Methane fluxes and their controlling processes in the Baltic Sea

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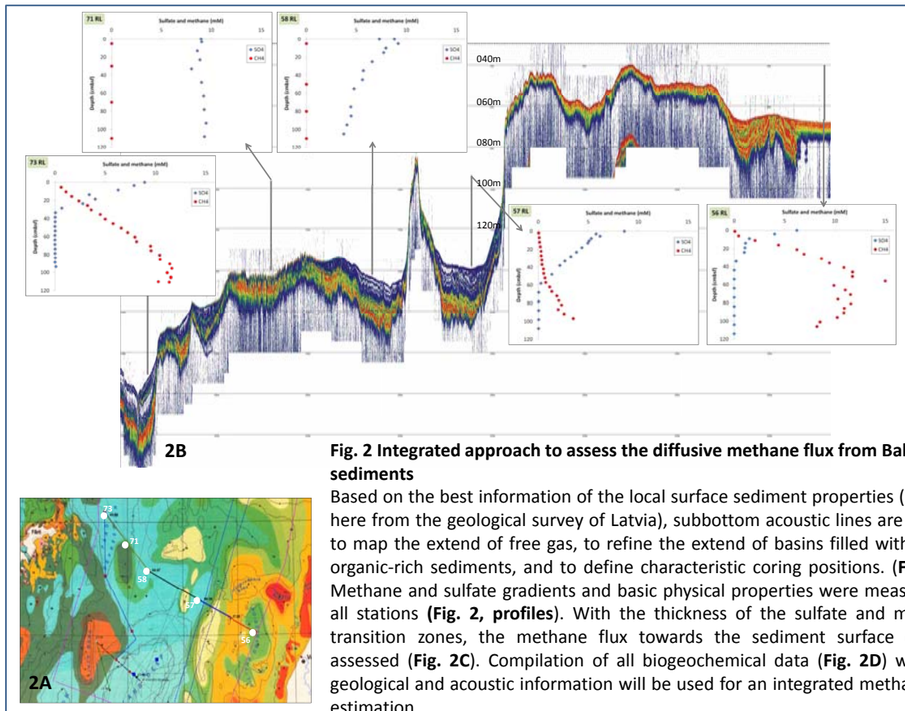
BALTIC GAS

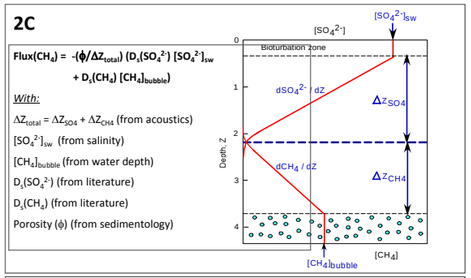
Introduction

The Baltic Sea (BS) is an ideal natural laboratory to study the methane cycle in the framework of diagenetic processes. It is a brackish marginal sea with a salinity gradient from nearly marine to almost limnic conditions. The strong permanent haline stratification leads to large vertical redox gradients in the water column in the central part of the BS, which are perturbed by saline inflows from the North Sea. The sedimentation history resulted in the deposition of organic-rich young post-glacial sediments over older glacial and post-glacial strata with very low organic content.

The project BALTIC GAS within the BONUS+ eranet initiative aims to map the occurrence of free shallow gas in the young Holocene sediments, to quantify the methane fluxes through the sediments, into the water column and the atmosphere, and to investigate the processes and parameters governing methane generation and consumption.

During expedition MSM 16/1 of RV *Maria S. Merian* in August 2010, various subbottom profiling systems were used to map the thickness and structure of organic-rich deposits and build the base for a detailed coring program for biogeochemical analysis, including methane, sulfide and sulfate, iron and other relevant compounds, as well as incubation experiments for studies of methanogenesis and methanotrophy. In addition, the distribution of the gas in the water column was mapped towards the sea surface .





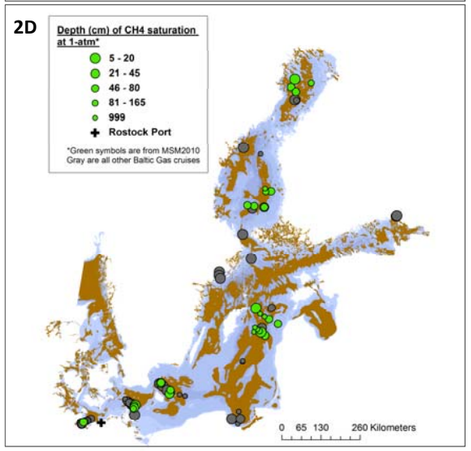


Fig. 2 Integrated approach to assess the diffusive methane flux from Baltic Sea sediments
Based on the best information of the local surface sediment properties (**Fig. 2A**, here from the geological survey of Latvia), subbottom acoustic lines are chosen to map the extend of free gas, to refine the extend of basins filled with young organic-rich sediments, and to define characteristic coring positions. (**Fig. 2B**). Methane and sulfate gradients and basic physical properties were measured at all stations (**Fig. 2, profiles**). With the thickness of the sulfate and methane transition zones, the methane flux towards the sediment surface can be assessed (**Fig. 2C**). Compilation of all biogeochemical data (**Fig. 2D**) with the geological and acoustic information will be used for an integrated methane flux estimation.

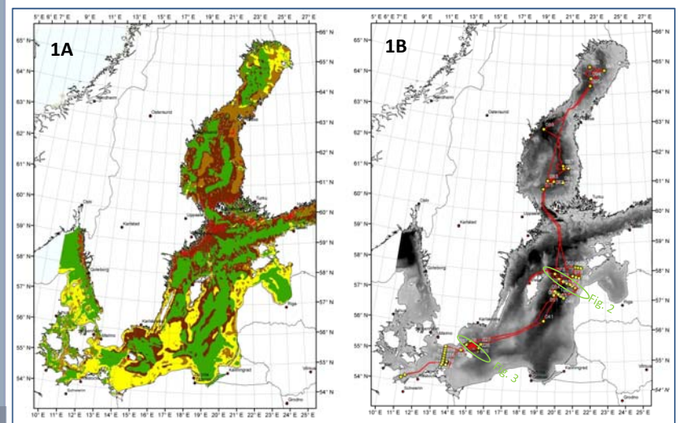


Fig: 1: (A) Map of the sediment distribution in the Baltic Sea (yellow: sandy sediments; brownish: hard bottom/hard clay; green: fine-grained mud; from the BALANCE project, http://balance-eu.org). The fine grained, organic-rich muddy sediments are mainly found in the basins. **(B)** Map showing cruise track, station positions, and main bathymetry of the Baltic Sea. Notice the different basins separated by sills.

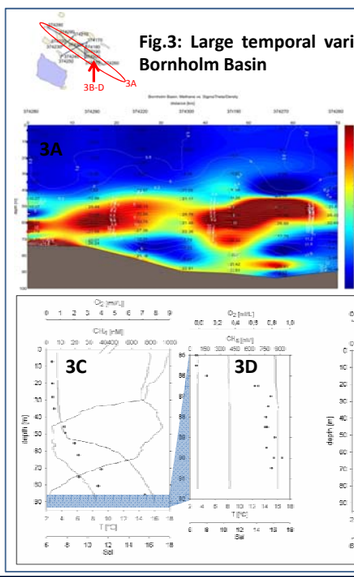


Fig.3: Large temporal variations of methane concentrations in the Bornholm Basin

The methane inventory in the Bornholm Basin drastically changed between December 2009 and August 2010. **(A)** Section NW of Bornholm in Dec. 2009 with a distinct midwater maximum layer. **(B)** Profile of water column properties at station 374200, **(C)** resampled in Aug. 2010. **(D)** High resolution sampling of the lower part of the section in summer.

The oxygen-rich bottom water layer originating from inflow from the North Sea turned anoxic during the 6 months interval. Correlation of high methane concentrations with anoxic conditions is observed in several of the Baltic Sea Basins.

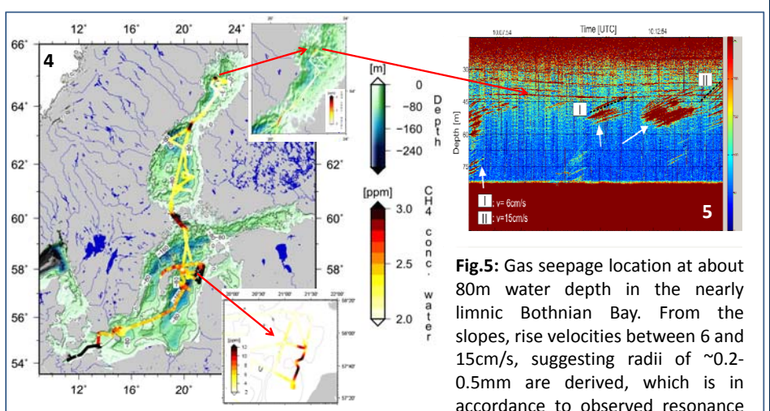


Fig.4: Surface water concentrations were measured throughout the survey, pointing to individual sources. Surface concentrations in the northern Basins are generally low, except for local high over concentrations caused by gas seepage.
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Fig.5: Gas seepage location at about 80m water depth in the nearly limnic Bothnian Bay. From the slopes, rise velocities between 6 and 15cm/s, suggesting radii of ~0.2-0.5mm are derived, which is in accordance to observed resonance phenomena.
Generally, seepage appears to be of minor importance for the methane cycle in the Baltic, likely due to the thin and shallow layer of methanogenic sediments.