Summary

Rationale

Anthropogenic activity, and especially fossil fuels combustion and cement production, lead to continuous increase of atmospheric CO_2 partial pressure (pCO_2) in the last decades. The oceans and the seas absorb globally ca. 30% of that emission reducing in that way negative pressure of CO_2 on climate. However, dissolution of CO_2 in seawater has also negative consequences for marine ecosystems. Since CO_2 dissolved in seawater forms the diprotic carbonic acid, hydrogen ions are released, and thus pH decreases. This phenomenon is known in the scientific literature as "ocean acidification" although seawater does not really become acidic but only moves from its alkaline character towards the acidic regime. Ocean acidification has been recognized as one of the greatest threats for marine ecosystems not only by scientific community but also in EU legislation. EU Marine Strategy Framework Directive explicitly points out that the EU Member States should put more attention to ocean acidification, and emphasizes the necessity to include measurements of pH and of the CO_2 partial pressure (pCO_2) into the description of the environmental status of marine regions. There is a general belief that the magnitude of ocean acidification can sufficiently be quantified from the atmospheric pCO_2 levels and the CO_2 exchange between seawater and the atmosphere. This is approximately true for oceans. However, it is not the case for coastal seas, and especially the Baltic Sea, because several other processes and mechanisms are influencing the seawater pH. These form the so called acid-base system – a complex net of interrelationships between chemical species and processes that control the seawater pH. At present, the knowledge on the structure and functioning of the acid-base system contains a lot of gaps and/or shortcomings, which lead to wrong conclusions and questionable predictions of the future pH development. The results obtained in the proposed project will allow to estimate structure and functioning of the acid-base system in the Baltic Sea, what will highly increase the accuracy of pH and pCO_2 calculations. It is very important for the Baltic Sea ecosystem, which due to the low buffer capacity of seawater is much more sensitive to ocean acidification than open ocean regions.

Objectives

Two main objectives were defined in the proposed peoject:

- Improvements of the calculations of pH and pCO_2 in the Baltic Sea by taking into account all important peculiarities/anomalies occurring here, what will significantly reduce uncertainty in predictions of the future pH development in Baltic (and possibly also in other coastal seas).
- To investigate experimentally and parameterize biogeochemical processes that may influence the structure and functioning of the acid-base system. Processes and interactions, which are insufficiently characterized or entirely missing in the present description of the Baltic Sea acid-base system include: (i) dissolved organic matter as a carrier of acidic functional groups, (ii) mineralization of organic matter as a source of CO_2, (iii) borates as an important component of total alkalinity at low salinities in the Baltic Sea, (iv) particulate carbonates as a carrier of total alkalinity, (v) sediments and oxic/anoxic deep water layers as regions, where denitrification, sulphate reduction and organic matter mineralization are controlling the acid-base system.

Methodology

The work planned within the proposed project has been distributed into seven tasks: one is related to the coordination, five focus on the experimental investigations and one common task is related to sensitivity studies in order to estimate the importance of the results for the characterisation and for model simulations of the Baltic Sea CO_2 system.

Altogether three research cruises are planned within the project – each lasting ten days. Two cruises, in autumn 2017 and spring 2018, are planned on s/y Oceania, which belongs to the IO PAN (Host Institution). The third sampling in the open Baltic is planned for summer 2017 and will be performed from other research vessel since s/y Oceania will go for another Arctic expedition at that time. Additionally, river water (Vistula, Oder and Kalix) will be sampled in winter and summer 2017 to cover seasonal variability in characterization of mineralization dynamics of terrestrial organic matter. The full set of parameters measured within the proposed project will include: total alkalinity, inorganic carbon concentration, pH, pCO_2, concentration of dissolved organic carbon, concentrations of particulate inorganic and organic carbon, carbon stable isotopes, concetrations of: oxygen, boron, nutrients, sulphides, sulphates, absorbtion spectra of organic matter in infrared, temperature and salinity. All the measurements and analyses will be performed at IOPAN laboratories using the best available methods.