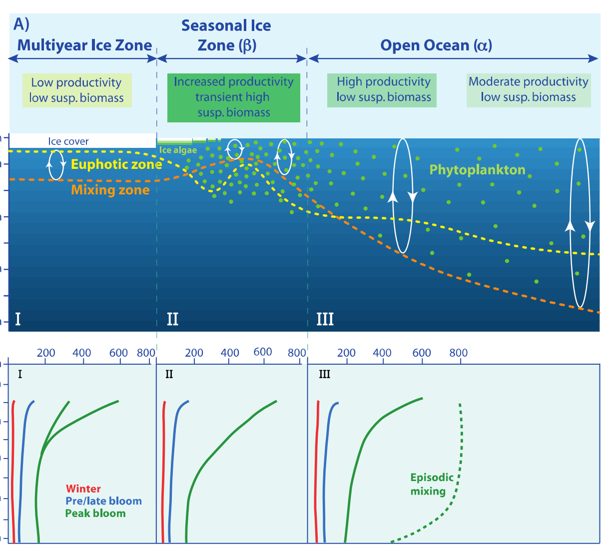
Sinking rate of large copepod FP (*Calanus*)		**≈100 m d^{-1}**
Retention time of FP in euphotic layer approx 50 % of FP is degraded in upper 100 m		**< 1 d**
Visible effect of microbial community		**> 2 d**
Effect of microbial + *Calanus*		**< 2 d Instant?**

Composition matters: Seasonal export of phytoplankton

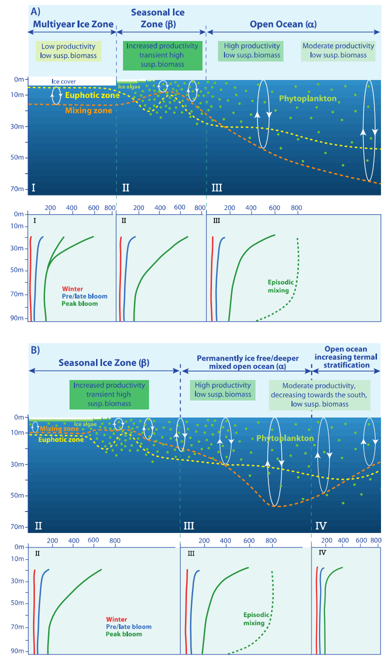


FUTURE PERSPECTIVES

Vertical carbon export shaped by physical environment



Wassmann & Reigstad (subm)



Future perspectives for vertical carbon flux

MYI sone gone
Thermal stratification limits production and episodic mixing in south, and vertical export

Wassmann & Reigstad (subm).

Message to take home

- **Stratification matters**: regulates primary production, vertical distribution of grazers, downward mixing of organic material
- **Zooplankton community matters**: small species promote regeneration, while larger species in variable degree contribute to faecal pellet flux, but also retention
- **Phytoplankton community matters**: small cells slower sinker than larger or cyst forming species; but contribute
- **Depth matters**: shallow areas provide shorter time for retention
- **To understand the pelagic-benthic coupling we have to understand the retention**; pelagic community an efficient retention filter

Thank you for the attention

Photo Rudi Caeyers, UiT