

Arctic deep-sea ecosystems

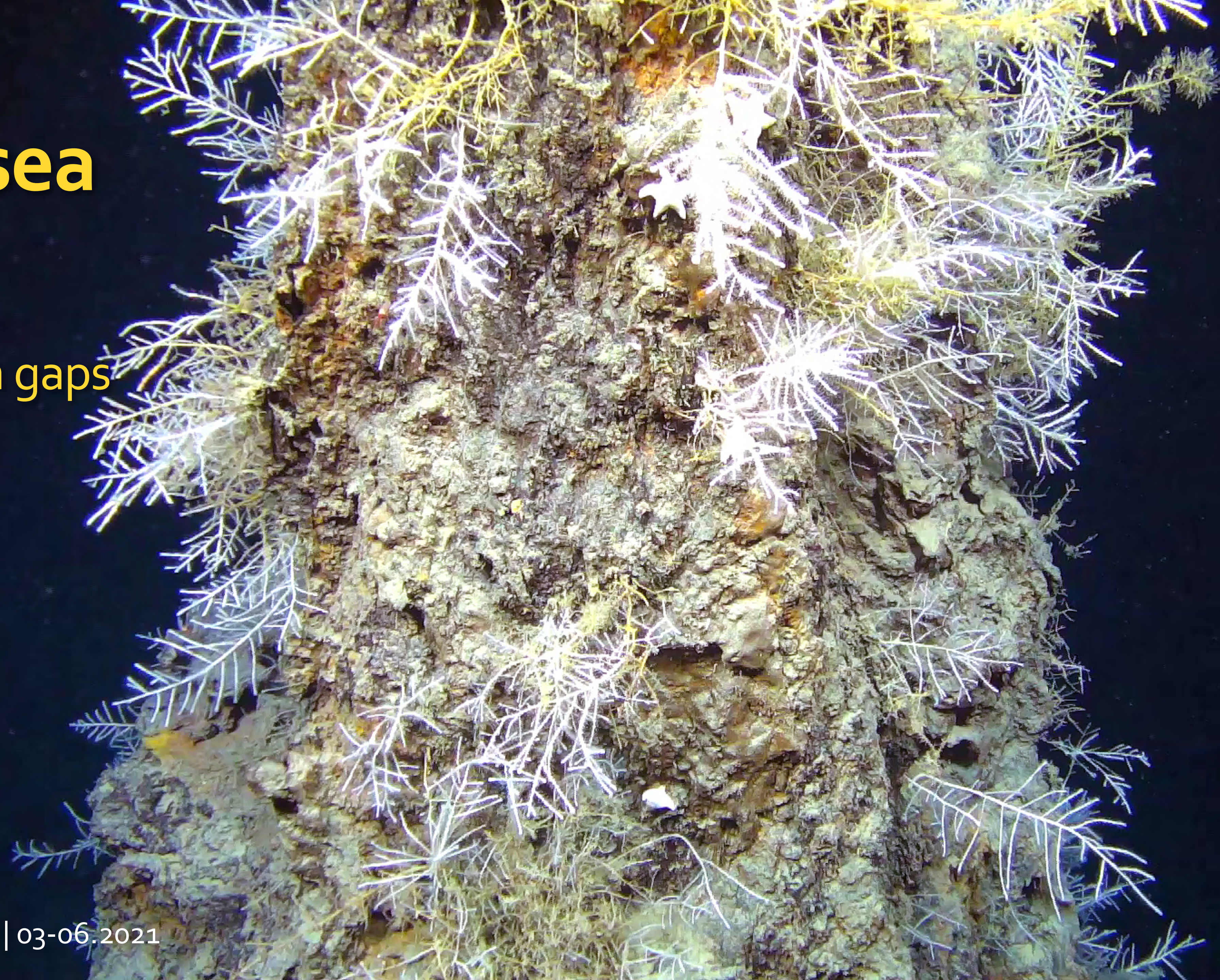
overview and research gaps

Pedro A. Ribeiro

Centre for Deep-Sea Research
University of Bergen



Marine Minerals Digital Seminar | 03-06.2021



How to develop a solid knowledge base?

Knowledge scale

BIODIVERSITY

- Species diversity
- Functional diversity
- Molecular diversity
- Microbes to megafauna



CDeepSea-UiB

How to develop a solid knowledge base?

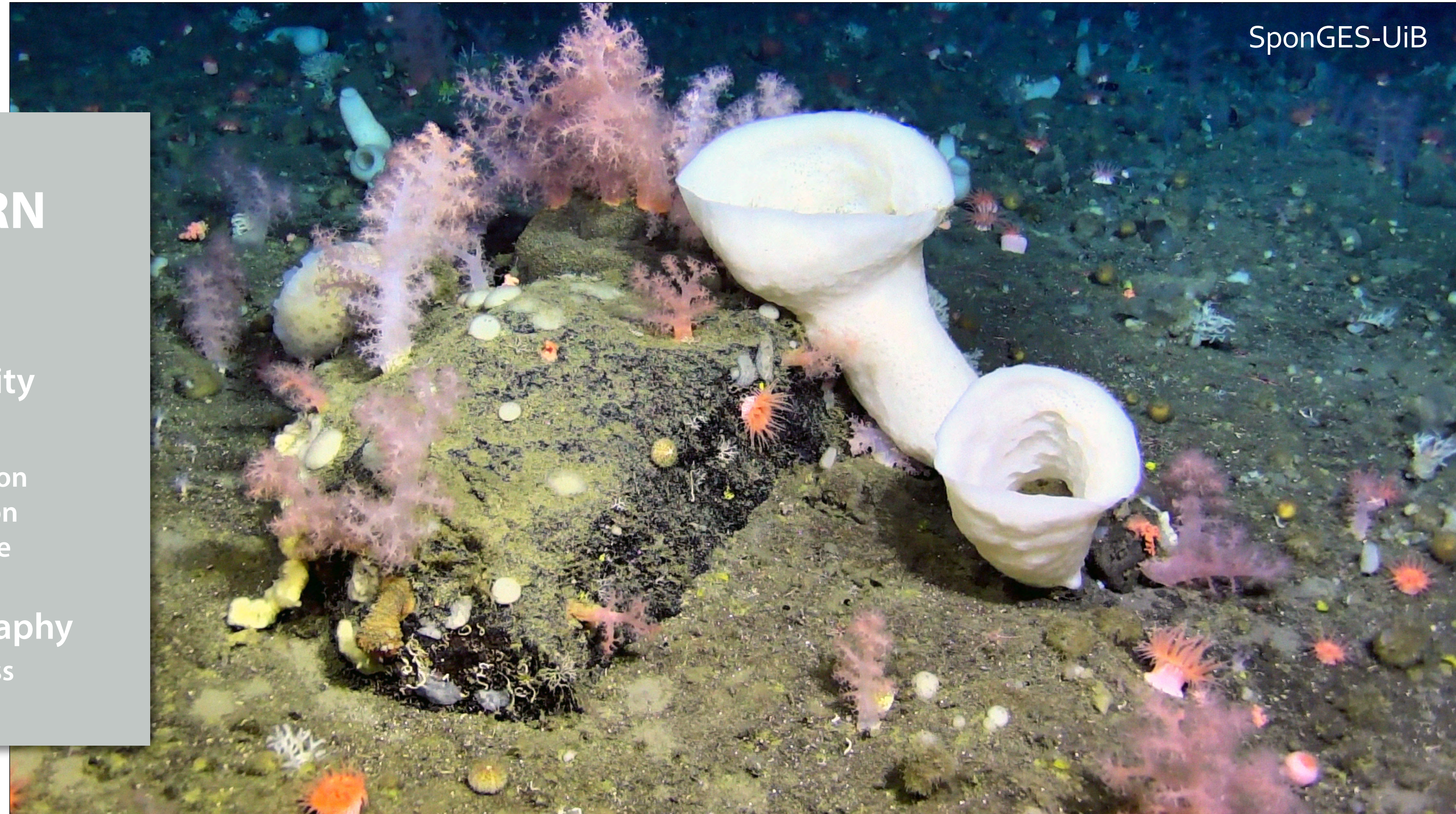
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PATTERN

- Community structure
 - Composition
 - Distribution
 - Abundance
- Biogeography
 - Uniqueness



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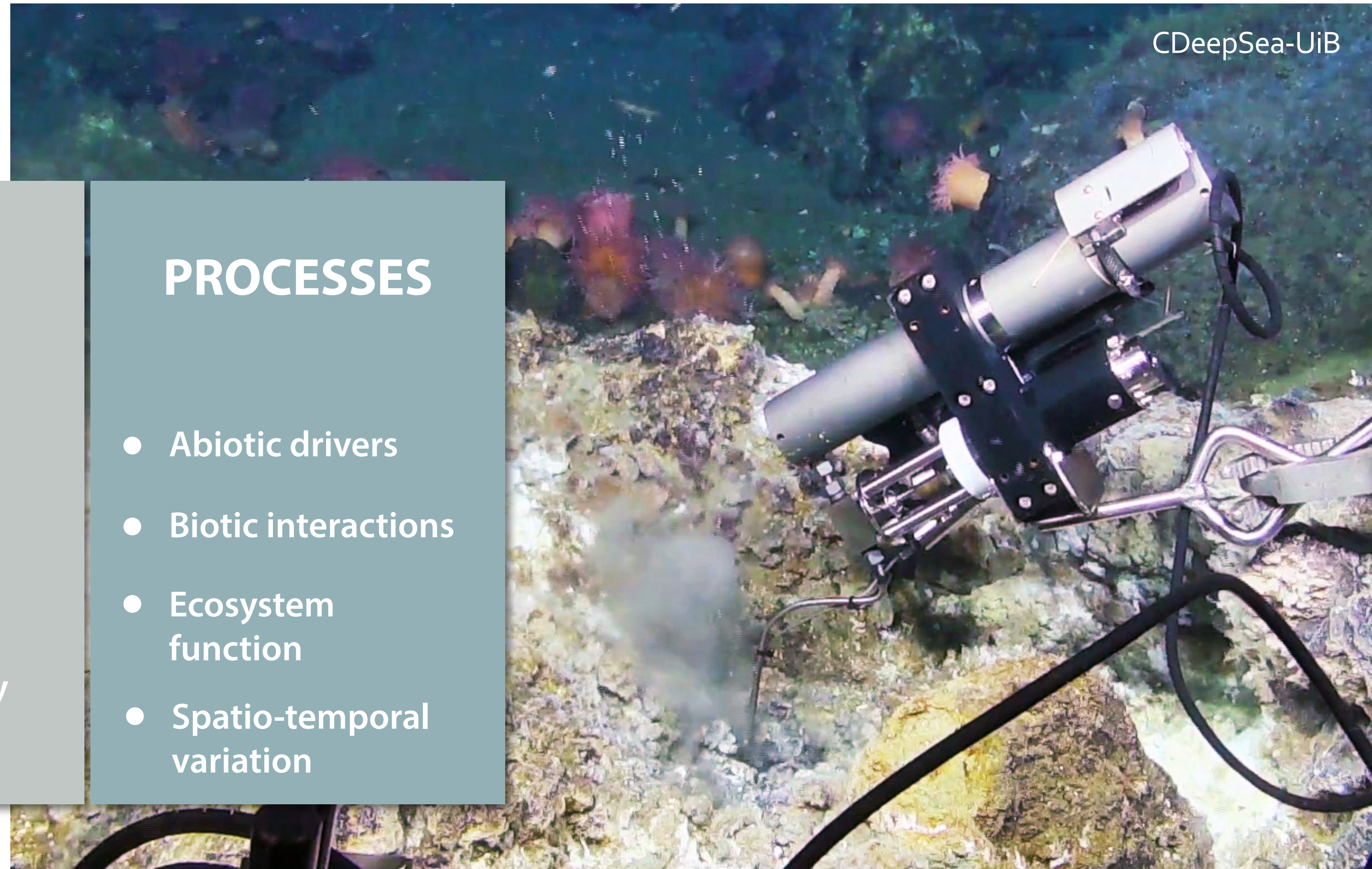
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- Abiotic drivers
- Biotic interactions
- Ecosystem function
- Spatio-temporal variation



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LINKS

- Dispersal
- Connectivity
- Metapopulation dynamics

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RESILIENCE RECOVERY

- Mortality rates
- Recovery potential
- Recolonisation pathways
- Ecological risk assessment

Deep-sea benthic habitats

Remote and diverse

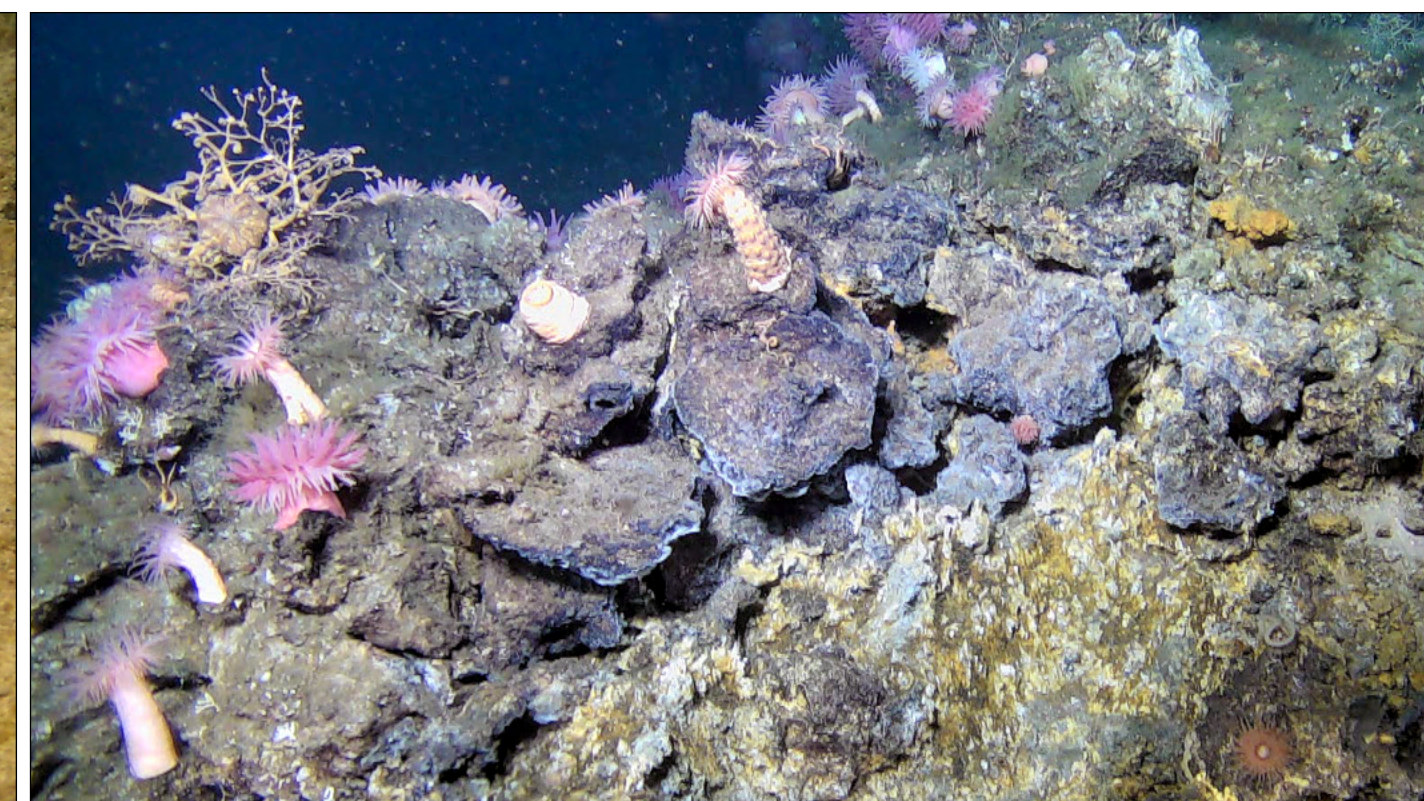
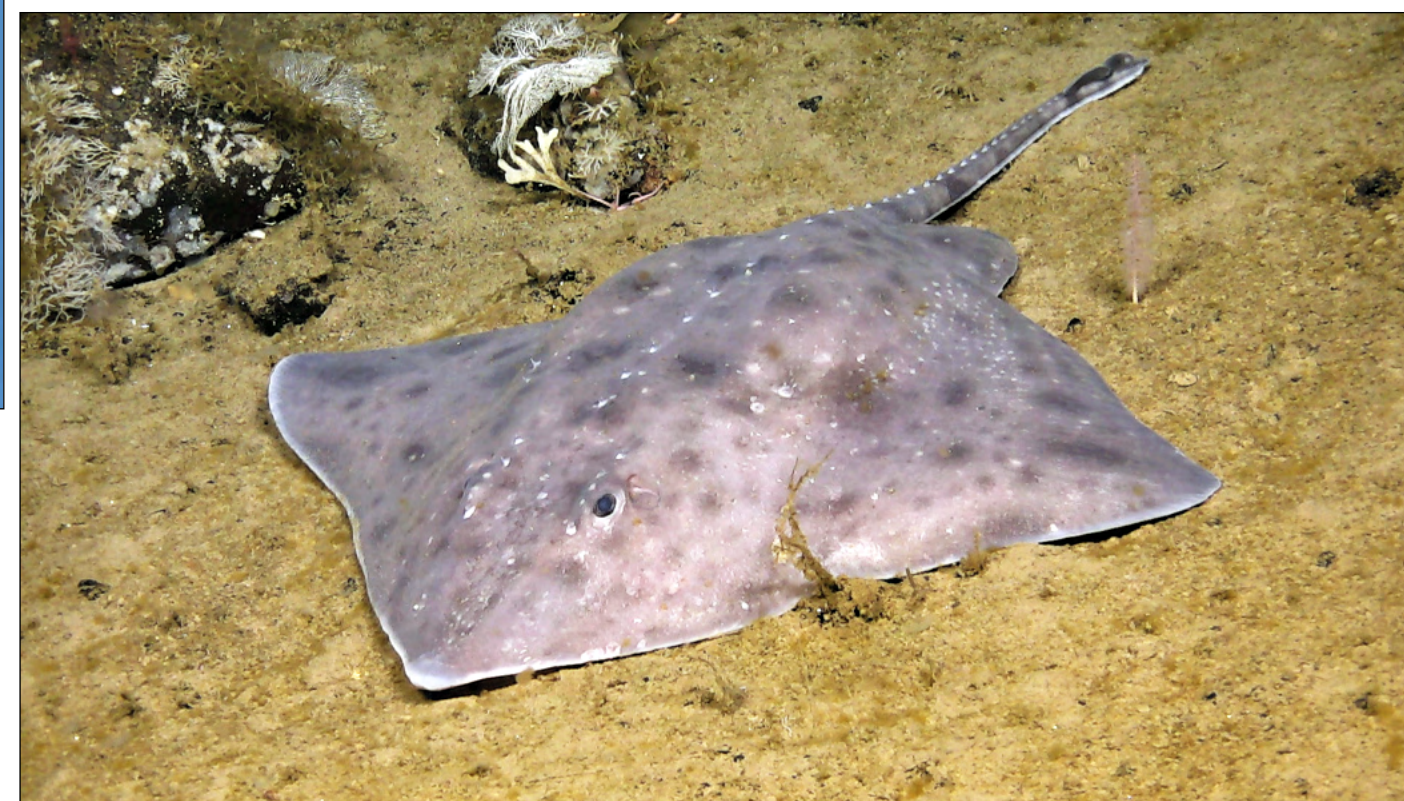
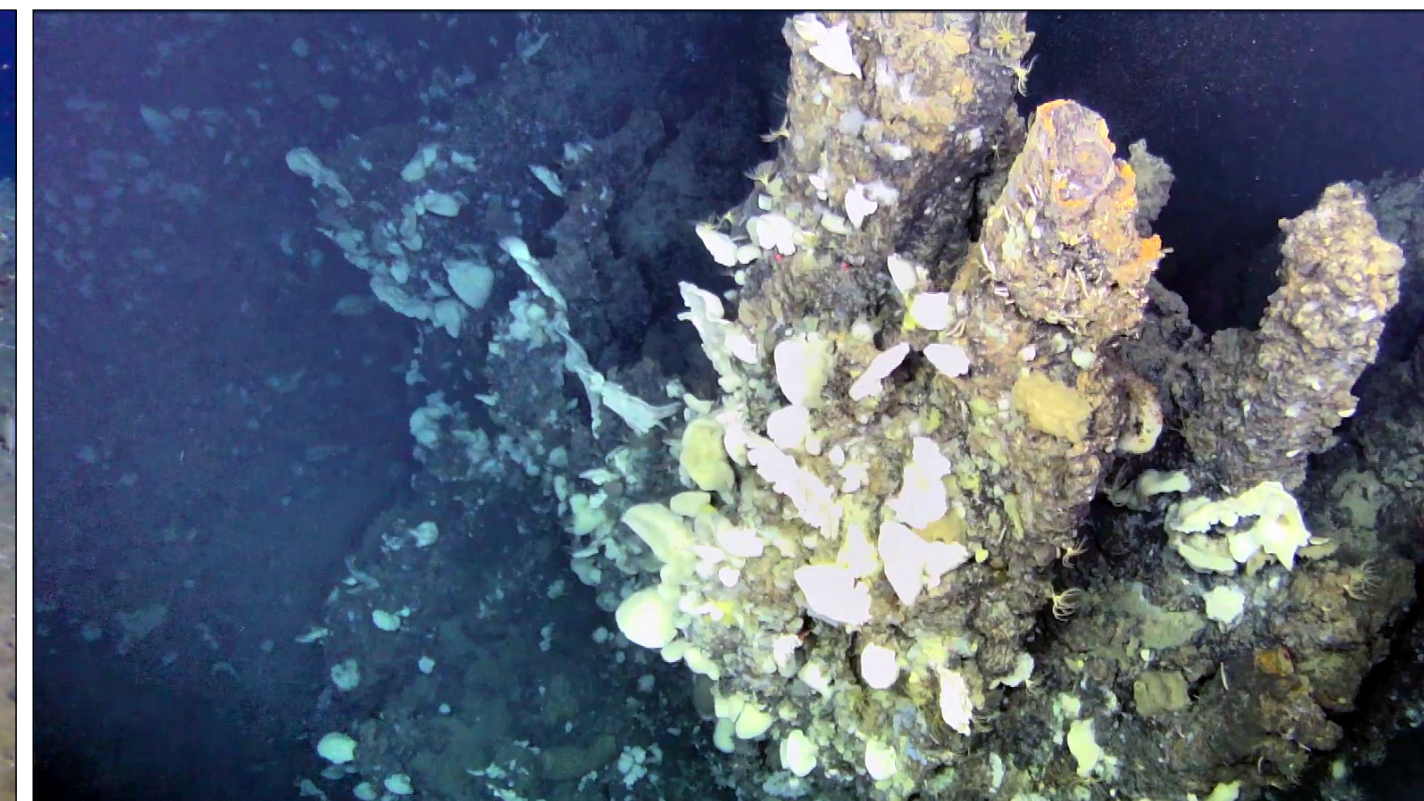
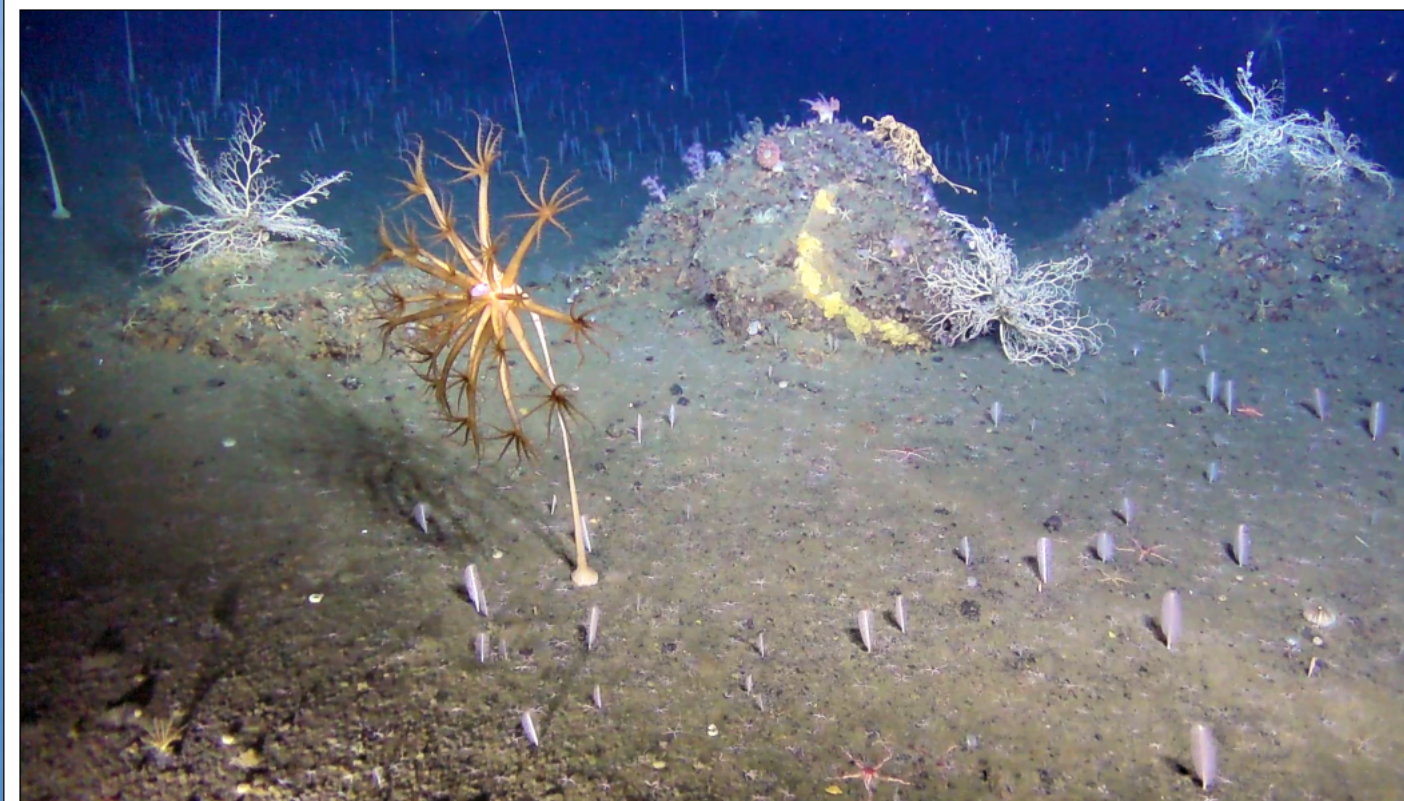
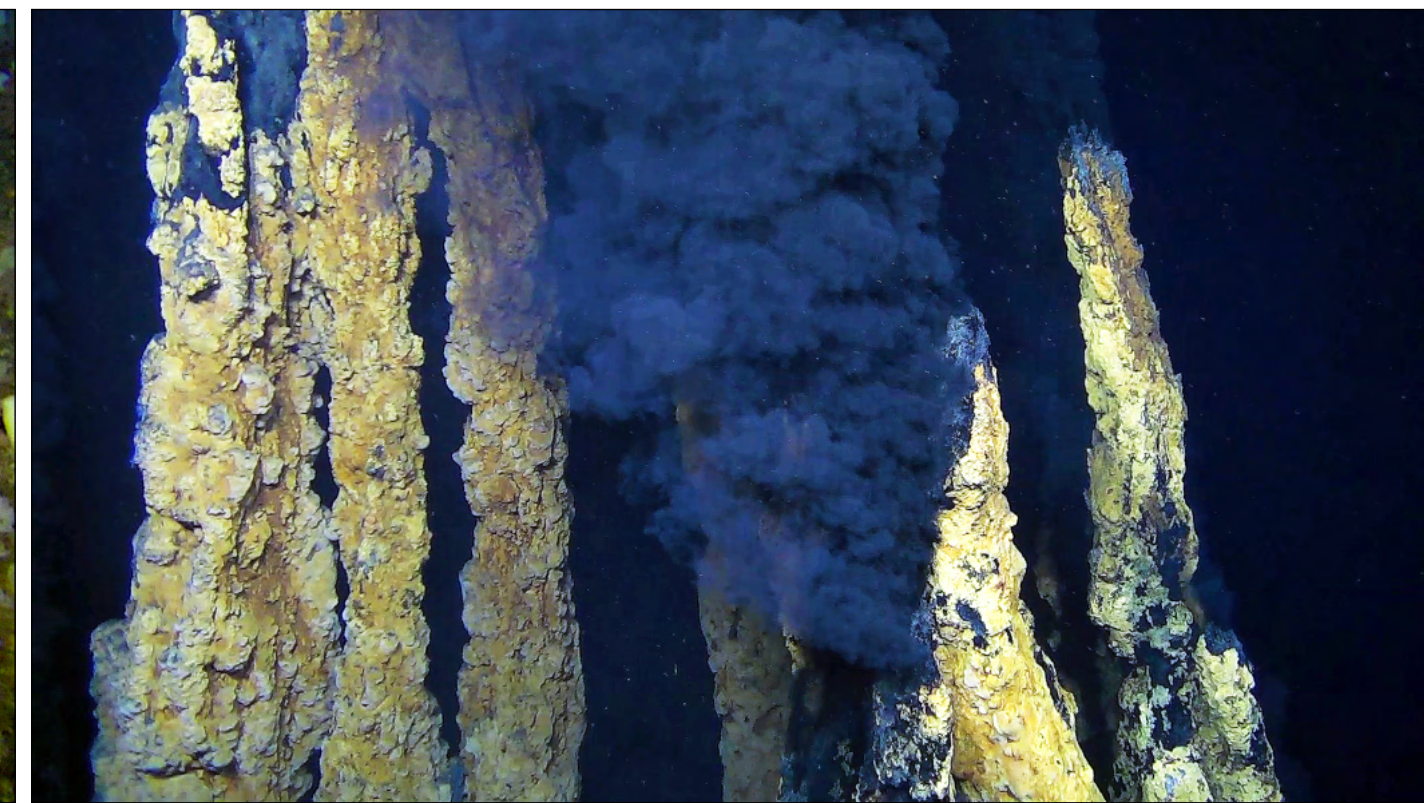
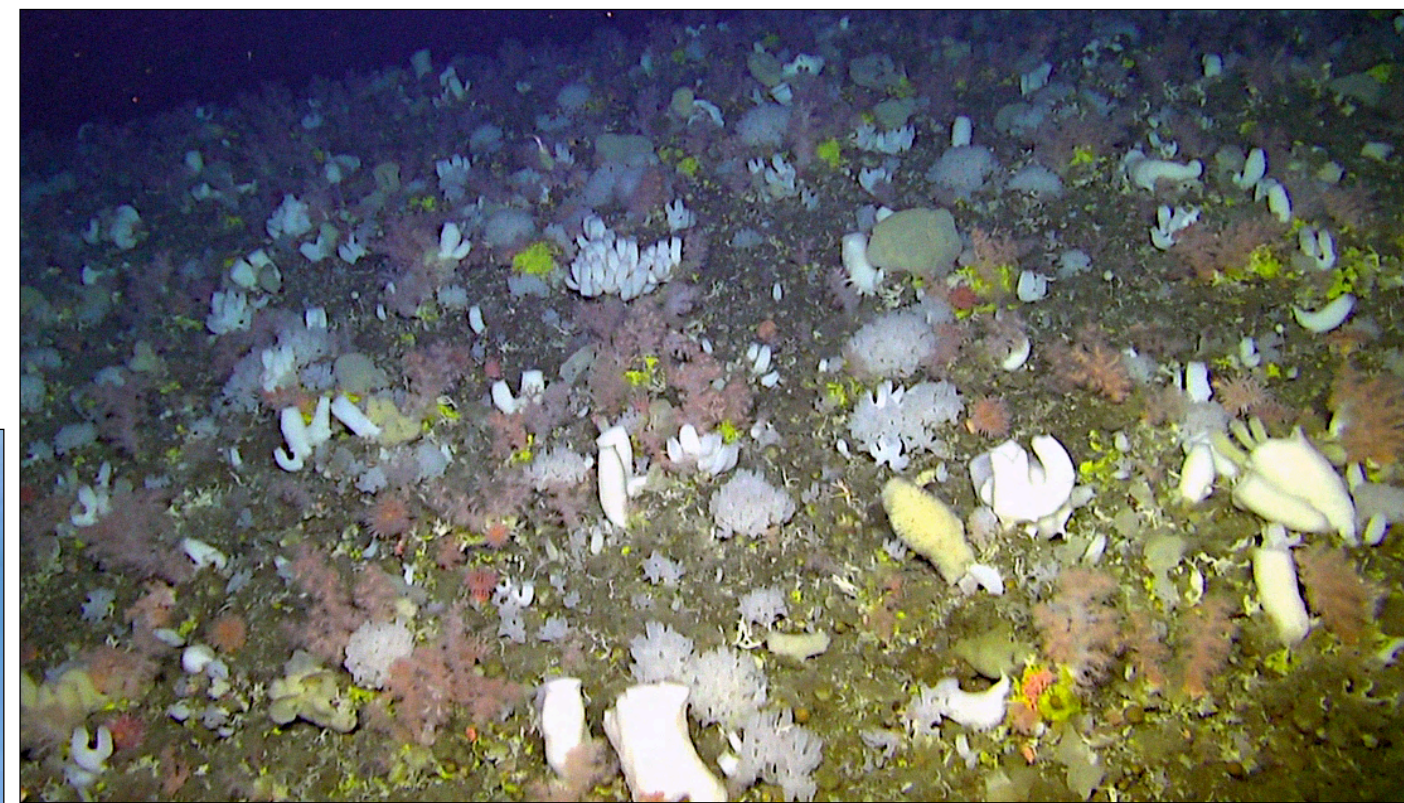
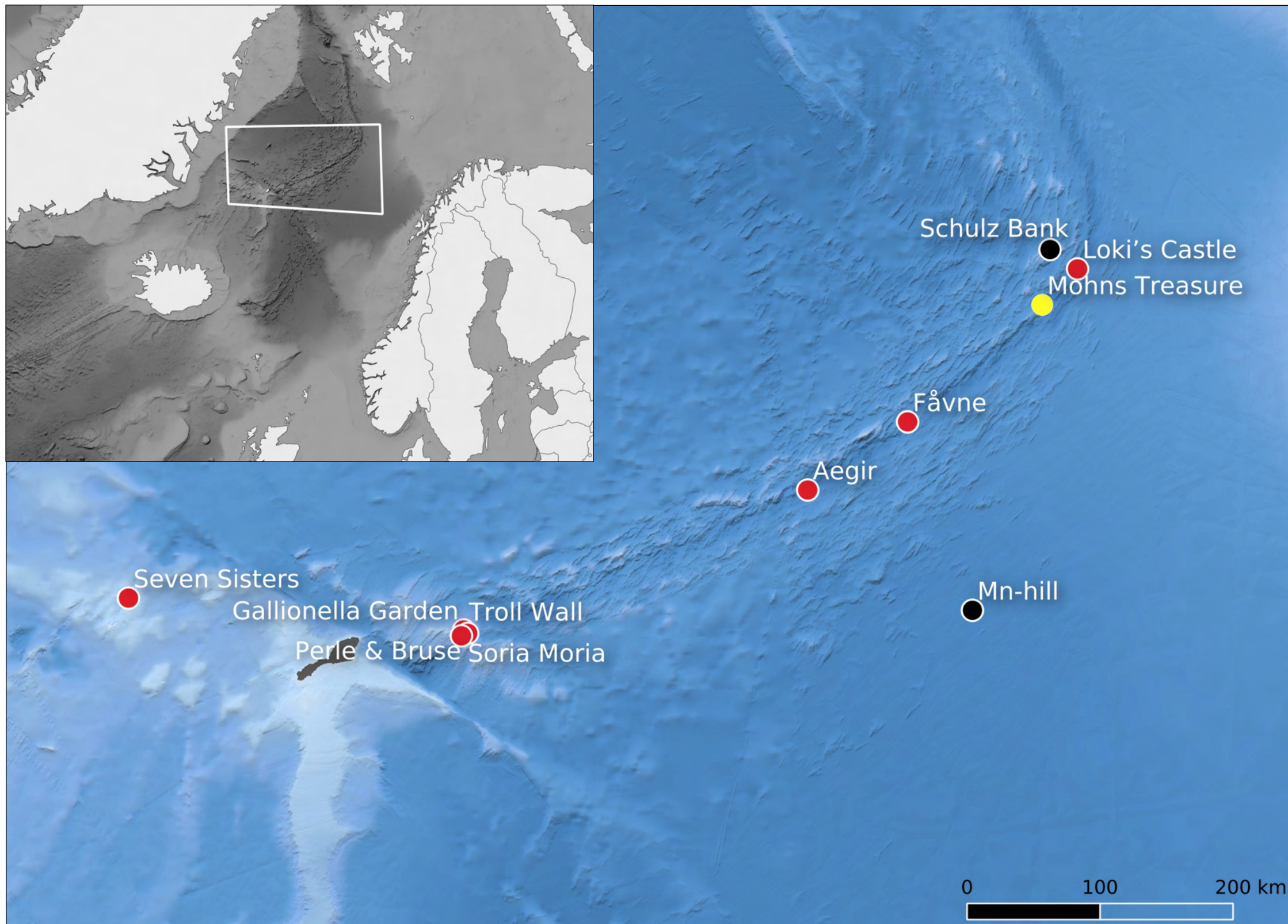


Image credit: SponGES (top left) and CDeepSea-UiB

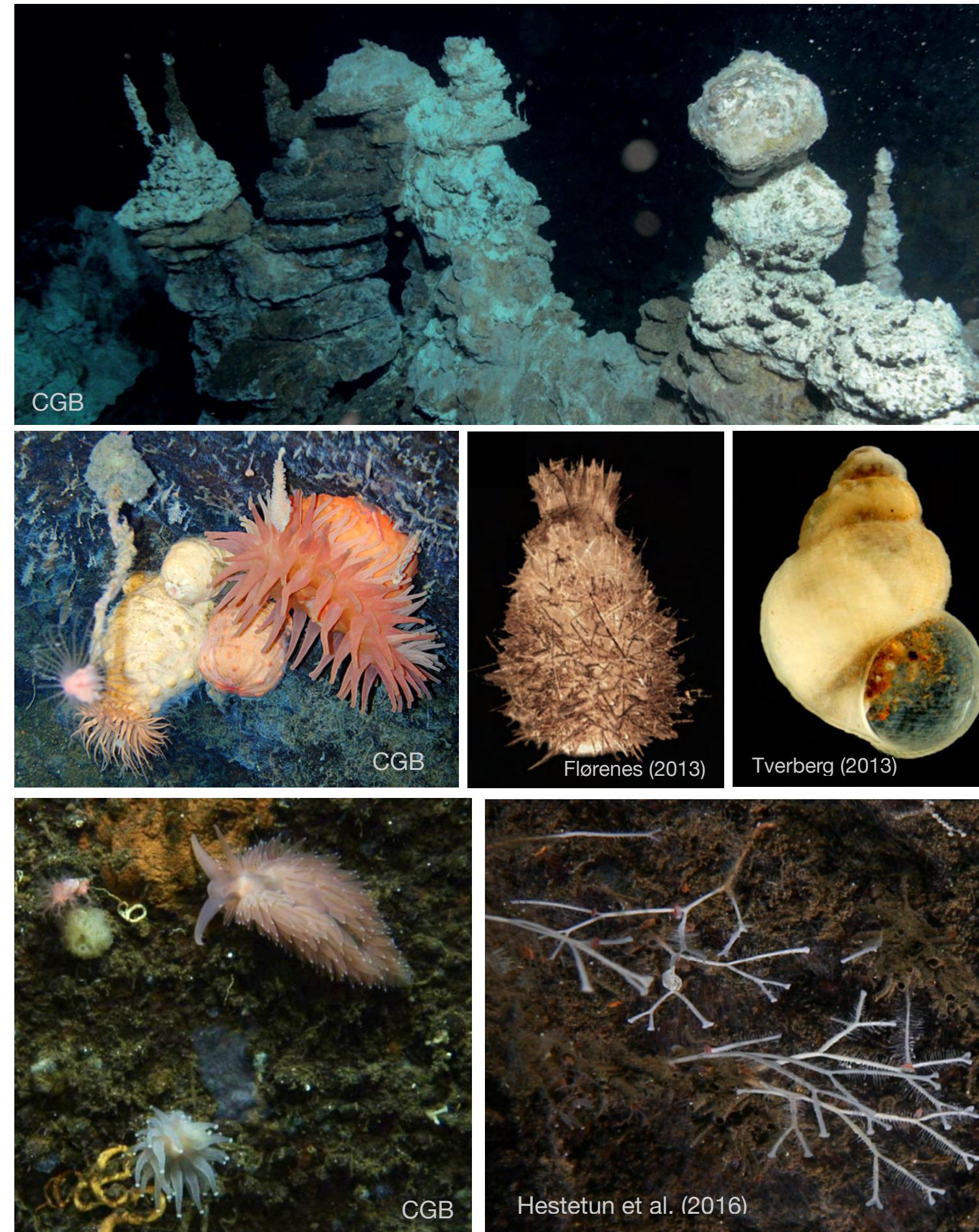
Hydrothermal vents

Vent & Seep Fauna in Norwegian waters

A project funded by the Norwegian Biodiversity Information Center (Artsdatabanken)


- Relatively recent discovery (2005-2018)
- Rare and isolated habitats
- Deeper vents host a specialised fauna
- Some species are endemic to the region
- Reasonably well-known fauna, but some species remain undescribed
- Smaller size fauna poorly-known
- Species lists in preparation

Jan Mayen Vent Fields



Loki's Castle Vent Field



PI: Dr Mari H. Eilertsen, University of Bergen
www.ventandseepfauna.com  @VentSeepFauna

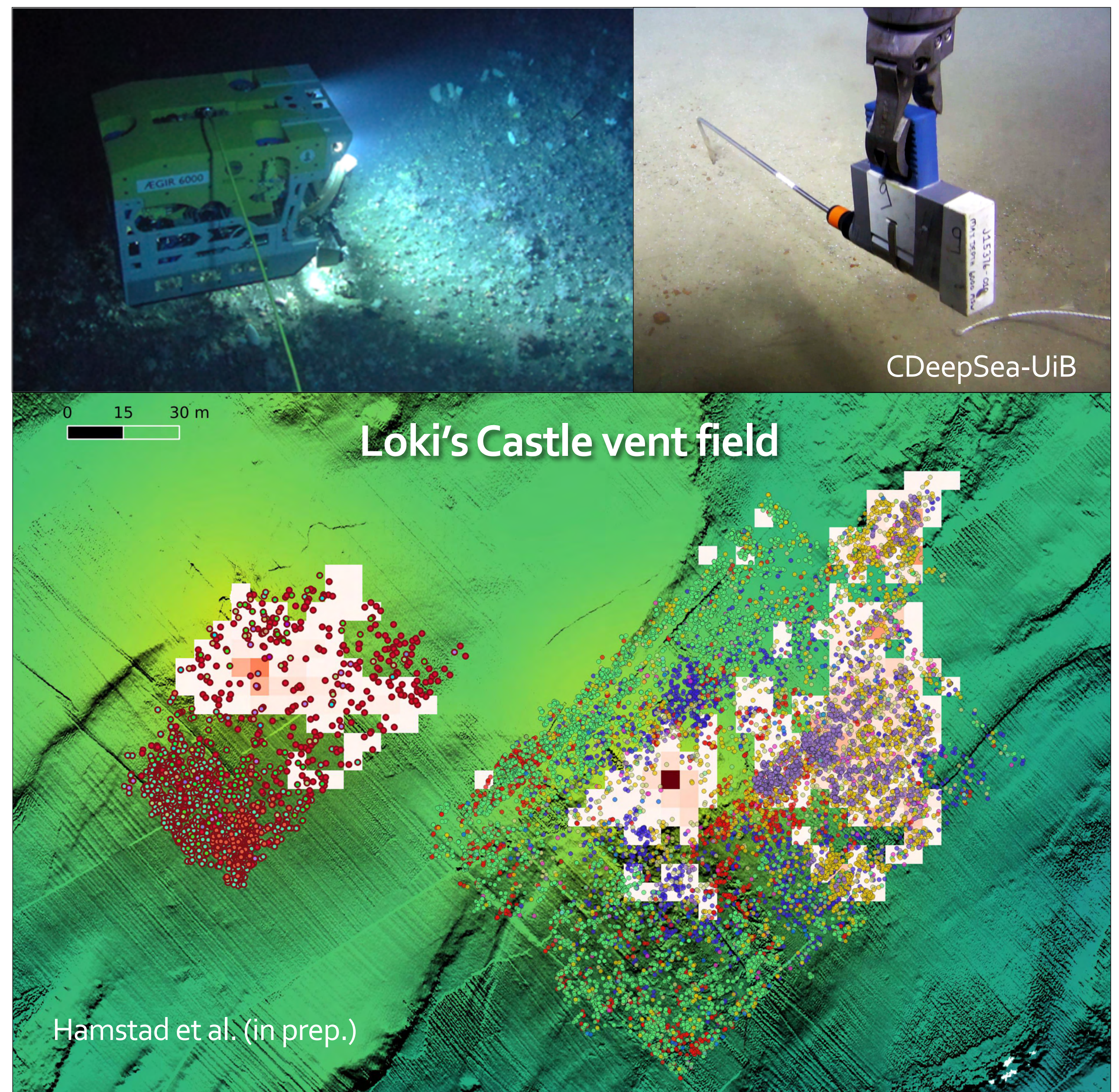


ARTSDATABANKEN

Hydrothermal vents

Important research gaps remain:

- Habitat mapping
- Physical and biological drivers of community structure
- Ecosystem function (trophic structure, biomass)
- Larval biology, reproductive cycles, dispersal potential
- Connectivity
- Metacommunity dynamics



Ridge Ecology

PI Dr Pedro Ribeiro, University of Bergen

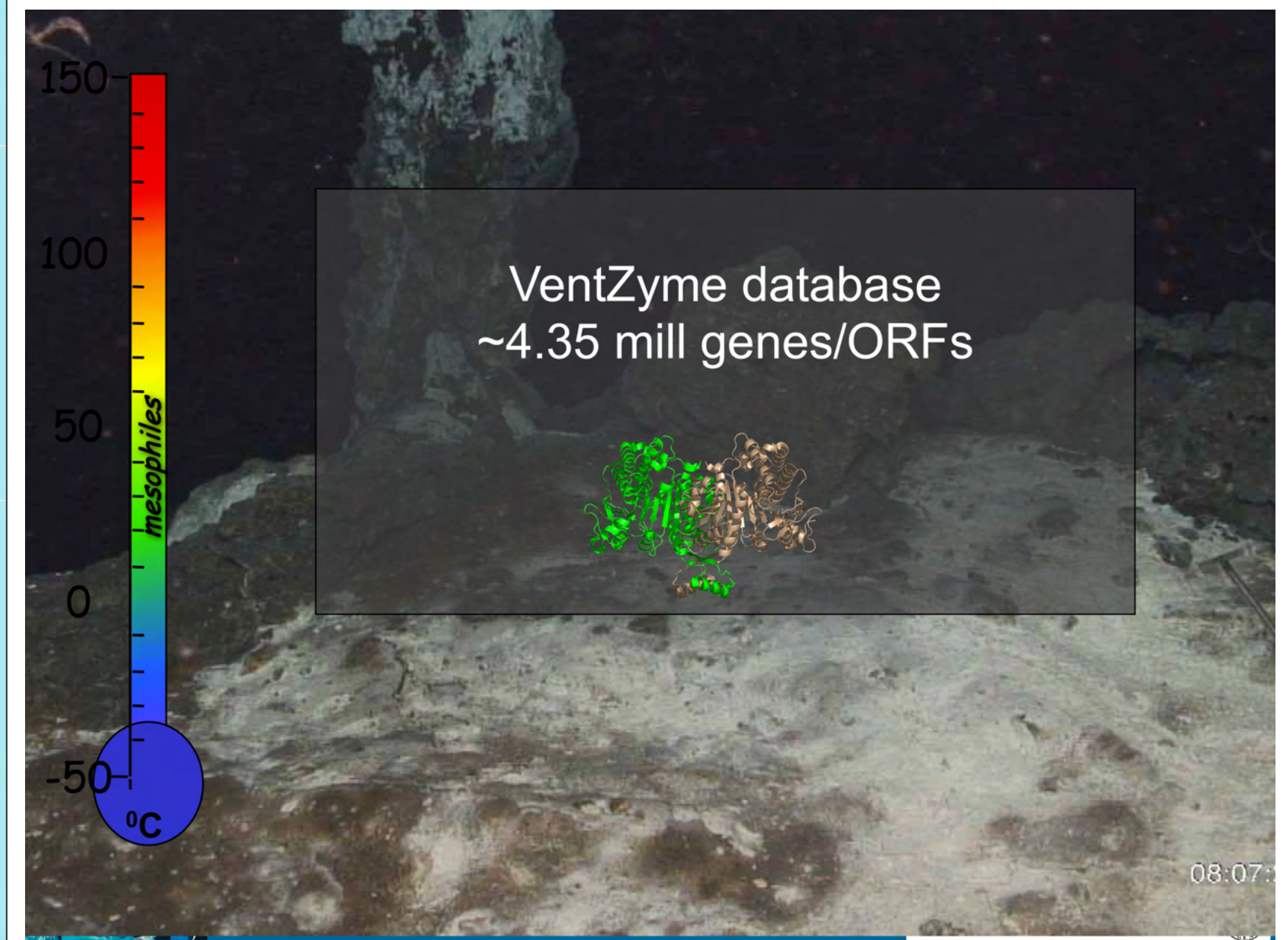
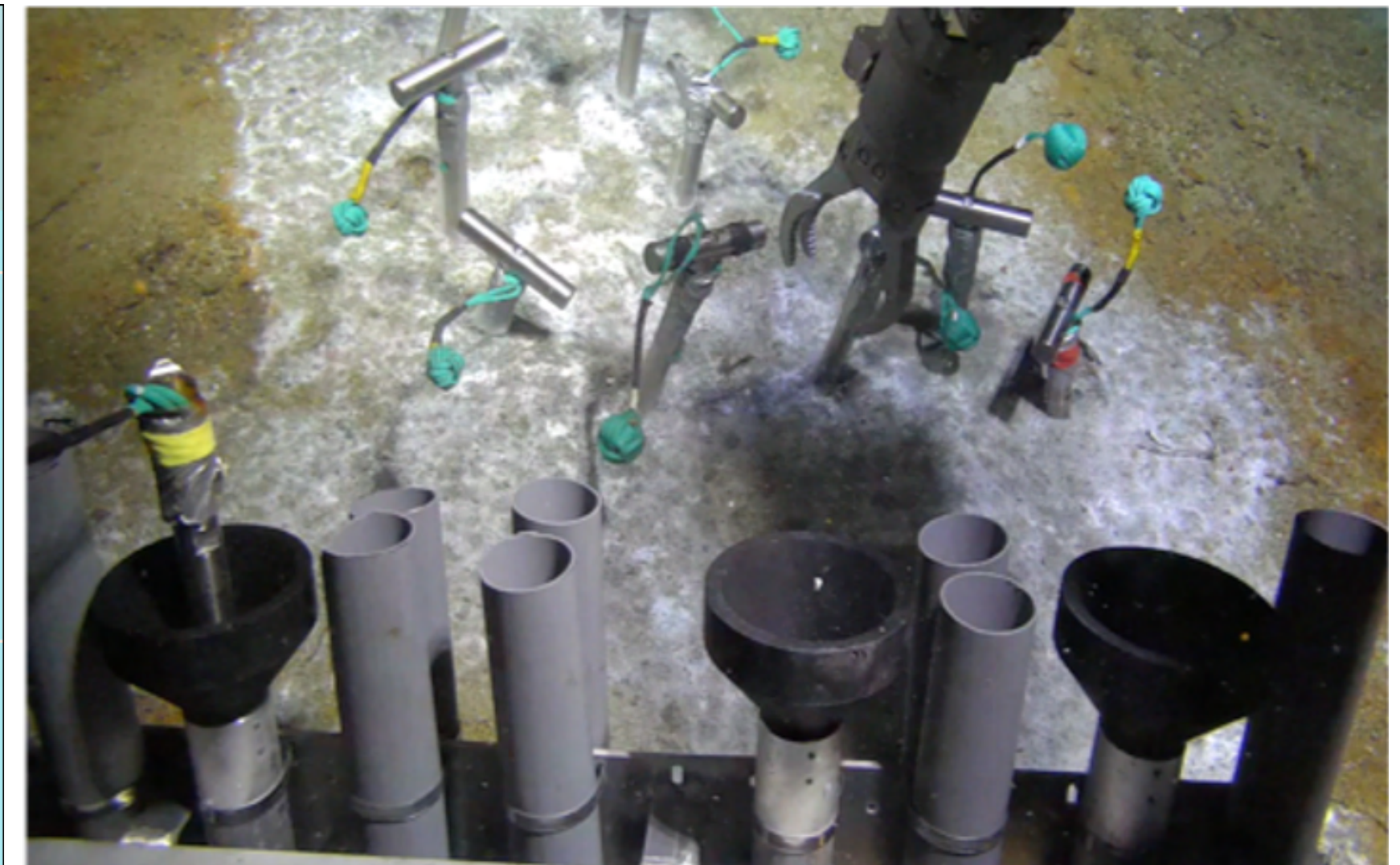


Hydrothermal vents

Microbial communities:

- Active research in biodiscovery and bioprospecting

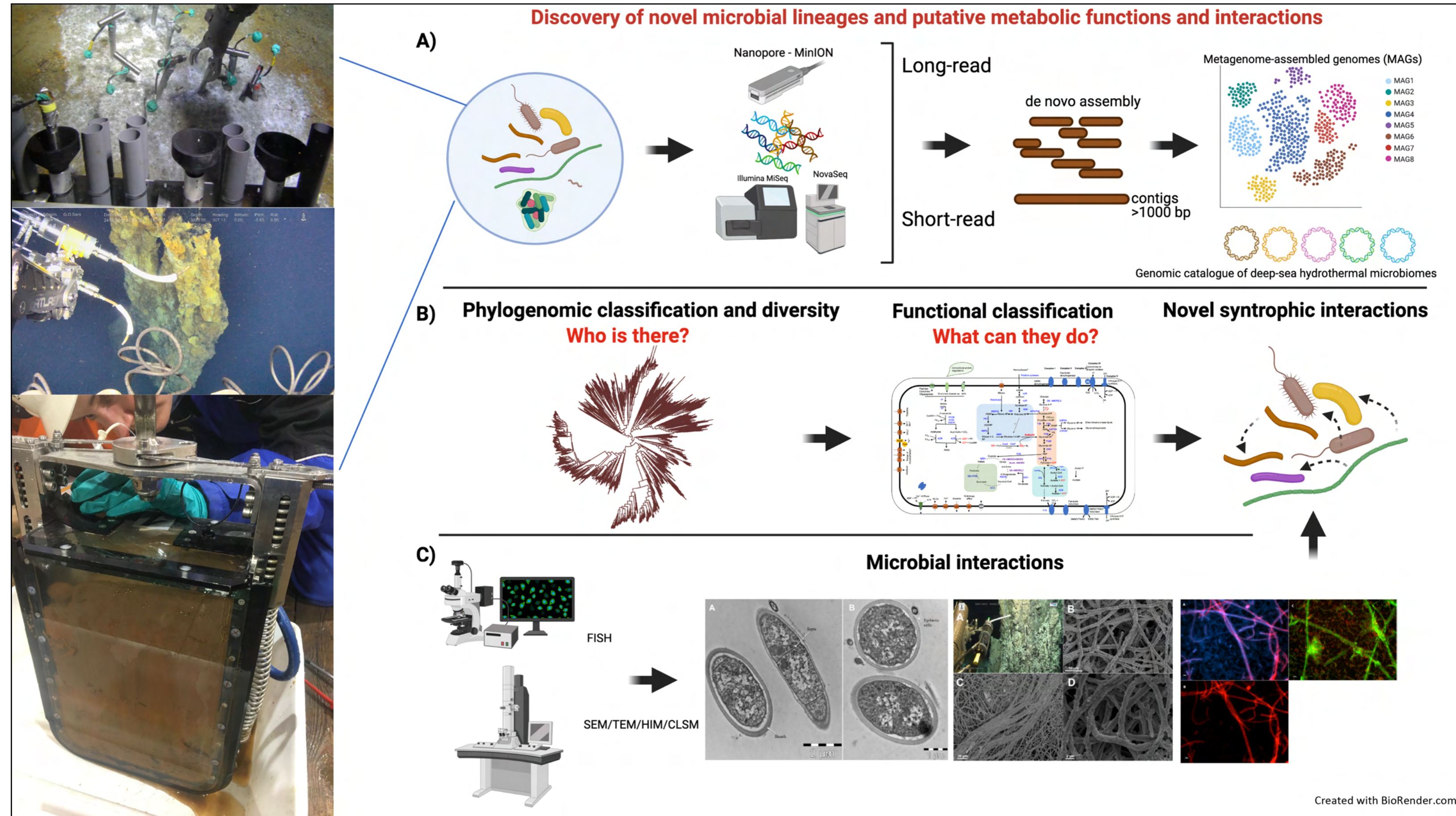
Biotechnology Applied research	
Are there any useful enzymes?	
	2009-2012 Metagenomics and metaproteomics of deep artic hydrothermal systems
 The Research Council of Norway	
Biogoldmine 2011-2016	
	NorZymeD 2012-2018
InMare: Industrial applications of Marine Enzymes (2015-2018) Virus-X: Viral Metagenomics for innovation values (2016-2019)	
	Horizon 2020 European Union Funding for Research & Innovation



Hydrothermal vents

Microbial communities:

- Active research in biodiscovery and bioprospecting
- Phylogenetic and metabolic diversity
- Functional ecology
- Environmental drivers of microbial community dynamics



DeepSeaQuence

PI Dr Runar Stokke, University of Bergen



Inactive vents

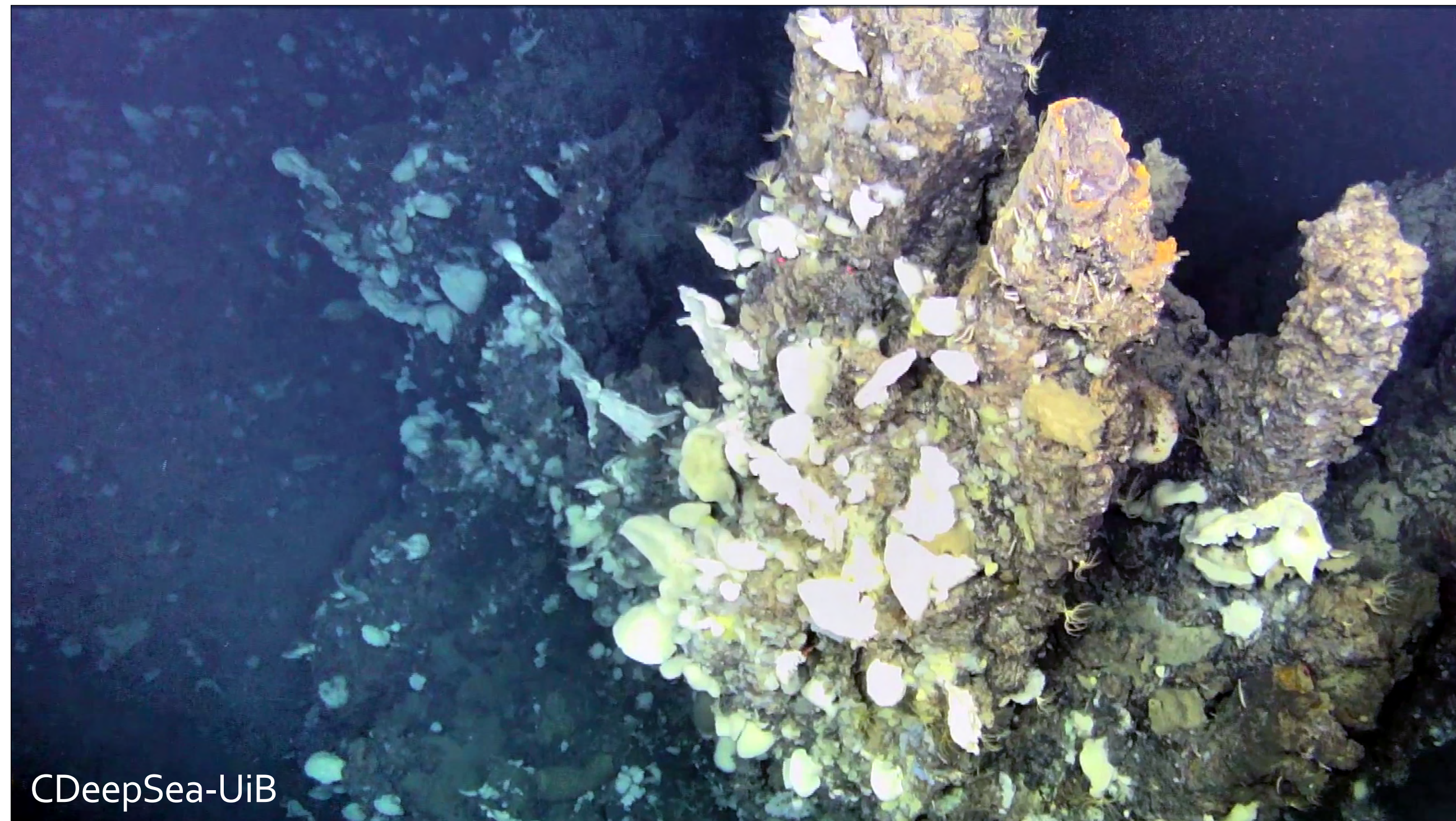
- Received much less attention compared to active vents
- Some areas host a conspicuous fauna
- Video footage and samples collected
- No quantitative studies on community structure
- The existence of a specific associated assemblage has not been investigated
- No studies on environmental drivers or potential links to active vents



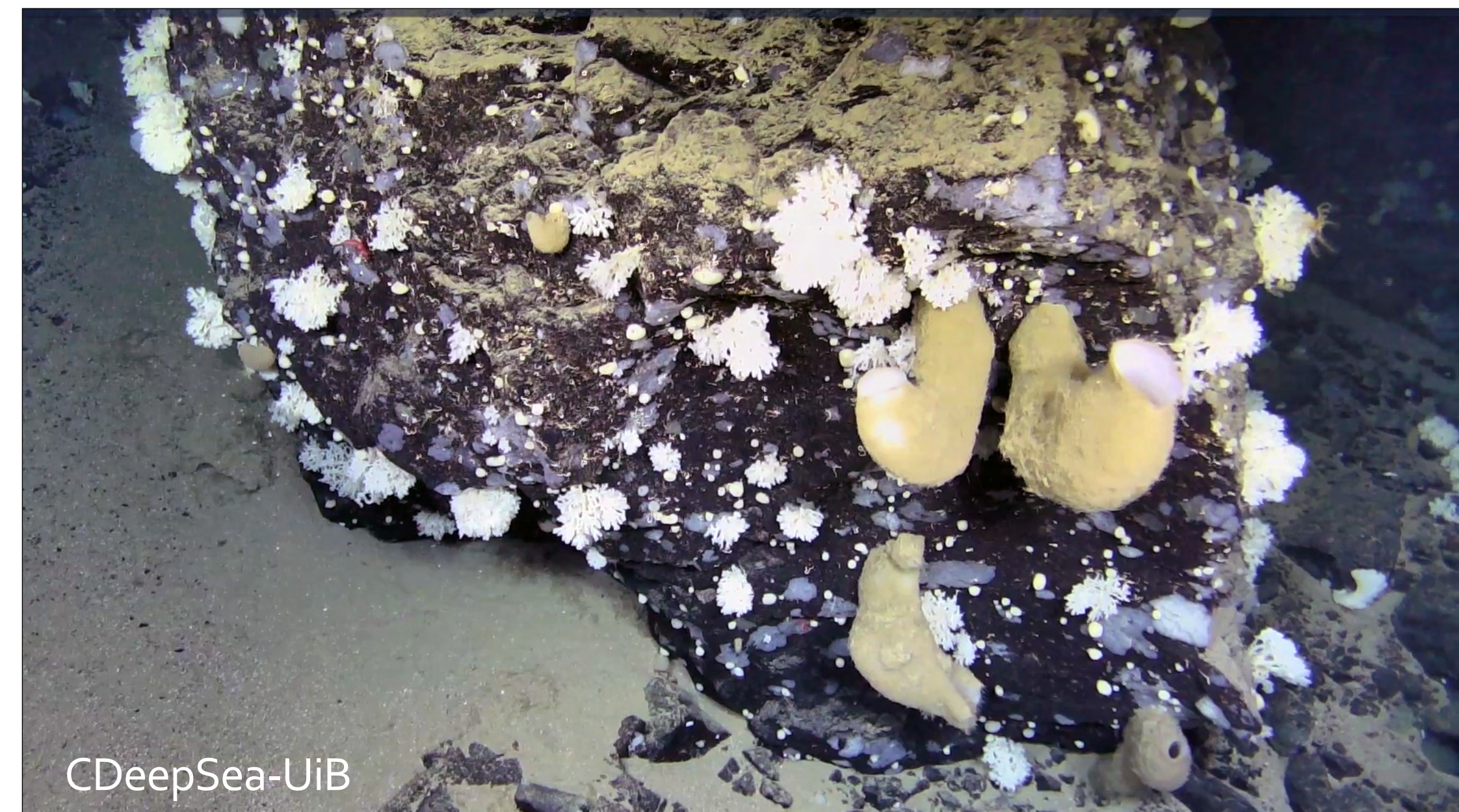
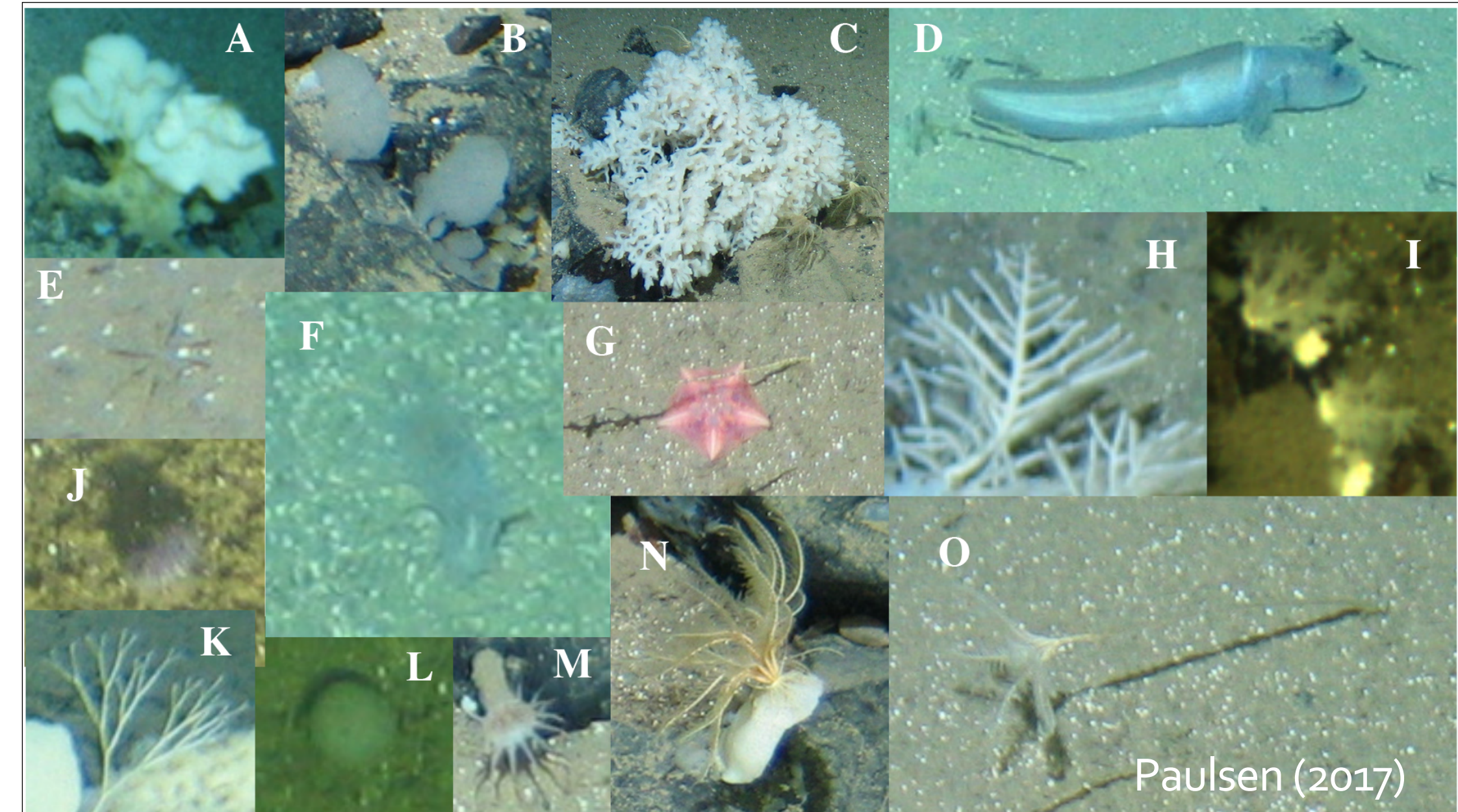
“Extinct” vent sites

Mohns Treasure

- Recent studies of benthic megafauna communities on basalt and sediment (Paulsen 2017; Ramirez-Llodra et al. 2020) (Project *MarMine*)
- Additional surveys by CDeepSea-UiB also on inactive chimneys

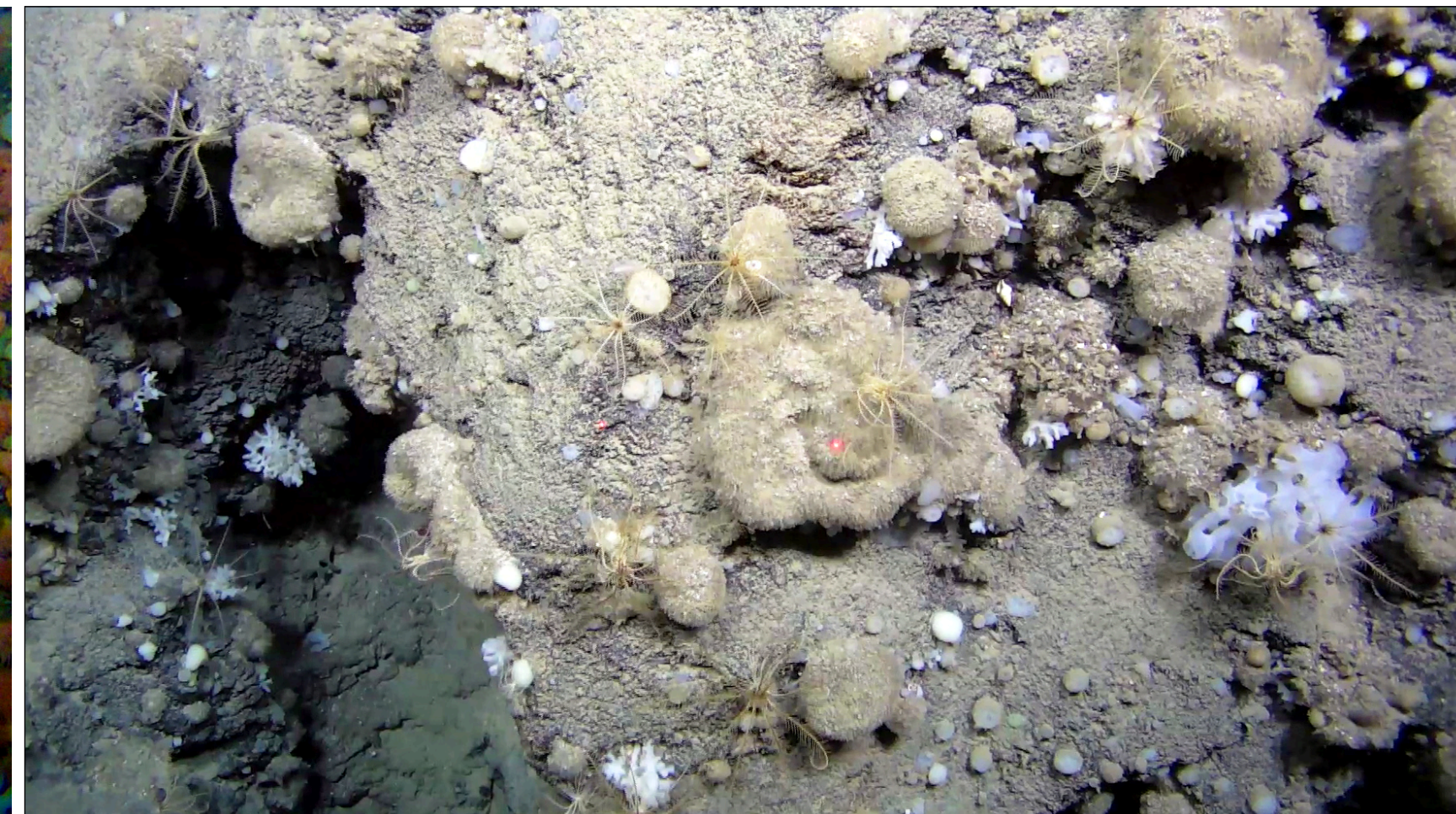
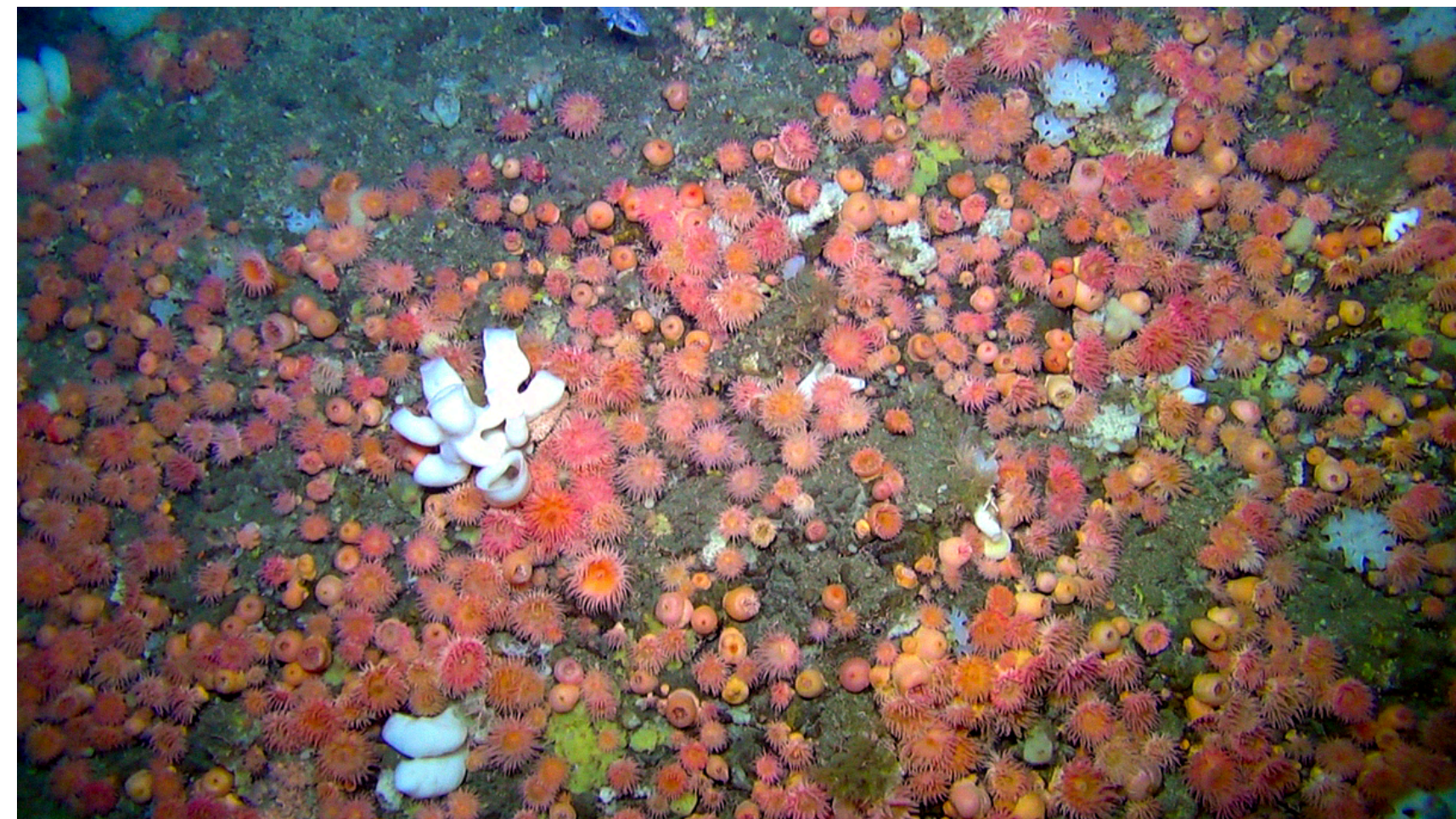
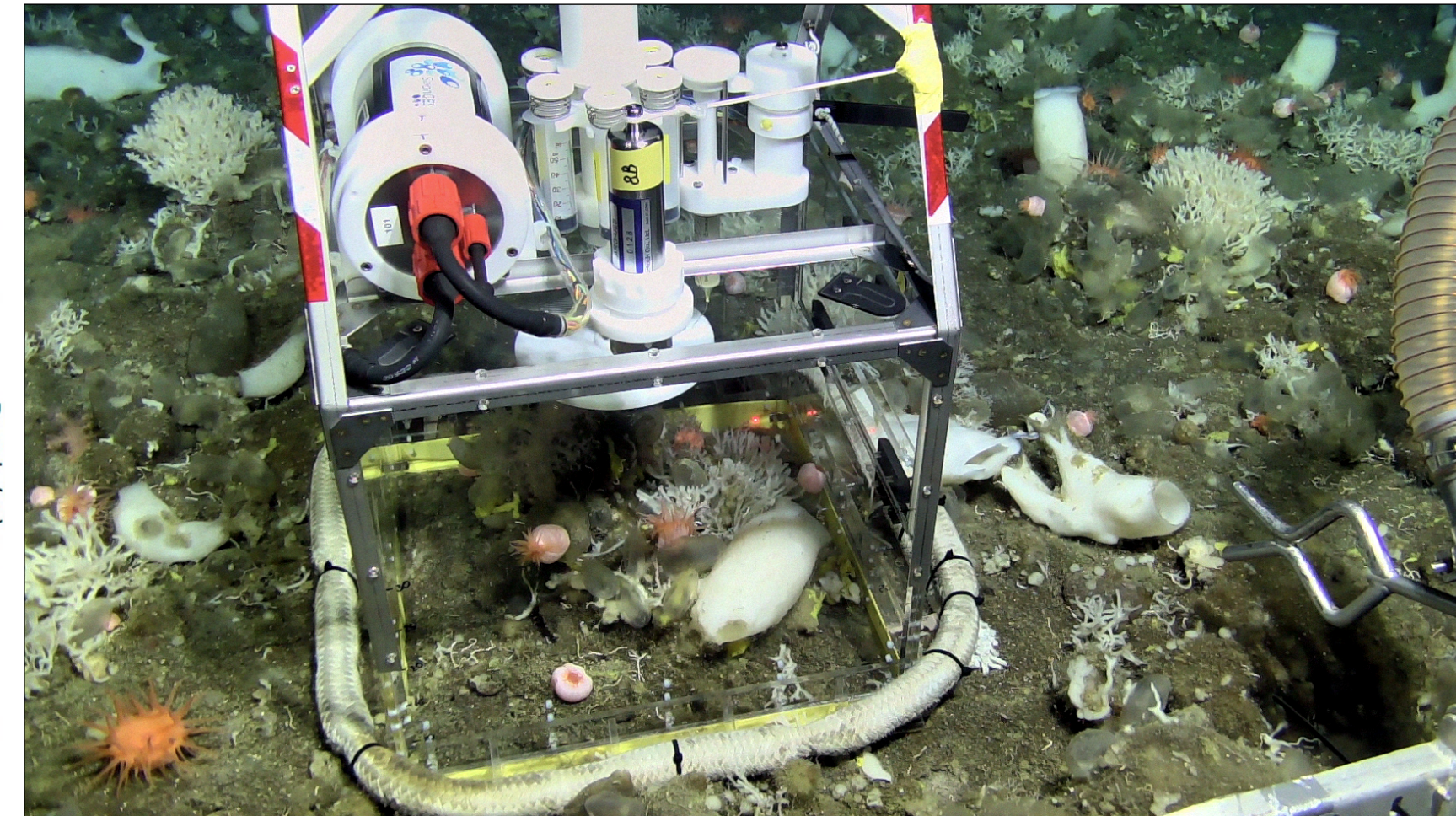
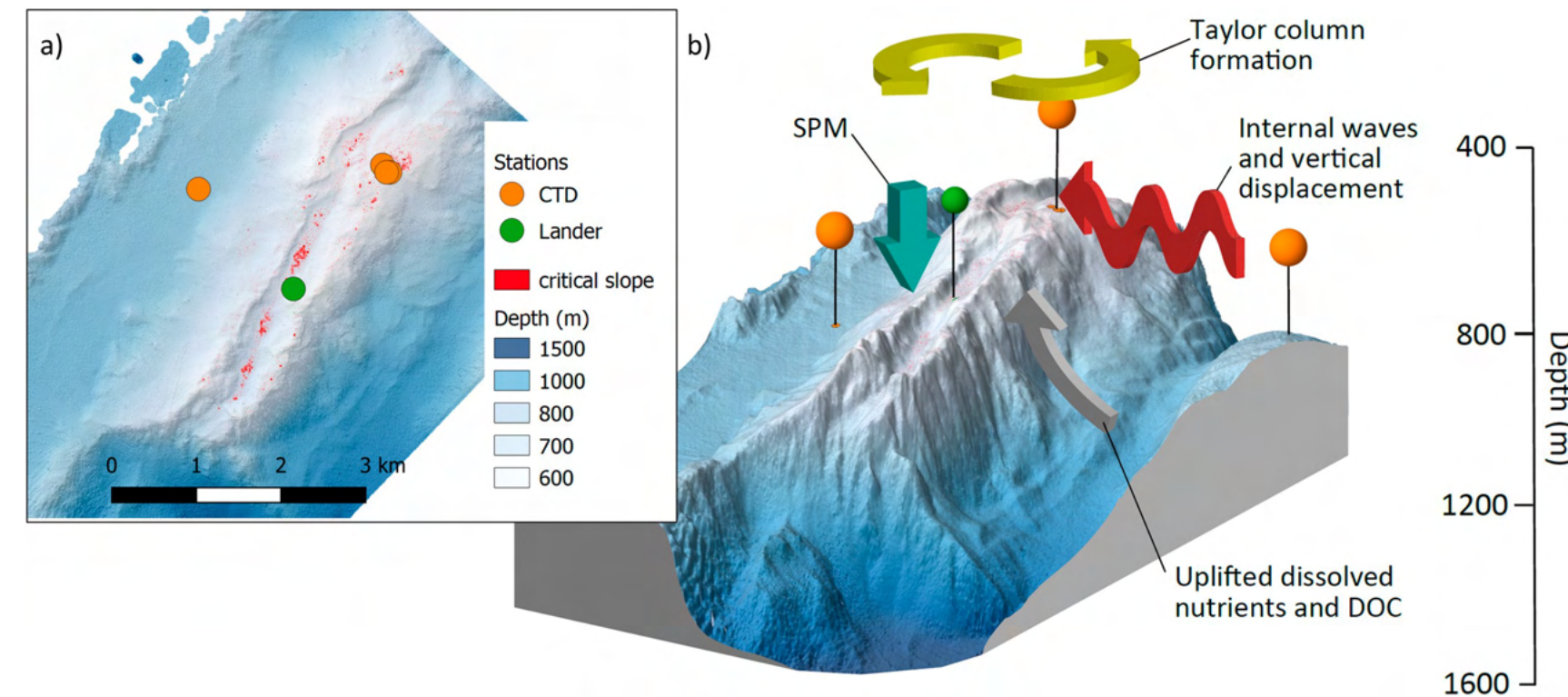


MarMine (NTNU)



Seamounts

- Isolated topographic features on the seabed
- Environmental conditions may vary locally, influencing biological communities
- Research essentially limited to the Schulz Bank
- Host vulnerable ecosystems, such as deep-sea sponge grounds
- Hotspots of biodiversity and biomass



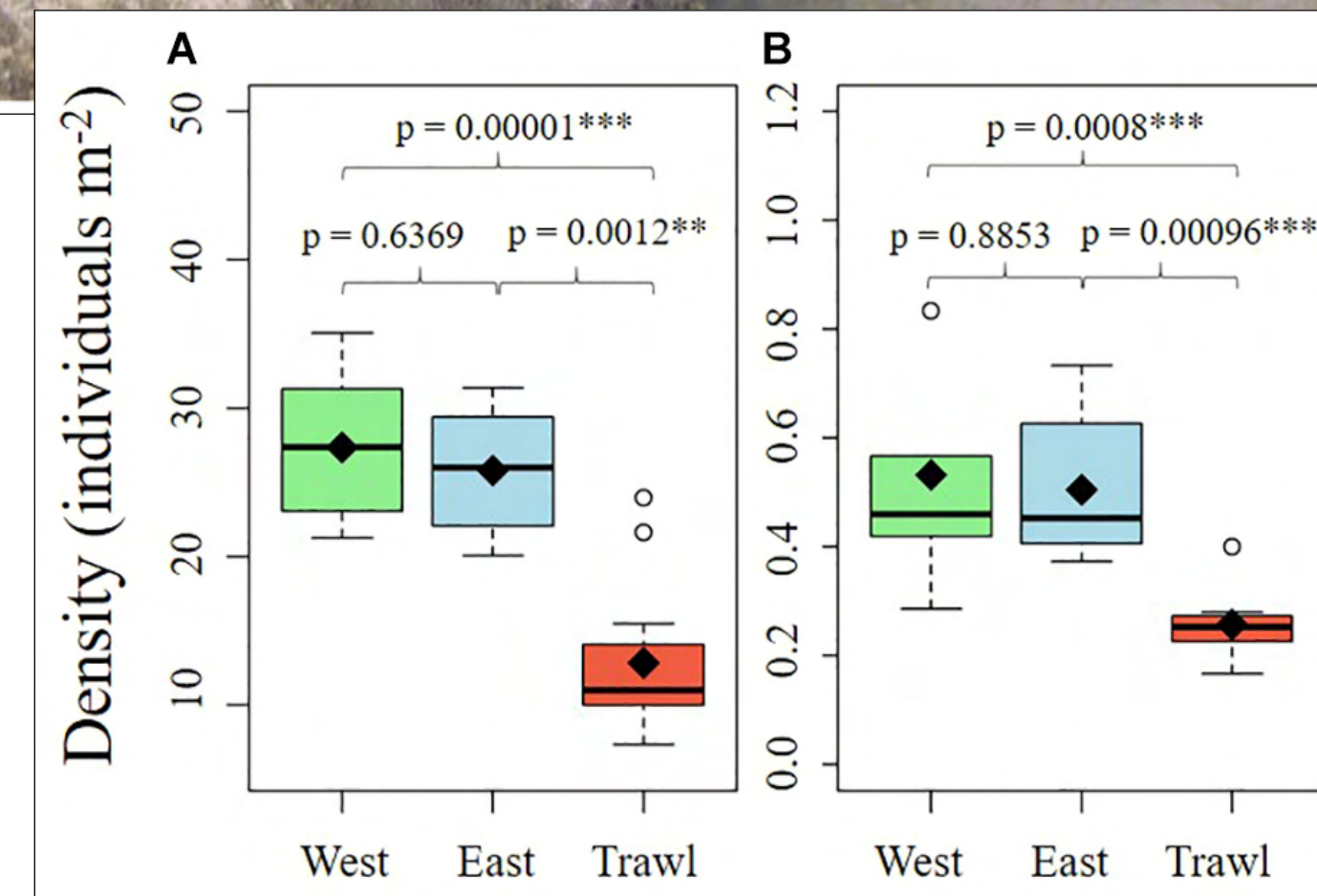
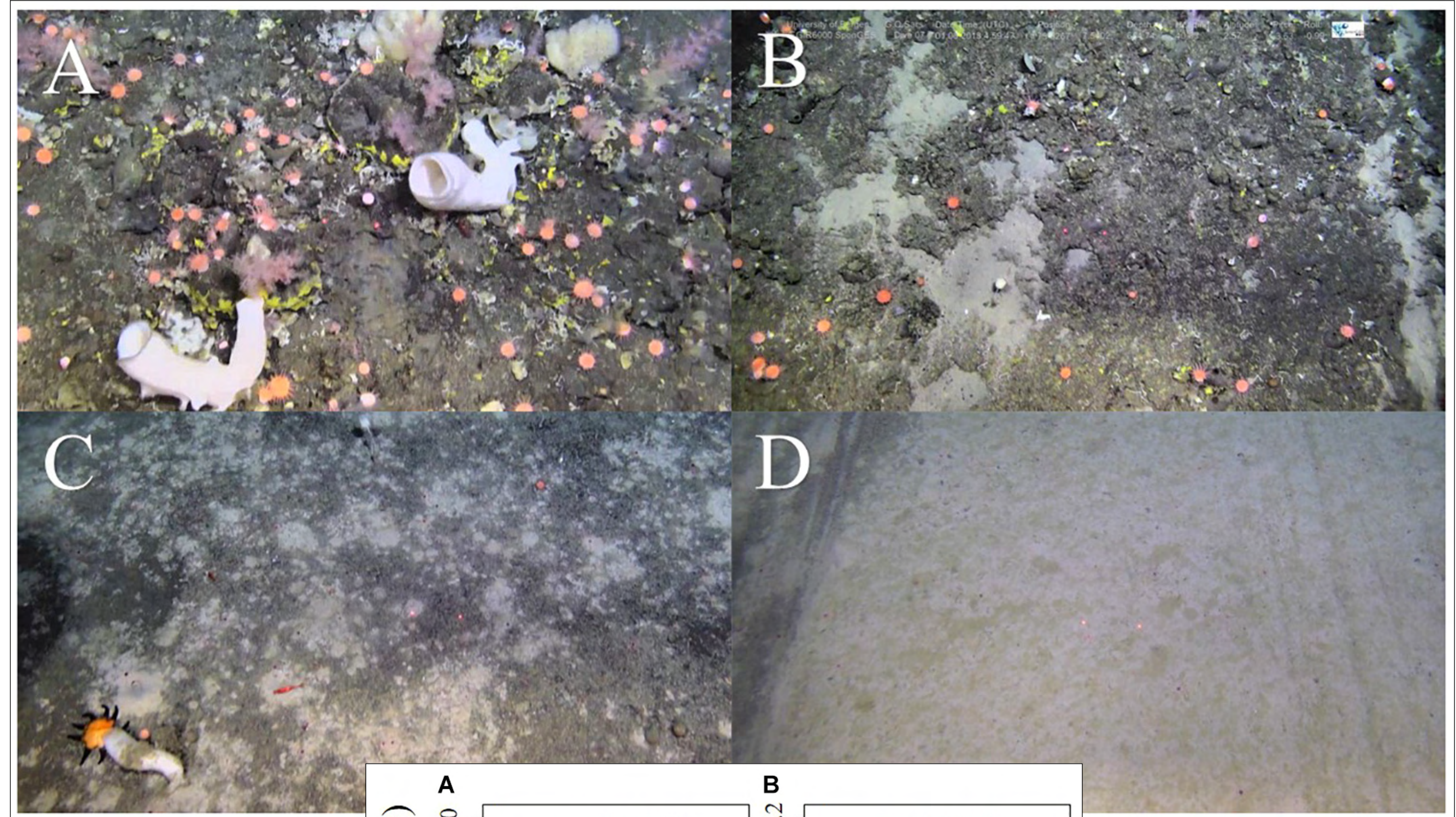
SponGES

PI Prof. Hans Tore Rapp & Dr Joana Xavier, University of Bergen



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- Host vulnerable ecosystems, such as deep-sea sponge grounds
- Hotspots of biodiversity and biomass
- Studies suggest very slow recovery after disturbance



Morrison et al. (2020)

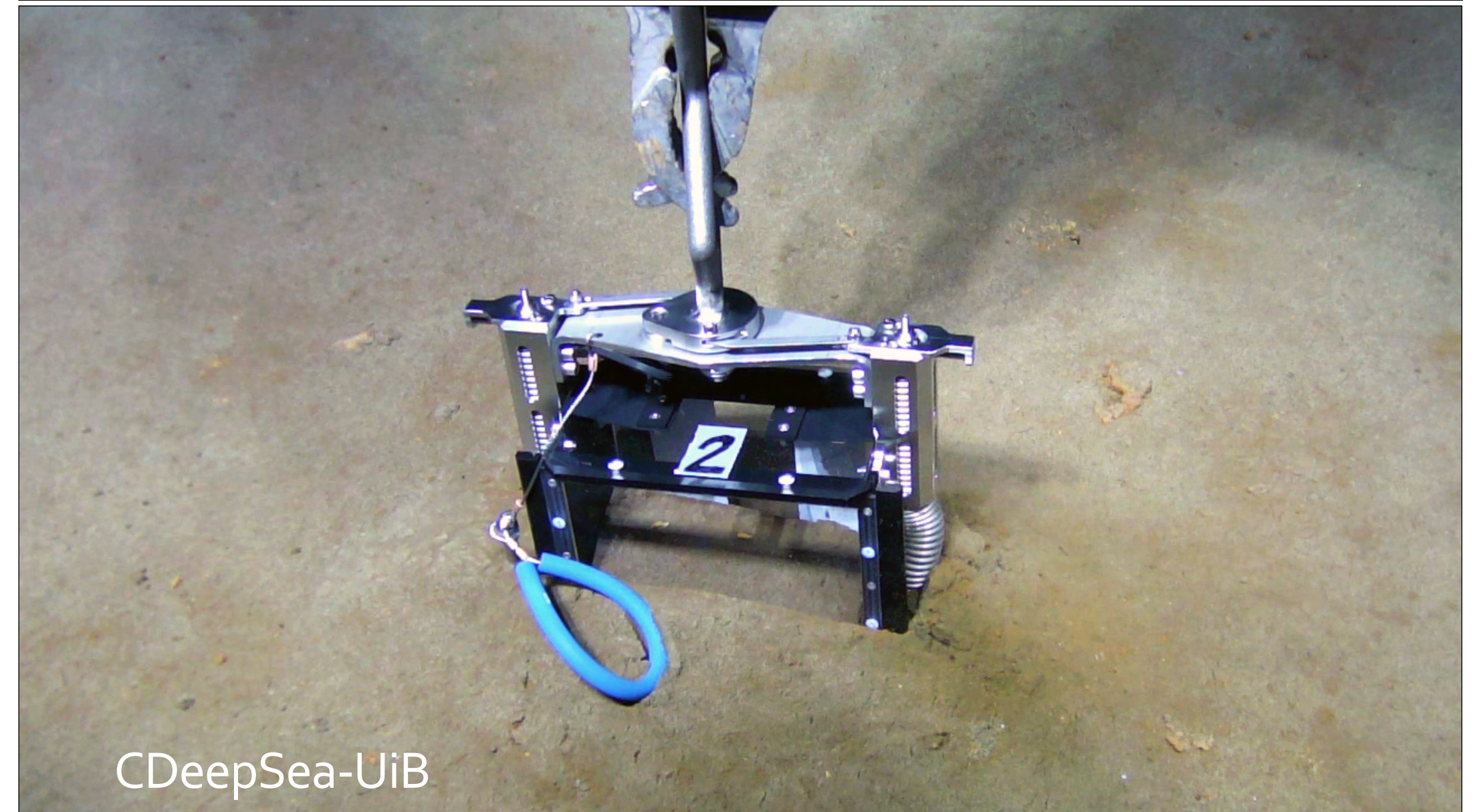
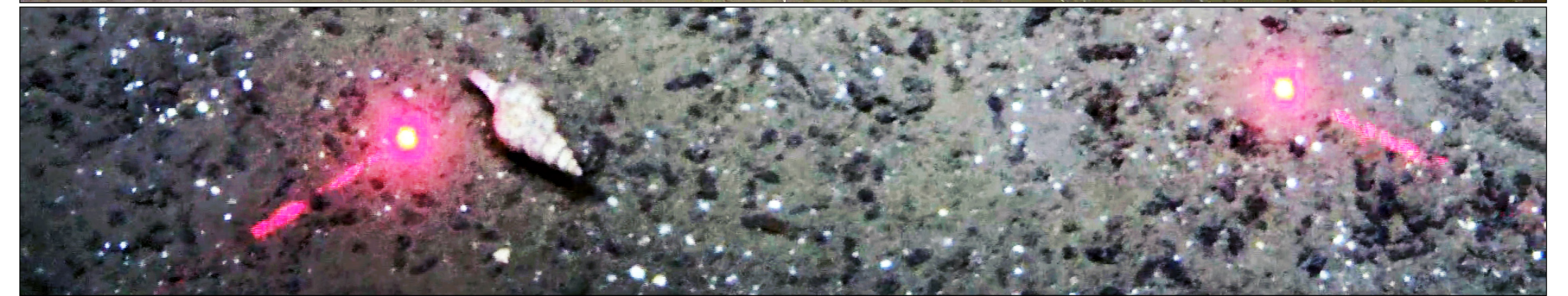
SponGES

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Soft bottom habitats

- Only larger epifauna is visible on video
- Smaller size classes (macro and meiofauna) make up most of the metazoan biomass
- Little is known about soft-bottom infauna on the deeper part of the continental shelf, including the Arctic Mid-Ocean Ridge (Ramirez-Llodra et al. 2020)



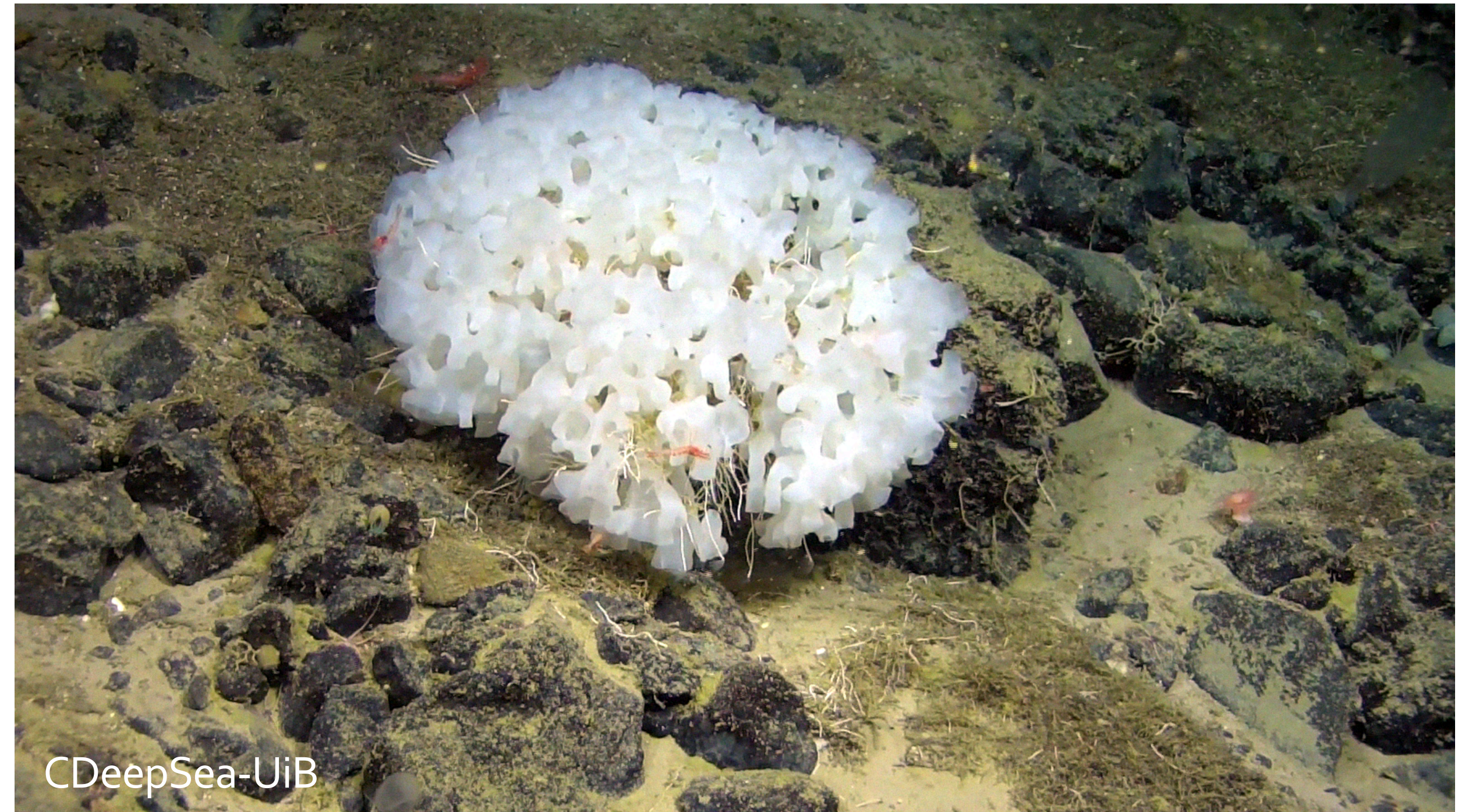
Summary of research status

Level of knowledge	Research topic	ACTIVE VENTS	INACTIVE VENTS	HARD BOTTOM (SEAMOUNTS)	SOFT BOTTOM
RESILIENCE & RECOVERY	Environmental risk assessment				
	Recolonisation pathways				
	Recovery potential			<div></div>	
	Disturbance effects			<div></div>	
LINKS	Metapopulation dynamics				
	Connectivity	<div></div>		<div></div>	
	Dispersal				
PROCESSES	Spatio-temporal variation			<div></div>	
	Ecosystem function	<div></div>		<div></div>	
	Biotic interactions	<div></div>		<div></div>	
	Abiotic drivers	<div></div>		<div></div>	
PATTERN	Biogeographic patterns	<div></div>		<div></div>	<div></div>
	Community structure	<div></div>	<div></div>	<div></div>	<div></div>
BIODIVERSITY	Molecular diversity	<div></div>	<div></div>	<div></div>	<div></div>
	Species diversity	<div></div>	<div></div>	<div></div>	<div></div>
		<div></div> Limited knowledge/sampling	<div></div> In progress	<div></div> Good knowledge	

Research needs for environmental management planning

1. Baseline studies

- Long-term measurement of environmental conditions to assess natural variability
- More complete mapping of habitats and communities
 - Seamounts hosting manganese crusts
 - Seamounts hosting VMEs
 - Inactive sulphide areas
 - Soft bottom areas (covering extinct SMS deposits)



- Ecological baseline / ecosystem function

Research is needed to understand how environmental variability influences community patterns and ecosystem function

Research needs for environmental management planning

2. Recolonisation potential

- Investigate larval dispersal ability
- Characterise fine-scale deep ocean currents
- Estimate population connectivity patterns
(particularly important for species on patchy habitats)
- larval biology + oceanography + modeling + genetics

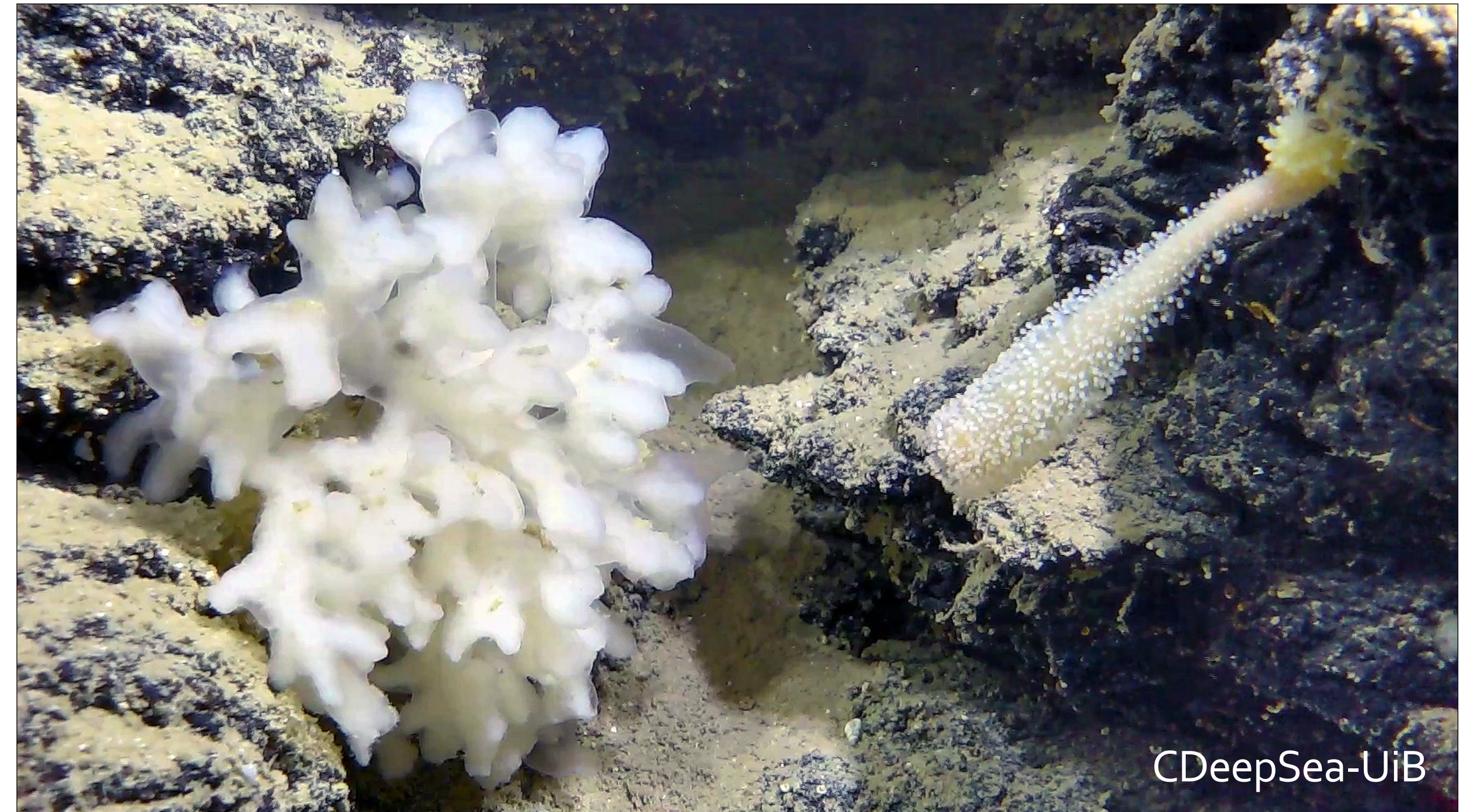


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Research needs for environmental management planning

3. Physical and toxic effects of mining plumes

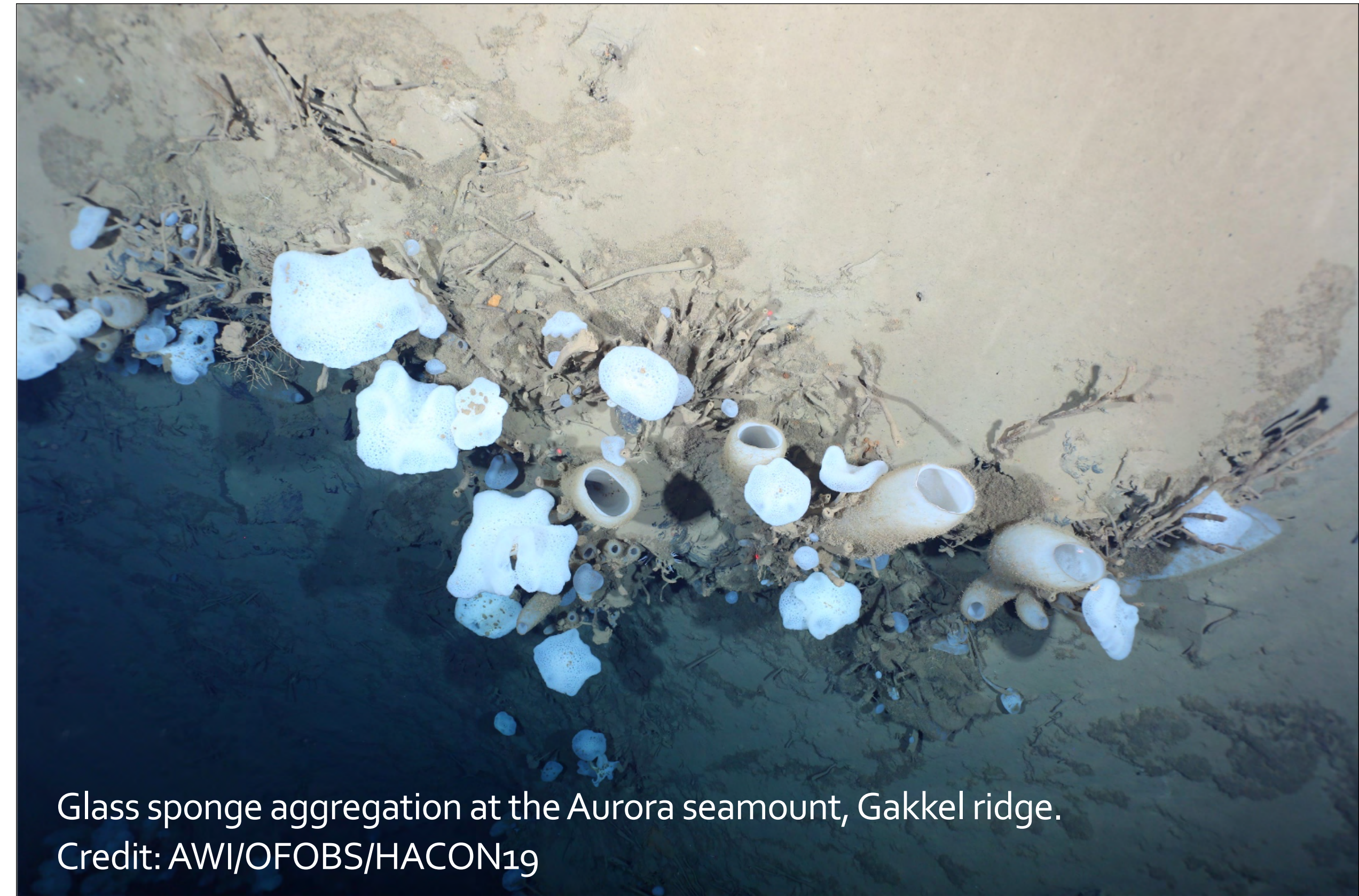
- Suspended particles and dissolved metals
- Plume dispersal modelling
- Ex-situ and in-situ exposure studies to quantify impact on survival, physiology and ecosystem function
- Model potential broad-scale effects of industrial exploration and exploitation of seabed mining - cumulative impacts



Research needs for environmental management planning

4. Ecological risk assessment

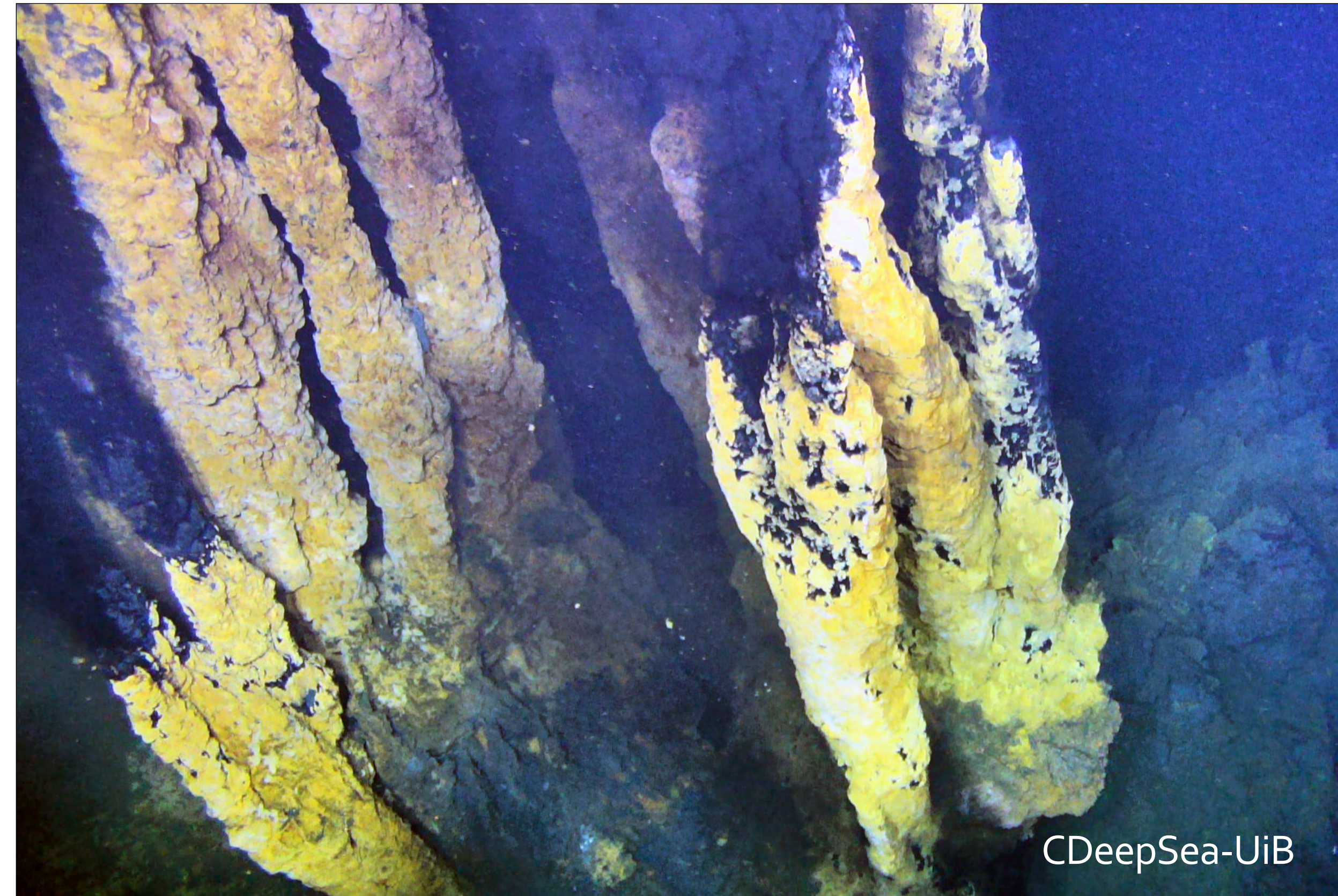
- Establishes the risk framework for deep-sea mining
- Identifies potential hazards
- Analyses the ecological risk of mining activities based on the available data
- Benefits from collaboration with the industry
- Continually evaluated and updated through monitoring of risk indicators



Glass sponge aggregation at the Aurora seamount, Gakkel ridge.
Credit: AWI/OFOBS/HACON19

Possible contributions to the regulatory framework

- Ecological risk assessment
- Identification of reliable environmental and ecological variables to monitor, as well as standards and thresholds
- Habitat classification for area-based management
Identification of possible protected areas
- Transparency in data sharing and mining operations
Promoting sharing of data (technological, environmental) between industry stakeholders and scientists



CDeepSea-UiB

Thank you for your attention

The UiB team:

Hans Tore Rapp

Mari H. Eilertsen

Joana R. Xavier

Heidi Meyer

Anna Patova

Tone Ulvatn

Ida Hamstad

David Rees

Solveig Thorkildsen

Ida H. Steen

Runar Stokke

Håkon Dahle

Anita-Elin Fedøy

Rolf Birger Pedersen

Eoghan Reeves

Thibaut Barreyre

and many more...

