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AARHUS UNIVERSITY
DEP. OF BIOSCIENCE

Predicting drivers and distributions of deep-sea ecosystems: A cold-water coral case study

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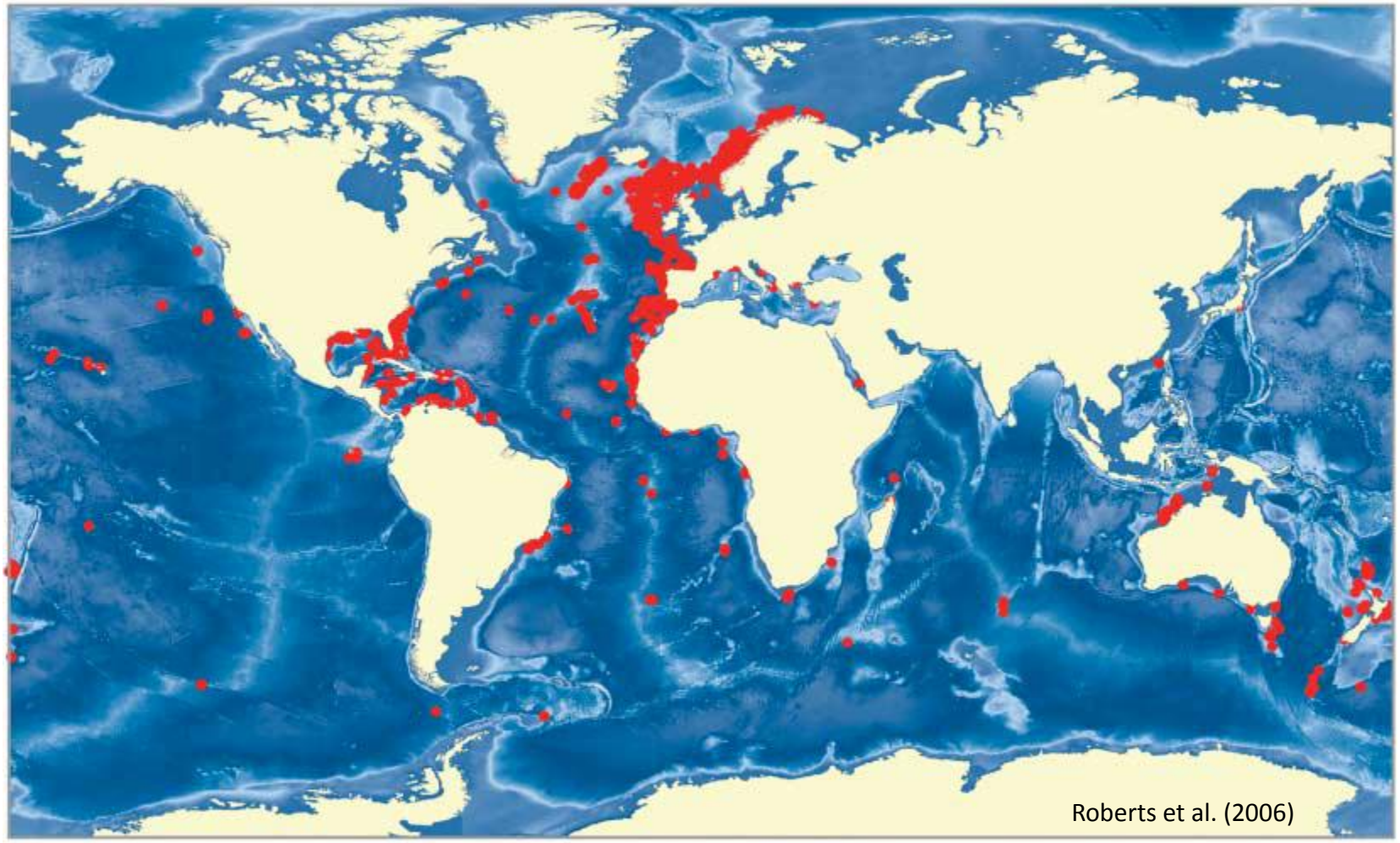
Global distribution of reef-forming cold-water corals

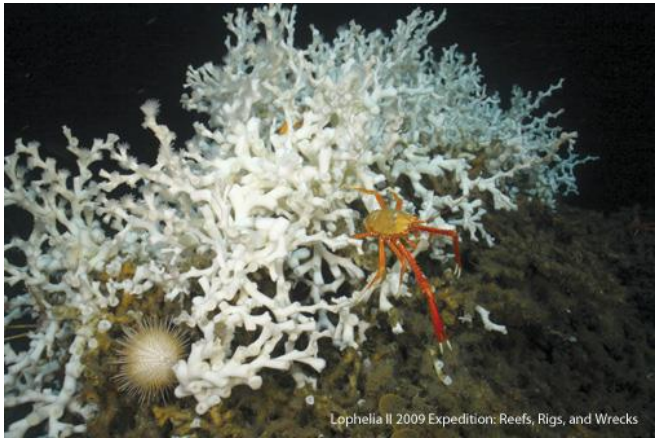


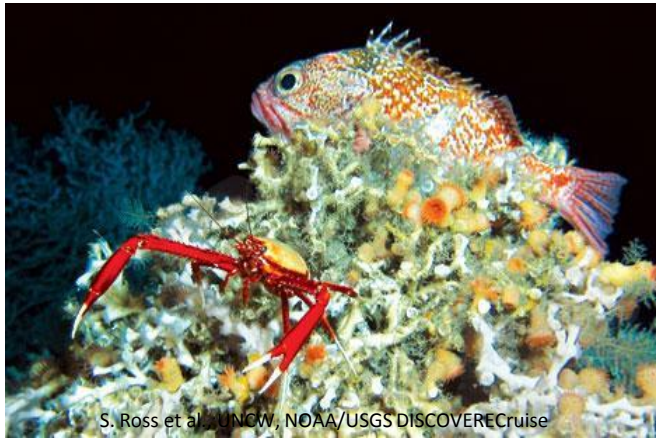
Background, facts and figures

- **Lophelia pertusa**: Most abundant CWC species in the NE Atlantic (individuals, frameworks, colonies, depth range 120 – 1000 m)

- In-situ data are limited, but results indicate high biomass levels and biodiversity (> 1300 species have been found with cold-water corals in the NE Atlantic)

- Often found at or near local mixing hotspots, i.e. abrupt topographic features (carbonate mounds, seamounts, canyons)





CWC monitoring: Challenges and needs

- Expensive and time consuming mapping and sampling effort
- Quantitative, non-invasive observations
- High-end tools for multidisciplinary sampling at high resolution (high-end ROVs, integrated benthic sampler, multibeam bathymetry)
- Cost-effective monitoring strategies (establishing a network of scientific reference sites; developing cross-program standards, indicators and data collection)
- Supplementary tools (dynamic models, species distribution models)


Photo: Marine Institute, Ireland

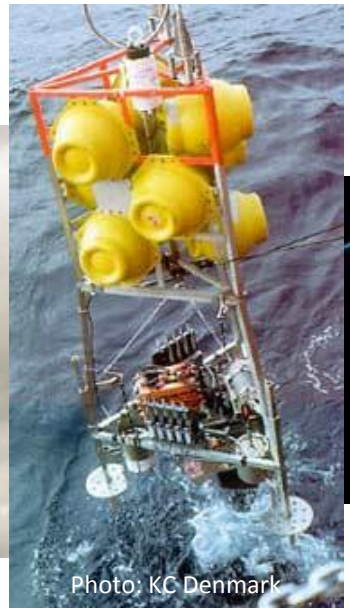


Photo: KC Denmark

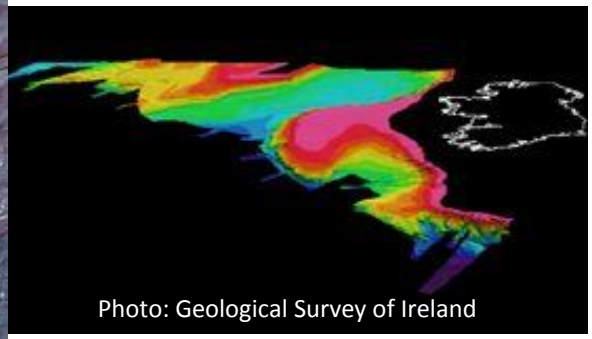
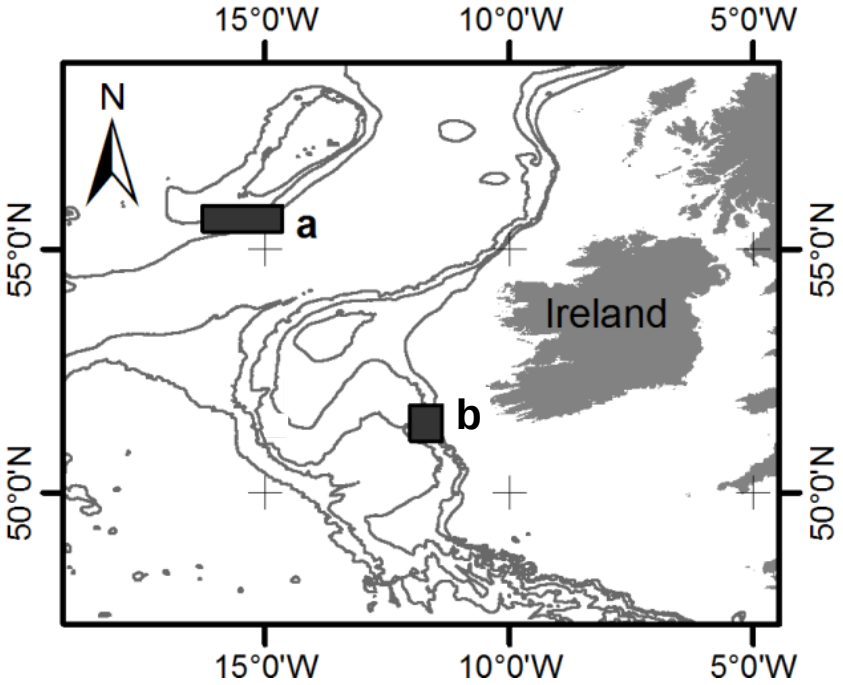


Photo: Geological Survey of Ireland

Scientific questions and **methods:**

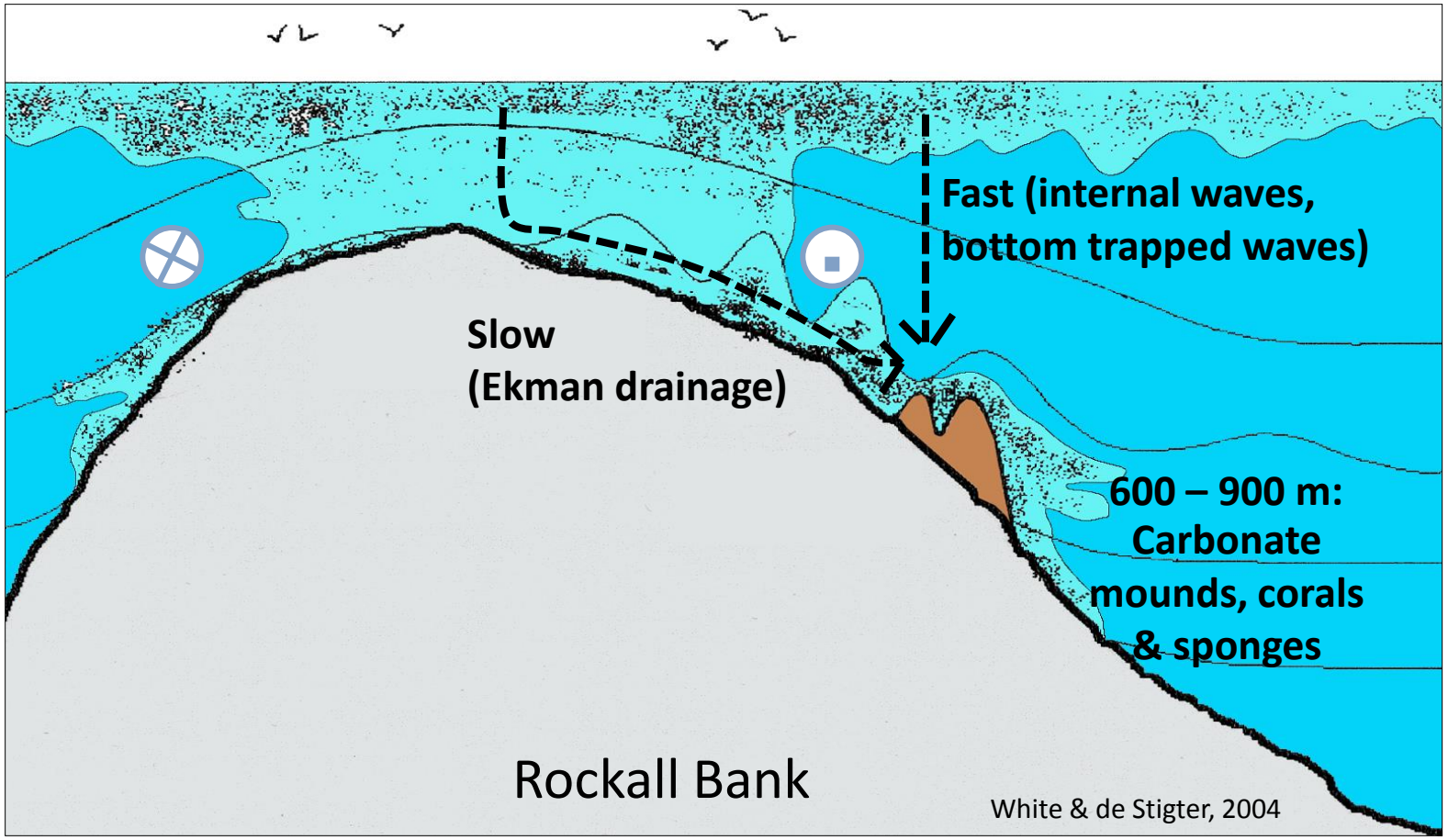
- What are the linkages between benthic hydrodynamics and cold-water coral occurrences? Identifying mixing hot spots and possible food supply mechanisms (**3D hydrodynamic modelling**)

- Can high-resolution data from 3D hydrodynamic models help to improve predictions of coral distributions (**species distribution modelling - SDM**)

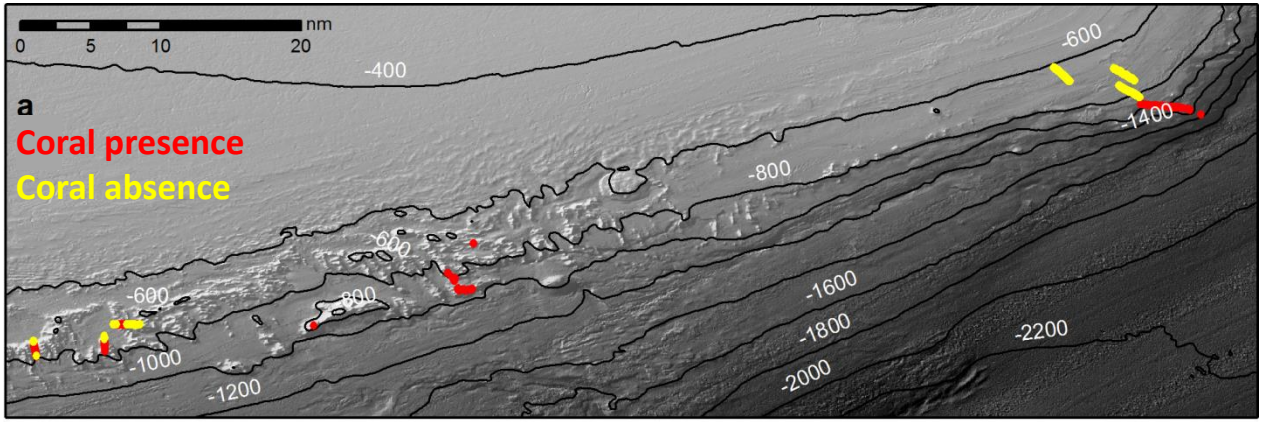


a. Logachev mounds
b. Belgica mounds

Pelagic-benthic coupling at Rockall Bank : Source to sink

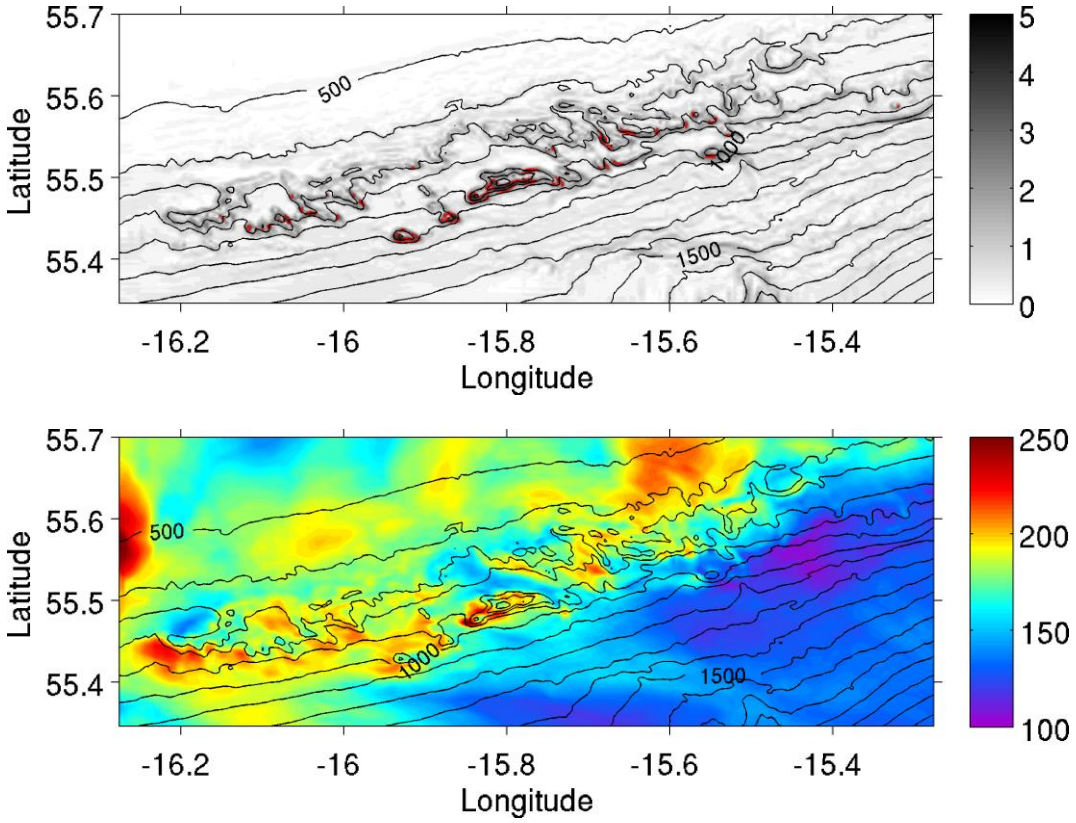


Modelling of near-bottom hydrodynamic processes at observed CWC presence / absence locations and beyond



- ROMS-AGRIF, embedded grids (inner model grid: 250 m resolution), 32 vertical layers, high resolution bathymetry (INSS), open boundaries, climatological and tidal forcing
- High resolution matters: Resolving complex carbonate mound structures at spatial scales > 250 m not possible
- Downside: High computational effort, long simulation times

Direct connection to surface production - Internal hydraulic jumps ?



Tidal excursion inverse Froude number $Fr^{-1} = \frac{dh}{dx}\frac{N}{\omega}$

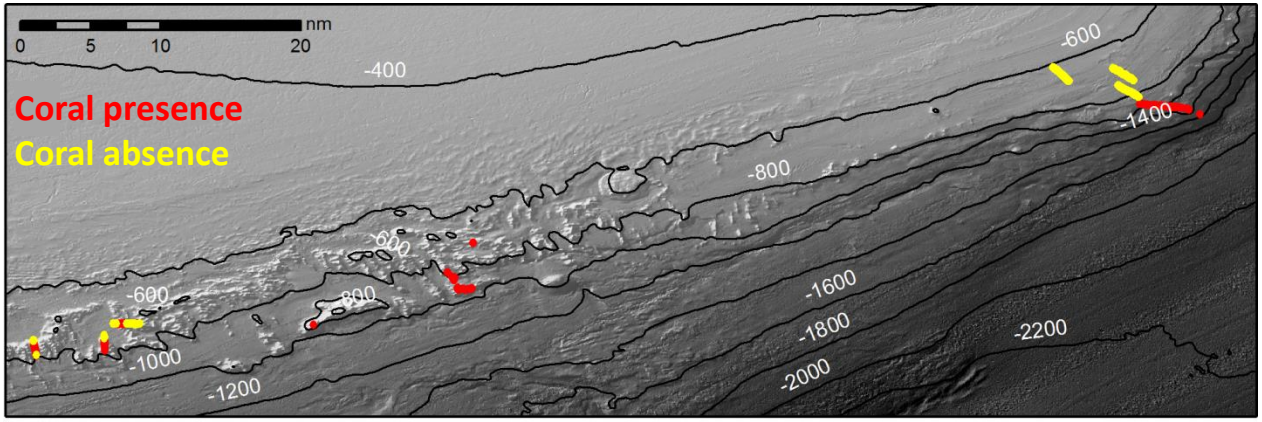
Vertical displacement scale U/N (m)

Internal hydraulic jumps at $Fr^{-1} > 3$ AND large U/N

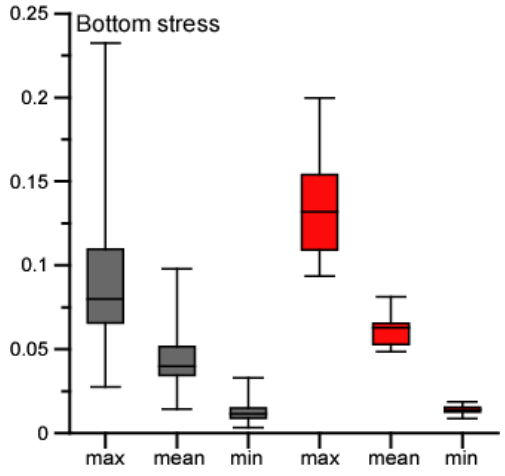
Modelling species distribution using high-resolution terrain data and hydrodynamic data

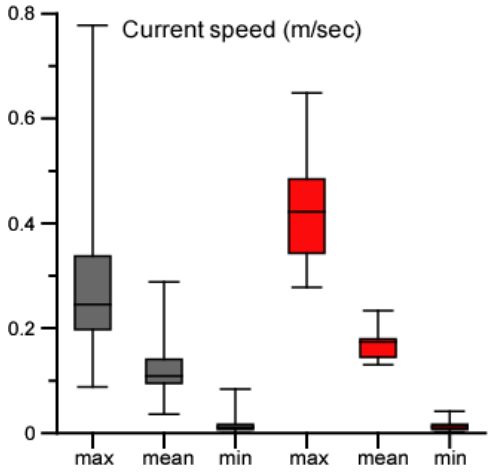
- SDMs analyse relationships between species occurrence data (presence/absence) and environmental predictor variables

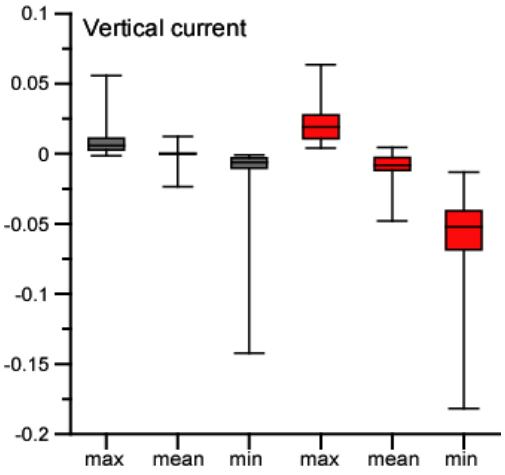
- SDMs provide statistical estimates of the potential species distribution in geographic space

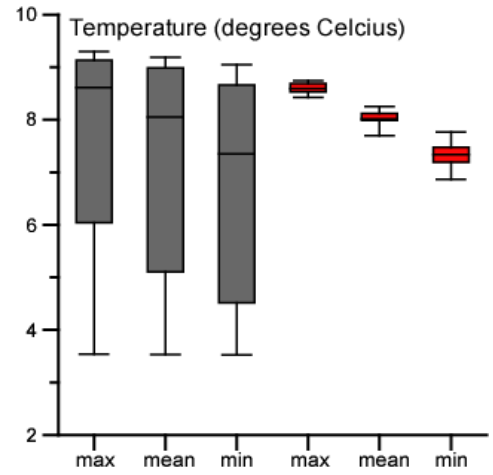


Environmental predictors – some examples





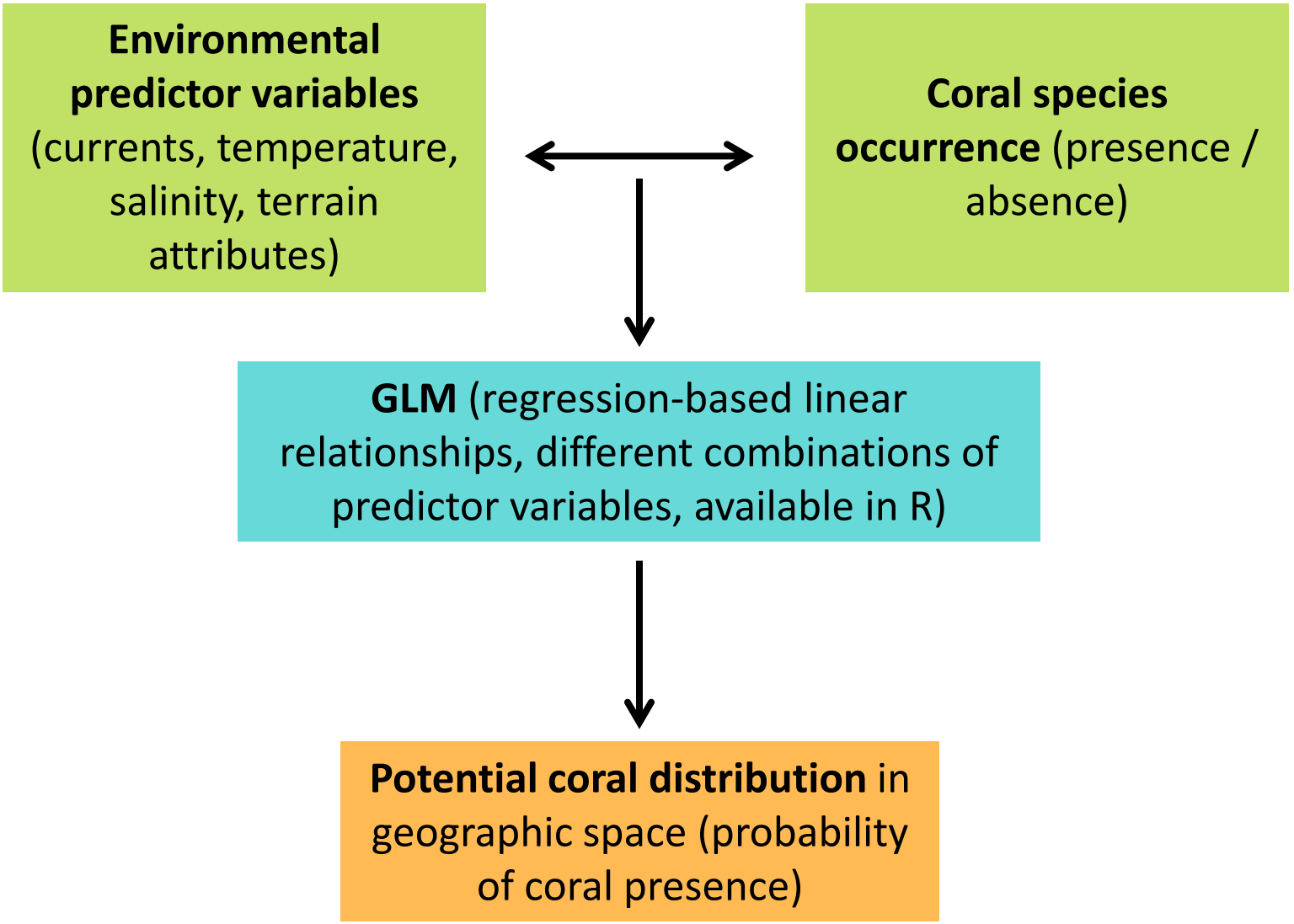




Coral presence (living corals)

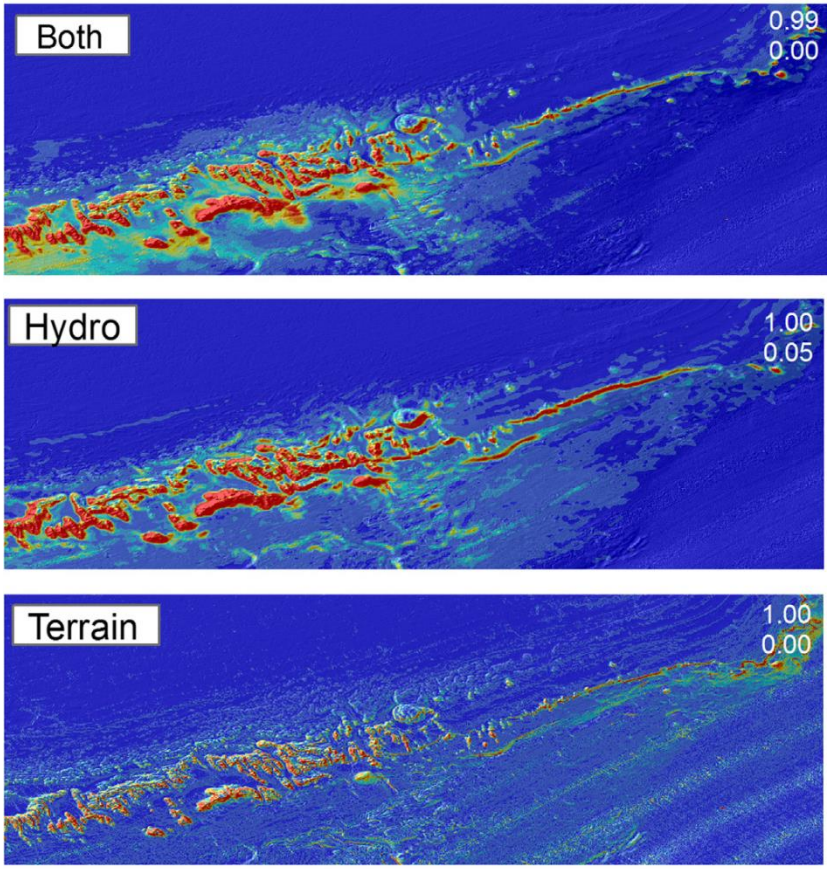
Coral pseudo-absence (1000 random background points)

Generalized Linear Model (GLM): Modelling framework



Predicting CWC distribution: Combinations of high resolution hydrodynamic and terrain data

Rengstorf et al., 2014



Both model (bottom slope, BPI – Bathymetric Position Index, vertical velocity, bottom stress)

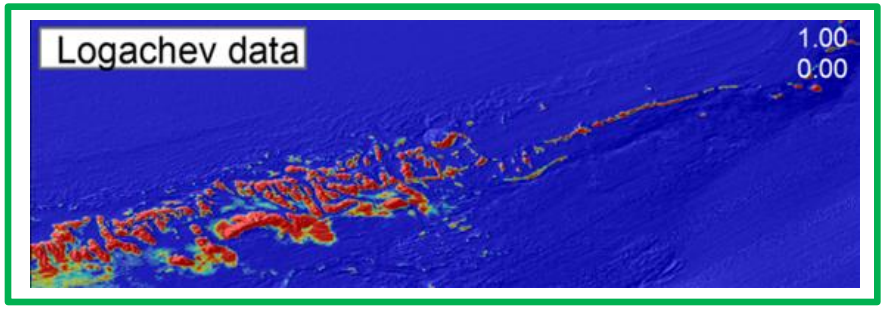
Hydro model (vertical velocity)

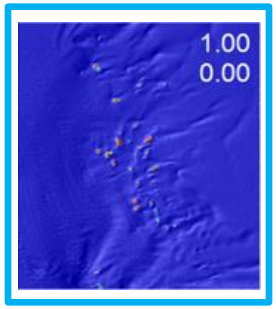
Terrain model (slope, BPI)

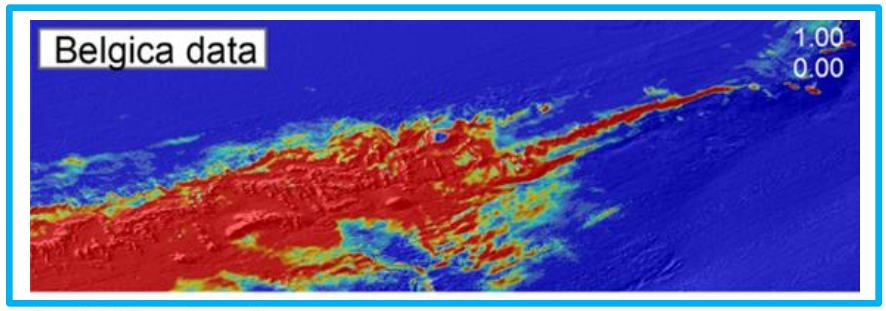
Predicting CWC distribution: Model transferability

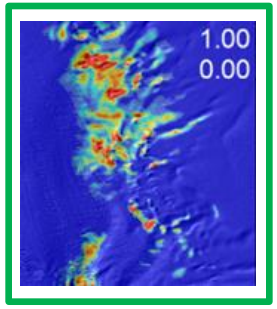
Rockall Bank
(Logachev)

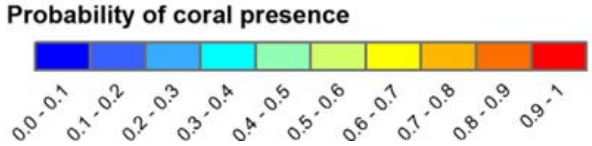
Porcupine Seabight
(Belgica)











Rengstorf et al., 2014

Calibration / training area

Projection area

Summary and outlook

Lessons learned:

- Data from high resolution hydrodynamic models provide new and useful functional predictors for SDM.
- Increasing the level of complexity (more environmental descriptors) improves SDM model performance in one study area, but decreases model transferability to another.

Benefits:

- Powerful planning tool for habitat surveys and deep-sea monitoring.
- New insights into ecological niche stability.
- Support deep-sea management and conservation.

What can go wrong?

- A lot **;-)**

Careful interpretation of SDM model results in deep-sea habitats, very often few observations for calibration and validation.

Acknowledgements

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Thank you!