Climate change and recovery from eutrophication reduce benthic fauna and carbon processing in a coastal sea

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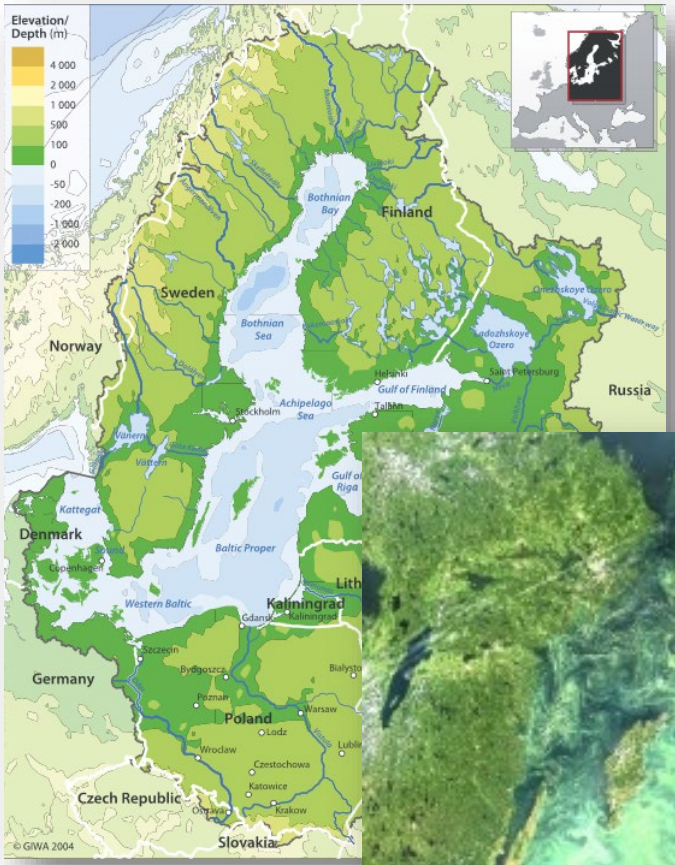
Stockholm University
Baltic Sea Centre

FINLAND
TVÄRMINNE BENTHIC ECOLOGY TEAM
est. 2006

UNIVERSITY OF HELSINKI

The Baltic Sea



Kahru & Elmgren 2014
Biogeosciences

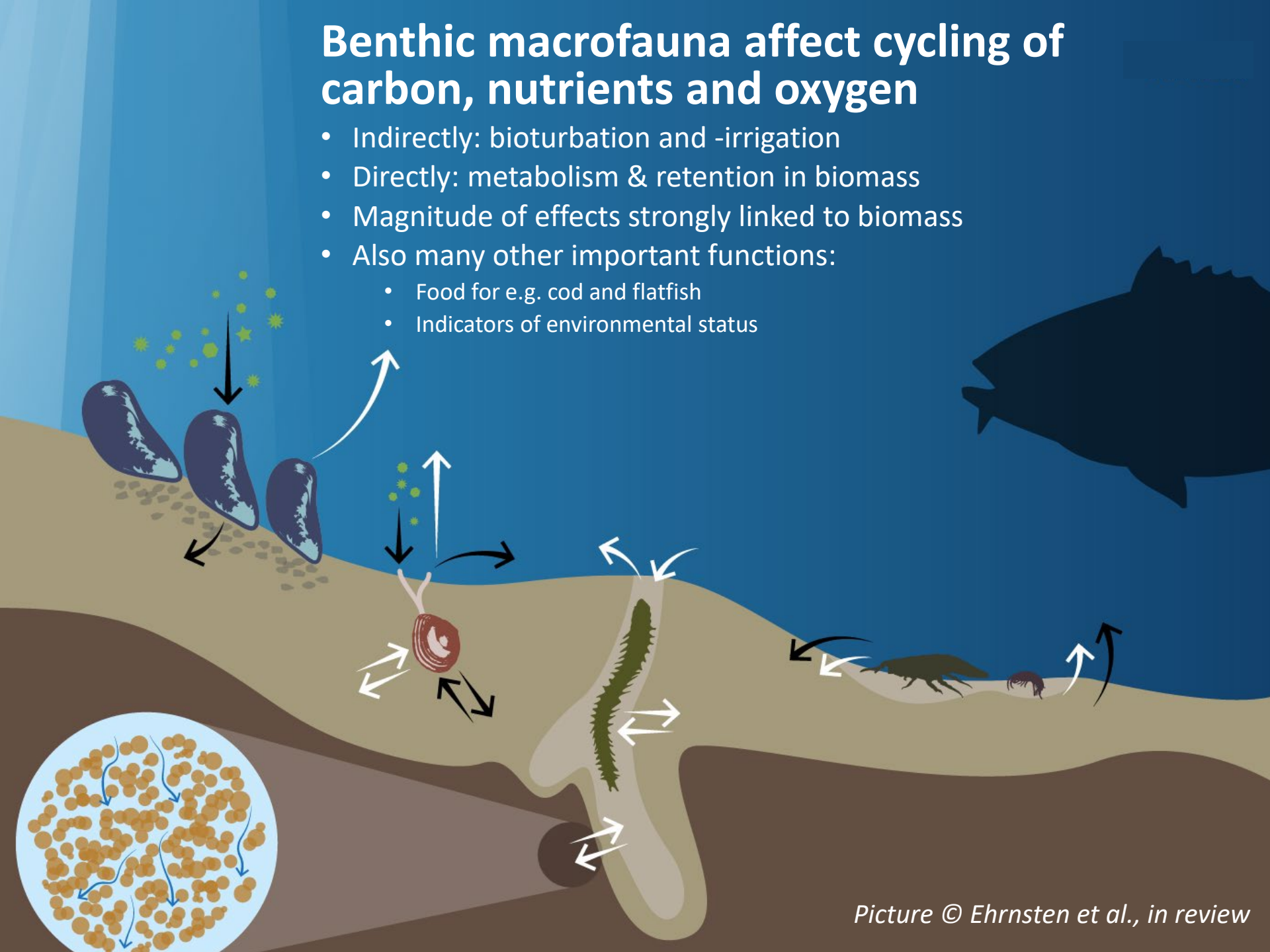
Large catchment and limited connection to the ocean

- Brackish water
  - ➢ Few species
- Heavily affected by nutrient loading - eutrophication
  - ➢ More phytoplankton
  - ➢ More sedimentation
  - ➢ More food for benthic animals
  - ➢ Hypoxia, “dead bottoms”

Norkko et al. 2013 Scientific Reports

Benthic macrofauna affect cycling of carbon, nutrients and oxygen

- Indirectly: bioturbation and -irrigation
- Directly: metabolism & retention in biomass
- Magnitude of effects strongly linked to biomass
- Also many other important functions:
  - Food for e.g. cod and flatfish
  - Indicators of environmental status



Picture © Ehrnsten et al., in review

Aim:

- Effects of changing climate and nutrient loads on biomass and metabolism of benthic fauna in the Baltic Sea

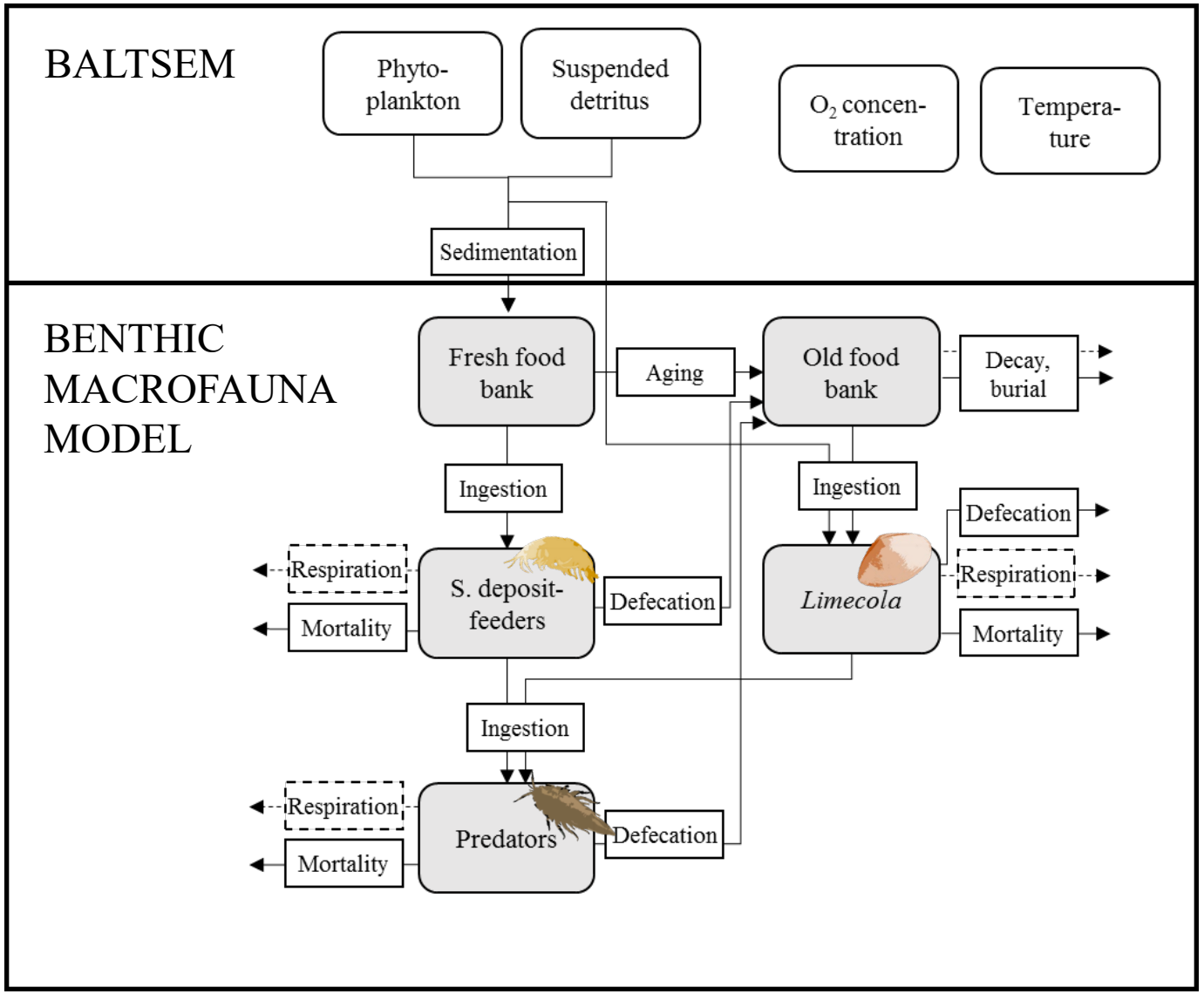
Methods

- Extension of the hydrodynamic-biogeochemical model BALTSEM[1] to include benthic fauna
- 'Baseline' hindcast simulation 1970-2012
- Scenarios with changing nutrient loads with and without climate change -2100

	Abbreviation	Description	Time frame
Nutrient loads			
	Baseline	Observed historical nutrient load time-series	1961-2012
	BSAP	Nutrient loads following the Baltic Sea Action Plan	2013-2098
	REF	Monthly mean loads 2012-2014	2013-2098
	HIGH	Monthly mean loads 1980-1990	2013-2098
Climate			
	Baseline	Actual weather, river runoff and boundary conditions	1961-2012
	RE_A1B_1	RCAO-ECHAM5 realisation 1, emission scenario A1B	1961-2098
	RE_A1B_3	RCAO-ECHAM5 realisation 3, emission scenario A1B	1961-2098
	RH_A1B_1	RCAO-HadCM3 realisation 1, emission scenario A1B	1961-2098
	RE_A2_1	RCAO-ECHAM5, realisation 1, emission scenario A2	1961-2098
	Current climate	Statistical forcing	1961-2098

[1] Savchuk et al. 2012 BNI Tech. Rep. *link*
Gustafsson et al. 2012 *AMBIO* doi.org/10.1007/s13280-012-0318-x
Gustafsson et al. 2017 *Biogeochemistry* doi.org/10.1007/s10533-017-0361-6

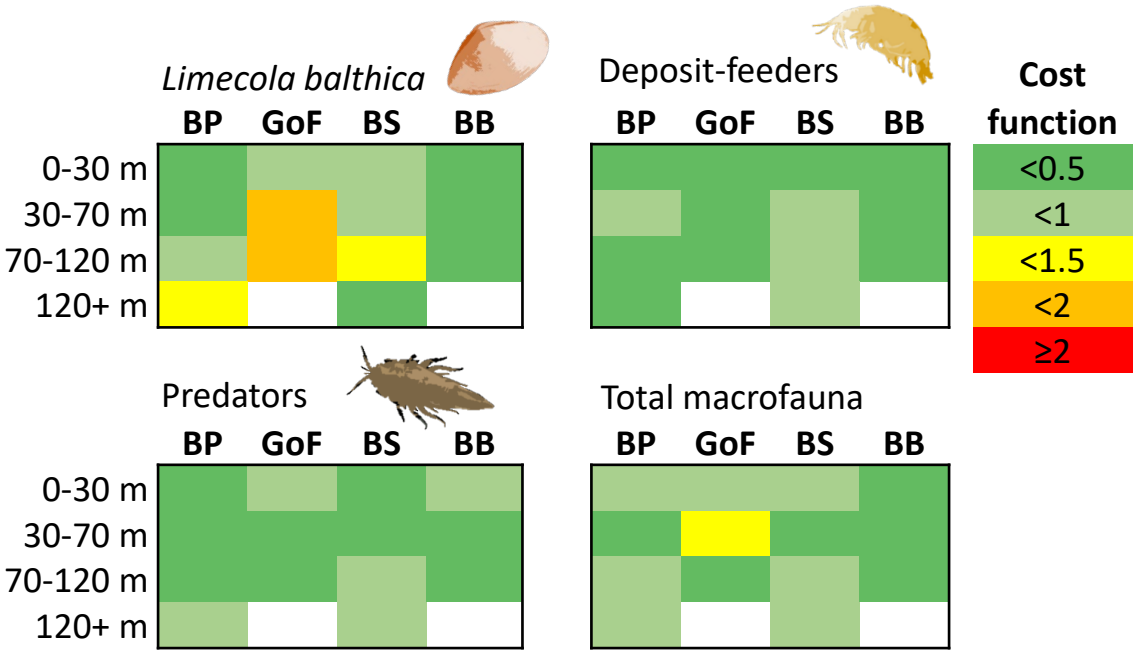
Model setup

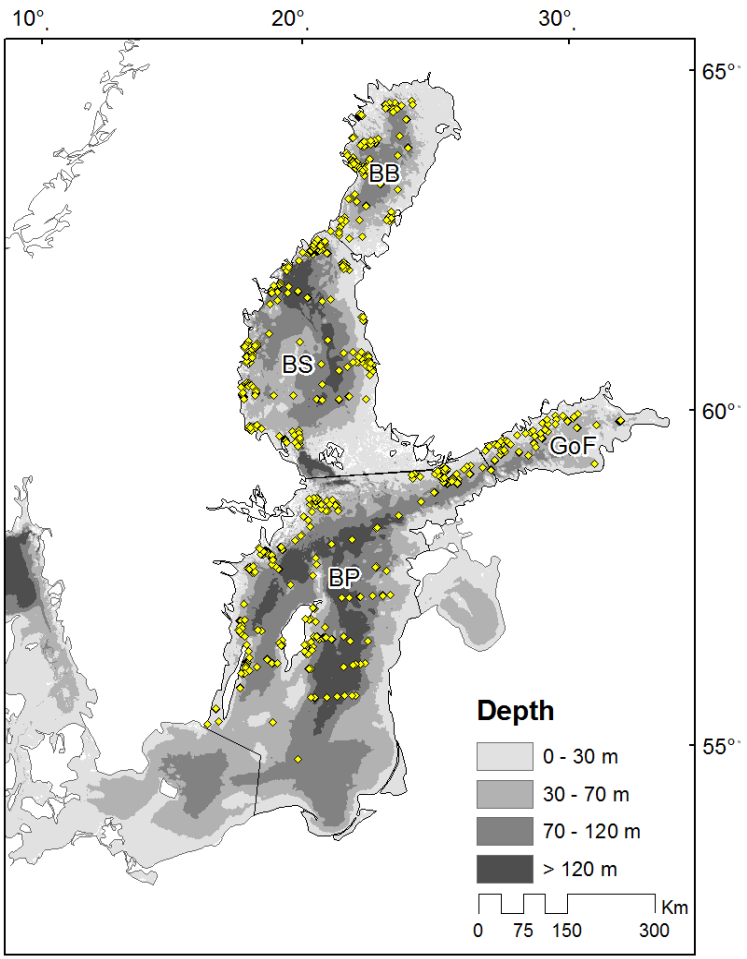


Ehrnsten et al. 2019 *J. Mar. Syst.* doi.org/10.1016/j.jmarsys.2019.04.003

Results – validation

- Simulated biomasses of benthic fauna mostly follow observed patterns over depth and between sub-basins
- But many uncertainties in both data and model

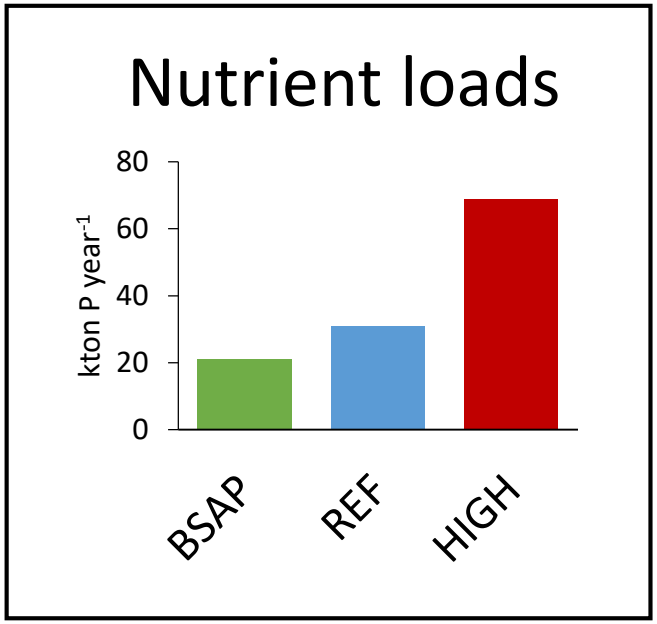


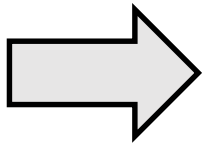


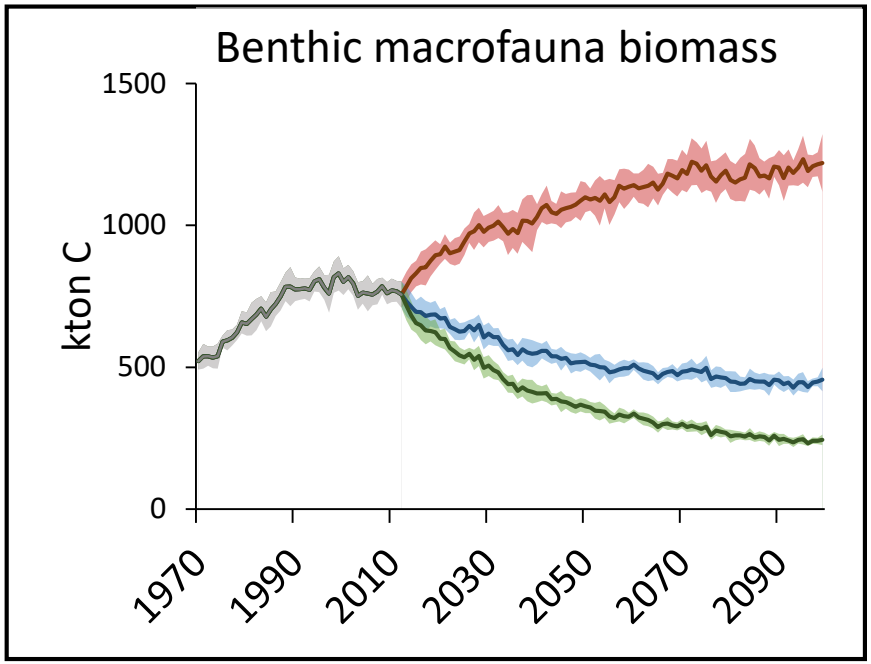
Observations of present (1990-2012) macrofauna biomass in the Baltic Sea (N= 4750)

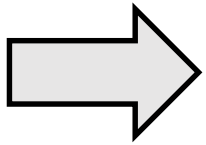
Ehrnsten et al. 2020 *Glob. Change Biol.* doi.org/10.1111/gcb.15014

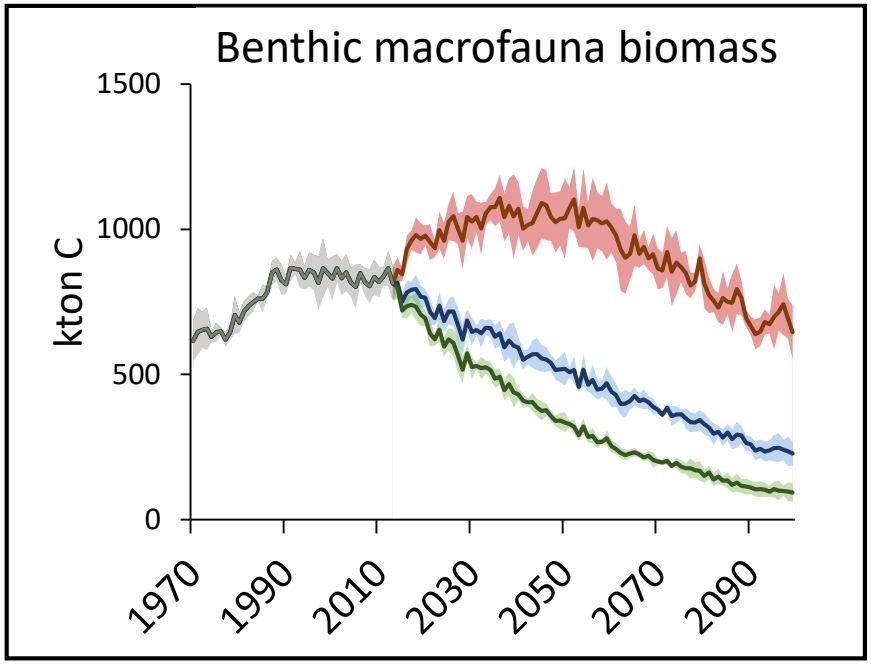
Results – scenarios











Take-home message

CLIMATE CHANGE MAJOR DRIVER OF MACROFAUNA BIOMASS AND CARBON PROCESSING

Increased temperature

- More effective pelagic recycling of organic matter
- Less sedimentation
- Less food for benthic fauna
- **Less benthic biomass**
- Less (metabolic) carbon processing
- Weaker benthic-pelagic coupling

Want to know more?

Ehrnsten, E., Norkko, A., Müller-Karulis, B., Gustafsson, E. and Gustafsson, B. G. 2020. The meagre future of benthic fauna in a coastal sea –benthic responses to recovery from eutrophication in a changing climate. *Global Change Biology* 26(4):2235-2250 doi.org/10.1111/gcb.15014