Temporal and Spatial Changes in the Enrichment of the Sea Surface Microlayer in Organic Matter

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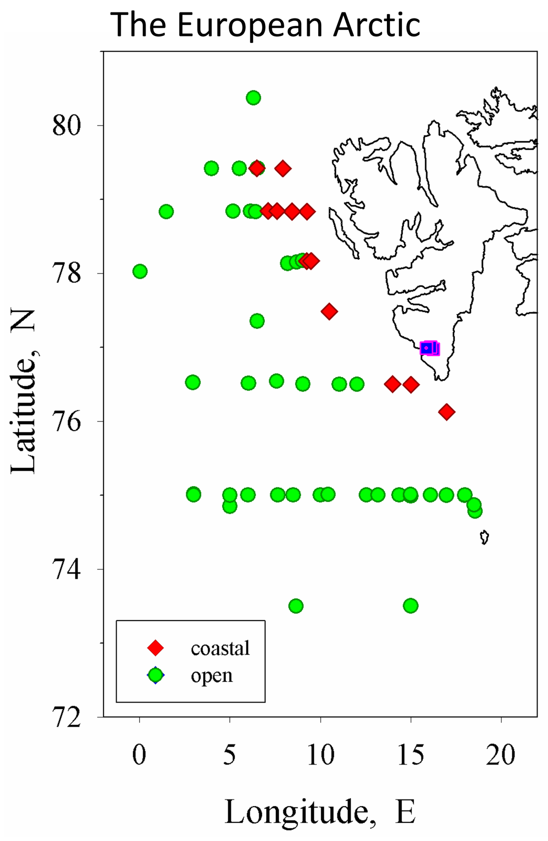
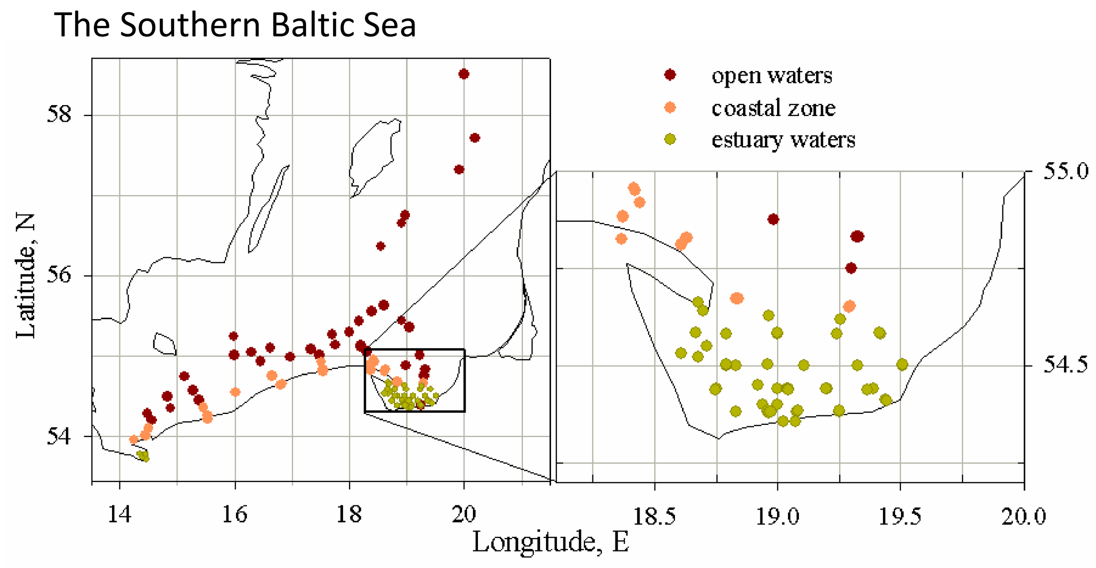
Study sites

The European Arctic



The Southern Baltic Sea



Surface water sampling is conducting by the Garrel Screen and Niskin bottle from r/v Oceania

- **Water depth**: surface micrometer (SML), and subsurface water layer (SSW, 1 m)
- **Regions**: (1) the Baltic Sea (BS): open water, coastal and estuary; (2) the Arctic (AREX): open and shelf (coastal) waters
- **Monitoring**: BS in spring, fall and winter; AREX in summer
- **Parameters**: temperature, salinity, CDOM, FDOM, phytoplankton classes, Chlorophyl-a, wind speed and direction, CO_2

Autonomous data of: pCO2 at seawater and EC CO2 at the athmosphere

Research Questions

Background: The sea surface microlayer (SML) is the first millimetre of the seawater surface layer. It plays a role in all processes at the interface between the sea and the atmosphere, including energy and gas exchange processes. For almost 20 years, our team has conducted studies on the SML, assessing the concentration of absorbing and fluorescing organic matter present and its influence on the spectrum of light entering and leaving the sea. The results have confirmed that the SML is ubiquitous, with its thickness being most significant at river mouths. An important parameter describing the SML, along with its thickness and the concentration of its various components, is the enrichment of the SML in organic matter, calculated as the ratio of the values of the physical quantity (describing organic matter) obtained for the SML and the subsurface layer (SSW).

(1) We are currently undertaking a project, SURETY (effect of organic matter SURface layer Enrichment on air-sea gas transfer velociTY), which aims to study the impact of surfactants, or surface-active organic matter, on CO2 sea-atmosphere gas exchange.

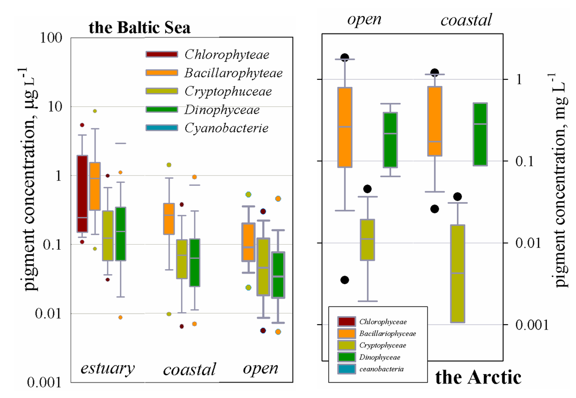
(2) The surfactant studies should allow us to determine the differences in SML surfactant enrichment values across several regions of the Baltic Sea and North Atlantic, classified as (1) estuarine waters, (2) coastal waters, (3) open waters of the Nordic Seas, and (4) Svalbard fjords.

(3) The data will enhance the parameterisation of gas exchange, specifically CO_2, at the interface between the sea and the atmosphere.

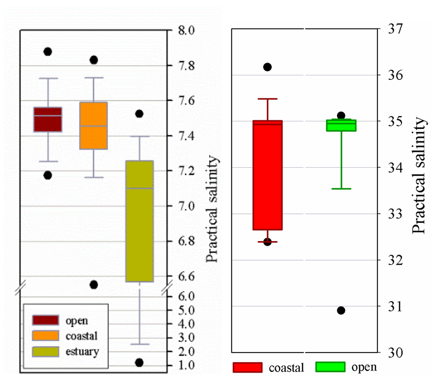
Variables

Environmental factors

Phytoplanacton clasess concentrations and practical salinity values shows differences between estuarine and open waters (in the Baltic Sea) and between shelves and open waters in the Arctic seas.



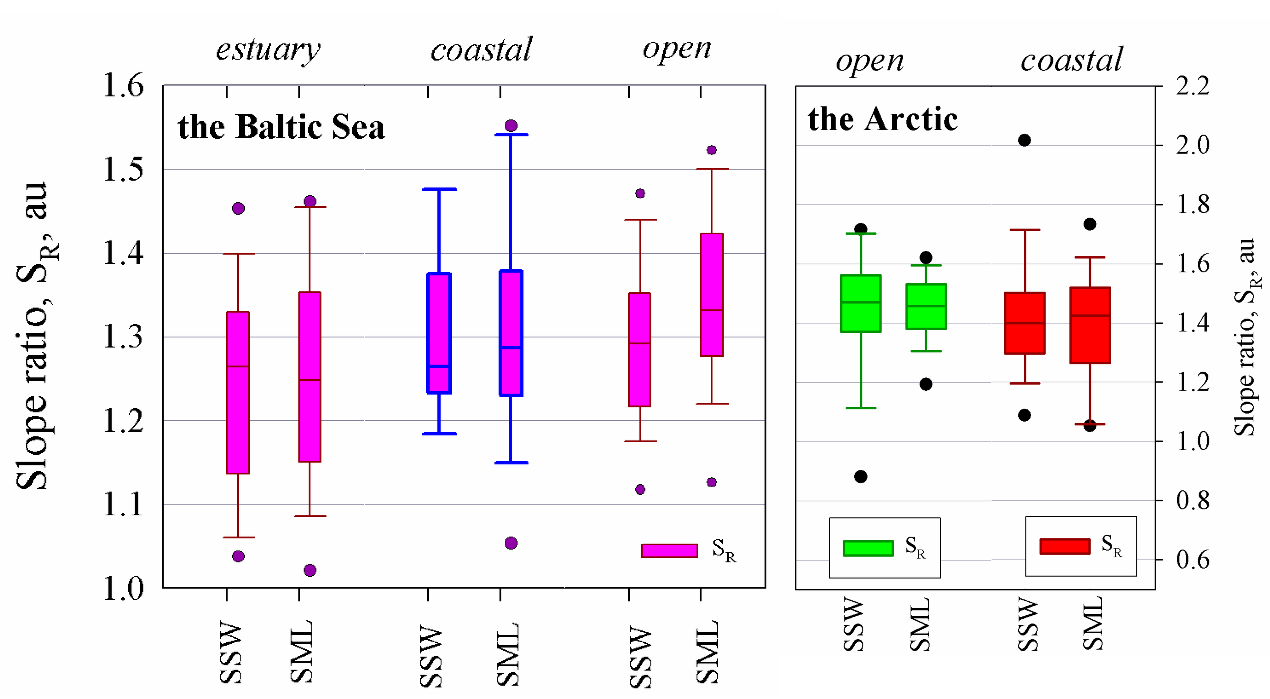
The box plot of phytoplankton classes concetration values in the Baltic Sea and the European Arctic.



The box plot of practical salinity values in the Baltic Sea and the European Arctic.

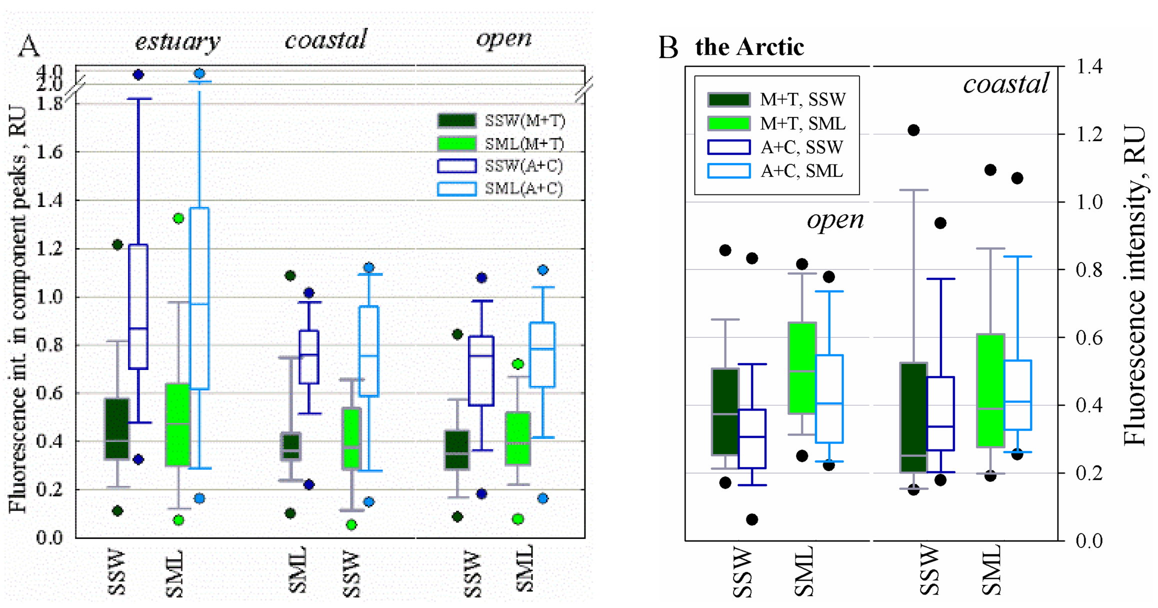
CDOM

The slope ratio, S_R - ($S_{275-295}/S_{350-400}$), a.u. – was calculated to have an nfo about the molecular weight of CDOM molecules that dominated in various areas of the Southern Baltic: estuary, coastal, open waters and in the Arctic. The values vary inversely with molecular weight. In the Baltic Sea there are higher molecular weighted OM than in the Arctic (lower S_R in BS than in AREX).



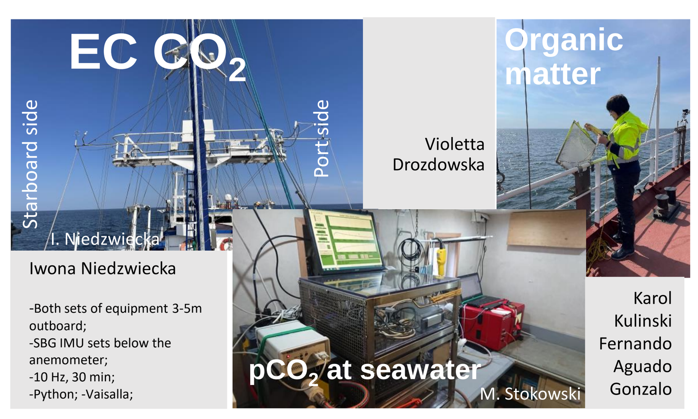
FDOM

Fluorescence intensitiy in peaks: A, C, M, T, R.U. – gives an info about the concentration of (allochthonous – A, C, and autohthonous, M,T) fluorescing fractions of marine FDOM. In the Baltic Sea the amount of M+T fraction is lower than A+C ones, while in the Arctic it's opposit.



SURETY

Team leader: Jacek Piskozub



Feature / Criterion	Bulk Method (indirect)	EC Method (direct)
Type of measurement	Indirect	Direct
Working principle	Flux calculated from **F = k × K_0 × ΔpCO_2**	Flux derived from turbulent covariance: **F = ρ × w′c′**
Required input data	pCO_2_water, pCO_2_air; temperature, salinity; wind speed	Fast-response CO_2 data, 3D wind, time synchronization
Main uncertainty	Parameterization of k (e.g. Wanninkhof, Nightingale)	Motion correction, WPL correction, high-frequency losses
Temporal resolution	Minutes to days	10–20 Hz (aggregated to 30 min)
Advantages	Simple implementation, suitable for long-term records, lower equipment requirements	Direct measurement, high temporal resolution, captures turbulence
Disadvantages	Dependent on empirical parameters, cannot capture turbulent variability	Complex analysis, expensive equipment, requires advanced processing

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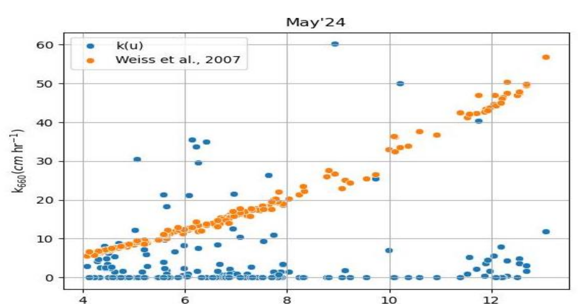
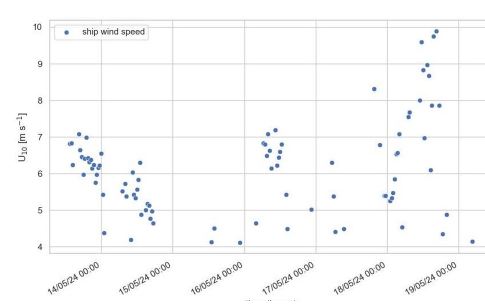
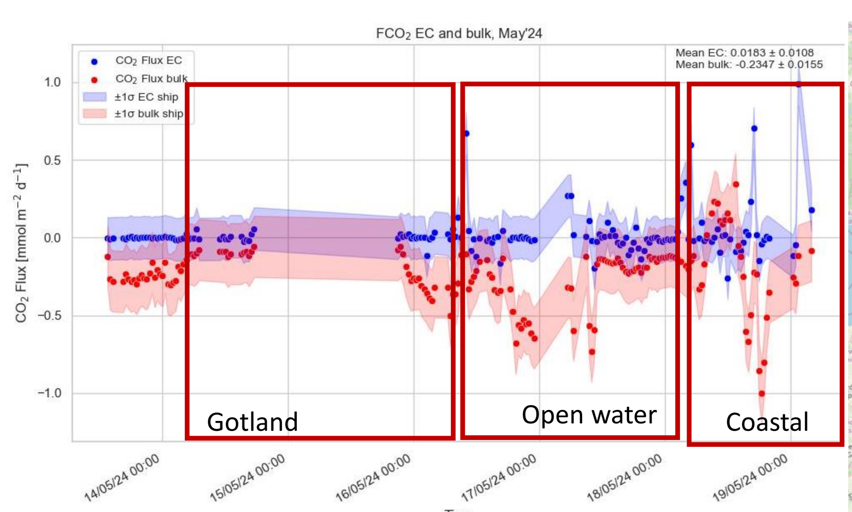
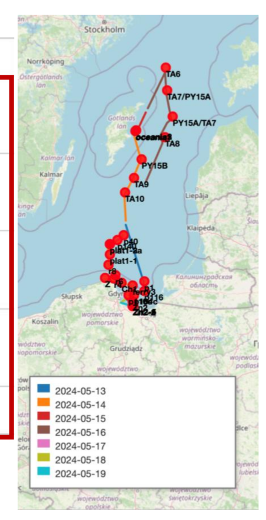
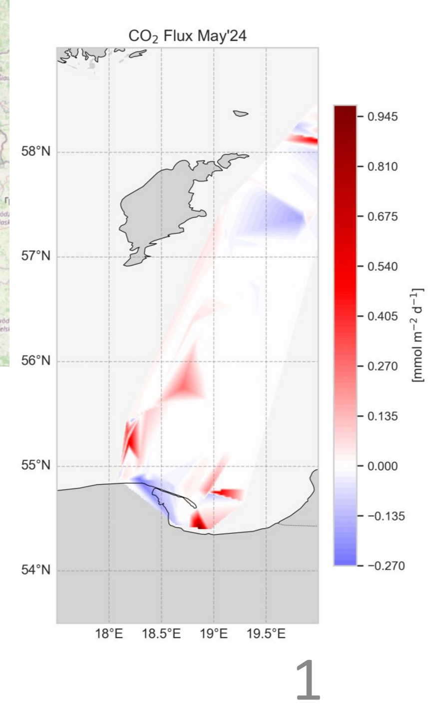
$k_{660} = 0.365{*}U_{10}^2 + 0.46{*}U10$
Weiss et al., 2007

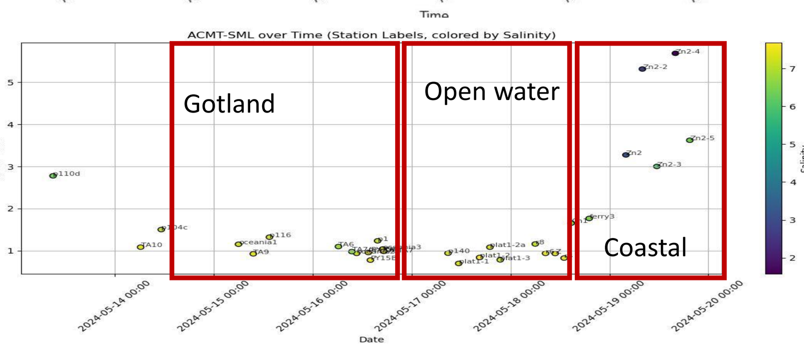












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Outlook

To correct uncertainties in direct and indirect CO_2 flux measurements and with the organic matter.
To compare the results for the Baltic Sea and the European Arctic.

Conclusions

- CDOM decreases with increasing salinity, and the values of chromophoric organic matter in SML are almost always higher than in SSW.
- As salinity increases and distance from land and river mouths grows, the molecular mass (SR) of organic matter in the SML and SSW decrease. The most notable prevalence of molecules with lower molecular weight in SML compared to SSW is found in open waters.
- A twofold greater proportion of allochthonous matter (A+C) compared to autochthonous matter (M+T) in all studied areas of the Baltic Sea, while on the Arctic the amount of A+C is lower that M+T;
- Organic matter act the surface suppresses gas transfer velocity.
- A consistent reduction in k was observed in areas with surface organic matter enrichement, suggesting organic films act as a barier to air-sea gas exchange.
- Despite iorganic suppression, the distribution of CO2 fluxes in the southern Baltic aligns with broader regional trends, indicating similar driving mechanisms.

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