Ocean acidification: global, regional, seasonal, observational, palaeoclimatic and microbial aspects.

Koninklijk Nederlands Instituut voor Zeeonderzoek

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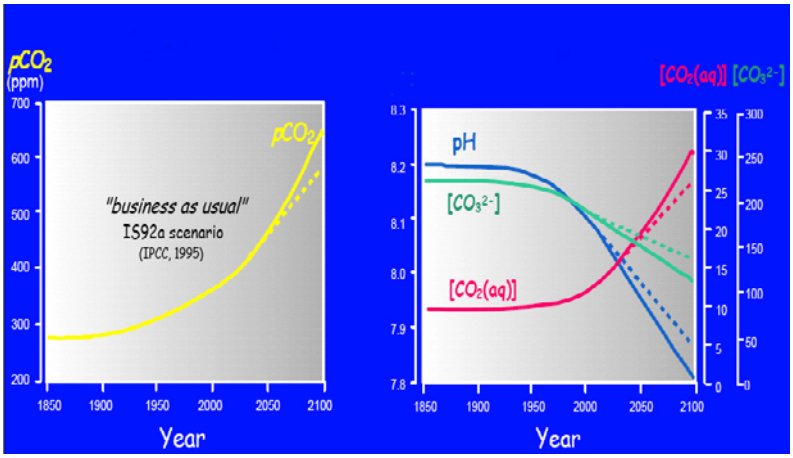
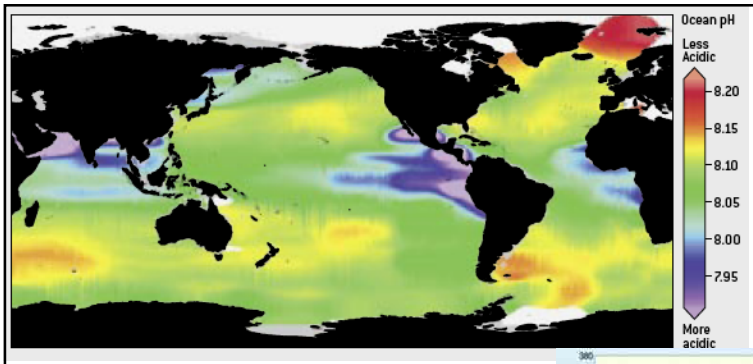
Ocean ecosystems, oceanic biodiversity - Is change expected as the ocean becomes more acidic? Are we monitoring the ocean?

GEO-tasks

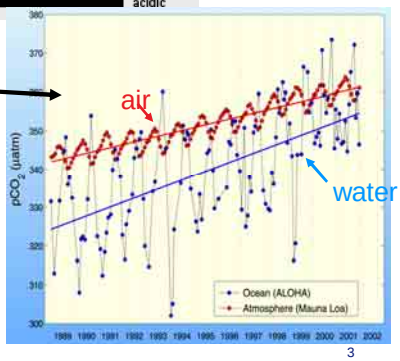
BI-06-02 ...monitor biodiversity..
EC-06-01 ...global carbon observations...
EC-06-05 ...new platform and sensors needs...





Present global surface pH

Hawaii Time Series:
Atmosphere - red
Ocean - blue



Like evaporation, there may be spatial and structure - time series stations capture high vertical resolution, high time resolution records, key to understanding vertical penetration and large scale 3-D pathways.

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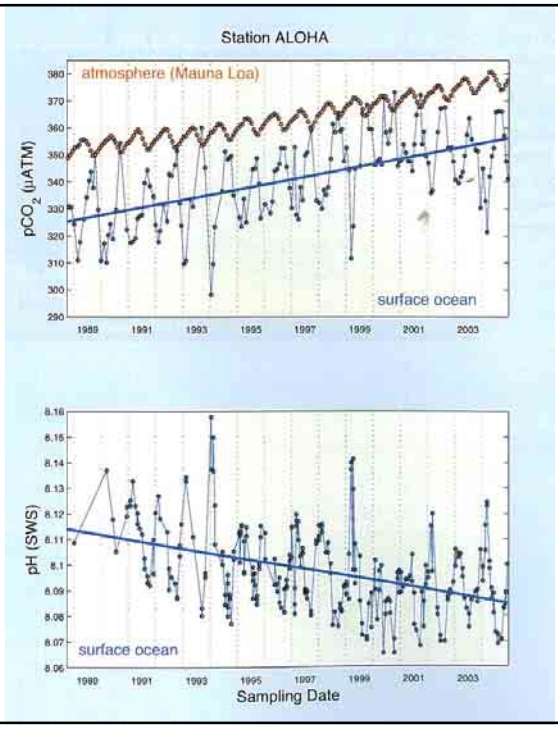
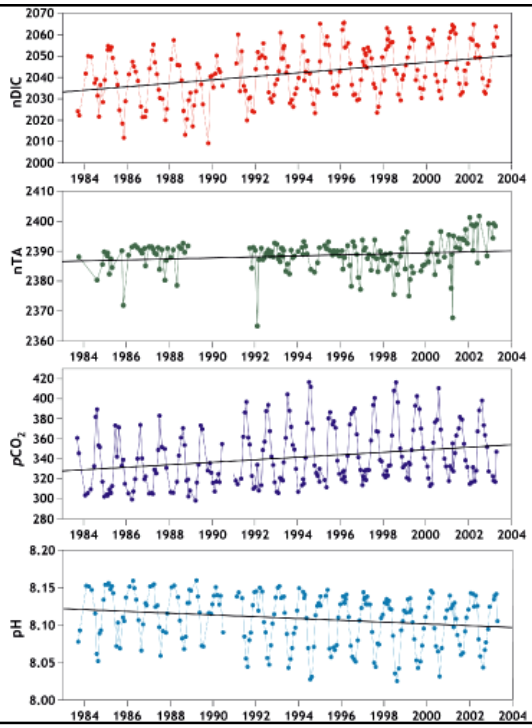
Long-term observations



Long-term observations
BATS



Long term observations
Equip existing buoys, moorings, SOO, cabled networks with pH and pCO_2 sensors

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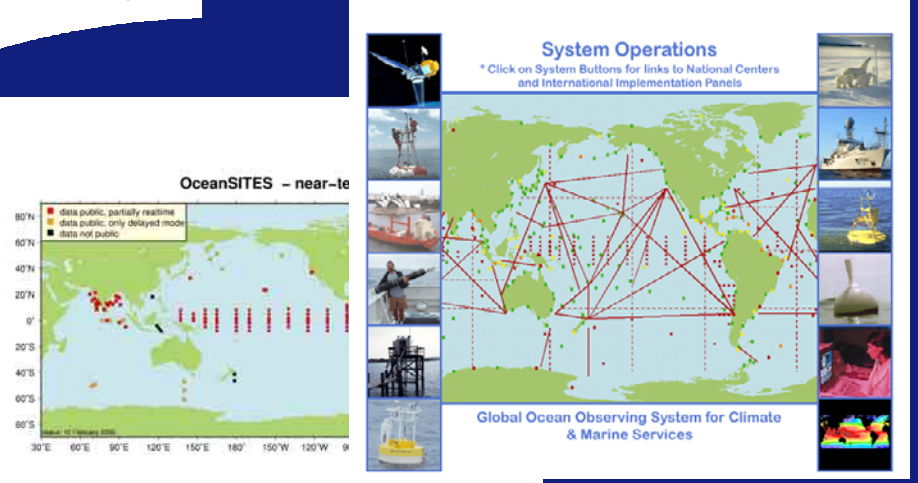
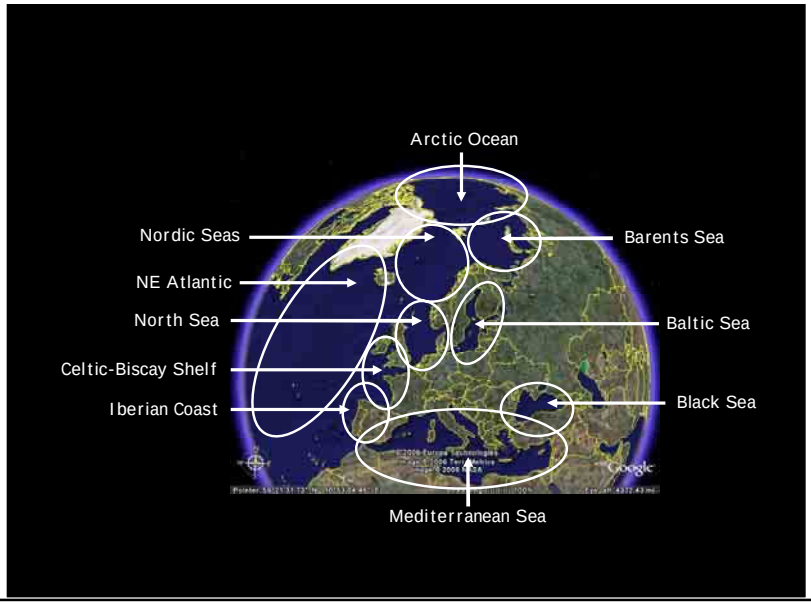


Het NIOZ maakt deel uit van NWO 6

Regional differences



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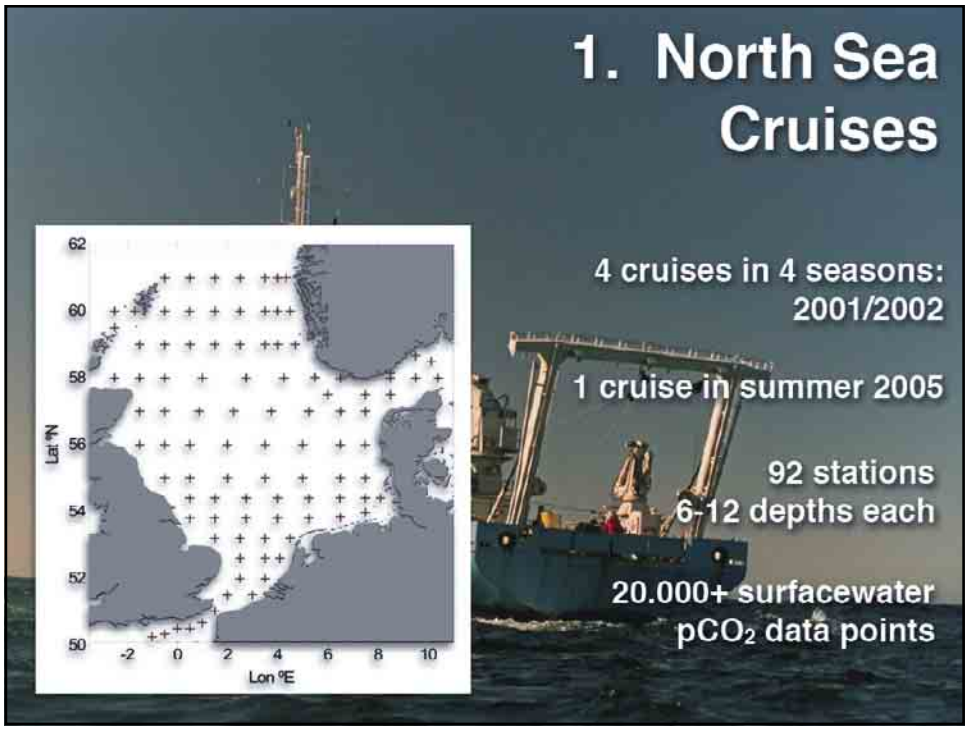
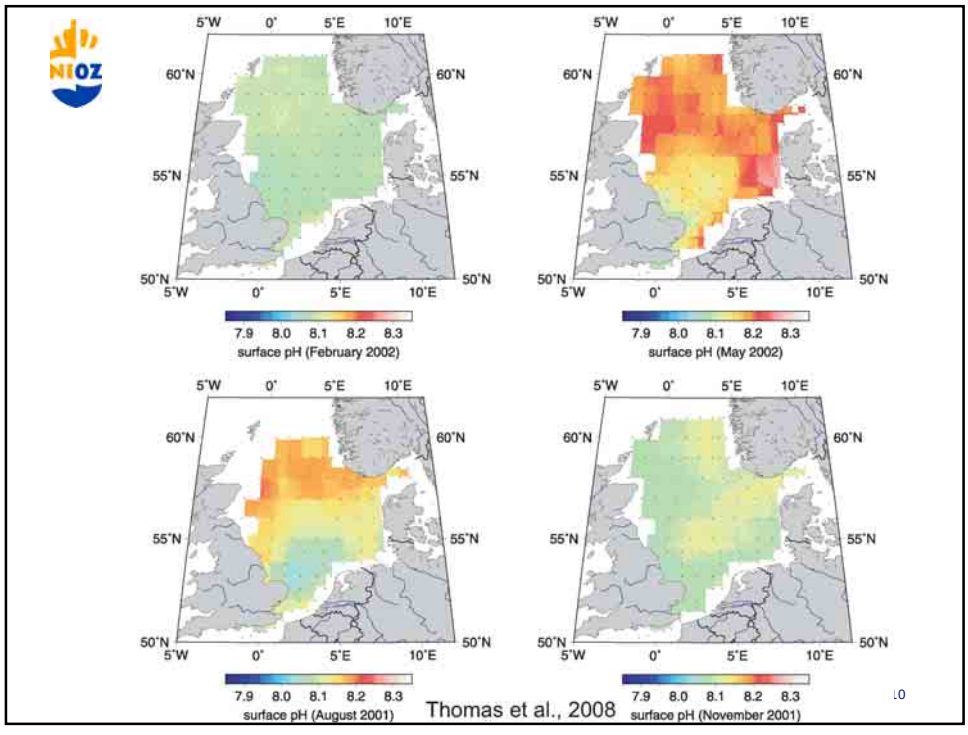
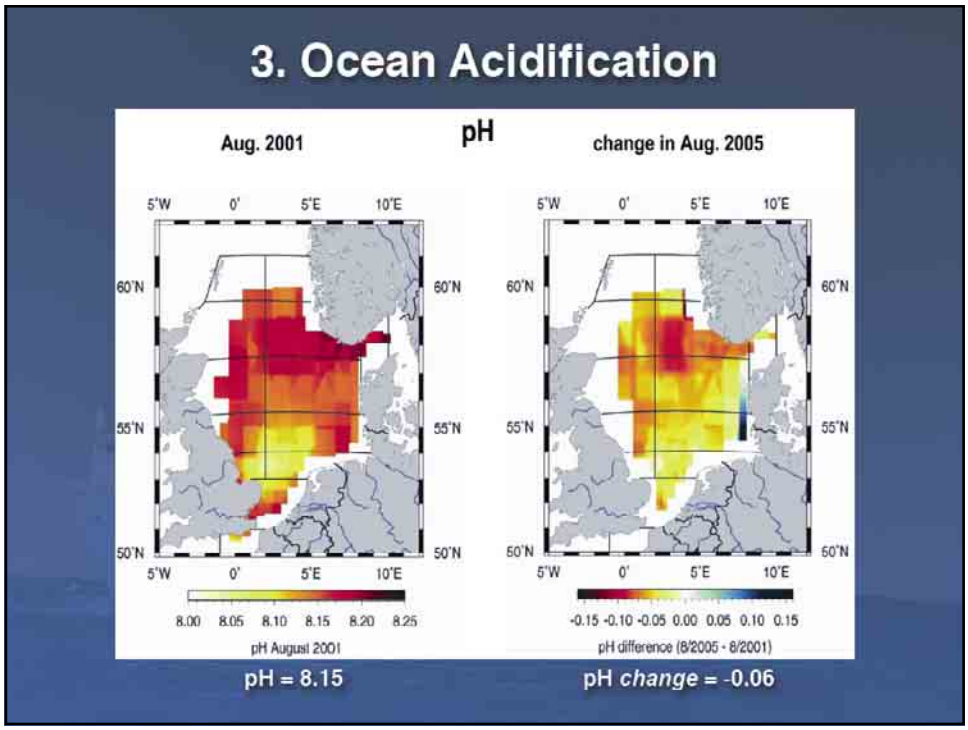
Changes of the CO_2 system in the North Sea.

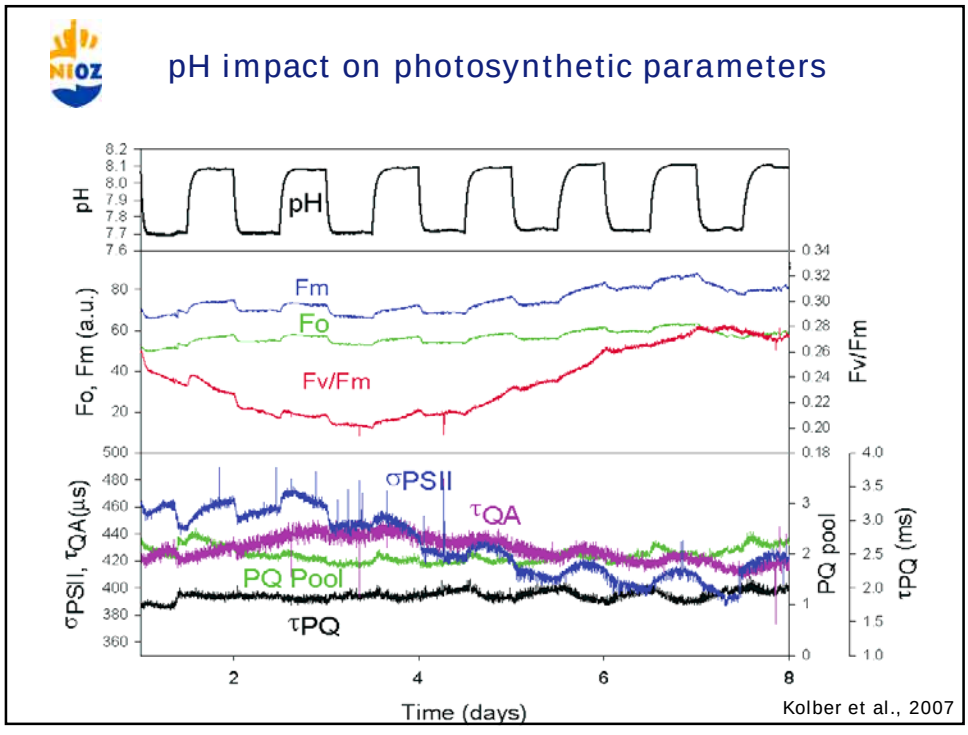
Steven van Heuven[3], Helmuth Thomas[1,2], Hein de Baar[1,3], Friederike Prowe[2], Yann Bozec[1], Laure-Sophie Schiettecatte[4], Kim Suykens[4], Mathieu Koné[4], Alberto Borges[4], Ivan Lima[5] & Scott Doney[5]

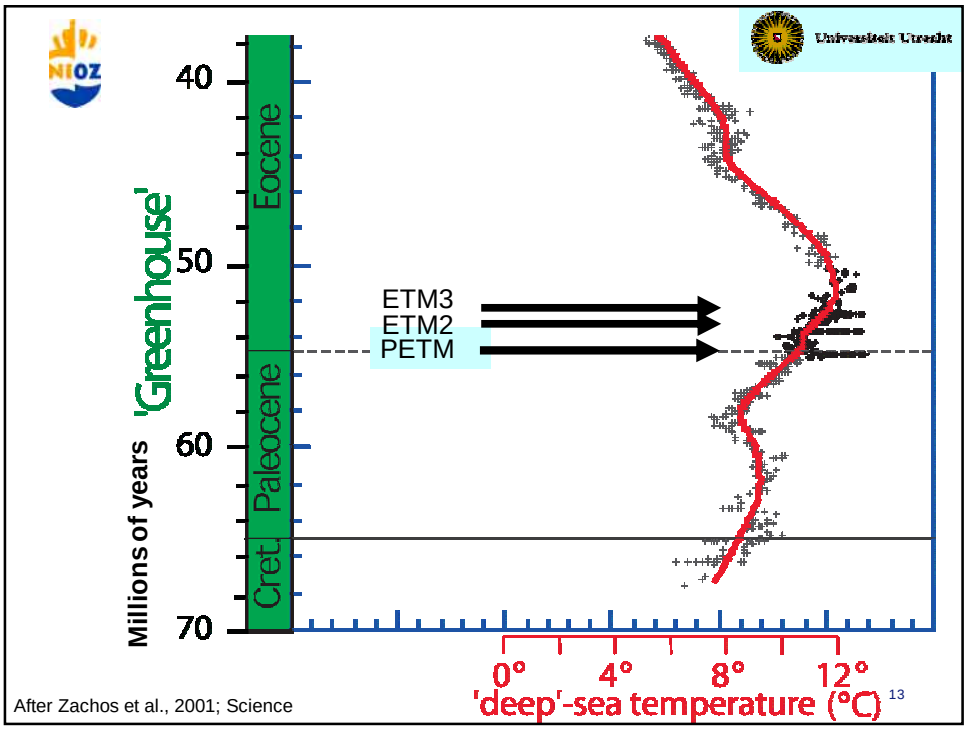
1: Royal Netherlands Institute of Sea Research, Texel, The Netherlands.
2: Dalhousie University, Halifax, Canada.
2: Rijksuniversiteit Groningen, Groningen, The Netherlands.
4: University of Liège, Liège, Belgium.
5: Woods Hole Oceanographic Institution, Woods Hole MA, USA.


1. North Sea Cruises
4 cruises in 4 seasons: 2001/2002
1 cruise in summer 2005
92 stations
6-12 depths each
20.000+ surfacewater pCO_2 data points
Lat °N
Lon °E

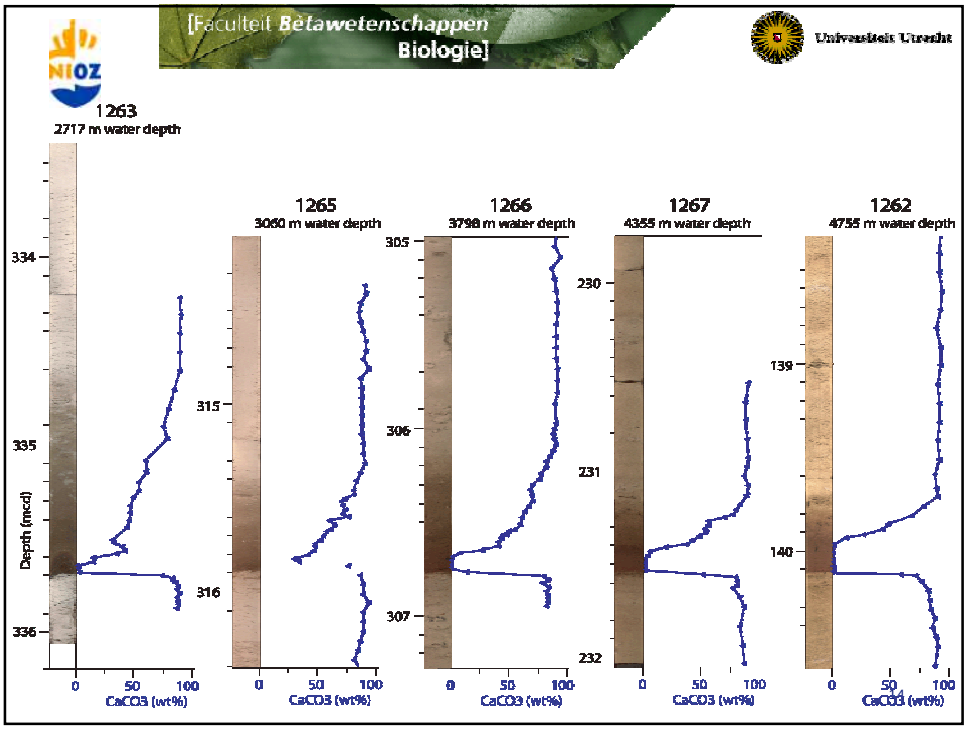

surface pH (February 2002)
surface pH (May 2002)
surface pH (August 2001)
surface pH (November 2001)
Thomas et al., 2008


3. Ocean Acidification
pH
Aug. 2001
change in Aug. 2005
5°W
0°
5°E
10°E
60°N
55°N
50°N
8.00 8.05 8.10 8.15 8.20 8.25
pH August 2001
-0.15 -0.10 -0.05 0.00 0.05 0.10 0.15
pH difference (8/2005 - 8/2001)
pH = 8.15
pH change = -0.06


pH impact on photosynthetic parameters
pH
Fo, Fm (a.u.)
Fv/Fm
σPSII, τQA(µs)
PQ pool
τPQ (ms)
Fm
Fo
Fv/Fm
σPSII
τQA
PQ Pool
τPQ
Time (days)
Kolber et al., 2007



After Zachos et al., 2001; Science



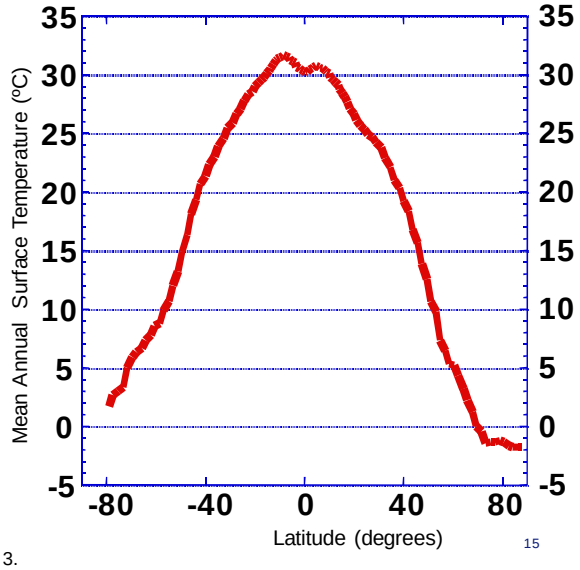
[Faculteit Bètawetenschappen Biologie]

Universiteit Utrecht

Climate modeling? Model-data mismatch!

Climate model for PETM:
Pole – equator – pole temperature

1120 ppm CO_2



Model output Huber and Nof 2006, Palaeo 3.

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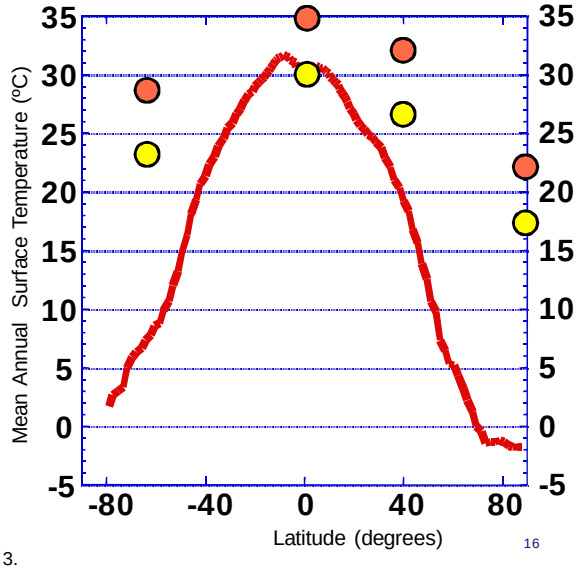
Model-data mismatch

Climate model

Pre/post PETM surface temperature

PETM temperature



Model output Huber and Nof 2006, Palaeo 3.

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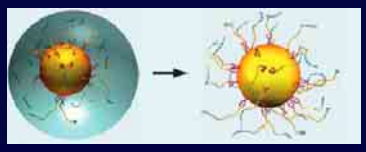
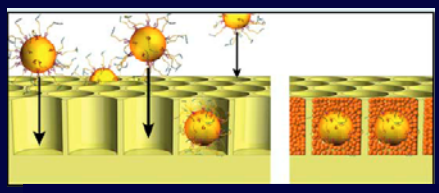
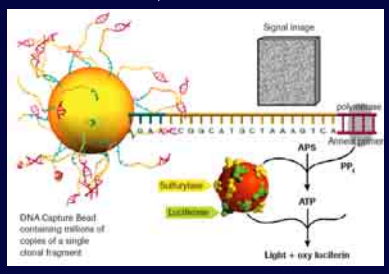
454 Sequencing Technology - Roche Applied Biosystems



Emulsified PCR Reactions
One template - one bead



PicoTiterPlate Reactions

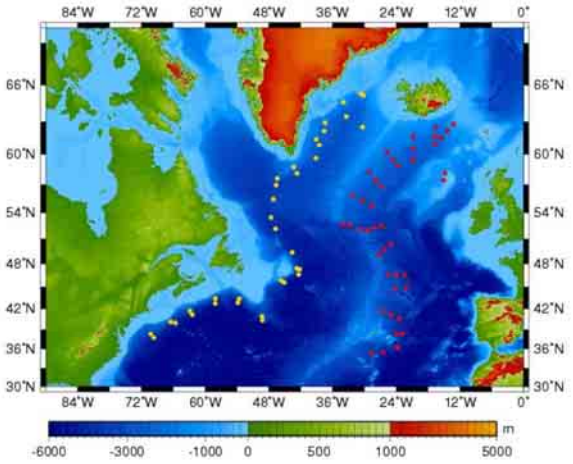


Solid Phase Pyrosequencing

~500,000 reads
80-230 bp in length -
Average = 100 bp

~ $0.02/read

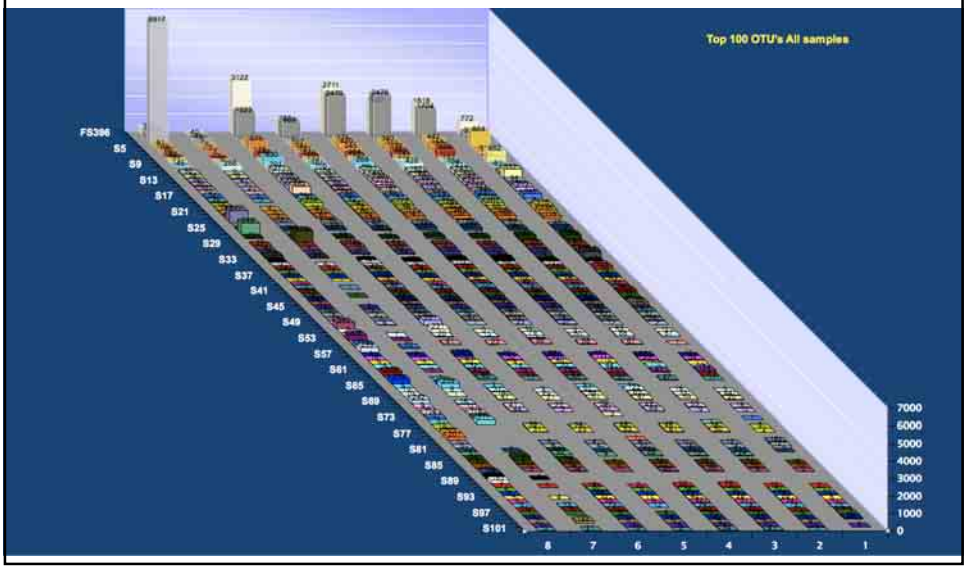
TRANSAT cruise following the flow of the North Atlantic Deep Water (NAD



Gerhard J. Herndl

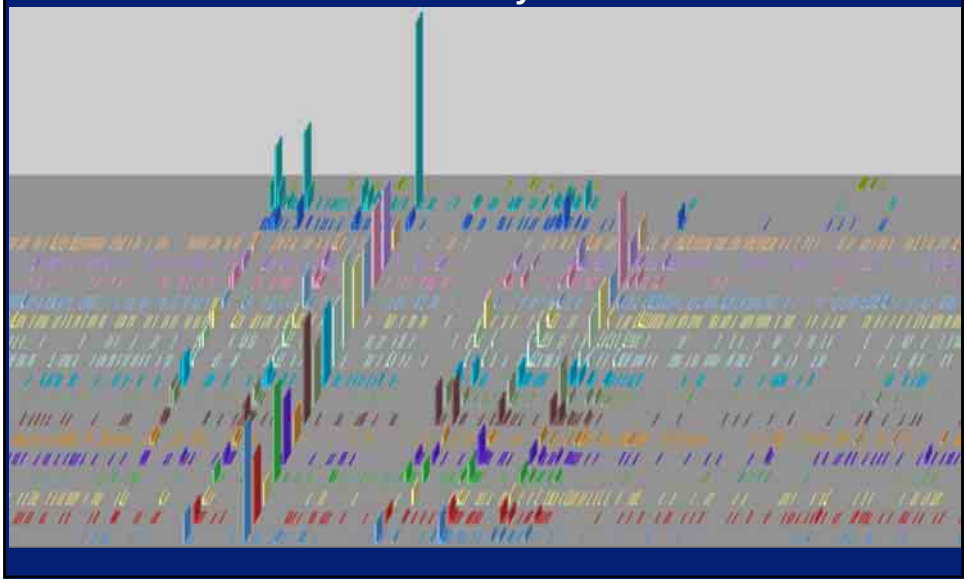
Map of the TRANSAT cruise tracks. Stations occupied during TRANSAT-1 (6 Sep – 4 Oct 02) are indicated by red dots, TRANSAT-2 (9 May – 6 Jun 03) stations are in yellow.

Rare Bacterial biodiversity

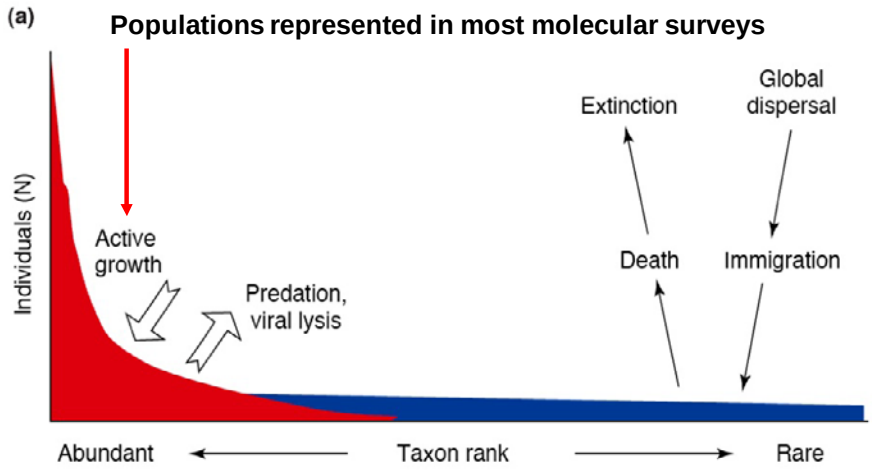


Visualization & Communication

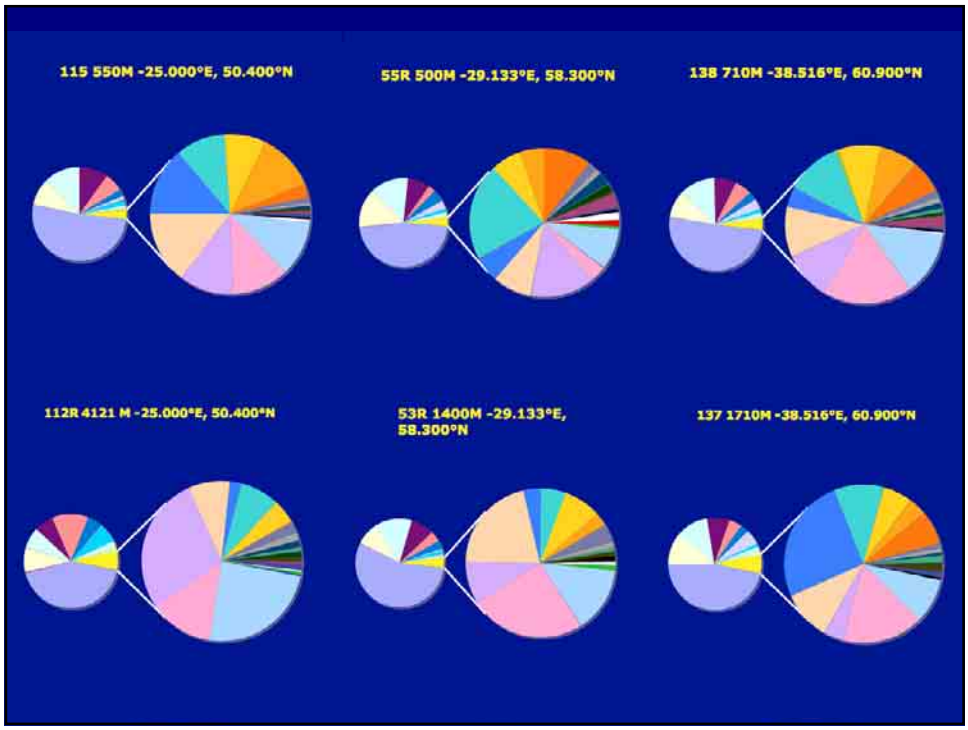
Microbial Skylnes



Unseen microbial diversity



CarlosPedro´s-Alio TRENDS in Microbiology Vol.14 No.6 June2006



Research Strategy and Science Agenda/Recommendations

POGO and GEOSS (Global) perspective:

- Embed OA research in a global context as far as Observations and Data management are concerned, i.e.:
a) Collaborate closely with global observation programs such as GEOSS, Ocean Sites, HOTS, BATS, ESTOC, DYFAMED, etc. to standardize and harmonize on observational instruments, their calibration, on new technical developments, data acquisition, data handling and databases (e.g. GLODAP), data transformation into information to politicians, decision makers, the public at large
b) Pay attention to capacity building (through POGO/SCOR or others) realizing that the oceans are all connected and that two thirds of the oceans are in the southern hemisphere, whereas the funding is in the northern hemisphere
c) Repeat WOCE lines and revisit JGOFS stations

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Research Strategy and Science Agenda/Recommendations

- MB/ESF (European) perspective:

-Tune new OA research to existing programs with an OA component (EPOCA, CarboOcean, GMES, ...)

-Make sure that observations are made and data are handled under the (future) coordinating umbrella of EMODN (European Marine Obseration and Data Network; EC blue book as a response on the green paper and Aberdeen declaration) assuming that EMODN will collaborate with GEOSS, etc.

- Data mining; A lot of “hidden”, partly non-digitalized data relevant for OA are present in many European marine stations and institutes. Try to surface those data through the MARS (Marine Research Stations) organization

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Research Strategy and Science Agenda/Recommendations

- MB/ESF (European) perspective (continued):

- Make sure that OA research in Europe is well organized per region (Baltic, North Sea, N-E Atlantic, Mediterranean, Black Sea), although coordinated under one umbrella (EMODN) to make sure that instruments and data are harmonized.

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Research Strategy and Science Agenda/Recommendations

- ICoMM (International Census of Marine Life)/CoML (Census of Marine Life) perspective:

Microbes (Protisits, Bacteria, Archae, Viruses) rule the biogeochemical C, N, S, etc. cycles. Because we don't have any idea how the microbial diversity (including the rare biodiversity) responds to OA we don't have a clue about changes in biogeochemical cycles and therefore about the future climate (e.g. N_2-fixing bacteria, NH_4^+ using Archaea, AOM, Annamox, SO_4^--reducing bacteria, etc., etc.)

-Hence, lab-, mesocosm- and in-situ experiments are badly needed to better understand OA-related changes in microbial communities

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Research Strategy and Science Agenda/Recommendations

-ICoMM (International Census of Marine Life)/CoML (Census of Marine Life) perspective (continued):

-Don't focus on (de)calcification only!!

- Changes of microbial diversity and associated biogeochemical cycles must be followed through seasonal high-resolution studies over the year since the pH (as well as other parameters) will change dramatically time wise.

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Research Strategy and Science Agenda/Recommendations

- General perspectives:

- Perform high-resolution palaeo-climatic studies of palaeo greenhouse/low pH worlds (e.g. PETM, ELMO's, etc.) to learn from the past; Remember, the past is the key to the future!

-Economic and social consequences of an acid ocean (fisheries, shell fisheries, aquaculture, climate change, tourism, red tides, etc.)

-Outreach

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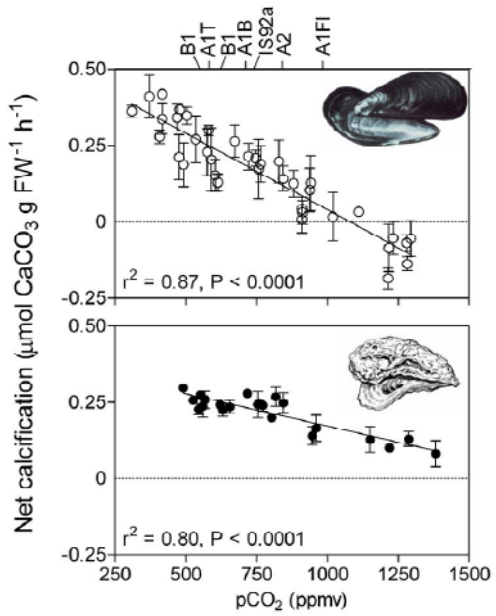

Mytilus edulis

Crassostrea gigas

Gazeau, F., C. Quiblier, J. M. Jansen, J.-P. Gattuso, J. J. Middelburg, and C. H. R. Heip. 2007
Impact of elevated CO2 on shellfish calcification
Geophysical Research Letters
34:L07603

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Thank you for your attention

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