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From the Baltic Sea to the Arctic: International and Interdisciplinary Research Cruise of r/v OCEANOGRAF and s/y OCEANIA

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1. INTRODUCTION

The Baltic Sea is a semi-enclosed, brackish water body that receives significantly more freshwater input from rivers and precipitation than it loses through evaporation and outflow. To balance this excess, there is a continuous surface outflow of brackish Baltic water through the Danish Straits, Kattegat, and Skagerrak. The outflowing surface water joins the Norwegian Coastal Current and flows along the coast of Norway into the Barents Sea. Additionally, the catchment area of the Baltic Sea is more than four times larger than its surface area, making it especially vulnerable to the accumulation of pollutants, originating from a densely populated and highly urbanized regions of Central and Eastern Europe (HELCOM 2010).

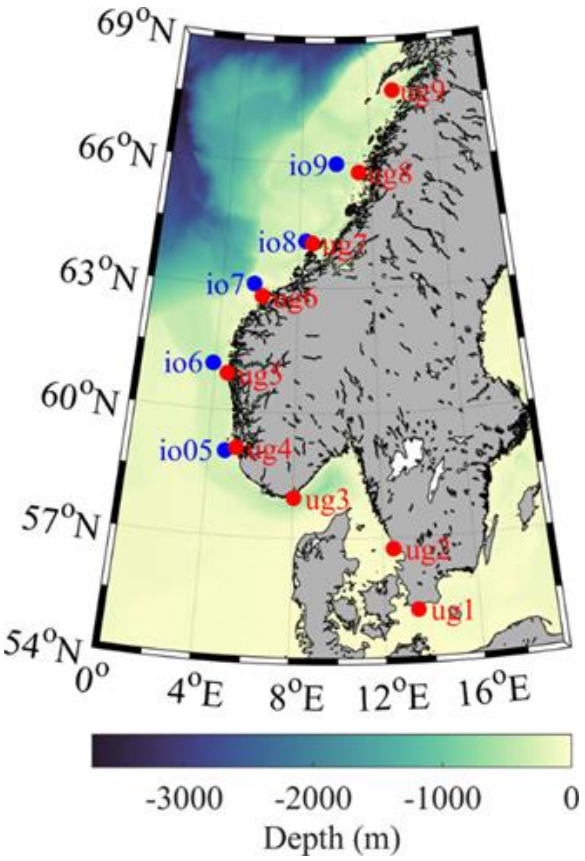

Fig. 1. The map of sampling stations by r/v OCEANOGRAF (red) and s/y OCEANIA (blue).

We hypothesized that the outflowing Baltic water carries possible pollution, relatively high load of nutrients, dissolved organic matter, and planktonic organisms from the Baltic Sea, enriching and influencing the fully saline Nordic Seas this way. To test this hypothesis, two Polish research vessels, r/v OCEANOGRAF (University of Gdańsk) and s/y OCEANIA (Institute of Oceanology PAS), followed the Baltic seawater outflow along the Scandinavian Peninsula (Fig. 1), working together in international and interdisciplinary teams. The goal of the project was to study these brackish water masses, along with their physico-chemical properties and associated biota, flowing out from the Baltic Sea towards the Arctic.

2. PRELIMINARY RESULTS

Twenty surface drifters launched during the cruise remained on the continental shelf, distinguishing the Norwegian Coastal Current from the offshore Norwegian Atlantic Slope Current; some ended up in the Barents Sea, confirming a northward path of Baltic seawater outflow reaching high latitudes, as predicted by the numerical Regional Arctic System Model of high horizontal resolution.

The chemical analysis of seawater revealed differences between offshore and coastal zones, and along the transect. Elevated concentrations of phosphate and nitrate in coastal waters suggest the land-based runoff, while variations in conductivity and total organic carbon reflect the mixing of waters from different origins. We observed decrease of stable carbon isotopes (δ13CPOC) values northwards and variable stable nitrogen isotopes (δ15NPOC). Results also showed the marygenic origin of chromophoric dissolved organic matter in all samples, with a sharp decrease in aromaticity northwards. Additionally, a net output of perfluoroalkyl and polyfluoroalkyl substances, a group of persistent, toxic, synthetic chemicals, from the Baltic towards the North Sea, was detected at low levels in all samples, and at higher concentrations

in surface waters. The highest total mercury concentration in suspended particulate matter was measured near Bodø, while in zooplankton and phytoplankton at the Baltic Sea – North Sea section. The sea surface microlayer was enriched with heavy metals, polycyclic aromatic hydrocarbons and elemental carbon, related to the combustion of fossil fuels. The sea surface microlayer was enriched with heavy metals, polycyclic aromatic hydrocarbons and elemental carbon. On most of the stations it was directly related to the anthropogenic origin, mainly from combustion of fossil fuels (Diesel and organic burning).

Gradual decrease in chlorophyll *a* concentration in surface waters was observed northwards; and marker pigments analysis showed the occurrence of diatoms, prochlorophytes, prasinophytes, cryptophytes, chlorophytes, and cyanobacteria in varying proportions along the transect. $\Delta N_2/Ar$, a tracer for N_2 fixation, indicated similar variable trends. Consequently, we observed a shift in phytoplankton communities: from the predominance of cyanobacteria in the Baltic Sea, a bloom of diatoms in Kattegat, to dinoflagellates- and diatoms-abundant waters further north. Interestingly, in the coastal waters of the Norwegian Sea, single trichomes of poor-conditioned cyanobacteria *Nodularia spumigena* and *Aphanizomenon flos-aquae* were observed, possibly transported from the Baltic Sea. Underwater Vision Profiler revealed changes in the concentration of zooplankton and marine snow, with decreasing amounts of detritus towards the north. Additionally, hydroacoustic data, collected using split beam echosounder, demonstrated northward acoustic biomass growth, patchy horizontal distribution of biological objects, and the impact of thermohaline on their vertical distribution.

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