Technology requirements for sensor systems in the marine environment

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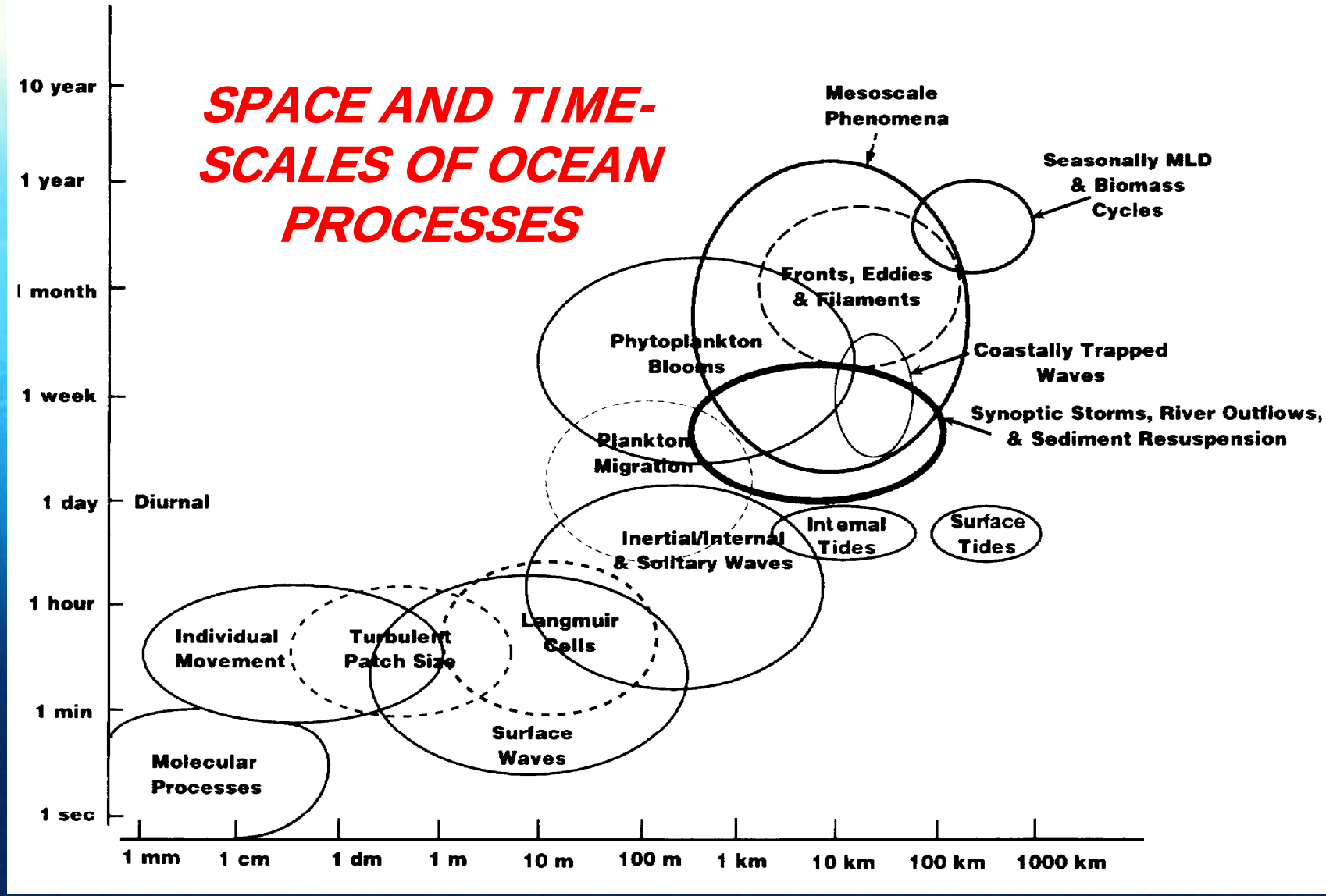
- *Why we need marine sensors- scales and big questions*
- *Brief look at present "state of art"*
- *Challenges facing marine sensor networks*

Scales of processes in the ocean

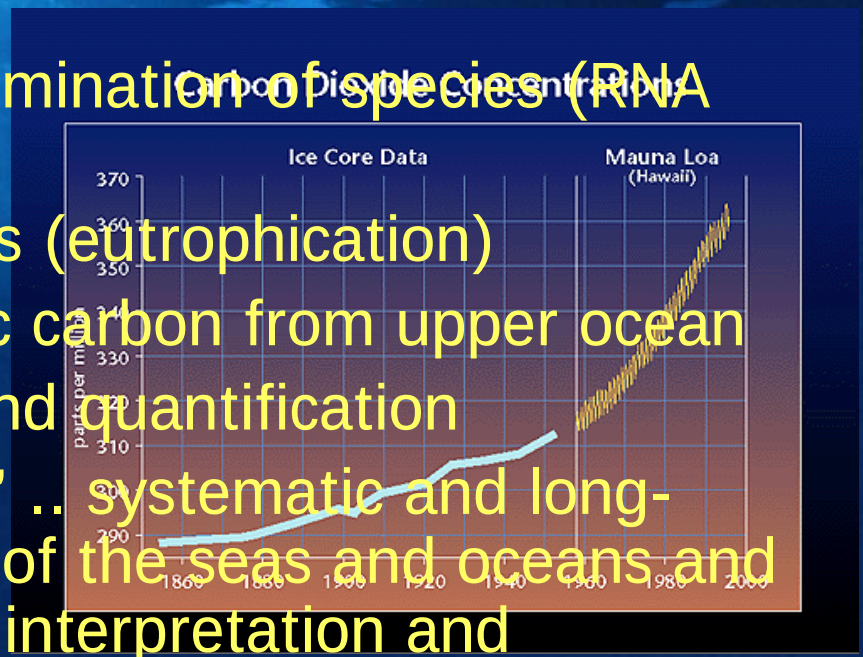
~70% of planet covered with ocean to average depth of ~3900m

SPACE AND TIME-SCALES OF OCEAN PROCESSES



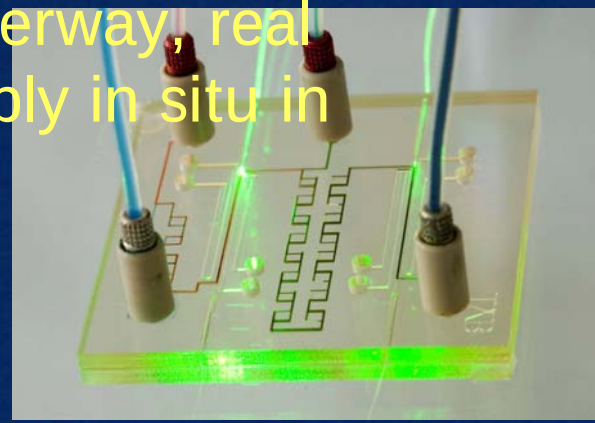
Big questions in Marine research where sensor systems relevant

- Carbon dioxide uptake by ocean and ocean acidification (pCO_2 pH)
- Biodiversity and in situ determination of species (RNA DNA technologies)
- Nutrient loads in coastal seas (eutrophication)
- Fluxes and cycling of organic carbon from upper ocean
- Episodic events- detection and quantification
- Operational oceanography- " .. systematic and long-term routine measurements of the seas and oceans and atmosphere, and their rapid interpretation and dissemination..."- now casts, forecasts etc.
- Many other areas of research exist where sensors needed



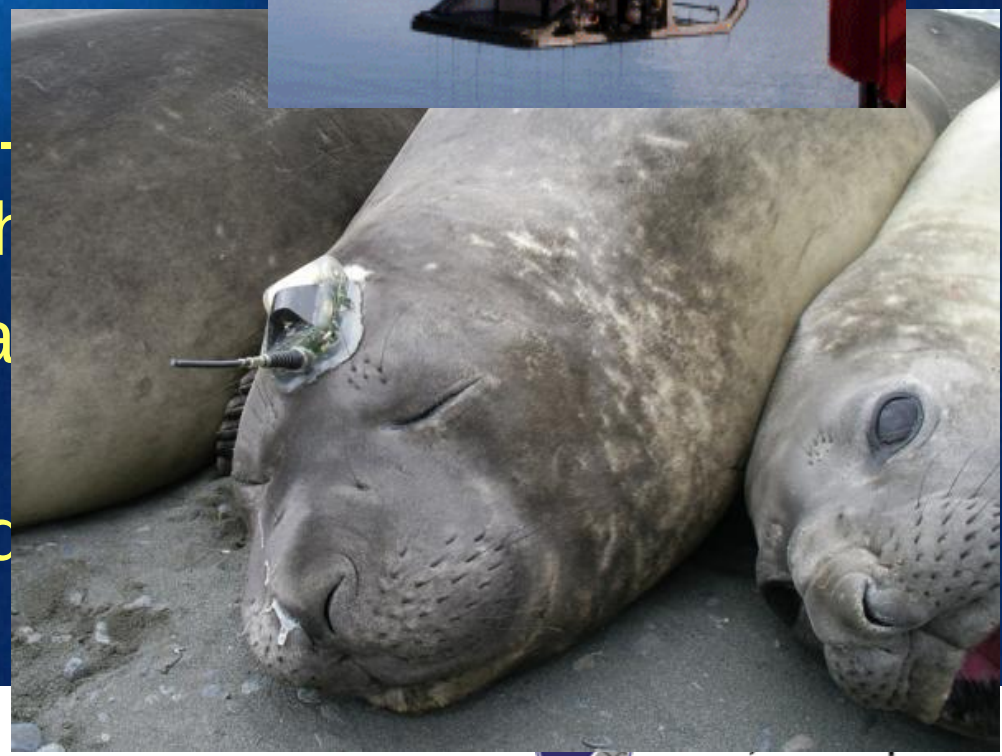
Sensors –"State of Art"

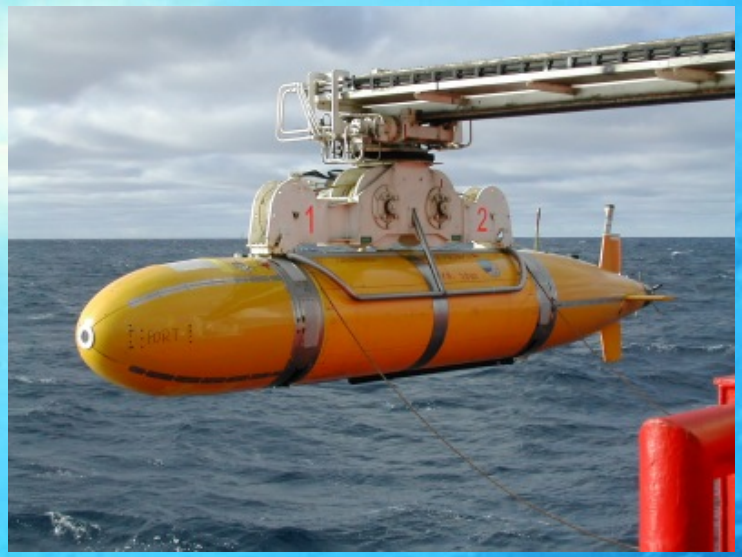
- Many physical parameters can be measured routinely: T, salinity, pressure, currents, fluorescence (algal biomass), surface satellite data
- Chemical measurements systems still developing; optrodes for O_2 some large scale nutrient systems
- New generation of miniaturised LOAC systems presently evolving (nutrients, metals, flow cytometers etc.)
- Whilst bench system developments underway, real challenge is to have them working reliably in situ in the ocean.



Present platfor s:

- ***Physical system on which***
- Fixed- buoy systems, and ben observatories
- Free floating systems, some w control (Argo)
- Manned submersibles- remotely operated vel
- Autonomous Underwa gliders)
- Fleets of instrumentec
- Organisms



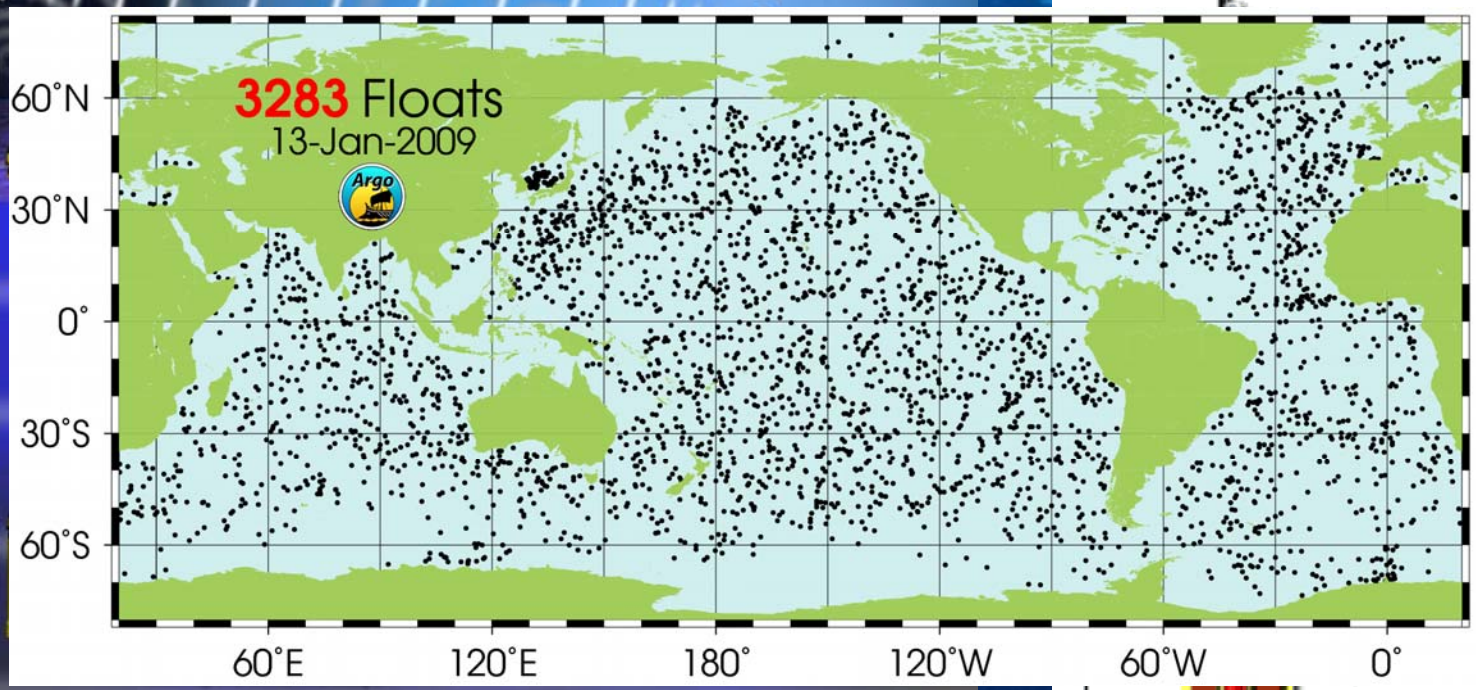


Autonomous Underwater Vehicles (AUVs) and gliders

- AUTOSUB is an example autonomous underwater vehicle, ~7 m long and ~1 m in diameter. System under development 6000m depth 6000km range.
- Gliders- low energy propulsion for long upper ocean surveys

Networks: Argo global array

http://www.argo.ucsd.edu/index.html

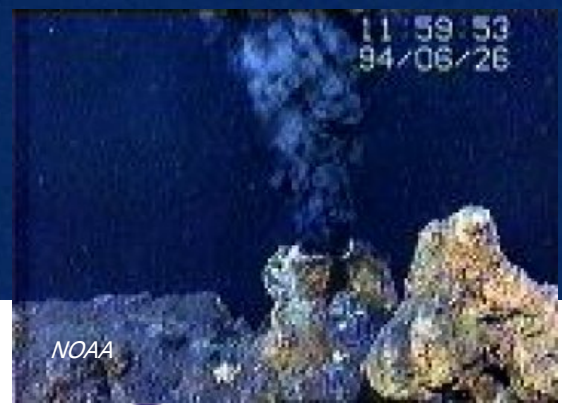


BUT only limited chemical sensor systems

Challenges for sensors in the ocean-

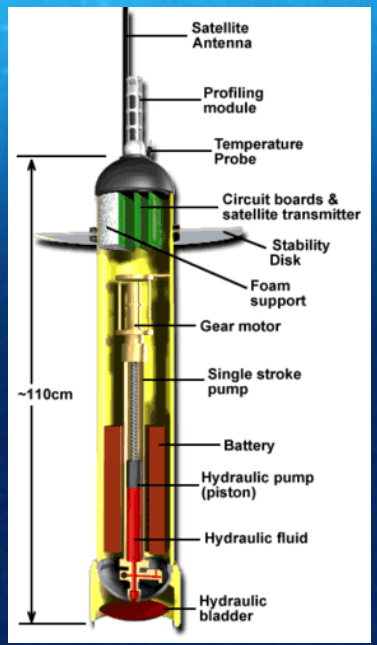
Common issues for long time or space scales:

- Energy
- Data storage/processing/.. Not so much of an issue for medium sized systems
- For chemical systems reagent stability, varying temp and reaction rates
- Position location and navigation underwater (must be at surface for GPS)
- Stability of systems under varying T (25-2ºC) and P (1-1000 atm)
- Others..



Transfer of information-

- *NO wireless below surface and narrow acoustic bandwidth*
- *Cabled benthic instrument array (issues of limited locations, inflexibility)*
- *Via satellite- sensor returns to surface and send data to base*



1. *< Argo floats classic example of float system*
2. *MaClane profiling CTD > (works up to 5000m) future units to send data back from surface*

Biofouling

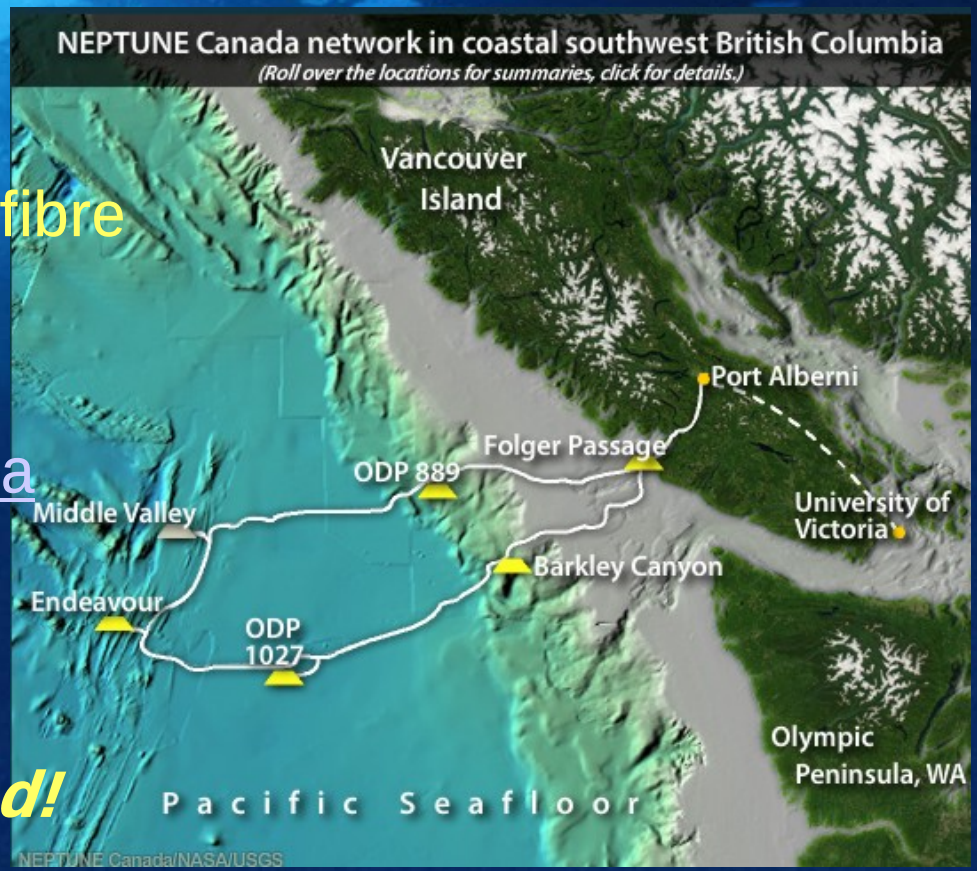
- Especially a problem in upper ocean and near shore waters
- Film of organics will coat most surfaces almost instantly in seawater
- Micro and macro!

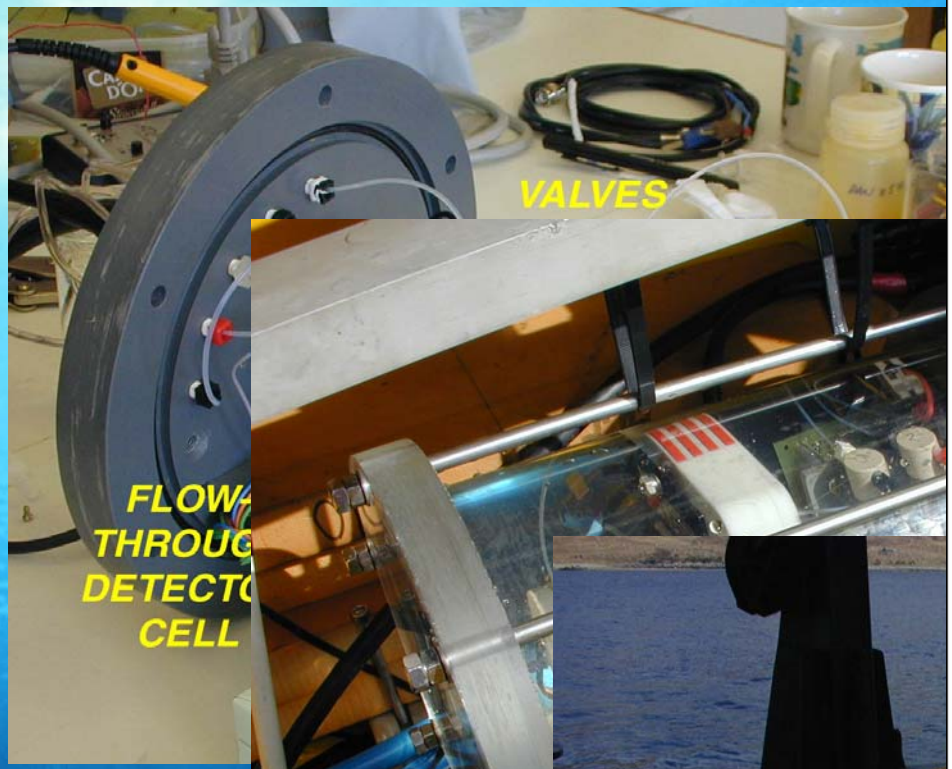
- Approaches: use of Cu materials, wipers, chemical attack (acid, oxidising agent), bio-incompatible surfaces etc.

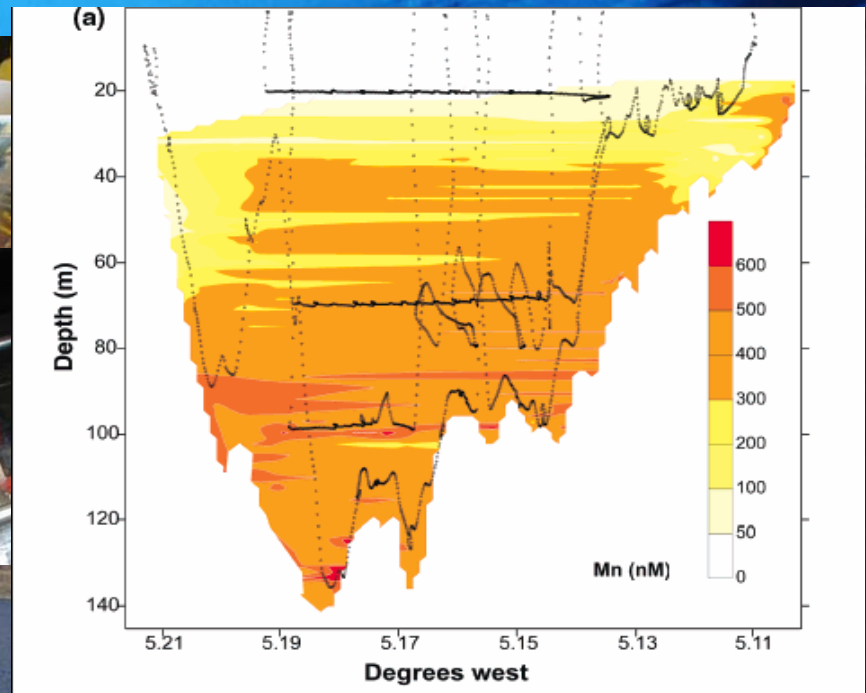
The future: one view of networks of platforms and sensors

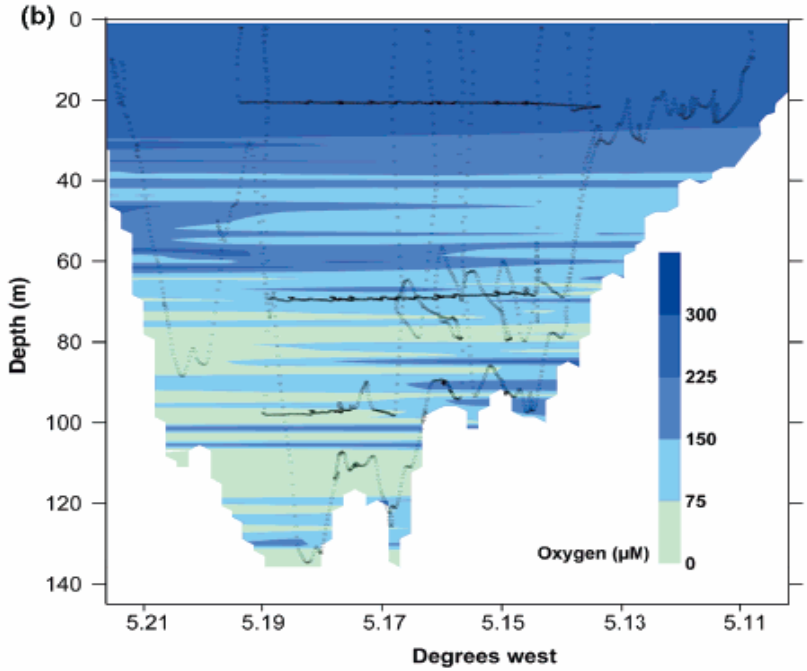
Future benthic observatory developments will include:

- Micro sensors on a variety of platforms
- Platforms will be networked- fibre optic cabled systems
- See http://www.neptunecanada.ca goes live 8 December 2009
- ***New ideas to give a step change in observation of ocean systems still needed!***









Statham et al. (2005)
*Env. Sci. Tech., **39**, 9440*

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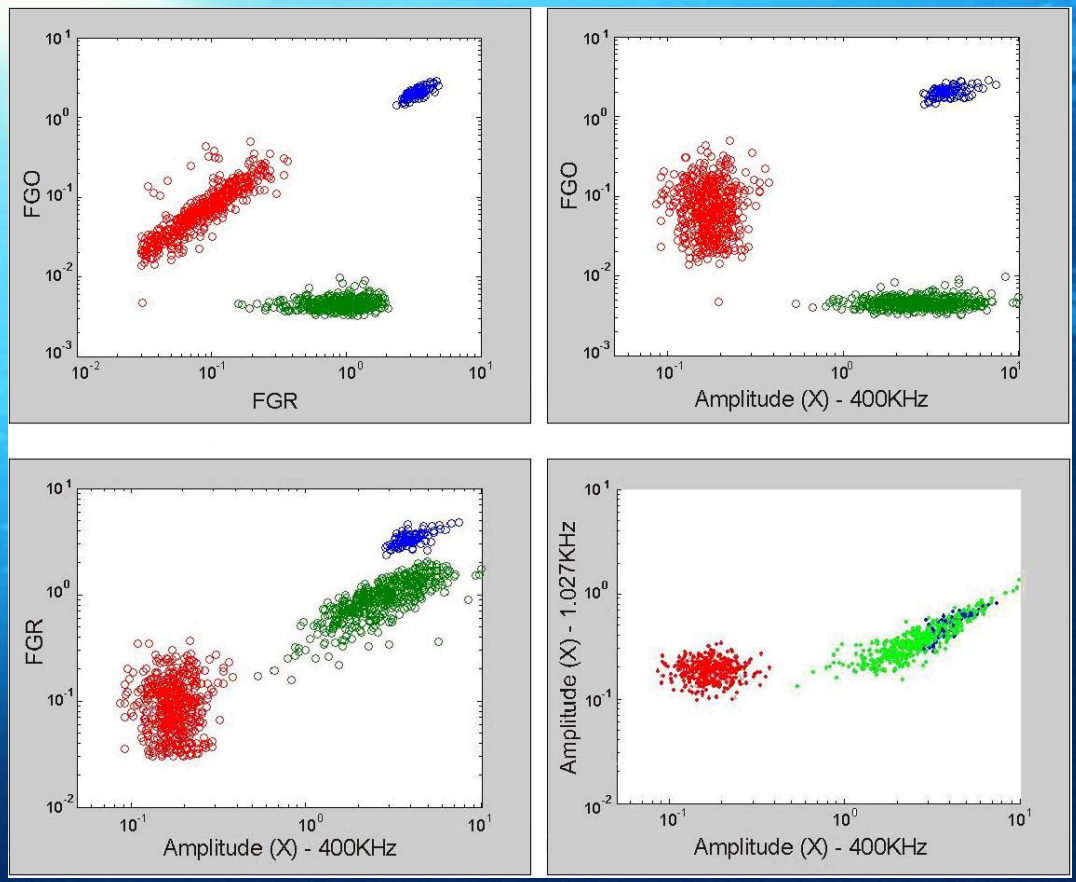
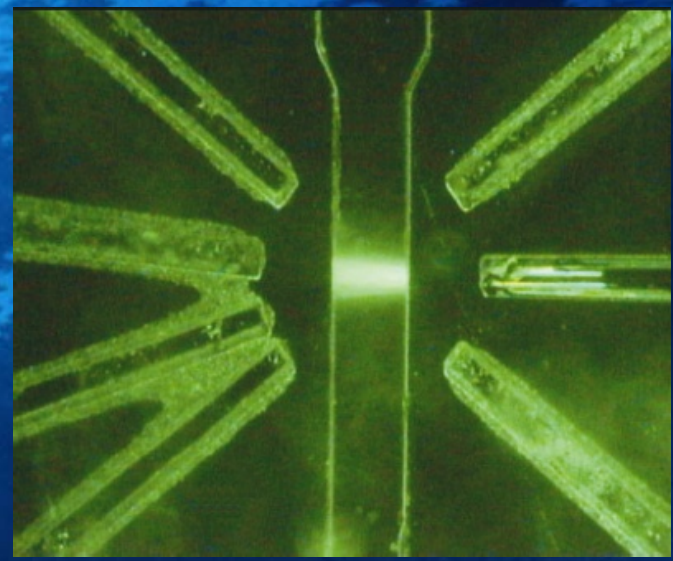
Biological sensors: Cytometer





Simultaneous electrical impedance and optical fluorescence measurement of individual phytoplankton

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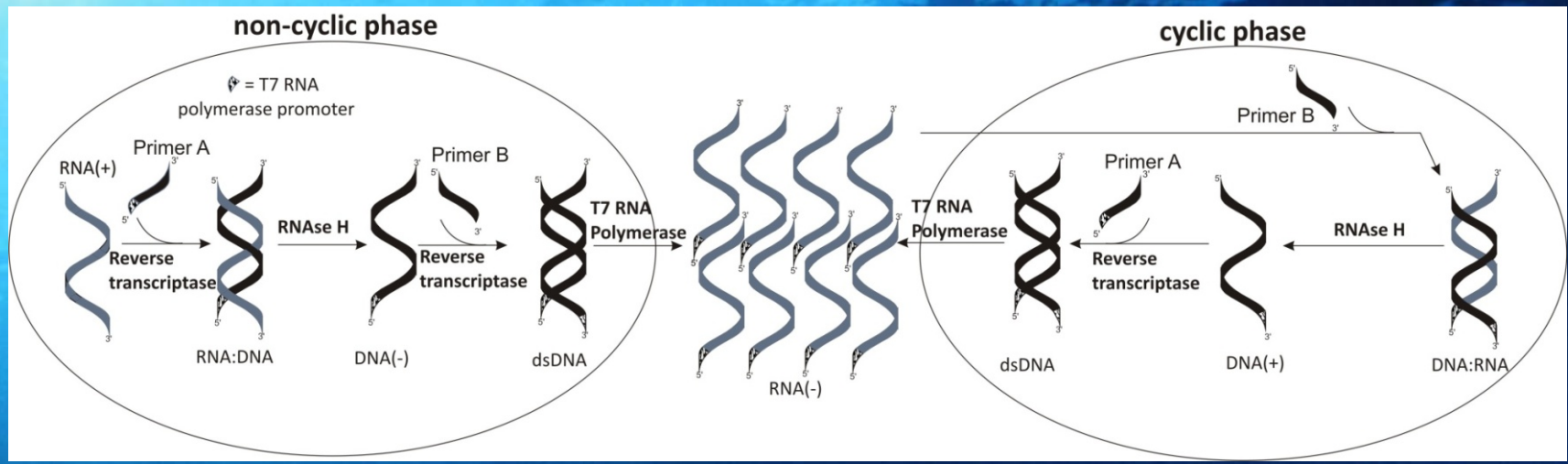
Biological sensors: RNA analyser



- NASBA (nucleic acid sequence-based amplification)
- Quantitative (internal reference)
- Isothermal amplification
- Aim = Lab on a chip solution with integrated extraction and NASBA