A 1 D Size-resolved Model of Particle Dynamics below the Mixed Layer.

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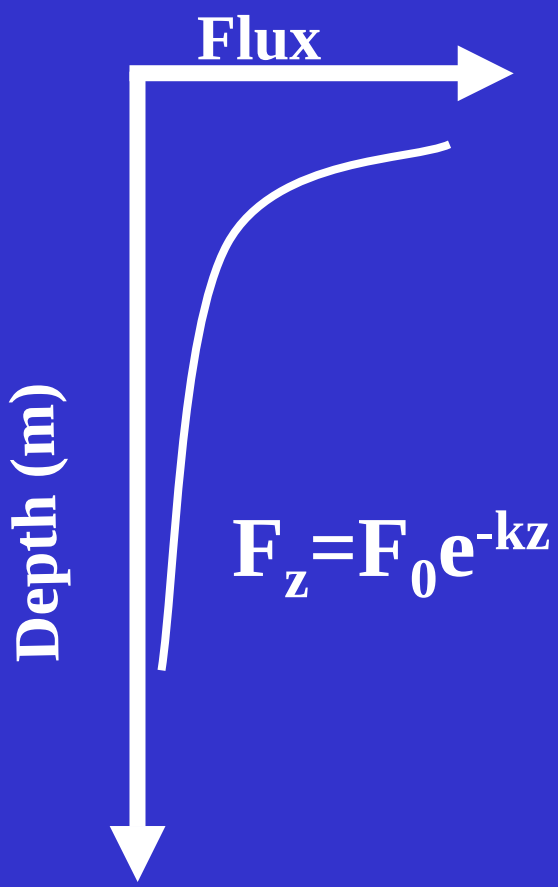
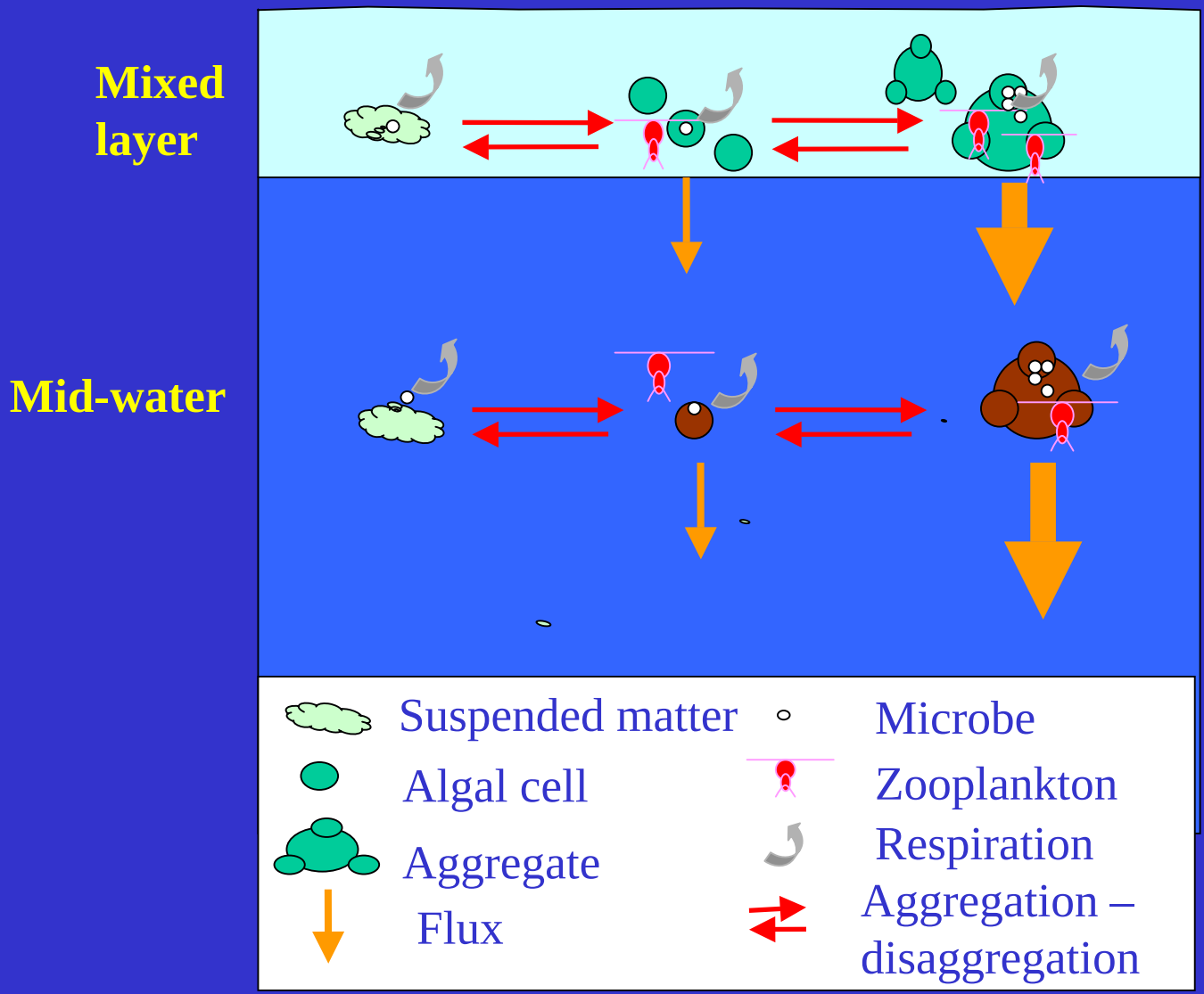
Classical way to model the vertical flux



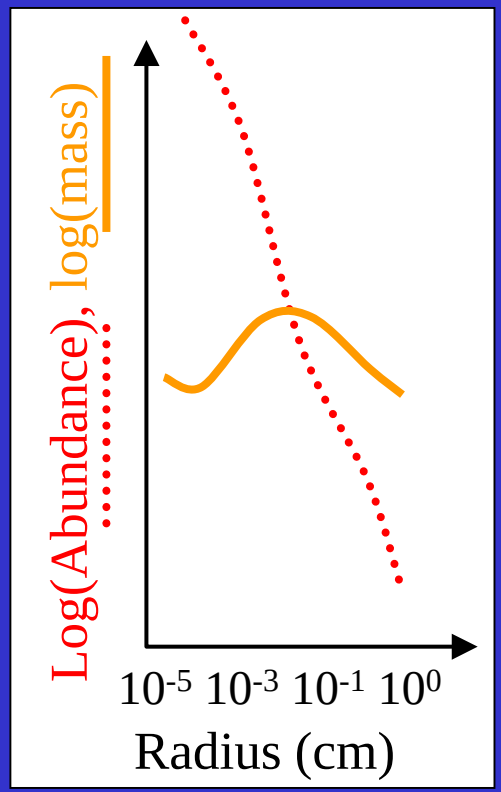
Role of particles in the ocean

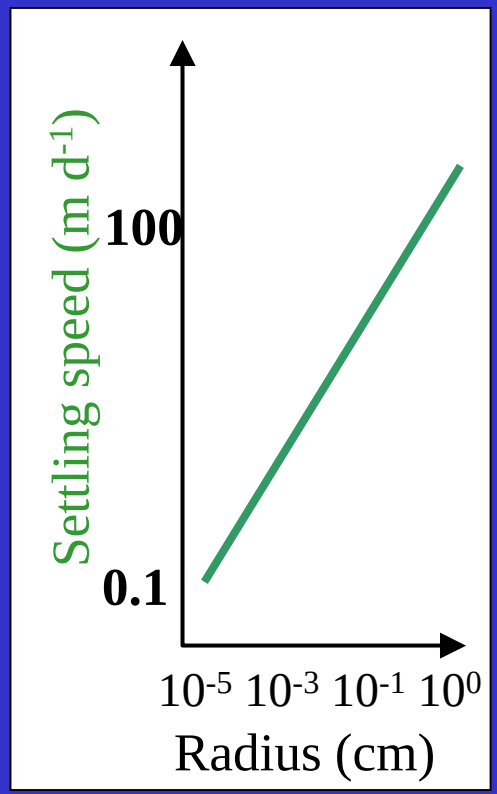


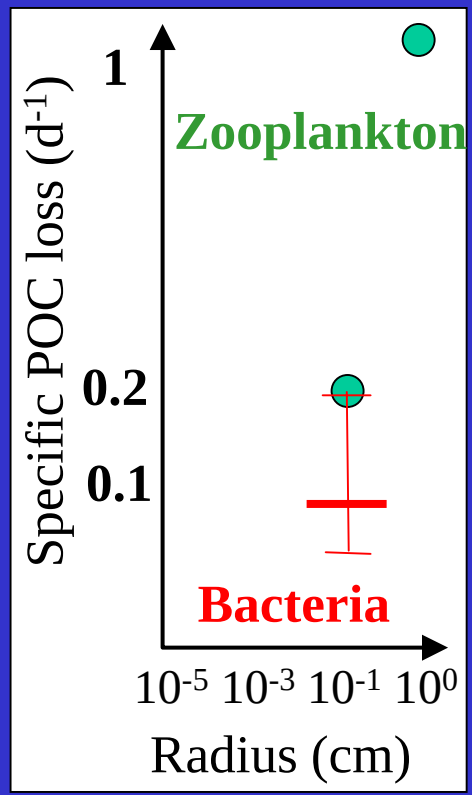
Questions and approach

- Questions
  - ✓Do we know enough about rates and processes to predict particle size distribution?
  - ✓Can we predict the vertical flux knowing the size spectra and the mechanisms?
- Approach
  - ✓ Model particle dynamics and organism interactions.
  - ✓ Compare results to observed particle size spectra in mid water.

Particle properties







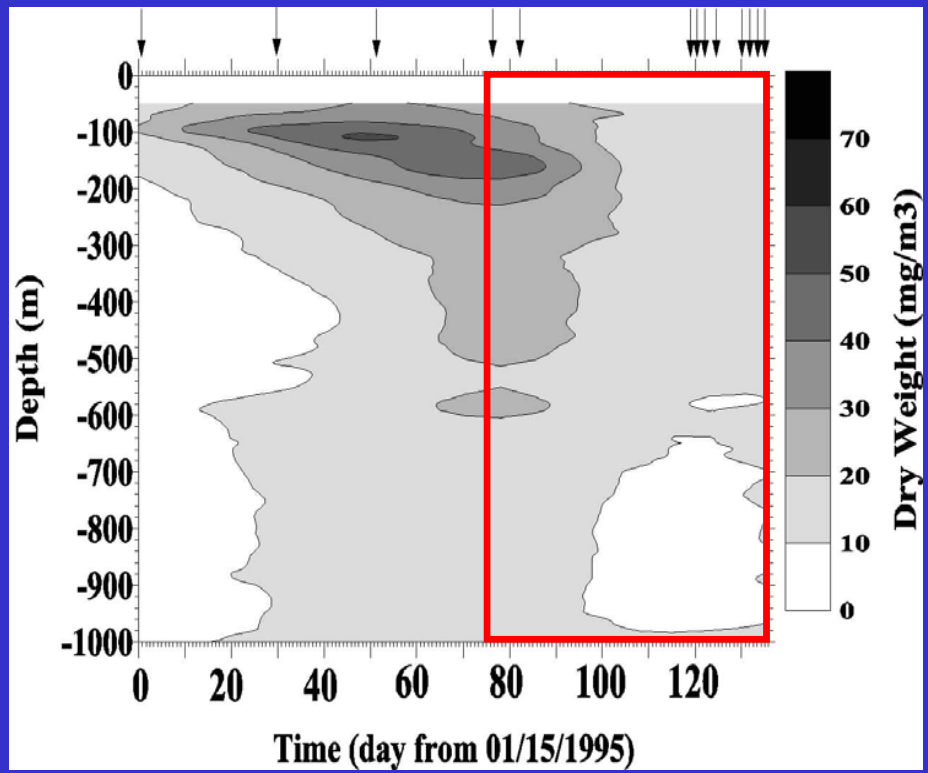
- Number and Mass distribution are a function of size.
- Settling speed is a function of size.
- Bacterial and zooplankton activity may also be a function of size.

The model(s)

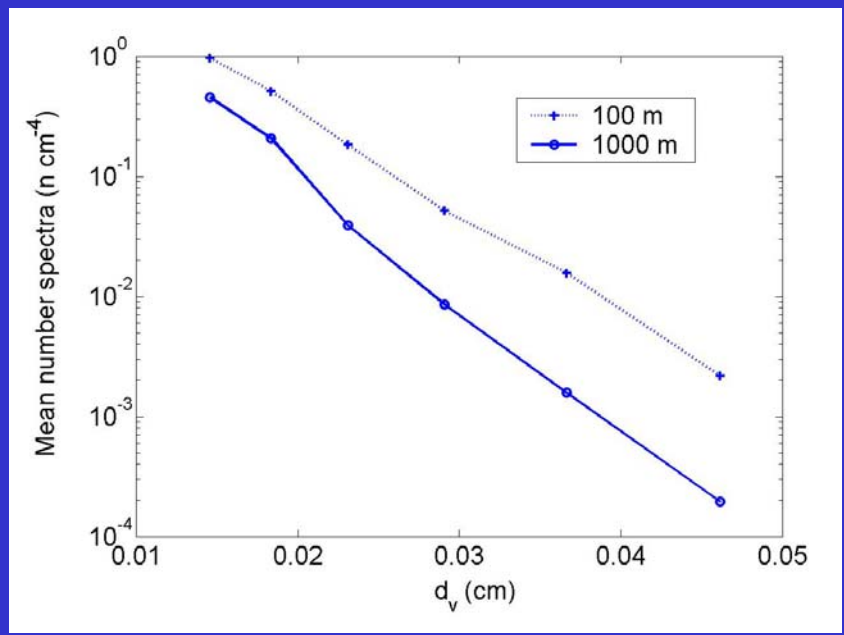
- 5 different size dependent functions for
  - ✓**Settling**
  - ✓**Coagulation (**shear, differential settling)
  - ✓ **Bacteria** (respiration, shrinking)
  - ✓ **Zooplankton flux feeding** (respiration and particle break up)
  - ✓**Zooplankton filter feeding** (respiration and particle break up)
- 7 different models using different combinations of the functions
- Predict the size distribution with time and depth (100-1000 m).

Data

- JGOFS time series station (microbe, zooplankton and phytoplankton distribution, vertical flux).
- The Underwater Video Profiler, size resolution 0.15 – few mm.

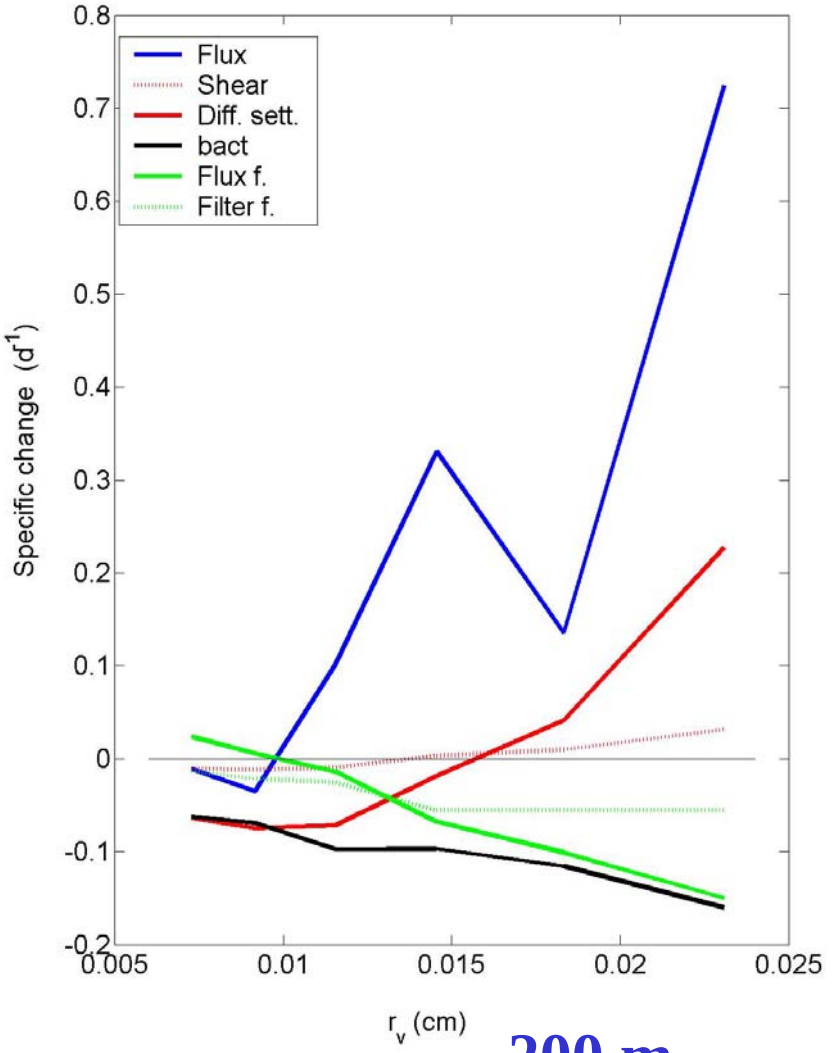


Spatial and temporal mass distribution

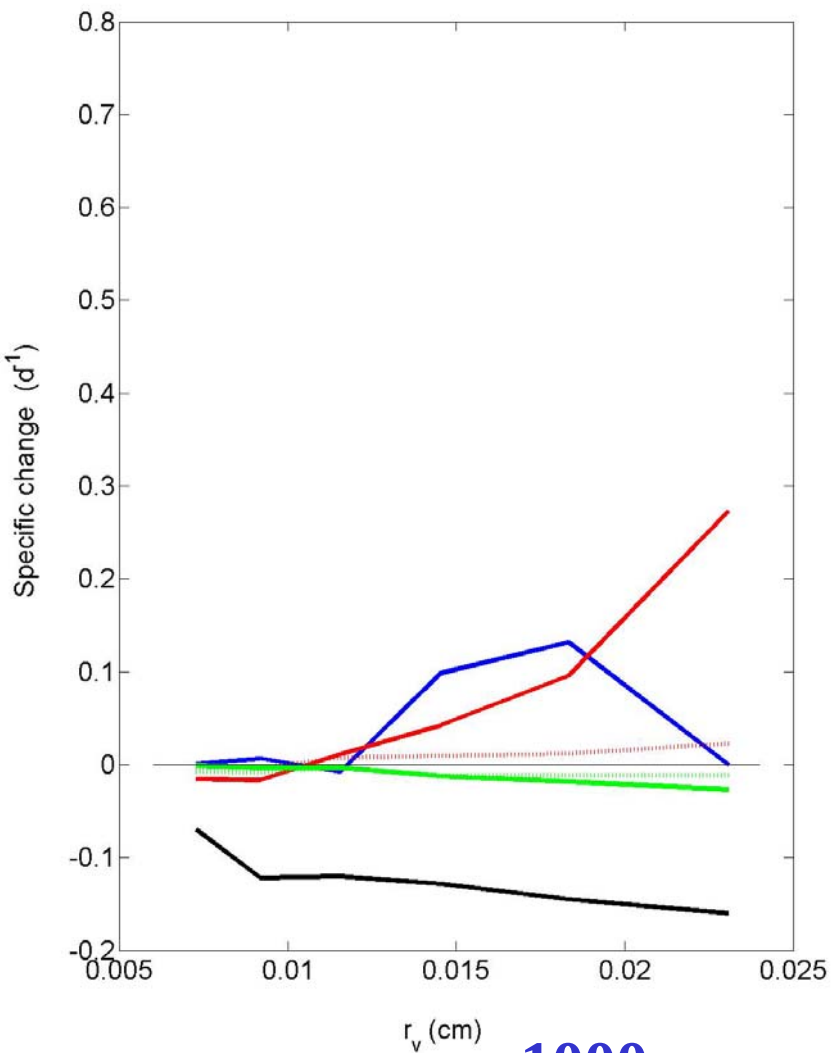


Mean number spectra

Specific rate of mass change (model)

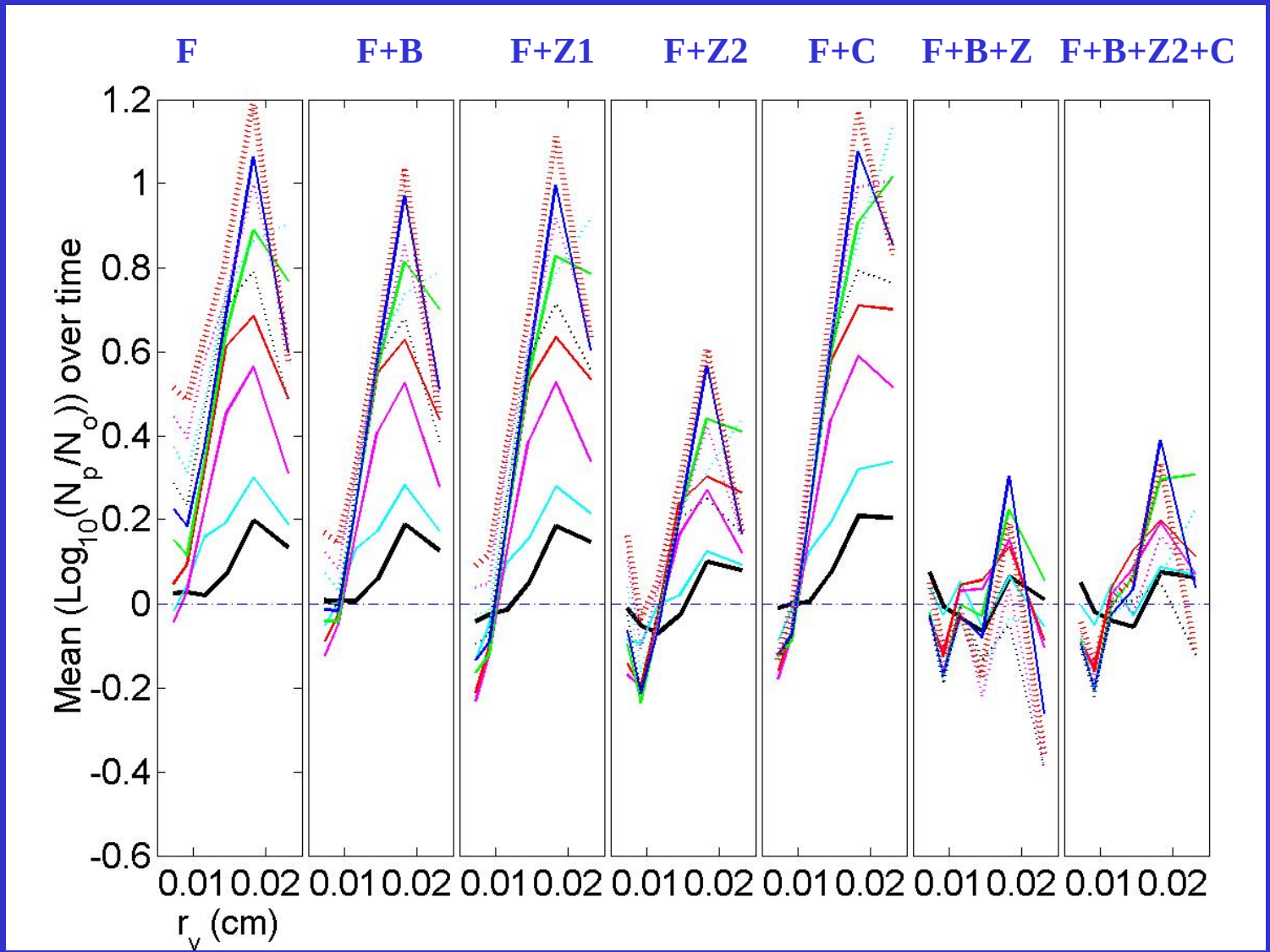


200 m

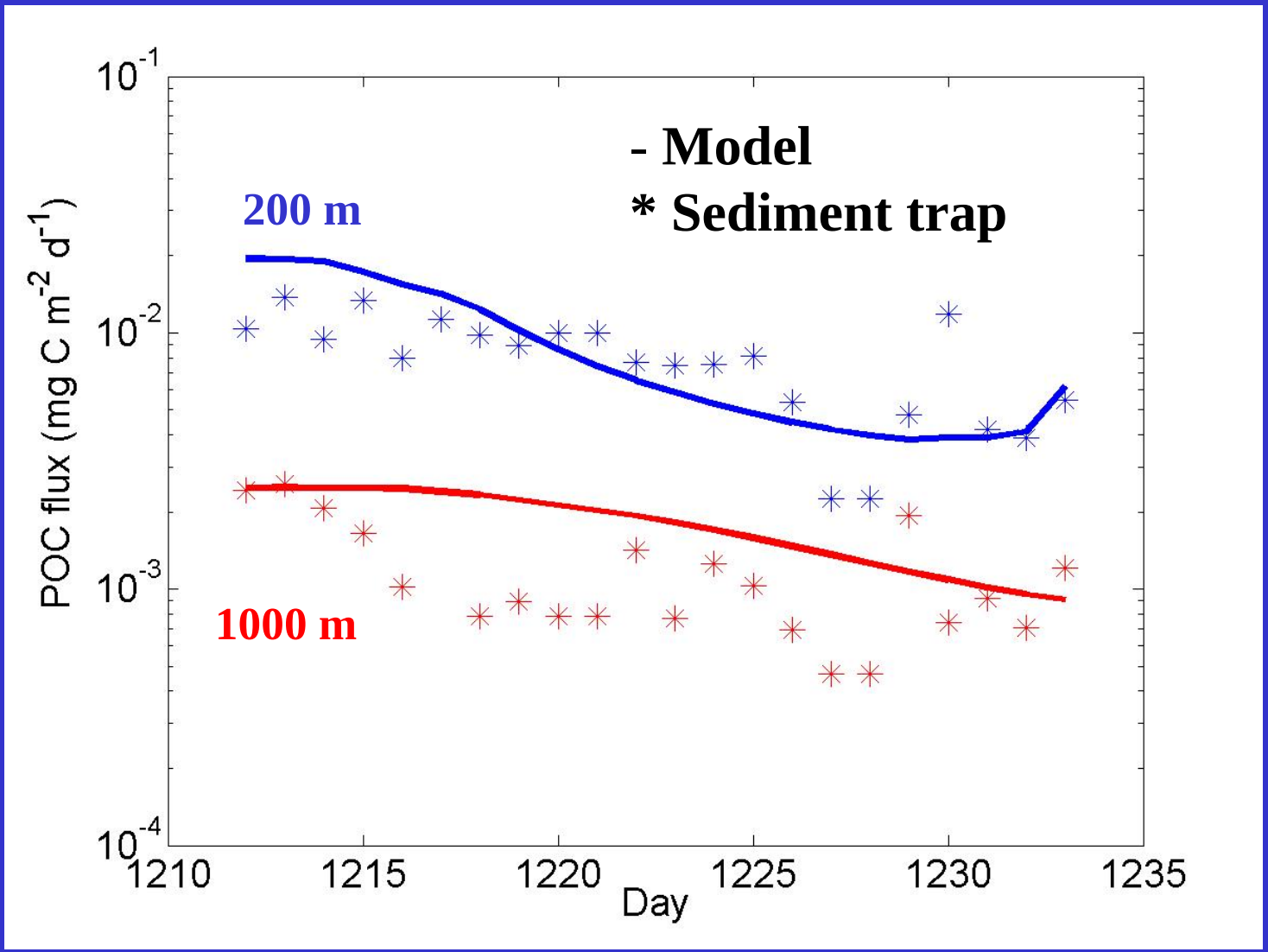


1000 m

Comparison with measured size spectra



Comparison with sediment trap flux



Conclusions

- The mid water is not a ‘black box’.
- The calculated zooplankton and bacterial patterns are consistent with observed particle distribution and flux.
- Predicted fluxes are in agreement with measured ones.
- The important process was consumption and break up of large particles (flux feeding).

Future work

- need for better data on particle properties and chemical contents in the mid-water.
- need for information on particle break up by zooplankton and bacteria.

Equations

$$\frac{\partial n(m)}{\partial t} = -w(m)\frac{\partial n(m)}{\partial z}$$ } Settling

$$+ 0.5\alpha \int_0^m \beta(m_1, m - m_1) n(m1) n(m - m_1) dm_1$$

$$- n(m)\alpha \int_0^\infty \beta(m, m_1) n(m_1) dm_1$$ } Coagulation

$$+ b \; m \frac{\partial n}{\partial m}$$ } Bacteria

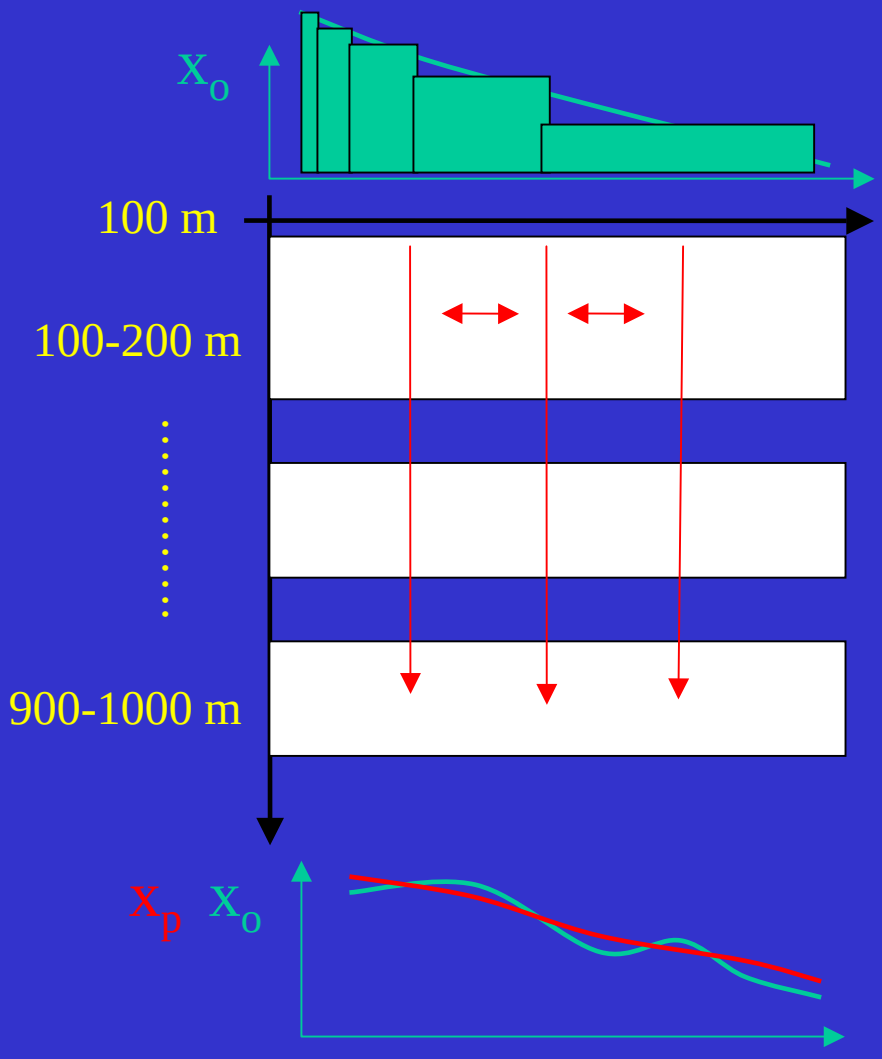
$$- N \; c \; n(m)$$ + redistribution } Filter feeder

$$- N\pi(ar)^2 w(m) n(m)$$ + redistribution } Flux feeder

Standard parameters

- **Standard Parameters** (constant in time and depth)
  - ✓ Fractal dimension, $D_3 = 2.33$
  - ✓ Excess density = 0.04 g m^{-3}
  - ✓ Initial particle diameter, $d_0 = 5$ μm
  - ✓ Particle stickiness, $\alpha = 0.4$
  - ✓ Filtration rate $c = 25 * 10^{-5}$ and $25 * 10^{-3}$ m^3 d^{-1} for meso and macrozooplankton.
  - ✓ Detection radius, r_1 and r_2 = 1 and 20 mm for meso and macrozooplankton.
  - ✓ Bacterial respiration rate, $b = 0.08$ d^{-1}

Model implementation



- Calculate sectional size spectra
- Force the model at 100 m with an observed particle spectra.
- Calculate the predicted spectra from 100 to 1000 m.
- Compare the predicted and observed abundance by the ratio = $\mathrm{Log}_{10}(x_p / x_o)$