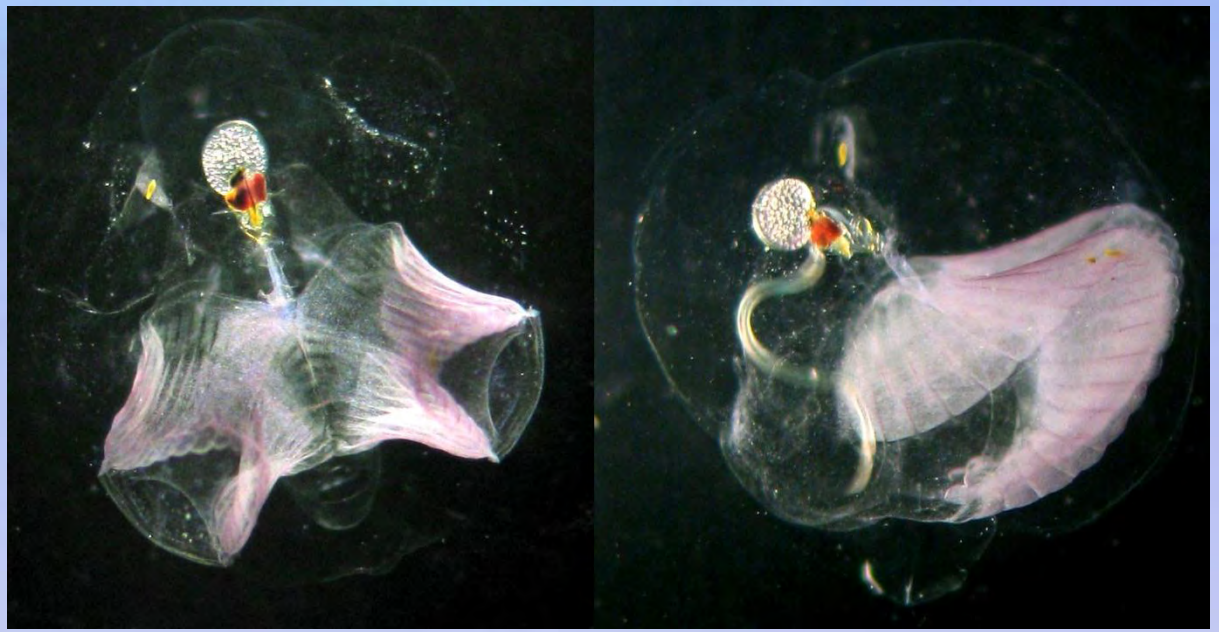
Marine snow originating from appendicularians:

Age-changes in houses settling characteristics

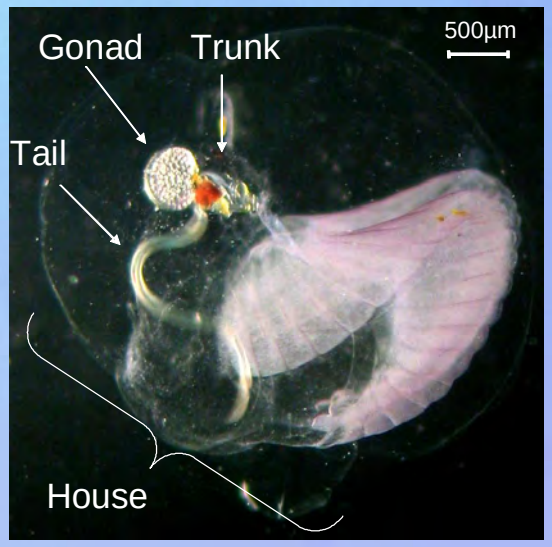


Fabien Lombard & Thomas Kiørboe

DTU

What is an appendicularian??

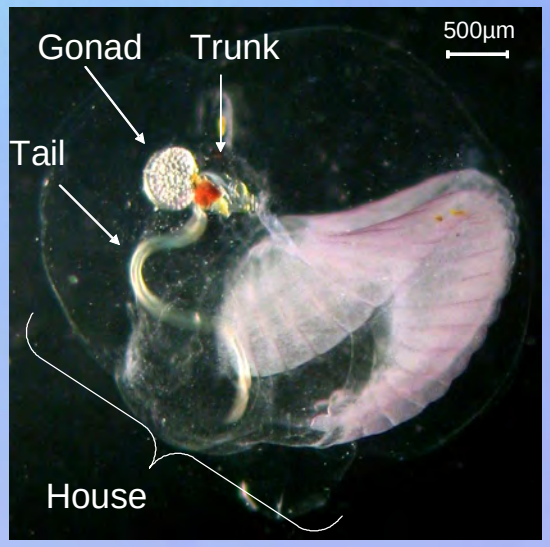
- Zooplankton
  - Pelagic tunicates
  - Often second after copepods
- Filter feeder
  - Use gelatinous houses to filter small particles
- Short life cycle (7 days 15°C)
- High growth rate (0.5 - 1.5 d^{-1})
- High production of detritus
  - Discarded houses
  - Fecal pellets



Oikopleura dioica

Discarded houses

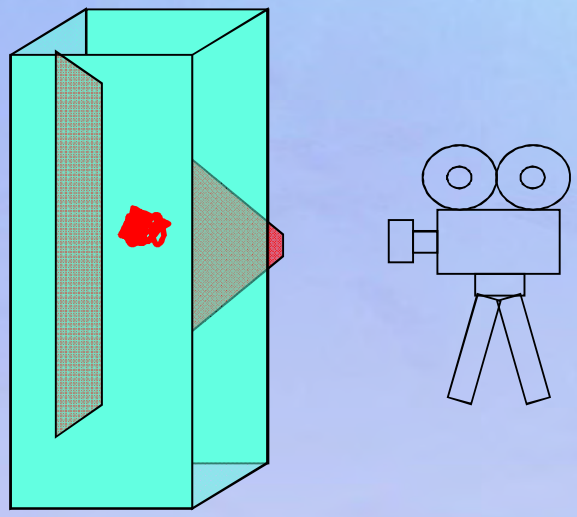
- Major source of marine snow
- Production: 10-26 houses d^{-1}
- Rapid disappearance in water column
  - Too quick to be caused by bacterial action
  - Due to zooplankton or other process?
- What happens to particles once produced?
  - Effect of age?
  - Effect of zooplankton?
  - Effect of ballast particles?



Oikopleura dioica

Methodology

Å Following particles during sedimentation (as they get aged)



-Houses produced at the same salinity and temperature than in the observation chamber

-Size monitored

-Incubation in rotating bottles between observations

-Houses filmed at different time intervals after discarding

-Weight calculated from house size and sinking speed

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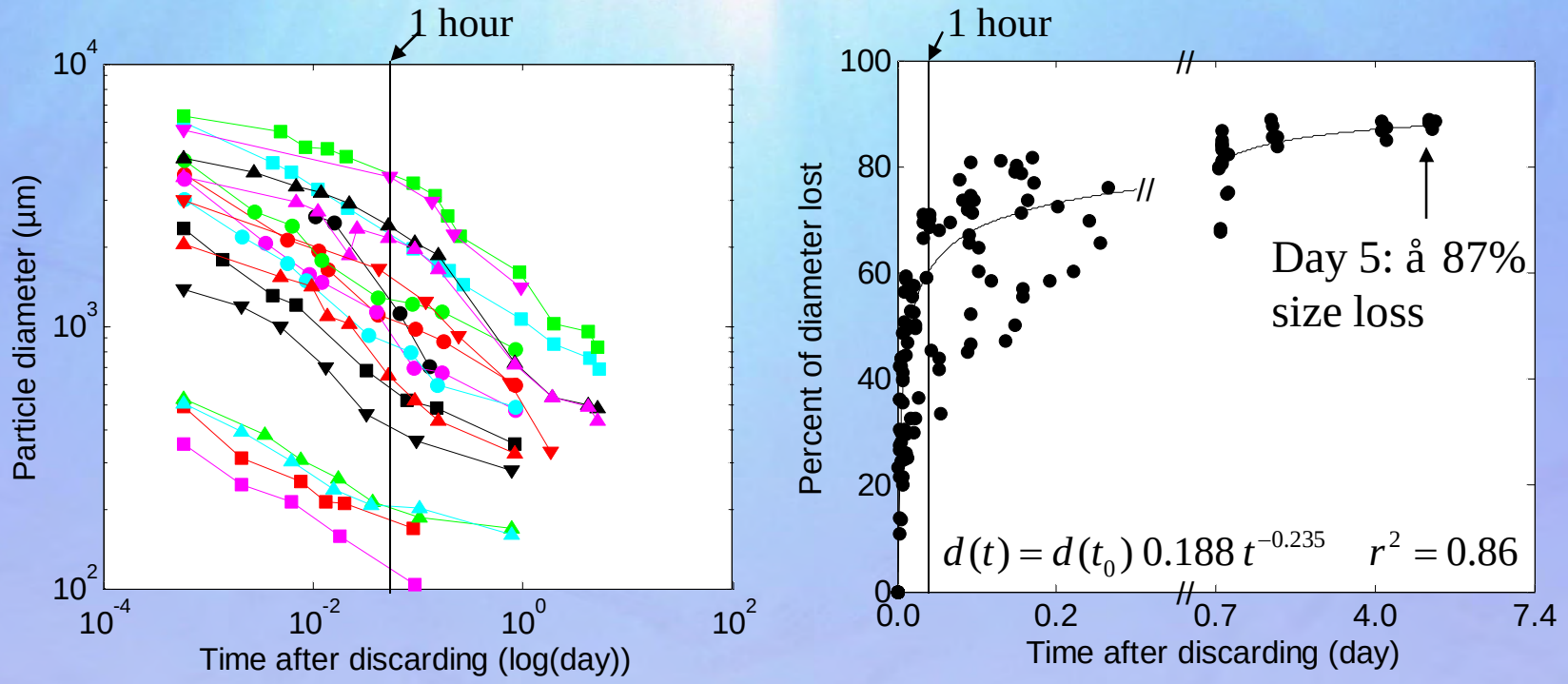
Age effect on size



- Similar change without influence of initial house size
- Rapid deflating process :
(1 hour after discarding ⇨ 61% loss in diameter - 90% in volume)
- Slow down progressively
- Only due to a physical deflating / compression process: ñBalloon effectò

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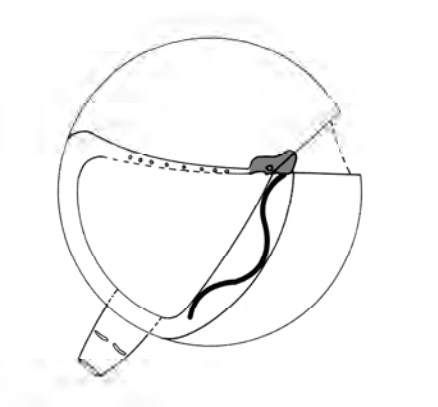
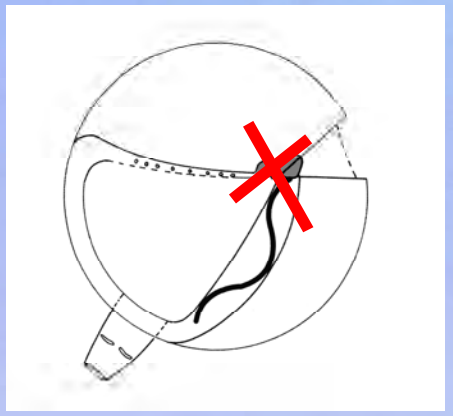
Deflation / compression process

Balloon effect



Deflation / compression process

Balloon effect



Deflation / compression process

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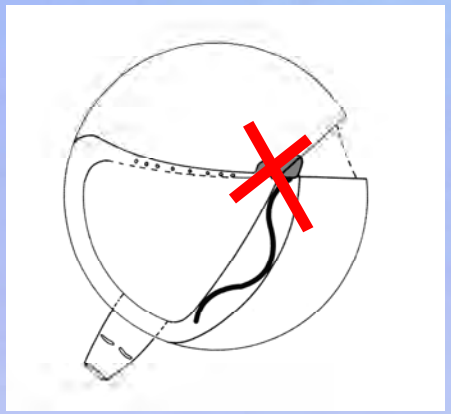
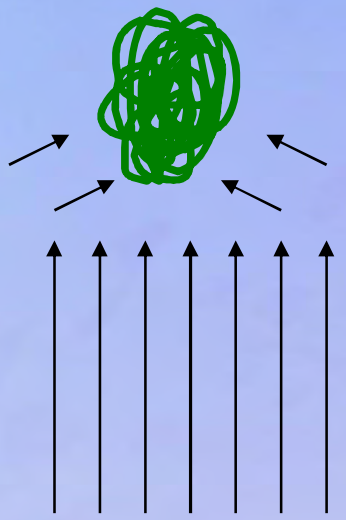
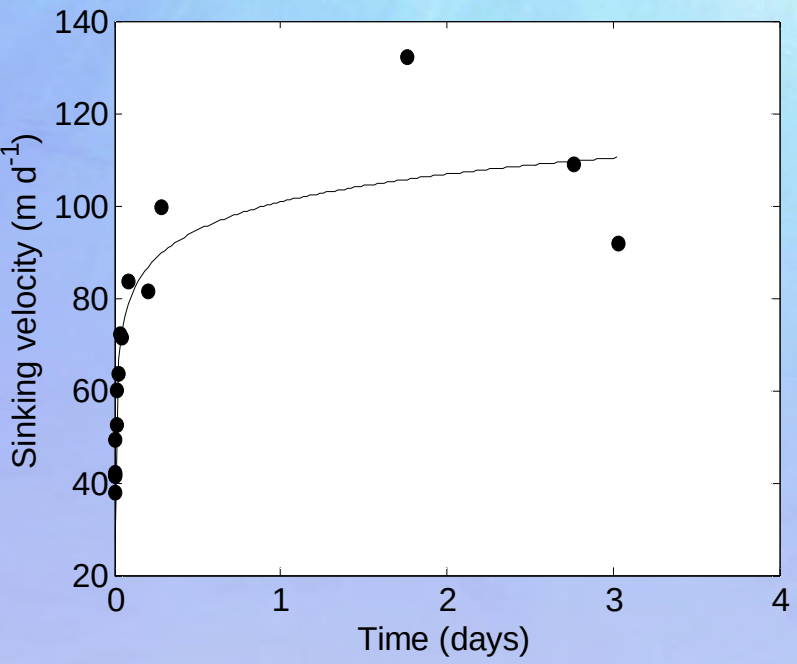
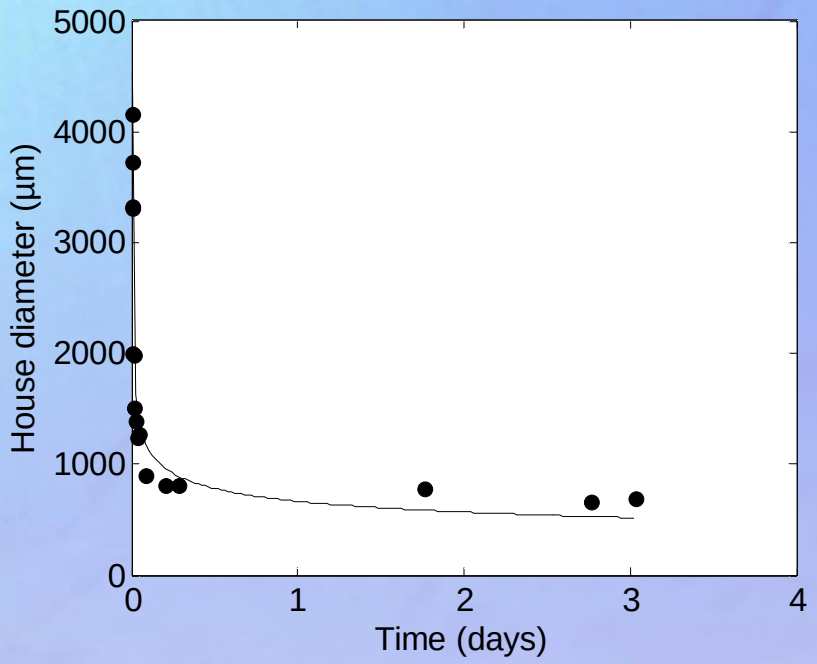


Compression effect



Age effect on Sed. rate





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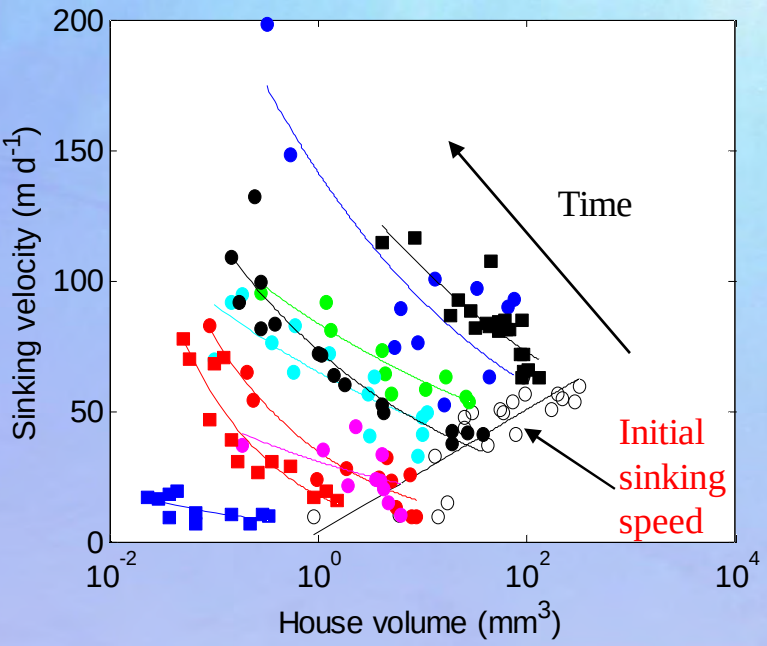
Sinking speed evolution



In all cases within 2 days of observations:

- 2 order of magnitude decrease in volume
- Sedimentation rate increase x 2-3

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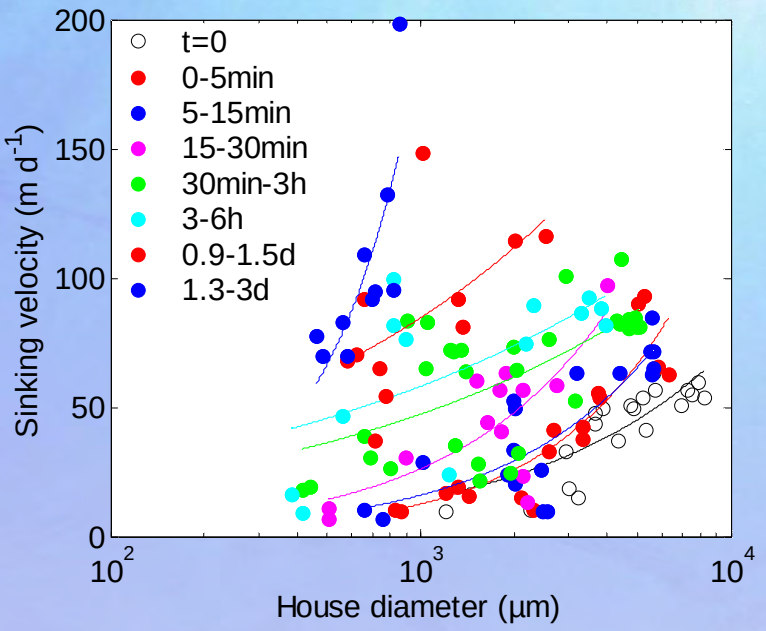
At different age intervalsé



In all cases within 2 days of observations:

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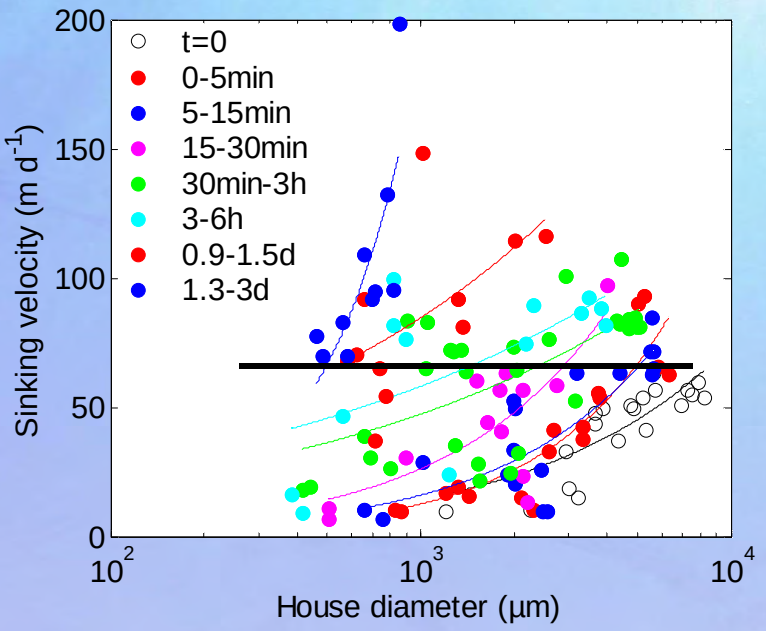
Theory: large particles sediment faster than small ones

True within a similar age interval

Lombard & Kiørboe (2010) DSR I

At different age intervalsé



In all cases within 2 days of observations:

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Theory: large particles sediment faster than small ones

True within a similar age interval

Not true if age is not taken in account

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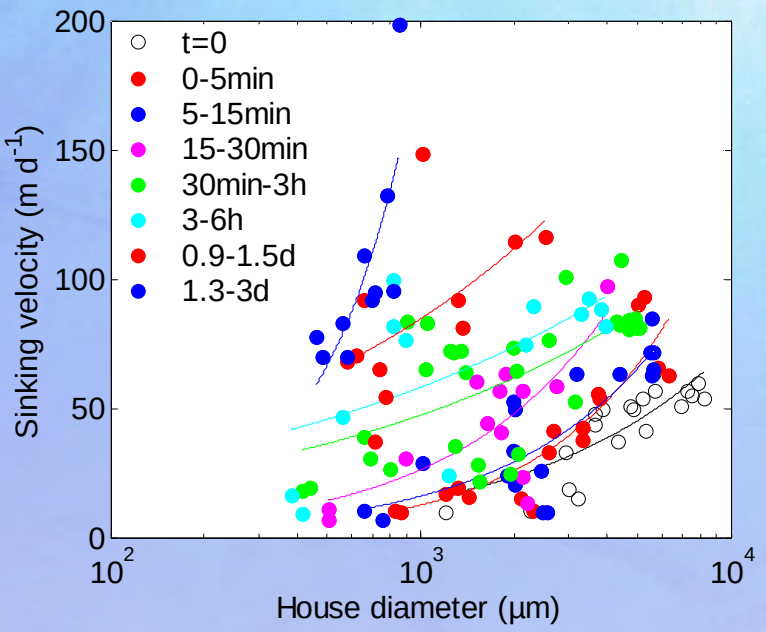
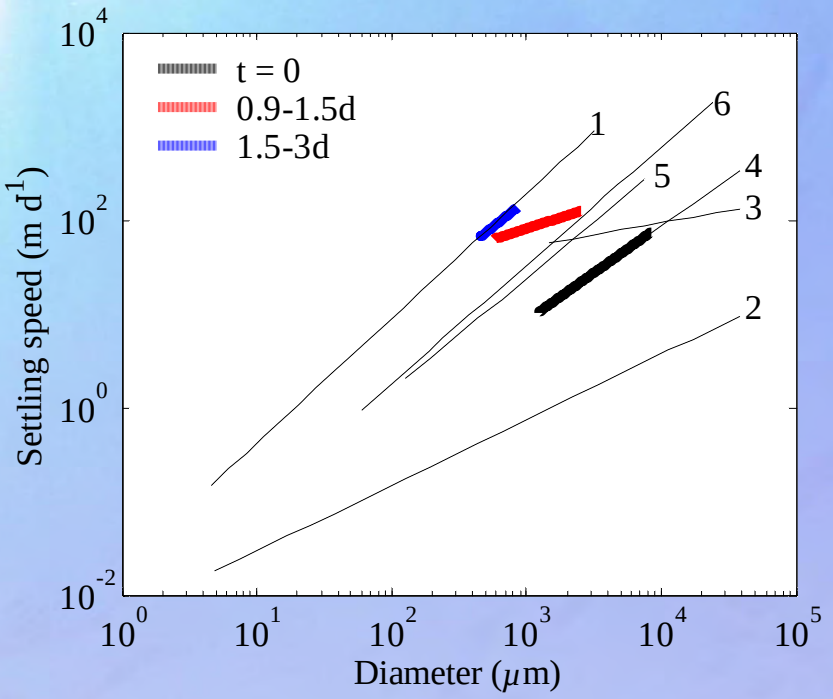
At different age intervalsé





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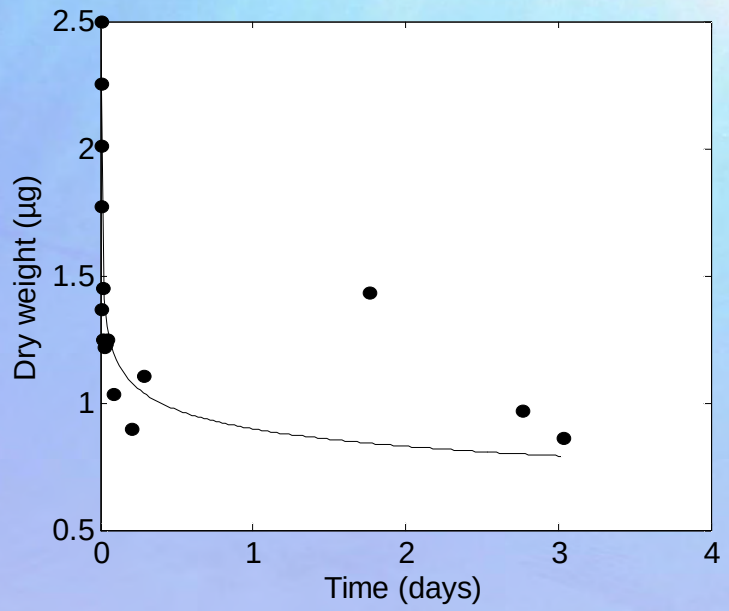
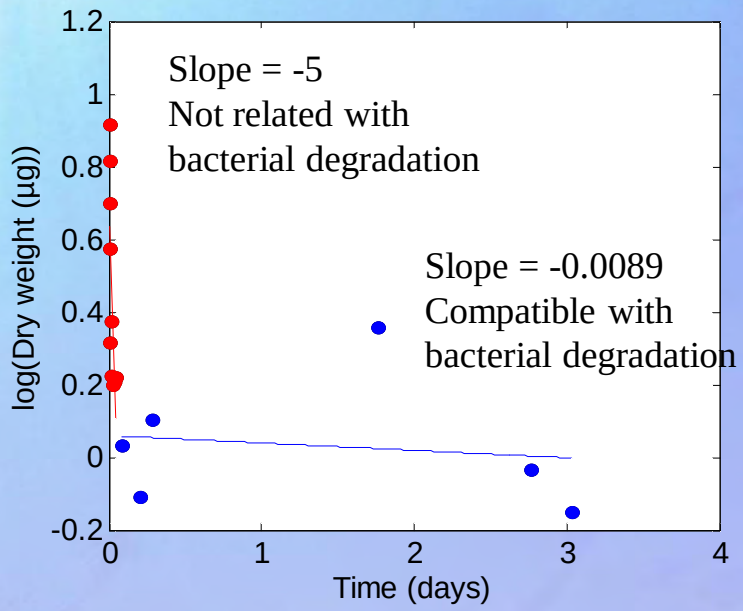
1-2: Stemmann et al 2004 — Coag. Model ±
3: Alldredge & Gortchalk 1988 } Sea surface
4: Alldredge & Gortchalk 1989 }
5: Syvitski et al 1995 } Depth
6: Guidi et al 2008 }

May explain changes in settling characteristics of marine snow
-other kind of marine snow may have similar changes (maybe in a lesser extend)

Density and weight





Decrease of total weight

-Rapid decrease during the first hour (10 - 60% of mass loss)

-Slower decrease afterward (bacterial degradation?)

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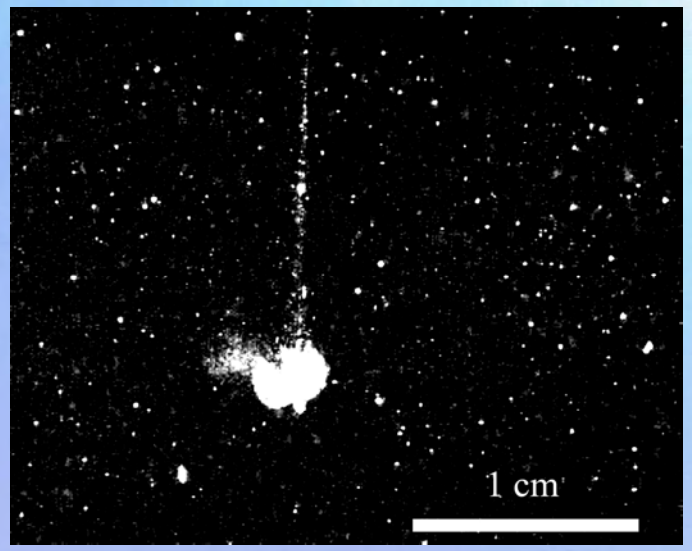
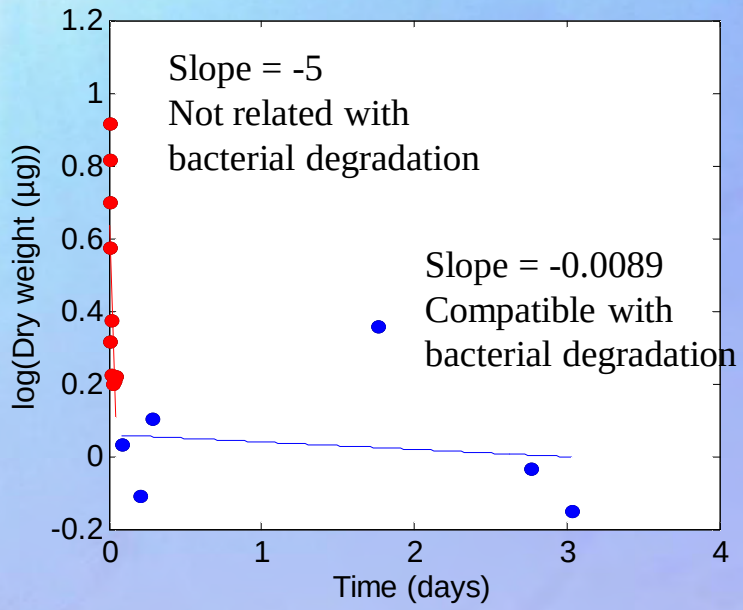
Density and weight





Decrease of total weight

-Rapid decrease during the first hour (10 - 60% of mass loss)

-Slower decrease afterward (bacterial degradation?)

During the first hour, deflation process is so intense (65% diameter loss; 92% volume) that the house leaks some of it particle contents

⇨ Plume of particles (observed in 7 case over 9 observations)

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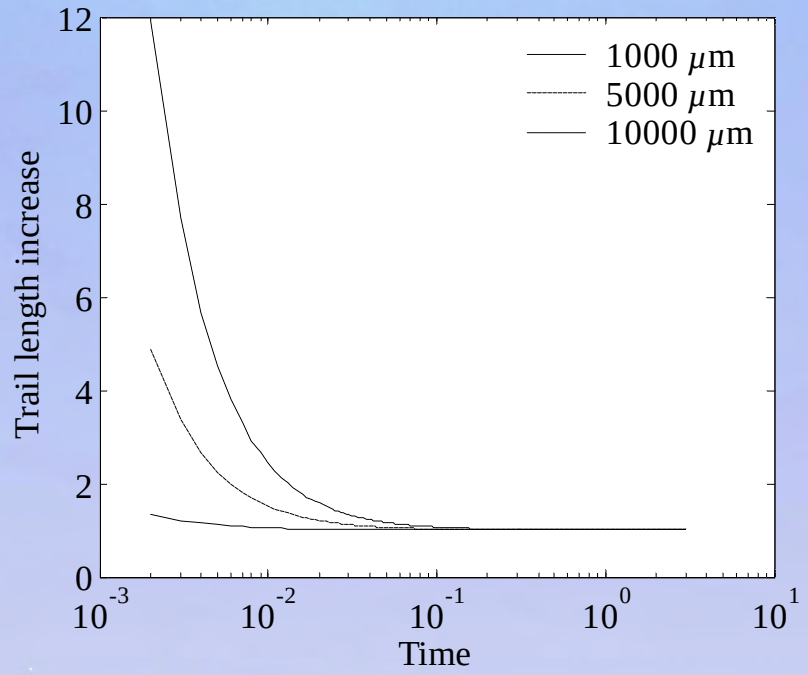
Potential consequences of deflation

-Decrease weight : Decrease the carbon export
-Increased chemical trail length and concentration left by the aggregate when settling (compared to particles that not deflate)
-Additional particles in the trail
⇨Easier localization by detritivoreous organisms
⇨increased patchiness in water column



(Houses initial size)

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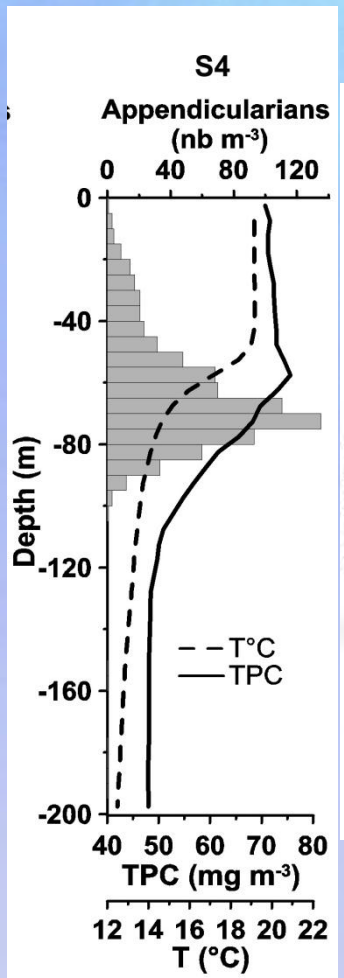
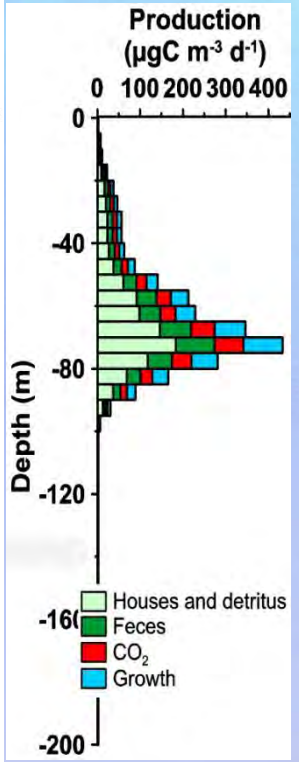
Video *in situ* data

UVP data

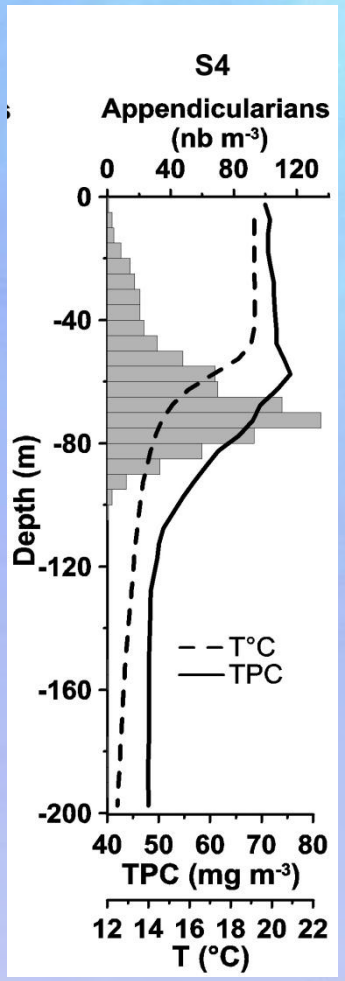
Production rates (using a model Lombard et al 2009)

What happens to houses once produced ?





Video *in situ* data



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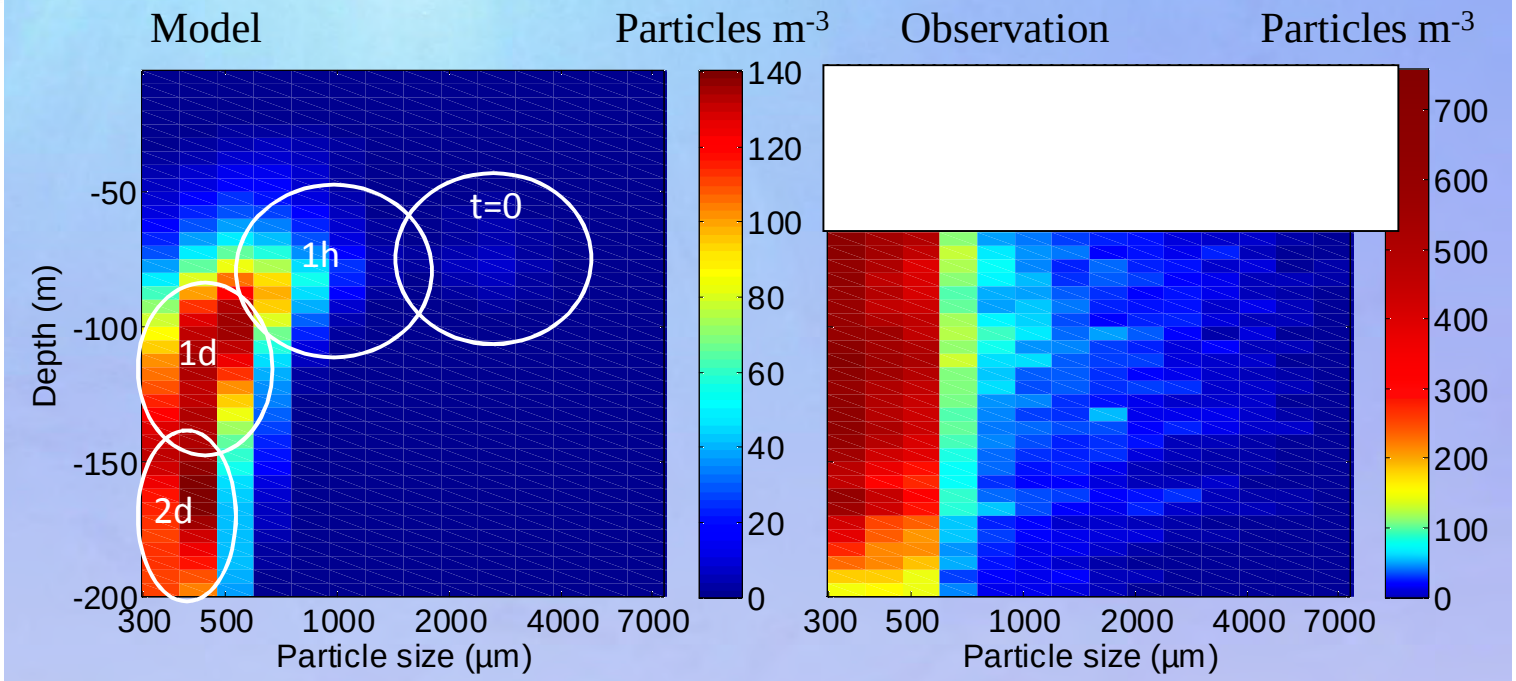
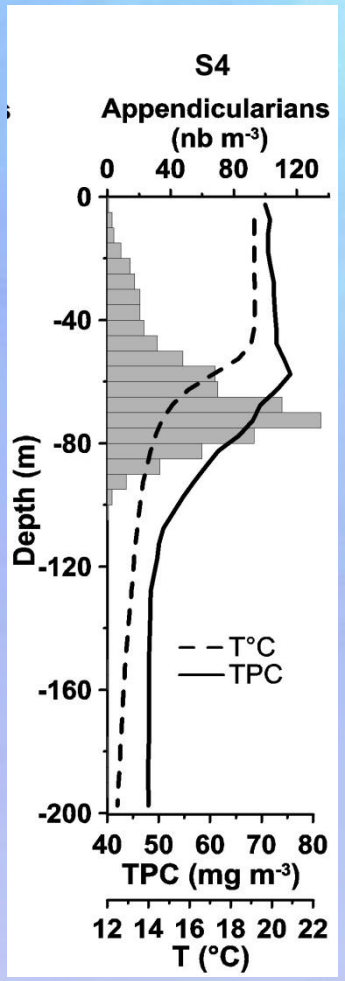


up to 20-40% of 300-500 µm particles in the 100-200m depths may be of appendicularian origin

Video *in situ* data



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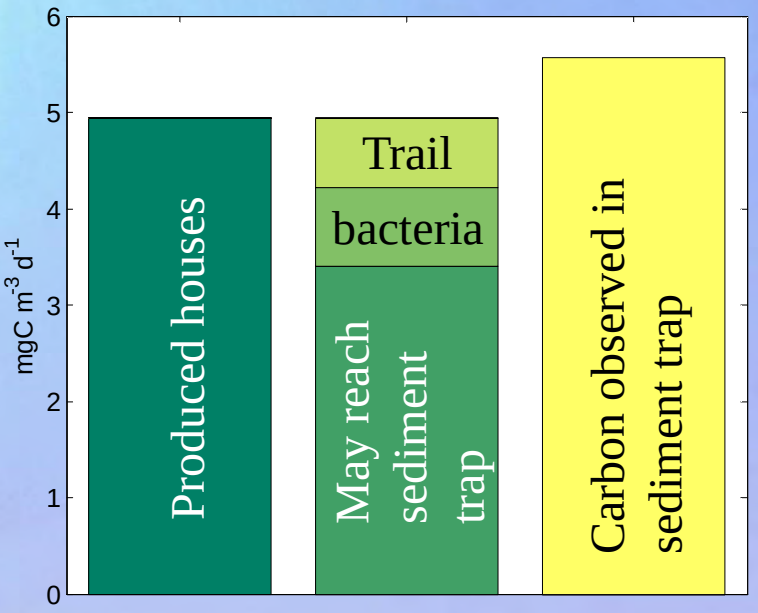

14 % is lost in particles trail during the first hour
16 % is consumed by bacteria before leaving the upper 200 m

Need to estimate:

Zooplankton action
What happens to fecal pellets
Other mesopelagic processes

Conclusions

- Appendicularians houses deflates after discarding
  - Rapid process (1 hour: 92% loss in volume)
  - Decrease of size, increase of density and sinking velocity
  - Other kind of marine snow may experience similar changes (~~deflation,~~ compression)

- Loss of weight
  - Due to deflating process, the house loss a large amount of it particle contents
    - 20-60% loss in mass within one hour
    - Only during the first hour
  - Decrease significantly the carbon vertical transport due to appendicularians
  - Increase the chemical signal left by house: increased colonization by detritivorous organismsé . Increase the degradation rate

- Need to be considered in future
  - marine snow modeling studies
  - estimations of appendicularians contribution to the vertical flux

Thanks for your attention

Many thanks to:
J-M Bouquet, E. Thompson, M. Koski, E. Selander, T. Kiørboe