# BEnToolsMaPs - From Biodiversity to Ecosystem Functions:
## Seafloor Tools for Integrative Management of Marine Protected Areas

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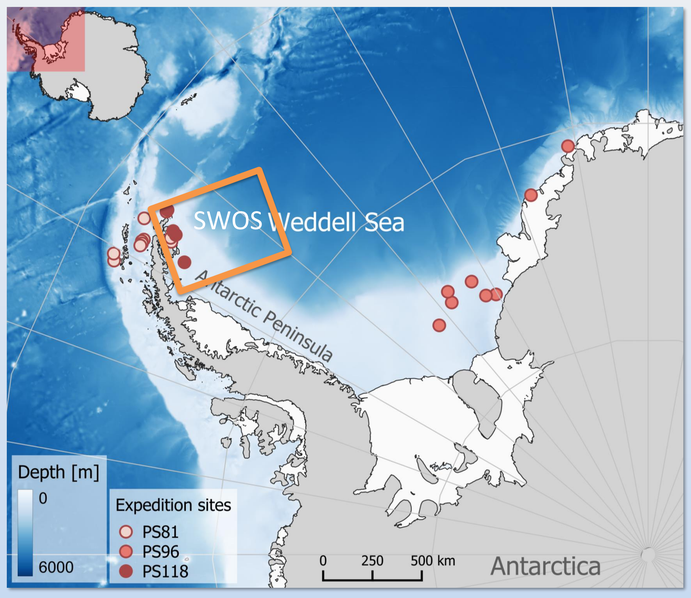
## Motivation

The Southern Ocean and the Antarctic Peninsula region in particular face increasing climate change pressures. International initiatives such as the **Southern Ocean Action Plan** (UN Decade 2021-2023) aim to protect this unique ecosystem.

**The quantified contribution of seafloor organisms to ecosystem services, such as carbon storage and cycling, is still under-researched**. Gaining better knowledge of their functions can help ensure that conservation measures, such as Marine Protected Areas (MPAs), effectively address the essential ecological processes necessary for ocean health.

## Study Area




## BEnToolsMaPs Objectives

**O1 Seafloor biodiversity of meio- & macrofauna in the Weddell Sea** under different climatic regimes

**O2 Functional & genetic approaches for benthic community assessment** in combination with classical methods for an accelerated analysis of benthic ecosystems

**O3 Understanding the ecosystem functions in the sediments** i.e., bioturbation and carbon cycling and key taxa and functional groups

**O4 Spatial modeling of biodiversity and ecosystem functions** using quantification and mapping tools in benthic shelf and shelf slope habitats

**O5 Knowledge transfer to conservation planning & management** about seabed meio- & macrofauna and functions for the protection of biodiversity and integration into MPA initiatives

## Communication of seafloor functions for marine spatial planning

**BEnToolsMaPs aims** to
- integrate **structure and function** knowledge of **seafloor systems** in the **Southern Ocean**
- support informed decision-making for the **sustainable management** of **carbon storage** and **biodiversity-related ecosystem services**

**With whom?**
- Stakeholder dialog in **national forum** of the **Biodiversity** of the **Blue Ocean Cluster**
- **Commission** for the **Conservation of Antarctic Marine Living Resources (CCAMLR)**, specific working and planning groups
- Public

**Tools**
- interactive maps
- fact sheets
- seafloor function models

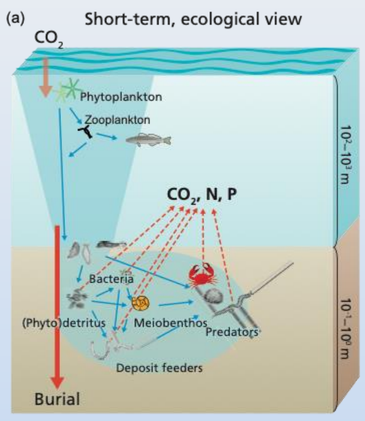
*Ocean News*

**hidden diversity treasures of Antarctic seafloor become stars**

**WP 5**

## Integration of biodiversity and ecosystem functions

provides standardized data and a conceptual model as base for spatial mapping



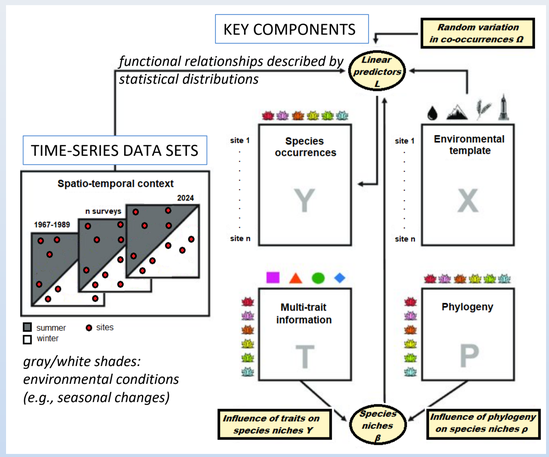

General scheme of seafloor organisms and their role for biogeochemical cycling in marine sediments. Modified from Middelburg 2018

- **Integration of benthic community and abioticdata** for analysis of environmental drivers
- Submission of **georeferenced biodiversity and habitat characteristics** to data portals (e.g. CRITTERBASE)
- Statistical **analysis of seafloor community, bioturbation and C cycling interactions**
- **Conceptual model of Weddell Sea shelf biodiversity and ecosystem function interaction**

**WP 3**

## Hierarchical Modelling of Species Communities (HMSC)

integrates community-level random effects, environmental covariates, presence data; can identify and measure climate-driven shifts and species responses




Conceptual framework of the HMSC Model (mod. from Ovaskainen et al. 2017)

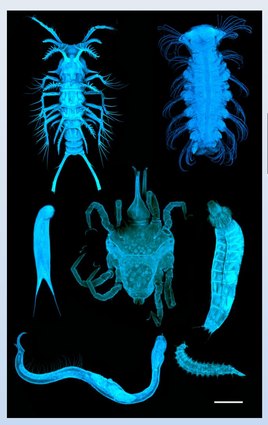
- **Data (white boxes)**
  - **Occurrence data (Y matrix):** Records species occurrences across different spatiotemporal contexts
  - **Environmental covariates (X matrix):** Includes physico-chemical variables (e.g., water chemistry, depth)
  - **(Multi) Trait data (T matrix):** Represents functional traits of species, depicted with geometric shapes and colors
  - **Phylogeny (P matrix):** Captures evolutionary relationships among species
- **Estimated parameters (yellow boxes and ellipses)**
  - linear predictors (L)
  - random variation in species co-occurrences (Ω)
  - species niches (β)
  - trait influence on niches (γ)
  - phylogenetic signal (ρ)

*HMSC integrates species occurrences or abundances data with environmental covariates, species traits, and phylogeny (Ovaskainen et al., 2017)*

**WP 4**

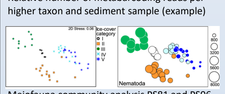
## Biodiversity assessment of benthic communities

integrating high-throughput molecular and functional-group techniques with morphological methods

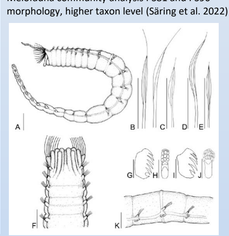


Meiofauna organisms from the Antarctic (PS81). CLSM-scans by S. Durst, J. Schuckenbrock

Relative number of metabarcoding reads per higher taxon and sediment sample (example)




Meiofauna community analysis PS81 and PS96 morphology, higher taxon level (Säring et al. 2022)



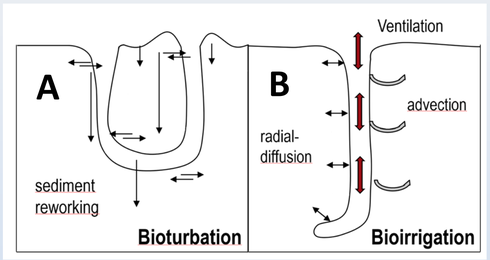
*Anobothrus konstantini* Säring & Bick, 2022

- **Metabarcoding** of sediment inhabiting meio- and macrofauna communities
- **Comparison of diversity assessment** by metabarcoding and morphological methods
- **Barcoding** of meio- and macrofauna species to complement morphological descriptions, description of new species
- **Macrofauna community description**: taxonomic and functional group approach

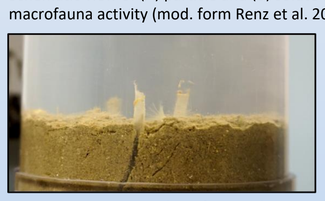
**WP 1**

## Quantification of sediment reworking activity

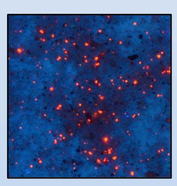
by linking fauna-induced transport processes and relating them to key taxa




Schematic view of (A) particle and (B) solute transport caused by macrofauna activity (mod. form Renz et al. 2017)



Burrow structures resulting from sediment reworking activity (PS 129).



Fluorescent particulate tracers (luminophores), used for particle mixing analysis

- **Bioturbation quantification and modelling,** using luminophores, chlorophyll a, bromide
- **Bioturbation (BP) and bioirrigation (BIP) potential determination** to assess community bioturbation performance
- **Linkage of C cycling and bioturbation activity** to quantify the ecosystem service of C storage in Southern Ocean sediments

**WP 2**

**Project Partners**
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[3]Helmholtz Institute for Functional Marine Biodiversity at the University of Oldenburg, Germany
[4]Senckenberg am Meer, Wilhelmshaven, Germany

**Key references**
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Middelburg, J. J. (2018). "Reviews and syntheses: to the bottom of carbon processing at the seafloor." Biogeosciences **15**(2): 413-427.
Renz et al. (2017). "On the necessitiy of simplification when bioirrigation is treated as an ecosystem function." [Poster presentation]. Baltic Sea Science Conference 2017, Rostock, Germany.
Säring, F., et al. (2022). "Sea-ice-related environmental drivers affect meiofauna and macrofauna communities differently at large scales (Southern Ocean, Antarctic)." Marine Ecology Progress Series 700: 13-37.

**Funding**
BEnToolSMaPs, Grant No. 03V01841; MARE:N - Marine and Polar Research Program Marine Biodiversity

Projektträger Jülich Forschungszentrum Jülich
Bundesministerium für Bildung und Forschung