Marine snow originating from appendicularians:

Age-changes in houses settling characteristics

Fabien Lombard & Thomas Kiørboe
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
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?
Methodology

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

Lombard & Kiørboe (2010) DSR I
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: "Balloon effect"

\[
d(t) = d(t_0) 0.188 t^{-0.235} \quad r^2 = 0.86
\]

Lombard & Kiørboe (2010) DSR I
Deflation / compression process

Balloon effect
Deflation / compression process

Balloon effect
Deflation / compression process

Balloon effect

Compression effect
Age effect on Sed. rate

- Lombard & Kiørboe (2010) DSR I
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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Theory: large particles sediment faster than small ones
True within a similar age interval

Lombard & Kiørboe (2010) DSR I
In all cases within 2 days of observations:
- 2 order of magnitude decrease in volume
- Sedimentation rate increase x 2-3

Theory: large particles sediment faster than small ones
True within a similar age interval
Not true if age is not taken in account
In all cases within 2 days of observations:
- 2 order of magnitude decrease in volume
- Sedimentation rate increase x 2-3

May explain changes in settling characteristics of marine snow
- other kind of marine snow may have similar changes (maybe in a lesser extend)
Decrease of total weight
- Rapid decrease during the first hour (10 - 60% of mass loss)
- Slower decrease afterward (bacterial degradation?)
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 its particle contents
⇒ Plume of particles (observed in 7 case over 9 observations)

Lombard & Kjørboe (2010) DSR I
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 do not deflate)
- Additional particles in the trail
  ⇨ Easier localization by detritivoreous organisms
  ⇨ Increased patchiness in water column

\[ \text{Trail length increase} \]

\[ \begin{align*}
1000 \, \mu m \\
5000 \, \mu m \\
10000 \, \mu m
\end{align*} \]

(Houses initial size)

Lombard & Kjørboe (2010) DSR I
Video \textit{in situ} data

UVP data

Production rates
(using a model Lombard et al 2009)

What happens to houses once produced?
up to 20-40% of 300-500 μm particles in the 100-200m depths may be of appendicularian origin
Video *in situ* data

What happens to houses once produced?

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 its 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 organisms. 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

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