

The future status of trophic regimes of the global ocean

Session: Scenarios and models to explore the future of marine coupled human-natural systems under climate change

Momme Butenschön, CMCC

ECCWO, 4th Symposium
Washington DC, 5th June 2018



CMIP 5 - Beyond global budgets

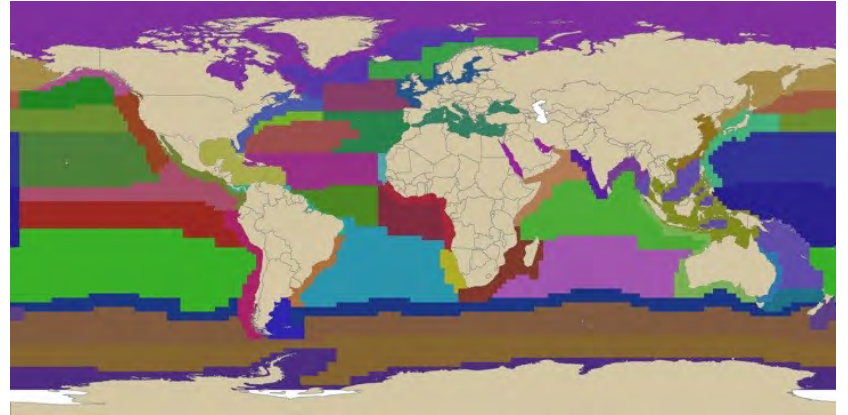
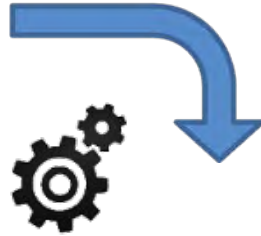
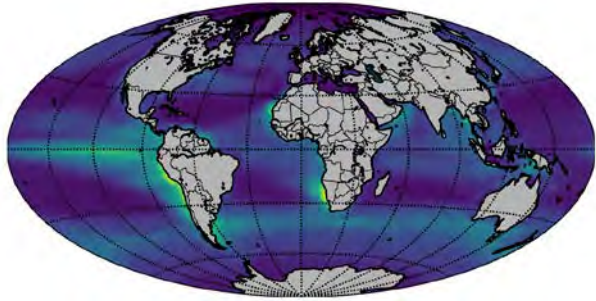
- Substantial amount of studies on global budgets in literature.
- Increasing interest in the spatial heterogeneity of climate change for a variety of reasons.
- Science: it's hard to grasp the underlying mechanisms from global budgets
- Policy: Mitigation or adaptation measures apply mostly at regional scale or smaller

- How do these global budgets emerge?
- What do the changes look like in different oceanic regimes?
- How do the oceanic regimes of the marine habitat themselves evolve?

=> Objective definition of oceanic regimes consistent with the fields emerging from ESM simulations.



Towards inherent dynamic oceanic regimes



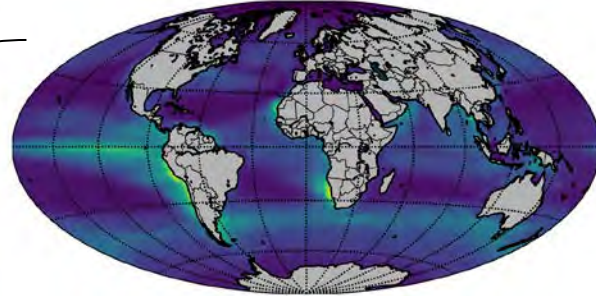
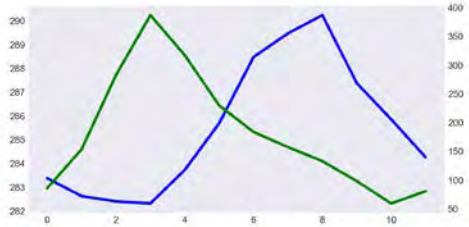
Scope

- Scope not a detailed description of the regional and local picture, but the functional distinction of inherent macro-regimes of the global ocean.
- Uncertainty is large and resolution of CMIP5 is coarse.

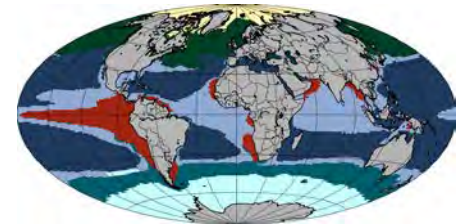
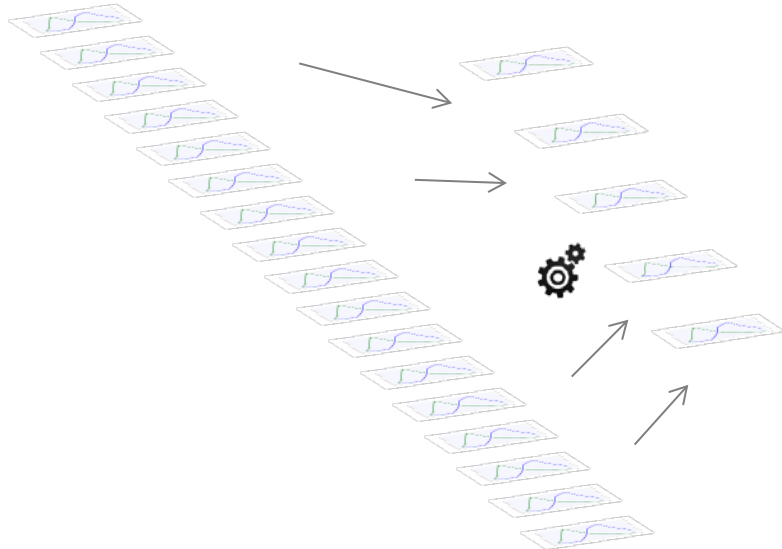
=> The representation of regimes should be as simple as possible, maximising the distinction of ocean classes.



Self Organising Map for global ocean regimes



Seasonal profiles of key variables for the marine ecosystem: sea surface temperature and vertically integrated primary production.



Unsupervised Neural Network Approach - Self Organising Maps

- Machine Learning: Unsupervised neural network (Kohonen-Map)
- Condensation of information contained in large datasets by classifying input samples into a low number of categories or classes identifying underlying centres of «gravity»
- (Related to k-means clustering)

- Requirements
 - Input dataset of samples
 - Similarity or distance function
 - Number of classes

- Input data is used to train the neural network in order to define the emerging classification
- Additional data samples can then be classified in macro-categories.



Technical details

- Input data in this case:
 - Ensemble of 13 CMIP5
 - Present day time slice from historical runs
 - Temperature and primary production profiles
- Classified data:
 - Same ensemble
 - End of century time slices
 - Range of scenarios (RCP 2.6, 4.5 and 8.5, here showing 2.6 and 8.5)

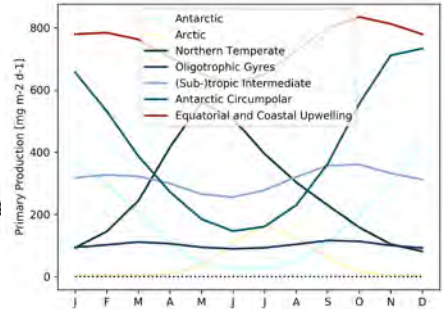
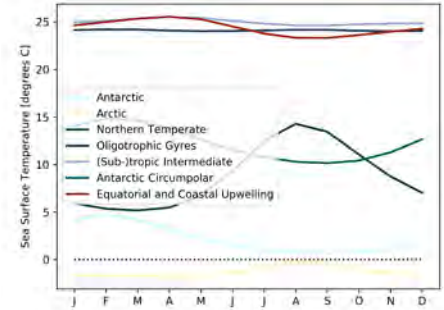
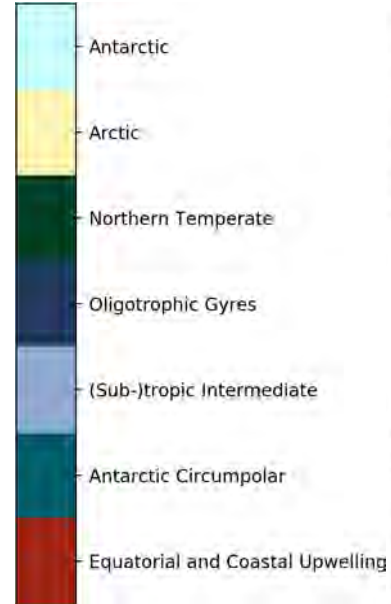
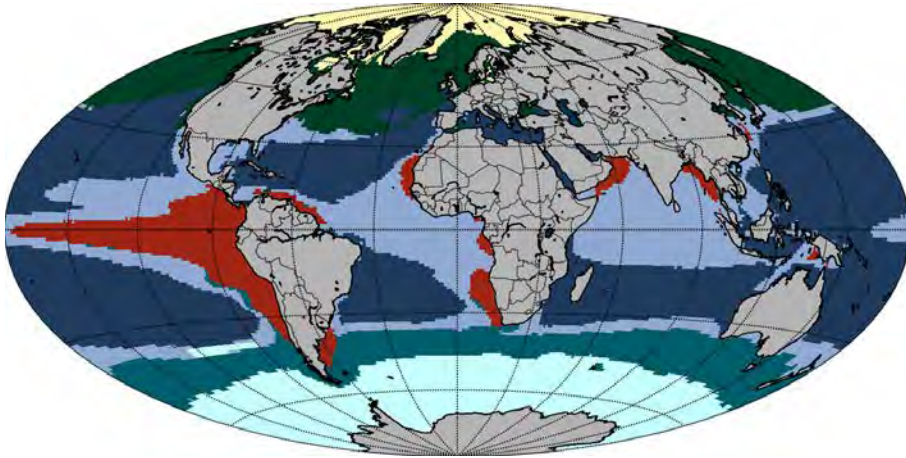


Technical Details

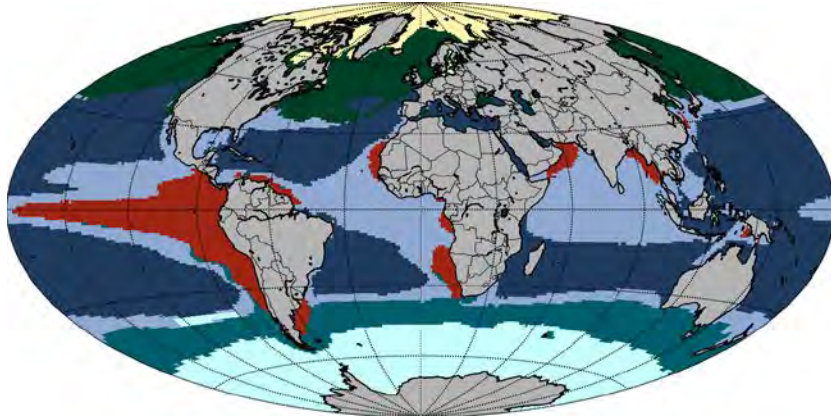
- Number of classes:
 - Determined by the lowest number of classes that perform sufficiently across a range of metrics:
 - SCI
 - Cumulative Variance
 - Mean Separation
- Ensemble weighted according to skill:
 - In reproducing emerging observational relationship of El Nino SST and PP anomaly (Kwiatkowski et al. 2017)
 - Reproduction of spatial patterns in SST and PP compared to remote sensing using SPAEF score (Demirel et al. 2018)



Oceanic Regimes at present day

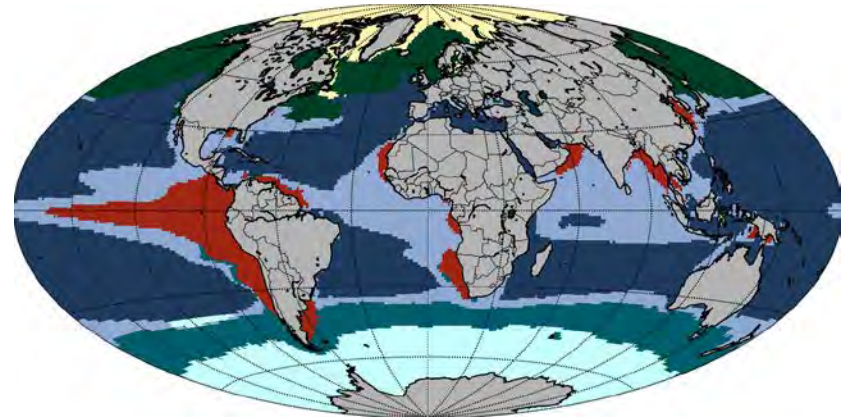


Projected state towards end of century

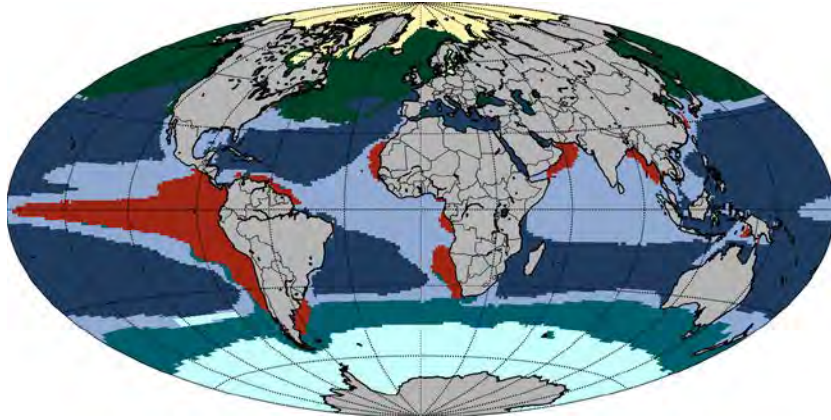


Present Day

RCP 2.6

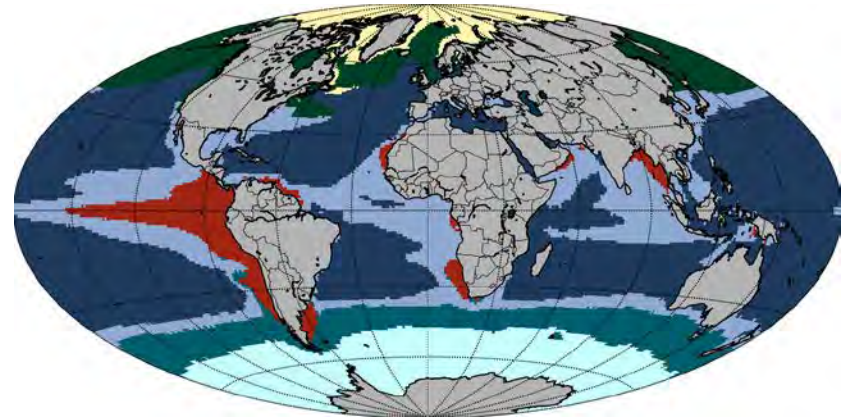


Projected state towards end of century

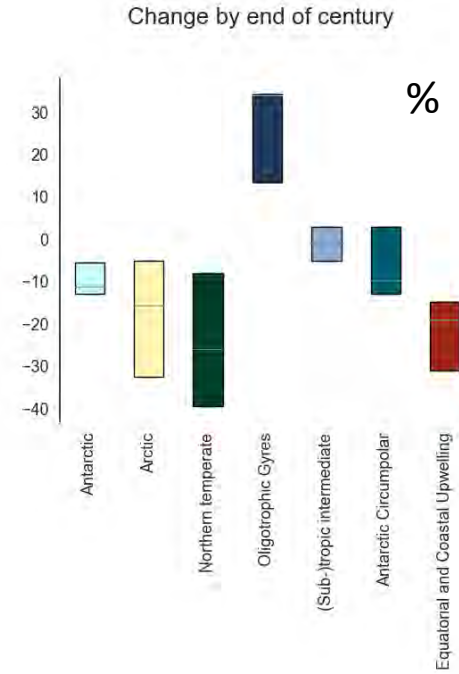
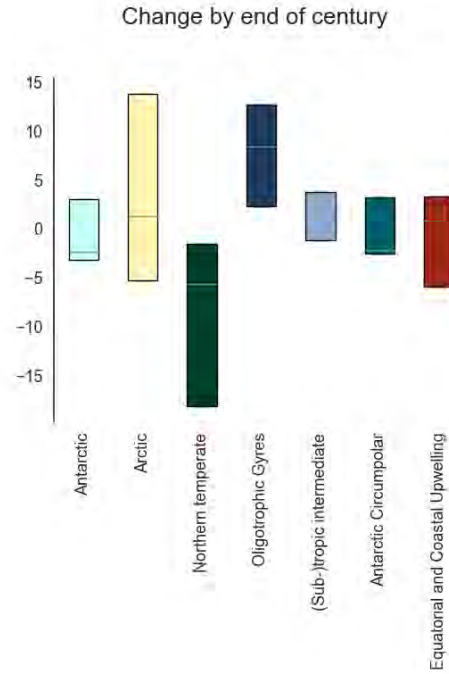
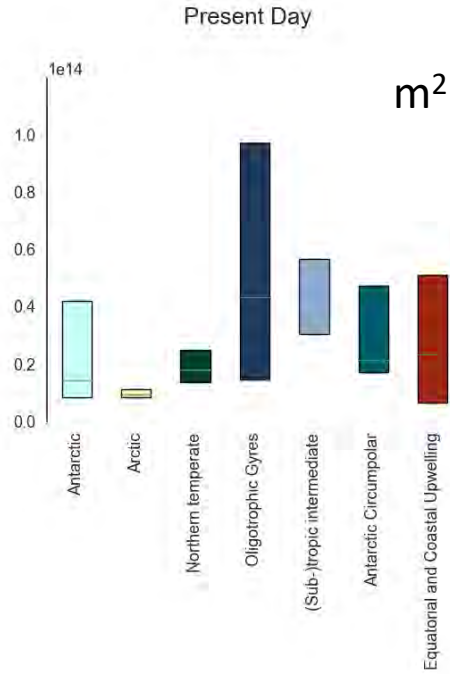


Present Day

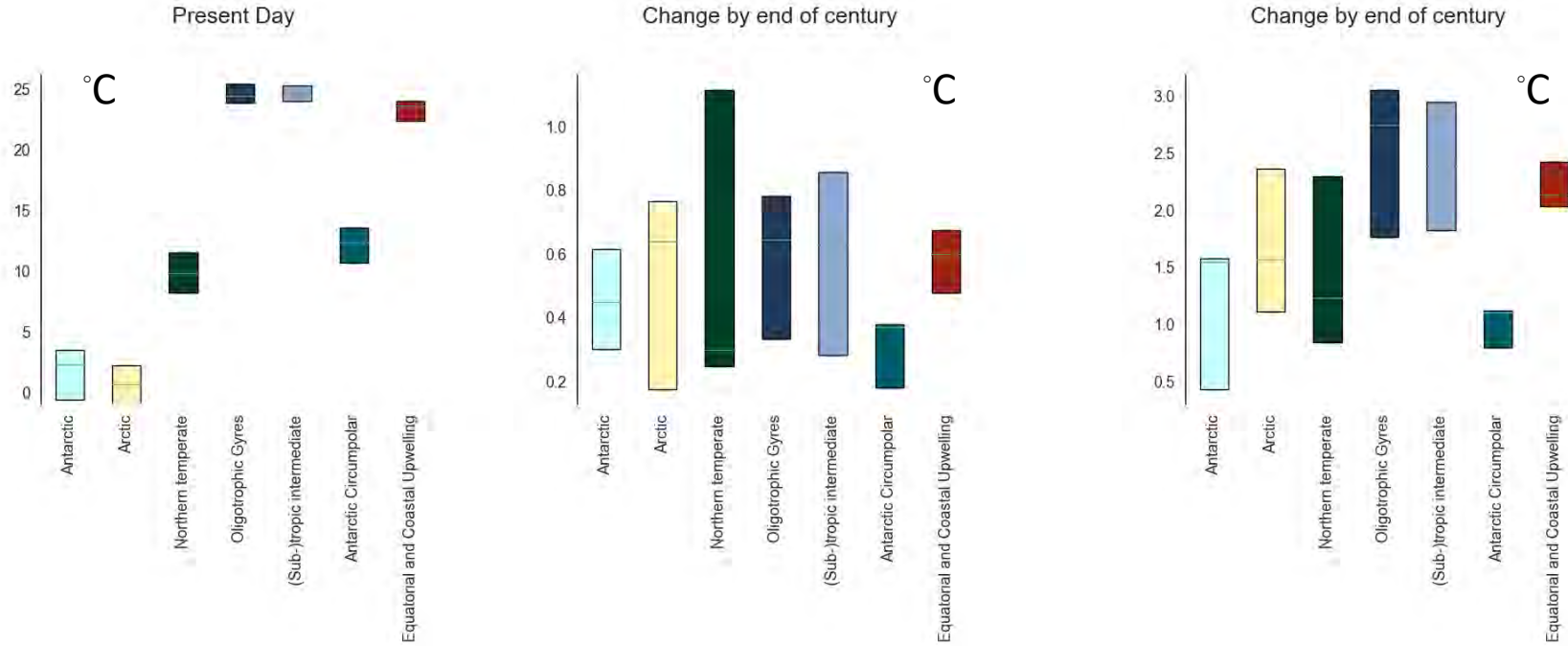
RCP 8.5



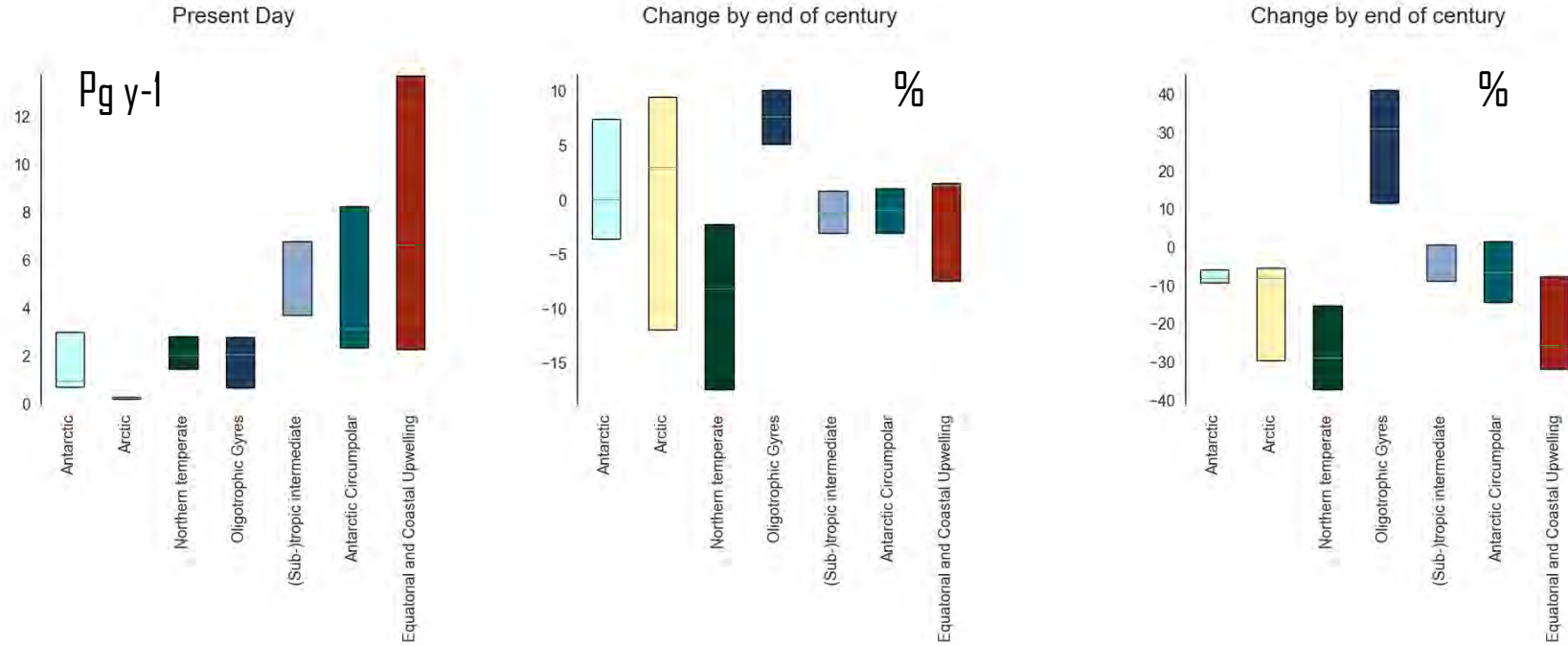
Emerging oceanic regimes – Surface Area



Emerging ocean regimes – Temperature

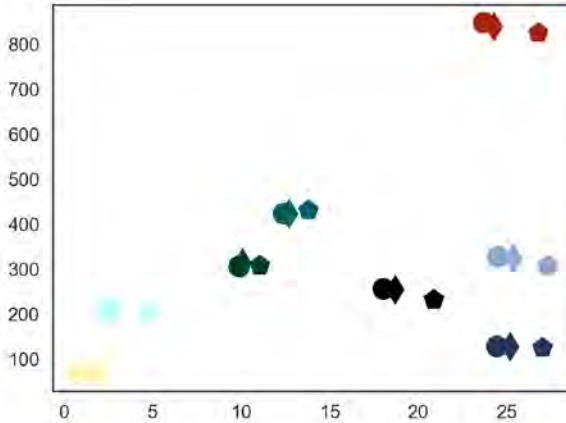


Emerging ocean regimes – Primary Production



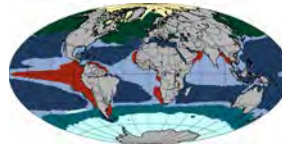
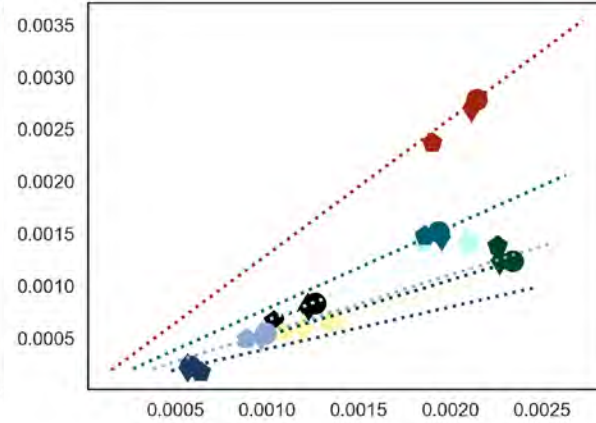
Emerging Functional relationships

Temperature [°C] vs
Primary Production
[mg m⁻² d⁻¹]



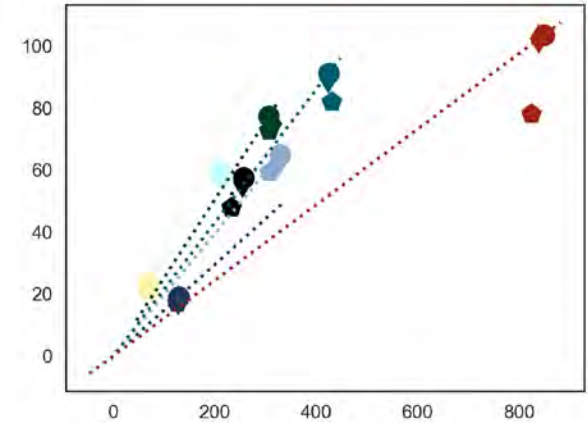
Balls: present day
Diamonds: EoC RCP 2.6
Pentagons: EoC RCP8.5

Phytoplankton [mol
m⁻³] vs Zooplankton
[mol m⁻³]



Lines represent the
present day ratio

Primary production [mg
m⁻² d⁻¹] vs Vertical
Particulate Carbon Flux
@100m [mg m⁻² d⁻¹]



Conclusions

- Oligotrophic Gyres are likely to increase in extension (by 2.5-12.5% under RCP2.6 and 13-35% under RCP8.5)
- Northern moderate regime is likely to decrease (by 1.5-18% under 2.6 and 8-39% under 8.5)
- Changes in polar regimes are largely uncertain under 2.6, decreasing 8.5 (Antarctic ~10%, Arctic 5-32.5%)
- Temperature is projected to increase in all regimes under both scenarios
- Significant changes in so-far investigated functional relationships only visible under RCP8.5.
- Indication for top-down controlled amplification in N-moderate regime and bottom-up controlled attenuation in upwelling zones.

More to follow, stay tuned....



Thanks.
Enjoy lunch (unless you have some
questions...)!

