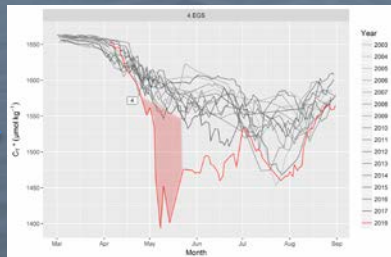
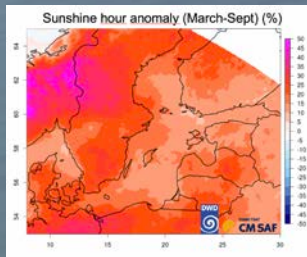


Dry, Warm, and Sunny: Response of net community production to extreme meteorological conditions in spring/summer 2018

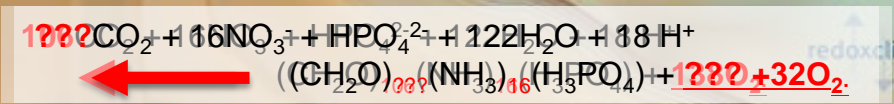
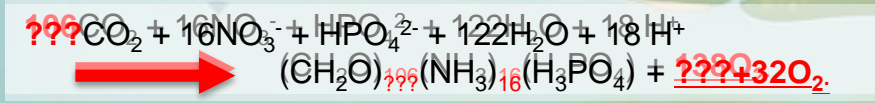
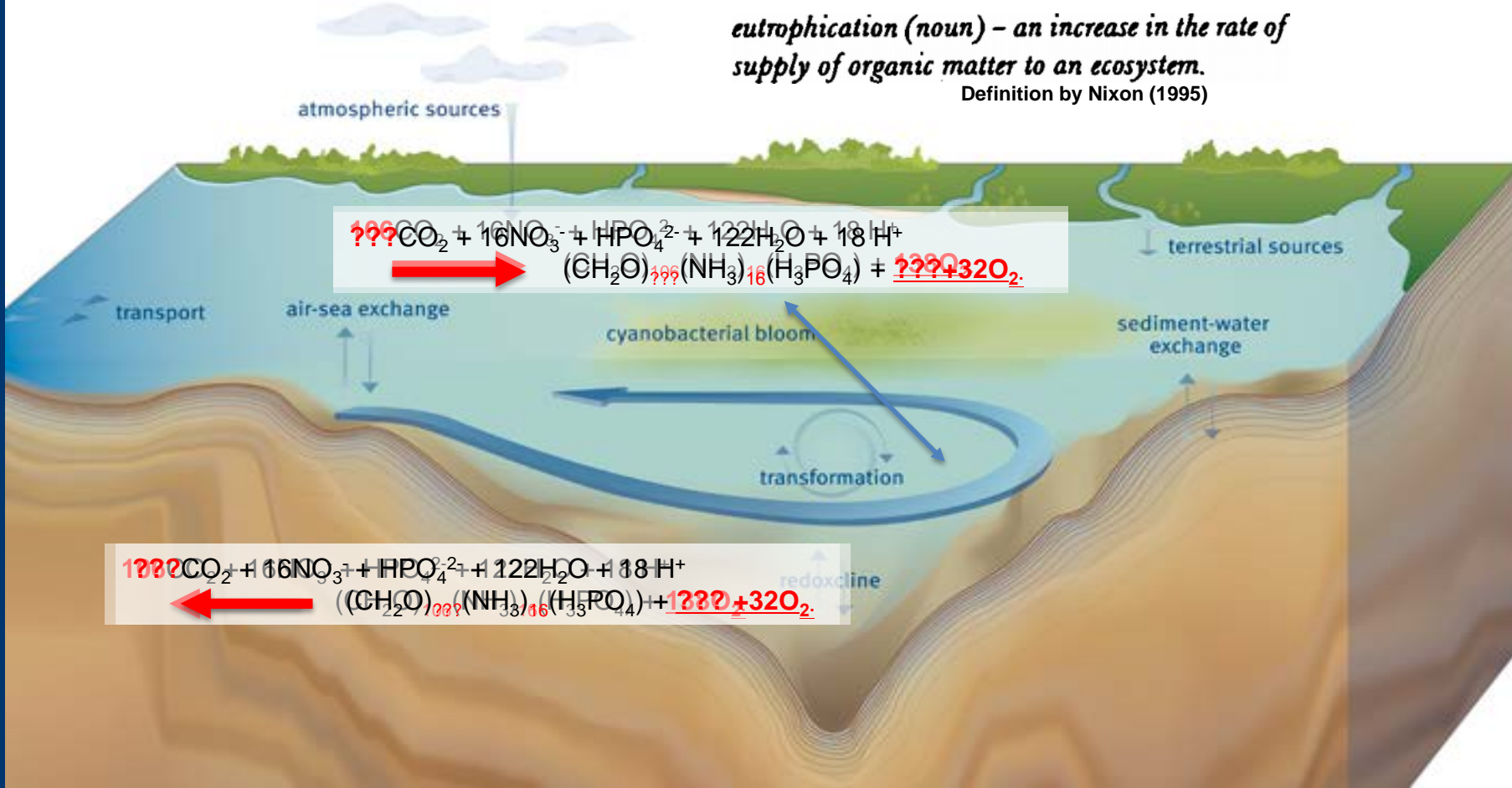
Gregor Rehder, Jens D. Müller, Monika Gerth, Bernd Schneider, Herbert Siegel, Norbert Wasmund, Henry Bittig, Anna Rutgersson (UU), Frank Kaspar (DWD), Laura Tuomi (FMI), Tero Purokoski (FMI)

gregor-rehder@io-warnemuende.de



eutrophication (noun) – an increase in the rate of supply of organic matter to an ecosystem.

Definition by Nixon (1995)



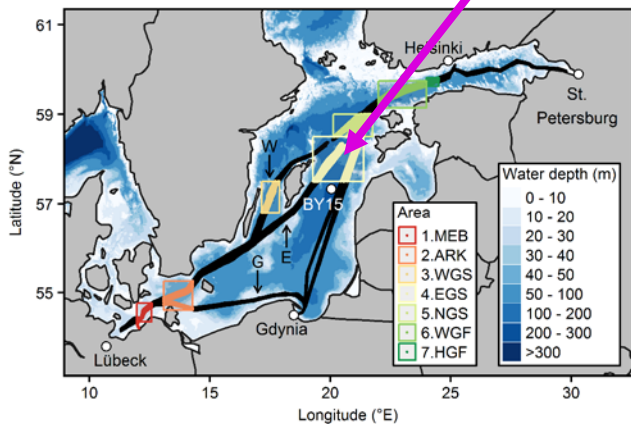
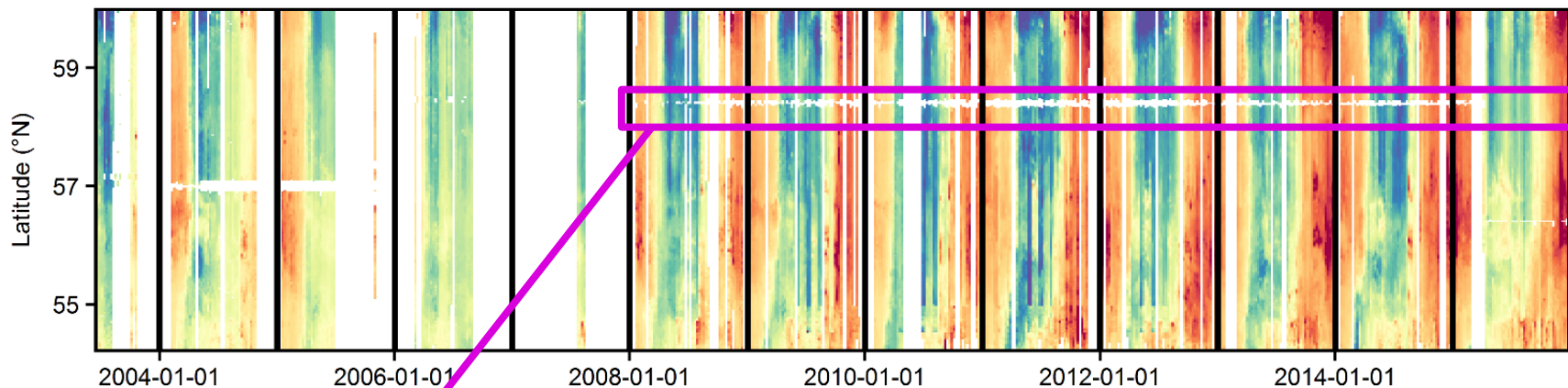
- Increased nutrient loads have led to enhanced productivity, leading to algal blooms, and fostering oxygen debt in the deep basins of the Baltic
- Strong and costly actions have been taken to mitigate this situation, formalized by HELCOM commitments and the BSAP, as well as the MSFD
- The change of ecosystem state has been and is surveyed through the HELCOM monitoring commitments
- The importance of another major, yet non-local driver of ecosystem response, e.g. climate change, has only recently become a focus in the HELCOM strategic plan
- The very unusual meteorological conditions in spring/summer 2018 provided a – so far unique – insight into the potential of climatically driven changes on the Baltic Sea net productivity and biogeochemistry

Unusual biological productivity during the extreme spring/summer 2018

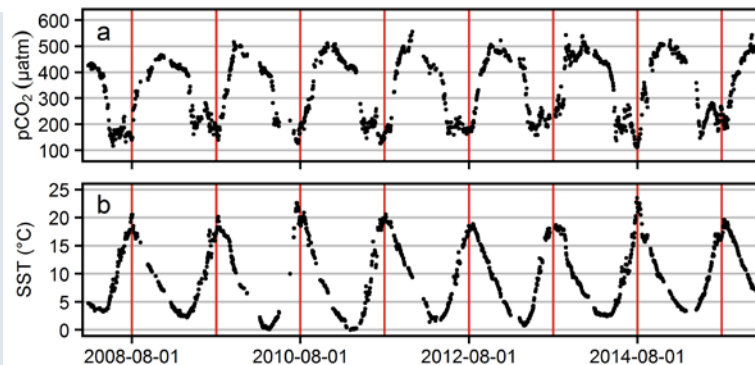
Rehder et al.

Baltic Earth workshop on Multiple drivers in the Baltic Sea region, Tallinn, Nov. 2018

Overview (pCO_2)



Schneider and Müller, 2018



$p\text{CO}_2$ – Productivity assessment

- Independent of C/N/P stoichiometry

Calculated net carbon production in the different basins during the spring bloom for 2009.

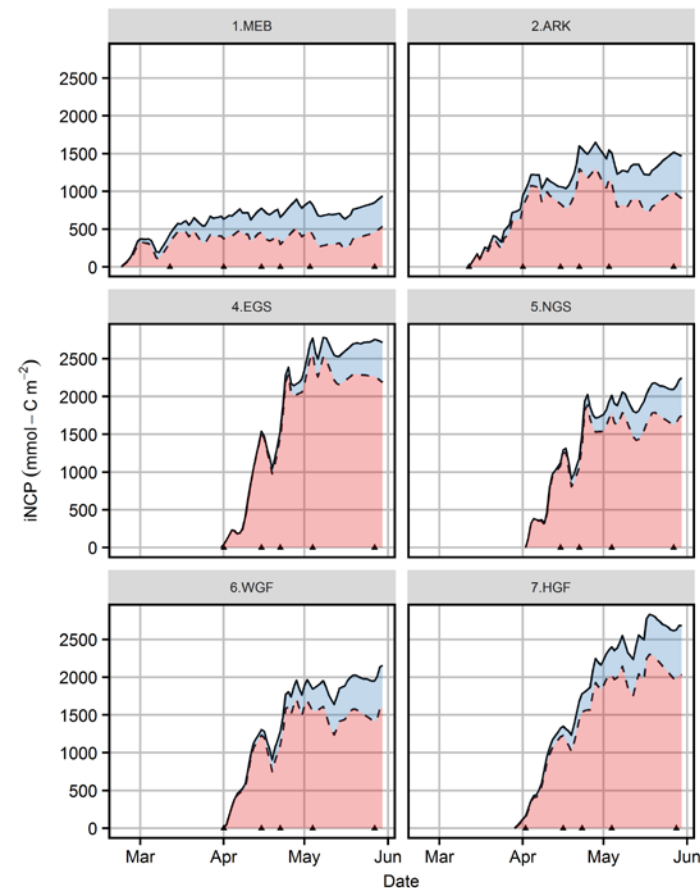
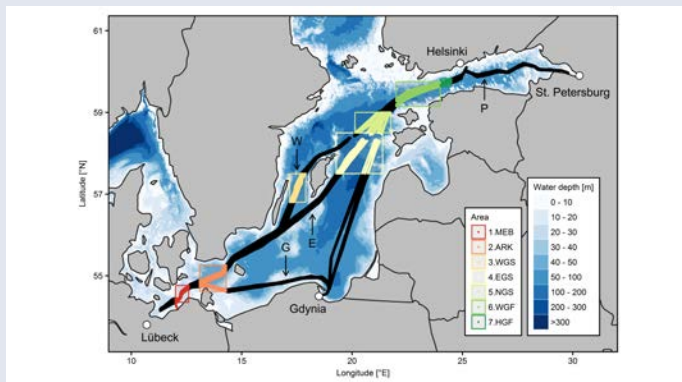
$$iNCP = (\Delta C_T \cdot z_{\text{eff}} + F_{AS} \cdot \Delta t) \cdot 0.8$$

F_{AS} – CO_2 exchange with the atmosphere;

z_{eff} – effective penetration depth;

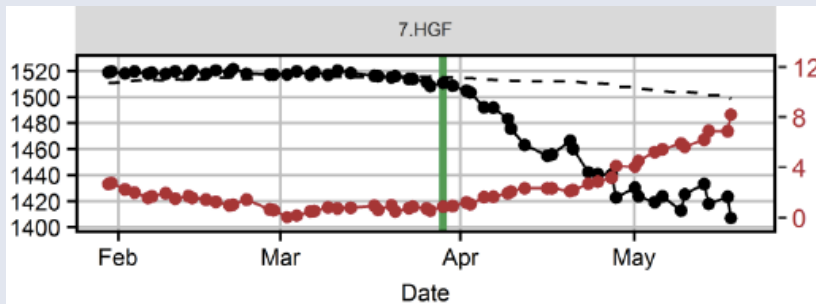
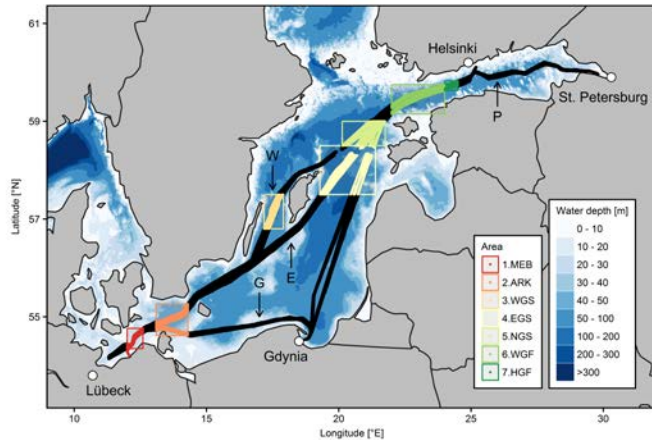
Δt considered time intervall;

Schneider and Müller, 2018



Tools for biogeochemical assessment

Onset of spring bloom

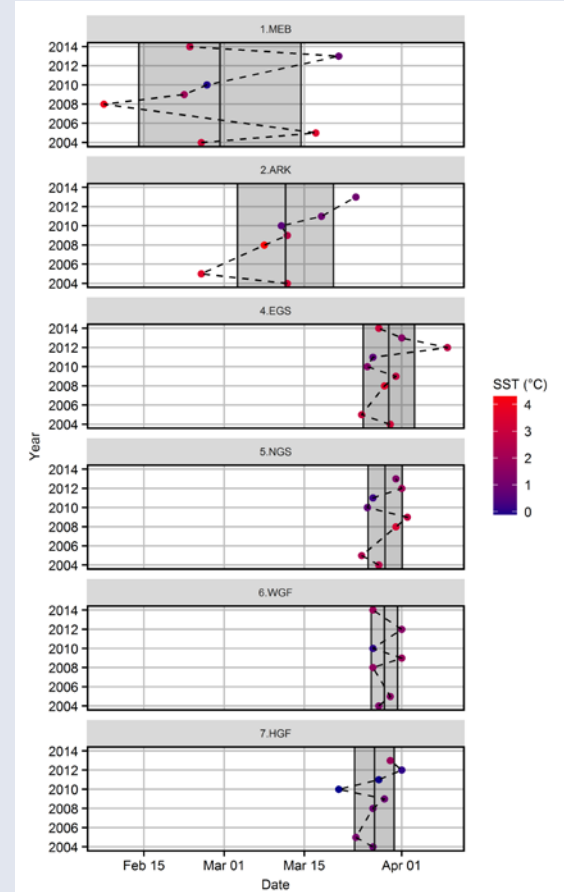


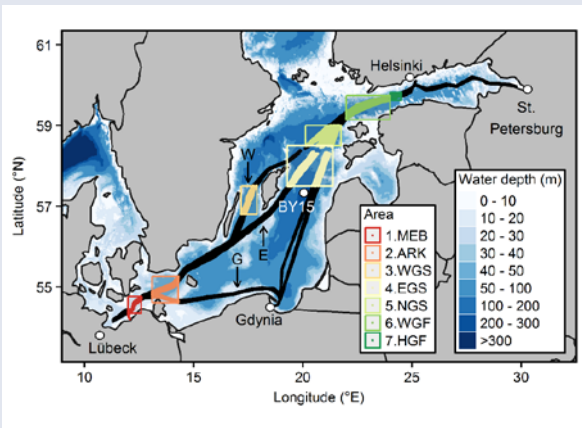
Onset of the spring bloom in the different sub-basins of the Baltic; Threshold is deviation of $1 \mu\text{mol}/\text{kg}^{-1}\text{day}^{-1}$

Left: diagnostic plot to derive onset (near Helsinki, 2009)

Right: Time and variability of the onset based on data 2004 to 2014 for the different sub-regions

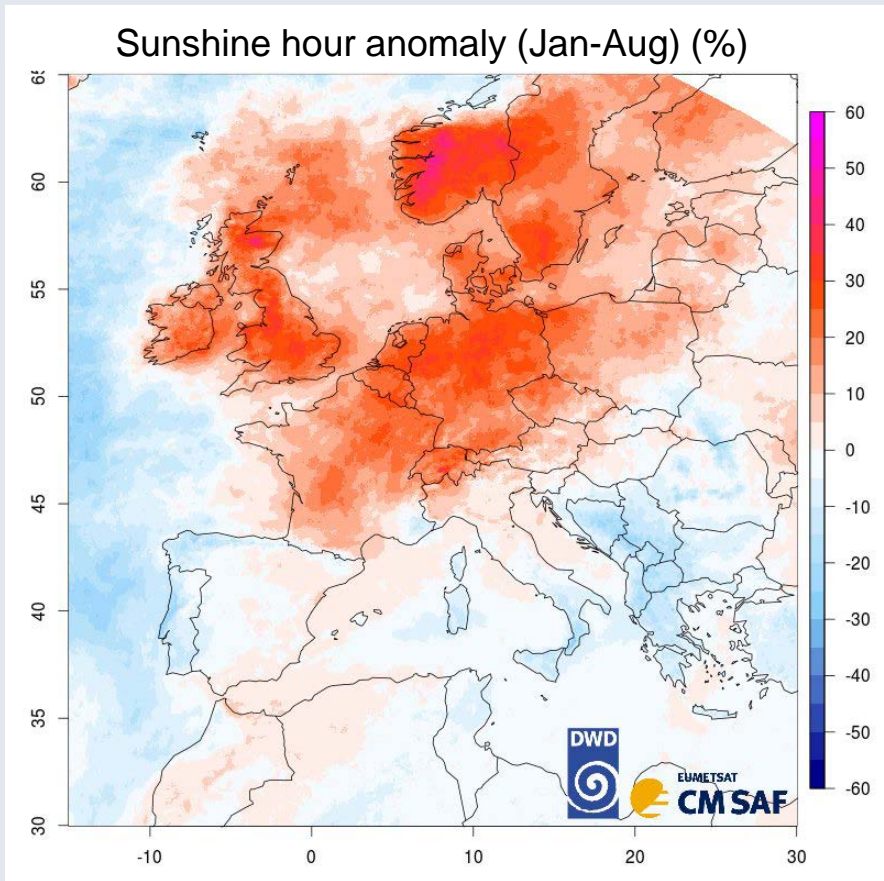
Schneider and Müller, 2008

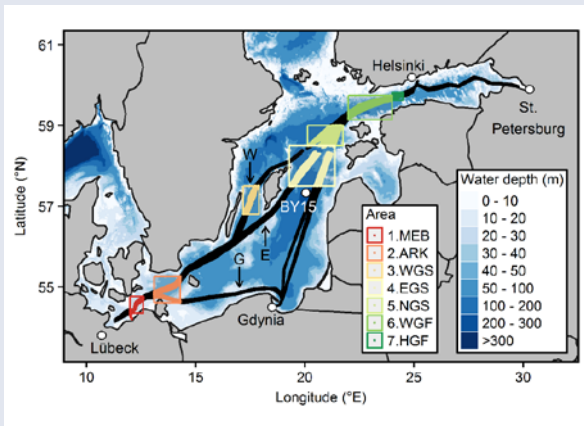




2018 – a year of meteorological extremes:

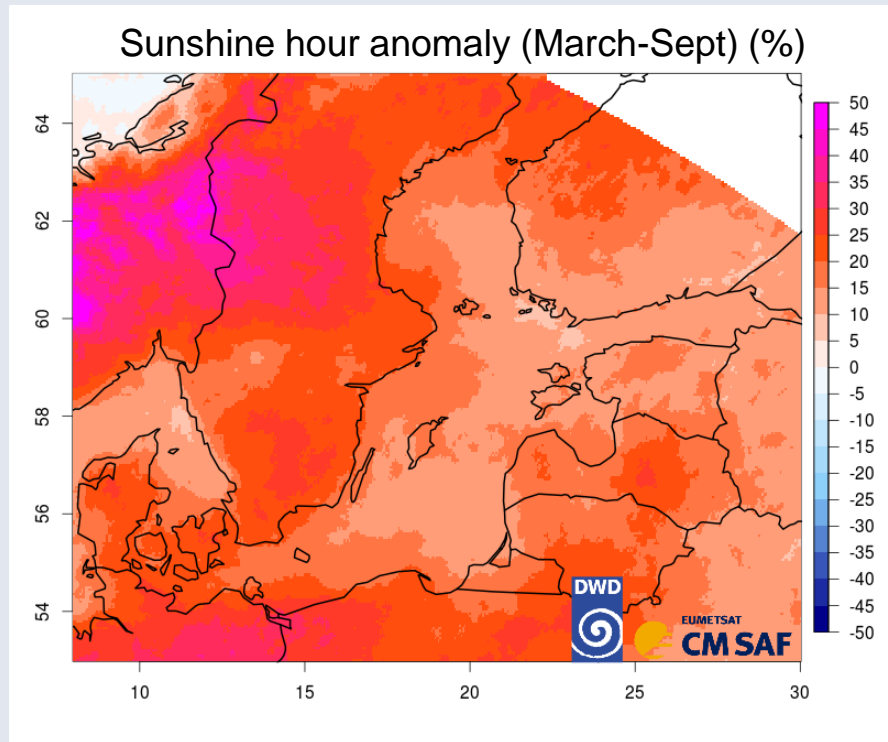
Dry, hot, sunny ...
... and large parts of the Baltic Sea right in the middle of it !





2018 – a year of meteorological extremes:

Dry, hot, sunny ...
... and large parts of the Baltic Sea right in the middle of it !





BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION



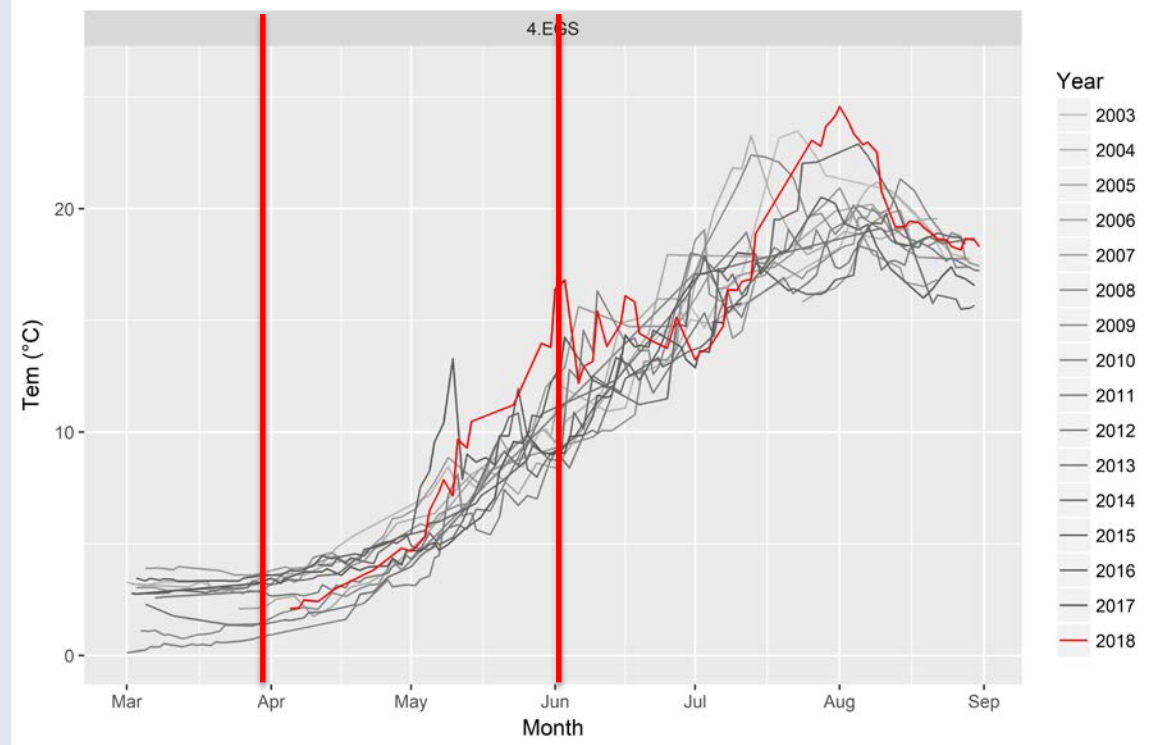
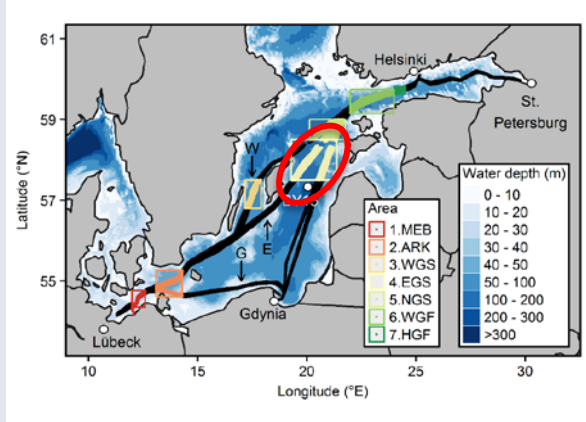
BONUS INTEGRAL

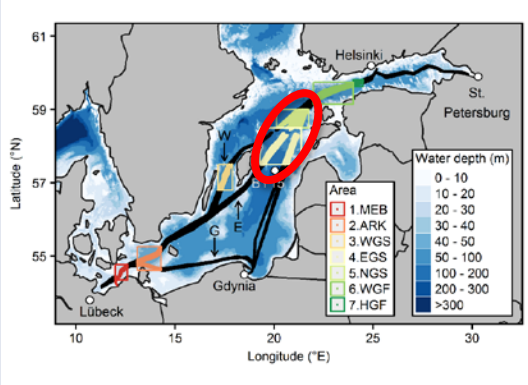
ICOS

INTEGRATED CARBON OBSERVATION SYSTEM



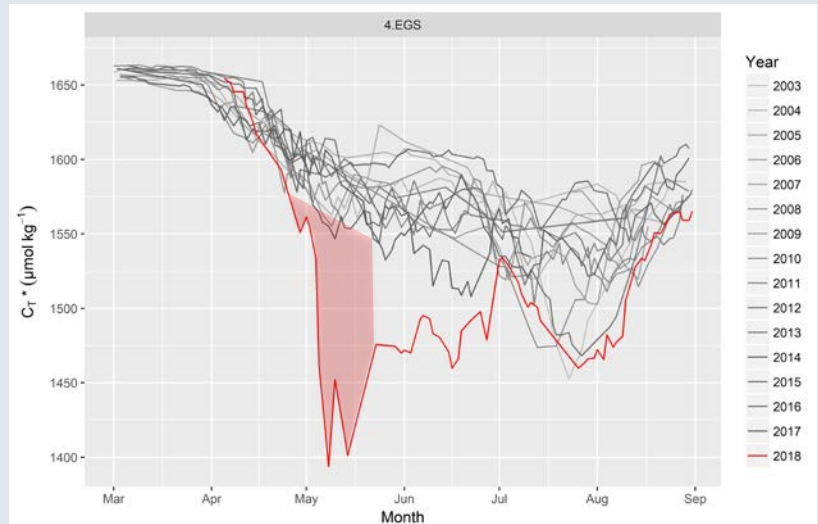
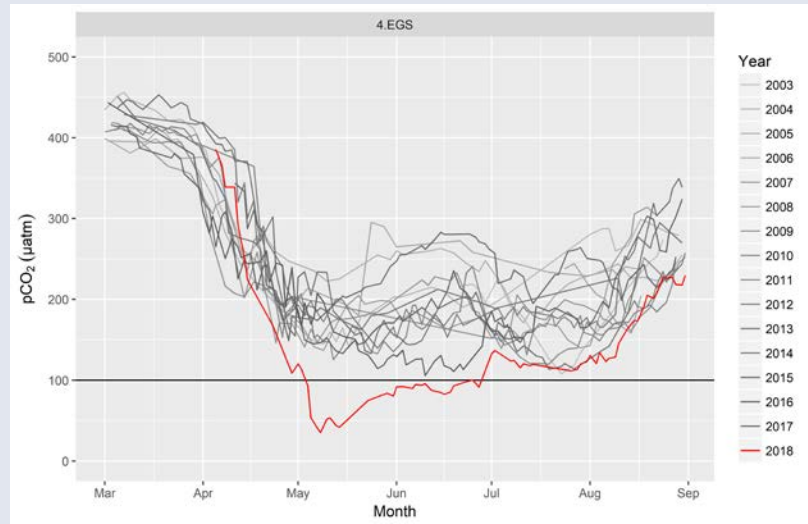
Summer SST





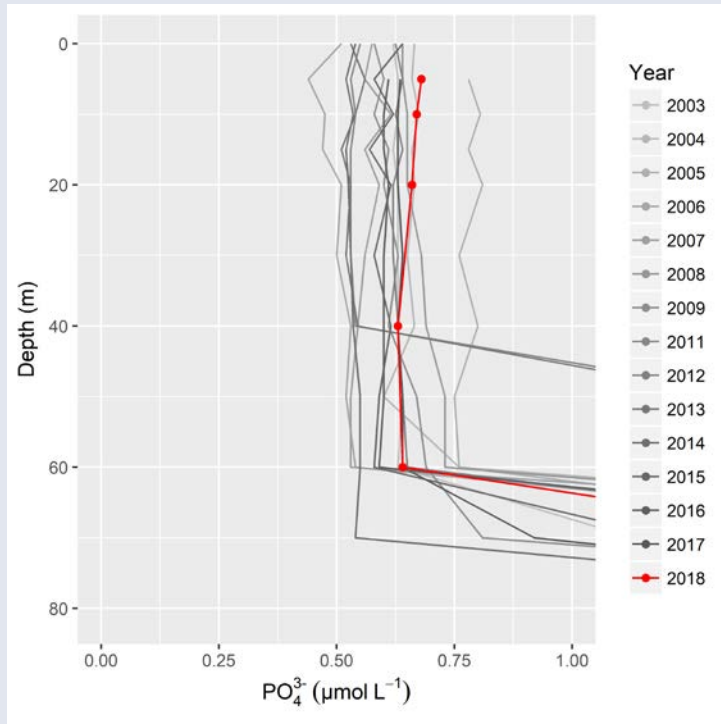
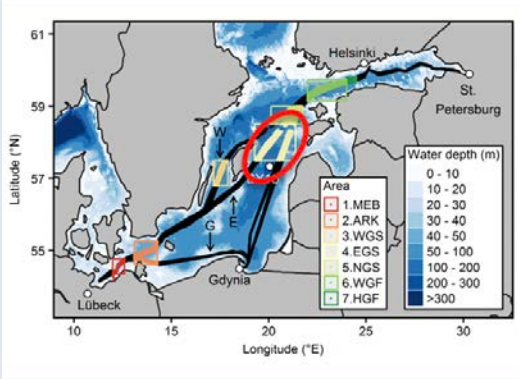
Latest Breaking News:
Eastern Gotland Sea : 57.5° - 58.5 N

- Extremely low pCO₂ in late spring 2018
- Unprecedented biomass production in late spring



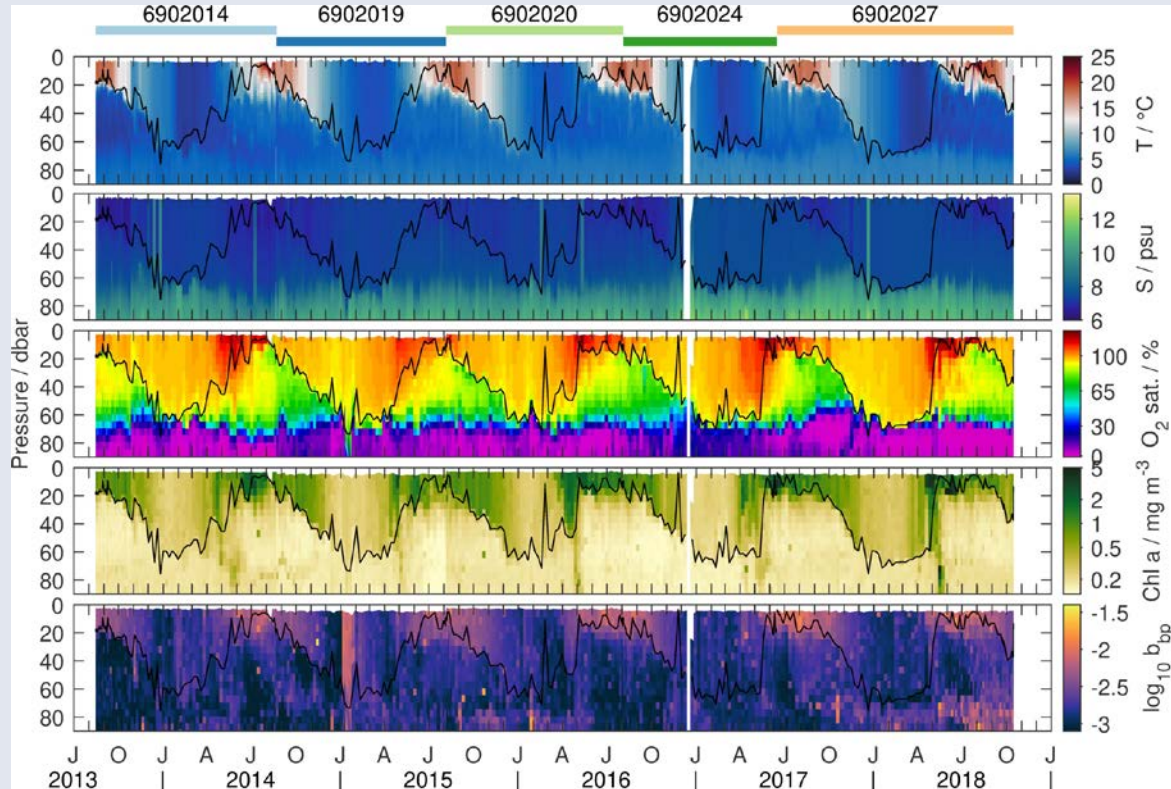


Winter nutrients

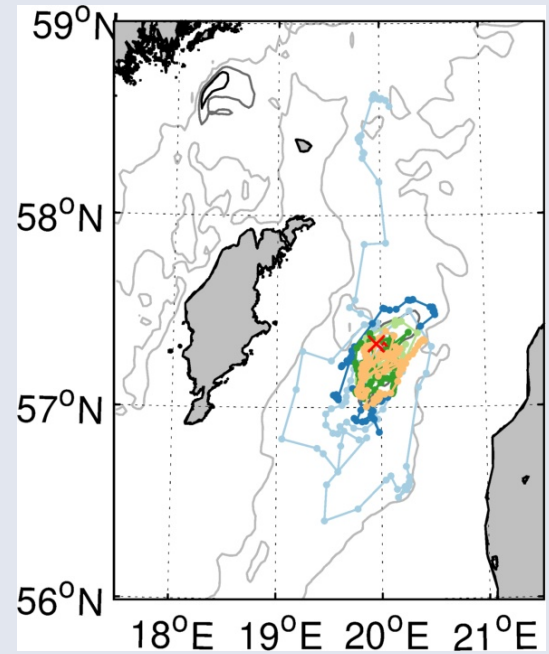


unsuspicious

Winter phosphate concentrations BY 15



FMI Argo Float data – 2013-2018



SST **MLD**

Chl a **O₂sat**



BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION



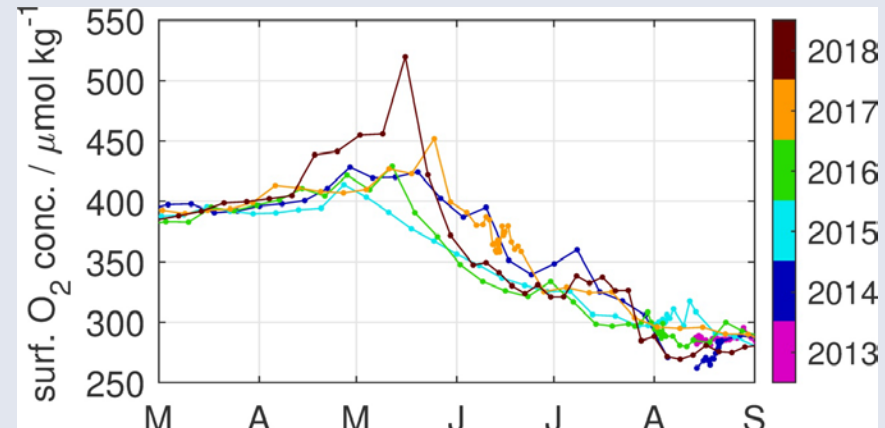
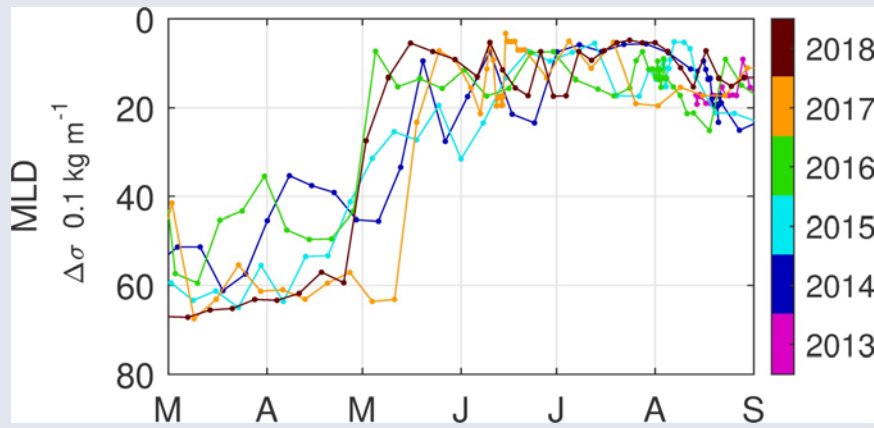
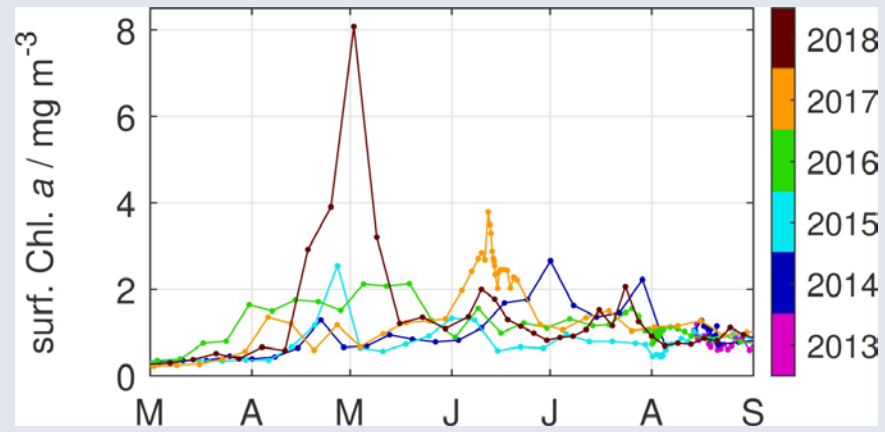
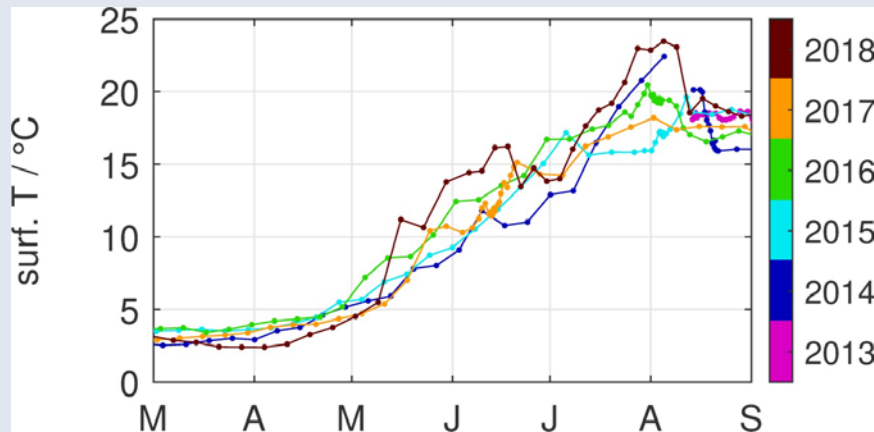
BONUS INTEGRAL

ICOS

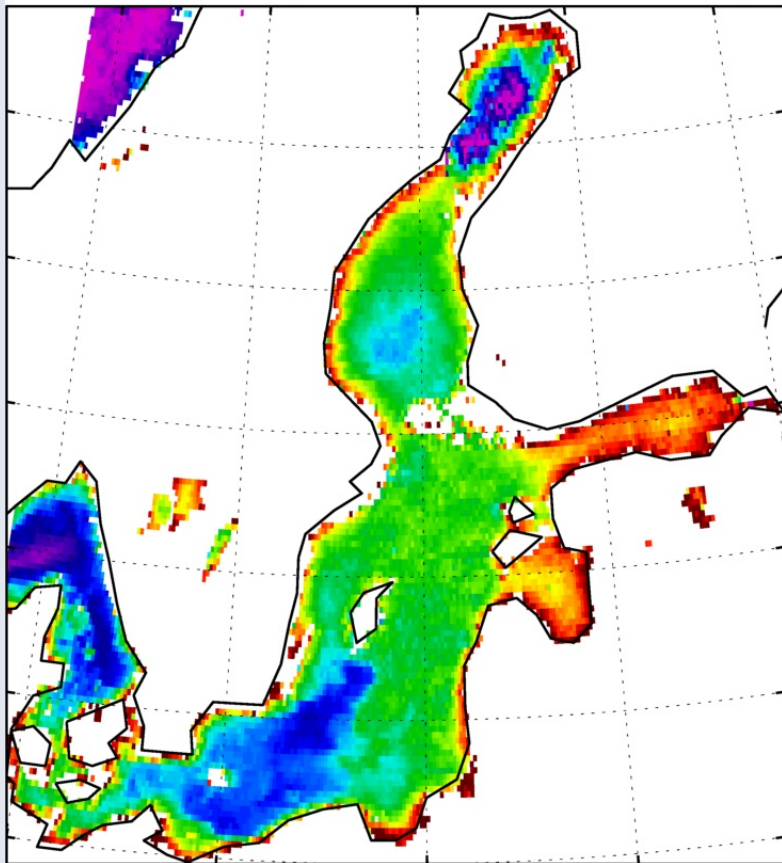
INTEGRATED CARBON OBSERVATION SYSTEM



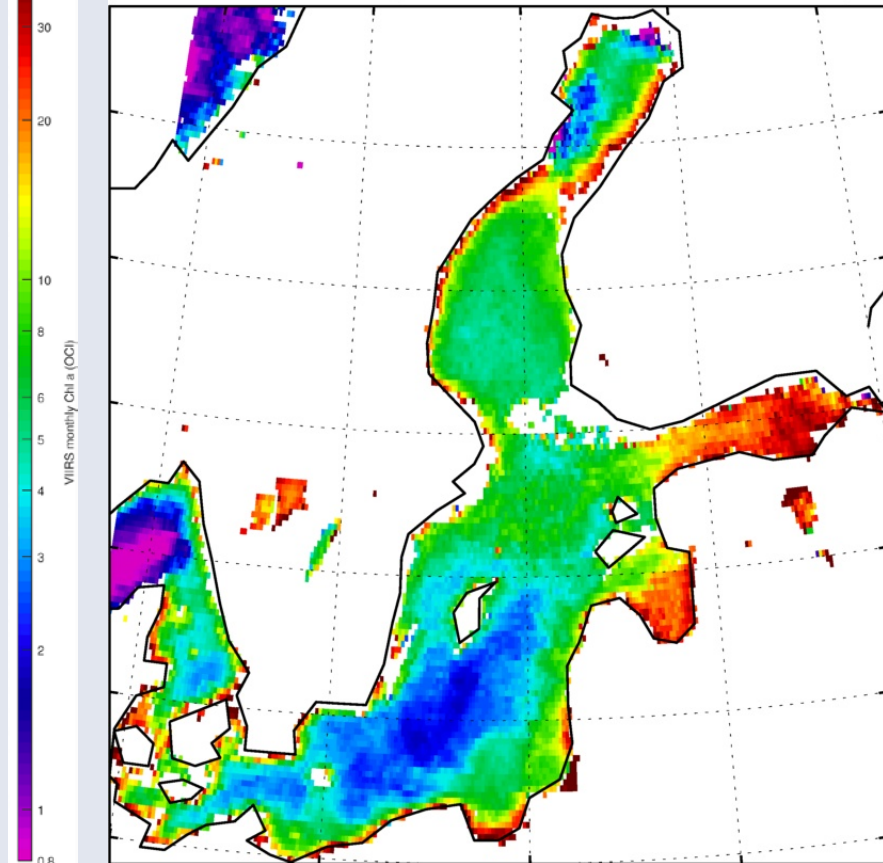
Surface productivity from Argo

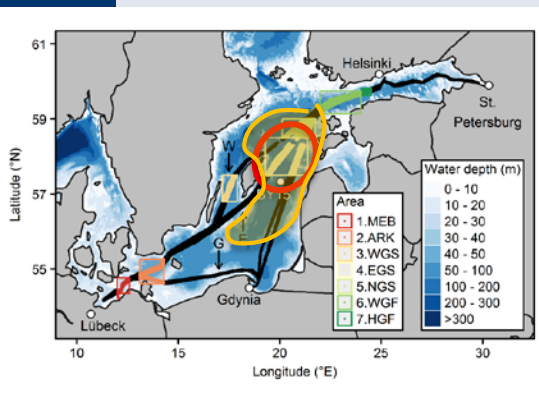


VIIRS monthly Chl a (OCI) 2018-May

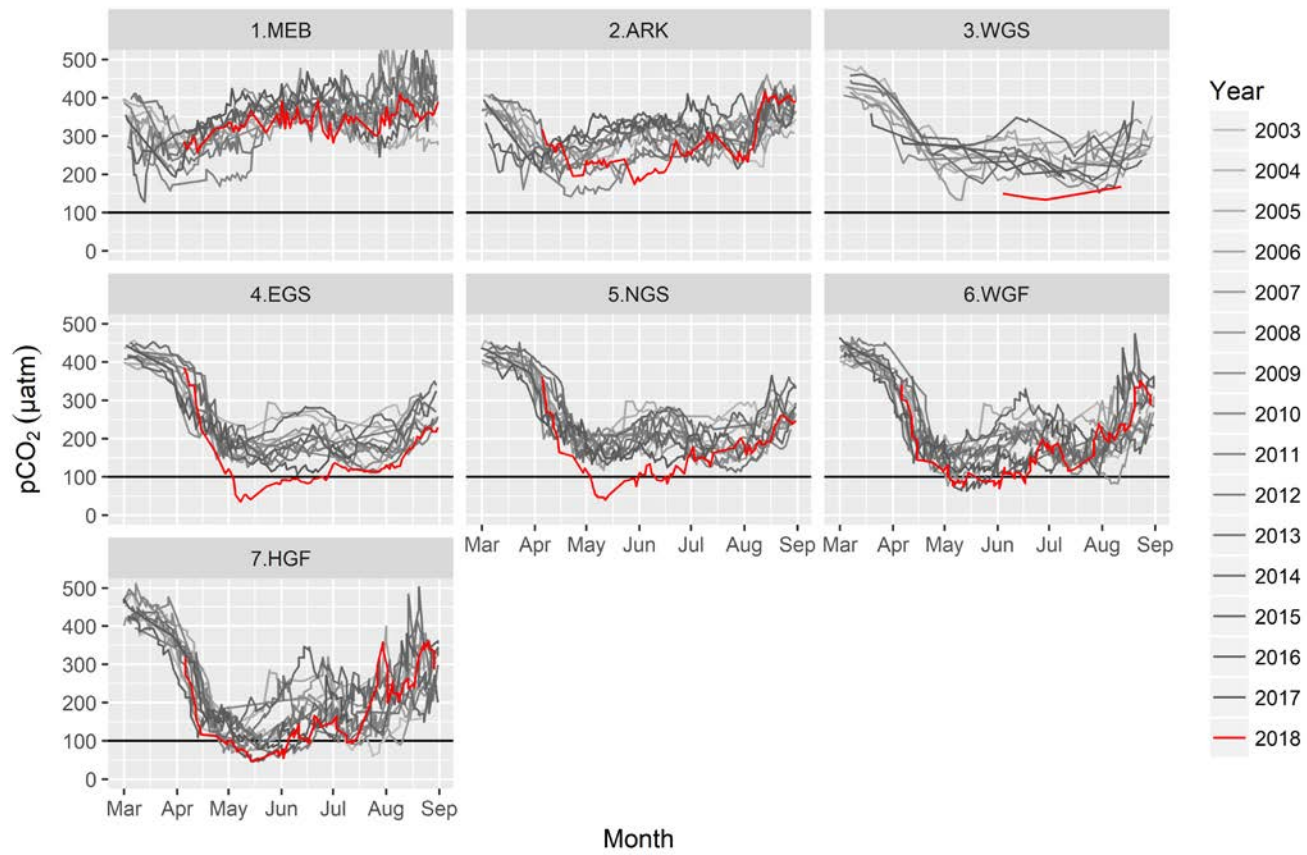


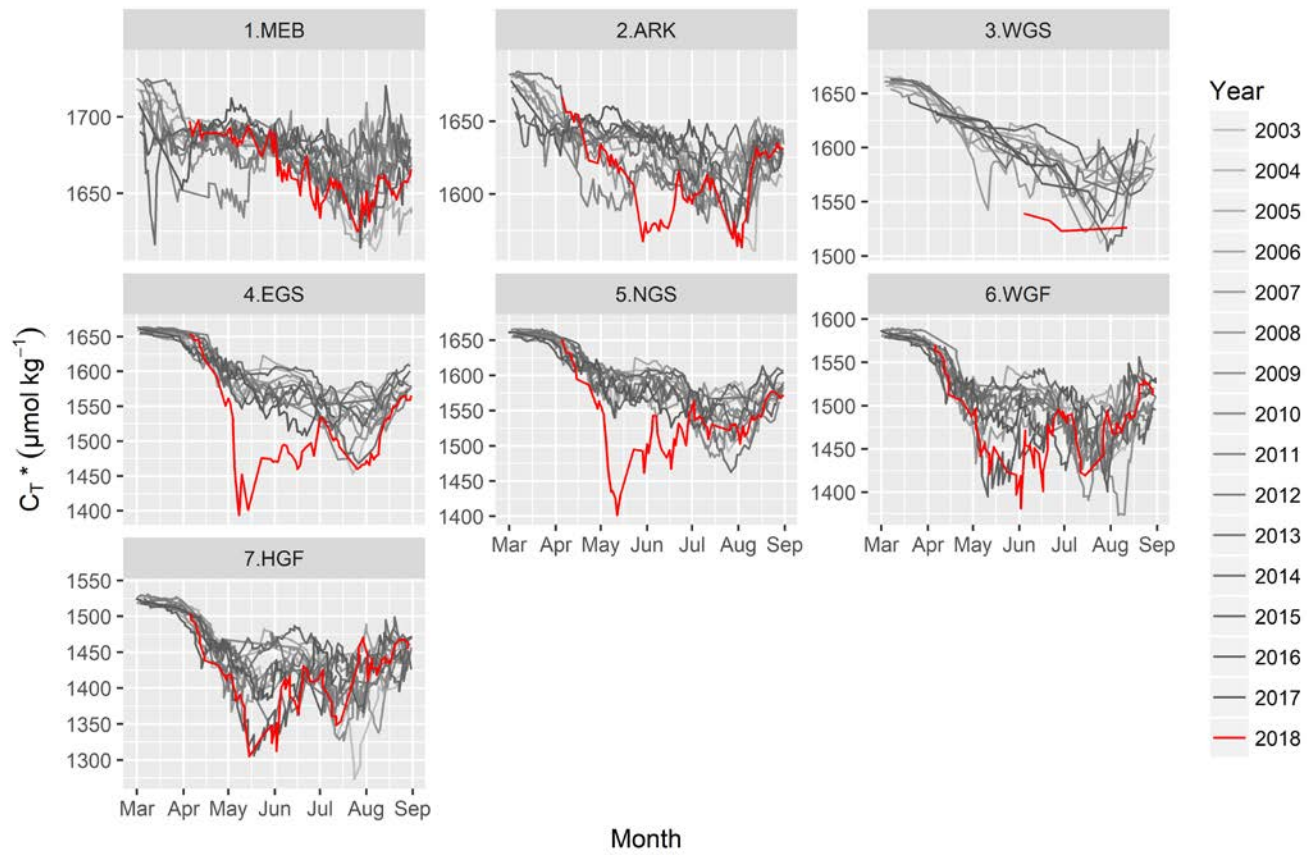
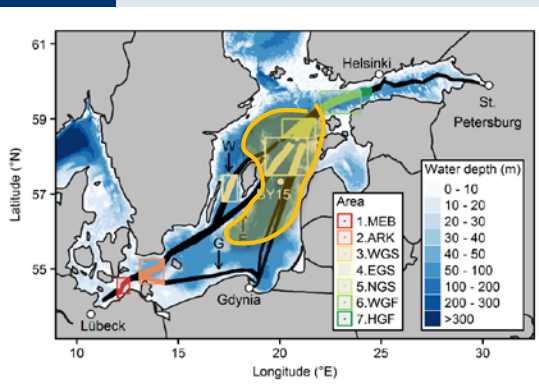
VIIRS monthly Chl a (OCI) 2017-May

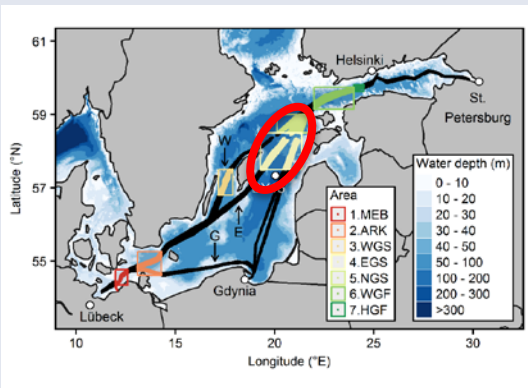




Areal extent

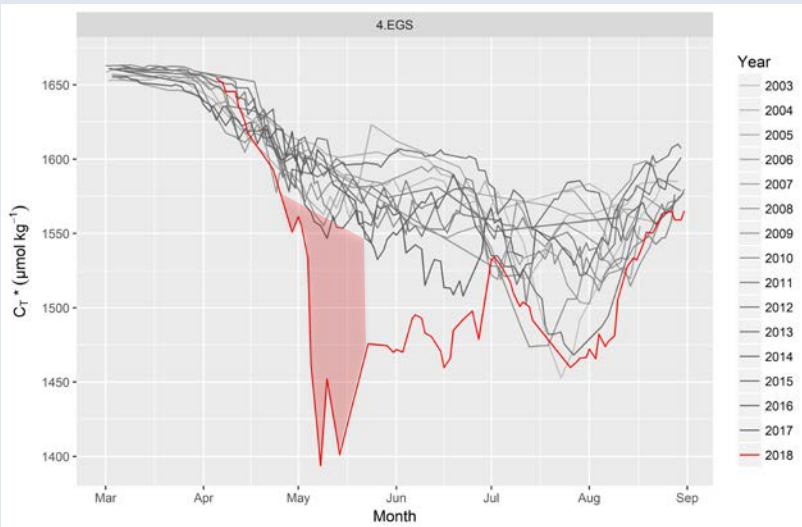






Severe possible implications for the fight against eutrophication if occurring more frequently !

- Extremely low $p\text{CO}_2$ in late spring 2018
- Unprecedented biomass production in late spring
- Carbon fixation (net carbon productivity) more than 3x that expected from N or P winter concentrations
- No signs for neither N- nor P-limitation during the **SPRING BLOOM**
- Derived entirely from novel high resolution monitoring technologies (VOS, Bio-Argo, Remote sensing)
- **Work on community composition in progress**
- **Singularity or glimpse into the future under debate**



Rehder et al.

Baltic Earth workshop on Multiple drivers in the Baltic Sea region, Tallinn, Nov. 2018

Acknowledgement: THE BONUS INTEGRAL project receives funding from BONUS (Art 185), funded jointly by the EU, the German Federal Ministry of Education and Research, the Swedish Research Council Formas, the Academy of Finland, the Polish National Centre for Research and Development, and the Estonian Research Council.



BONUS INTEGRAL



Thank you
for your
attention

