Acknowledgements

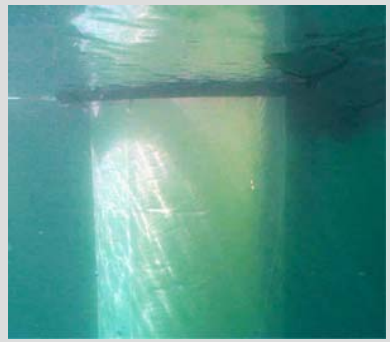
Thank you

- to Vicki, Mary, and Chris and the organising committee for pulling together this meeting and inviting me to be here
- to OCB office and NSF‘s Office of Polar Programs for sponsering this meeting
- to Scripps Institution of Oceanography for hosting us here

Pelagic mesocosms for future ocean simulations

OUTLINE:

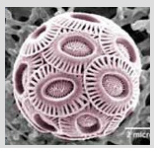
- Rationale
- Design
- Time scales
- Manipulation
- Study areas
- Summary
- Questions



Rationale

Ocean is becoming …	this will affect …	with impacts on …
warmer more stratified lower ventilation higher light availability lower nutrient supply	photosynthesis calcification metabolism growth reproduction diazotr. N-fixation …..	community production species succession trophic interactions biogeochemical cycling air-sea gas exchange …..
more acidic higher [CO_{2aq}] lower [CO_3^{2-}] lower carbonate sat.		

Ocean change → **Individual** → **Population** → **Community** → **Ecosystem**

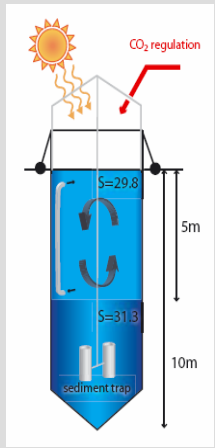



Rationale

Mesocoms can close the gap between highly controlled, but far from natural laboratory experiments and unconstrained natural systems

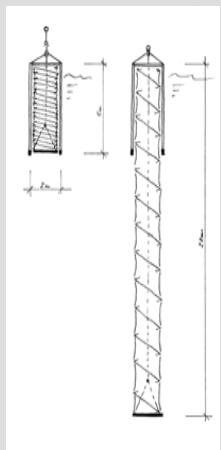
Mesocosm:

meso-scale enclosures containing a complex, close to natural ecosystem



Bergen Mesocosm Facility, Raunefjord 2005

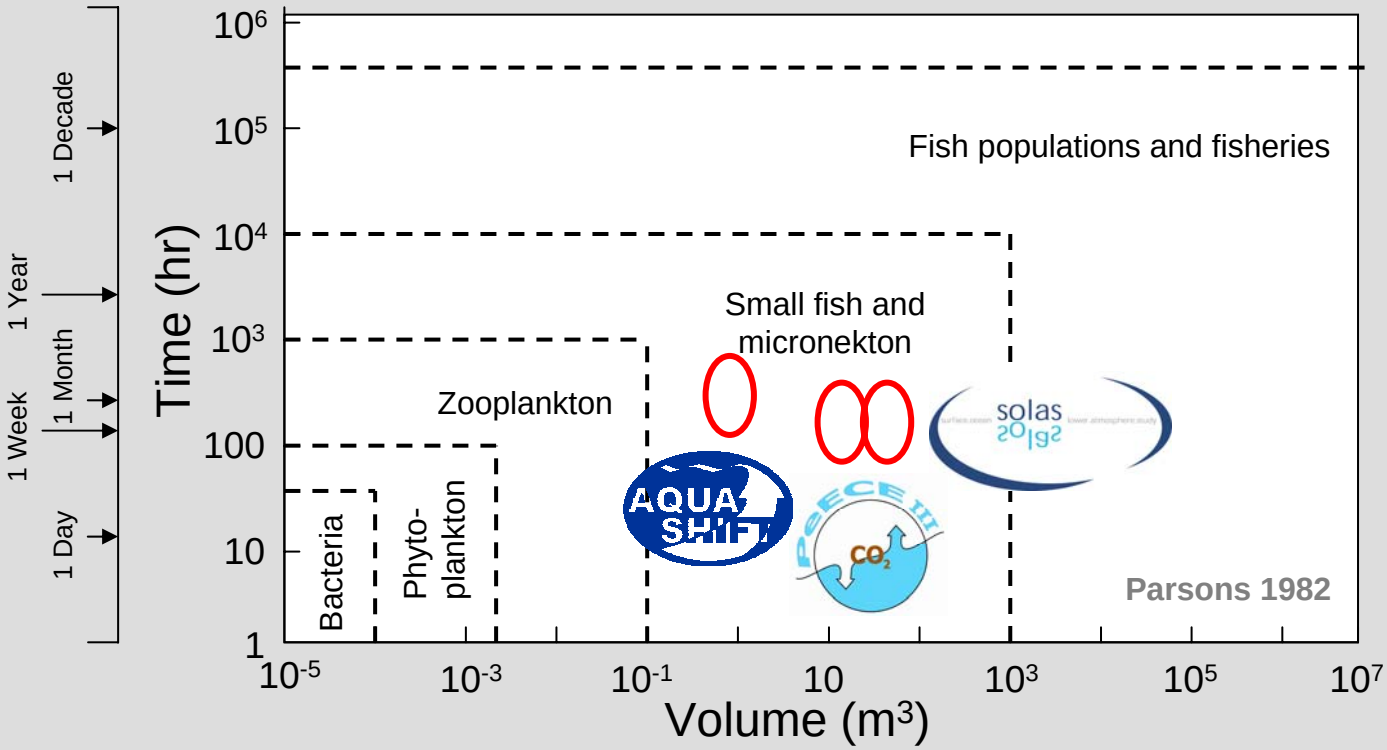
Mesocosms are *living models* of nature (Pilson & Nixon 1980)



Free-floating mesocosms, Baltic Sea 2007

Design

Relationship between organism life cycle and the size and cost needed for their containment



(CEE =Controlled Experimental Ecosystems)

Enclosure	Test tube	1 Litre	1 Ton	Fish tank	Small CEE / Large CEE	Fjord
Cost	$ 0.10	$ 5	$ 800		$ 100.000	
Replication		Multiple	Replicate controls/ Replicate treatment		1 control/1 treatment	

Design

Replication

- Replicate treatments (comparing mean and SD)
- Perturbation gradient (regression analysis)

Ambient seawater not a suitable control

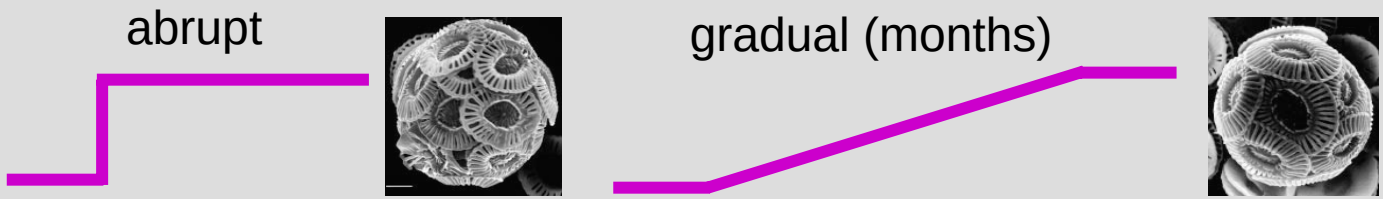
Duration

- Covering single events (plankton bloom)
- Covering seasonal/annual cycle

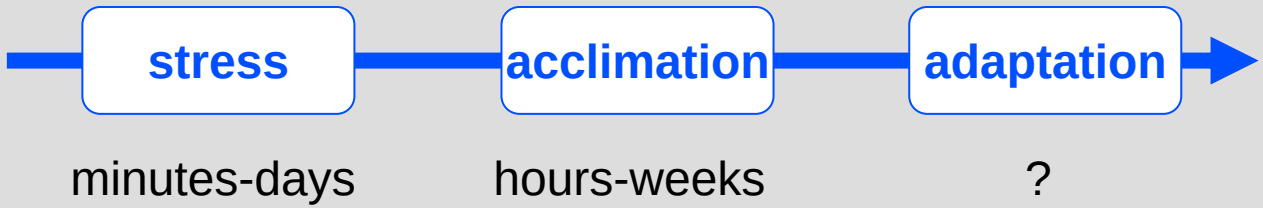
As time continues, deviation from the natural system increases

Time scales

CO_2/pH perturbation



Response



Effect

Manipulation

- enclosing a volume of water is a manipulation in itself – comparison with unenclosed ambient water misleading
- simultaneous filling of mesocosms
- other (unintended) perturbations may override the effects of the actual treatment e.g. stimulating a plankton bloom through decreased mixing or nutrient addition
- CO_2 aeration vs. acid/base addition (alternatively equimolar $NaHCO_3$/HCl addition)

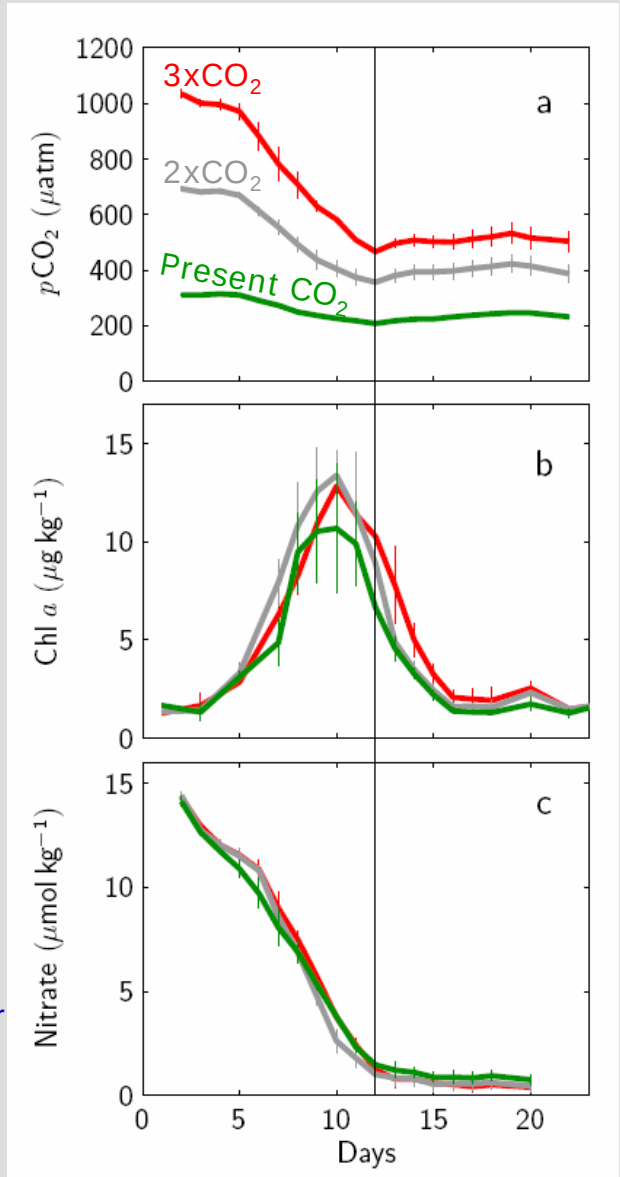
Manipulation

Nutrient (NO_3,PO_4) pulse was dominant perturbation determining plankton succession

Community appeared robust to CO_2 treatment wrt

- phytoplankton composition and cell cycle
- inorganic nutrient utilization
- bacterial abundance, diversity & protein production
- micro-zooplankton grazing
- copepod fecundity & hatching success
- viral abundance and diversity

Riebesell et al. accepted; Schulz et al., Allgaier et al, Bellerby et al., Egge et al., Larsen et al., Løvdal et al., Paulino et al., Carotenuto et al., Suffrian et al., Tanaka et al., all to be subm. to *BIOGEOSCIENCES* Special Issue



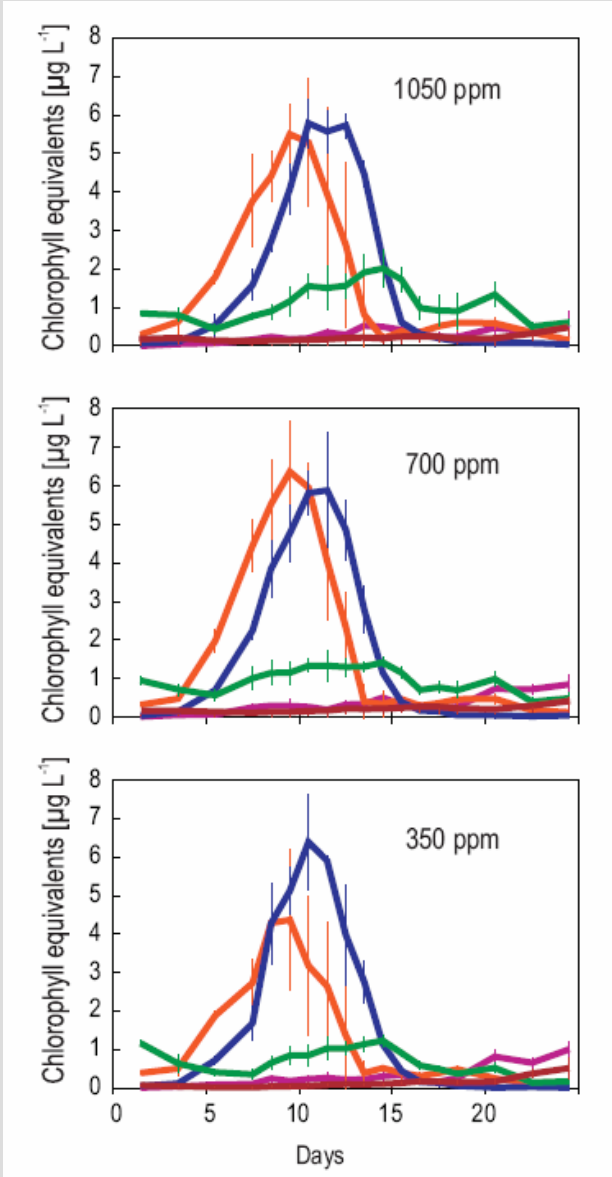
Riebesell et al. (accepted)

Manipulation

CO_2 treatment effects observed wrt

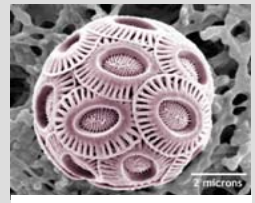
- Inorg. carbon consumption
- C:N:P stoichiometry
- Organic carbon loss
- DMS/DMSP accumulation
- Iodomethane production
- Iron availability

Riebesell et al. accepted, Vogt et al. subm., Wingenter et al. 2007; Sinha et al. 2007, Breitbarth et al. in prep.

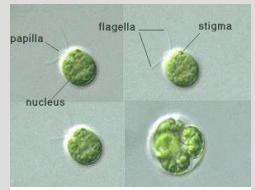


Riebesell et al. (accepted)

Diatoms

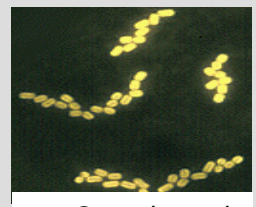


Coccolithoph.



Prasinophytes

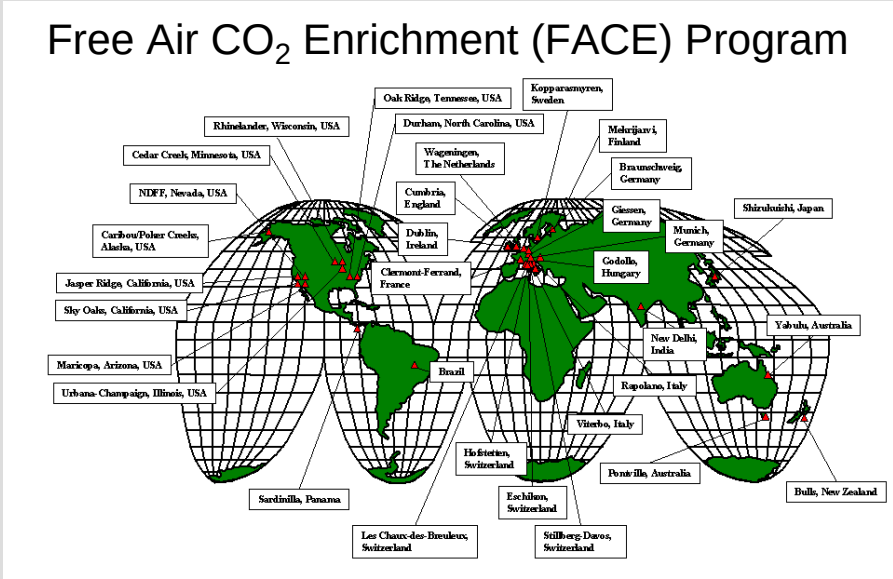
Dinoflagelates



Cyanobacteria

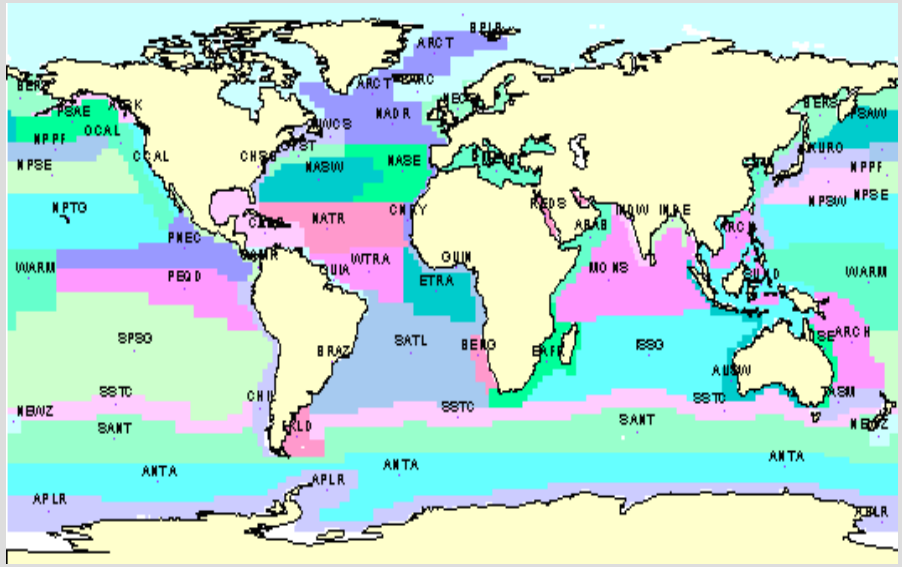
Study areas

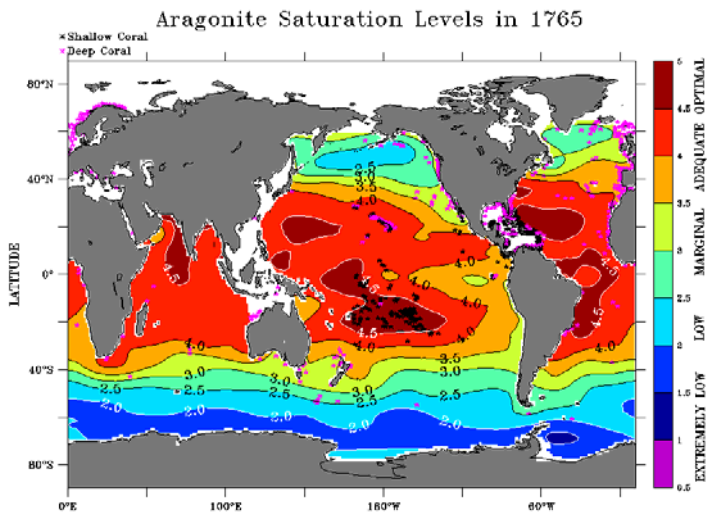
- Representative geographical locations
- Key ecosystems



Study areas

- Representative geographical locations
- Key ecosystems
- Biogeochemical provinces
- High priority areas:
  - polar lattitudes
  - warm & cold water coral reef systems
  - high productivity areas
  - areas experiencing sporadic iron input





After Feely et al. with modeled saturation levels from Orr et al (2005)

Summary

What mesocosms can do:

- test community level response to a well-controlled perturbation
- allow for system budgeting
- provide integrated data sets suitable for statistically analysis
- creat a platform for cross-disciplinary research on ocean change: from molecular biology to atmospheric chemistry

What mesocosms can NOT do:

- allow for fully reproducible experiments
- provide mechanistic understanding of underlying physiological processes
- cover time scales relevant for adaptation

Questions & critical issues

Questions

- Key pelagic ecosystems
- Pelagic processes sensitive to OA
- Priority study locations
- Tradeoffs between duration of experiment and comparability with natural system

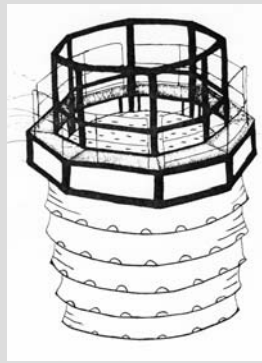
Time scales

- Abrupt vs. gradual acidification
- Differentiate between acute stress and chronic effects
- Acclimation - adaptation

Free-floating pelagic mesocosms

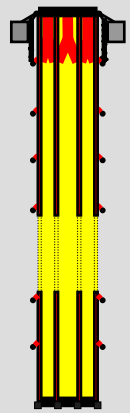
Celtic Sea, 1982

(Courtesy: Nick Owens, PML, UK)



Northeast Pacific, 2003

(Courtesy: S. Takeda,
Tokyo University, Japan)



Baltic Sea, 2007

SOPRAN 2007

Study area: Gothland Sea, Proper Baltic

Event: bloom of diazotrophic cyanobacteria

Set up: 6 free floating mesocosms

Manipulation: CO_2 gradient 350-1250 µatm through addition of $NaHCO_3$/HCl

Duration: 3 weeks

Drift: 10-15 nm /day

Surface Ocean Processes in the Anthropocene