- Monday, 14 November 2011 - Thursday, 17 November 2011
  3rd GEOTRACES Data-Model Synergy Workshop - GEOTRACES Meetings and Workshops

Observing particles in situ using optical cameras

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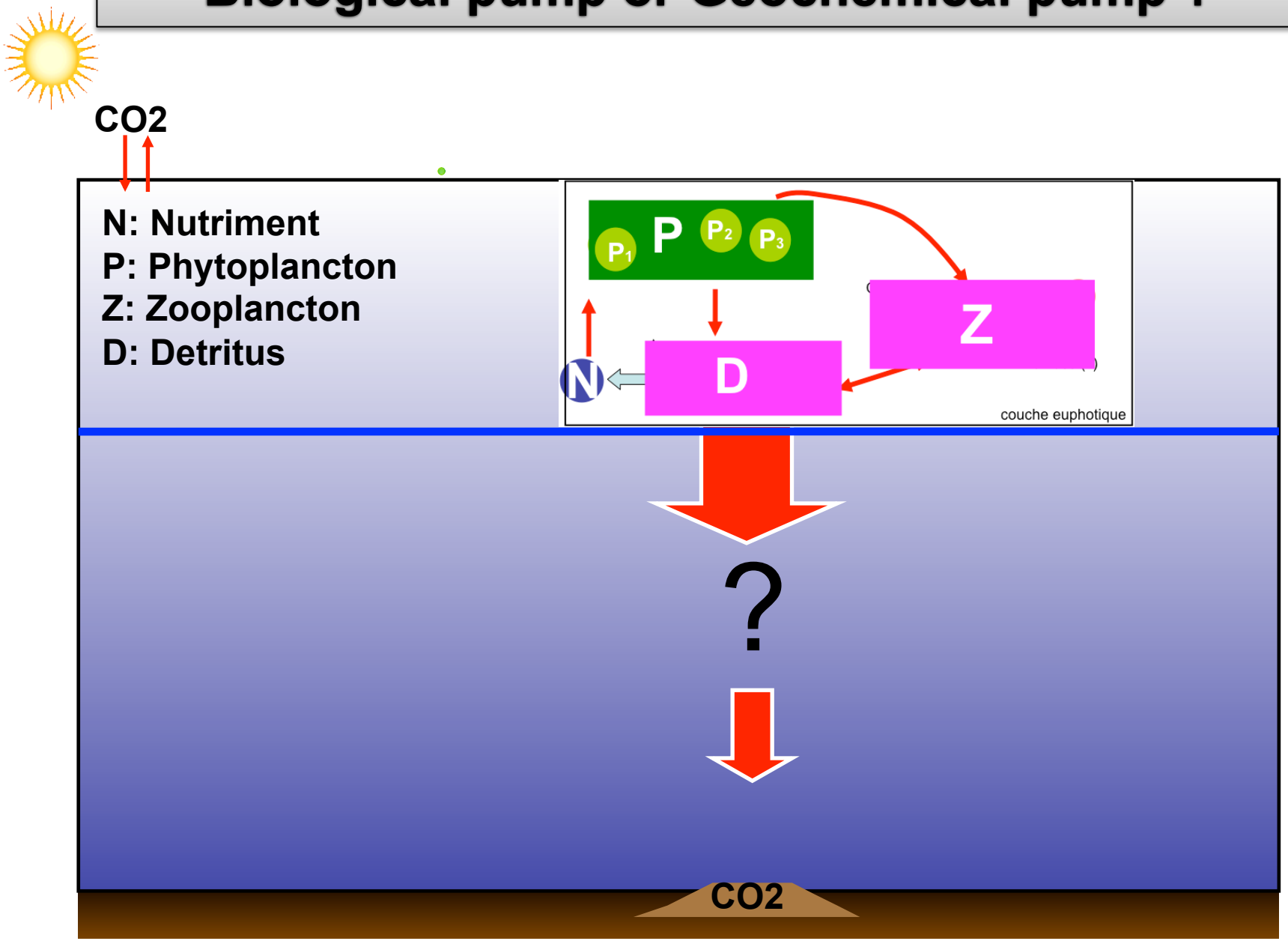
Biological pump or Geochemical pump ?



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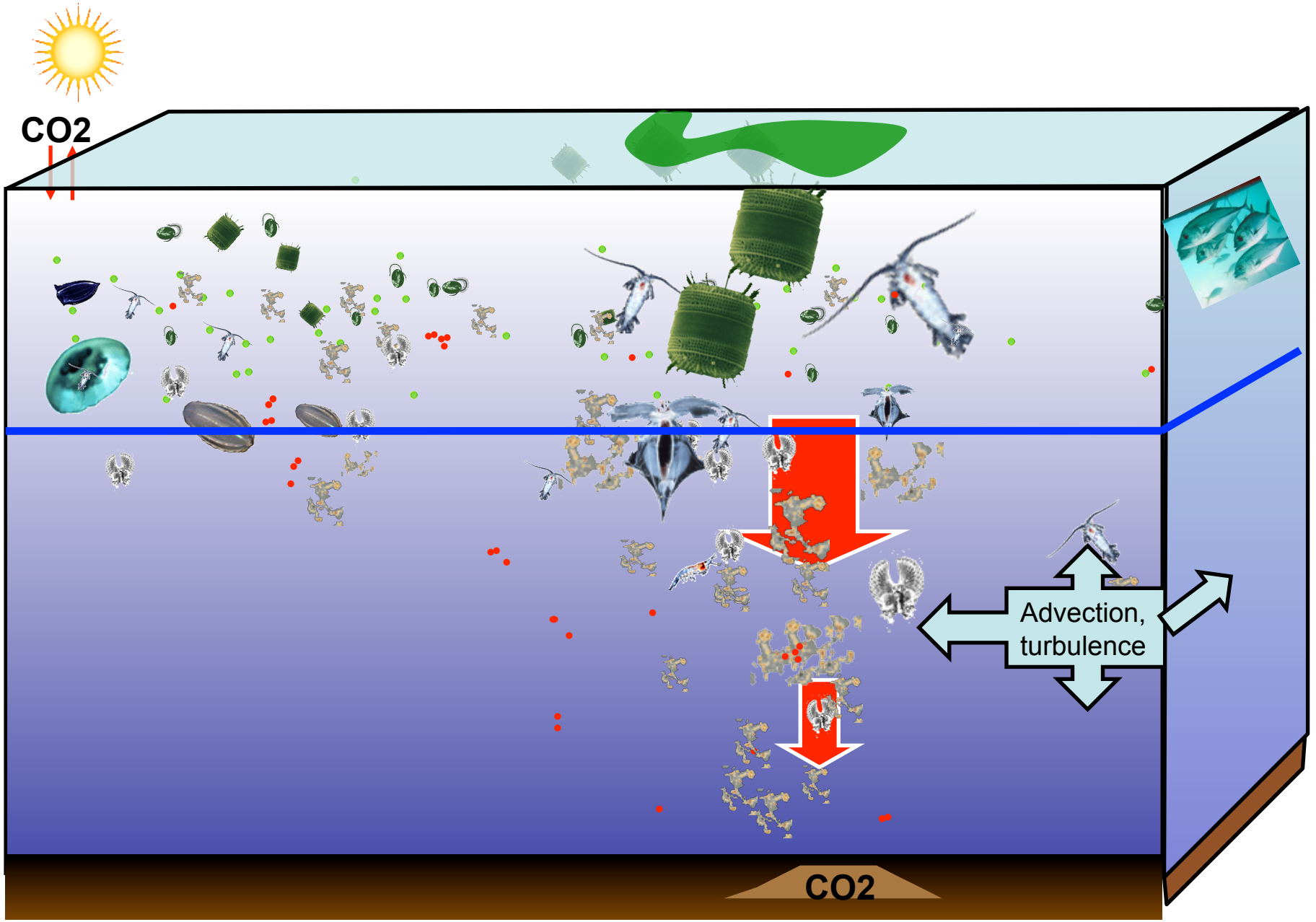

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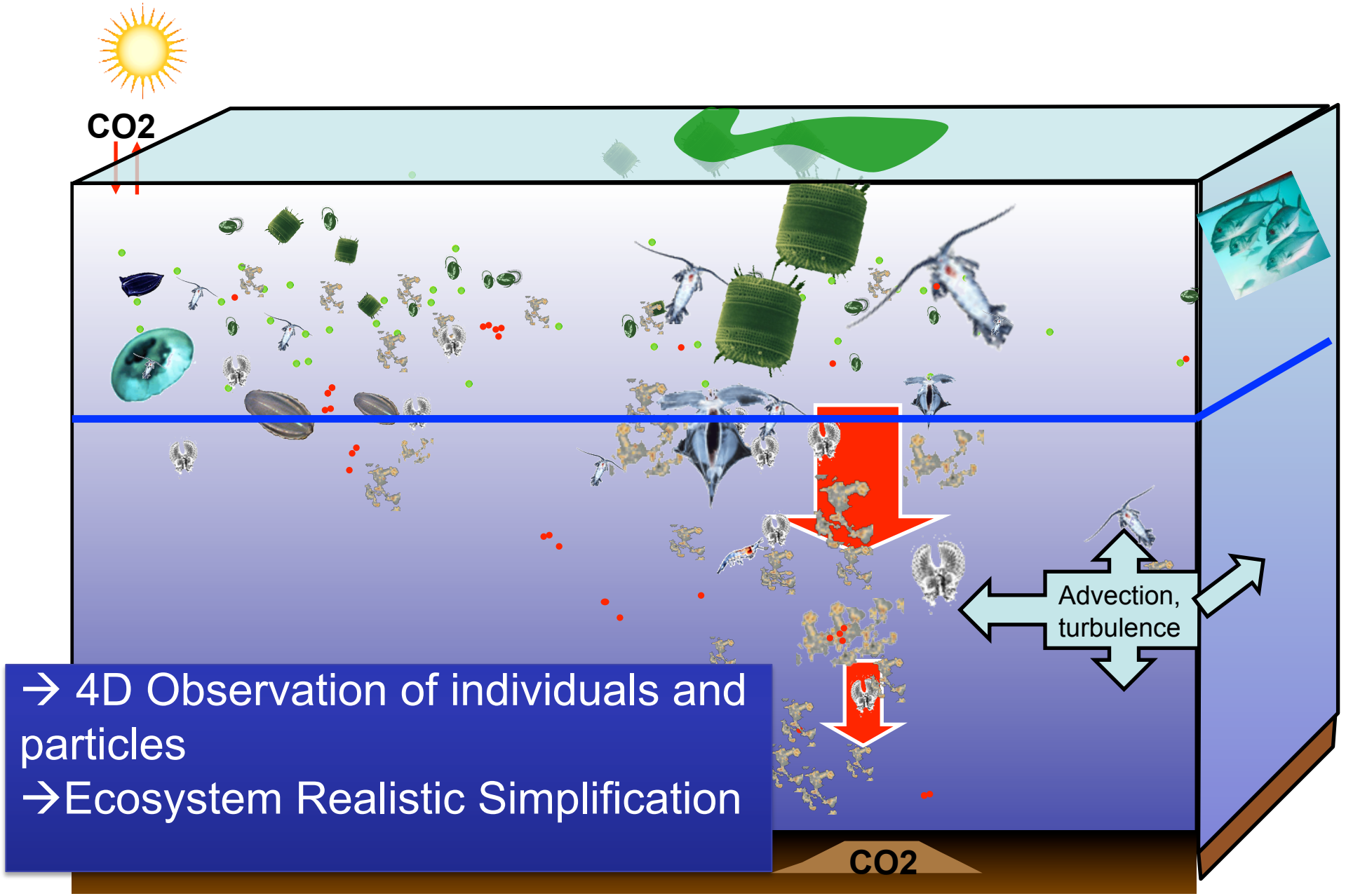
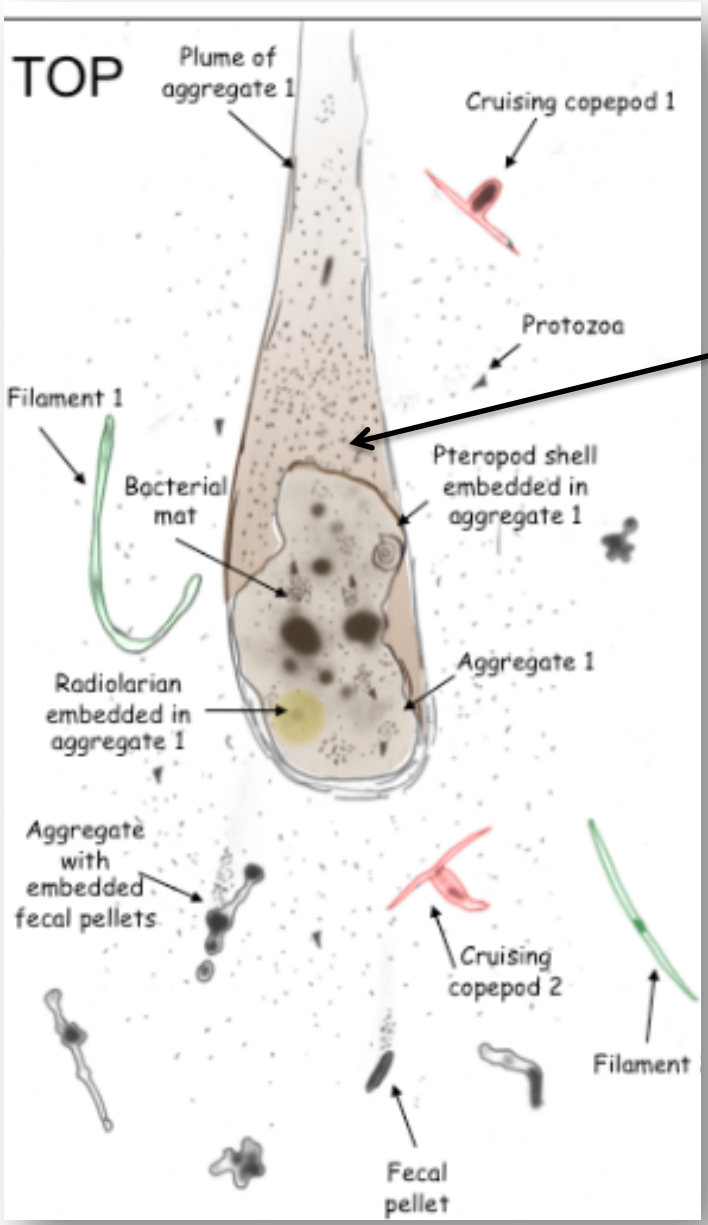


→ 4D Observation of individuals and particles

→Ecosystem Realistic Simplification

Particles in the sea, what are they ?



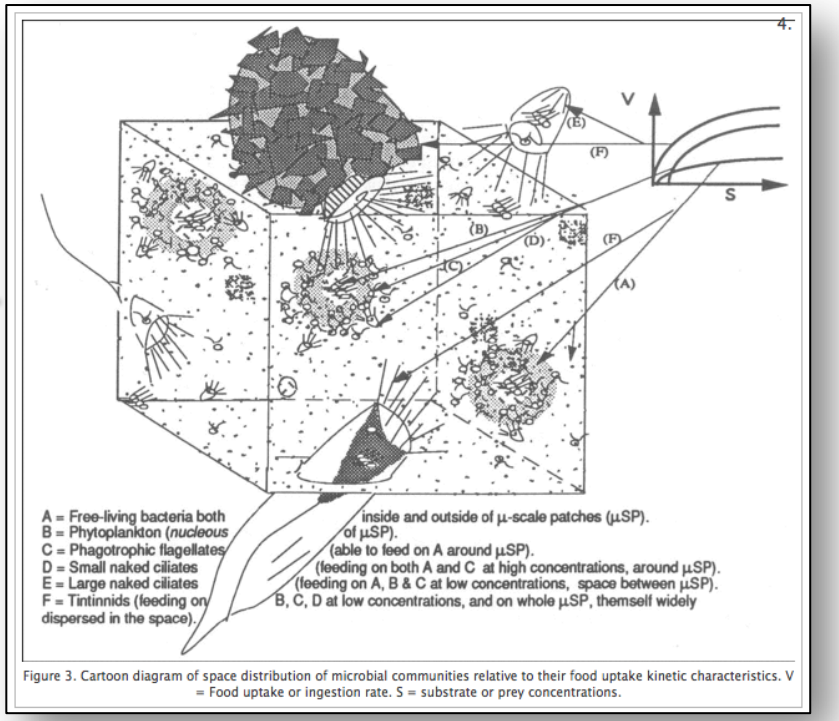


Figure 3. Cartoon diagram of space distribution of microbial communities relative to their food uptake kinetic characteristics. V = Food uptake or ingestion rate. S = substrate or prey concentrations.

Rassoulzadegan, 2010

Living particles (plankton)
Dead particles

Stemmann and Boss, 2012

Large Particles in the sea, why they sink ?

Organic matter
(fresh, refractory)

Porewater

Quartz

$CaCO_3$

Clay

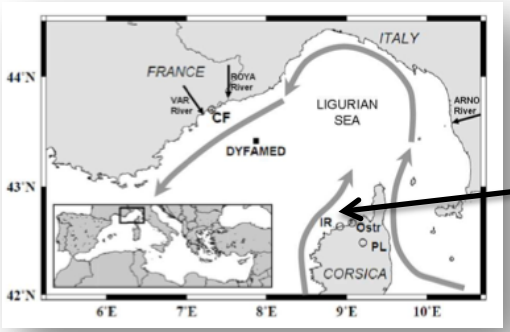
Sarmiento & Gruber 2006

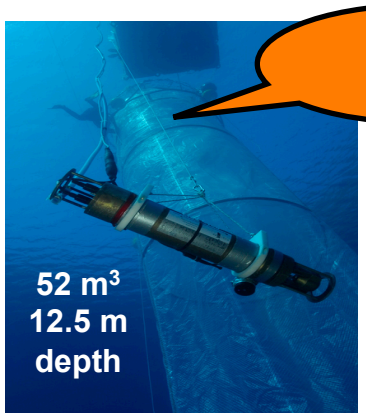
Shape
Size

Colonization
by organisms

$$W = (1 - P)\frac{2}{9}\frac{gr^2(\Delta\rho)}{\mu},$$

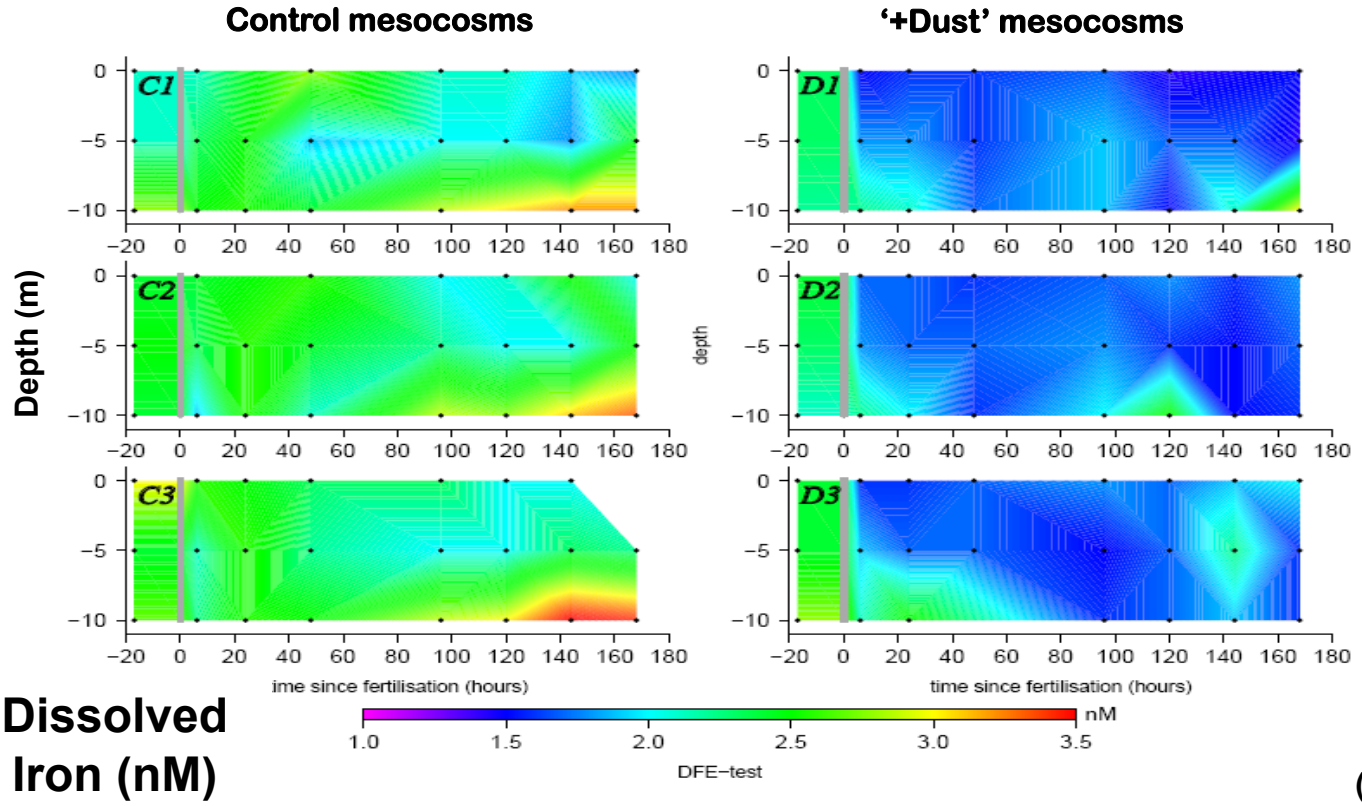
Particles in the sea interact with TEIs ?





Mesocosm exp. (DUNE project)

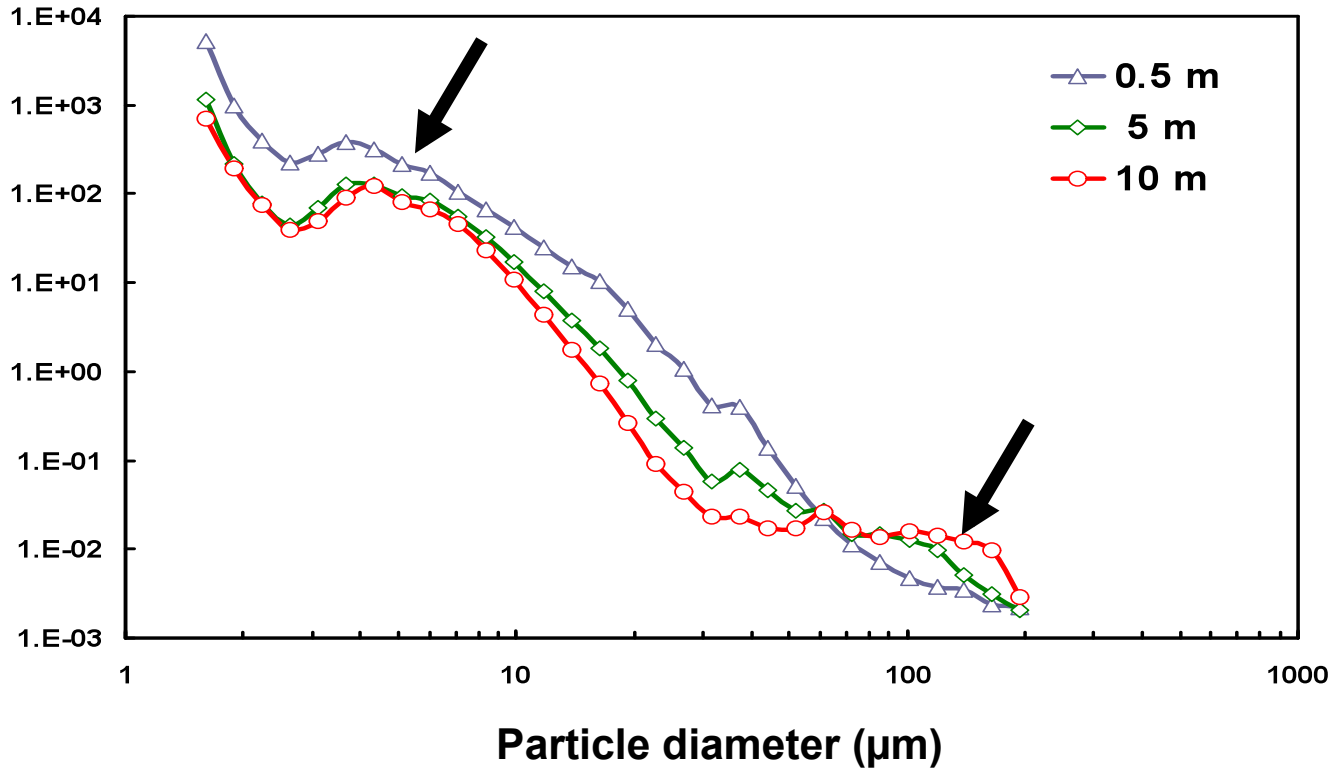
→ **NATURAL ASSEMBLAGE**



Dissolved Iron (nM)

(Wagener et al., 2010)

Results from DUNE mesocosm exp.: evidence of aggregates formation



Higher proportion of particles <60 µm in subsurface (or beginning of the experiment)
Increase of particles >60 µm with depth (or time)

→ Formation of organic-mineral aggregates

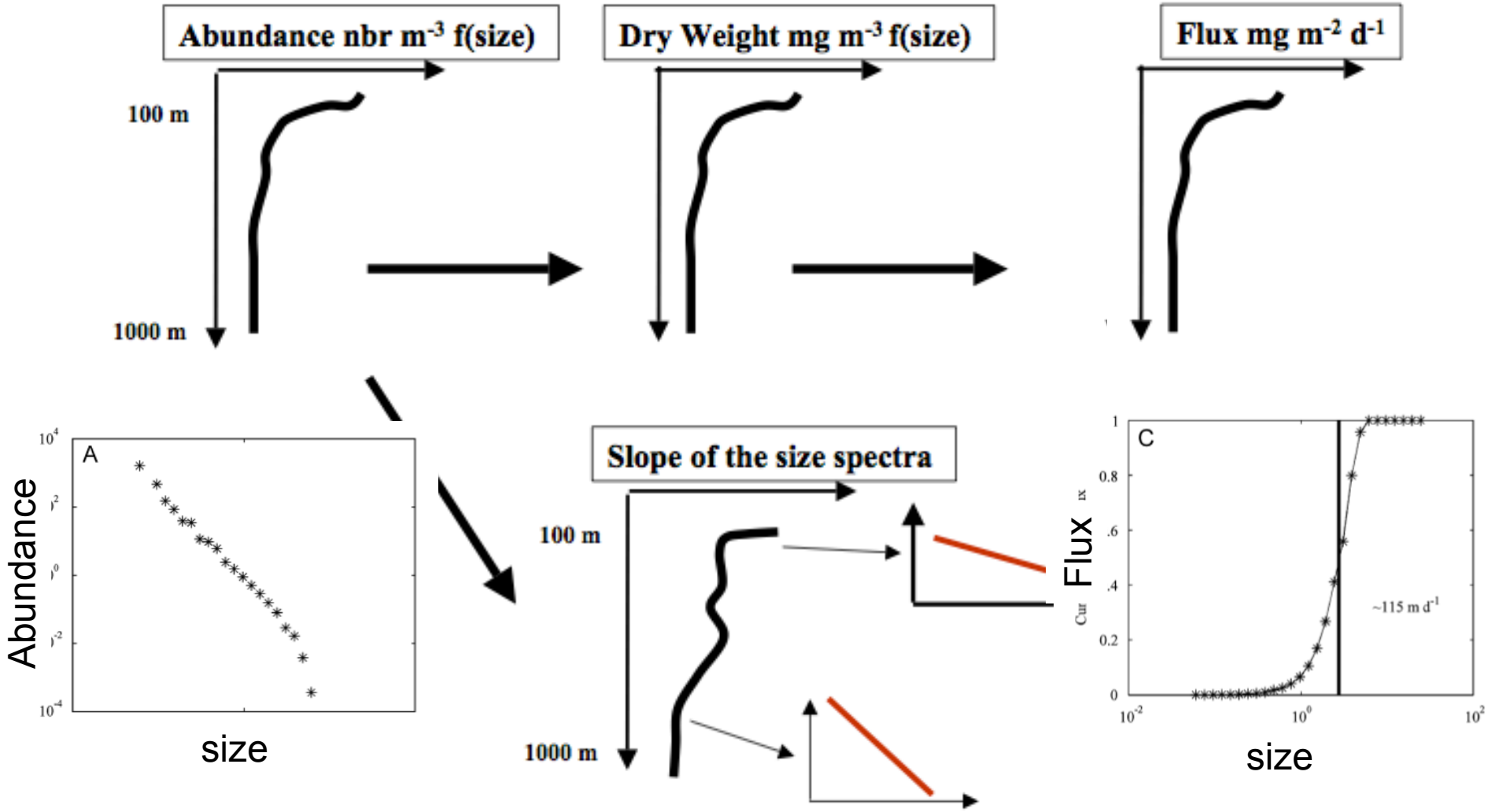
(Bressac et al., accepted)

How to detect, identify and measure particles and organisms size spectra?

Non exhaustive review of instruments sizing particles used in marine systems

System	Where	Technology	Size-spectra	Reference
Flow Cam	Lab (future in situ)	Camera	10 – 1000 µm	Sieracki et al. 1998
HIAC	Lab	Light extinction	1.3 – 600 µm	Stemmann et al. 2008
LISST	Lab/in situ	Laser	1.25 – 500 µm	Karp-Boss et al. 2007
LOPC	lab/in situ	Laser beams	100 – 3000	Herman et al. 2004
HoloMar	in situ	Holography	5 – 250 µm	Katz et al. 1999
SIPPER	in situ	Linescan-Camera	>100 µm	Samson et al. 2001
UVP	in situ	Camera CCD	100 – few cm	Picheral et al. 2010
Par Cam	in situ	Camera		Wefer and Ratmeyer, 1996; Iversen et al., 2001
VPR	in situ	Camera	100 – 1 cm	Davis et al. 1992
FlowCytomety	in situ	Laser and camera	1-100µm	Sosik

From profiles of abundance/size to profiles of flux

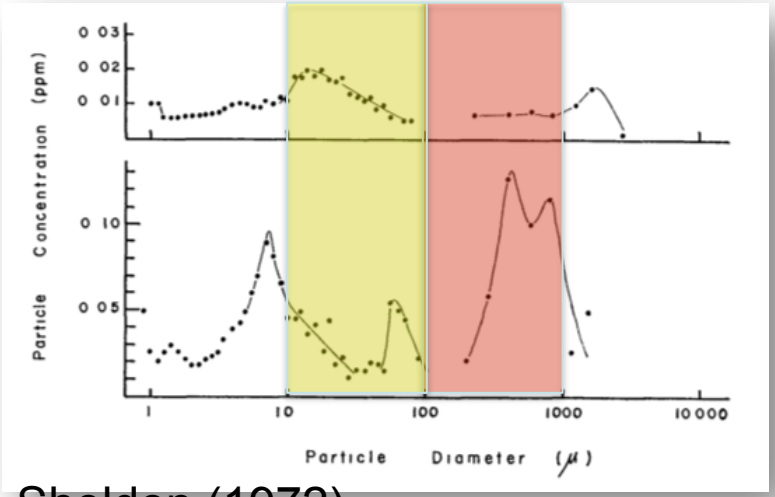


Guidi et al., 2008

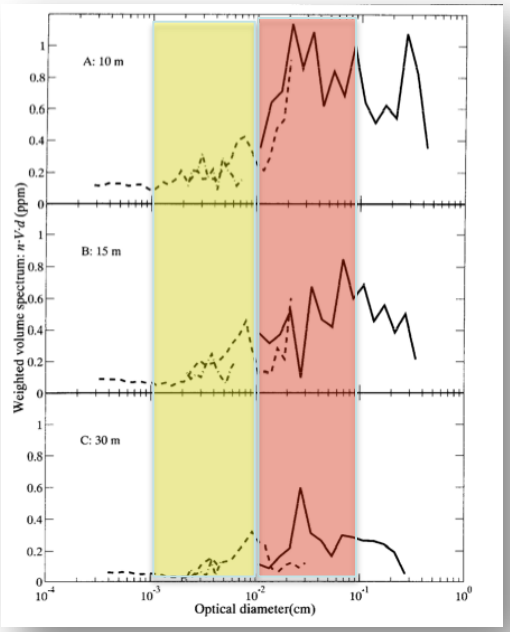
What processes change the size spectrum?

Can it be used to calculate other biogeochemical fluxes ?

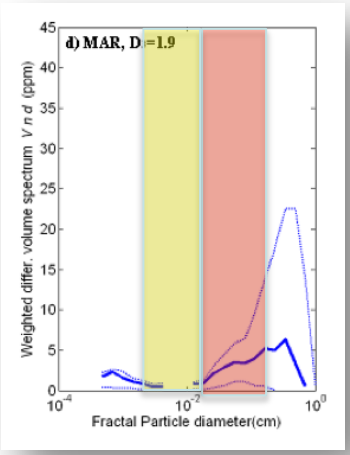
Where is the biomass or biovolume (from few µm to cm) ?

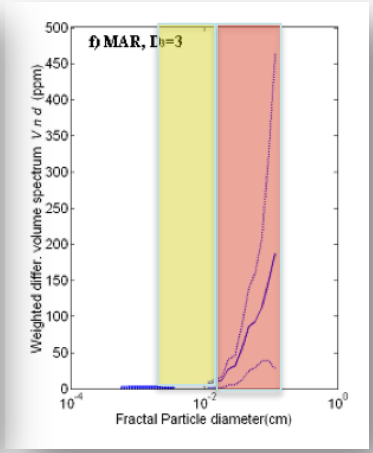


Sheldon (1972), coulter



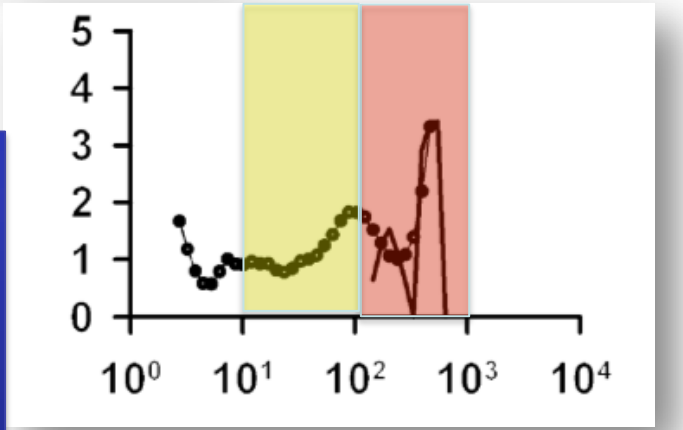
Jackson et al., 1997
several systems





Stemmann et al (2008), HIAC UVP

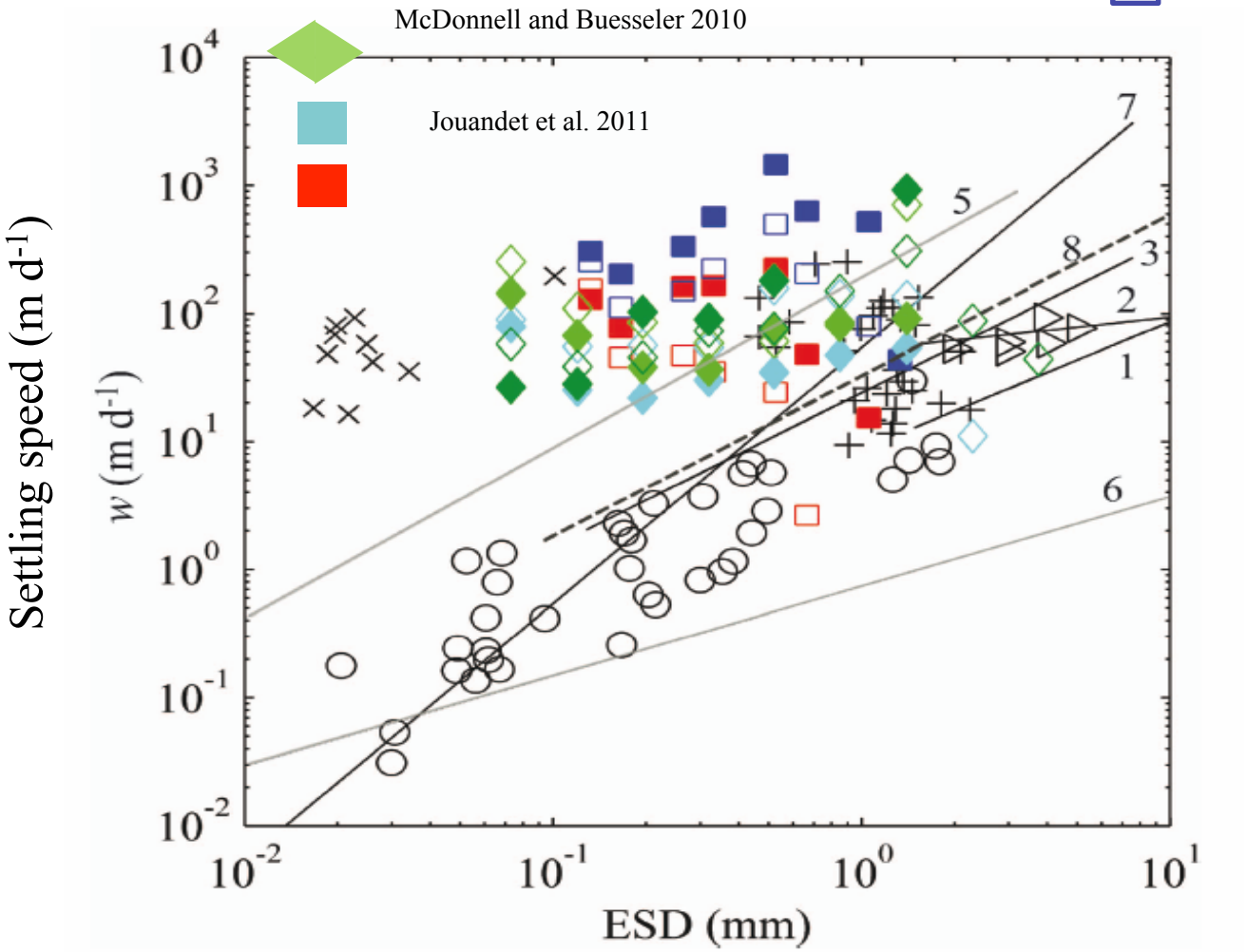
critical issue is converting size to volume (porosity ?) and then mass (density?)



Mikkelsen et al (2005)
LISST+DFC

The critical issue:
Size to Settling speed from the literature

$$F = C \times m \times v$$



Smayda (1970)

Shanks and Trent (1980)

Carder et al. (1982)

Azetsu Scott and Johnson (1992)

1—Diercks and Asper (1997)

2—Alldredge and Gotschalk (1988)

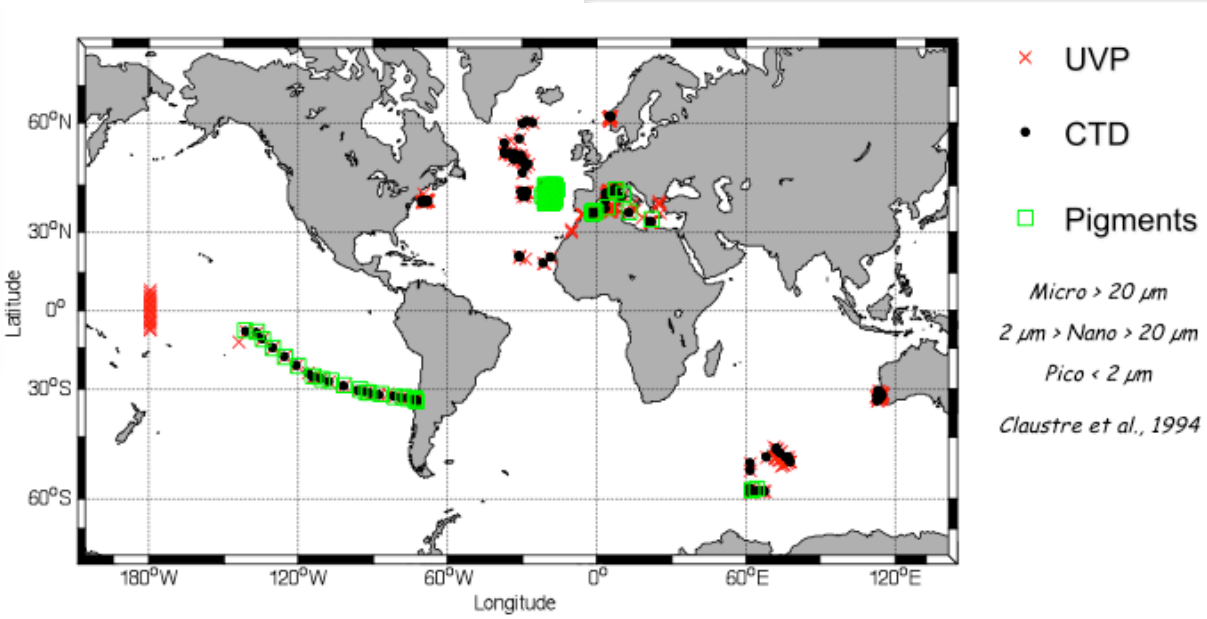
3—Alldredge and Gotschalk (1989)

4—Syvitski et al. (1995)

5/6—Stemmann et al. (2004)

7—Stokes law

Global patterns of particles size spectra



× UVP

• CTD

□ Pigments

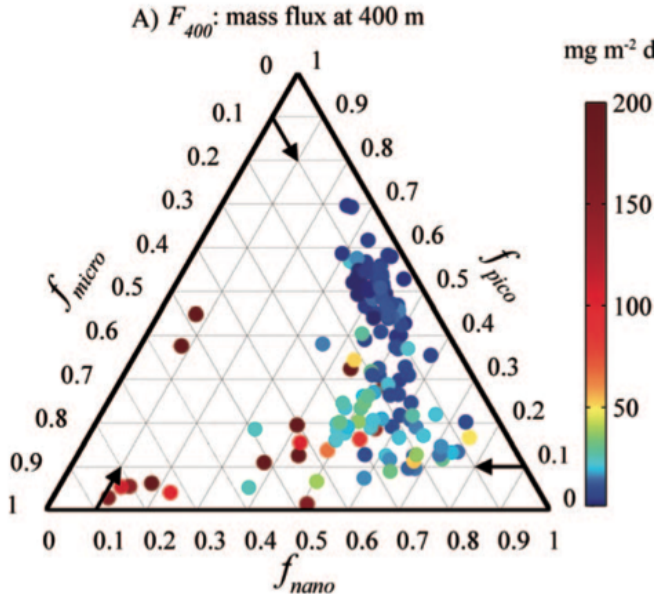
Micro > 20 µm

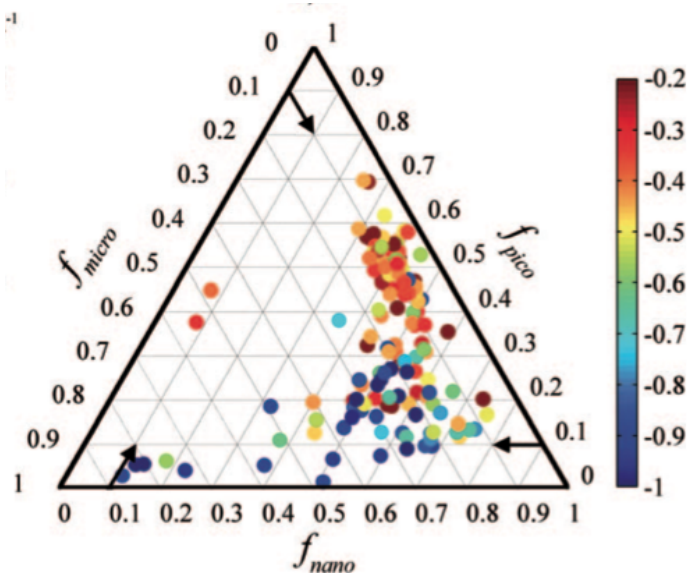
2 µm > Nano > 20 µm

Pico < 2 µm

Claustre et al., 1994

Guidi et al., 2009
UVP ESD >100µm
Upper 1000m, 400 profiles
- particle size decreases with depth
- particle size is set at the surface
- link between particle size and phyto. communities
- flux attenuation is greater in productive area





Vertical patterns of particle size spectra at regional scales

Coast/ocean interactions

McCave et al., 2001, North Atlantic

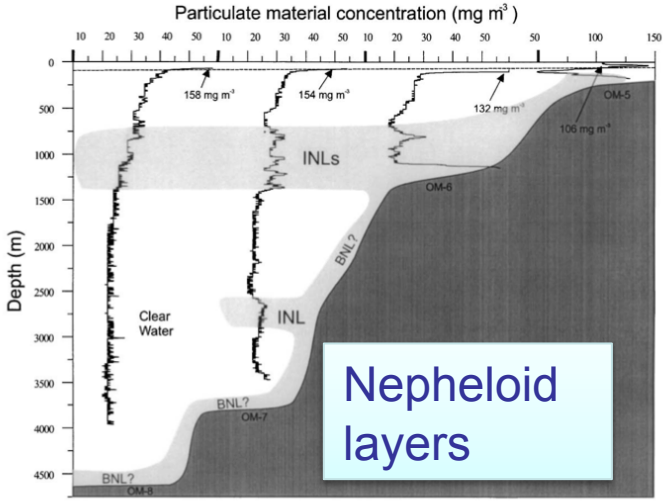
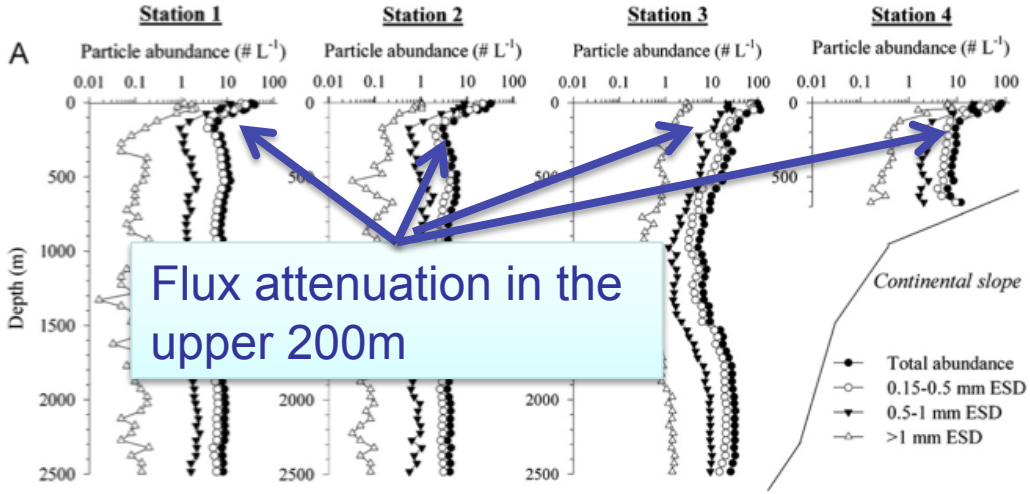
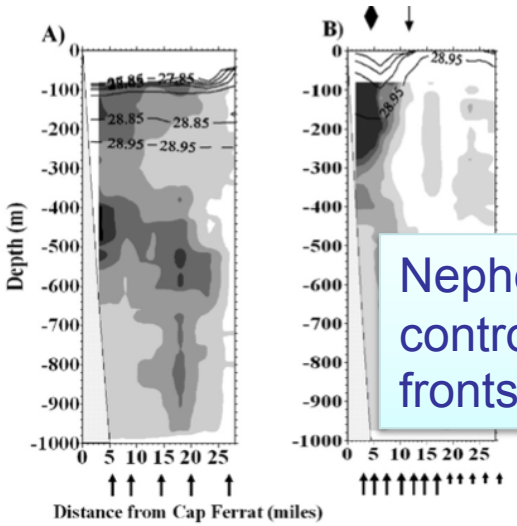


Fig. 6. Turbidity distribution (based on transmission) with depth over Goban Spur sediment trap transect during *D216* (Autumn). Data shallower than 100 m are not shown so as to allow a scale which reveals the structure of the deep water.

Open sea

Iversen et al., 2011, Tropical Atlantic

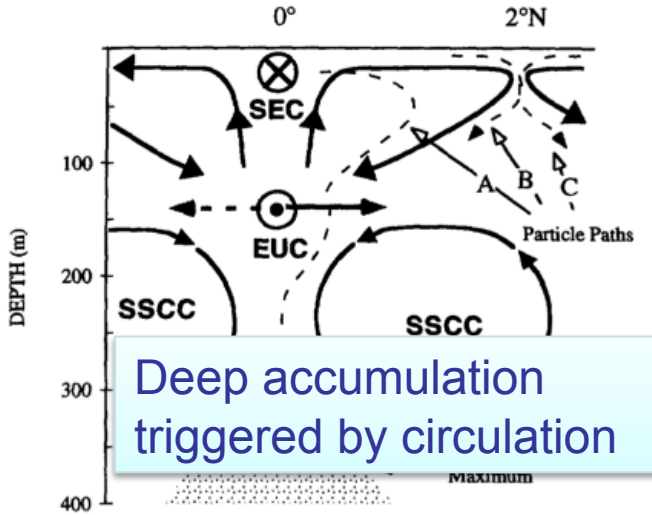




Stemmann et al., 2008 Mediterranean

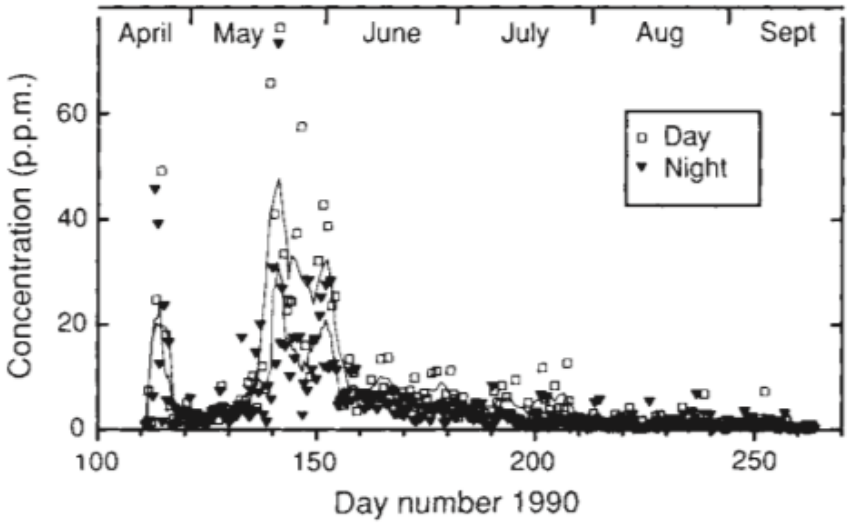
Nepheloid layers controled by fronts

Walsh et al., 1997 Equatorial Pacific



Temporal scales of particle variability

Short time scales



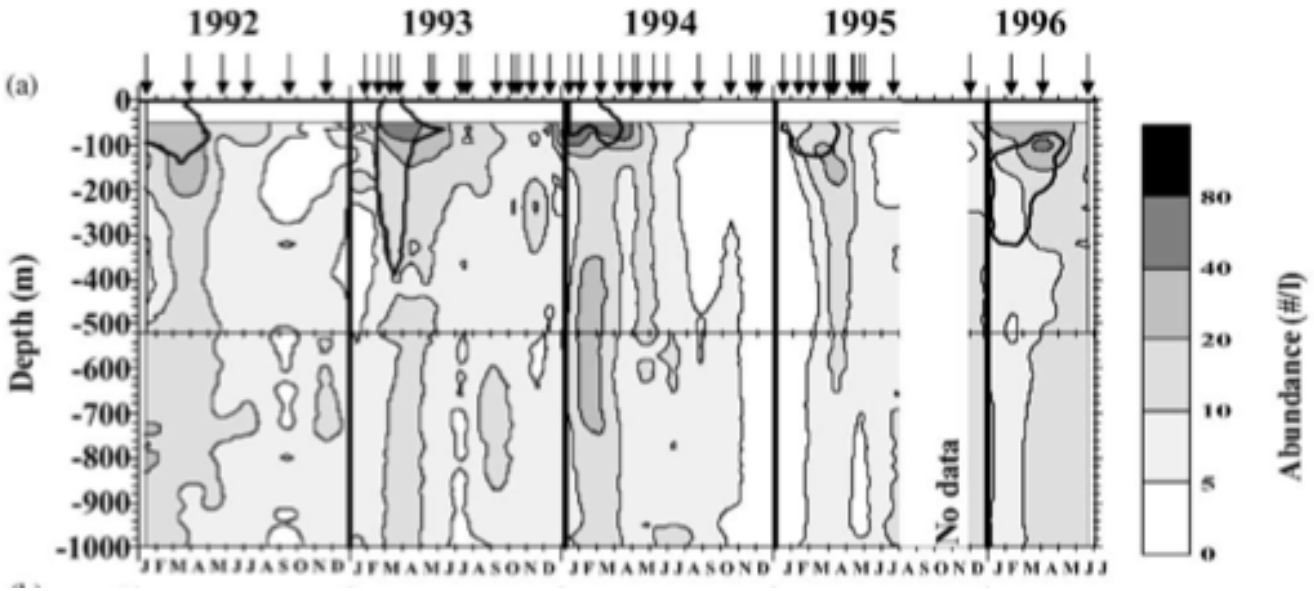
Lampitt et al., 1993, North Atl.

and then
Graham et al., 2000, Monterey Bay
Stemmann et al., 2000, Mediterranean Sea
Goldthwait et al., 2006, Monterey Bay

Hypothesis: DVM or
diel cycle in upper turbulence

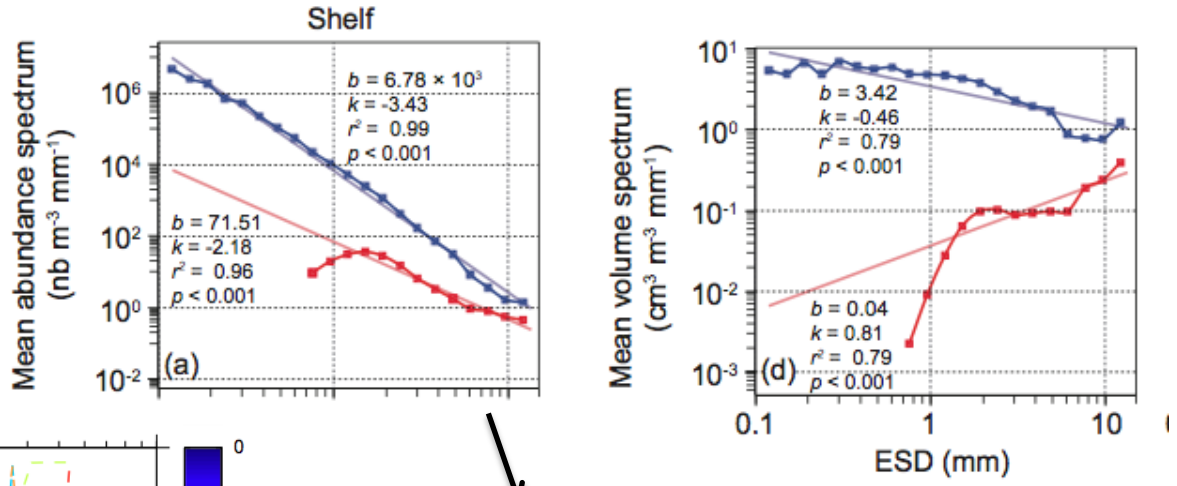
Long time scales

Stemmann et al., 2002
Mediterranean Sea

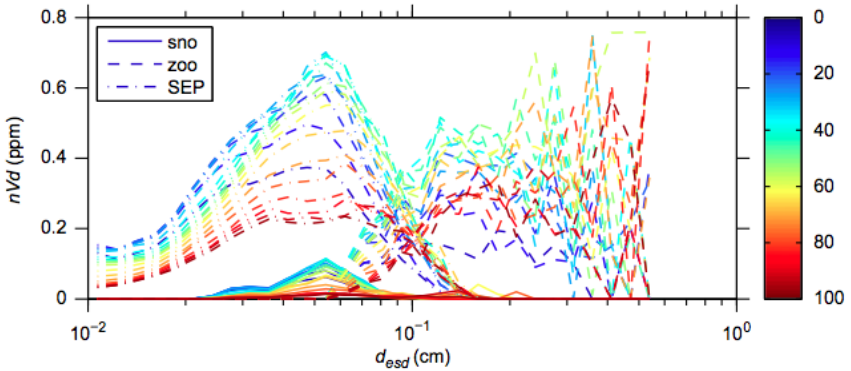


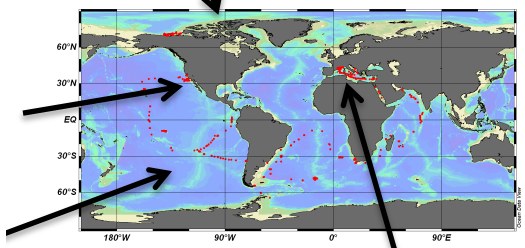
Particle/zooplankton

Forest et al., in prep
UVP, Arctic

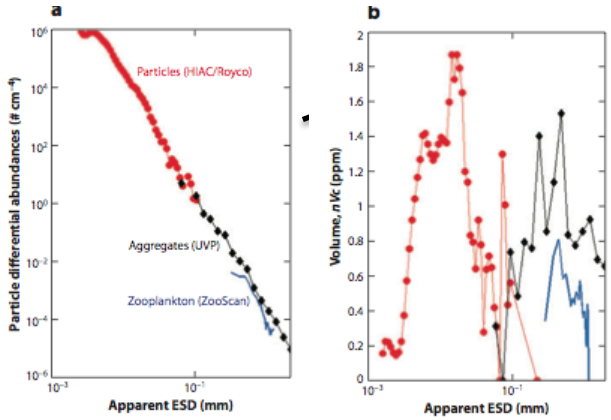


Jackson and Checkley (2011)
SOLOPC data Monterey Bay

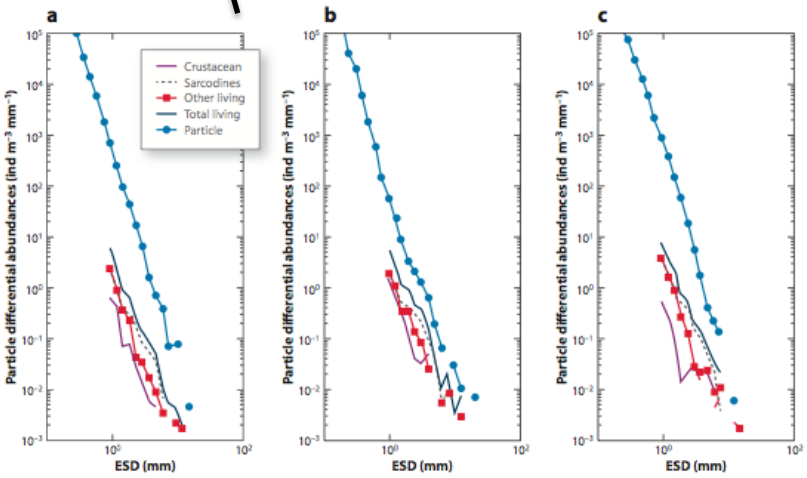




Stemmann and
Boss, 2012
UVP, Mediterranean



Stemmann and
Boss, 2012
UVP, Tropical S.
Pacific



Non exhaustive review of particle size structured models

Focus of the model	Spatial pattern	Constrain with data	Source
Coagulation in deep ocean, first equation for processes	0D	yes a	
Phytoplankton coagulation	0D	ph	0
Phytoplankton coagulation and fragmentation	0D	y f	
Ecosystem model with coagulation		n	
Ecosystem model with 2D spectra for particles	0D	no	Jackson et al., 2001
Particle transformation in mesopelagic layer	1D	yes, in situ partic spectra	Stemmann et al., 2004a, b
Ecosystem model with coagulation	1D to 3D	no vertical flux	Kriest and Evans, 1999 Kriest and Oschlies, 2008
Ecosystem model with coagulation, ballast	3D	yes, vertical flux	Gehlen et al., 2006

where are the data on particle size spectra ?

Particle dynamics in the sea. What is known, not well known and unknown?

Known: the ocean is a complex soup of particles

Not well know but will improve

- Particle spatial distribution,
- Particle transport as a function of size
- in situ Particle size spectra in relation to plankton community
- Particles shapes, organic matter quality (multispectral imaging)
- Particles ballast (optical properties)

Not known and difficult to measure/estimate

- processes acting on flux attenuation (bacteria/zooplankton) and impact on the other elements (TEI)
- Impact of coagulation and fragmentation from surface to the deep (TEP role)

Perspective for imaging
What is measurable (or can be estimated) by imaging now and in the future?

Organic matter
(fresh, refractory)

Porewater

Quartz

$CaCO_3$

Clay

Sarmiento & Gruber 2006

Mass
Shape
Size

Colonization
by organisms

$$W = (1 - P)\frac{2}{9}\frac{gr^2(\Delta\rho)}{\mu},$$

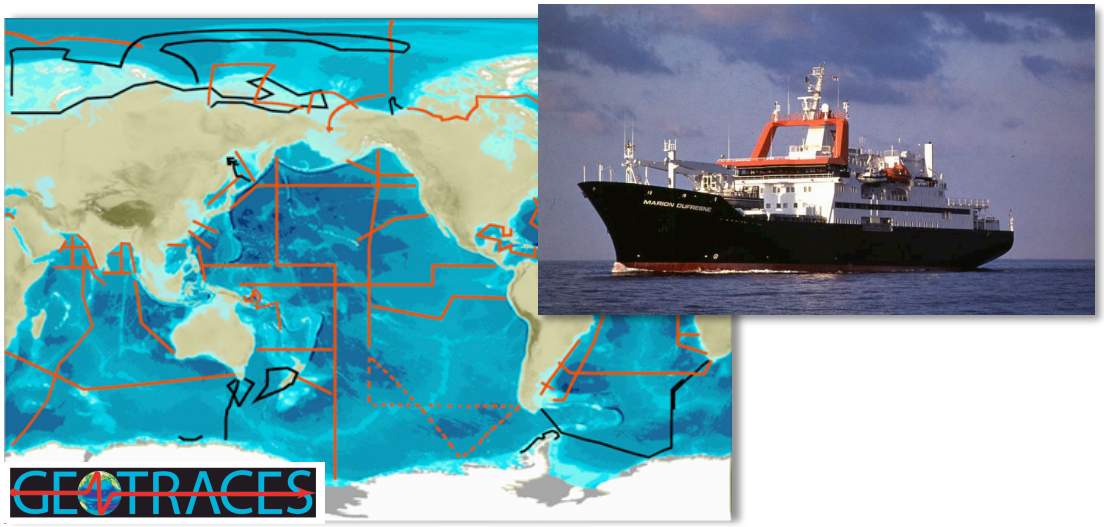
Images great perspectives

✓ Provide **Indicators of ecosystem status** (abundance, biomass, taxa, size spectra),
✓ Can be obtained using lab and in situ instruments, **they provide high frequency data, better technologies**

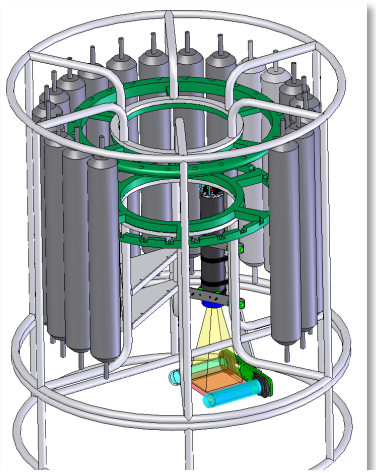
These indicators can be used to **develop mathematical models** also for zooplankton when size is important

- zooplankton size spectra to get information on physiological rates (Platt & Denman 1978, ... Baird et al., 2004, 2010, Zhou 2006, Maury et al.,2007).
- vertical distribution of appendicularian and effect on vertical fluxes (Lombard et al., 2009).
- appendicularians in recent PFT models (Berline et al., 2010).
- vertical distribution of particle fluxes (Stemmann et al., 2004).
- and particle dynamics models (see previous slide)

What could be measured by GEOTRACES in the close future?

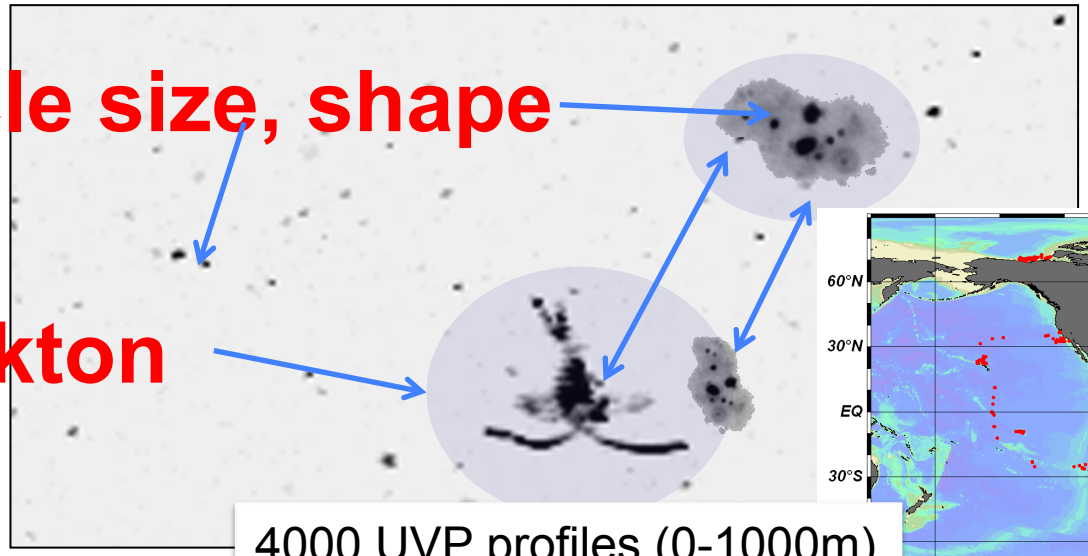


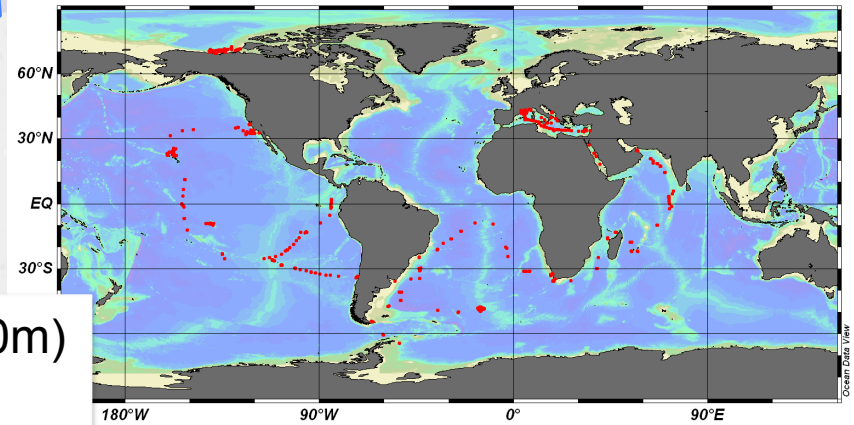
Use In situ instruments from ships
UVP, VPR, SIPPER, …



Particle size, shape

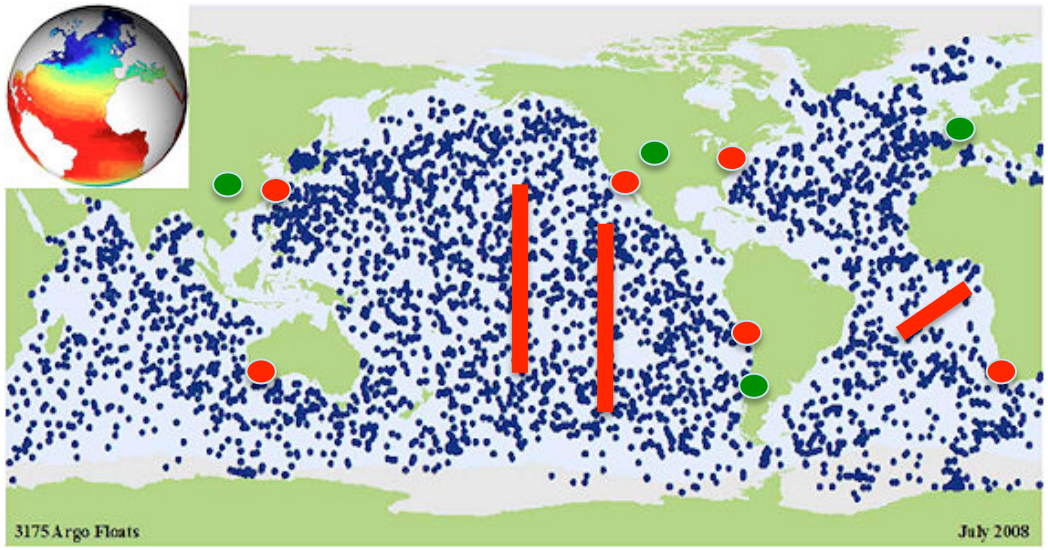
Plankton





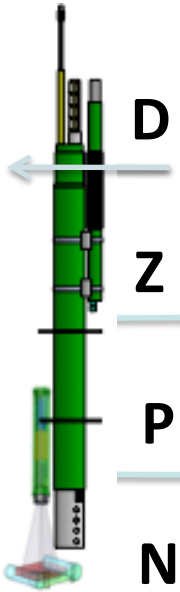
4000 UVP profiles (0-1000m)
one image every 10 cm

Partnerships with other programs: go from snapshots to continuous monitoring



Global network of observations
- ARGO-> BIOARGO+vision
- fixed stations + vision
- cruises of opportunity

Oceanographic data center for QC and large diffusion



Particulate Organic Carbon (size spectra)

macro and mesoplankton (Taxa size spectra)

Pico and microplankton (taxa, size spectra)

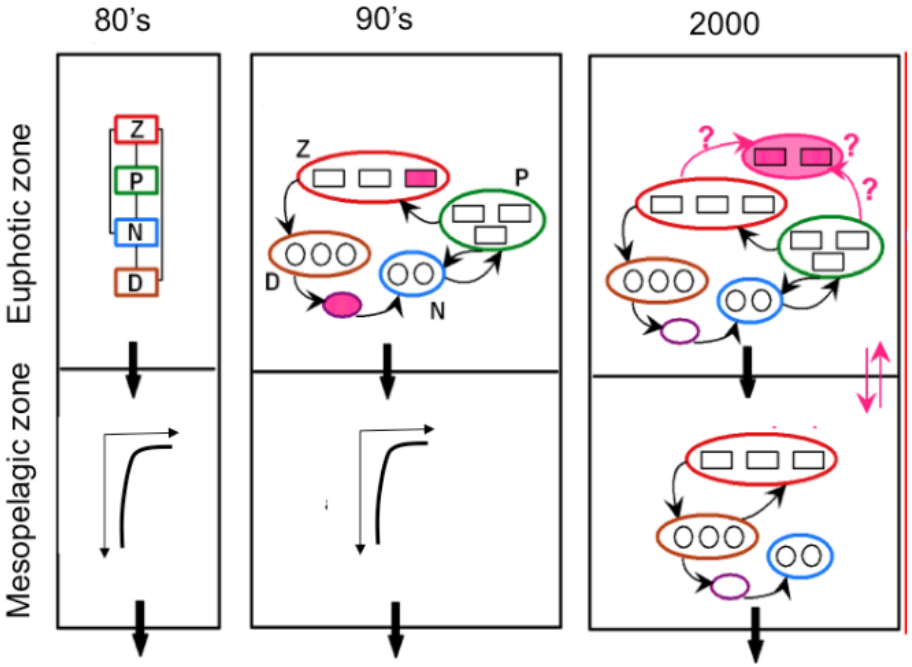
CTD and geochemical data

-Ecosystem monitoring

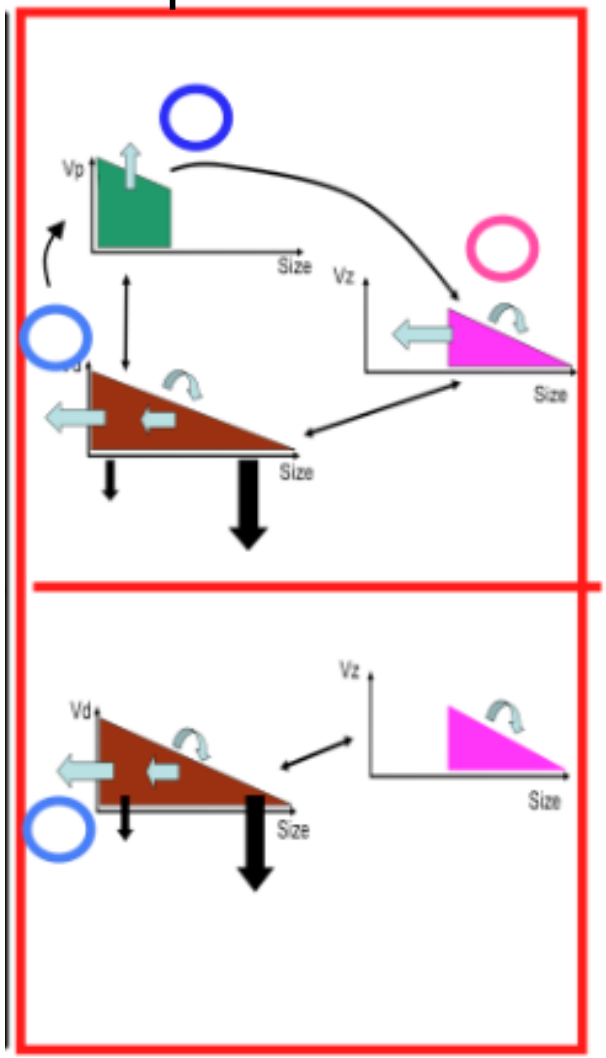
- Data assimilation in models for Carbone fluxes and marine ressources.

What should Biogeochemical models represent ?

The **past**: box models



The **Future**: box models + size spectra



✓Functional groups
✓Size spectra for particles, some zooplankton groups

Stemmann and Boss (2012)

THE KEY OF THE SUCCESS:

- **AGREED PROCEDURES (image format, treatment, semi-automatic recognition, intercalibration)**
- **AGREED DATA MANAGEMENT**
- **AGREED DATA DISTRIBUTION**
- **AGREED MODELING FRAMEWORKS**
- **SUMMER SCHOOLS FOR THE USERS**

The biological, particle community has not reached yet a sufficient maturity in using images.

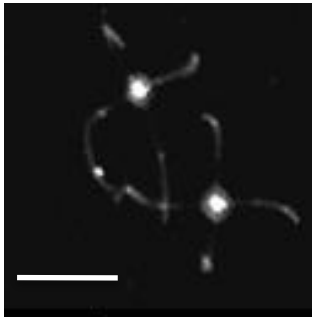
These are propositions that we could discuss now building on the biogeochemical community experience

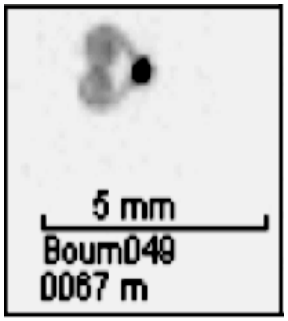
Thank you

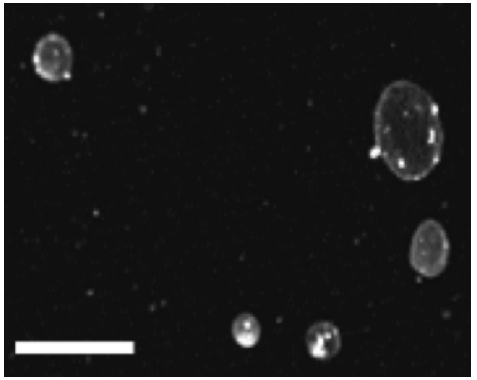
inviting me to this meeting

for listening

By the way, do you know what they are ???







✓Guidi, L., Gorsky, G., Claustre, H., Picheral, M., Stemmann, L., 2009. Contrasting distribution of aggregates > 100 μm in the upper kilometre of the South-Eastern Pacific. Biogeosciences 5, 1361-1372.
✓Guidi, L., Jackson, G.A., Stemmann, L., Miquel, J., Picheral, M., Gorsky, G., 2008. Relationship between particle size distribution and flux in the mesopelagic zone. Deep Sea Research Part I 55, 1364– 1374.
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