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Large-scale patterns in community composition and functioning of coastal plankton systems

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BlueAdapt final seminar 5.10.2023

Application of the Hierarchical Model of Species Communities (HMSC) to Baltic Sea phytoplankton at two scales

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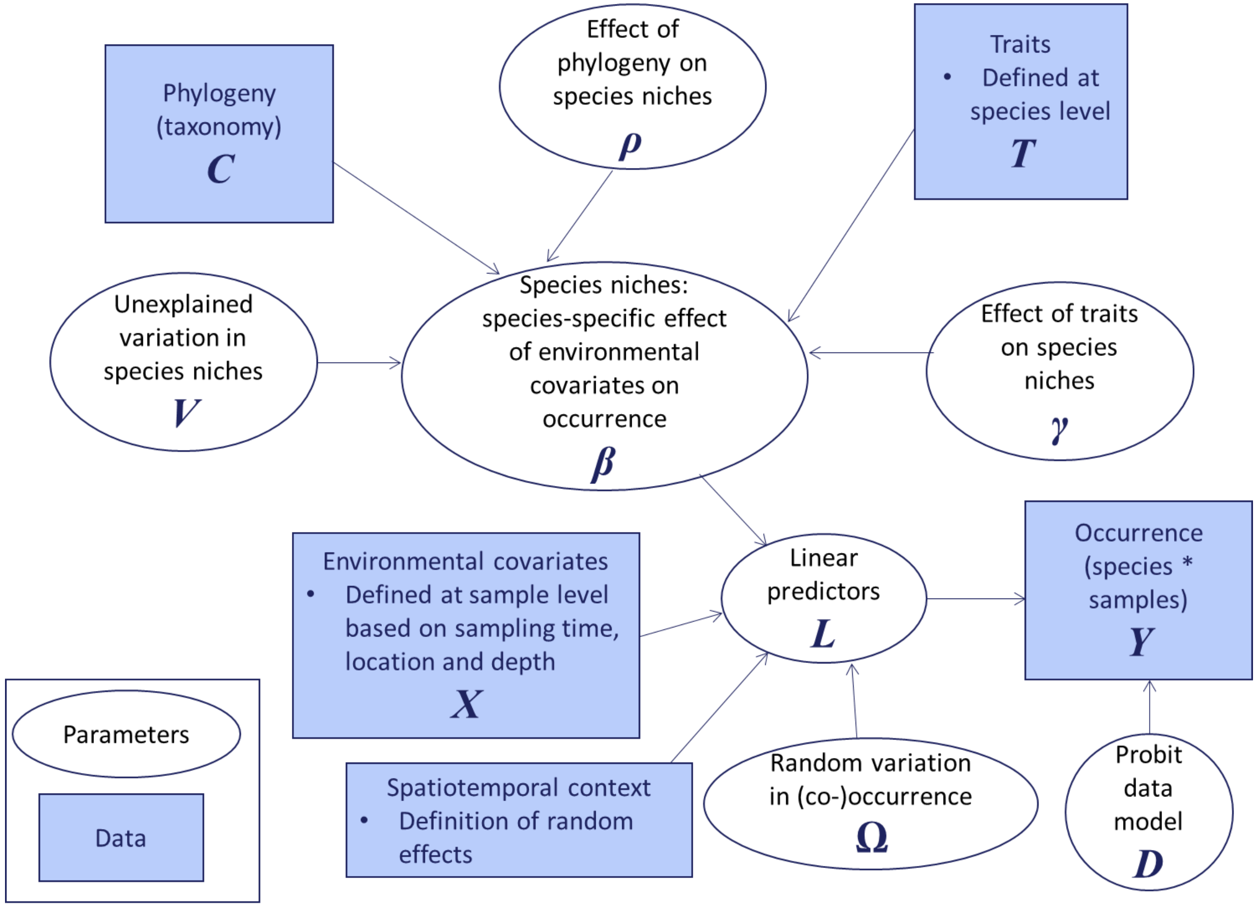

modified from Ovaskainen et al. 2017

- **Whole Baltic Sea** – long-term change **in the past**
- **Archipelago Sea** – significance of local land use in predicted responses to **future scenarios**

Case 1: Long-term phytoplankton community change in the Baltic Sea

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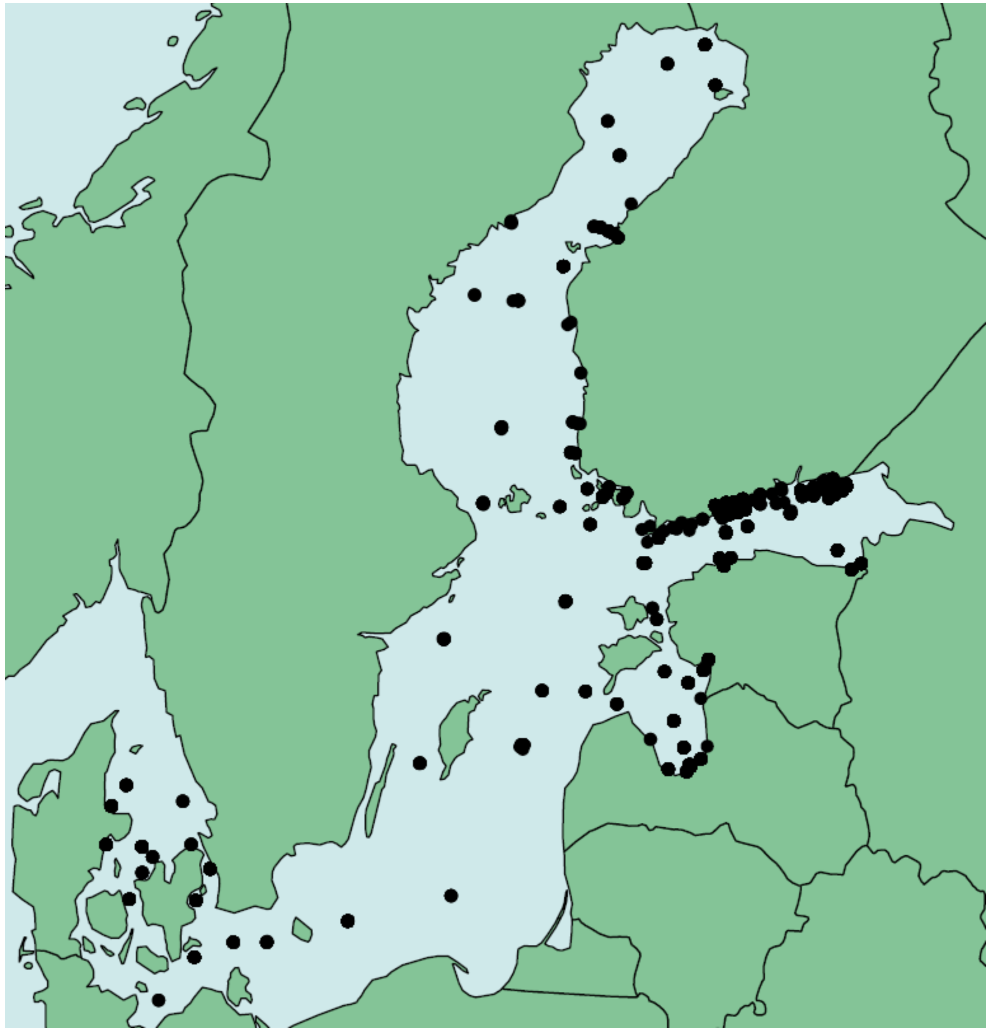
- Two approaches: 1) all data in one analysis, 2) data divided into three time periods to analyze change in **drivers**
- Long-term phytoplankton monitoring data (N=6878) from 1966-2008, shared by 9 institutions and harmonized by Olli et al. (2013)
- Matched environmental data: **T**, **S**, **chlA**, **total N**, **total P**
- Other fixed effects: **year (trend)** and **season**
- Random effects: **site** (subbasin, spatial) and **year**
- Binary functional trait data based on expert assignment (Klais et al. 2017)



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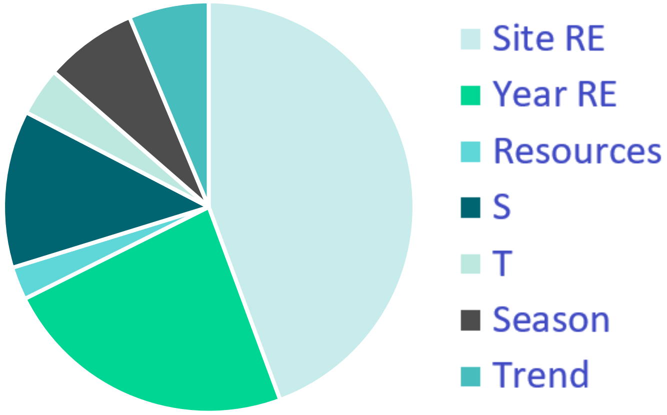
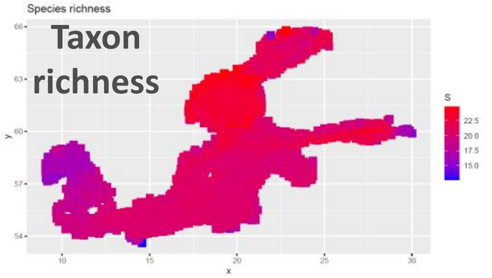
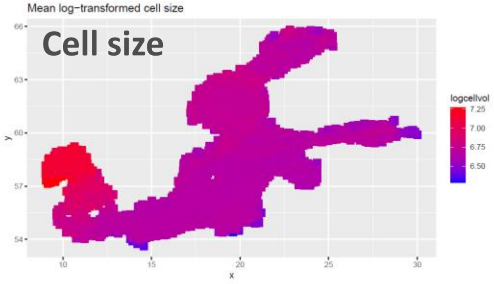
Change in taxonomic and functional composition

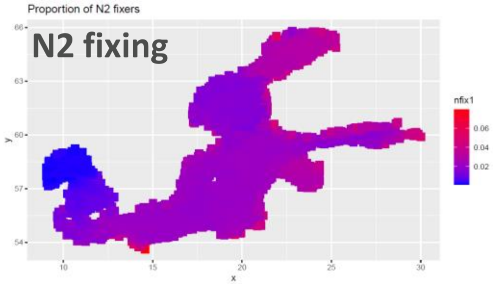
- Significant community change: some genera have increased (43%), some decreased (31%)
- All environmental factors were significant but random effects explained most of the variation
- Functional changes

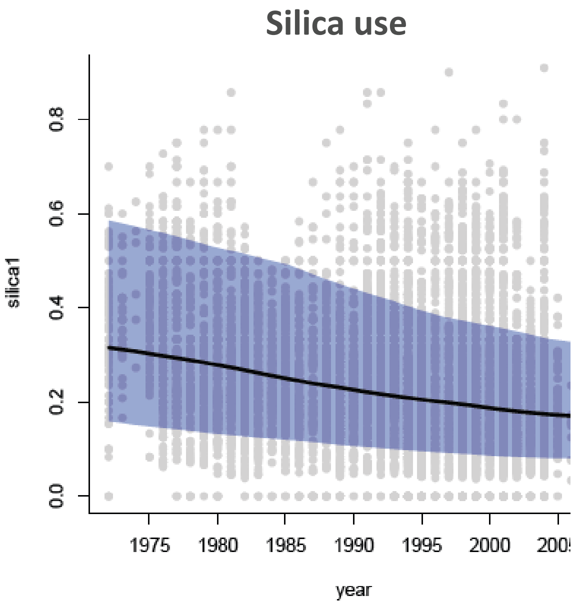
High unexplained spatial variance

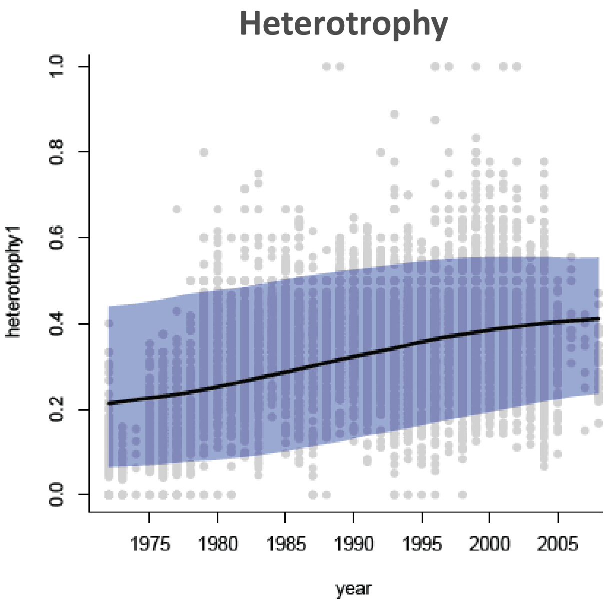


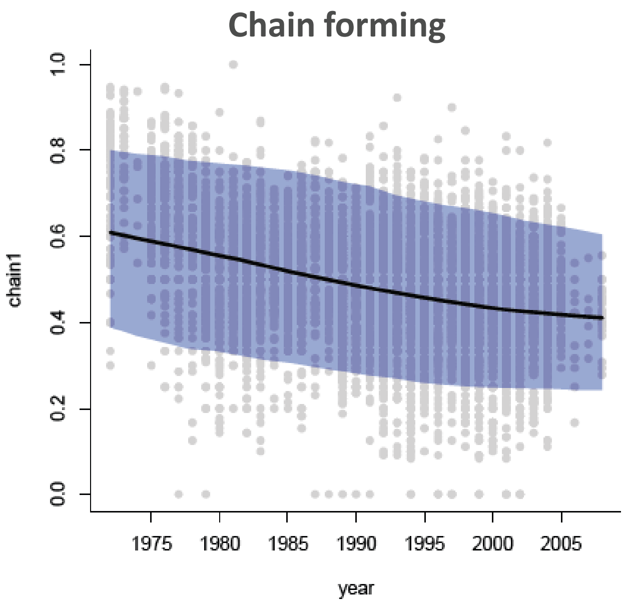












Fairly good model performance: AUC > 0.9 (> 0.8 in cross-validation)

Community drivers have changed

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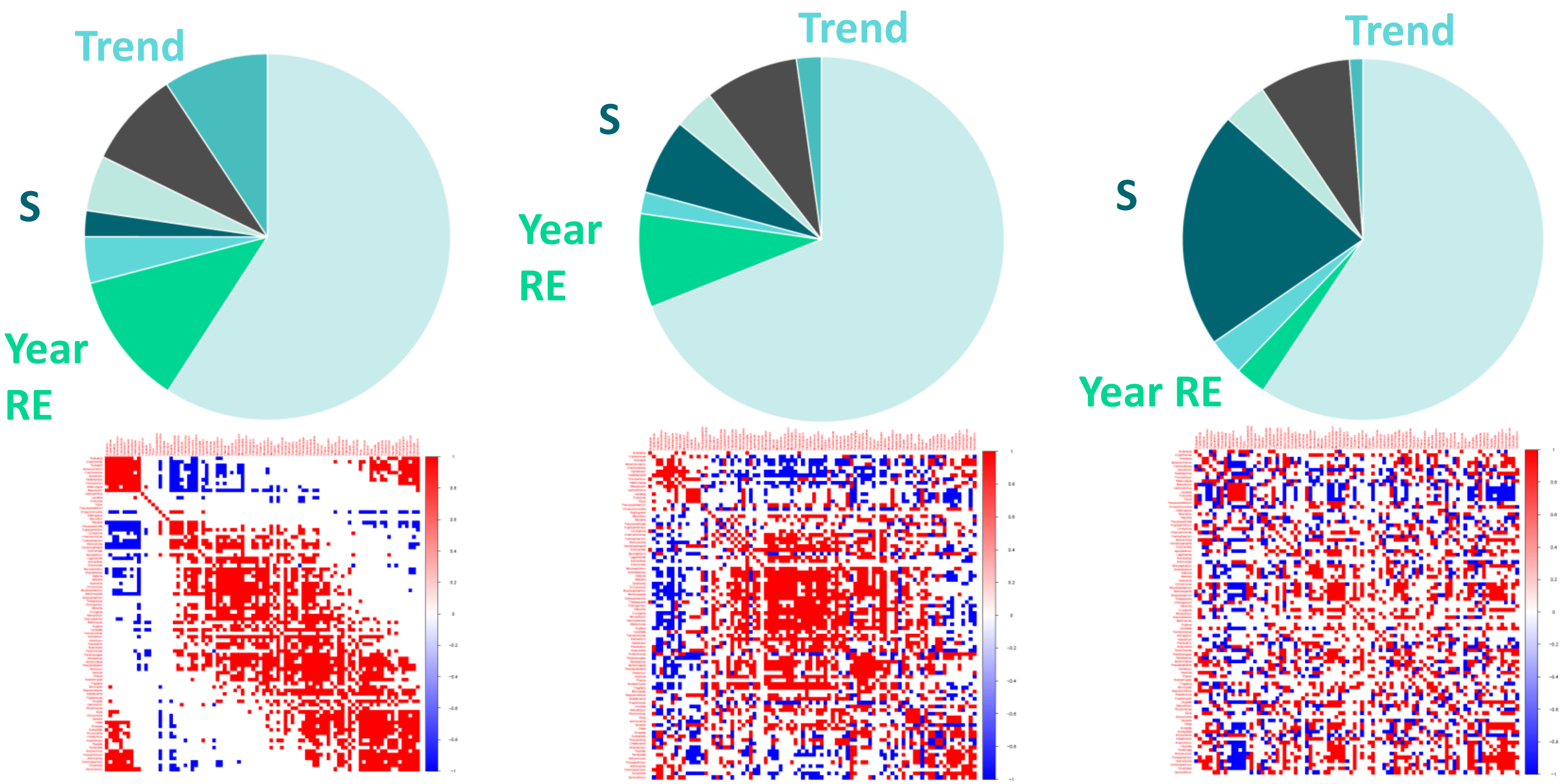
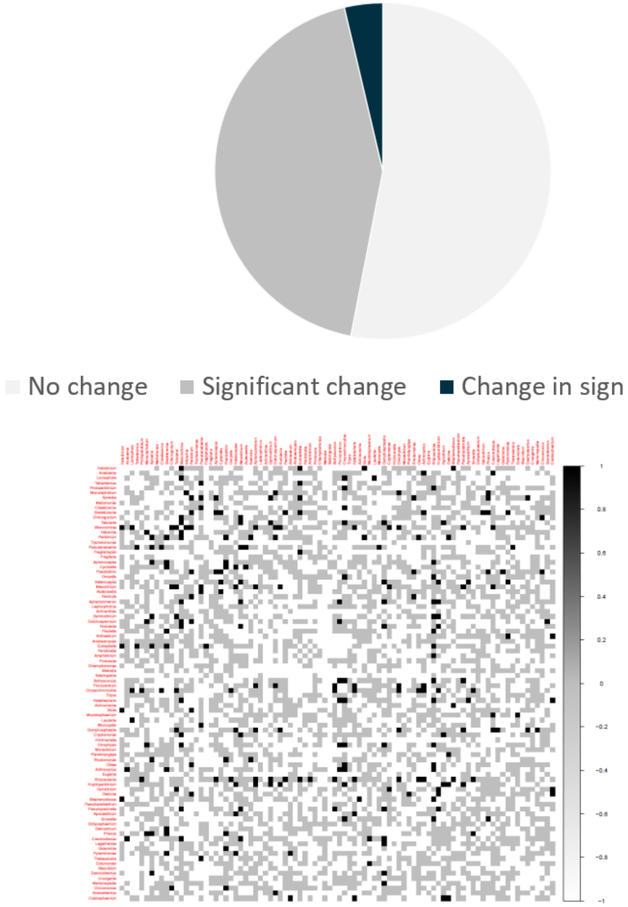
- Site RE
- Year RE
- Resources
- S
- T
- Season
- Trend

- The role of salinity has increased, temporal trend and yearly variation decreased
- Other spatial factors remain the most important driver, but spatial patterns have changed as well, as seen in the changing spatial associations

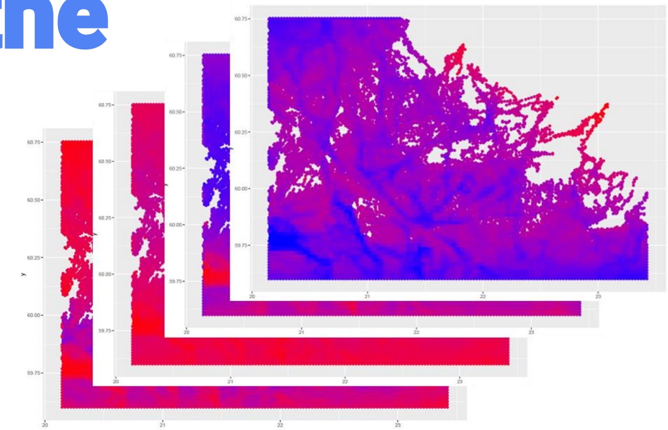
1966-1985 **1986-1995** **1996-2008**



Change in spatial associations between taxa



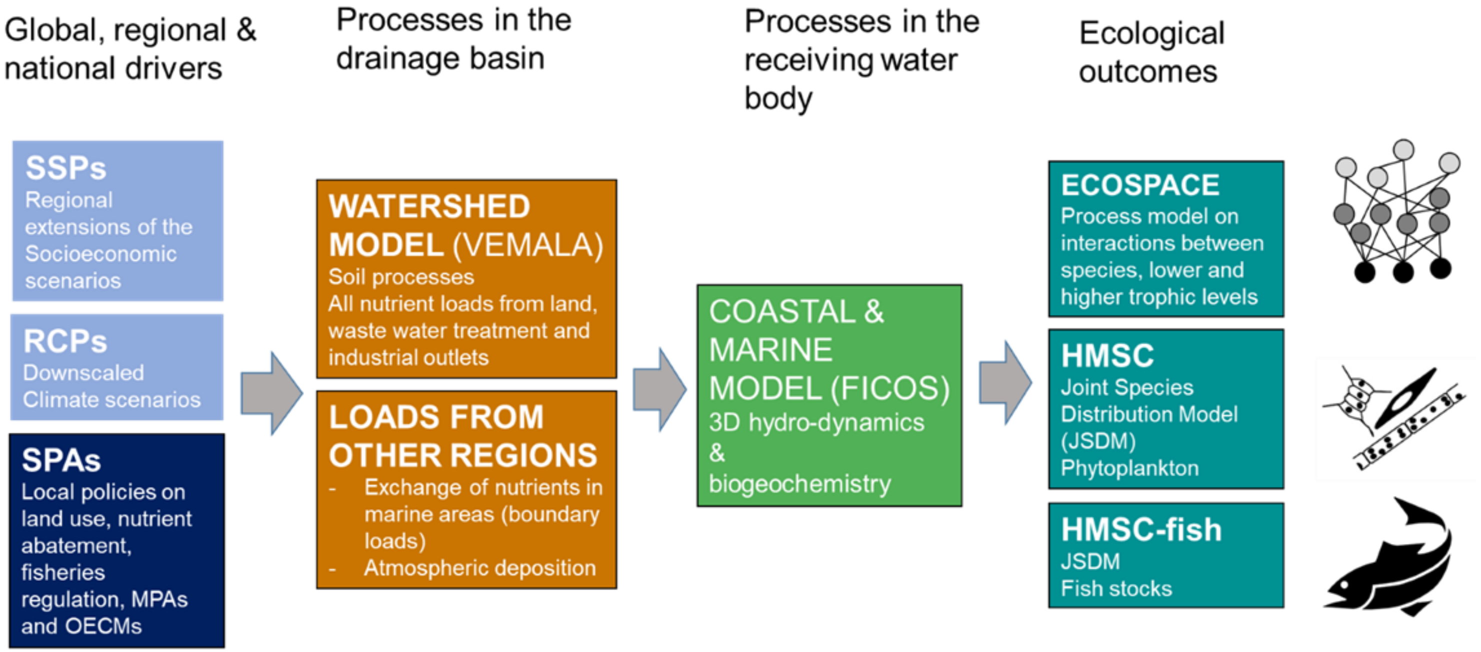
Case 2: Effect of local adaptation on the Archipelago Sea phytoplankon

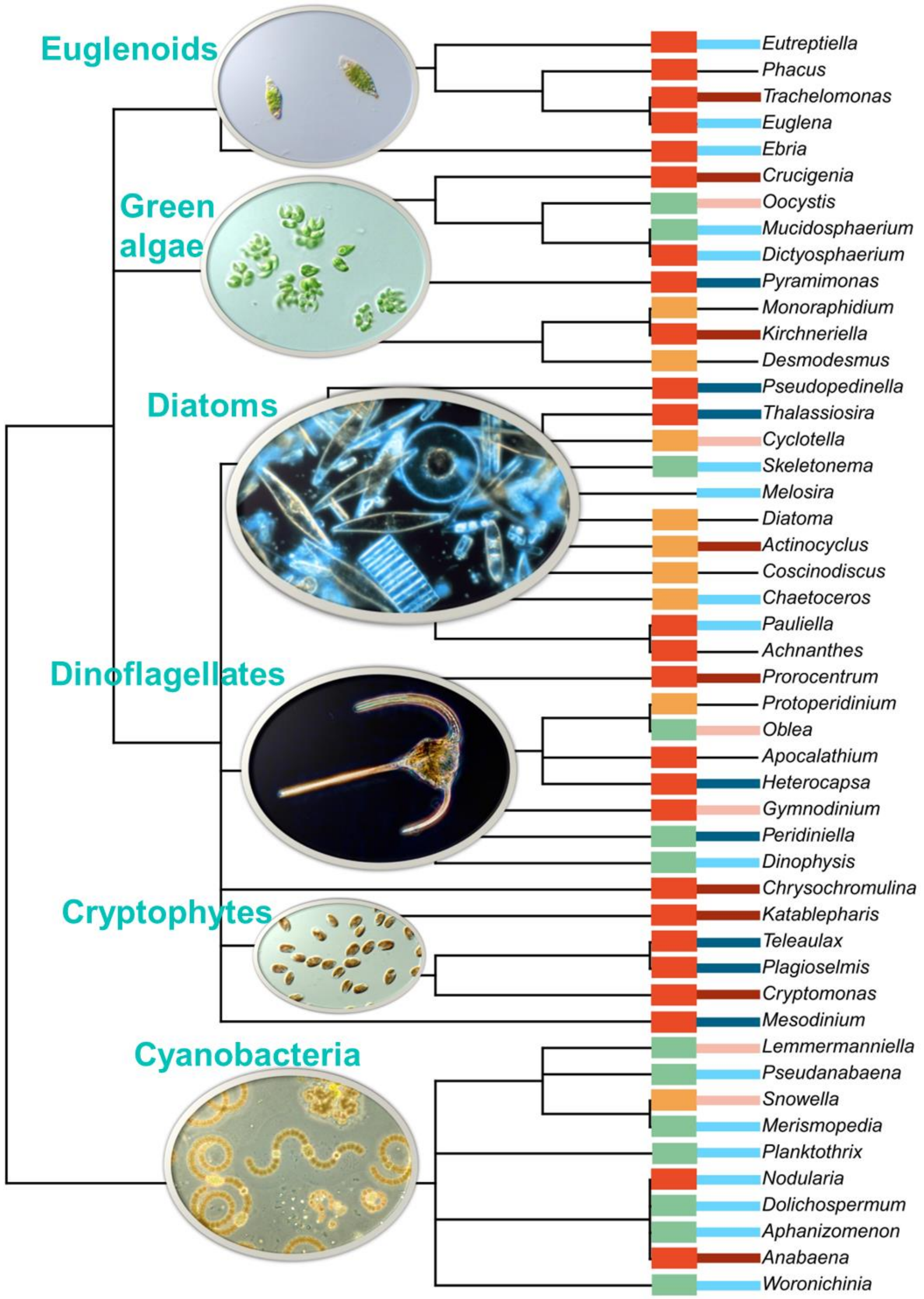


- Mechanistic catchment (VEMALA) and biogeochemical (FICOS) models used to run future scenarios until 2100
- FICOS output used as input for HMSC: season (T sum), nutrients, T, S, depth, ChlA
- No random effects to maximize variation captured by input variables
- HMSC fitted with phytoplankton monitoring data from 2006-2020 and input from validated FICOS hindcasts
- Average occurrence probability in different scenarios was calculated from predicted daily occurrence maps from 2051-2060 and 2091-2100

Scenarios – all combinations of:

- Three local Adaptive Strategies
  1. Plant-based agriculture
  2. Planned agricultural measures
  3. Present agriculture
- Three climate change scenarios
  - RCP2.6
  - RCP4.5
  - RCP8.5
- Two alternative climate models





The community will change

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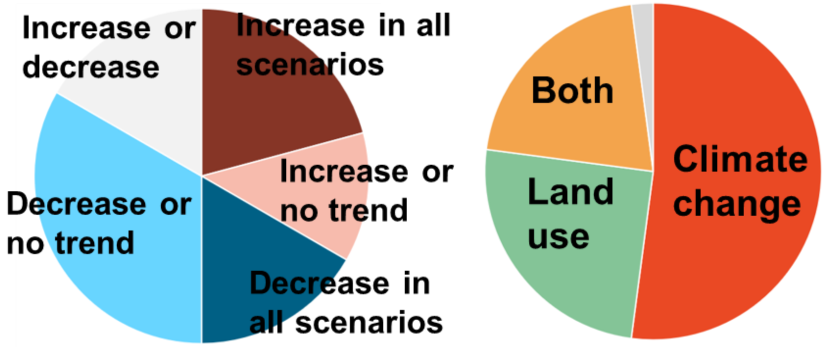
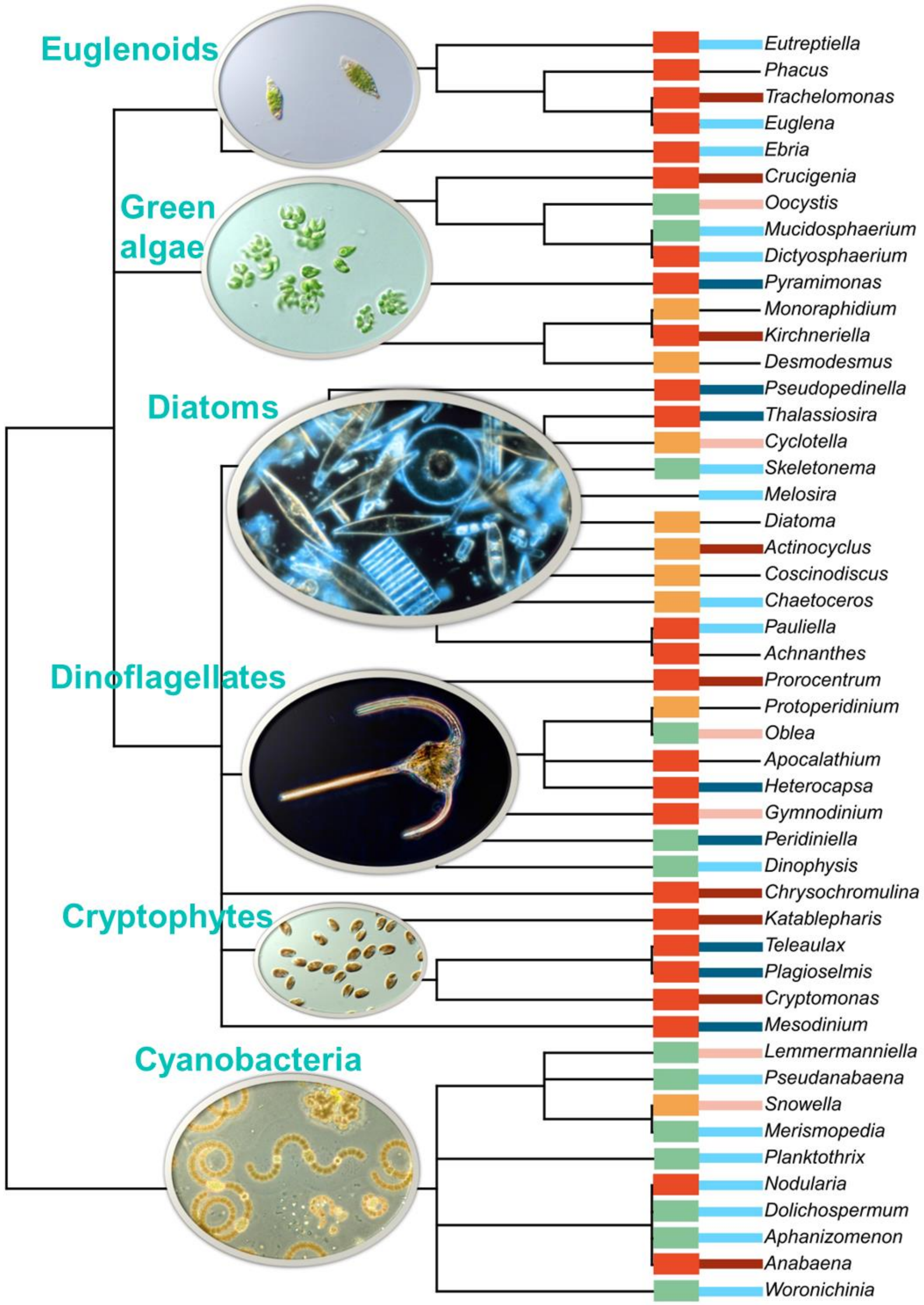
- Different taxa show contrasting trends and responses to climate change and local land use.
- Two megatrends across scenarios:
  - Climate-induced changes are expected even in the most optimistic climate change scenario
  - Implementation of the Baltic Sea Action Plan is assumed to lead to load reductions at regional level → more taxa decreasing than increasing



Proportions of genera with a given trend or driver

Ok model performance: AUC ~ 0.8 (> 0.76 in cross-validation)



Functional change and the effectiveness of local measures

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- Harmful genera are mostly predicted to decrease especially if local nutrient loads are reduced
  - Exceptions: *Prorocentrum* and *Chrysochromulina* are expected to increase due to climate change regardless of nutrient load reductions
- Inedible species mostly decreasing in response to nutrient load reduction, edible species either increasing or decreasing mostly due to climate change
  - NB: consistency with other ecological models not yet analysed!

→ Despite strong global and regional megatrends, local measures can be effective particularly in reducing local cyanobacterial blooms

Final remarks

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- Using mechanistic but biologically coarse models as input for detailed statistical community models is a working solution
    - Feedback loops from community composition to ecosystem-level processes are not included – this is a major remaining knowledge gap
- Changing drivers and high unexplained variation in the whole Baltic Sea analysis indicate that future scenarios should be interpreted cautiously
- Consistency of phytoplankton scenarios with the results on the food web and commercial fisheries?
- To correctly detect and predict ecosystem change, models must be regularly recalibrated and predictions updated → adaptiveness
- The predicted improvement is largely dependent on the implementation of the BSAP measures – will they actually be as effective as assumed in reducing nutrient loads?

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Archipelago Sea modelling crew:
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