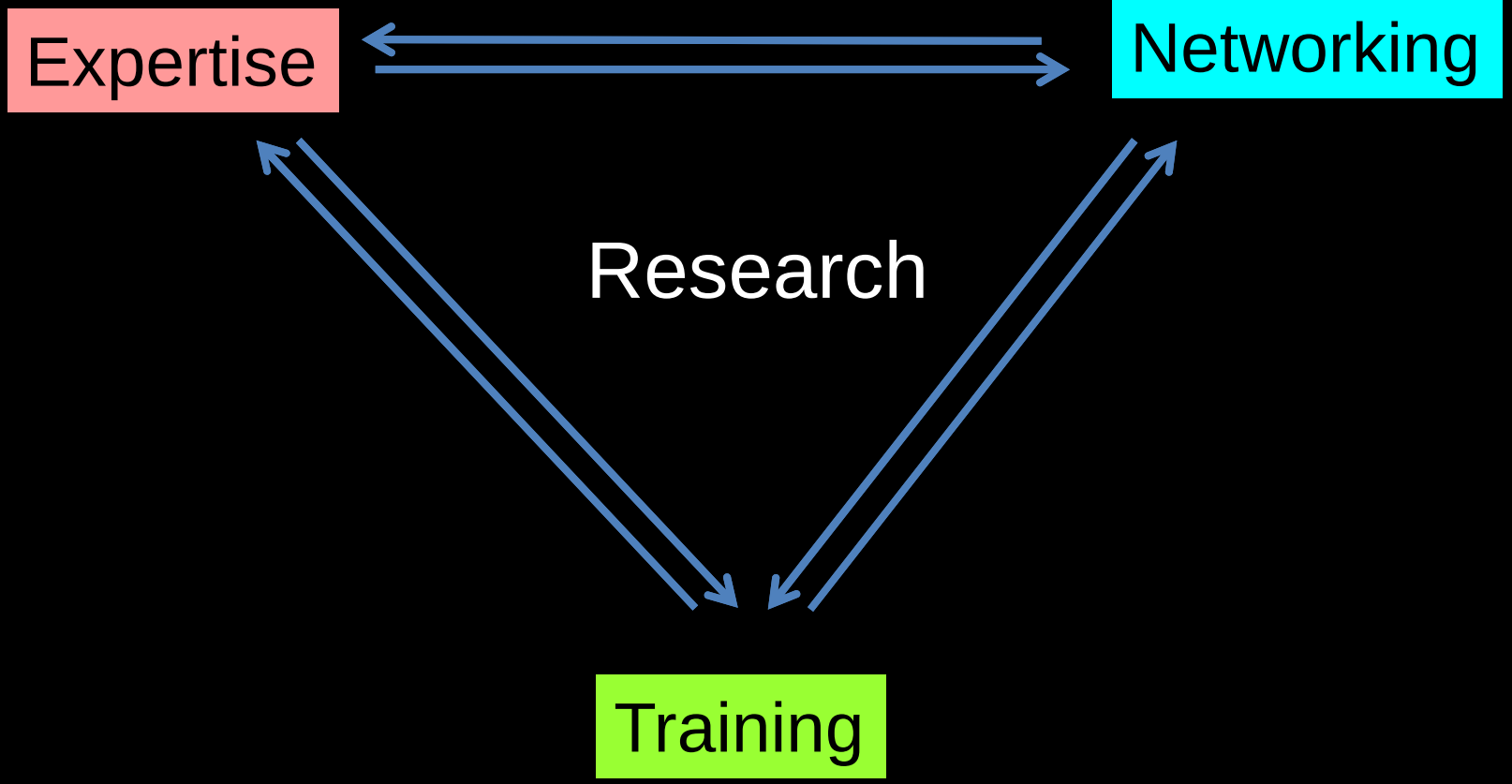
UNIVERSITEIT GENT

Reflections on past, present and future challenges in deep-sea research

Ann Vanreusel

Research

VLIZ jongerendag 15 februari 2013

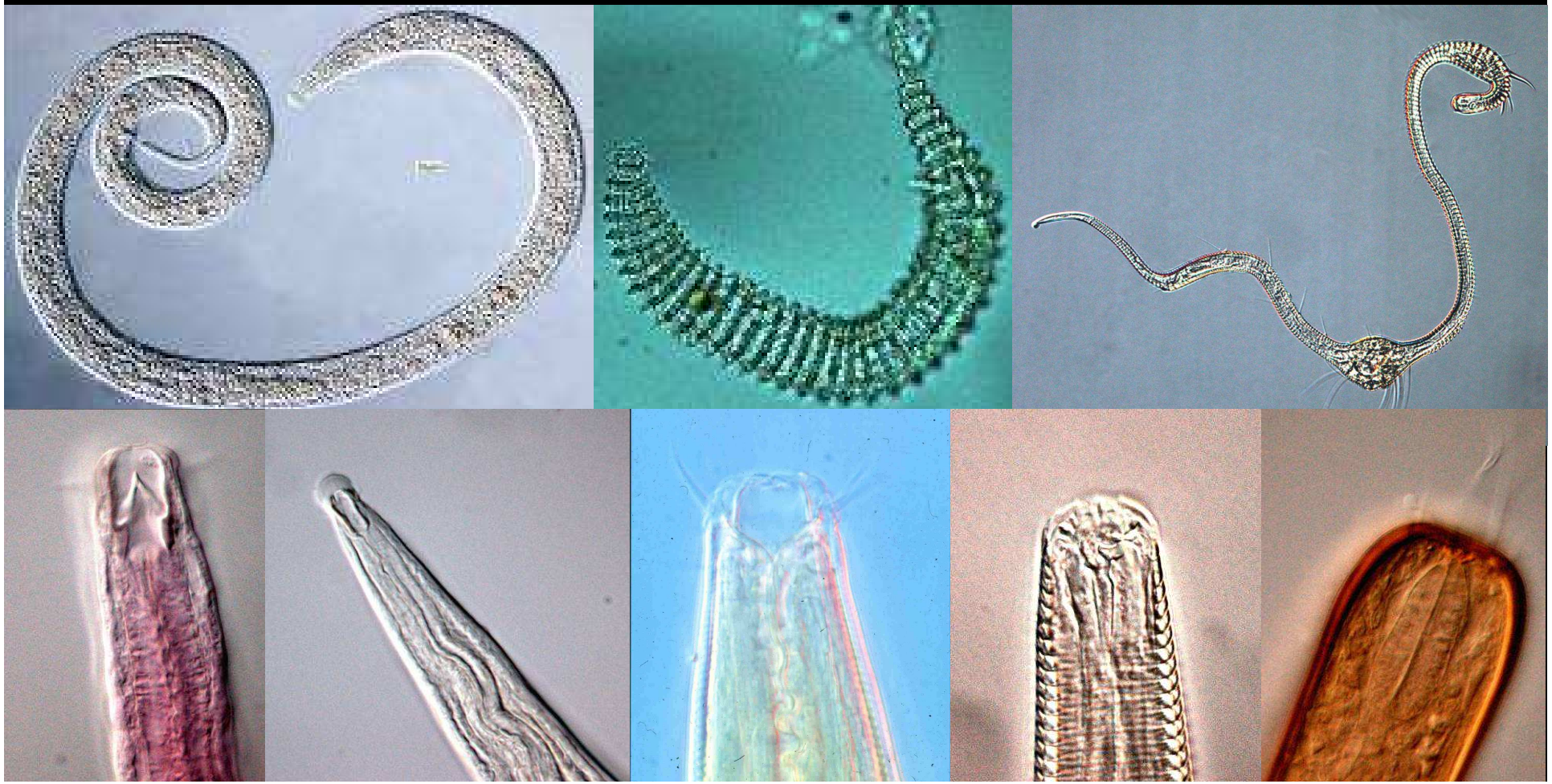

Expertise
Networking
Research
Training

Taxonomy of free-living marine nematodes

- School of University Ghent (Profs L. De Coninck, A. Coomans **and M.Vincx)**

Expertise

+ Marine benthic ecology (Prof C. Heip)

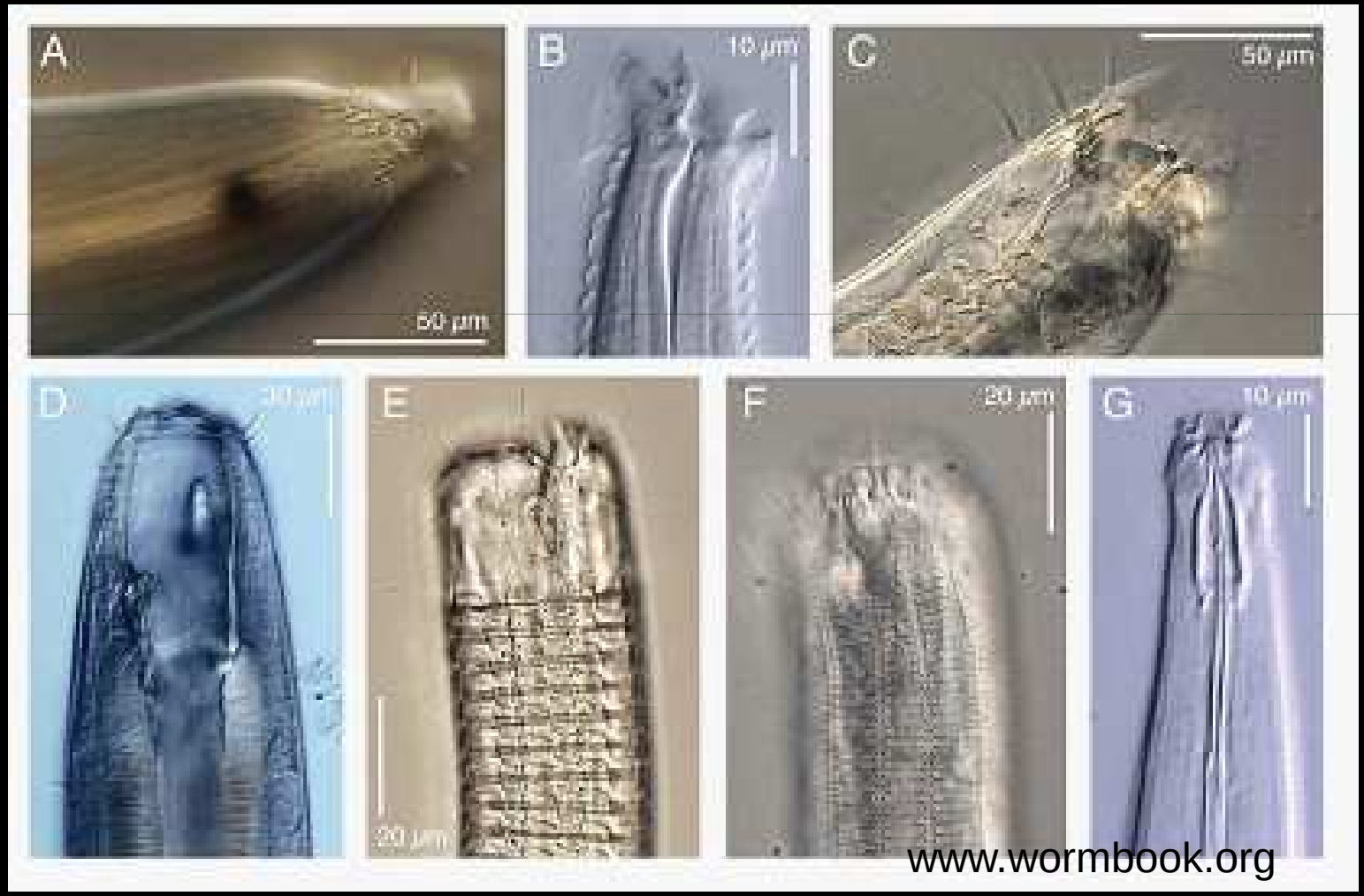


Small is not always popular……

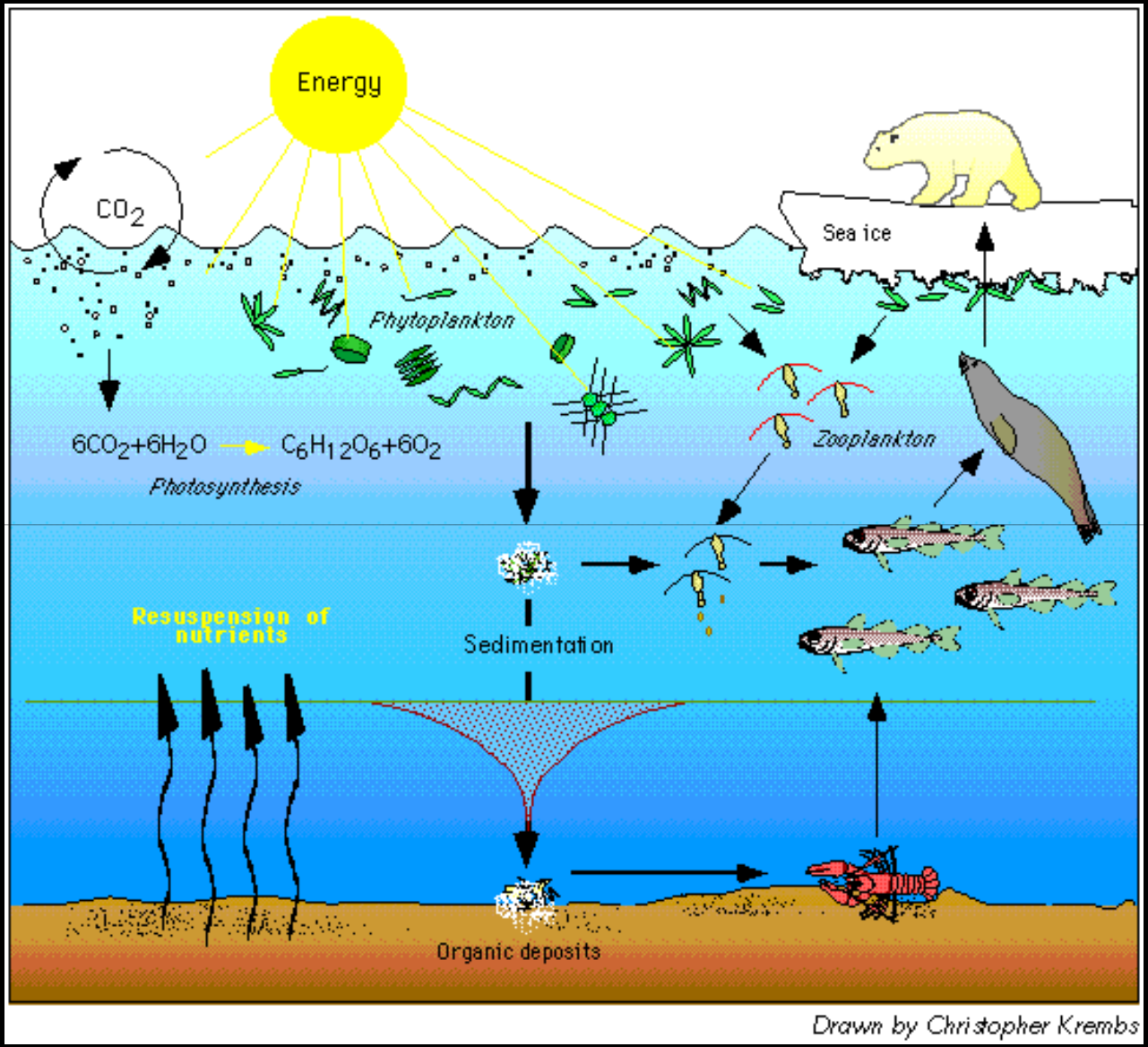
….also rather complex taxonomy ….(training required)

……but diverse and abundant in all marine sediments

especially in the deep sea.



No light below 1000 m ➔ Main food input from surface waters where phytoplankton blooms.



Only few % of surface organic matter arrives at sea floor …..

…….where it serves as food for the benthos.

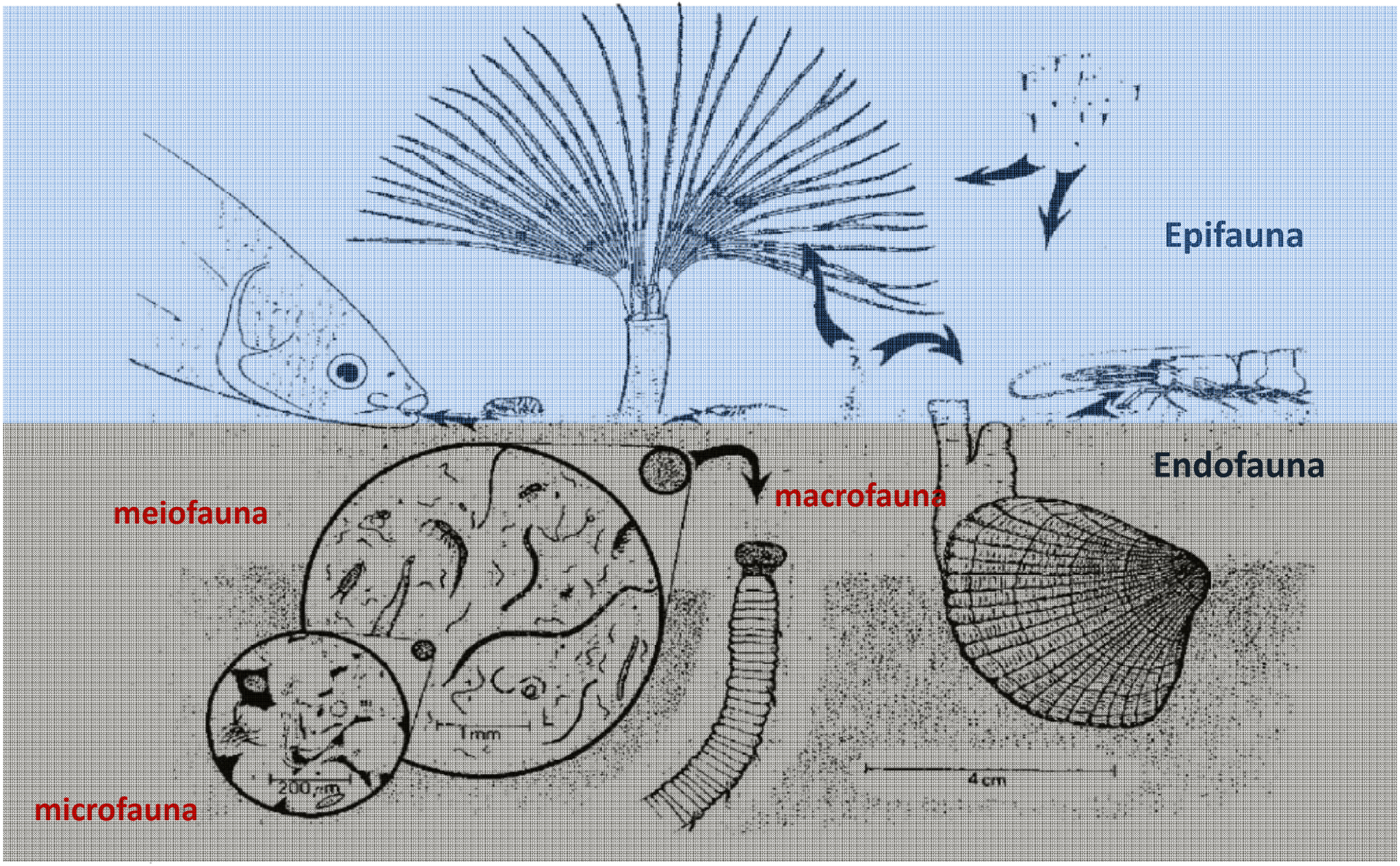


Figure 3.7.--Hypothetical benthic food web, illustrating possible connections between meiofauna and macrofauna (from Platt, 1981).

✓ Decrease in densities and biomass of benthic fauna with increasing water depth

✓ Lower biomass on seafloor of central oceans

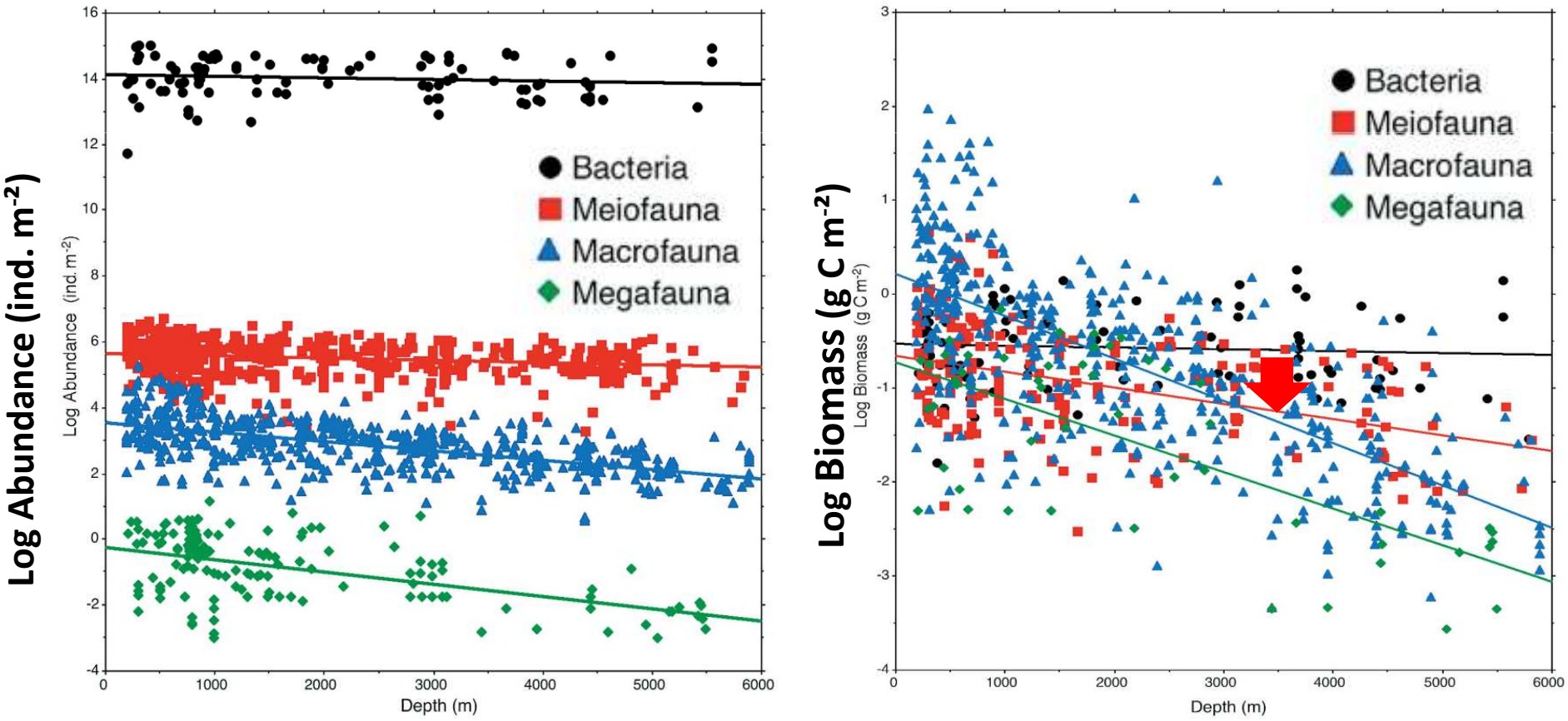
✓ **For smaller taxa the decrease is less prominent than for larger organisms**

✓ **Smaller organisms become relatively more important with depth in some areas**

Densities

Rex et al. (2006)

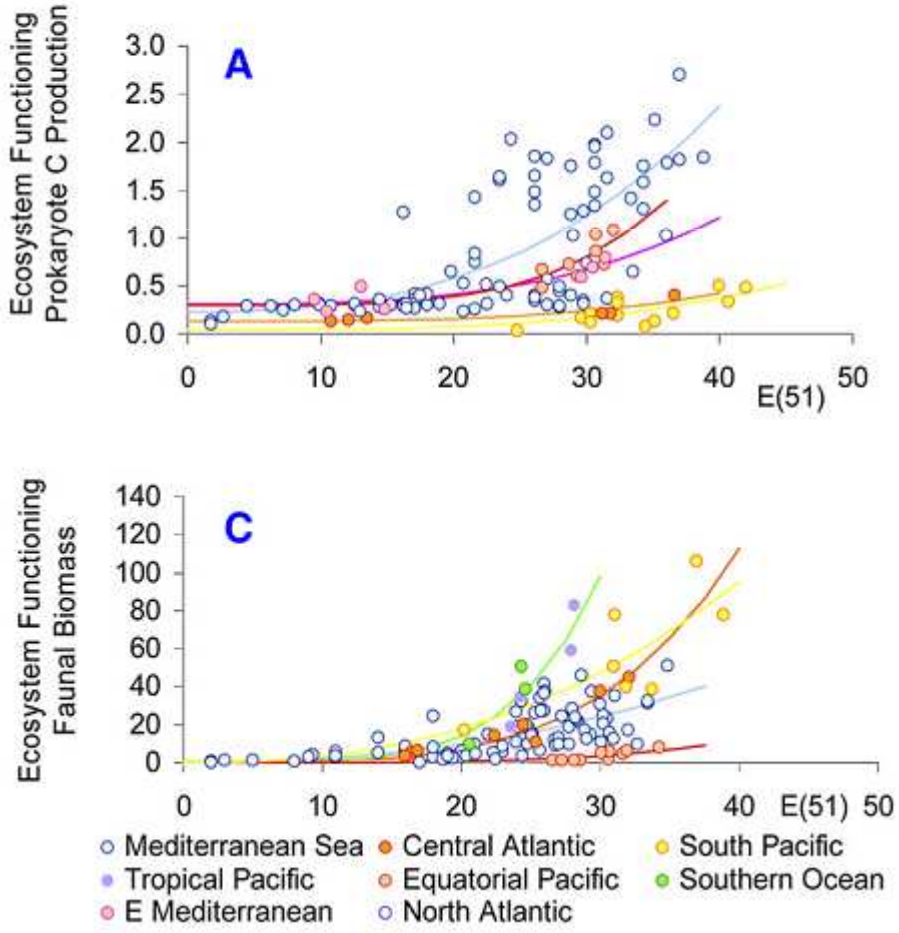
Biomass



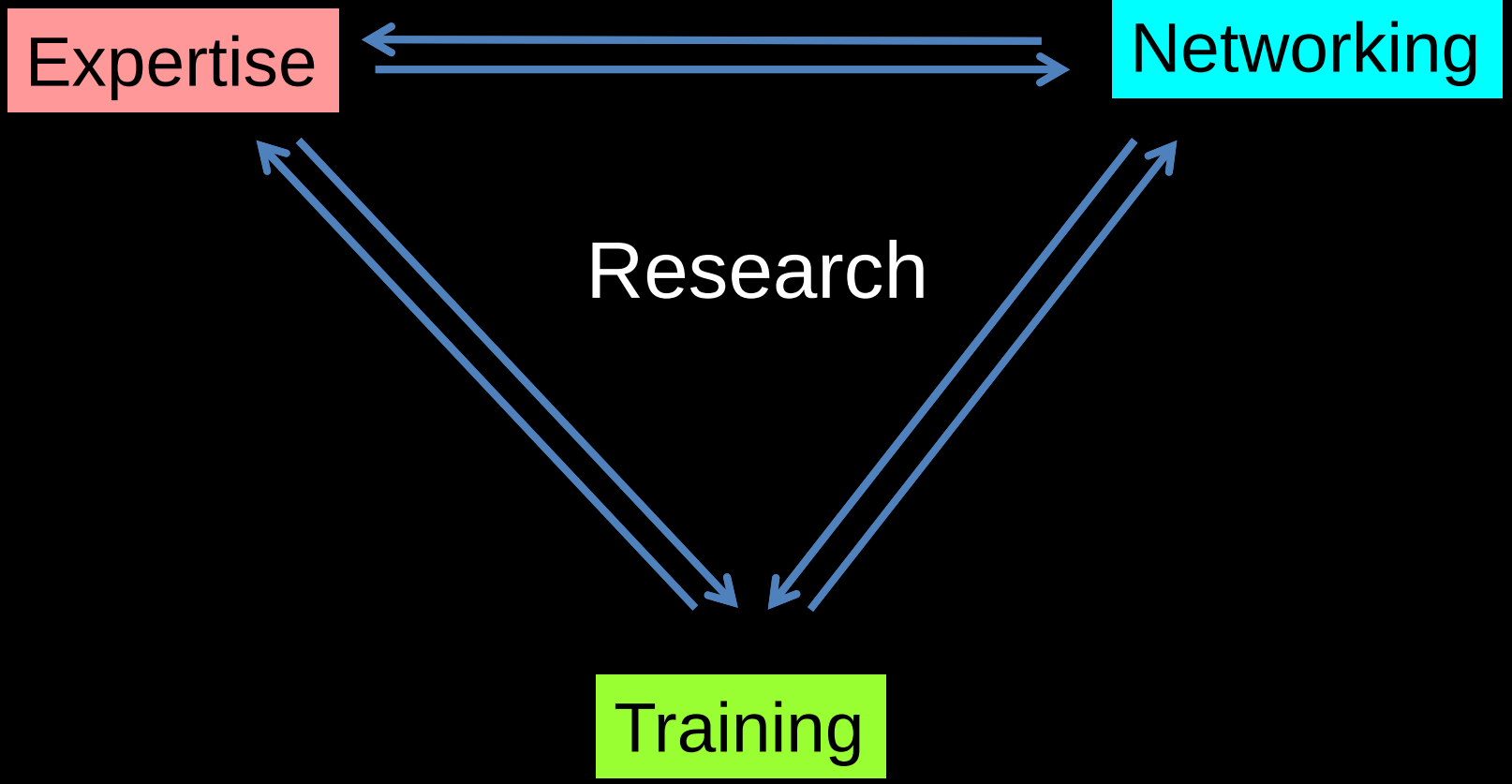
Current Biology *18*, 1–8, January 8, 2008 ©2008 Elsevier Ltd All rights reserved DOI 10.1016/j.cub.2007.11.056

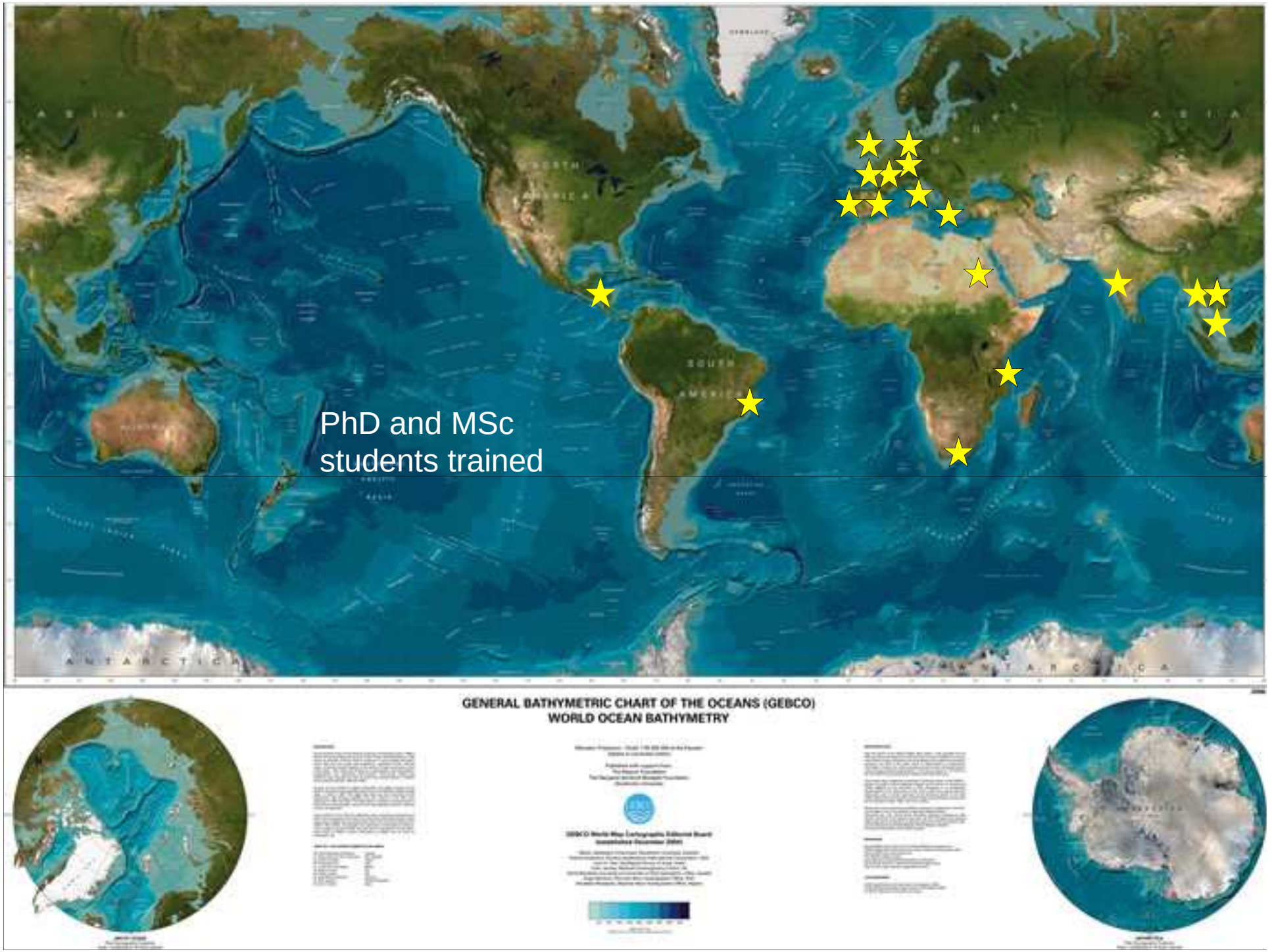
Nematodes used as model group for patterns and processes in the deep sea

Exponential Decline of Deep-Sea Ecosystem Functioning Linked to Benthic Biodiversity Loss



Danovaro et al 2008


Expertise
Networking
Research
Training


PhD and MSc
students trained
GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)
WORLD OCEAN BATHYMETRY

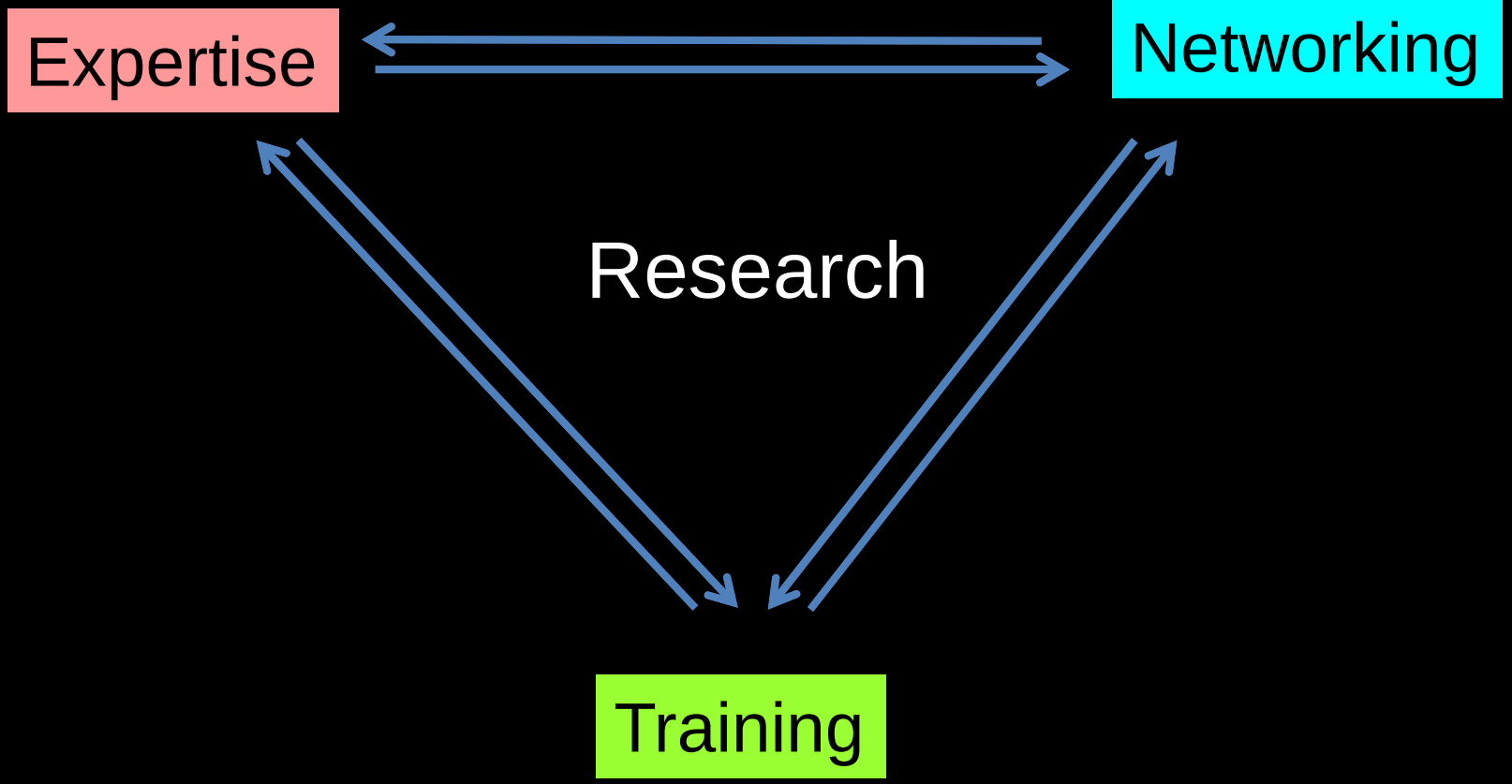
Recife, Brazil August 2012

Ho Chi Minh, Vietnam, September

Gent September 2011

Naivasha Kenya 2009

Photo N. Koedam

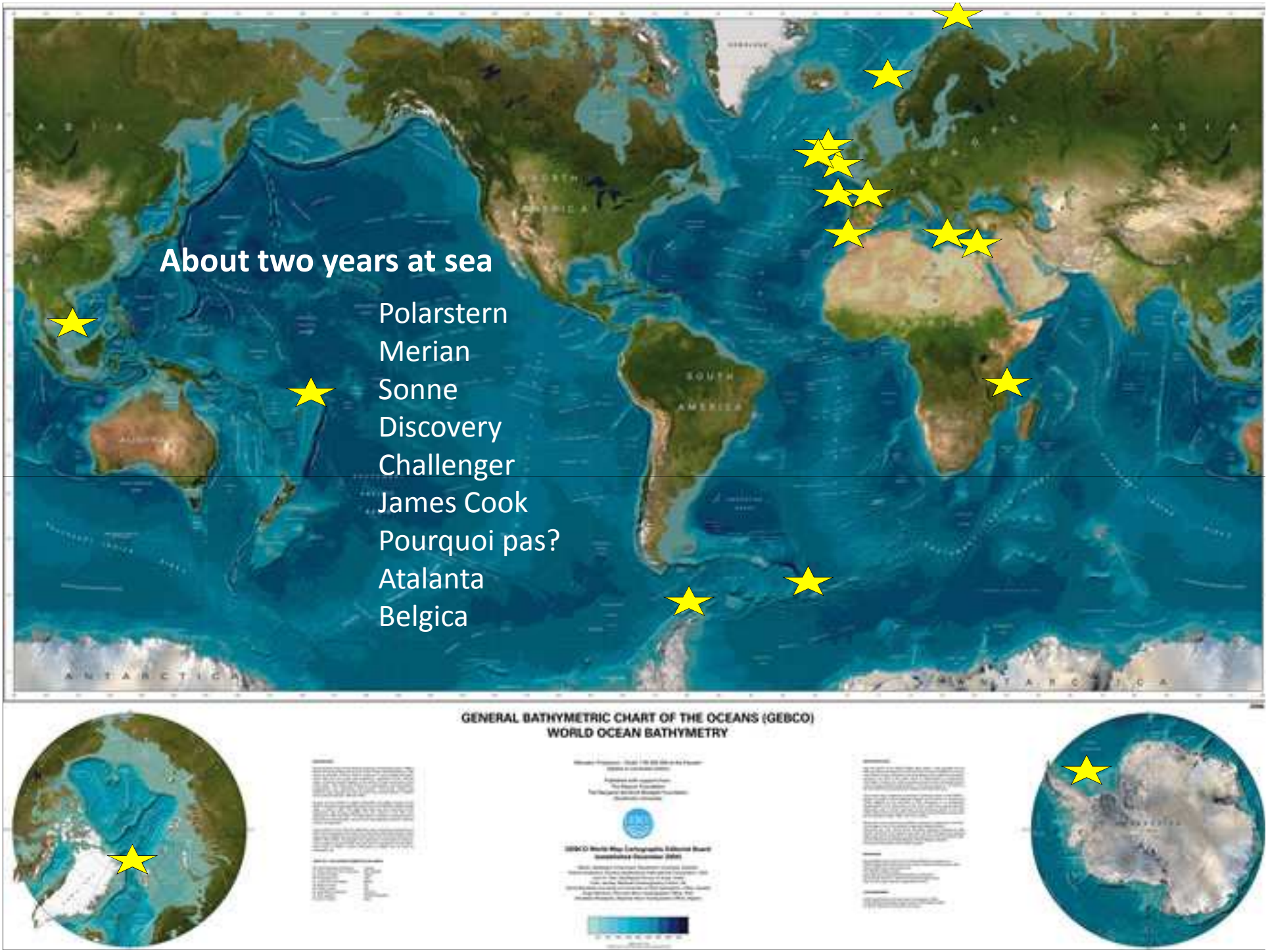

Expertise
Networking
Research
Training

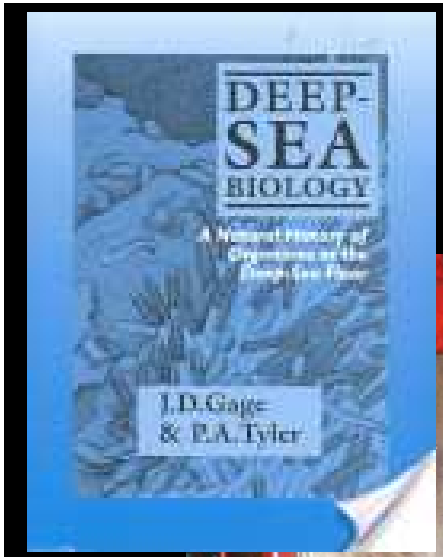
Field work

Coordination and Integration

International research projects

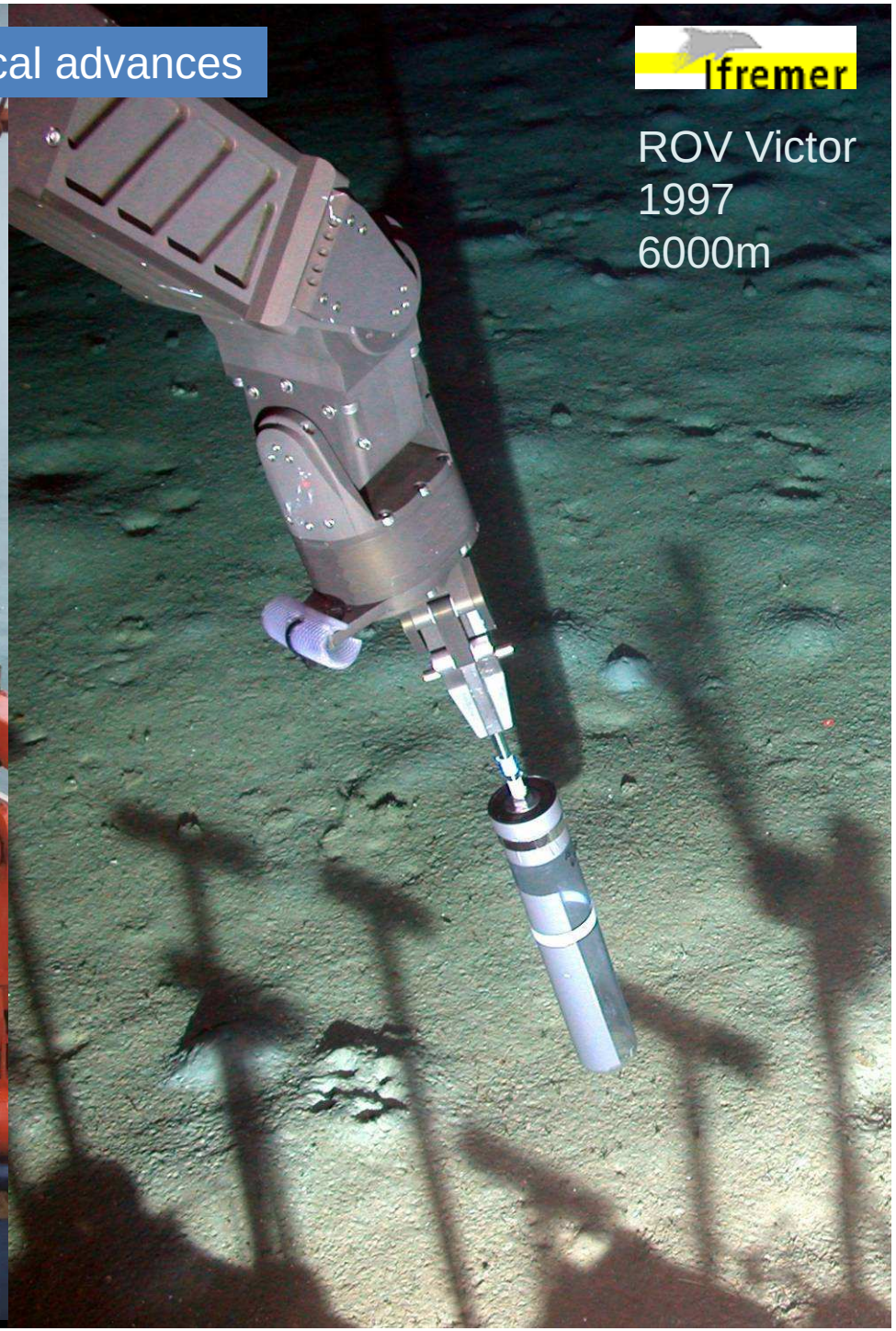
Networking


About two years at sea
Polarstern
Merian
Sonne
Discovery
Challenger
James Cook
Pourquoi pas?
Atalanta
Belgica
GENERAL BATHYMETRIC CHART OF THE OCEANS (GEBCO)
WORLD OCEAN BATHYMETRY


DEEP-
SEA
BIOLOGY
A Natural History of
Organisms at the
Deep Sea Floor
J.D.Gage
& P.A.Tyler


Blind sampling

Technological advances



ROV Victor
1997
6000m

-In situ real time observation

-In situ measurements

-High accesibility

-Large scale mapping

-Small scale sampling

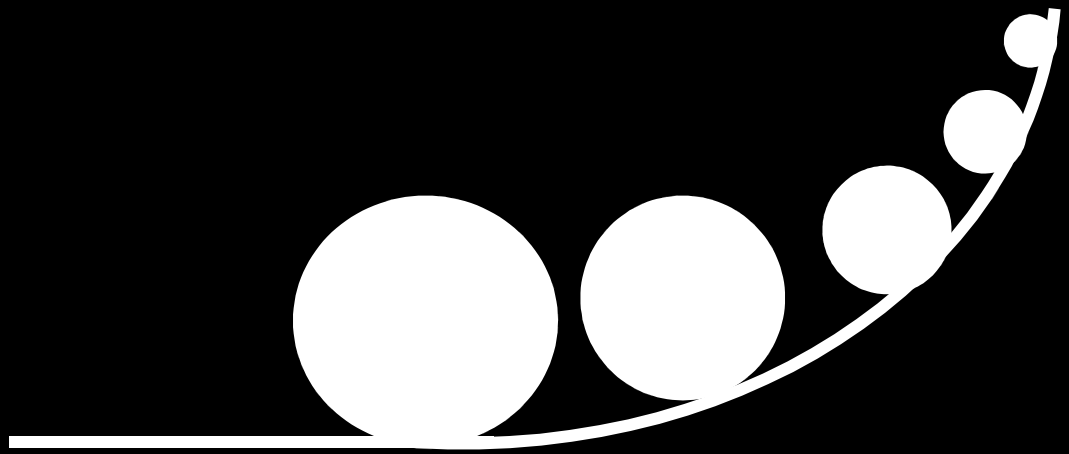
-Interdisciplinary approach

Field work

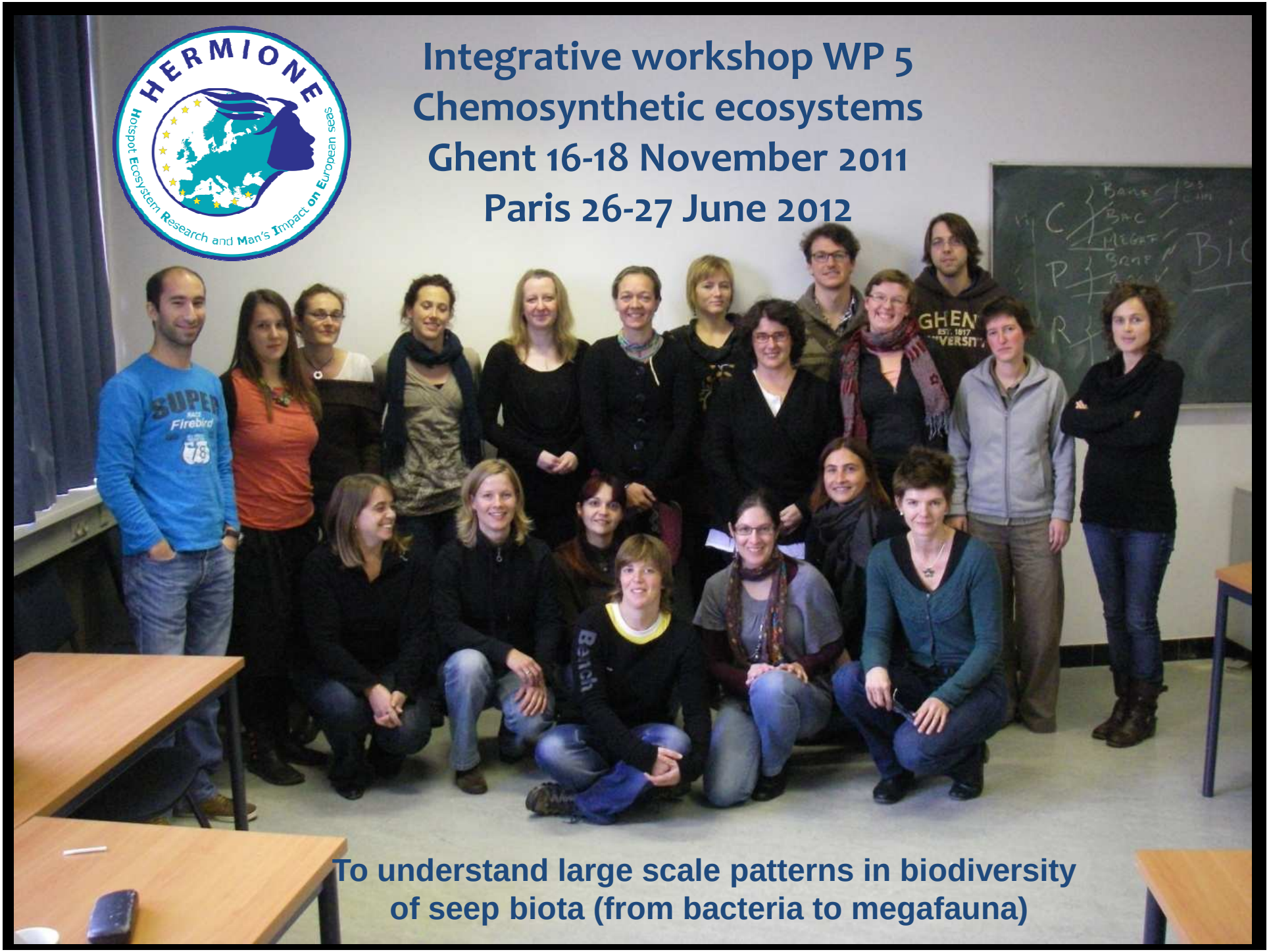
Coordination and Integration

International research projects

Networking



Integrative workshop WP 5
Chemosynthetic ecosystems
Ghent 16-18 November 2011
Paris 26-27 June 2012



To understand large scale patterns in biodiversity of seep biota (from bacteria to megafauna)

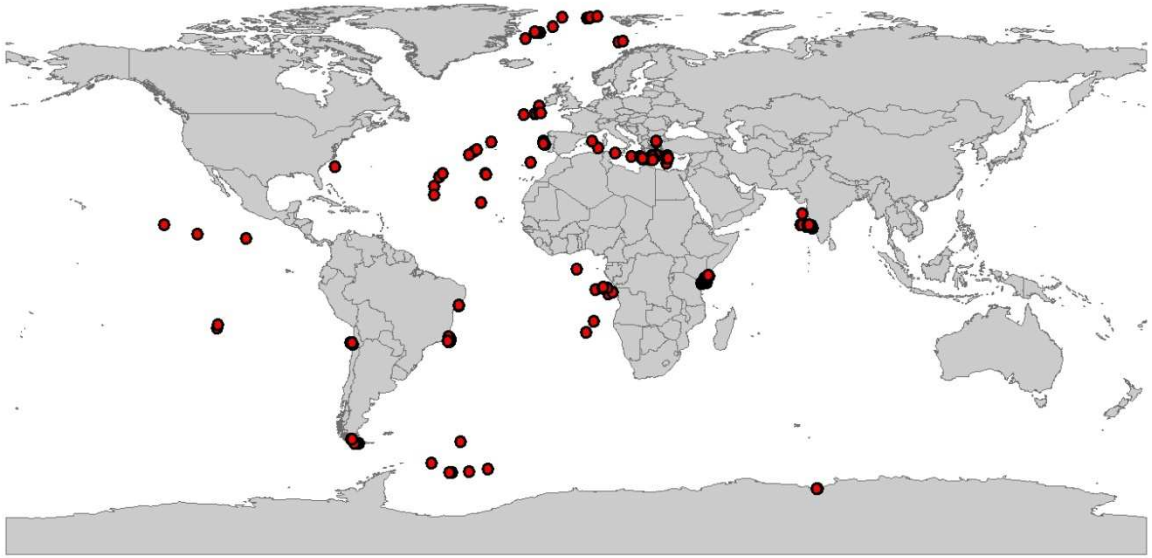
marine ecology
an evolutionary perspective

Marine Ecology. ISSN 0173-9565

SPECIAL TOPIC

The contribution of deep-sea macrohabitat heterogeneity to global nematode diversity

Ann Vanreusel[1], Gustavo Fonseca[2], Roberto Danovaro[3], Maria Cristina da Silva[4], André M. Esteves[4], Tim Ferrero[5], Gunnar Gad[6], Valentina Galtsova, Cristina Gambi[3], Veronica da Fonsêca Genevois[4], Jeroen Ingels[1], Baban Ingole[7], Nikolaos Lampadariou[8], Bea Merckx[1], Dmitry Miljutin[9], Maria Miljutina[9,10], Agnes Muthumbi[11], Sergio Netto[12], Daria Portnova[10], Teresa Radziejewska[13], Maarten Raes[1], Alexei Tchesunov[14], Jan Vanaverbeke[1], Saskia Van Gaever[1], Virág Venekey[15], Tania Nara Bezerra[1], Hannah Flint[16], John Copley[16], Ellen Pape[1], Daniela Zeppilli[3], Pedro Arbizu Martinez[9] & Joelle Galeron[17]



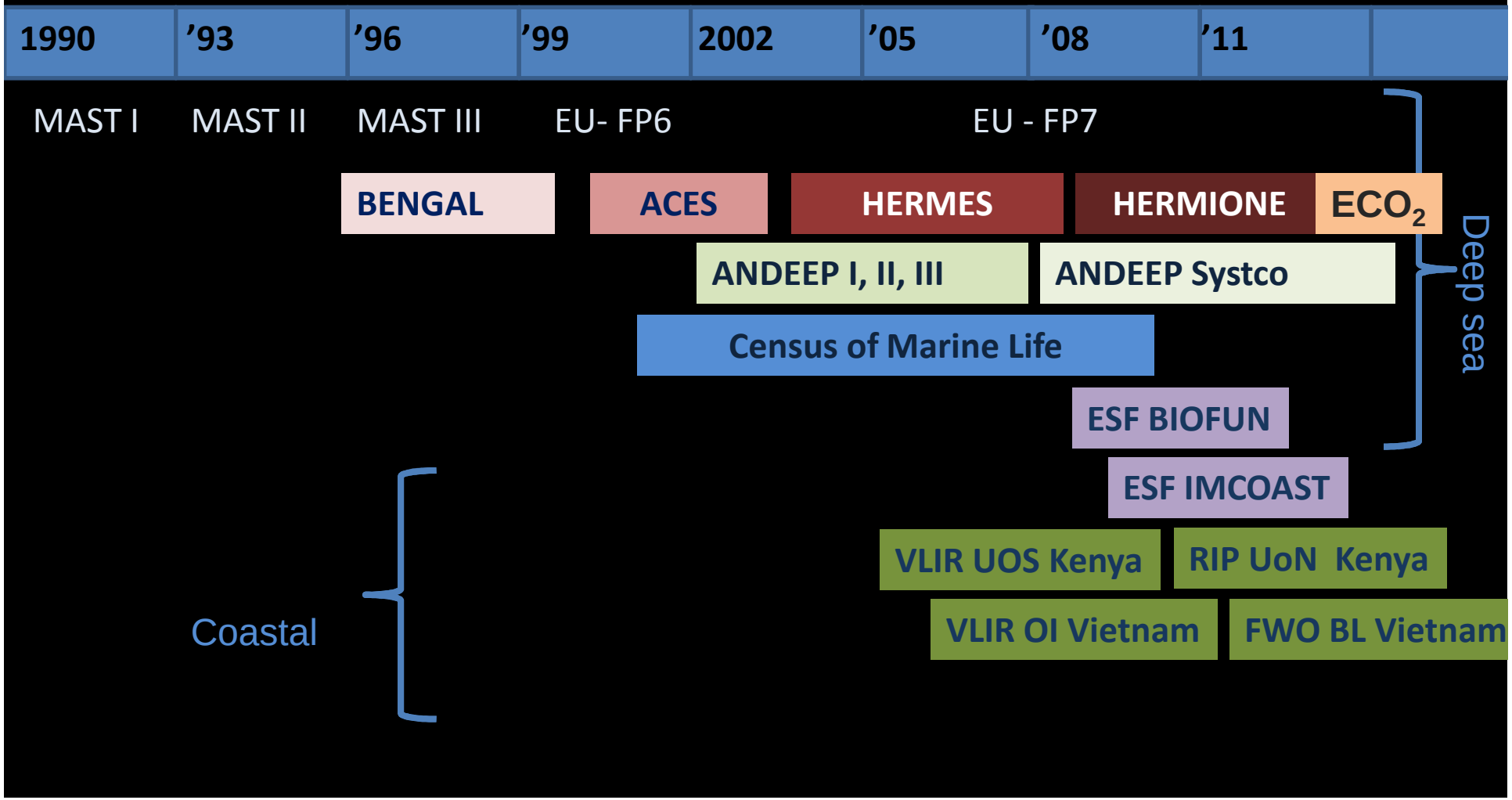
Collaborate – Meet and Share

➔ Enlarge scale

➔ Widen context

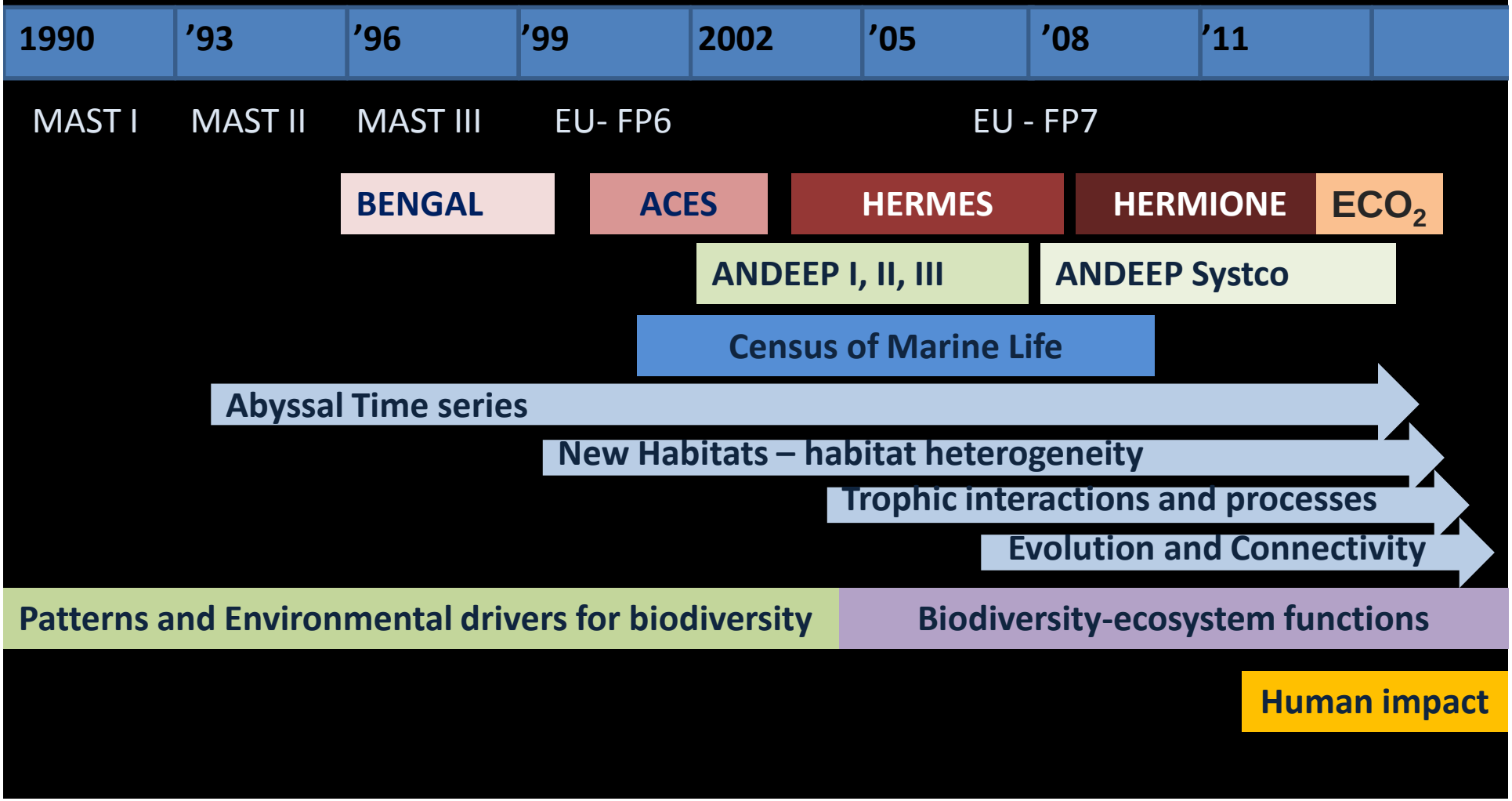
Benthos - Biodiversity

International → interdisciplinary



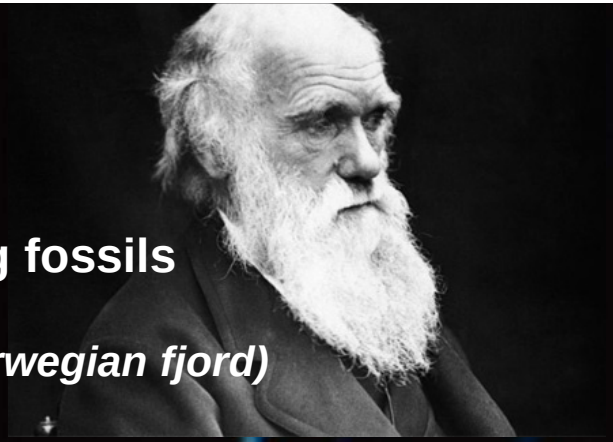
Benthos - Biodiversity

International → interdisciplinary




19th century

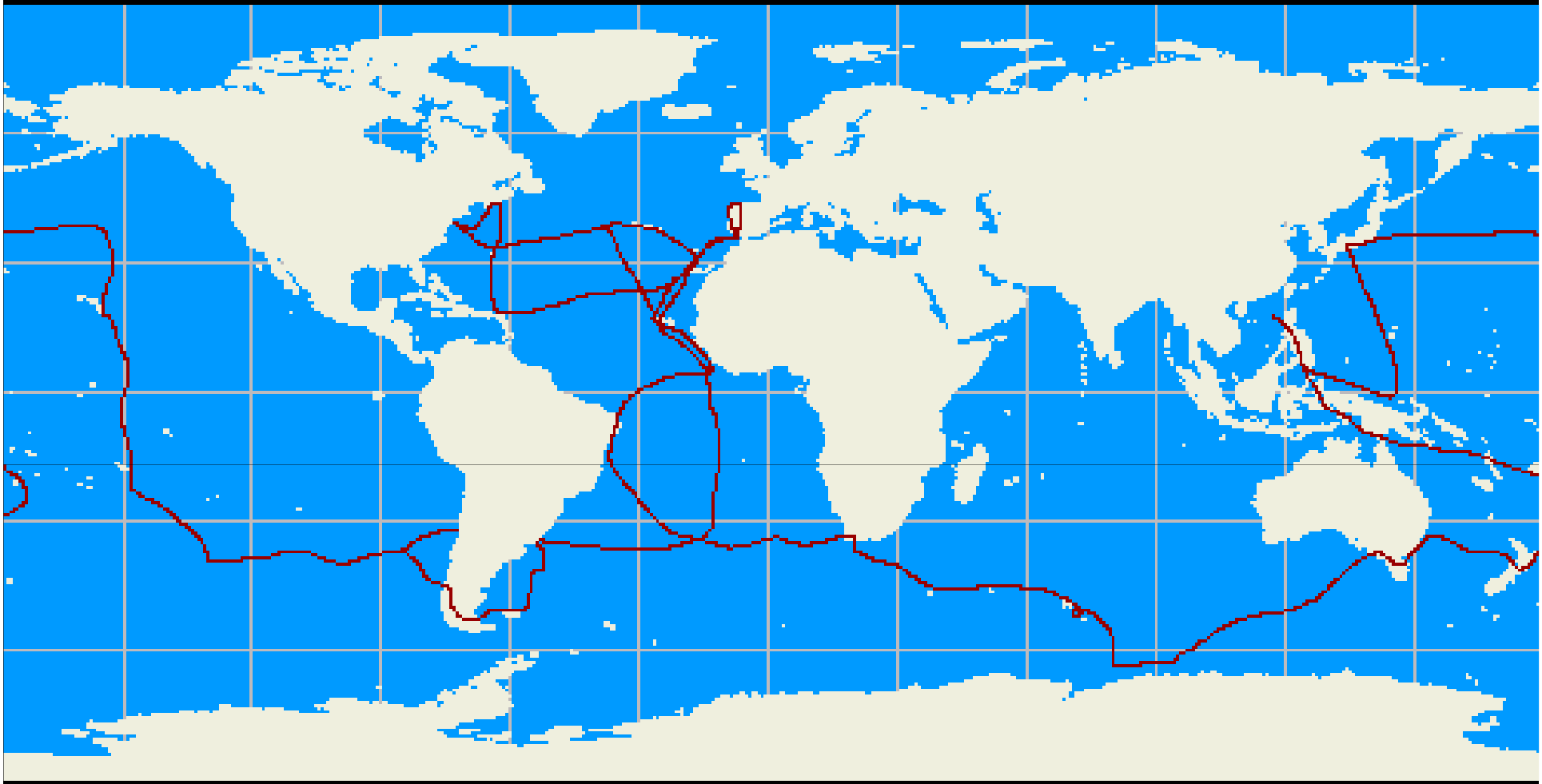
Darwin's origin of species (1859) :



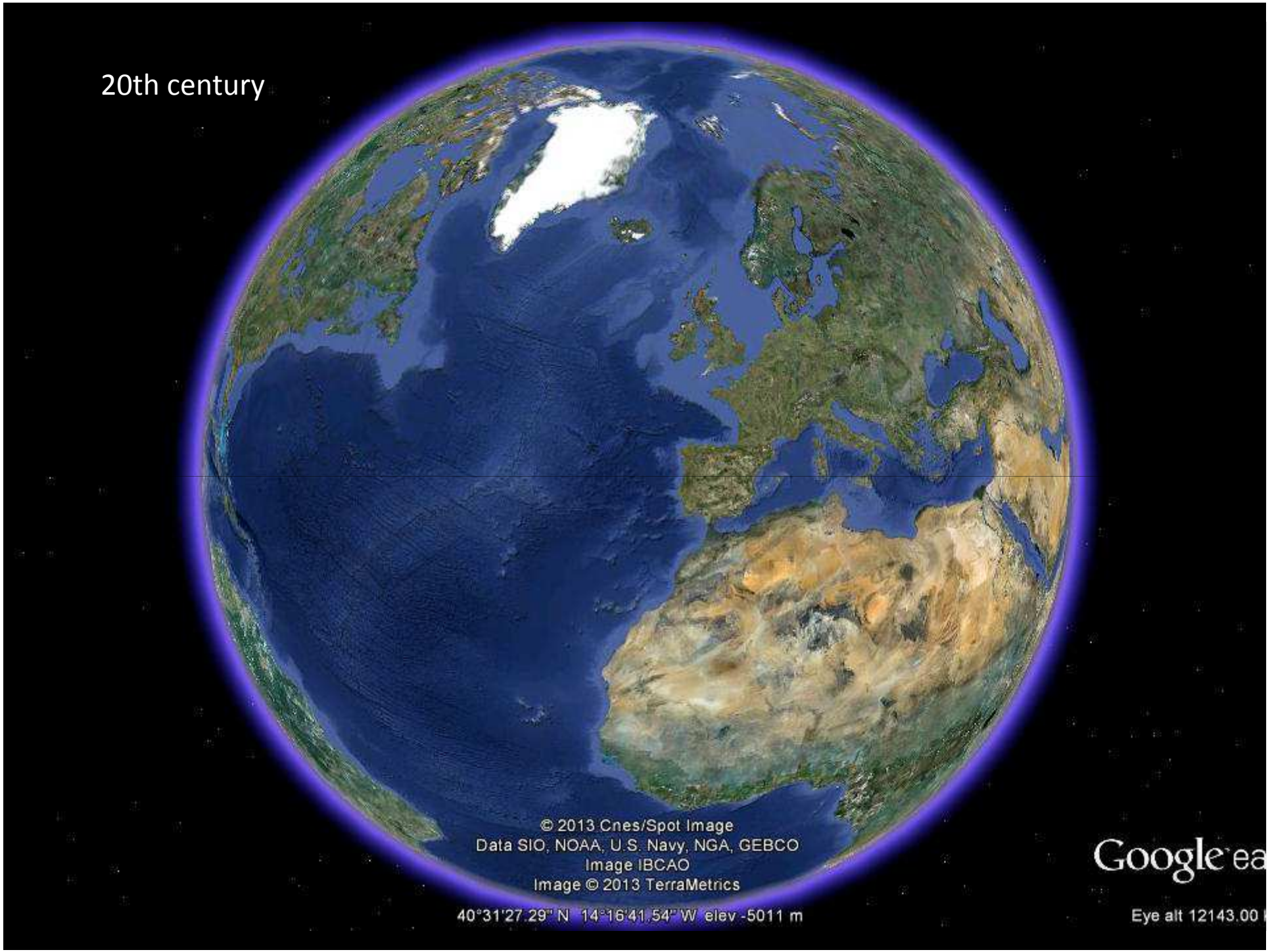
Azoic character of deep sea challenged
➔ idea of archaic life in deep sea : refuge for living fossils

(supported by stalked sea lily in Sars collection from Norwegian fjord)

The Challenger expedition of 1872-1876 was a scientific expedition that made many discoveries to lay the foundation of oceanography.



- ✓ no living fossils found
- ✓ sediments consist of ooze
- ✓ animal life up to 5.5 km (dredging)
- ✓ first indication of high biodiversity
- ✓ high degree of cosmopolitan species


20th century
© 2013 Cnes/Spot Image
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image IBCAO
Image © 2013 TerraMetrics
40°31'27.29" N 14°16'41.54" W elev -5011 m
Google ea
Eye alt 12143.00

Deep sea habitat discovery rate

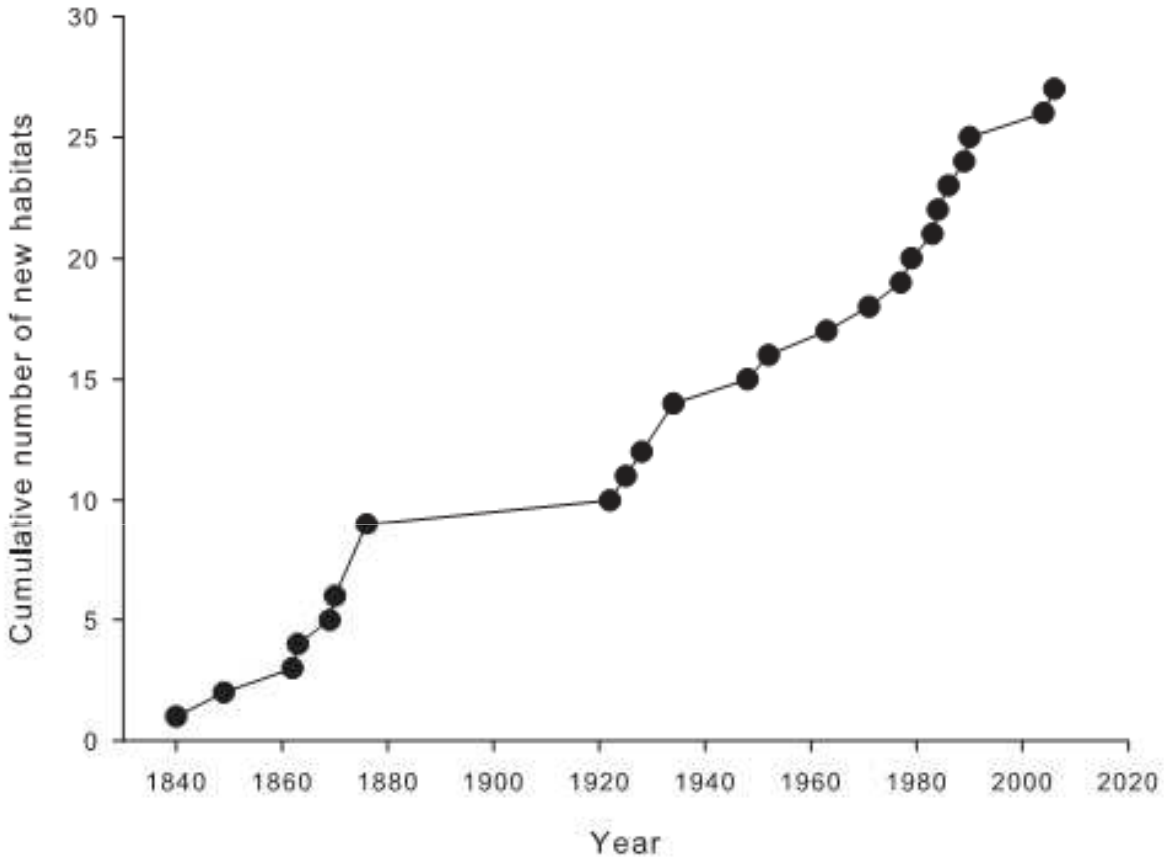
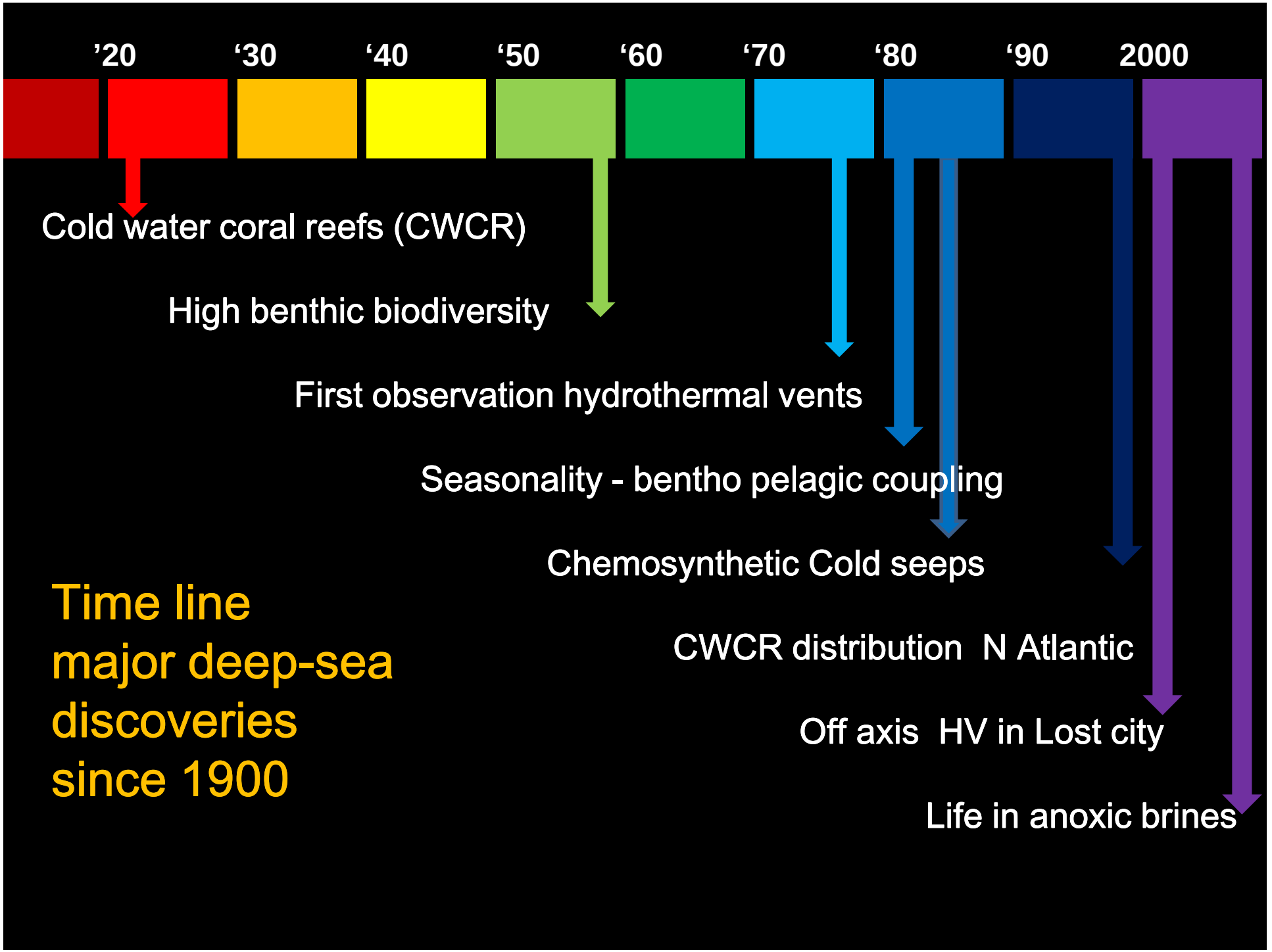


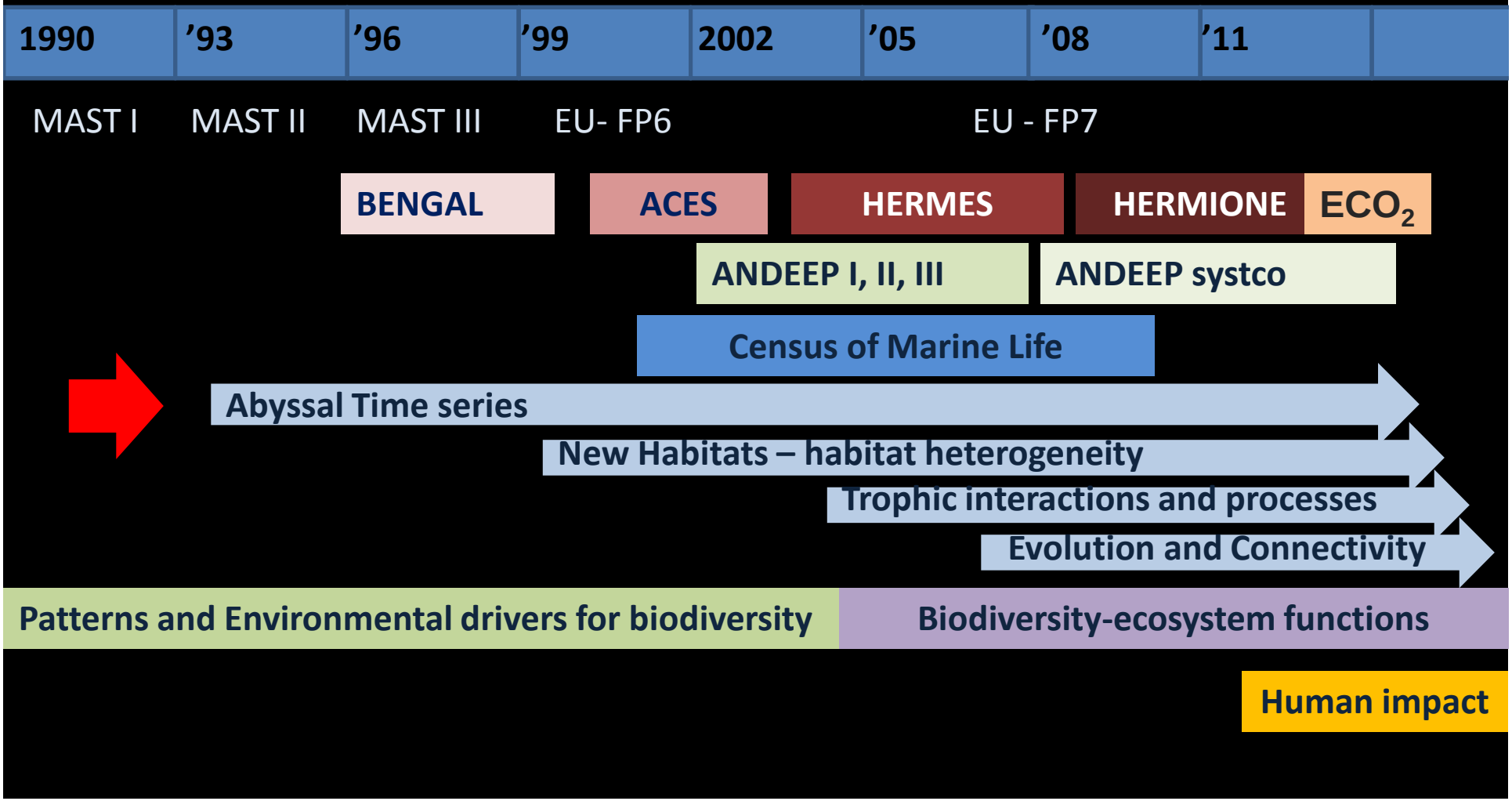
Fig. 2. Habitat discovery rate from Forbes' Azoic theory to date. For details of habitats considered, see Table 1.

Ramirez et al 2010


’20
‘30
‘40
‘50
‘60
‘70
‘80
‘90
2000
Cold water coral reefs (CWCR)
High benthic biodiversity
First observation hydrothermal vents
Seasonality - bentho pelagic coupling
Chemosynthetic Cold seeps
CWCR distribution N Atlantic
Off axis HV in Lost city
Life in anoxic brines
Time line
major deep-sea
discoveries
since 1900

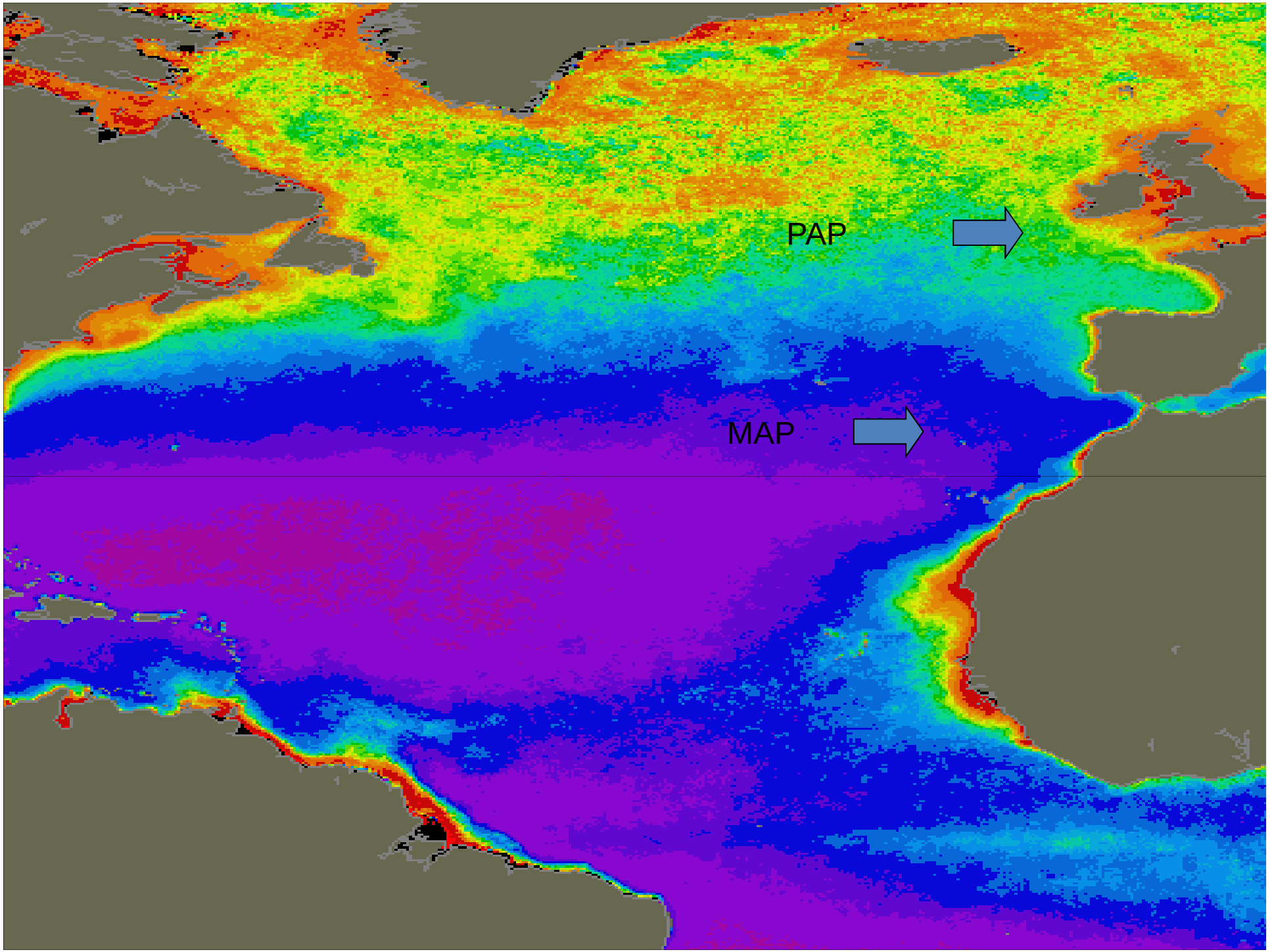
Benthos - Biodiversity

International → interdisciplinary



My first deep-sea campaign to the Porcupine Seabight and PAP in 1991 on board of the RV Challenger

Only two long term time series from the abyssal


PAP
MAP

Porcupine Abyssal Plain

(4850m)

Lampitt (1985)

Madeira Abyssal Plain

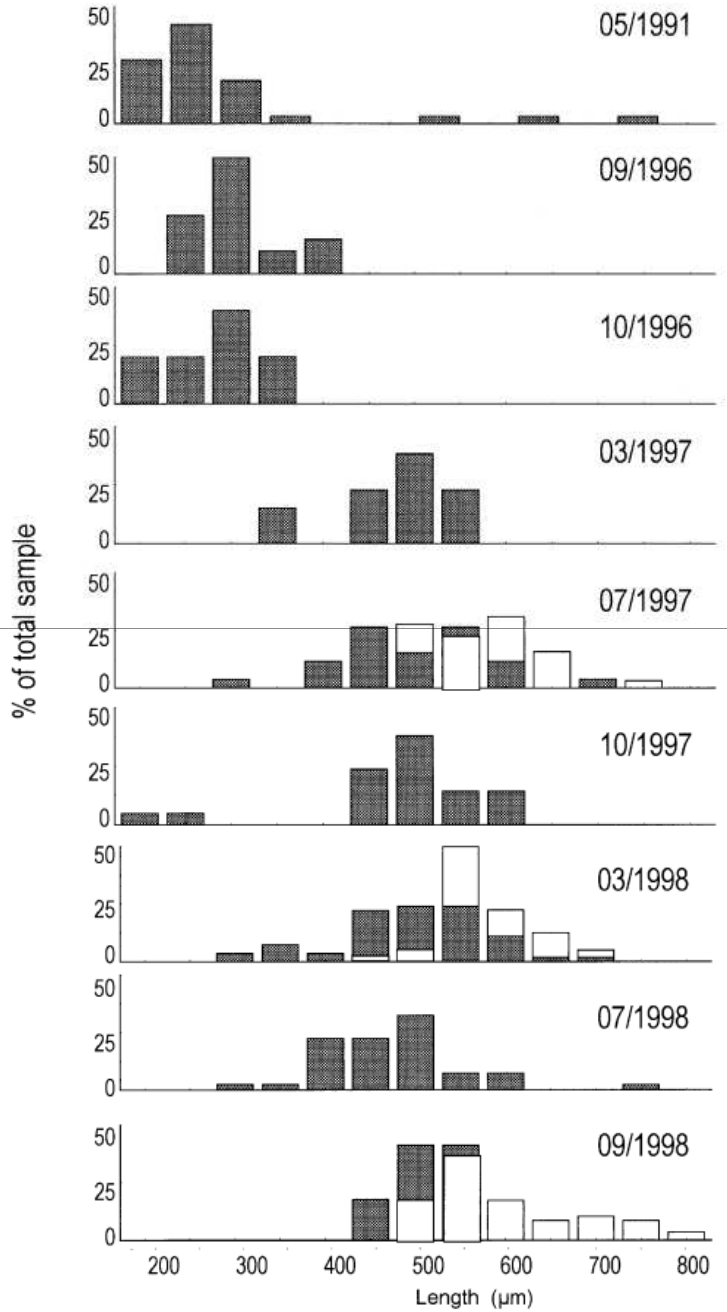
(4850m)

Rice, Thurston & Bett (1994)

Six months in the life of the seafloor

…. in one minute

March to September



Pergamon

Progress in Oceanography 50 (2001) 285–301

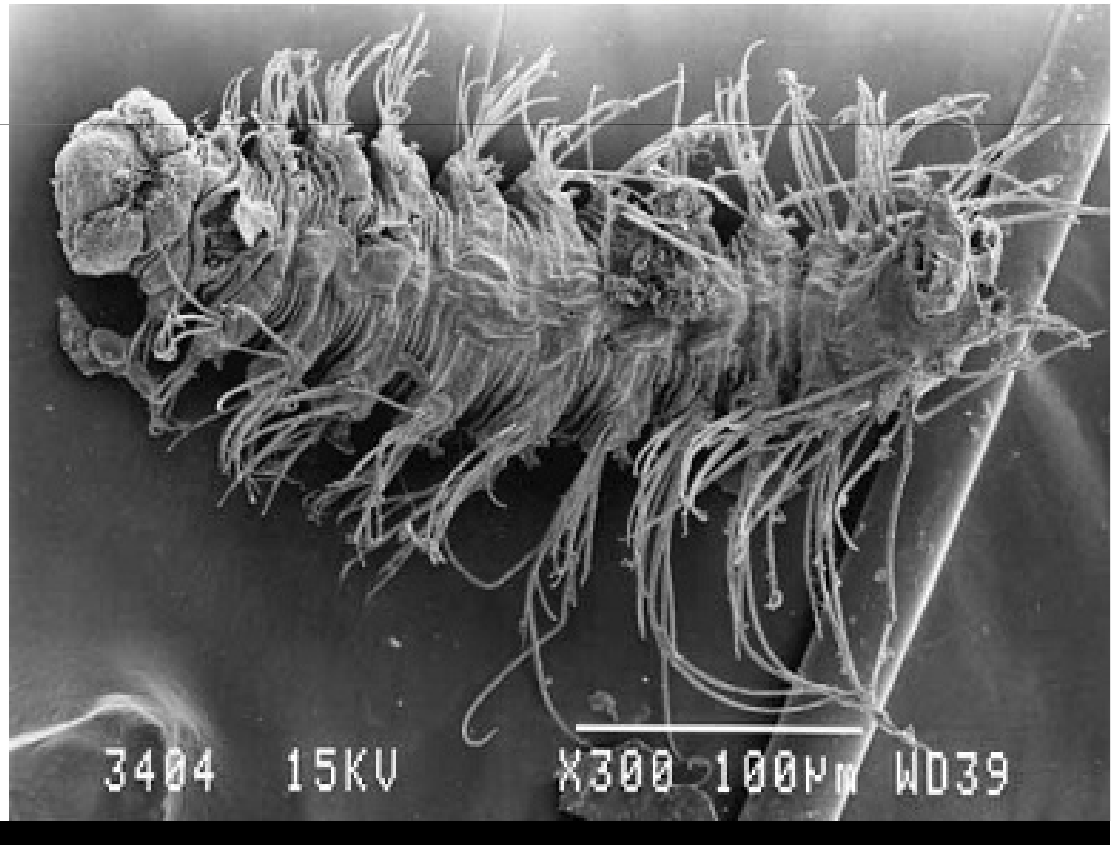
Progress in Oceanography

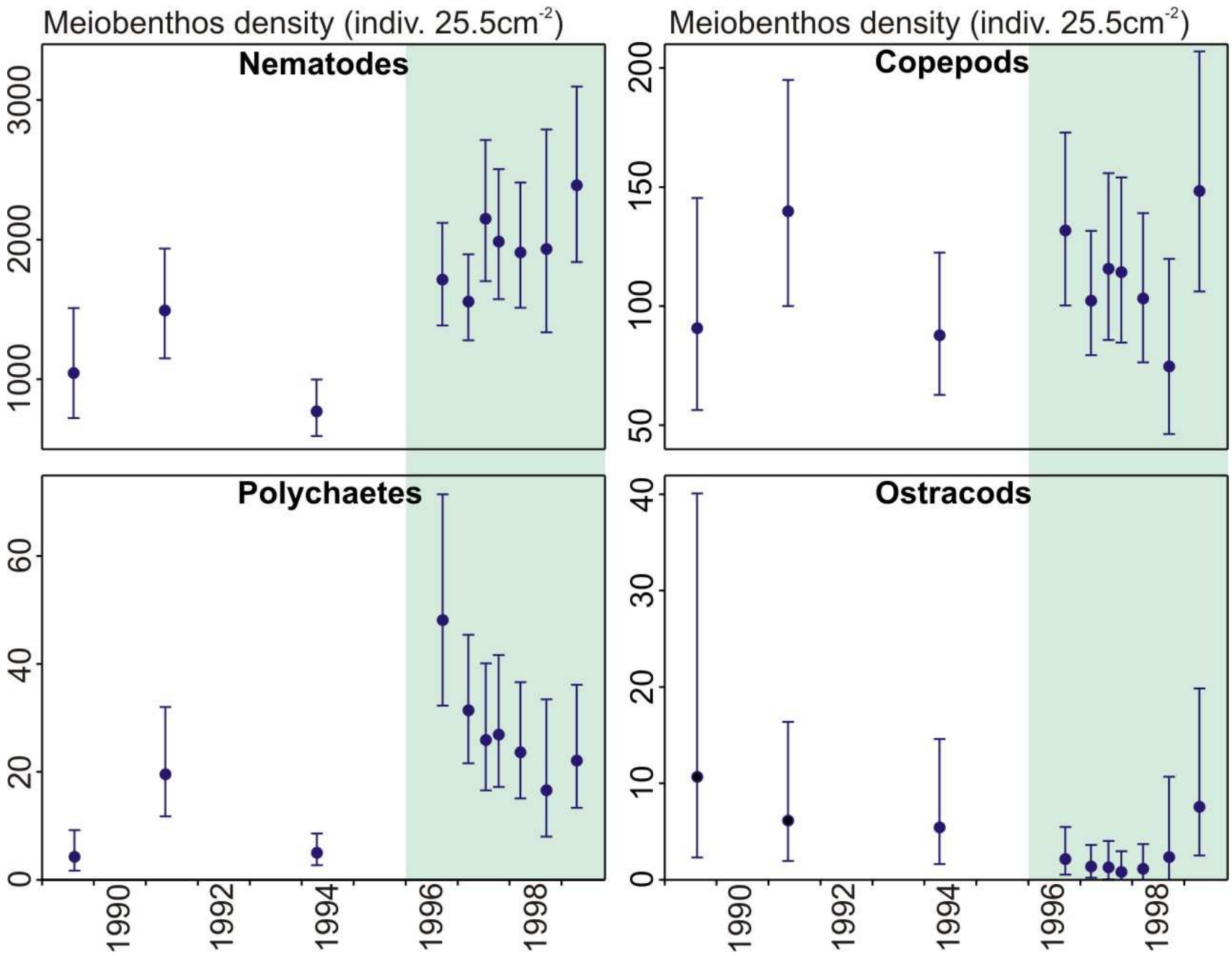
www.elsevier.com/locate/pocean

Evidence for episodic recruitment in a small opheliid polychaete species from the abyssal NE Atlantic

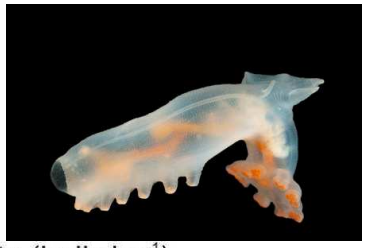
A. Vanreusel [a,*], N. Cosson-Sarradin [b], A.J. Gooday [c], G.L.J. Paterson [d], J. Galéron [b], M. Sibuet [b], M. Vincx [a]

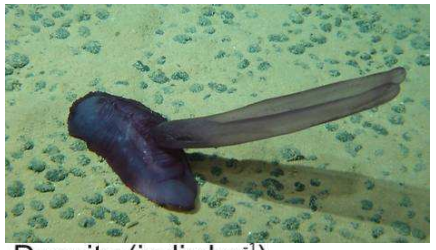
[a] *Marine Biology Section, Ghent University, Ledeganckstraat 35, B-9000 Ghent, Belgium*
[b] *IFREMER Centre de Brest, BP 70, 29280 Plouzané, France*
[c] *Southampton Oceanography Centre, Empress Dock, Southampton SO14 3ZH, UK*
[d] *The Natural History Museum, Polychaeta Research Group, Cromwell Road, London SW7 5BD, UK*

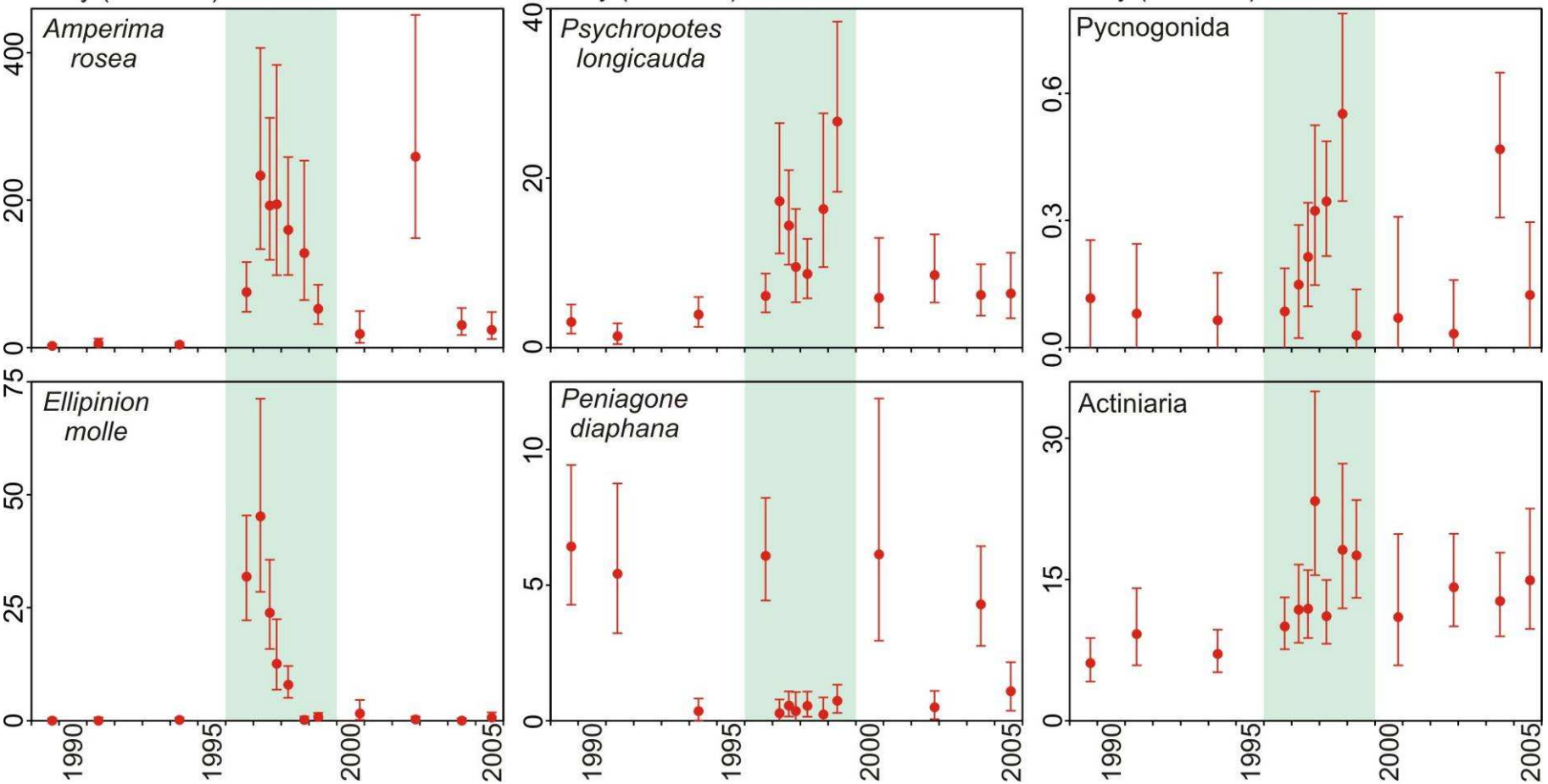




Kalogeropoulou et al 2010 DSR II







NOC

Billet, Bett et al 2010 DSR


Amperima rosea – deposit feeding holothurian
Picture NO

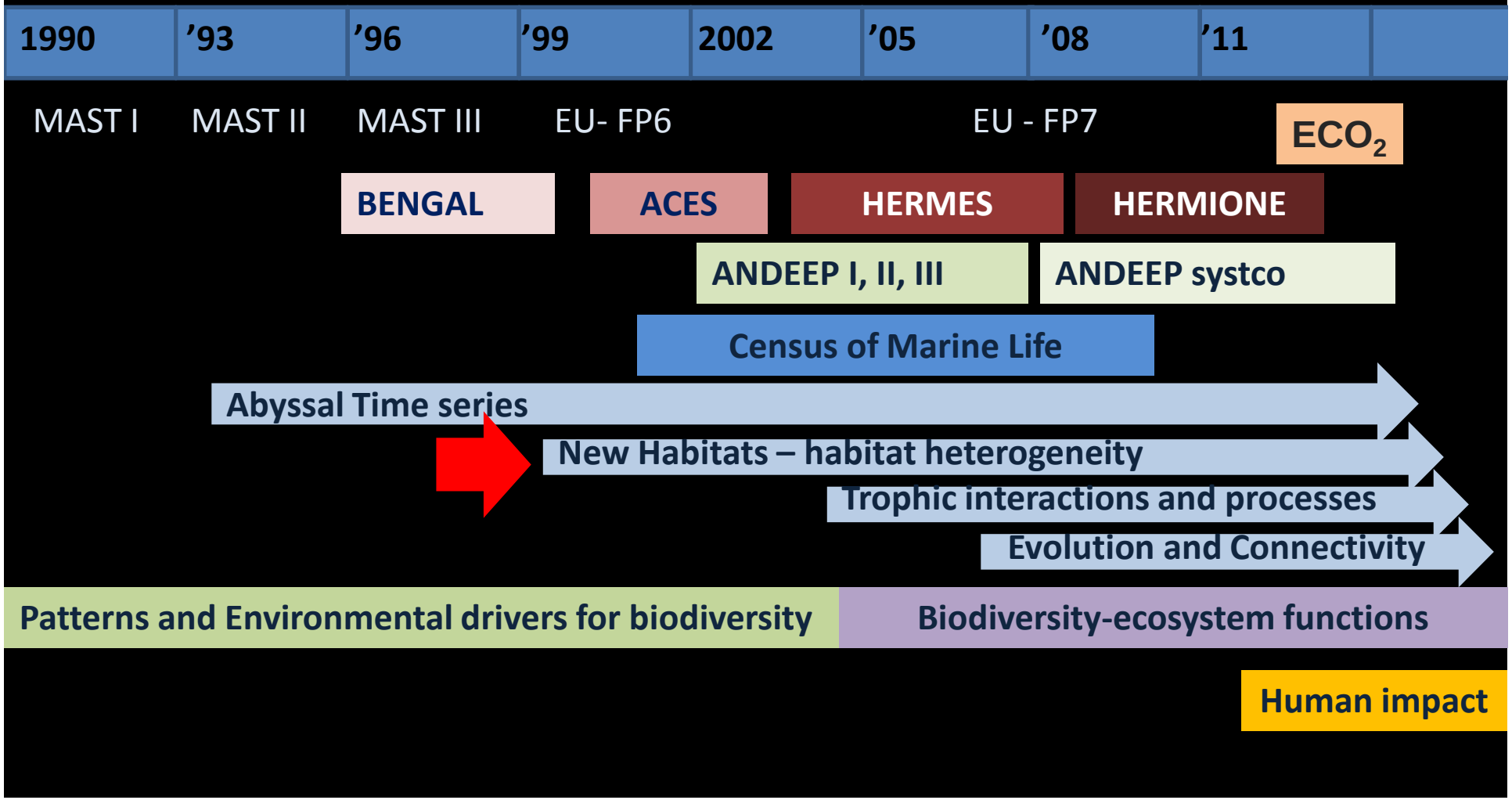
- The deep-sea floor is linked to ocean surface processes
- Rapid, large-scale changes occur in deep-sea ecosystems
- All components of the benthic community show a response at the same time
- Possible link oscillations (NAO Index)
- Climate affects the quantity and quality of carbon exported to the deep sea

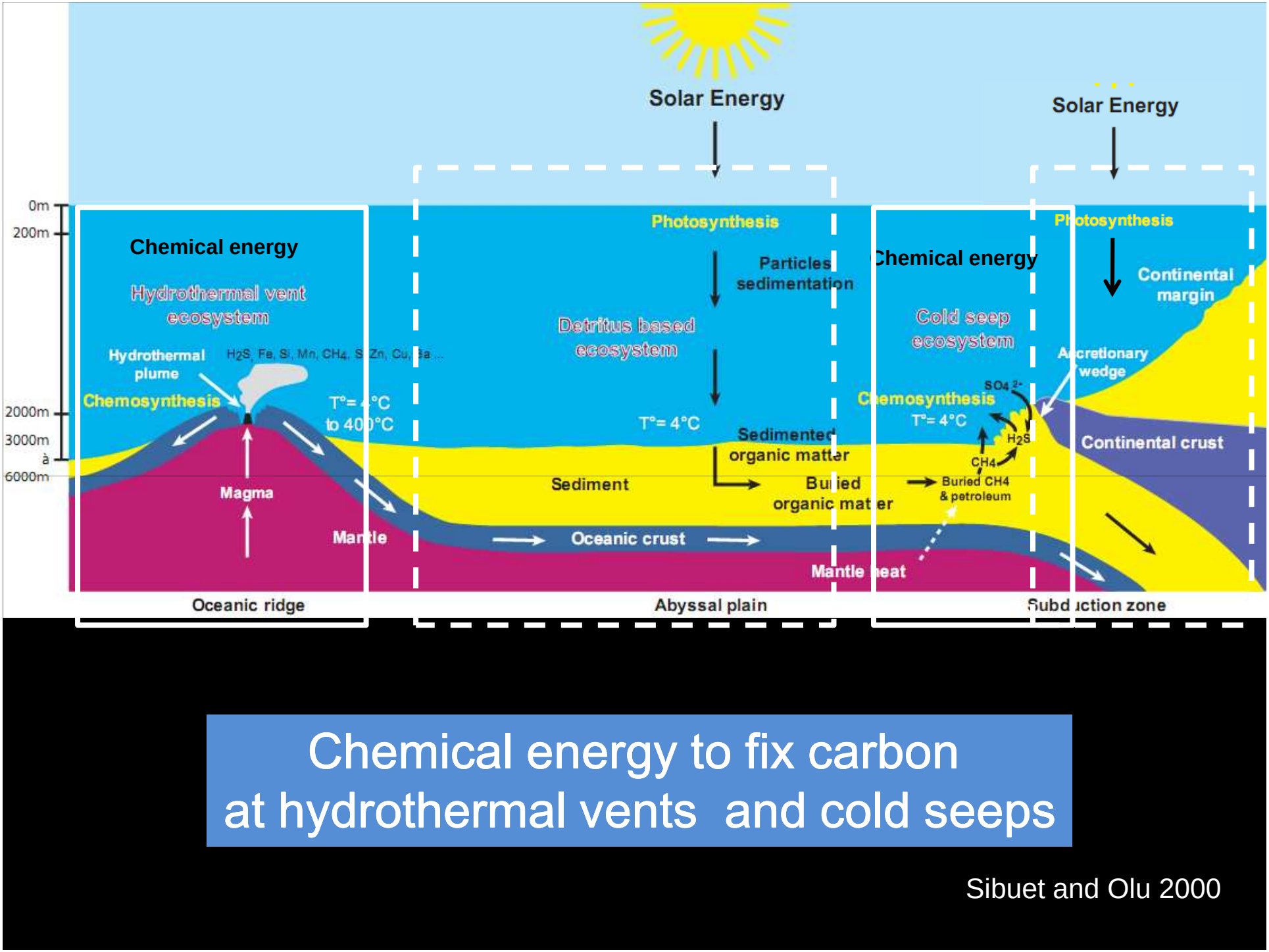
Billet et al 2010 DSR II

Persist, even if the work is hard and the end not visible

Benthos - Biodiversity

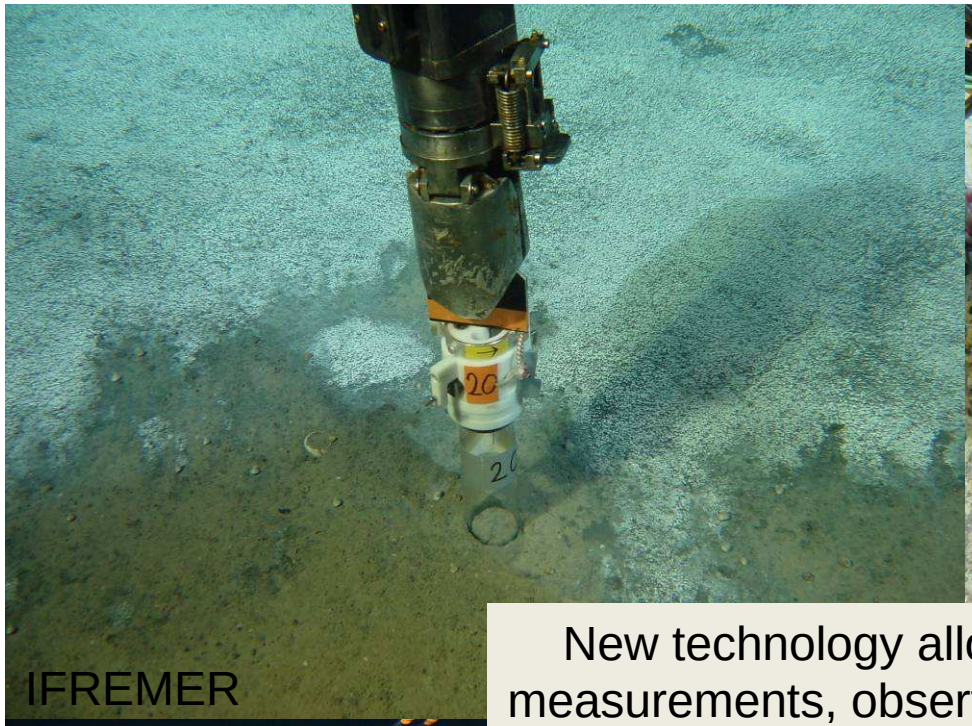
International → interdisciplinary



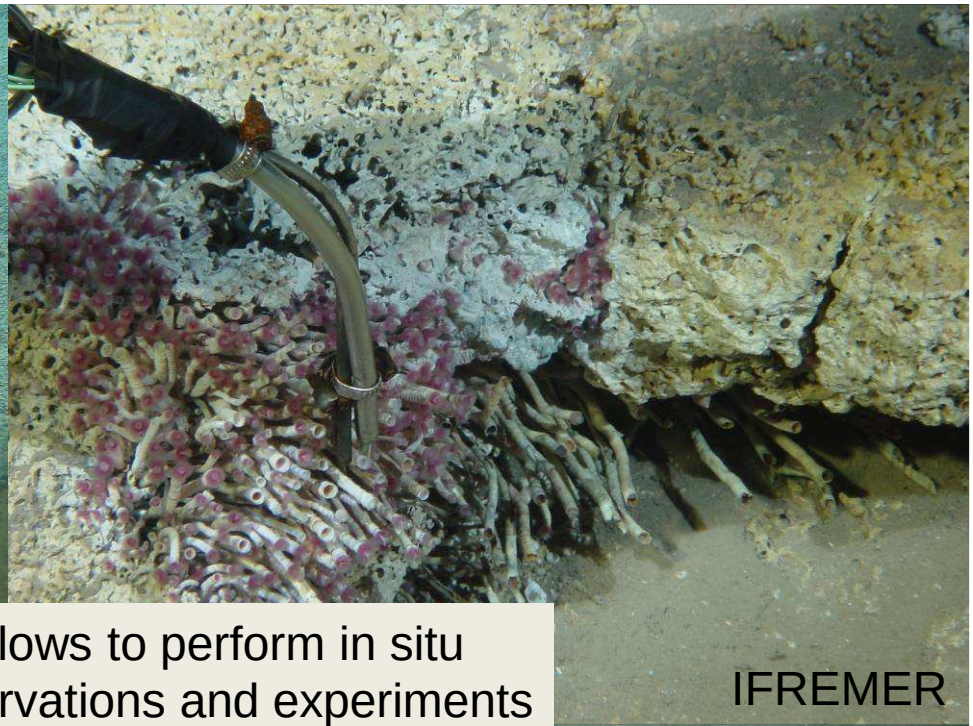


Chemical energy to fix carbon at hydrothermal vents and cold seeps

Sibuet and Olu 2000

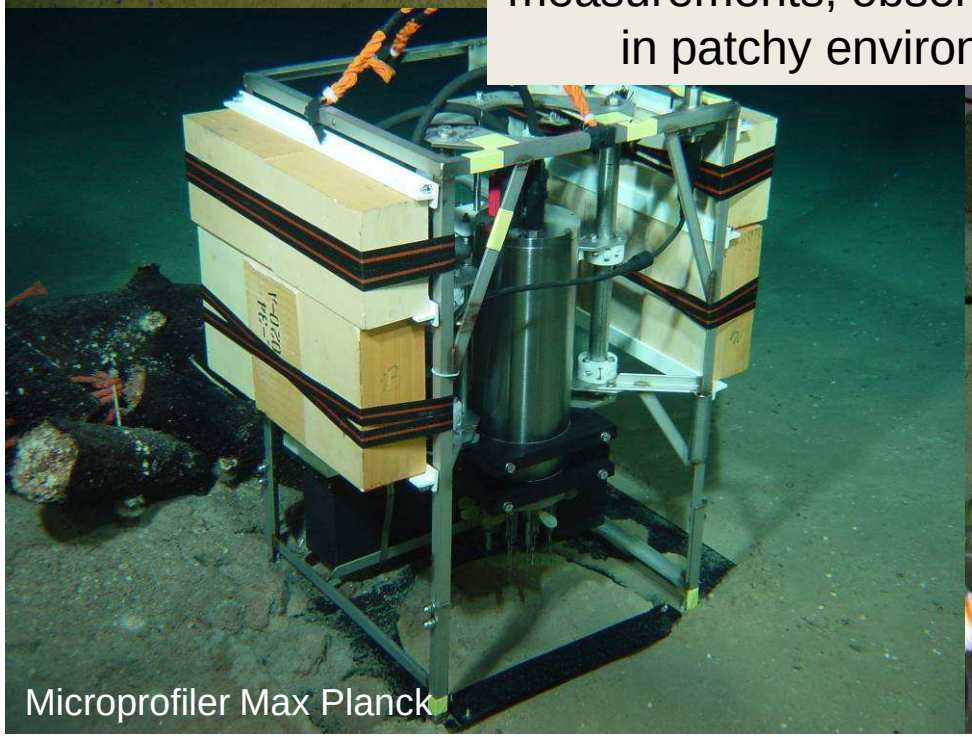


IFREMER

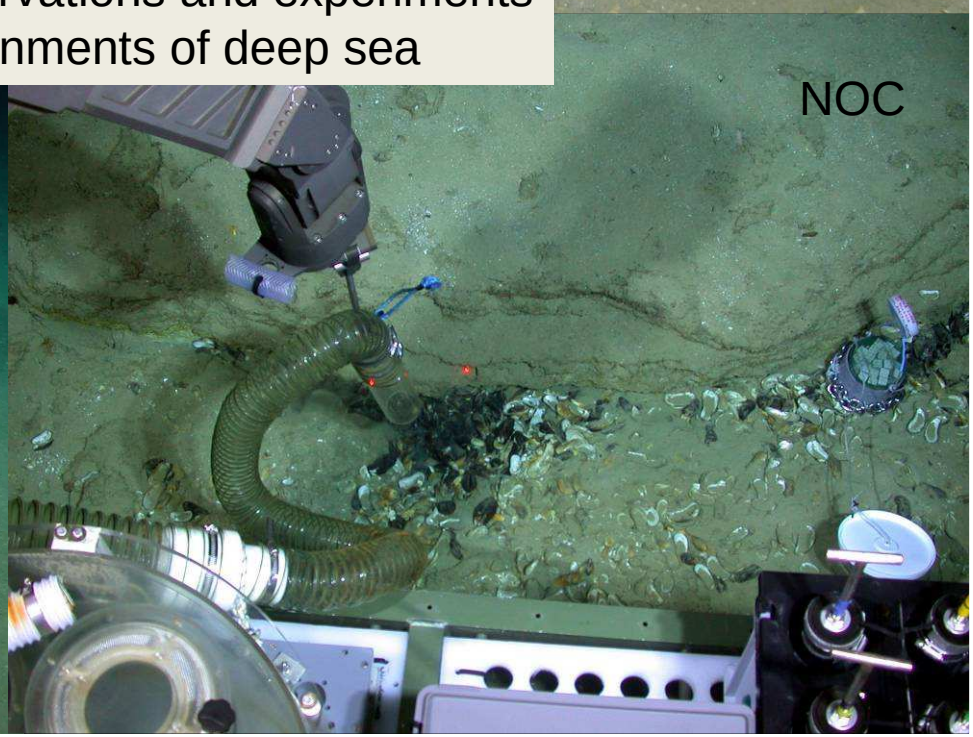


IFREMER

New technology allows to perform in situ measurements, observations and experiments in patchy environments of deep sea



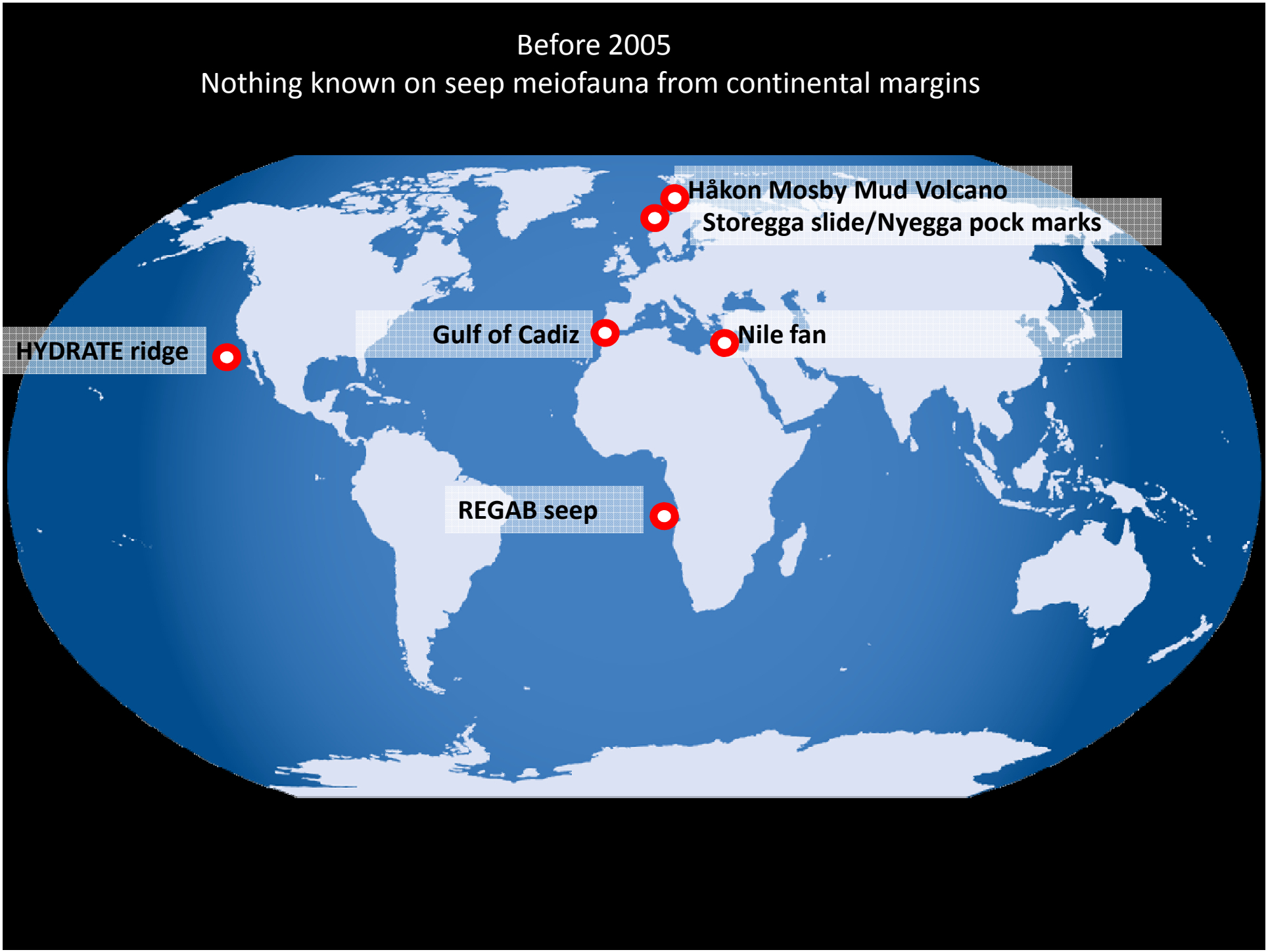
Microprofiler Max Planck



NOC

Before 2005

Nothing known on seep meiofauna from continental margins



Biodiversity of Cold Seep Ecosystems Along the European Margins

BY ANN VANREUSEL, ANN C. ANDERSEN, ANTJE BOETIUS, DOUG LAS CONNELLY, MARINA R. CUNHA, CAROLE DECKER, ANA HILARIO, KONSTANTINOS A. KORMAS, LOÏS MAIGNIEN, KARINE OLU, MARIA PACHIADAKI, BENEDICTE RITT, CLARA RODRIGUES, JOZÉE SARRAZIN, PAUL TYLER, SASKIA VAN GAEVER, AND HELEEN VANNESTE

OPEN ACCESS Freely available online

PLoS one

Ecology and Biogeography of Free-Living Nematodes Associated with Chemosynthetic Environments in the Deep Sea: A Review

Ann Vanreusel[1]*, Annelies De Groote[1], Sabine Gollner[2], Monika Bright[2]

1 Marine Biology Research Group, Ghent University, Ghent, Belgium, **2** Department of Marine Biology, University of Vienna, Vienna, Austria

Abstract

Background: Here, insight is provided into the present knowledge on free-living nematodes associated with chemosynthetic environments in the deep sea. It was investigated if the same trends of high standing stock, low diversity, and the dominance of a specialized fauna, as observed for macro-invertebrates, are also present in the nematodes in both vents and seeps.

Methodology: This review is based on existing literature, in combination with integrated analysis of datasets, obtained through the Census of Marine Life program on Biogeography of Deep-Water Chemosynthetic Ecosystems (ChEss).

Findings: Nematodes are often thriving in the sulphidic sediments of deep cold seeps, with standing stock values ocassionaly exceeding largely the numbers at background sites. Vents seem not characterized by elevated densities. Both chemosynthetic driven ecosystems are showing low nematode diversity, and high dominance of single species. Genera richness seems inversely correlated to vent and seep fluid emissions, associated with distinct habitat types. Deep-sea cold seeps and hydrothermal vents are, however, highly dissimilar in terms of community composition and dominant taxa. There is no unique affinity of particular nematode taxa with seeps or vents.

Conclusions: It seems that shallow water relatives, rather than typical deep-sea taxa, have successfully colonized the reduced sediments of seeps at large water depth. For vents, the taxonomic similarity with adjacent regular sediments is much higher, supporting rather the importance of local adaptation, than that of long distance distribution. Likely the ephemeral nature of vents, its long distance offshore and the absence of pelagic transport mechanisms, have prevented so far the establishment of a successful and typical vent nematode fauna. Some future perspectives in meiofauna research are provided in order to get a more integrated picture of vent and seep biological processes, including all components of the marine ecosystem.

Citation: Vanreusel A, De Groote A, Gollner S, Bright M (2010) Ecology and Biogeography of Free-Living Nematodes Associated with Chemosynthetic

Understanding **biological capacities** underlying the ecology of seep ecosystems

Feeding

Stress tolerance for anoxia and sulphide

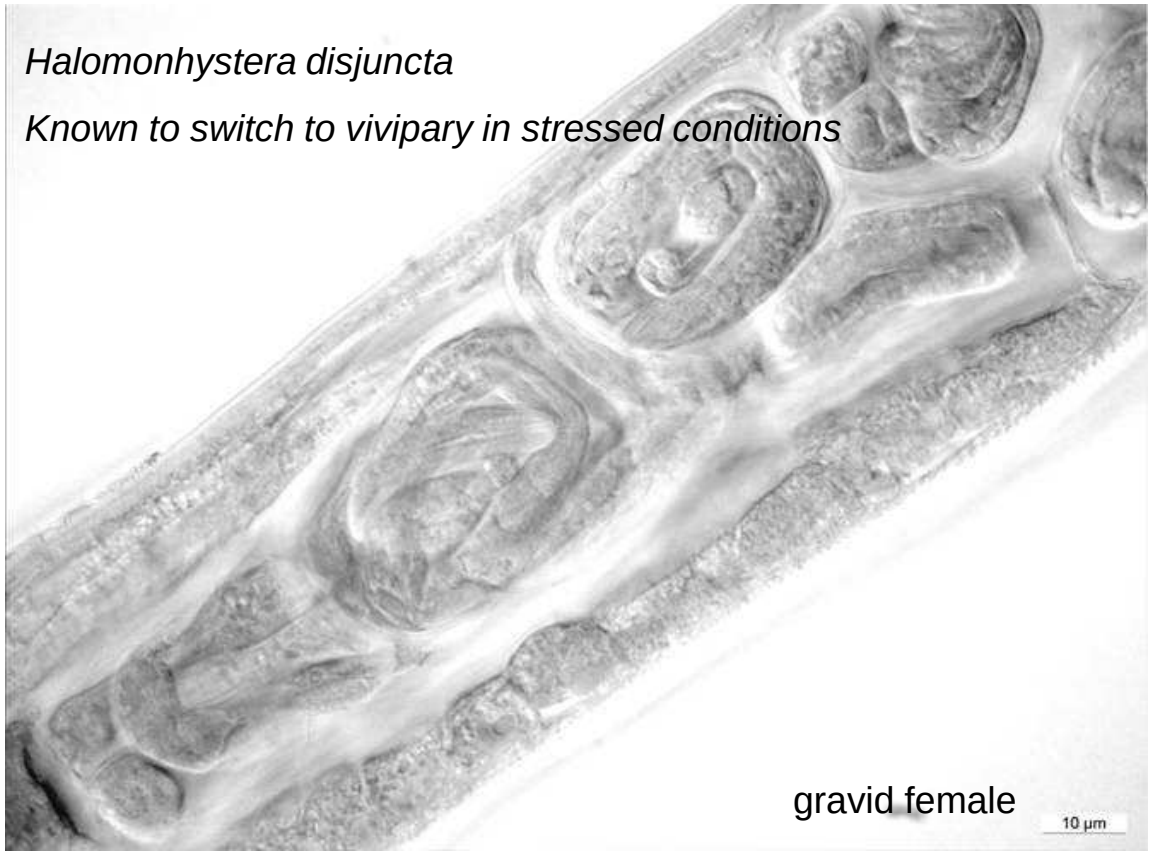
Biomass – production

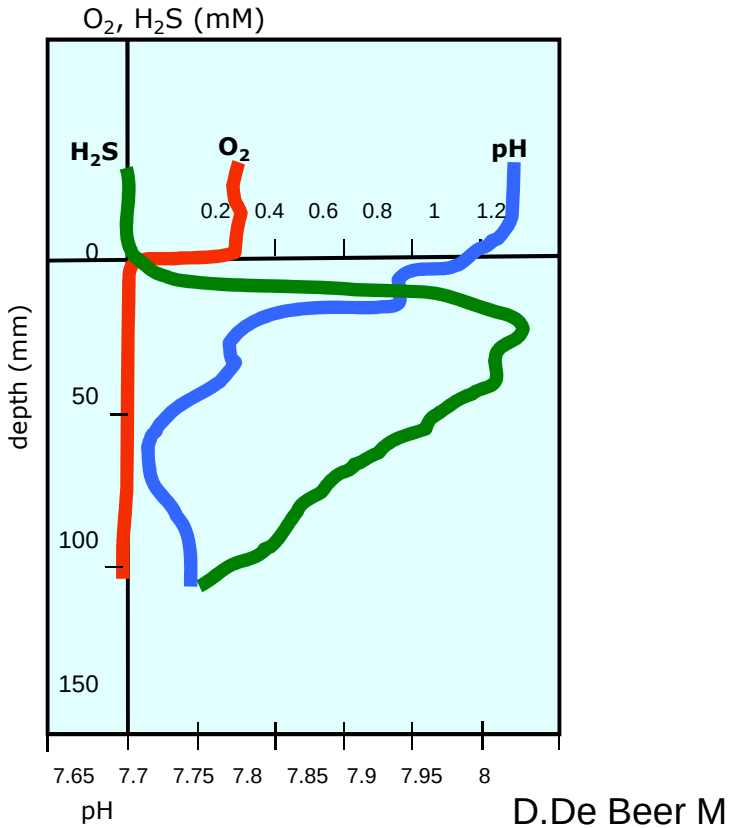
Reproduction - recruitment

Competition

Dispersal - mobility

What are the adaptations in order to survive the conditions at seeps?





D.De Beer M

- immediate motility of new recruits allows migration in and out anoxic sediment

- temporary availability of oxygen to embryos and juveniles is necessary for proper growth

- **top layer is high sulphidic**
- **oxygen penetrates less than 2 mm**

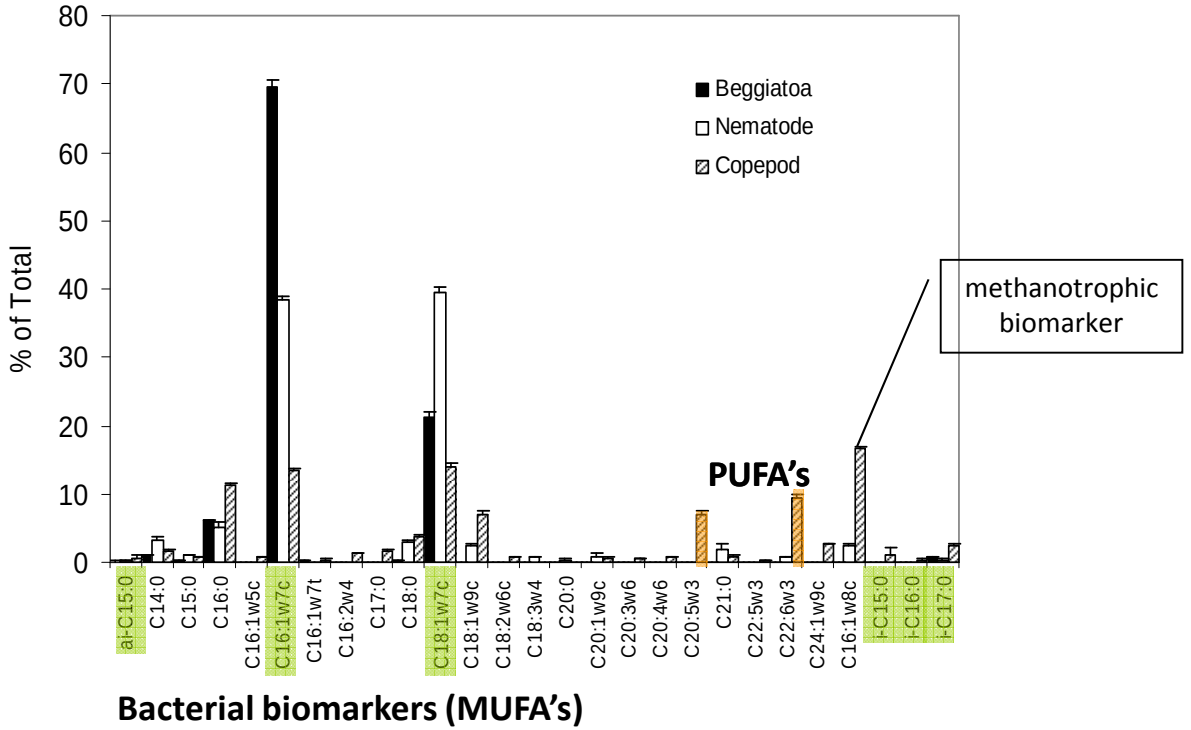
Van Gaever et al 2006

Trophic interactions of meiofauna in HMMV

Carbon-13 (^{13}C)

sample	average $\delta^{13}C$
***Beggiatoa* site**	
Bulk sed POC	**-28.1**
***Beggiatoa* sp.**	**-42.7**
Halomonhystera disjuncta	**-41.6**
Control site	
Bulk sed POC	**-22.1**
Nematodes	**-20.0**
Copepods	**-19.1**

Fatty acid analyses

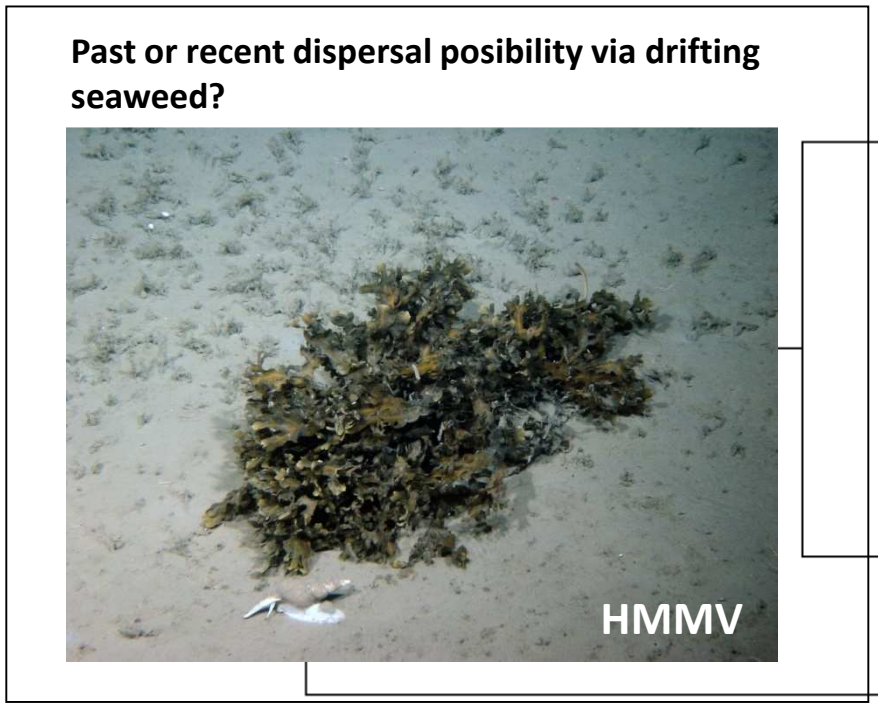


Indication of dependence on chemosynthetic derived food source by *Halomonhystera disjuncta*

Van Gaever et al 2009

Phylogentic tree: ITS

HD HMMV is one of several cryptic species from a species complex known to be associated with degrading macroalgae on temperate mud flats (GD1-GD5)
De Rycke et al

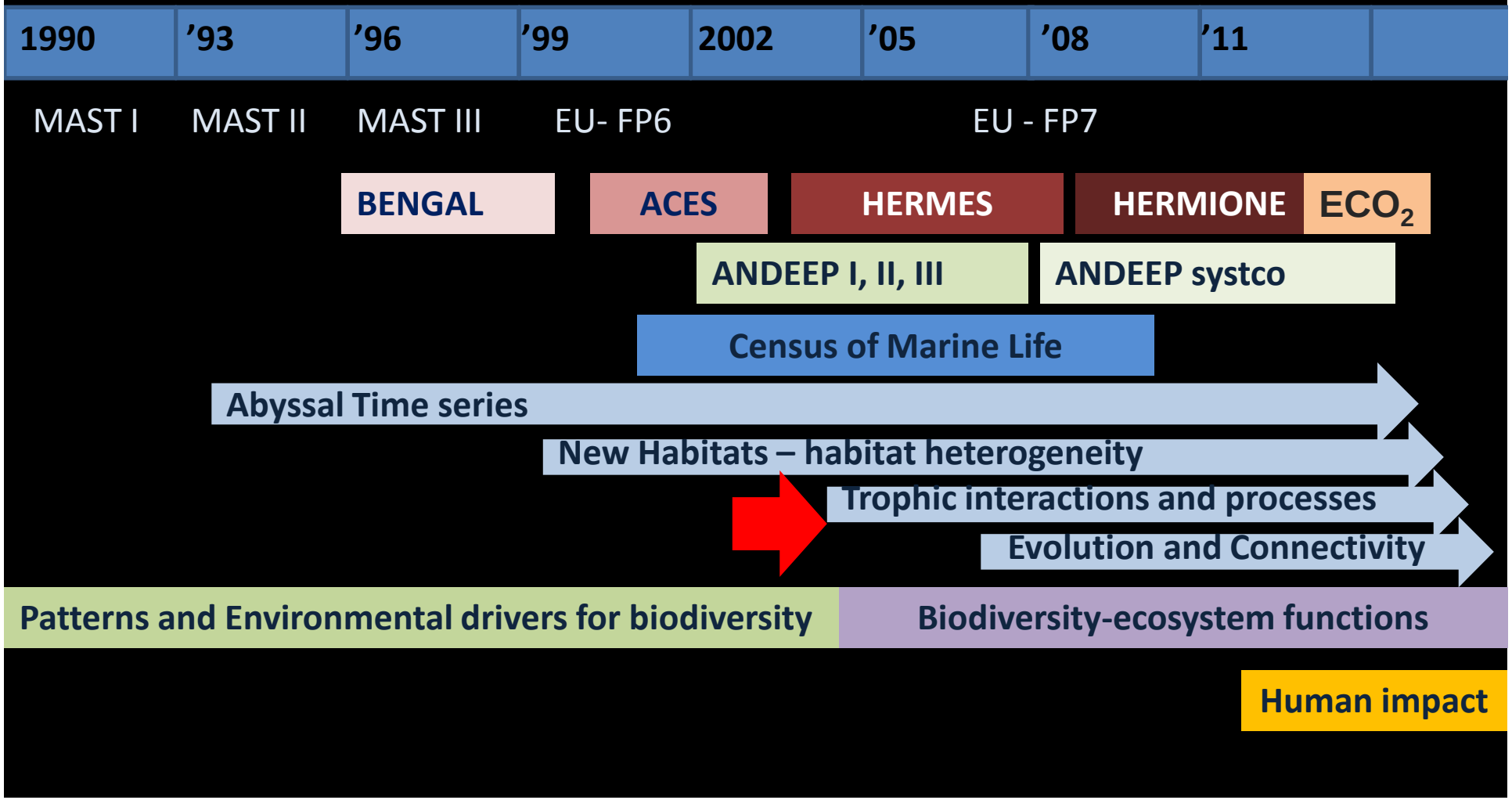


PhD Jelle Van Campenhout

Sometimes you have to go your own way

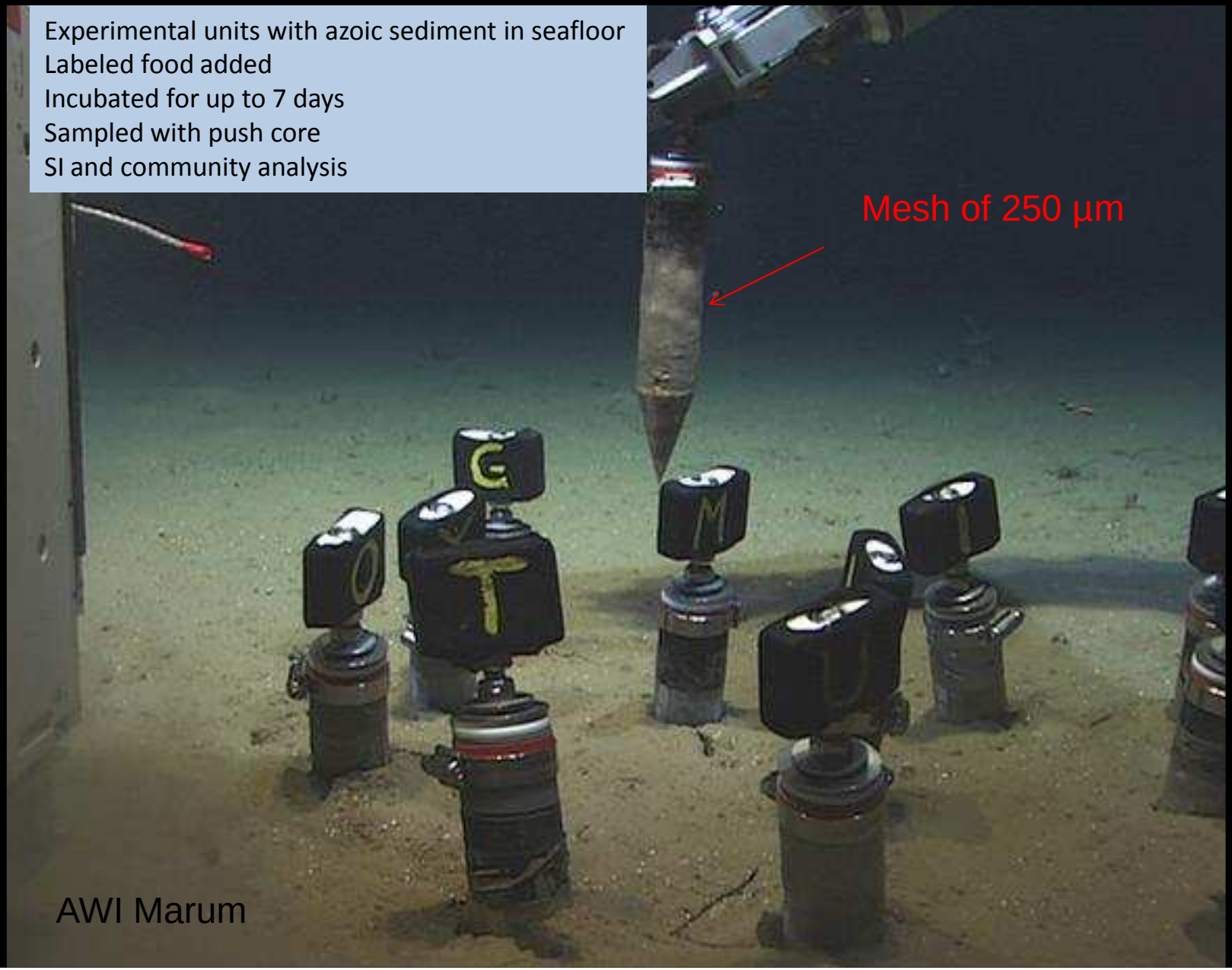
Benthos - Biodiversity

International → interdisciplinary



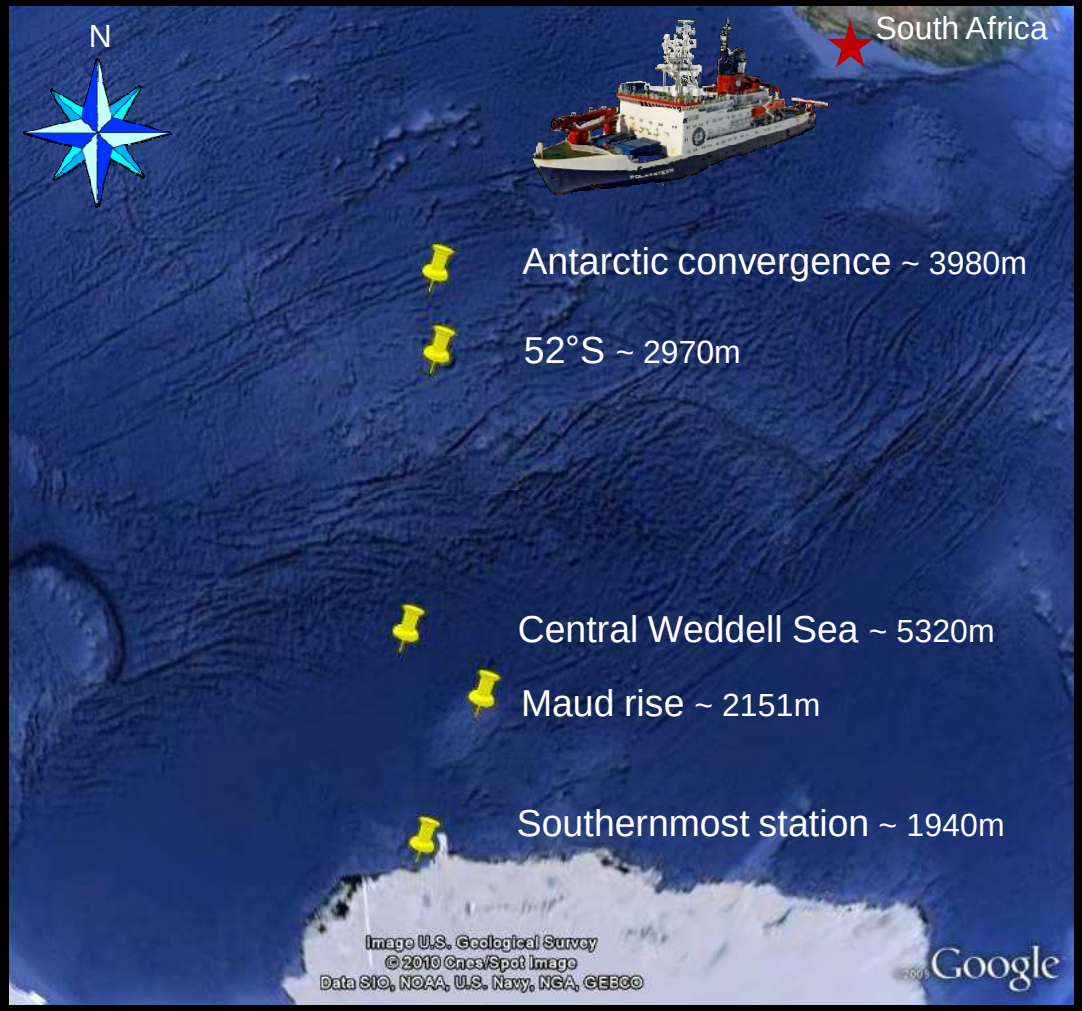
Guilini et al 2010

In situ colonization experiment, Arctic margin 2500 m



Guilini et al 2013

Natural biomarkers in nematodes along Southern Ocean transect

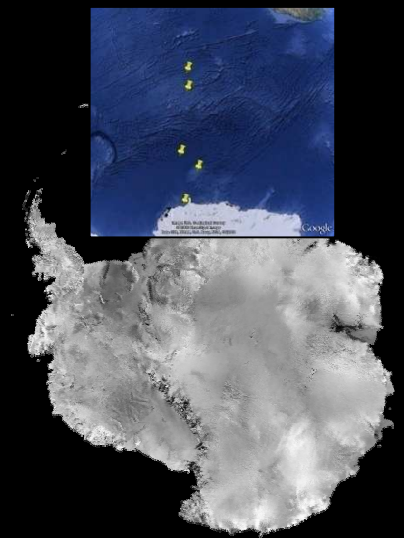


ANT XXIV-2

27/11/2007 – 04/02/2008
Cape Town – Cape Town

North –South transect crossing convergence to sample benthos of bathyal or abyssal depths

Repeated sampling at 52°S after 7 weeks, to investigate the effect of a phytoplankton bloom on benthos



Guilini K., G. Veit-Köhler, C., M. De Troch, D. Van Gansbeke, A. Vanreusel PiO 2013

Guilini et al 2013

Is there a dominance of particular FA's in deep-sea nematodes?

% of total FA	Polar Front	south Polar Front	south Polar Front (2nd visit)	central Weddell Sea	Maud Rise	Lazarev Sea
	Nema	Nema	Nema	Nema	Nema	Nema
∑ planktonic	68	59	65	67	67	63
∑ bacterial	4	6	4	-	3.5	2
Lipid (% dwt)	0.01	1.5	3	4	2.7	2.6

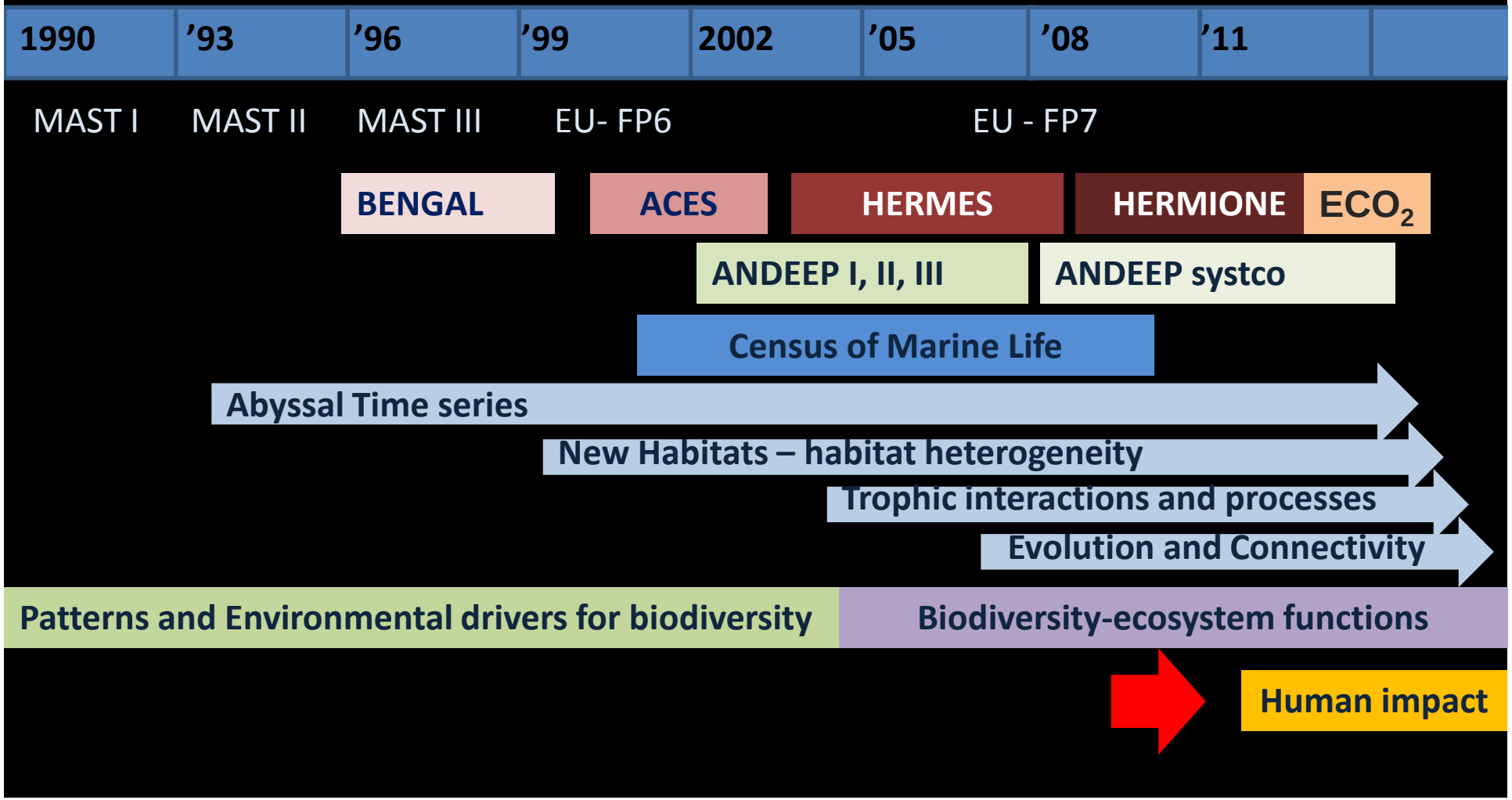
There is only a minute contribution of bacterial C to the nematode diet.

The generally low lipid content of the nematodes, together with predominance of typical phospholipids of biomembranes (20:5ω3, 22:6ω3 and 16:0) indicates that they do not accumulate lipids for energy storage.

Think of new approaches and tools

Benthos - Biodiversity

International → interdisciplinary



Deep-sea exploitation

2000's Climate change - CO_2 build up
Fishing in deeper water – overexploitation and habitat destruction

2010's Deep-sea mining and CO_2 sequestration

manganese nodules are rock concretions on the sea bottom formed of concentric layers of metal hydroxides around a core

➔ potential exploitation of polymetallic nodules

Submarine ferromanganese concretions were first discovered in the Kara Sea off Siberia in 1868.

Since the 1960s, manganese nodules have been recognized as a potential source of nickel, copper, cobalt, and manganese, which are likely to assume increasing importance as land-based deposits of these metals become depleted.

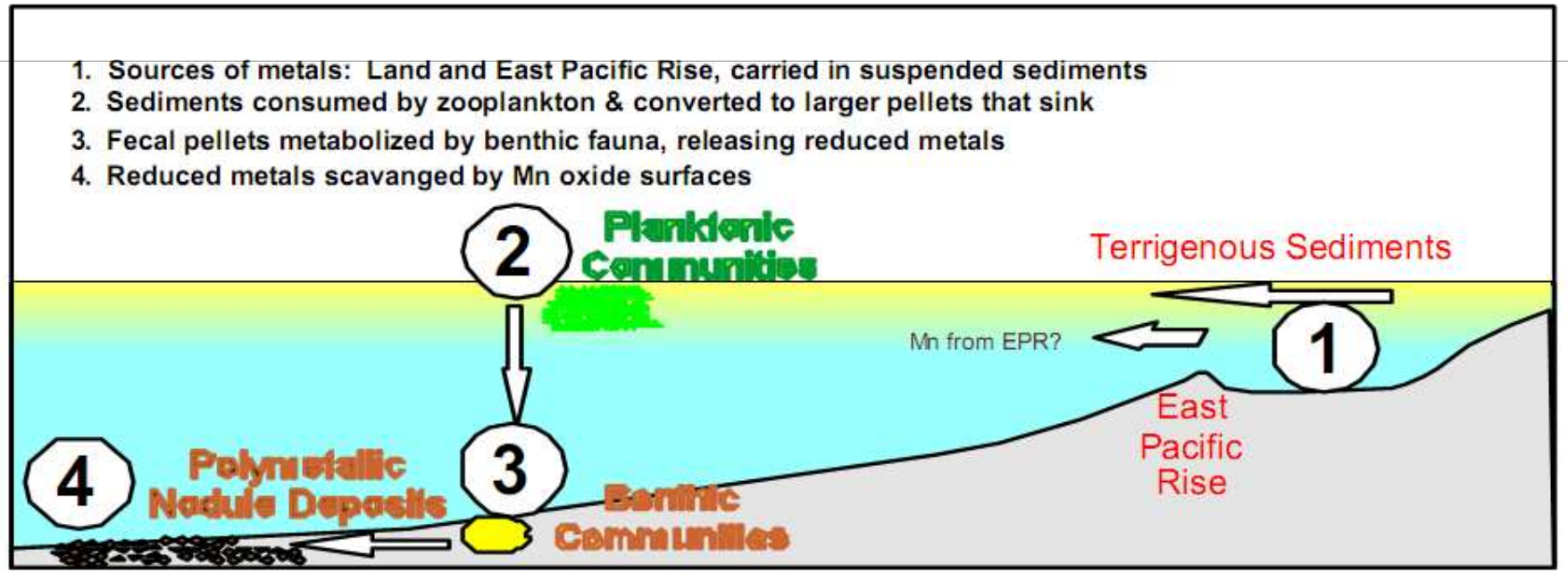
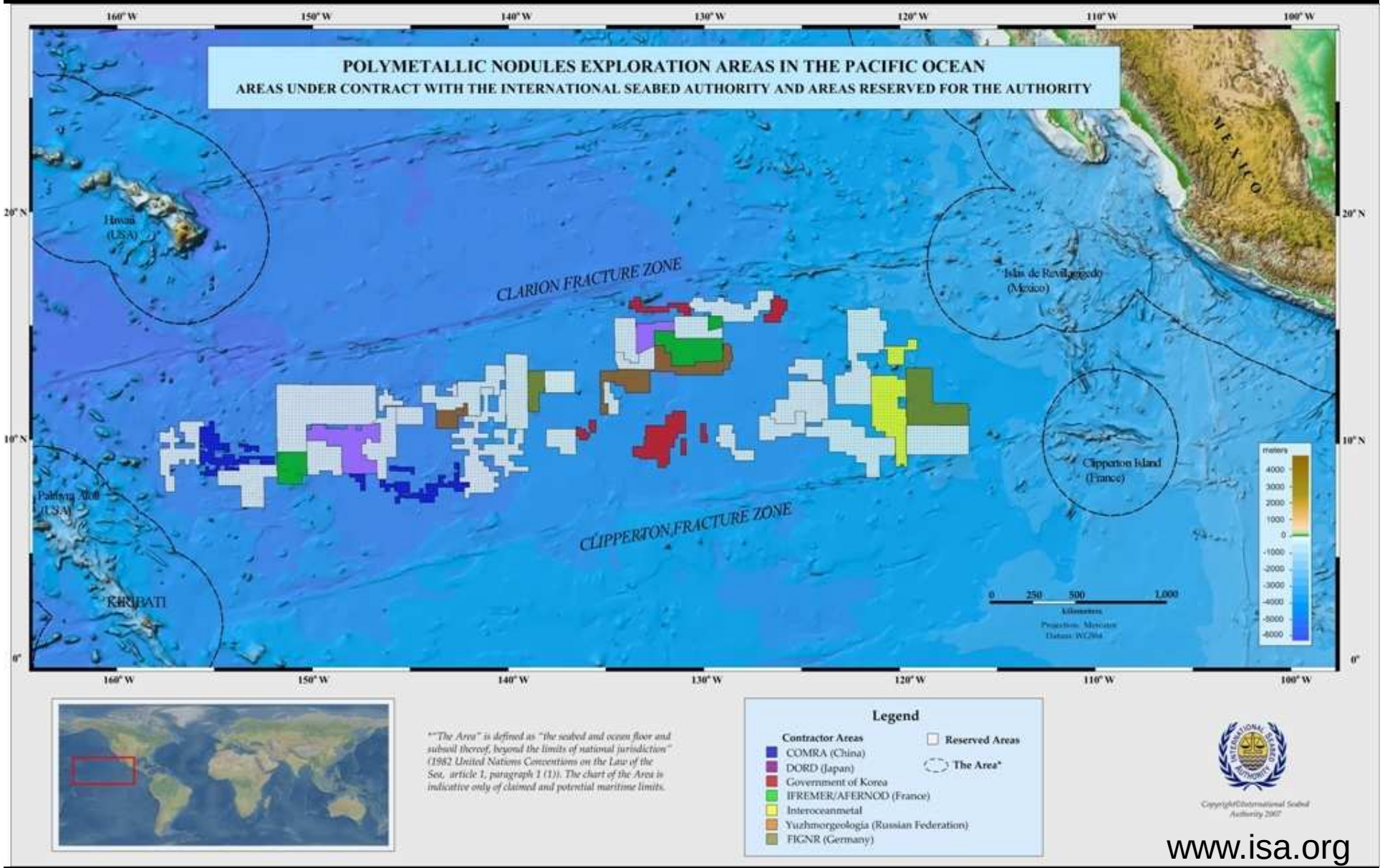


Figure 9: General Nodule Formation Model in the CCZ


POLYMETALLIC NODULES EXPLORATION AREAS IN THE PACIFIC OCEAN
AREAS UNDER CONTRACT WITH THE INTERNATIONAL SEABED AUTHORITY AND AREAS RESERVED FOR THE AUTHORITY
160° W
150° W
140° W
130° W
120° W
110° W
100° W
20° N
10° N
0°
MEXICO
Hawaii (USA)
CLARION FRACTURE ZONE
Islas de Revillagigedo (Mexico)
Clipperton Island (France)
Palmyra Atoll (USA)
KIRIBATI
CLIPPERTON FRACTURE ZONE
meters
4000
3000
2000
1000
0
-1000
-2000
-3000
-4000
-5000
-6000
0 250 500 1,000
Kilometers
Projection: Mercator
Datum: WGS84
"The Area" is defined as "the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction" (1982 United Nations Conventions on the Law of the Sea, article 1, paragraph 1 (1)). The chart of the Area is indicative only of claimed and potential maritime limits.
Legend
Contractor Areas
COMRA (China)
DORD (Japan)
Government of Korea
IFREMER/AFERNOD (France)
Interoceanmetal
Yuzhmorgeologia (Russian Federation)
FIGNR (Germany)
Reserved Areas
The Area*
Copyright©International Seabed Authority 2007
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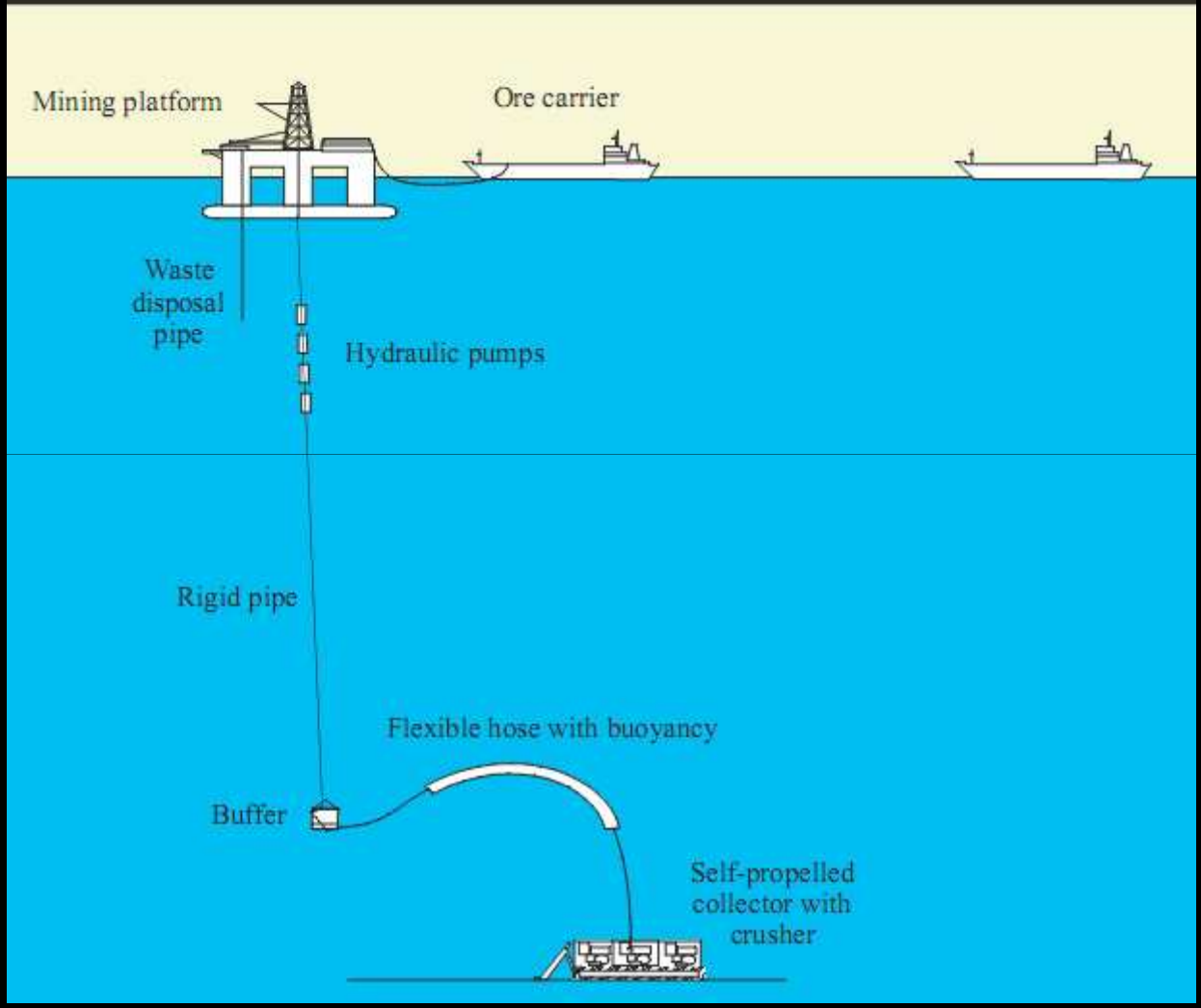
Hydraulic Mining System



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Protection of high seas needed because

Deep-sea floor is heterogeneous in time and space

Limited knowledge on ecosystem processes

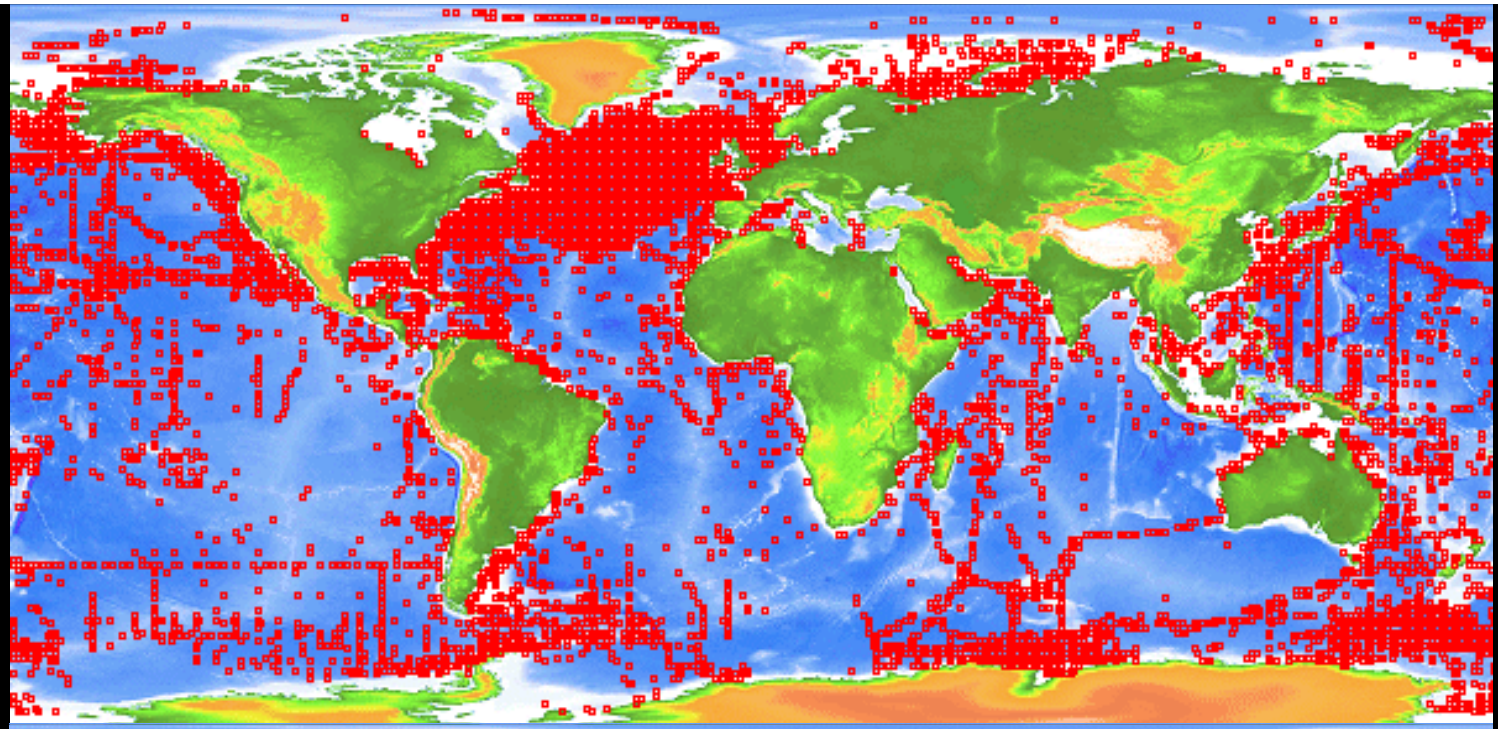
Unique fauna at different regions

→ isolated habitats

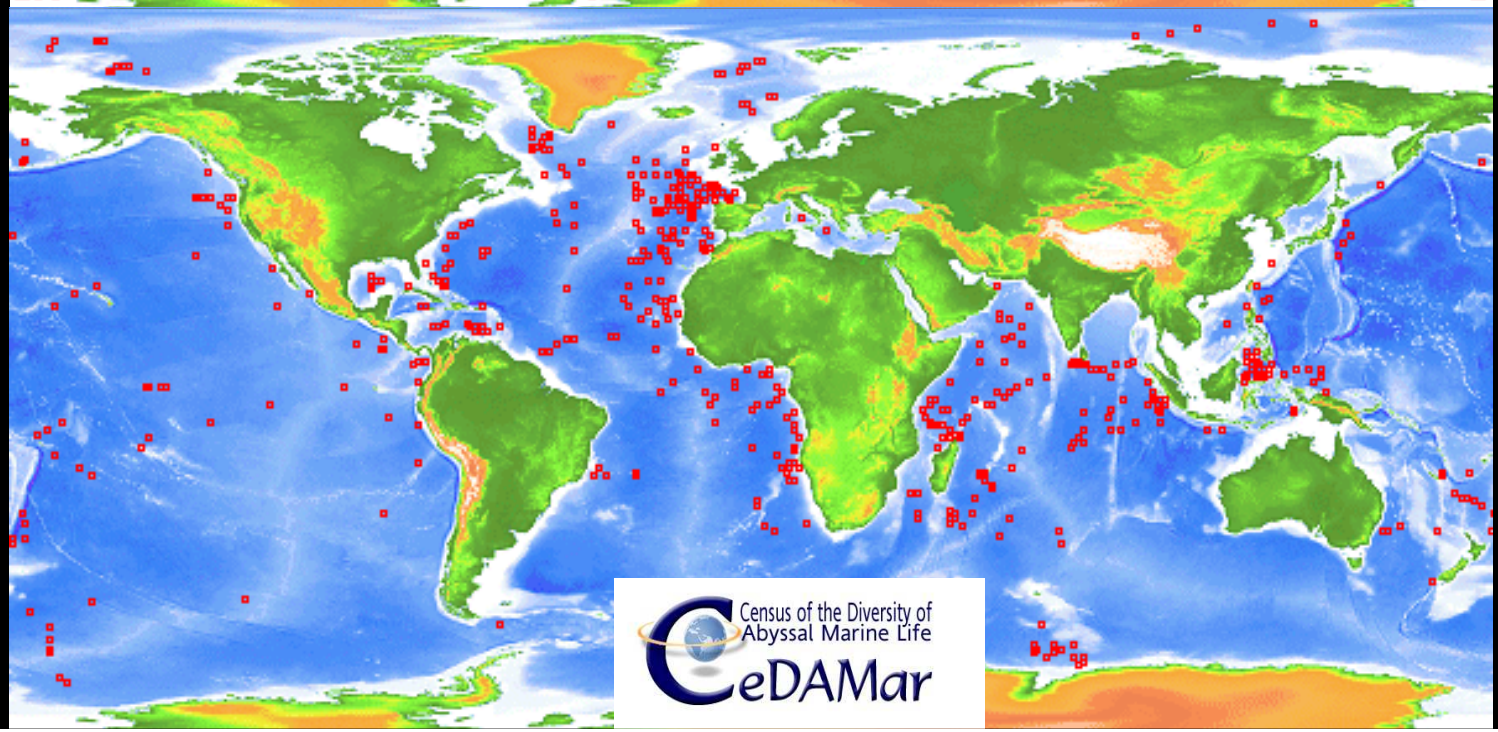
→ evidence for reduced exchange of species, populations (and genes) between locations

How can we manage the deep-sea if we have no base line?

< 100m



> 3000m



National Oceanography Centre, Southampton

Max Planck Institute for Marine Microbiology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