ADVANCING OUR UNDERSTANDING OF THE DEEP OCEAN IN THE 21st CENTURY: FROM SCIENCE TO TECHNOLOGY

Sven Thatje

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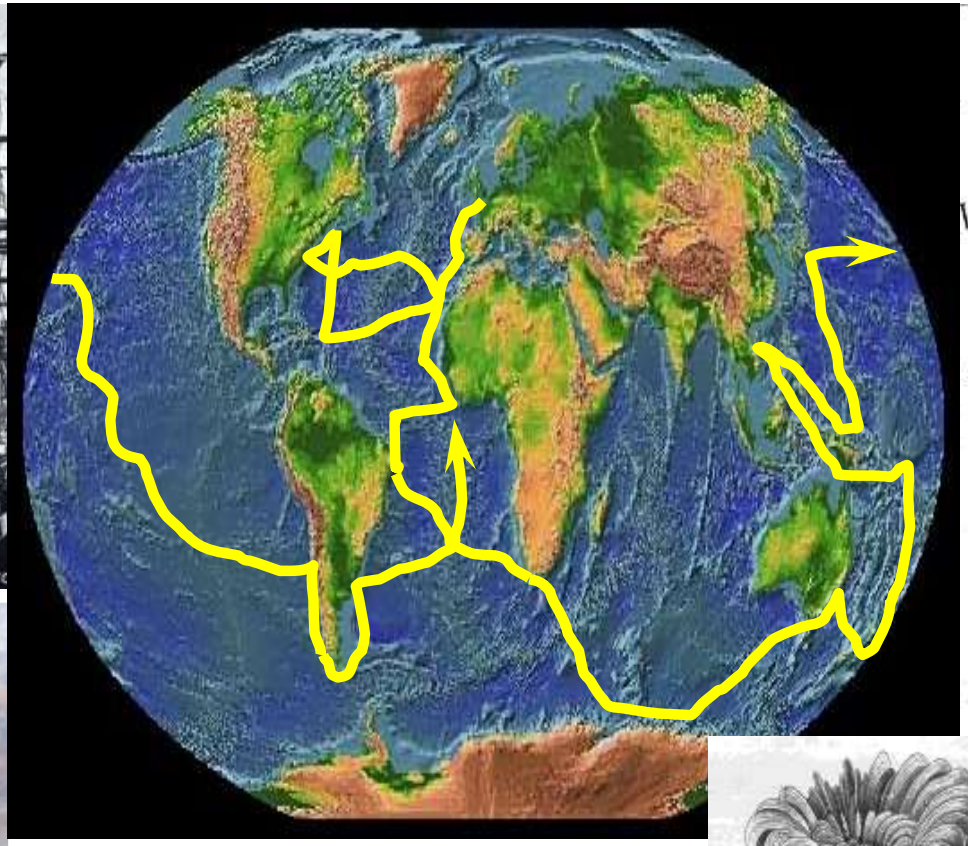
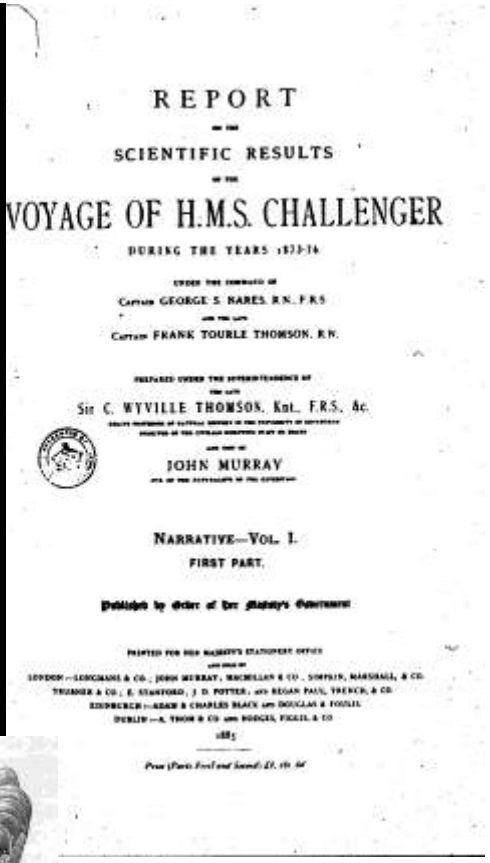
Outline

- Brief overview of deep-sea history & developments
- Scientific Questions & Methodological Challenges
- Exploring & Understanding the Deep Ocean
- Managing human impacts in the Deep Sea (examples from EU initiative MIDAS)
- Broad Scale *versus* Targetet Research (CHESSO example)

HMS Challenger Expedition: 1872-1876





REPORT

SCIENTIFIC RESULTS

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

Captain GEORGE S. NARES, R.N., F.R.S.

Captain FRANK TOURLE THOMSON, R.N.

Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.

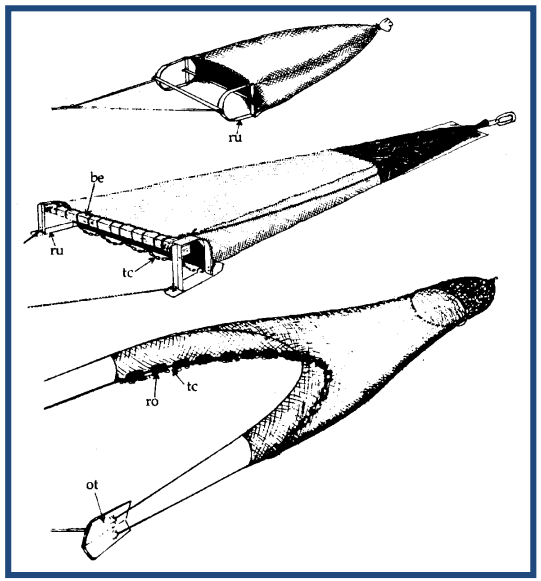
JOHN MURRAY

NARRATIVE—VOL. I.

FIRST PART.

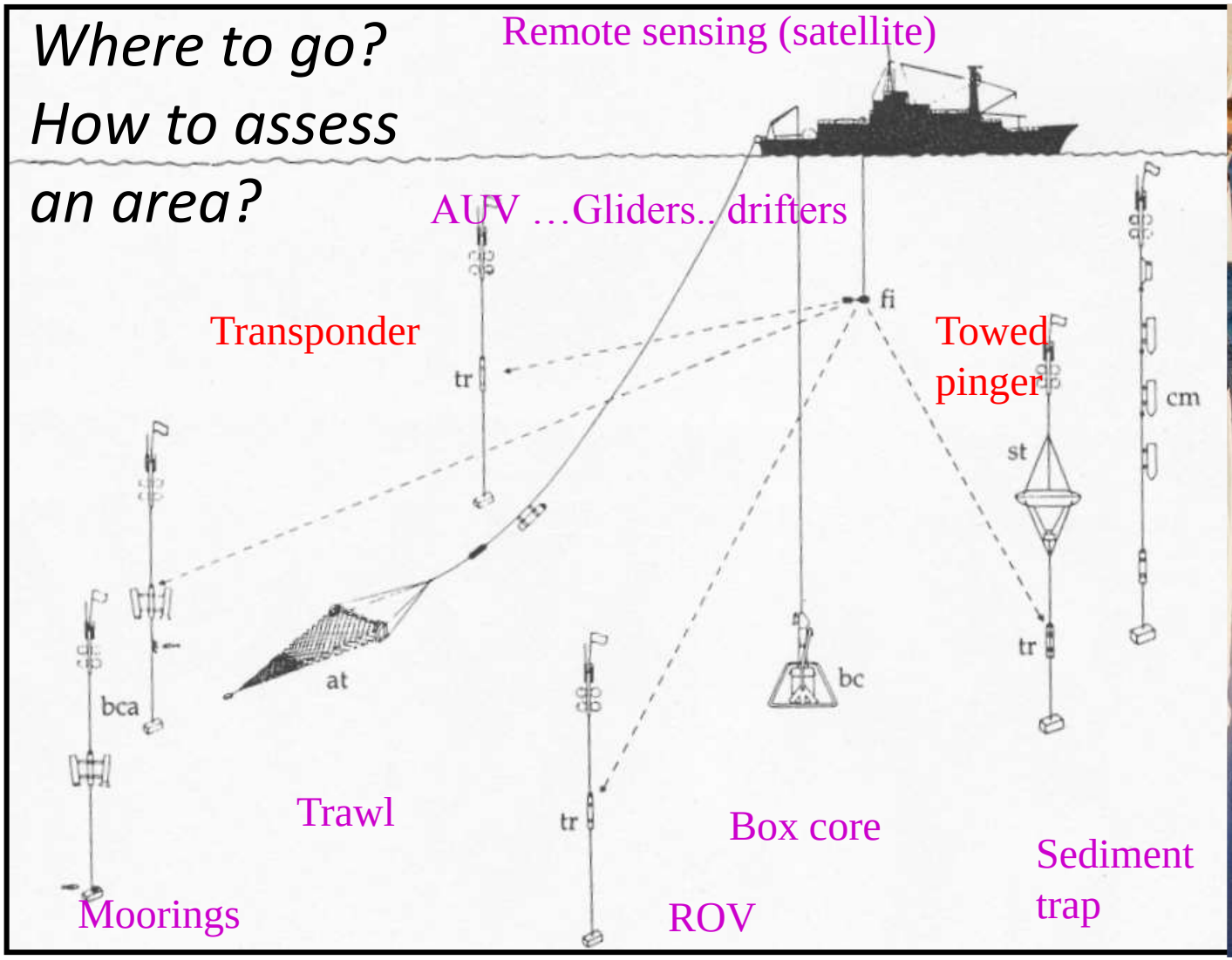
Sven Thatje

Investigating the Deep Ocean - Origins

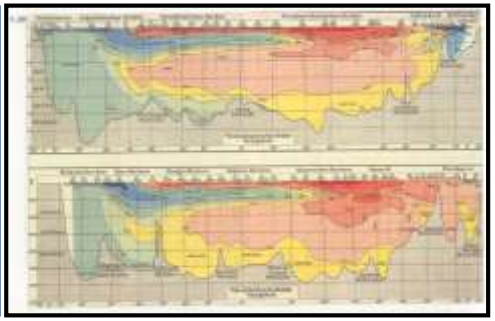


Sampling Gear (past & present)

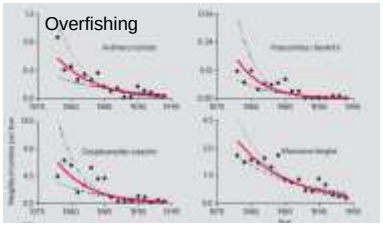
Where to go?
How to assess an area?



Investigating the Deep Ocean – Principal Challenges/Questions



- How do we sample the deep sea?
- How many species & where?
- How many ecosystems & function?
- Spatial & temporal scale/variability of habitats?
- What is man's impact on the deep sea?



HOW TO PRIORITISE?

- **How many species; when, where & why?**

(diversity and ecophysiology)

- **Ecosystems & function?**

(exploration versus targeted approach)

- **Spatial & temporal scale/variability of habitats?**

(mapping & monitoring)

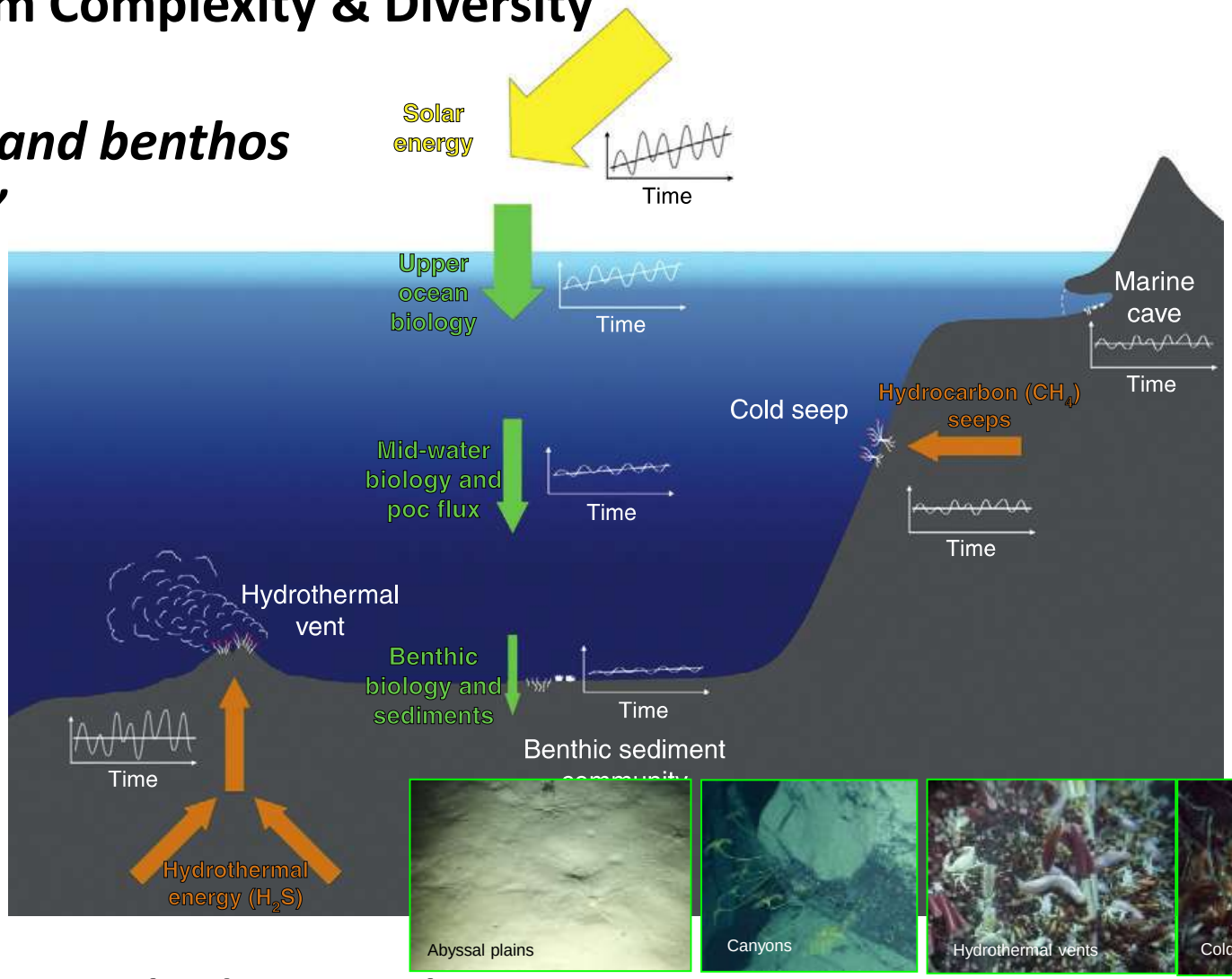
- **What is man's impact on the deep sea?**

(socio-economic needs – ecosystem functioning- sustainability)
(eg fisheries, mining…)

Chile's EEZ:
3 681 989 km²

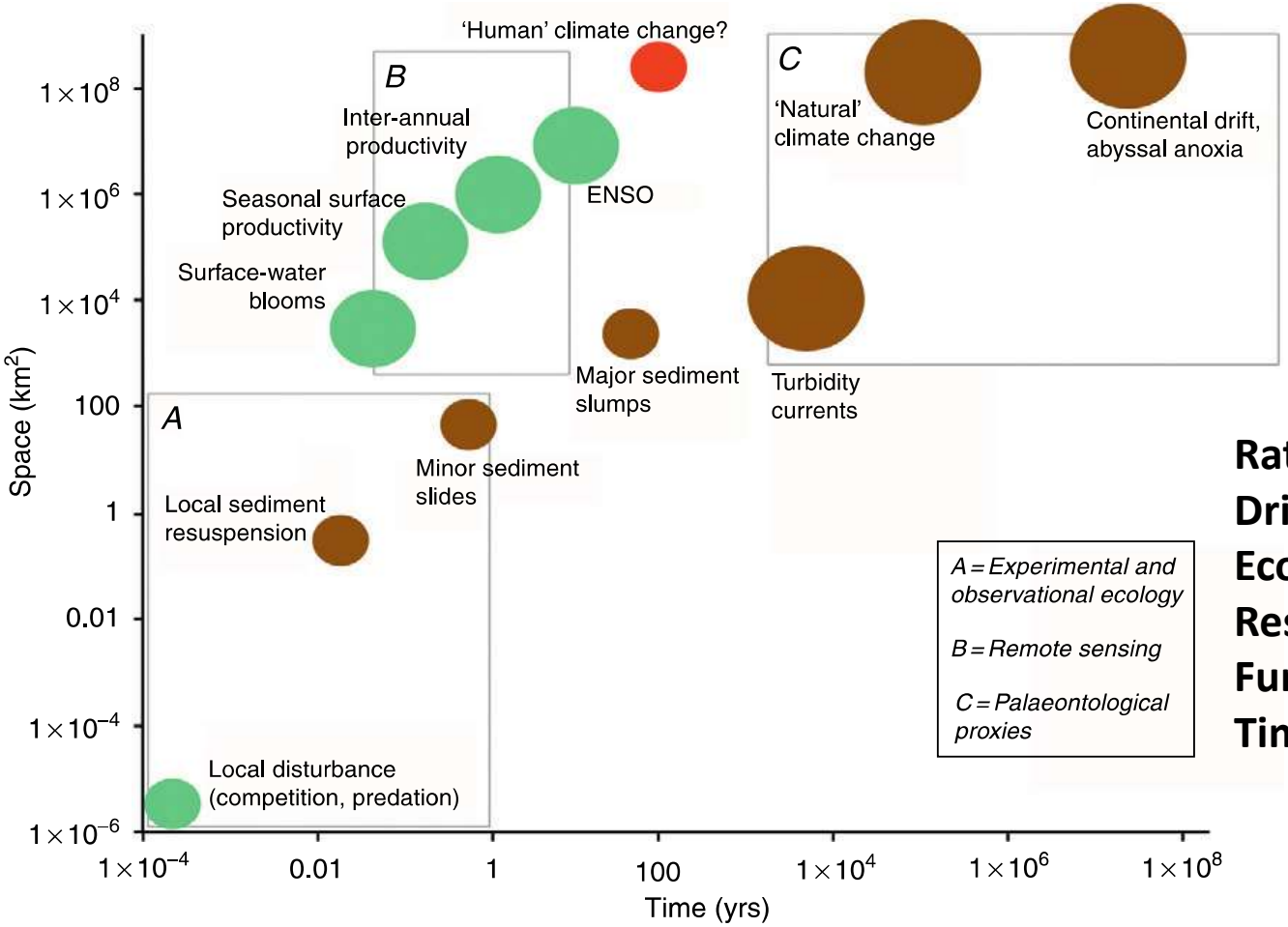
Ecosystem Complexity & Diversity

"Pelagic and benthos Coupled"



Glover, Thatje *et al.* Adv Mar Biol 2010

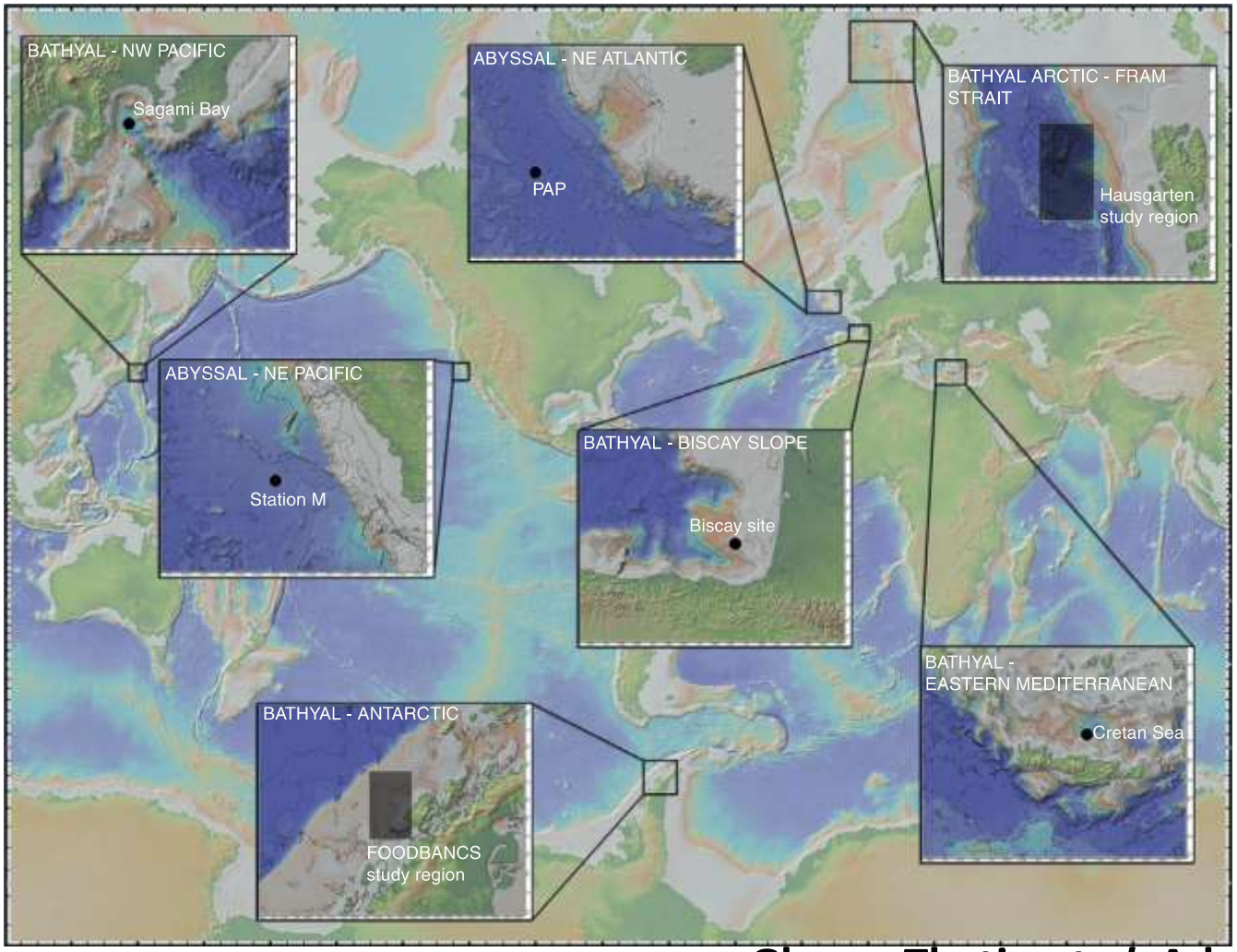
Changes in space and time?



Rates of change?
Driving forces?
Ecosystem stability?
Resilience?
Functioning/Services?
Time scale?

Glover, Thatje *et al.* Adv Mar Biol 2010

Ecosystem Change & Succession… *existing monitoring sites*



Glover, Thatje *et al.* Adv Mar Biol 2010

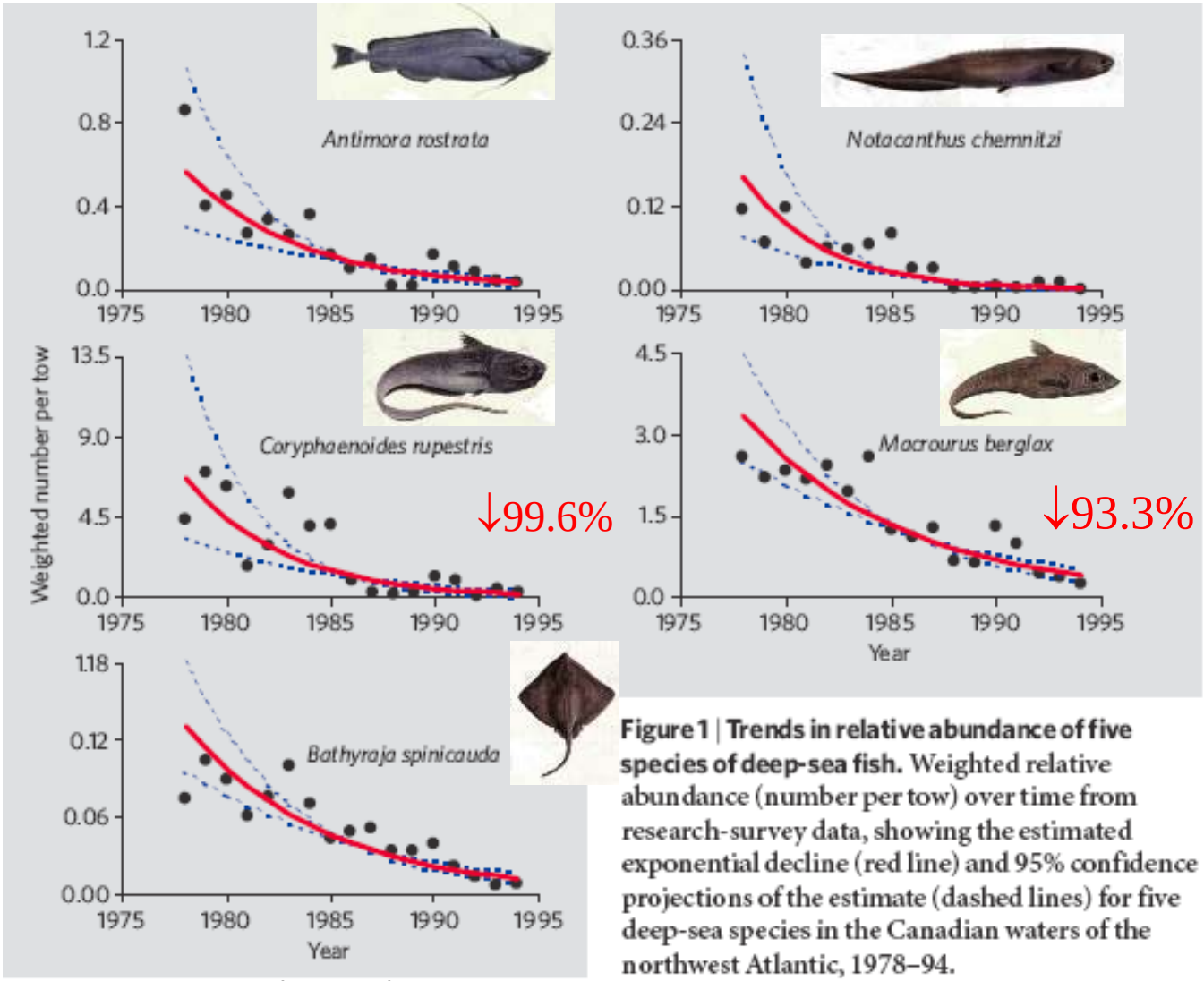


Figure 1 | Trends in relative abundance of five species of deep-sea fish. Weighted relative abundance (number per tow) over time from research-survey data, showing the estimated exponential decline (red line) and 95% confidence projections of the estimate (dashed lines) for five deep-sea species in the Canadian waters of the northwest Atlantic, 1978–94.

Devine et al. (2006) Nature 439: p29

Existing human impacts

Deep-Sea Fish follow global decline

Quantifying the living Resources

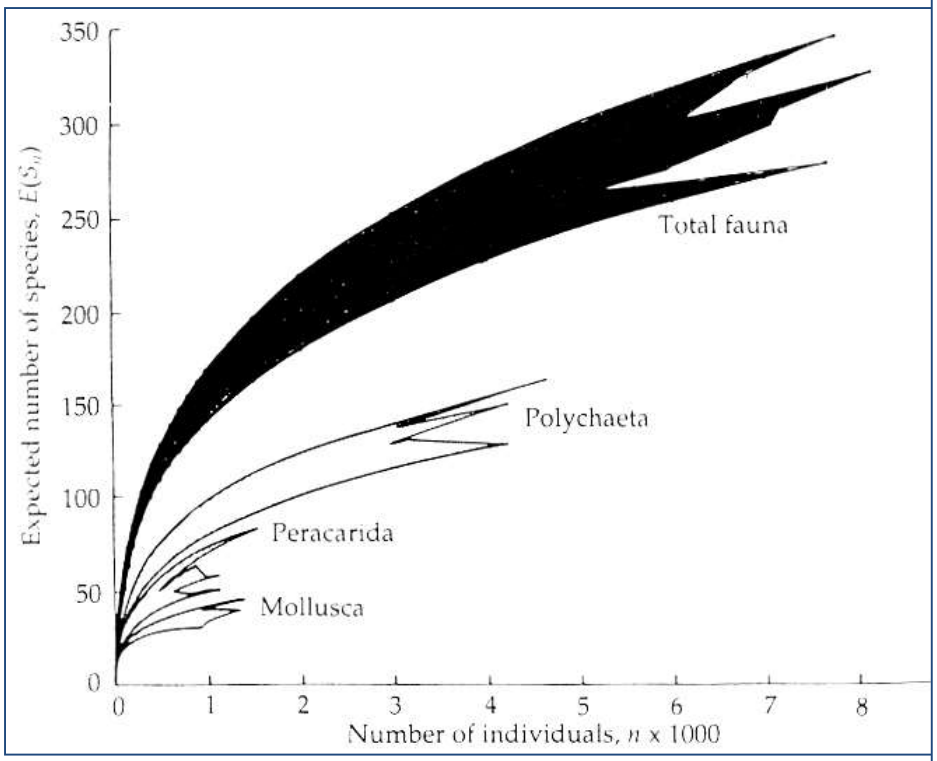
- Taxonomy (Experts)
- Securing knowledge (collections & management)
- Filling the Gaps (exploration)
- Making knowledge available
- ***=>> how to balance the effort?***



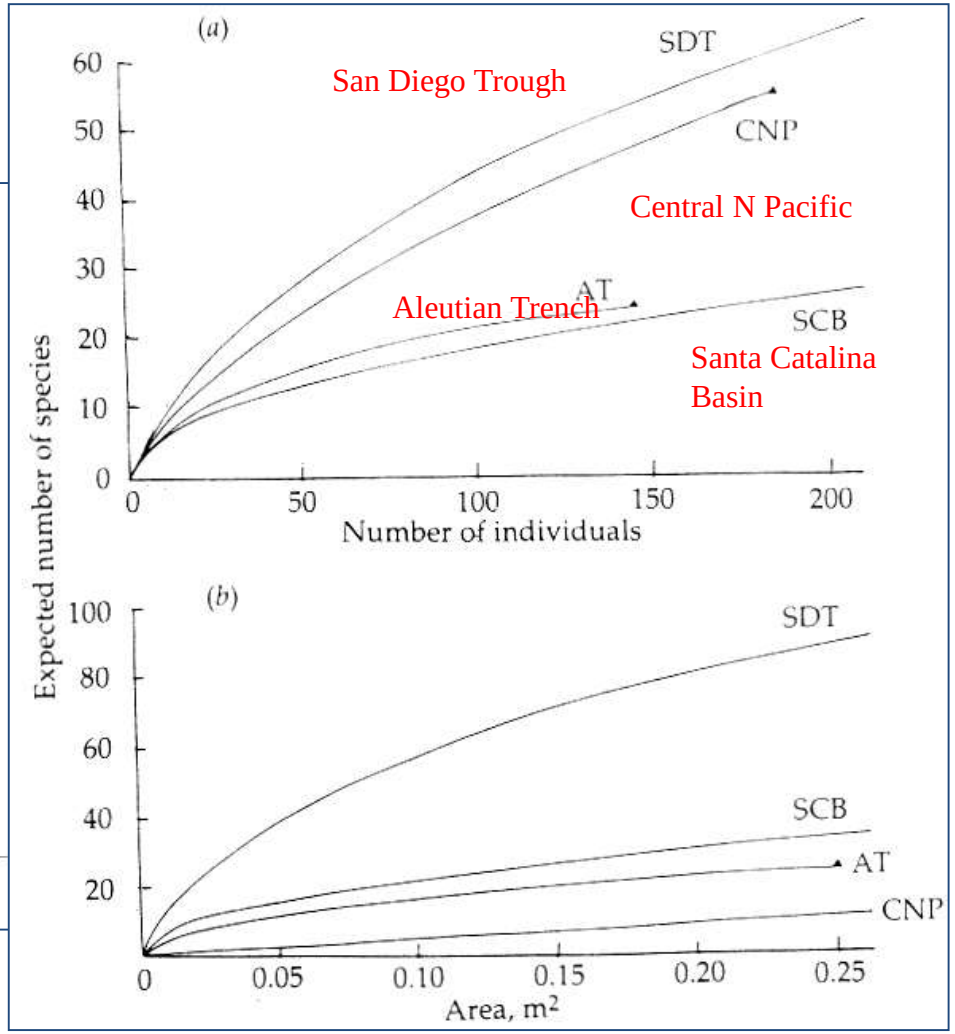


How many species?

See Gage JD and Tyler PA 1991 Deep-Sea Biology

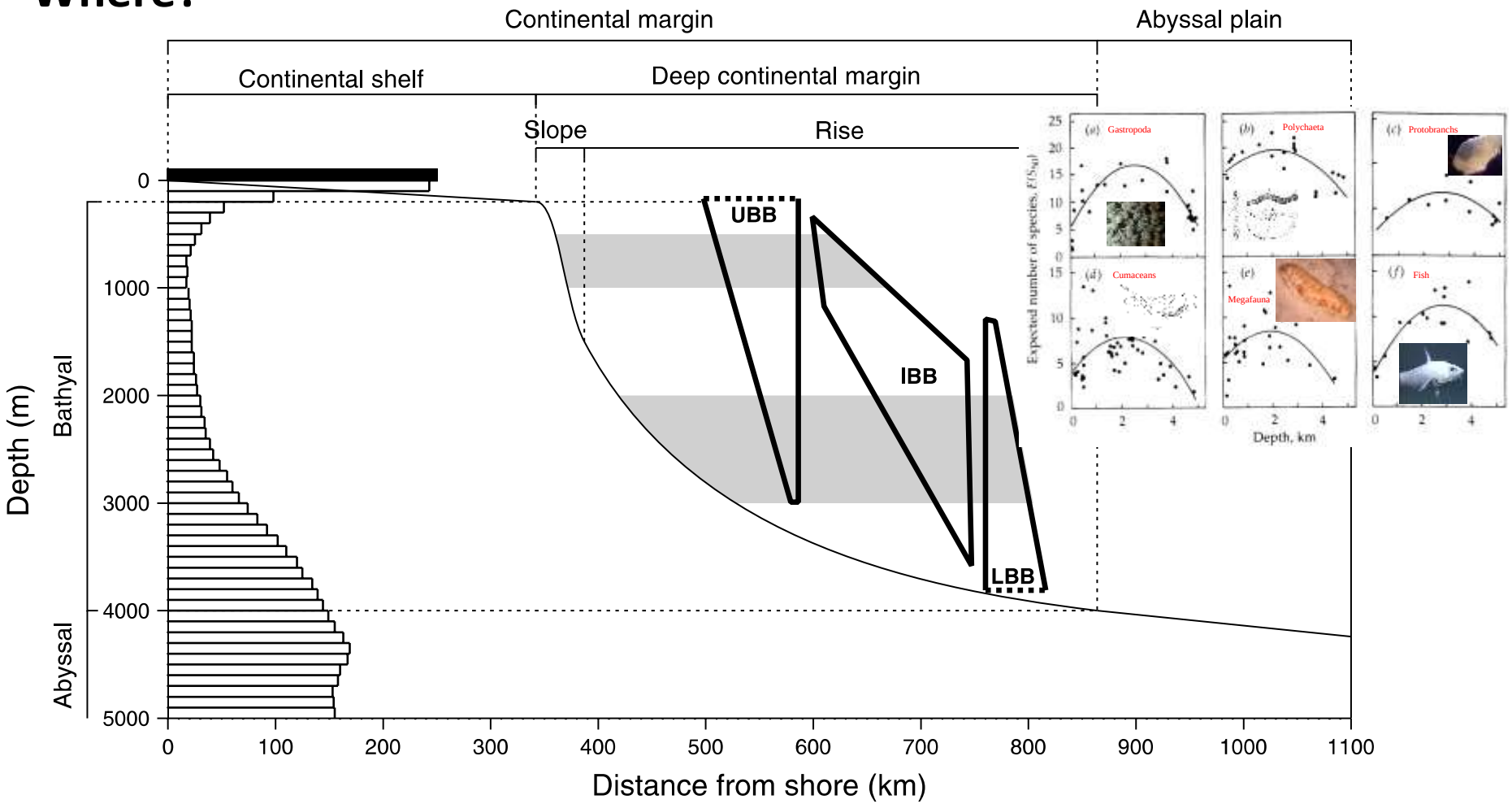


NW Atlantic 2100m depth



North Pacific

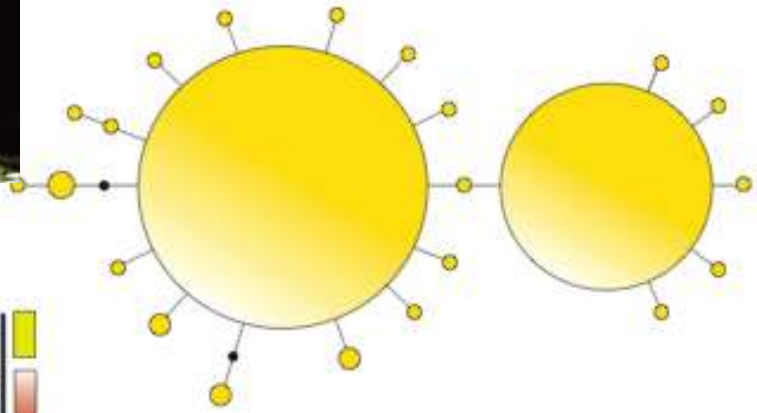
Where?

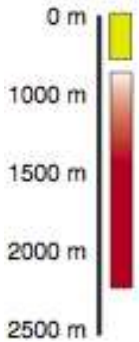


Brown & Thatje Biol. Rev. 2014

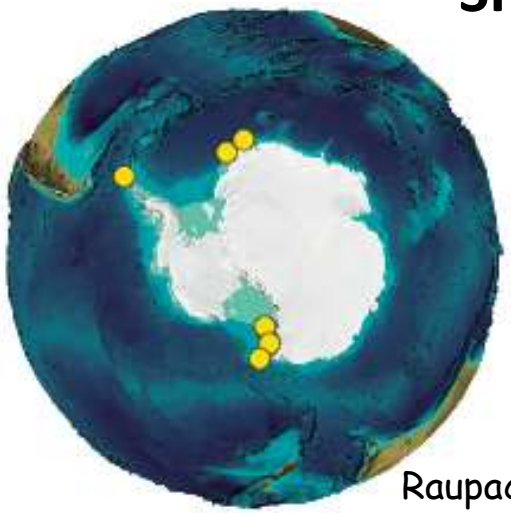
Broadcaster (dispersal & pop. connectivity)

Chorismus antarcticus



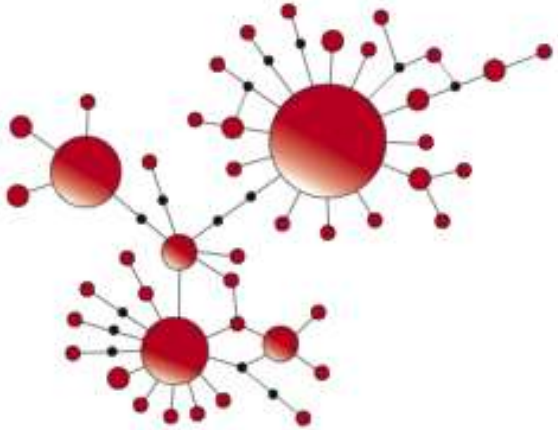


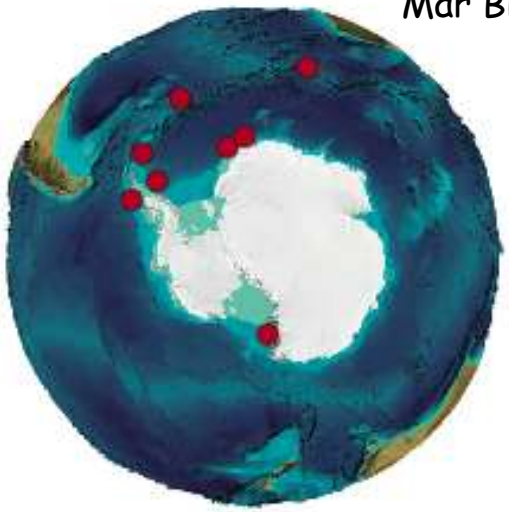
"SHALLOW"



Raupach, Thatje et al
Mar Biol. 2010

Nematocarcinus lanceopes





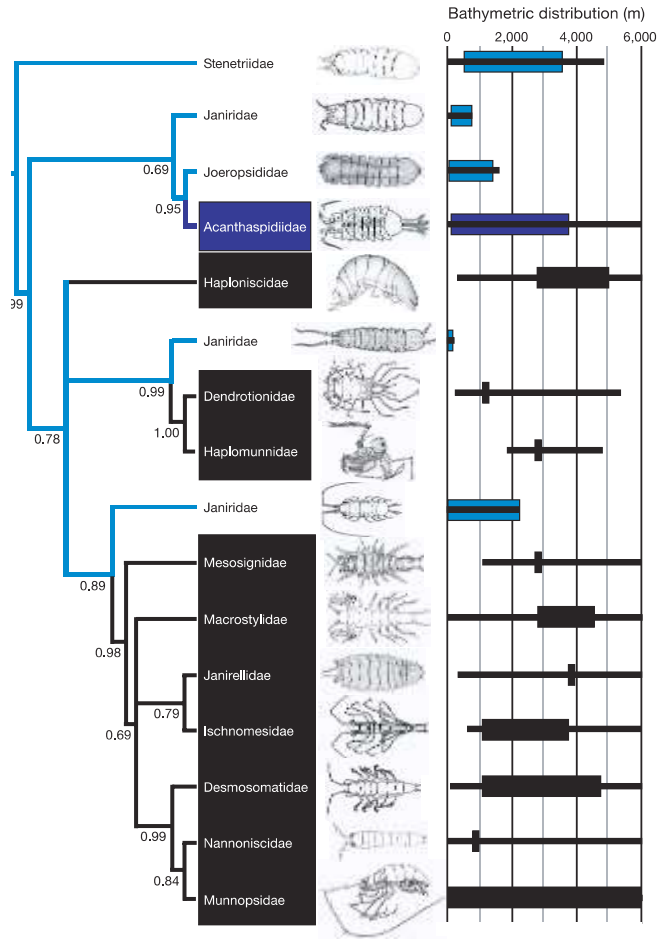
"DEEP"

mitochondrial cytochrome oxidase I (COI) gene

Vol 447|17 May 2007|**doi:10.1038/nature05827** nature

First insights into the biodiversity and biogeography of the Southern Ocean deep sea

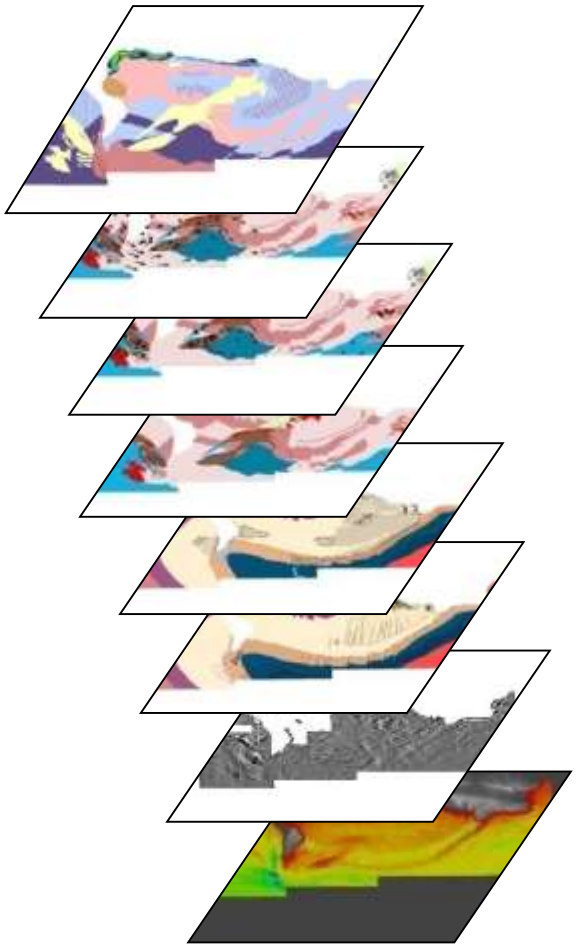
Brandt *et al.* 2007



Habitat Mapping: What to map, how and why?

- Morphology (i.e. bathymetry)
- Substrate/seabed sediment
- Physical or chemical parameters (e.g. temperature, salinity, C-content of the sediment)
- Habitats
- Feature locations
- Derived variables: slope, aspect, seabed rugosity, habitat patchiness…

=> Assessment of biological & geological environment



Traditional methods & development

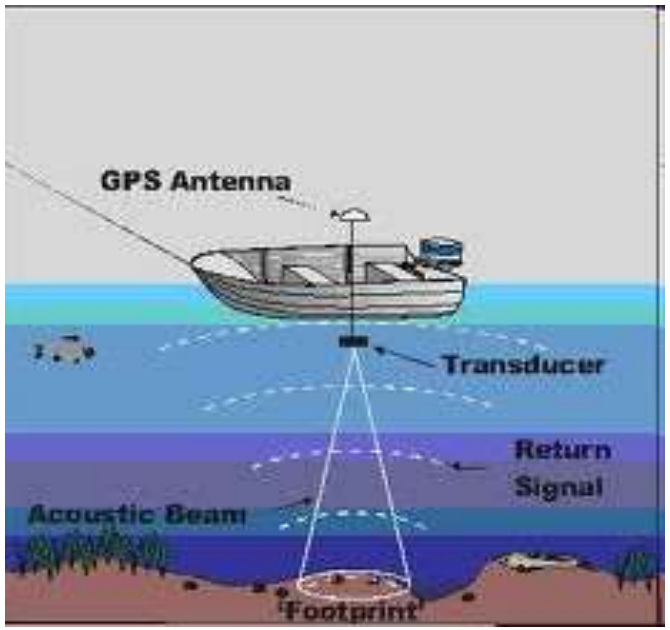
Optical (electromagnetic)

- Very much depth-limited
- Only useful for sea surface measurements, shallow waters or instruments close to seabed

www.biologyreference.com

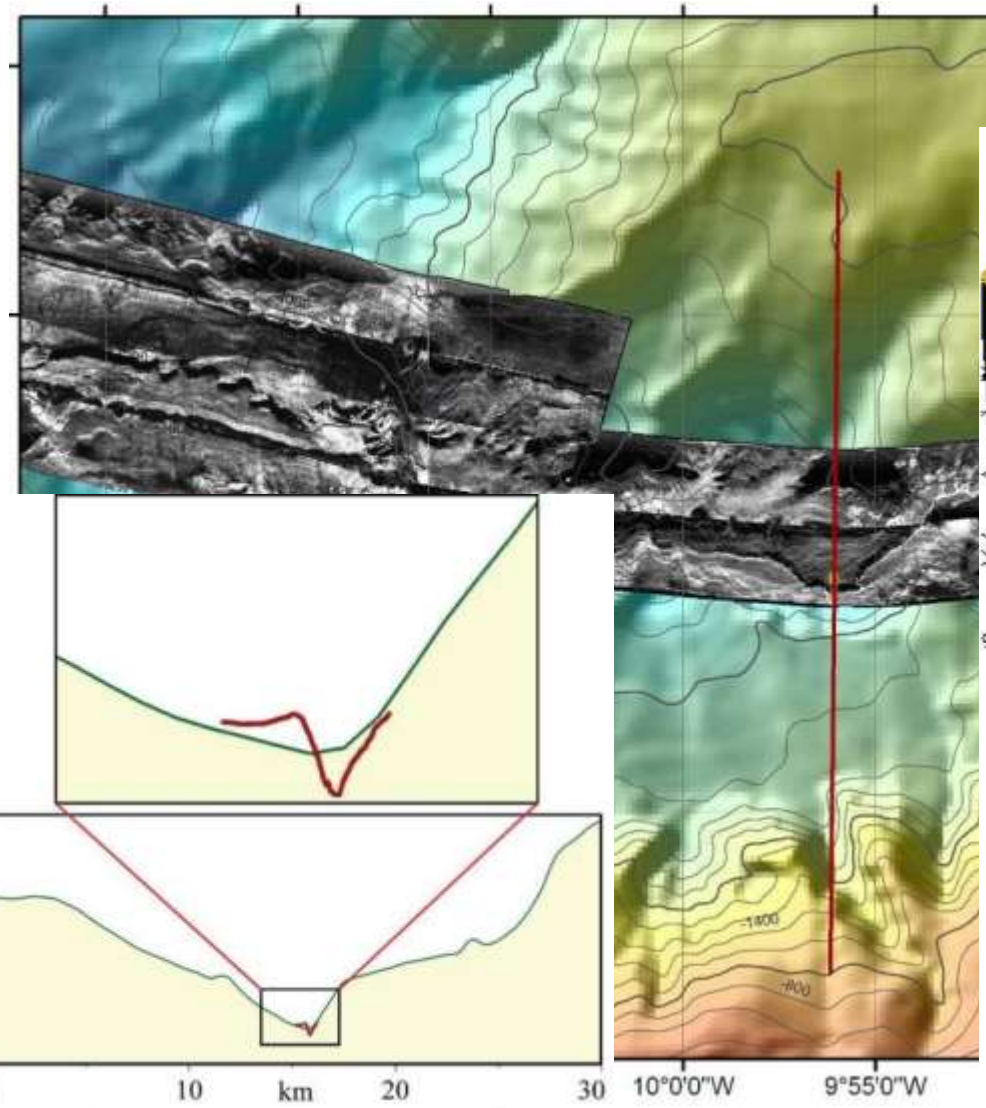
Acoustic

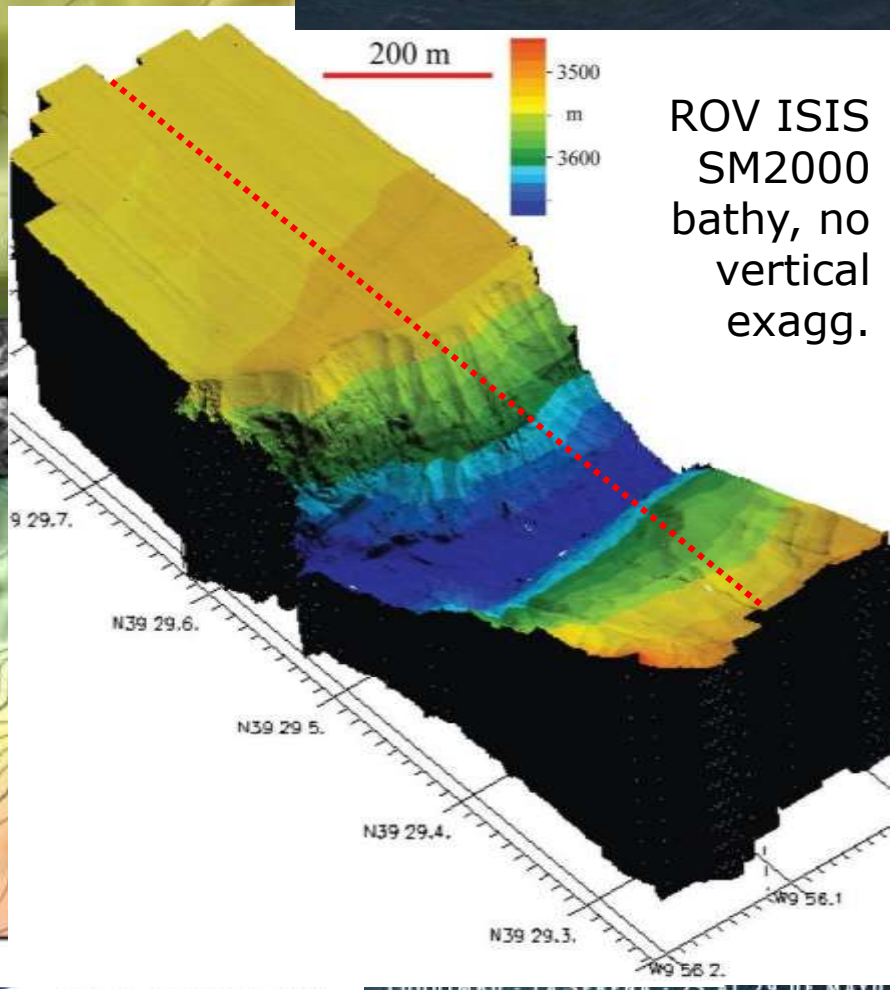
- Good penetration of water column
- Information about **depth and reflectivity** of the seabed
- Still affected by attenuation: trade-off between depth & resolution



Methods: it's all about scale

Fine-scale mapping is necessary to understand true deep-sea topography/morphology

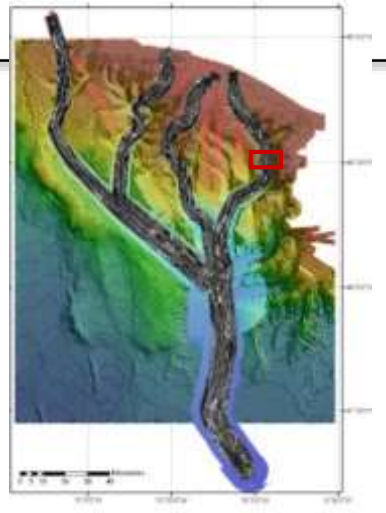


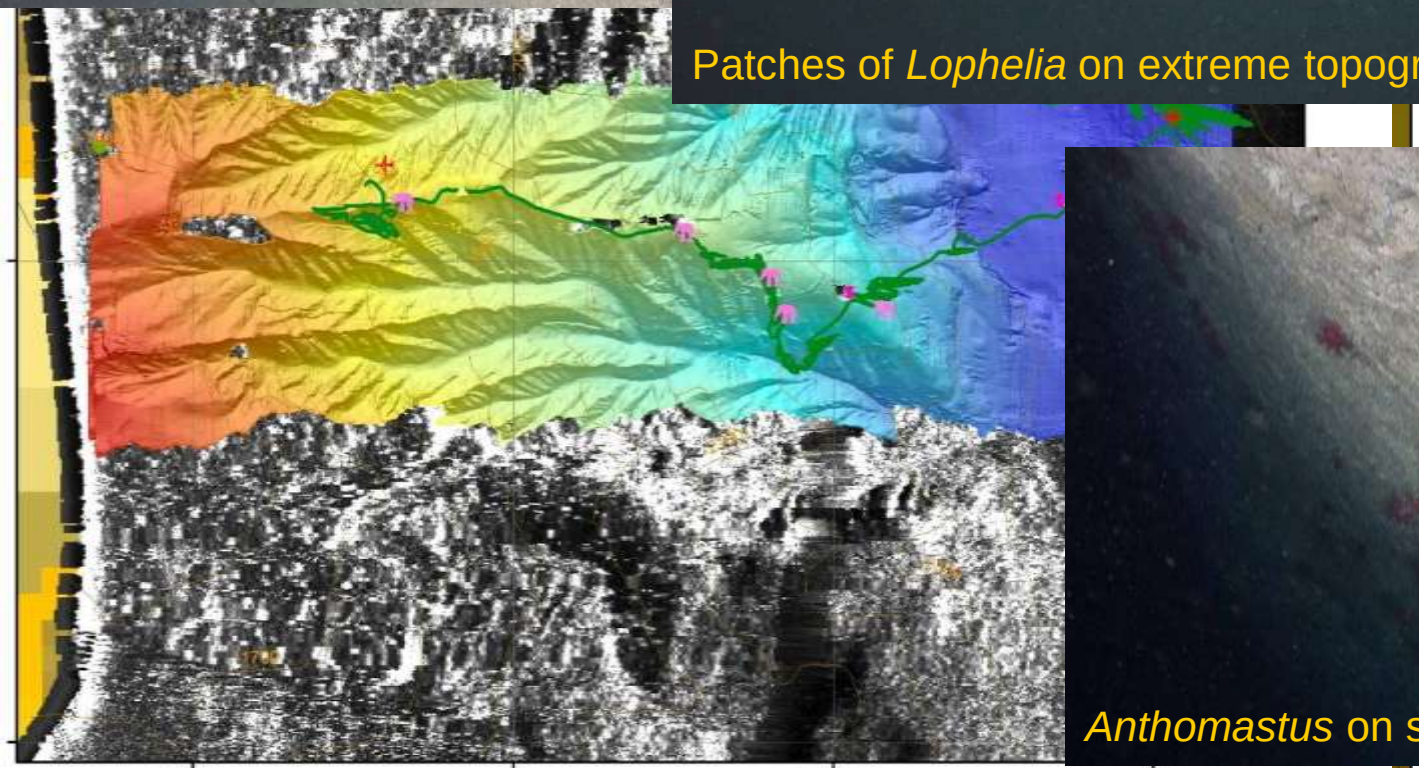


ROV ISIS SM2000 bathy, no vertical exagg.

Solitary soft corals

Patches of *Lophelia* on extreme topography





Anthomastus on softer substrates

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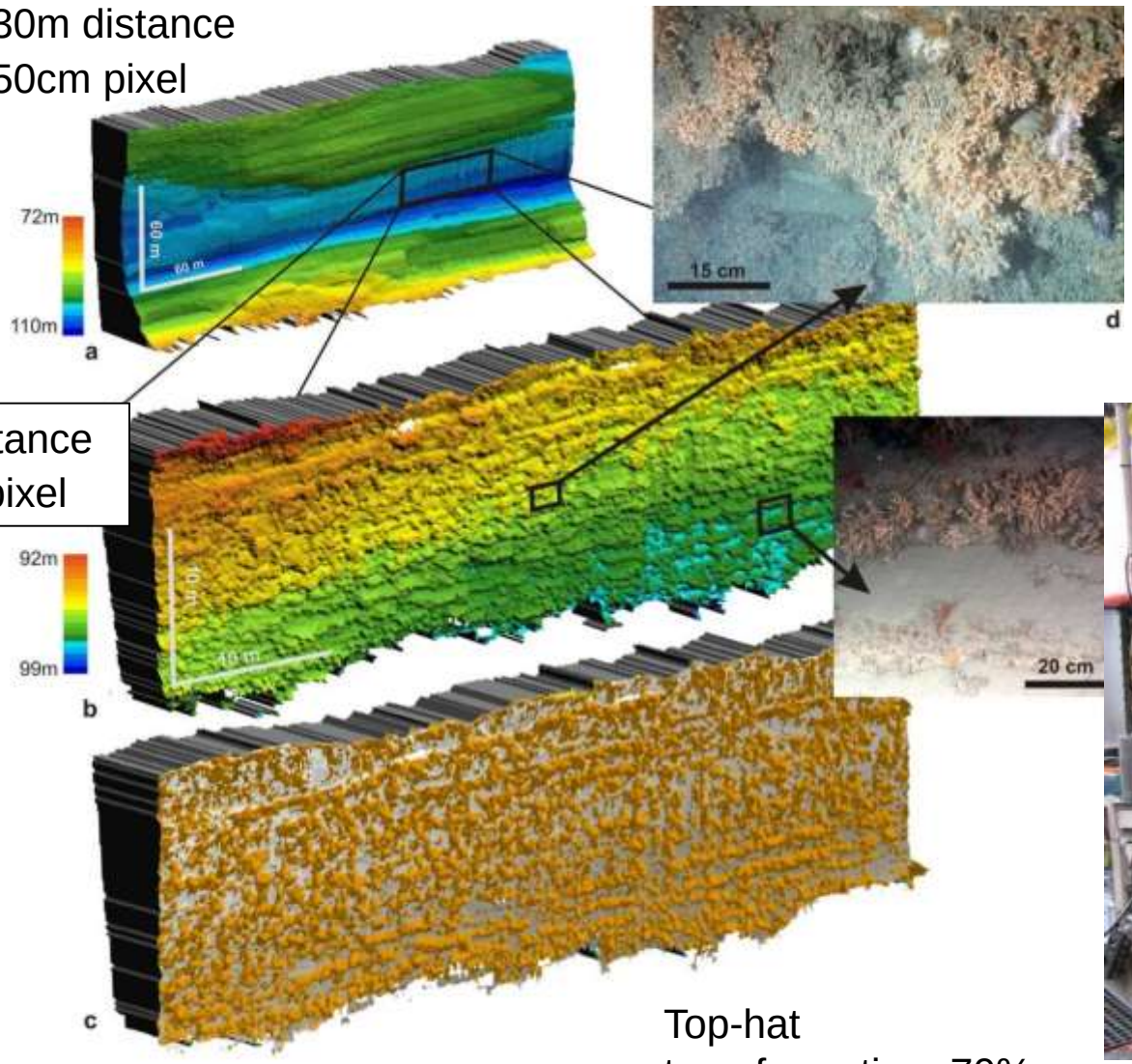
Investigating the Deep Ocean – Mapping the deep ocean

30m distance
50cm pixel



7m distance
10cm pixel

SM2000 multibeam on front of ISIS

Surveys at 4 different distances from cliff

Top-hat transformation: 70% coral cover

Marine Mineral Resources from the Deep Sea

Mn-Nodules

grow around a nucleus on sedimented abyssal plains (3000-6000m)

Ni, Co, Cu

Cobalt Crusts

grow on the flanks of old volcanoes (800-2500m)

Co, Ni, Cu

Massive Sulphides

form along mid-ocean ridge or at young active volcanoes (100-5000m)

Cu, Au, Zn, Ag

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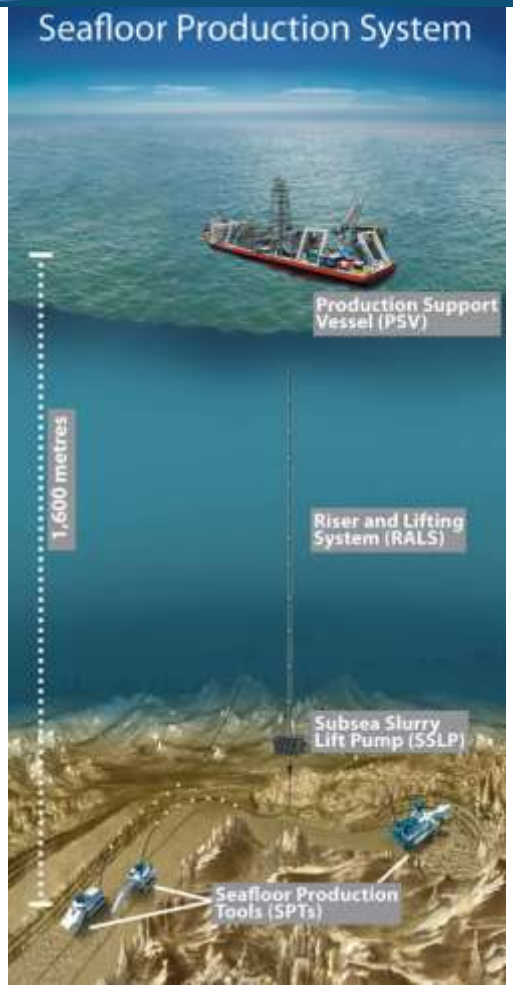
MIDAS

MANAGING IMPACTS OF DEEP SEA RESOURCE EXPLOITATION



Coordinator: P. Weaver; phil.weaver@seascapeconsultants.co.uk

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University of Southampton and Natural Environment Research Council

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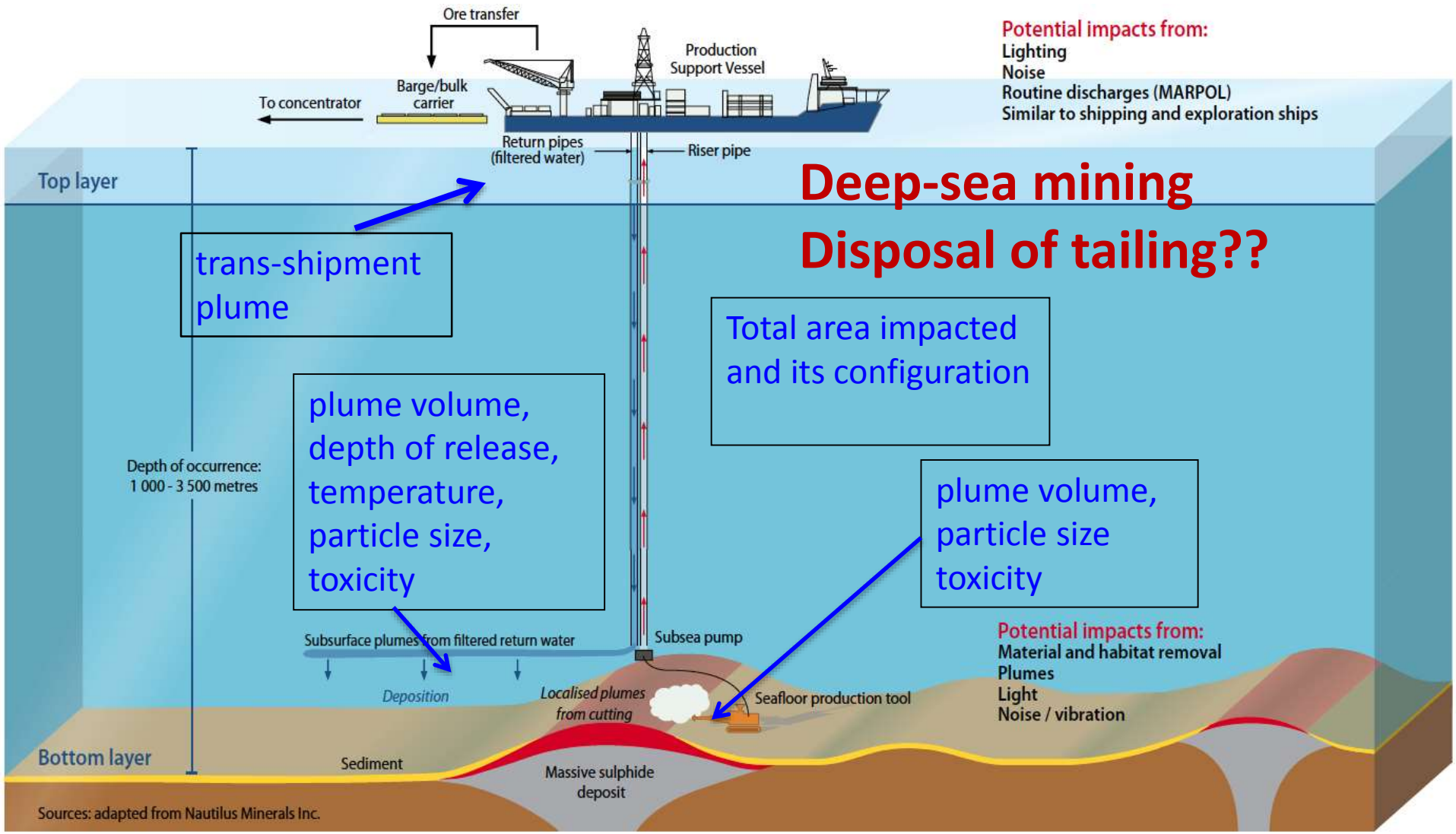
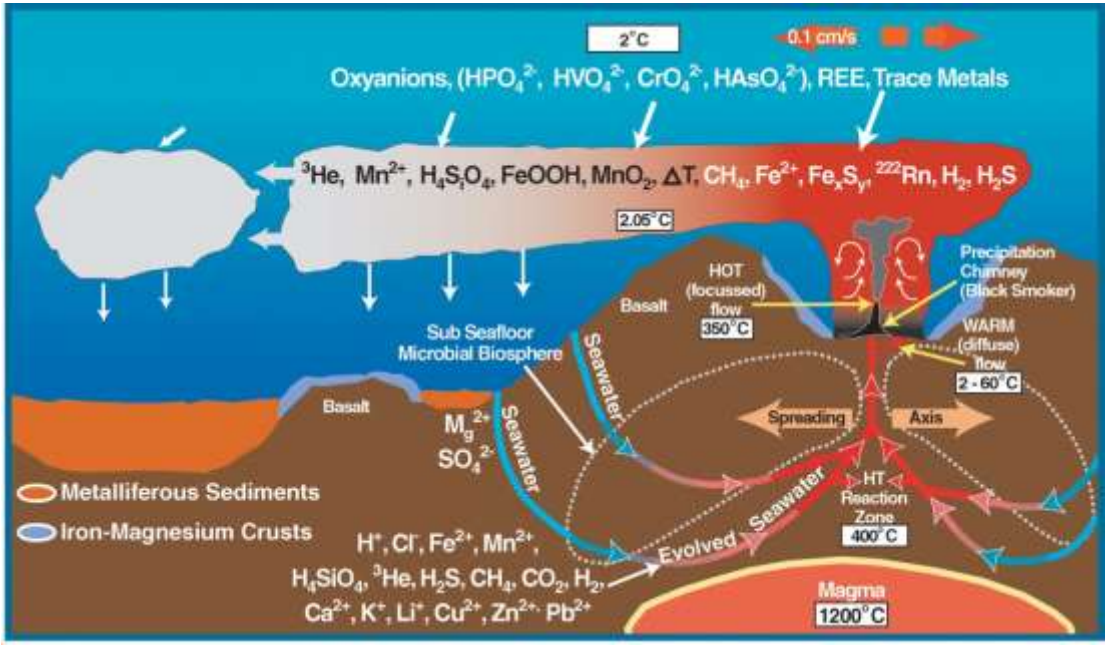
Environmental impacts from deep-sea mining



Secretariat of the Pacific Community (2103) *Deep Sea Minerals: Sea Floor Massive Sulphides, a physical, biological, environmental, and technical review. Vol. 1A, SPC*

What pollutants could we consider?

Deep-sea mining
Disposal of tailing



1) Metals and metal cocktails

Nodules (Mn, Co, Cu, Pb…)

Manganese crusts (Co, Pt group elements, Ni and rare earths)

Hydrothermal vents (Zn, Cu, Ag, Au…)

2) Lubricating muds

Nautilus™ - deep sea drilling in the Bismarck Sea, PNG

(Crowhurst & Lowe, 2011)

3) Polymetallic sulfides

(Cu, Zn, Pb, Ag, Au, Ba…)

4) Methane hydrates–

methane, CO_2, low oxygen

(being dealt with in other projects?)

5) Organic enrichment?

suspended clay minerals?

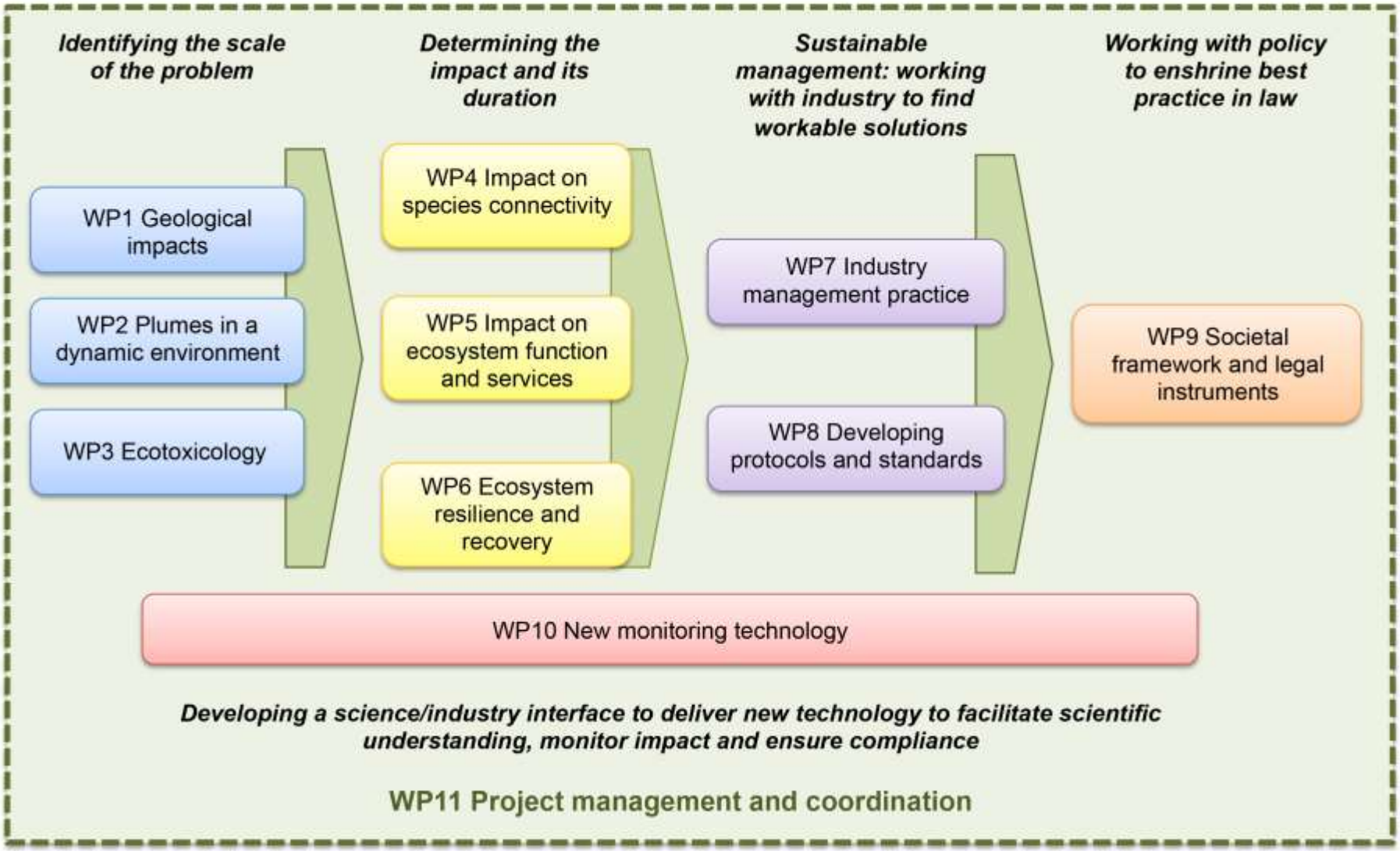
6) Rare earth elements in deep sea muds

(e.g. yttrium)

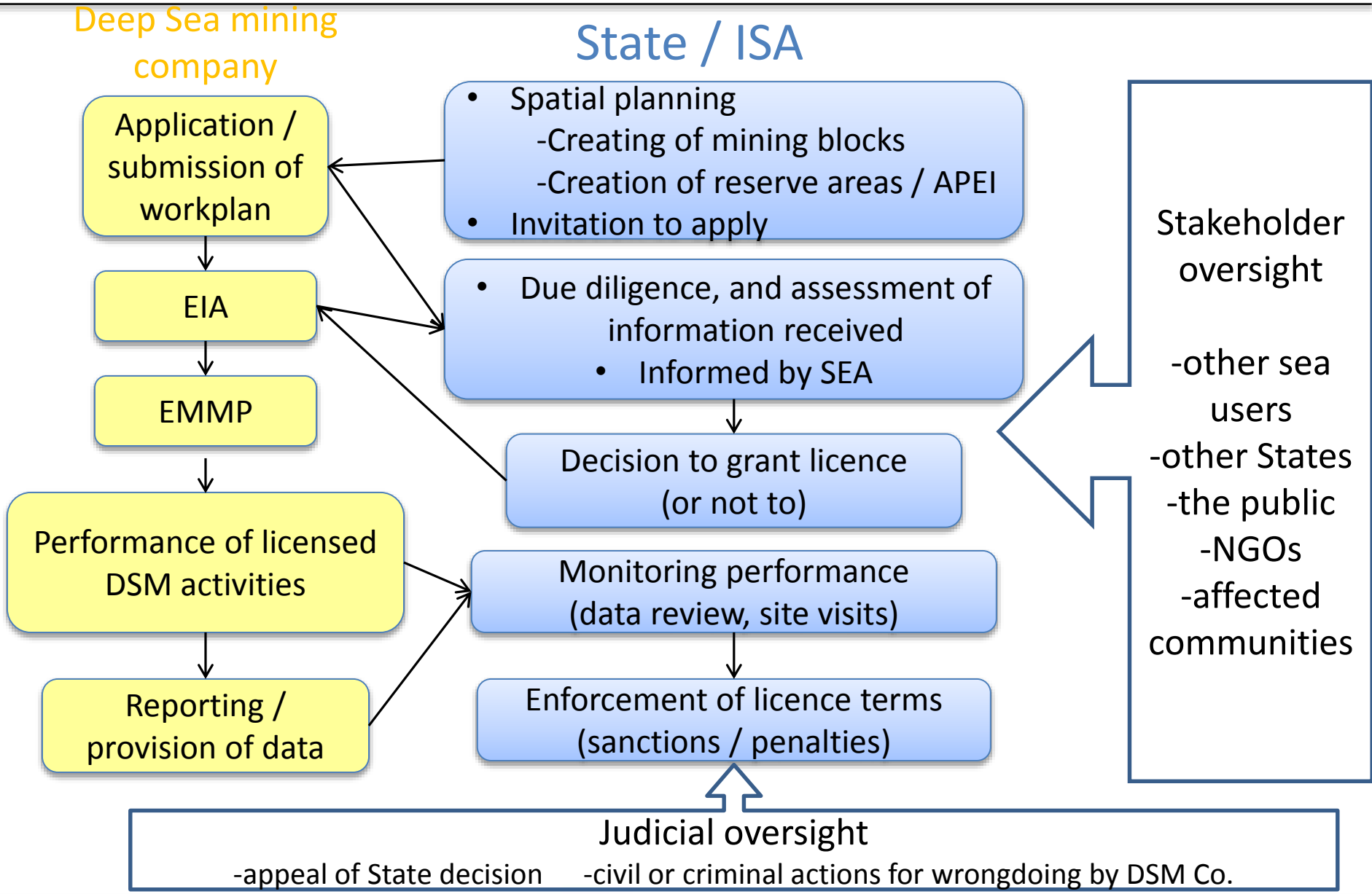
Ecosystem impacts?

MIDAS (FP7) Work Programme

Coordinator: Phil Weaver (contact: phil.weaver@seascapeconsultants.co.uk)



Informing stakeholders – influencing decision making

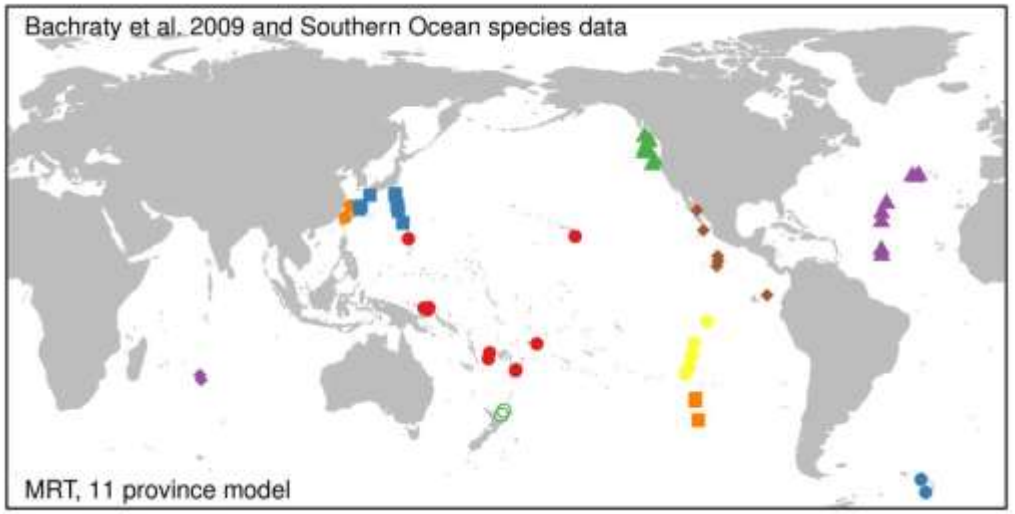


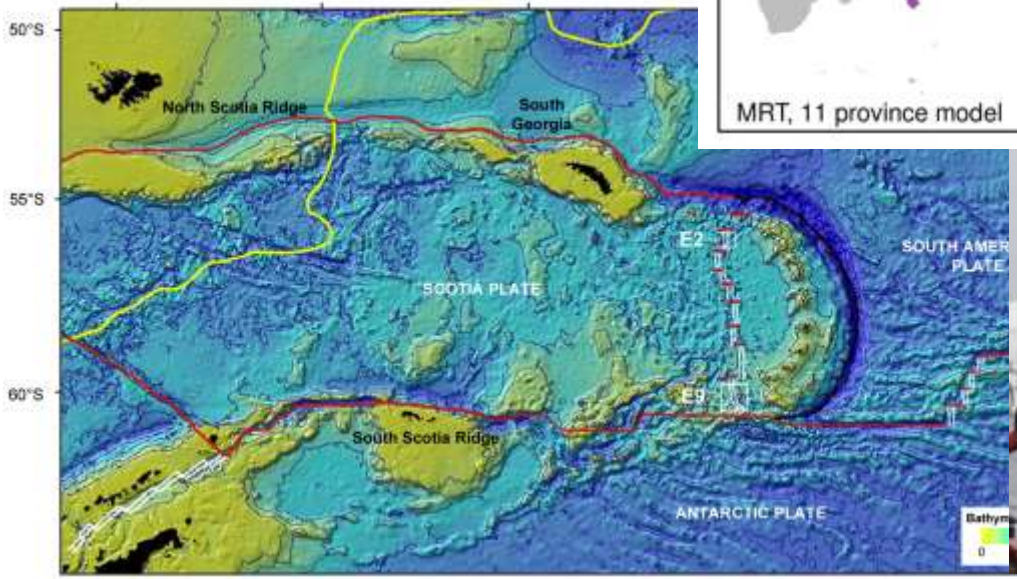
Investigating the Deep Ocean – Targeted Approach (multi-disciplinary)

OPEN ACCESS Freely available online

PLoS BIOLOGY

The Discovery of New Deep-Sea Hydrothermal Vent Communities in the Southern Ocean and Implications for Biogeography





ChEss
BIOGEOGRAPHY OF DEEP-WATER CHEMOSYNTHETIC ECOSYSTEMS

Marsh et al., (2013)

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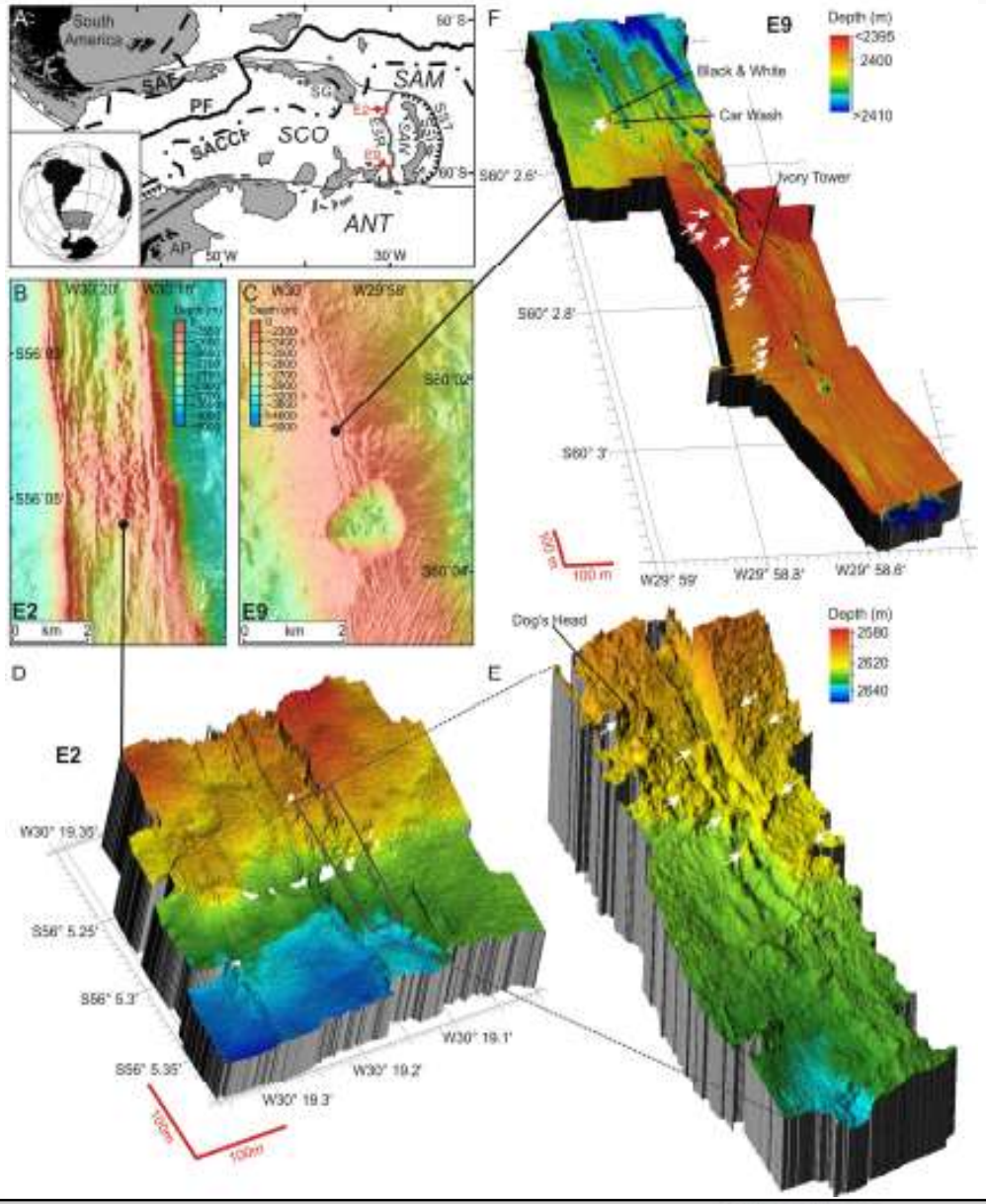

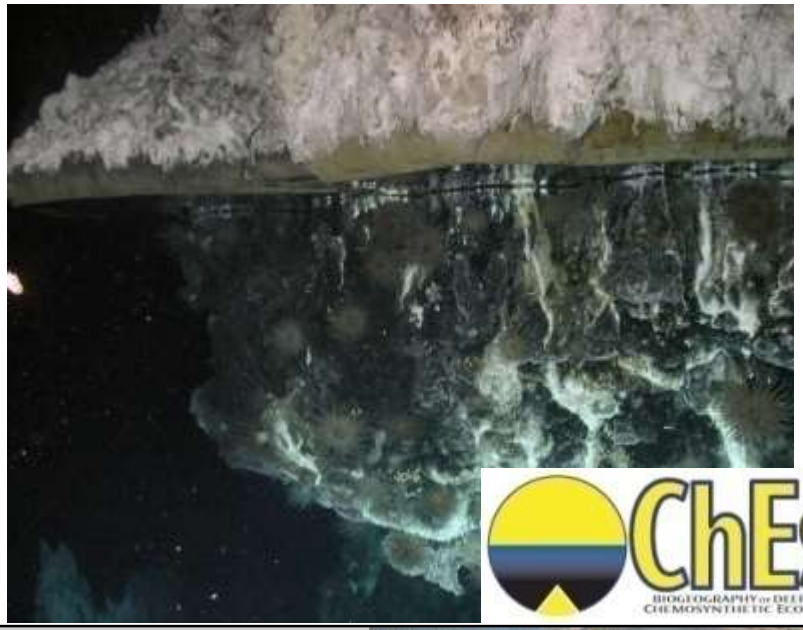

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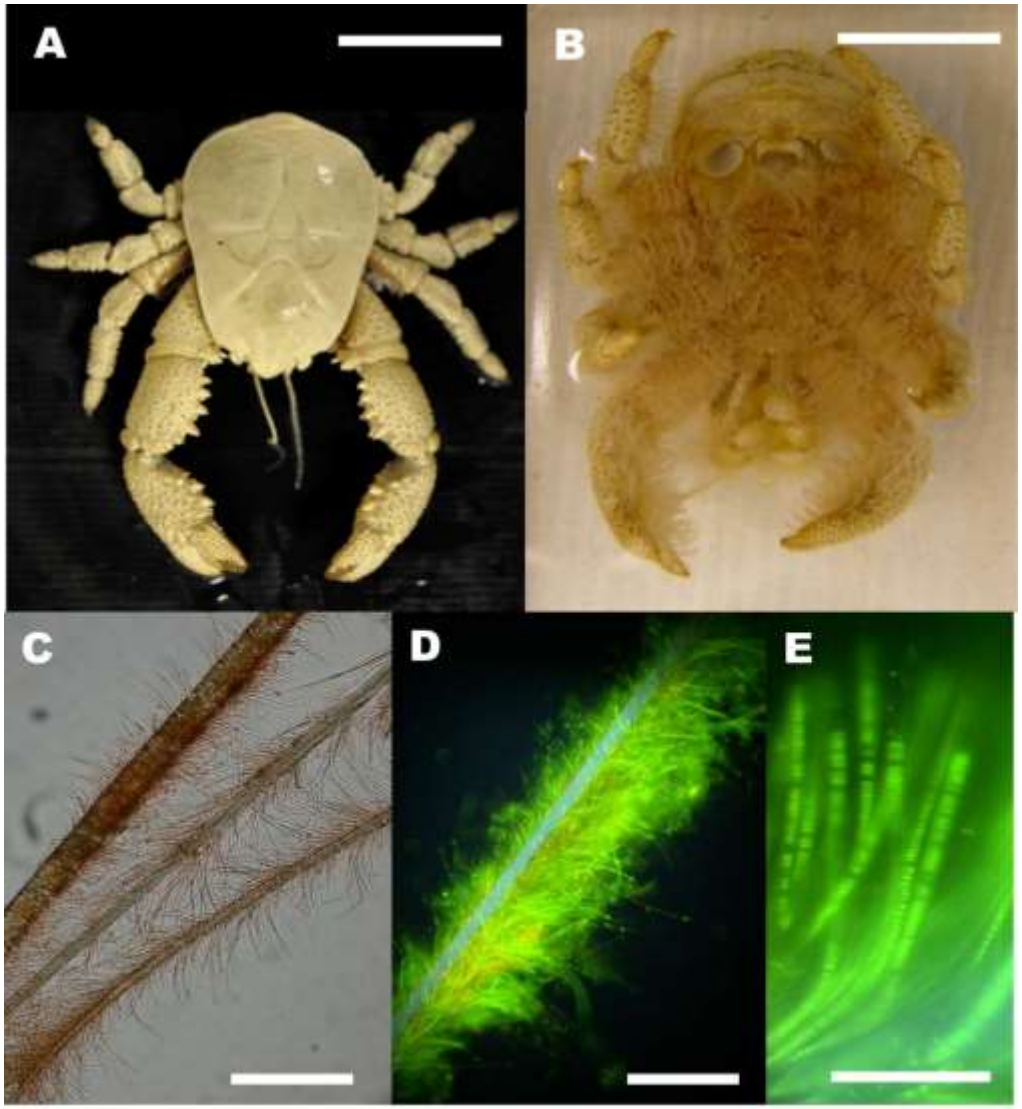

Kiwa tyleri sp.now.
Potential host-symbiont Association

Thatje et al.
PLOS ONE (June 2015)

Courtesy:
K. Zwirglmeier
et al. MicrobiolOpen (2014)

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BIOGEOGRAPHY OF DEEP-WATER CHEMOSYNTHETIC ECOSYSTEMS

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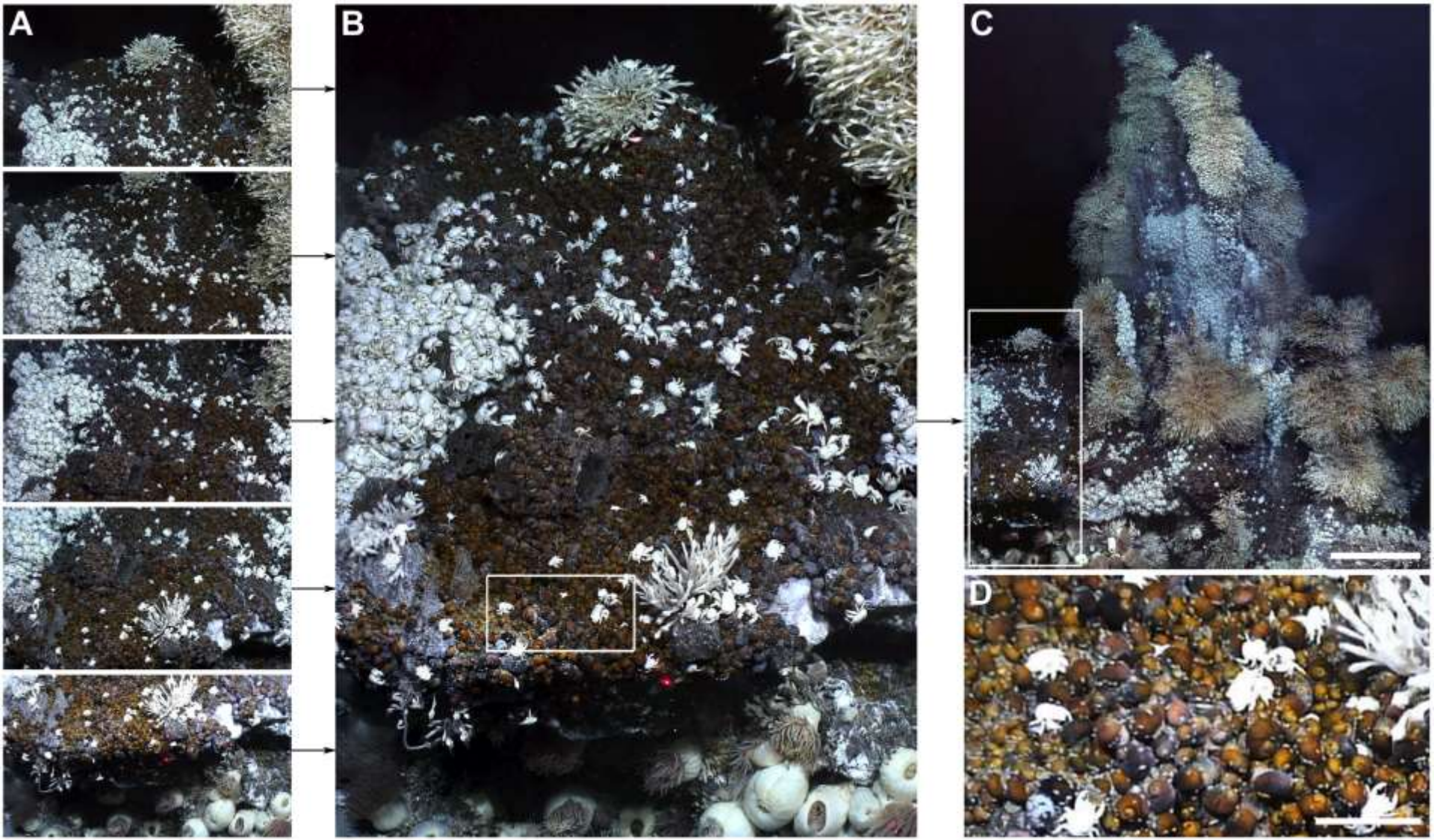
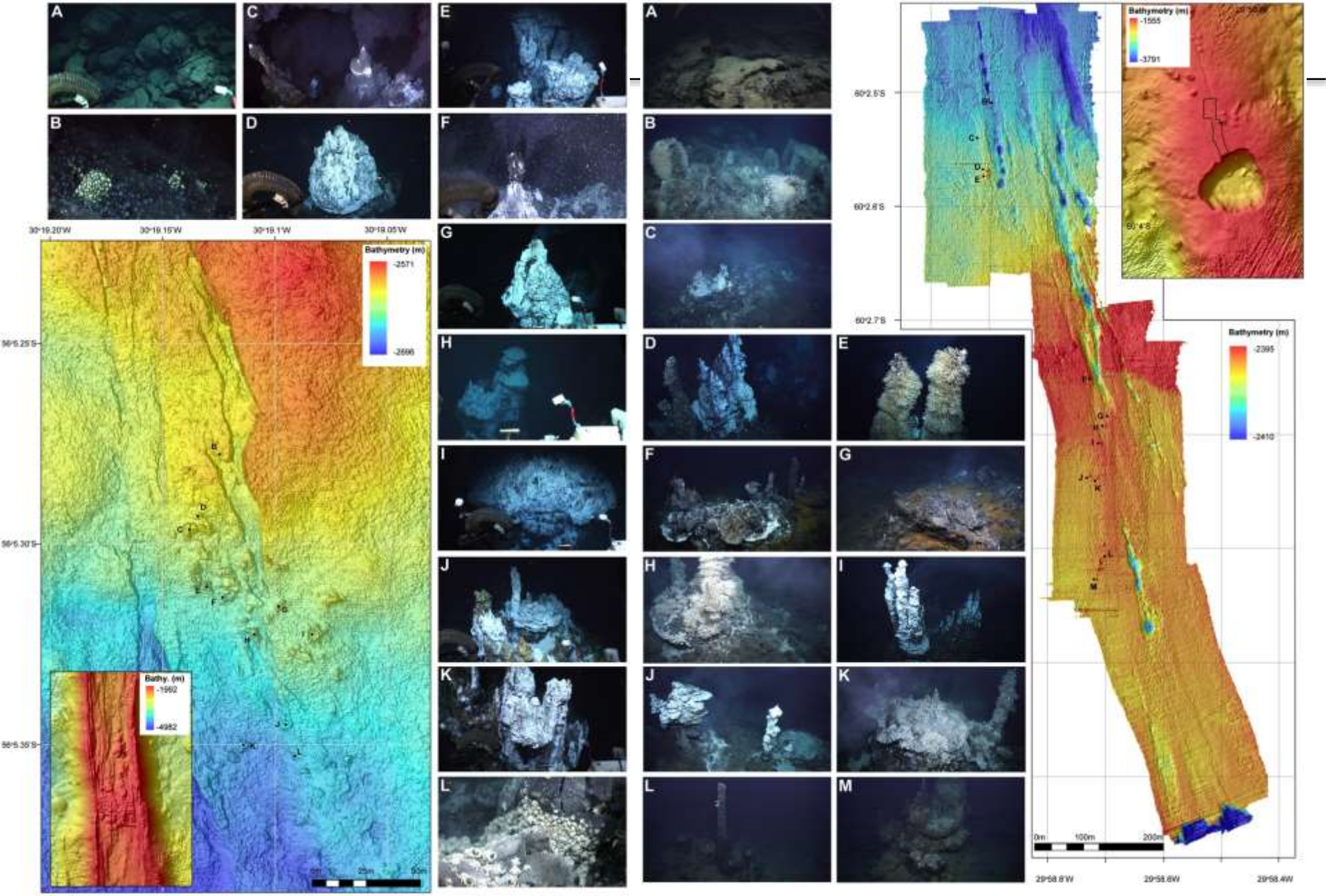


Marsh et al., DSR I (2013)



Marsh et al., DSR I (2013)

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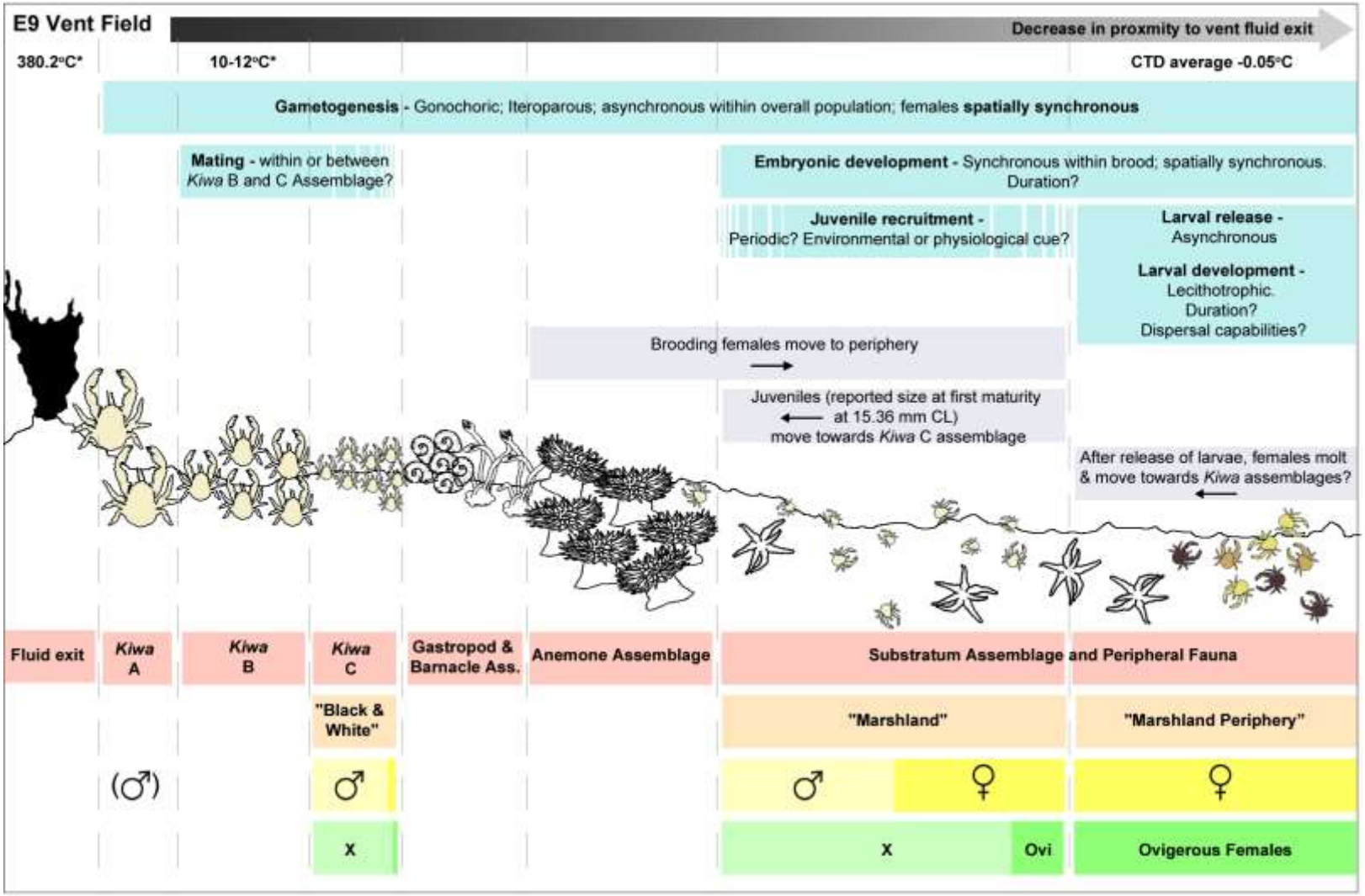
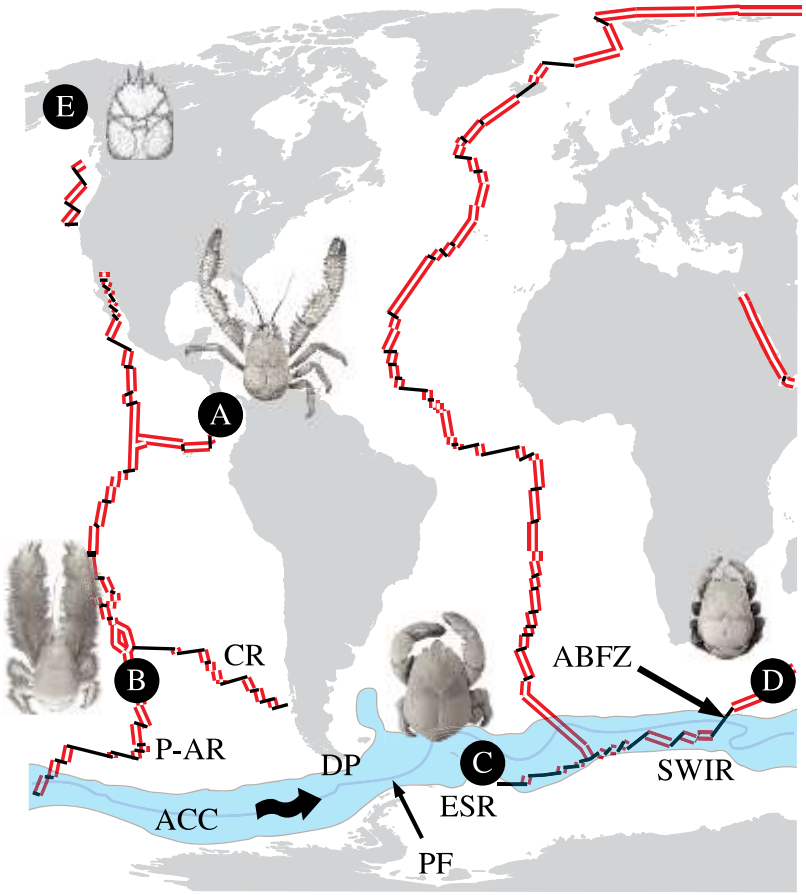
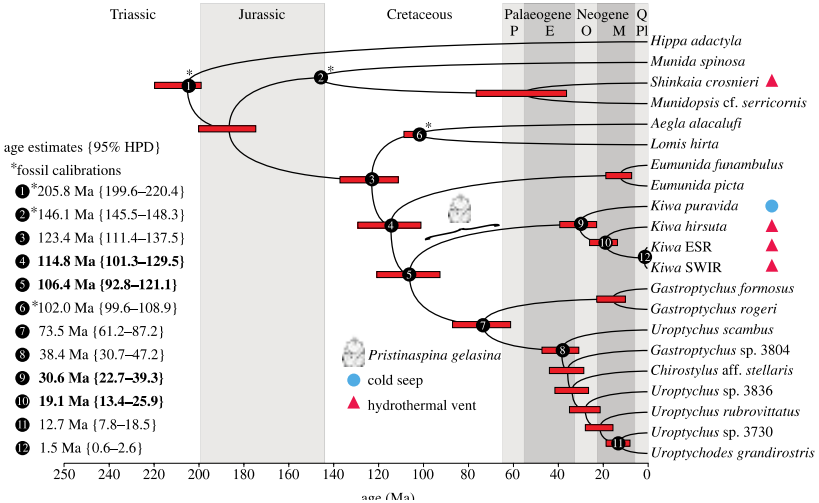
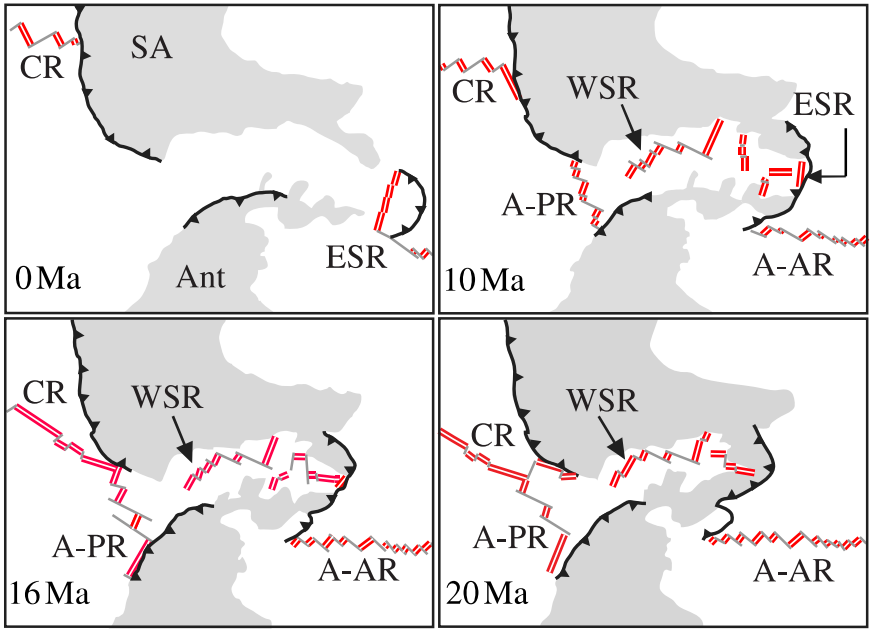


Marsh et al., J. Animal Ecology (2015)

Investigating the Deep Ocean – Targeted Approach (multi-disciplinary)







Evolutionary origins of life in the Deep

Roterman et al. Proc B 2013

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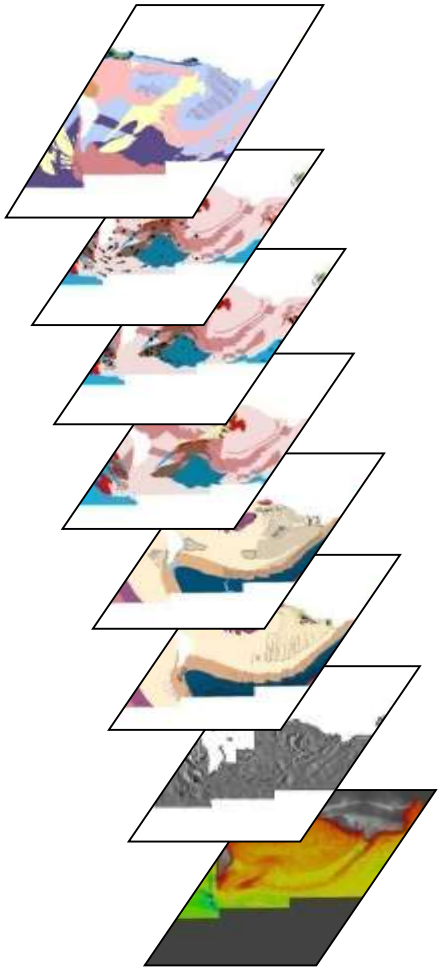
Deep-Sea Research in the 21st Century
Prospects & Challenges



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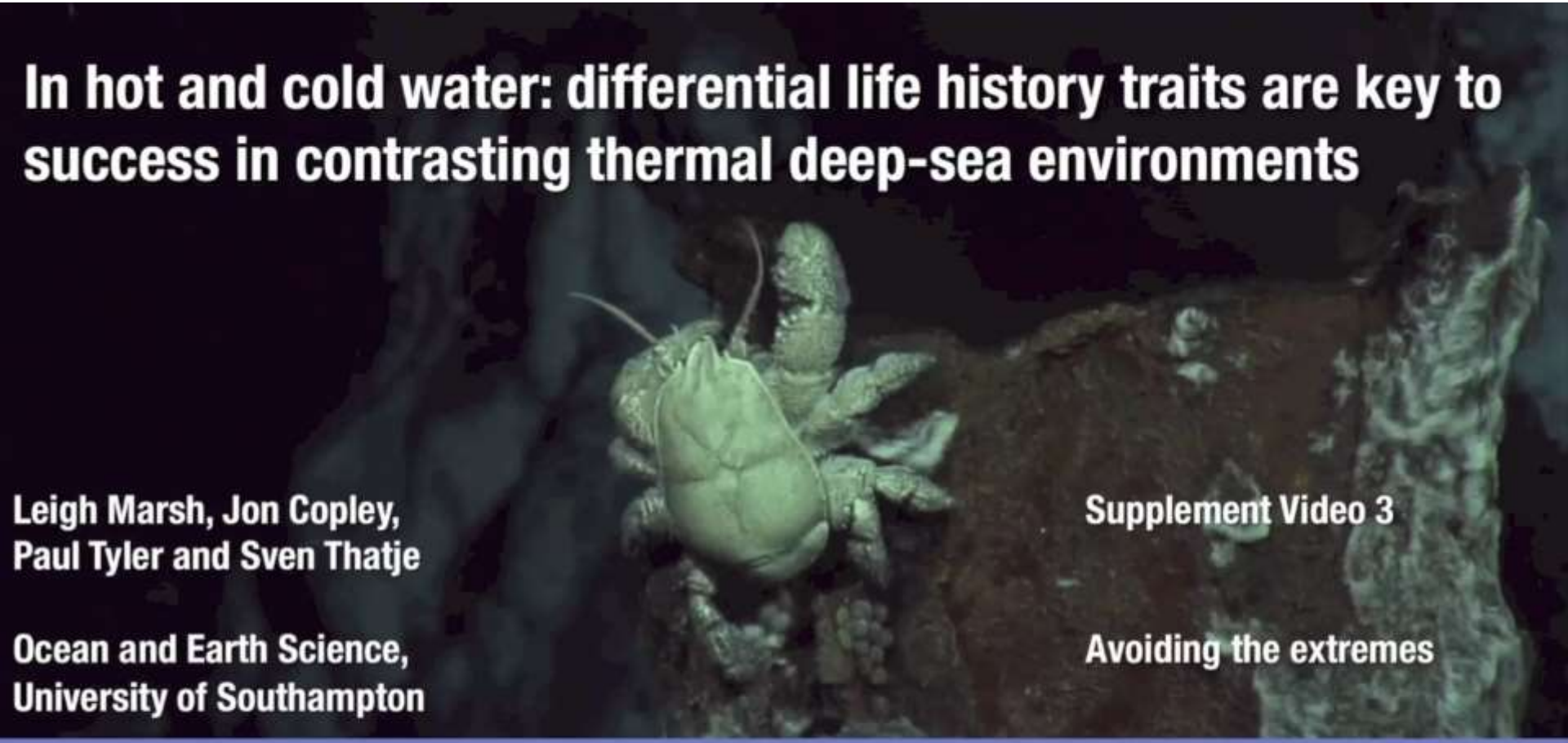
In hot and cold water: differential life history traits are key to success in contrasting thermal deep-sea environments
Leigh Marsh, Jon Copley, Paul Tyler and Sven Thatje
Ocean and Earth Science, University of Southampton
Supplement Video 3
Avoiding the extremes
Journal of Animal Ecology
British Ecological Society

Acknowledgements

Dr Jon Copley, Dr Douglas Connelly, Dr Veerle Huyvenne, Dr Daniel Jones, Dr Leigh Marsh, Prof Paul Tyler, Dr Phil Weaver & colleagues

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