Ocean Acidification (OA): Country Report submitted for Poland

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pH monitoring in the Polish Baltic Sea area

As part of the State Environmental Monitoring the Chief Inspectorate of Environmental Protection is in charge of monitoring water quality indicators including pH.

The latest available data concern to the ENVIRONMENTAL STATUS of POLISH MARITIME AREAS OF THE BALTIC STATE BASED ON MONITORING DATA FROM 2017 ON THE BACKGROUND OF THE YEARS 2007-2016 (The results pH of seawater are described on page 53).

Between 2007 and 2017, six times per year, Research Cruises in the Baltic Sea through the Polish exclusive zone (EEZ) collected measurement data that allowed to analyze the changes of pH in the sea water.

Against the background of the last ten years, the data obtained in 2017 shows an increasing tendency of sea water reaction, both in the entire area covered by the study and in the level of separated water bodies. Further, the average pH values in 2017 of individual water bodies were higher than the decade average.

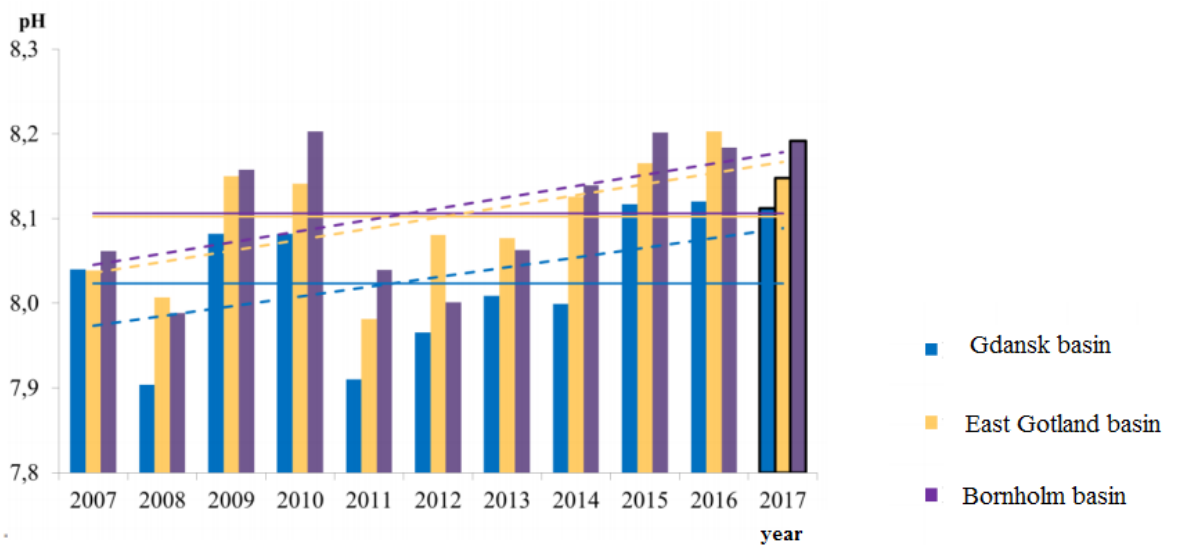

Fig. 1 Average annual pH values in the entire water column in the years 2007–2017 in separated waters of Polish sea areas; solid line - average 2007–2016, dashed line - tendency to change (http://www.gios.gov.pl/images/dokumenty/pms/monitoring_wod/ocena_2017.pdf)

The time variability of pH on the surface layer of the sea (0-10 m), which is a direct receptor for any changes in the atmosphere, showed similar regularities as observed in the last decade for the entire water column.

Changes in the reaction of sea water are largely the result of biological processes occurring on the surface layer of water. During intensive blooms of phytoplankton, in the process of photosynthesis, carbon dioxide and released oxygen are absorbed from the environment. Therefore, a correlation can be expected between the oxygen concentration and the pH value as well as the spatial and temporal variability of this parameter associated with the geographical and seasonal variability of photosynthesis intensity (Wesslander 2011). Seasonal variations in pH were associated with changes in primary production intensity. In 2017, the highest pH values were measured during the period of intensive vegetation (April-June). The characteristic vertical decrease in the pH from the surface to the bottom, related, among others with the reduction of dissolved oxygen consumed in deeper sea layers in chemical processes, is illustrated in Figure 2.

Wesslander K., 2011,The Carbon Dioxide System in the Baltic Sea Surface Waters

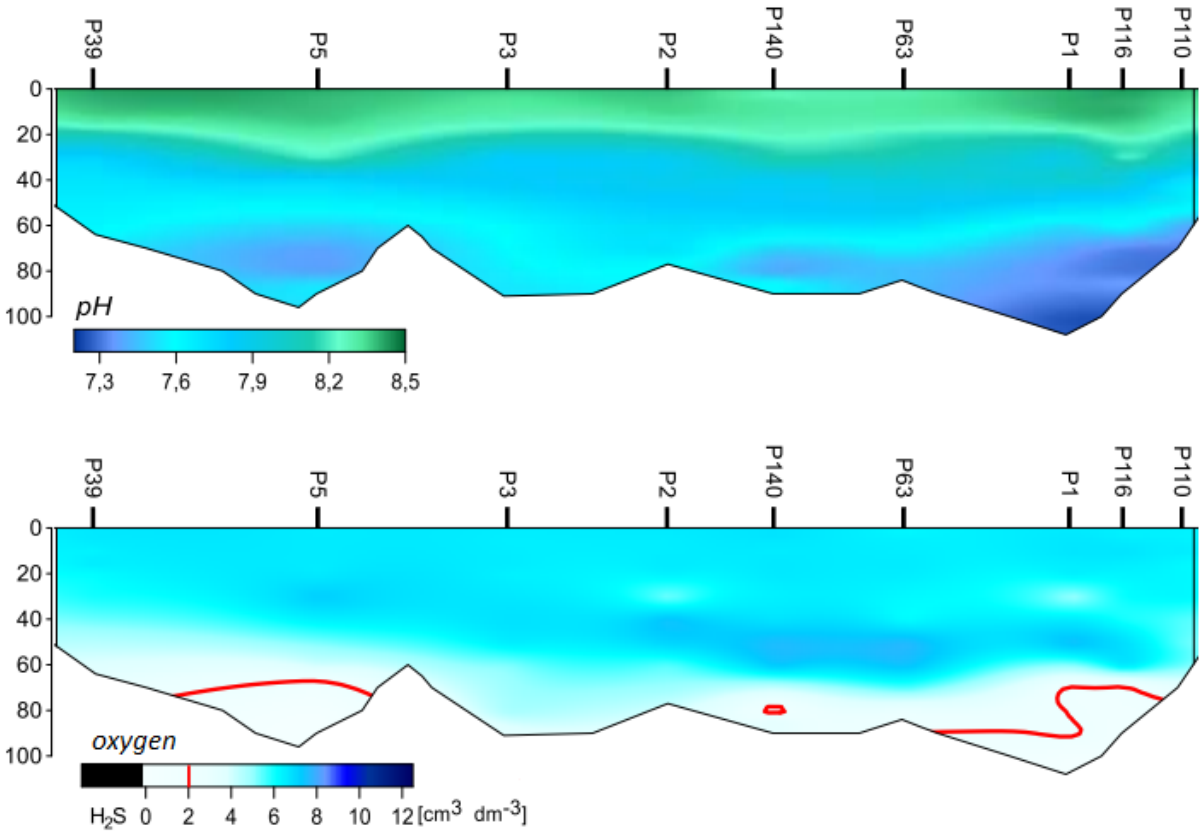

Fig. 2 Vertical distribution of pH and oxygen concentrations in the waters of the Polish exclusive economic zone along the deep-water section from the Bornholm Basin to the Gulf of Gdańsk (example situation from September 2017)

Popular science reports on ecological effects of OA

In Poland a lot of common available materials about ocean acidification are on the internet. Some documents are based on scientific reports.

Nauka o klimacie (the science of climate) - portal created by scientists associated with research into the physical foundations of climate change

- 20 FACTS ABOUT OCEAN ACIDIFICATION - the text is based on the summary prepared by Ocean Carbon and Biogeochemistry Project, the United Kingdom Ocean Acidification Programme and European Project on Ocean Acidification (EPOCA). 63 scientists from 47 institutions and 12 countries participated in the work. More information on the website: Ocean Acidification International Coordination Centre.
- MYTH: OCEAN ACIDIZATION DOES NOT DAMAGE MARINE ORGANISMS - the text is based on Waldbusser i in. (2014), Skeptical Science [1] , Skeptical Science [2] i Ocean portal - The explanation of damaging effects of CO_3^{2-} deficiency on crustaceans and coral reefs. Ocean acidification consists not only in the increase in the concentration of hydrogen ions (decrease in the pH) but also the HCO_3 anions at the expense of CO_3^{2-} .

Nauka w Polsce (The Science in Poland) is the largest publicly available information site dedicated to Polish science. The main task is to disseminate knowledge about the achievements of Polish scientists and popularize their achievements, including in the area of innovation. Articles published on the website are based on the latest scientific reports.

Selected articles about ocean acidification:

- By the end of the century, all reefs may become extinct - Rising sea surface temperatures and acidic waters could eliminate nearly all existing coral reef habitats by 2100, suggesting restoration projects in these areas will likely meet serious challenges, according to new research presented at the **Ocean Sciences Meeting 2020**. Scientists project 70 to 90 percent of coral reefs will disappear over the next 20 years as a result of climate change and pollution (source of data).

- IPCC: oceans and glaciers are being destroyed faster than previously thought - in the article there is information that rising sea and ocean temperatures and increasing acidification means a drastic threat to marine life and entire ecosystems. Even if greenhouse gas emissions are drastically reduced (and hence the temperature rise is limited to 1.5 ºC), up to 90% of coral reefs will probably die.

- Acidic oceans harm the cod larvae - A scientists' study from the German GEOMAR Helmholtz Center for Ocean Research Kiel, who cooperated with colleagues from France and Norway, confirms that the high concentration of carbon dioxide is destructive to the Atlantic cod species, especially in the early stages of life - eggs and larvae.

- The Arctic Ocean is becoming more and more acidic - In a report published in the journal Nature Climate Change, scientists reported that the acidification of the Arctic Ocean has increased significantly between the 1990s and 2010. The range of acidified

waters increased by as much as about 300 nautical miles north of the Chukchi Sea, to the area just below the North Pole. Acidification was also found much deeper than before - at 250 meters deep (compared to the previous 100 meters).

reports on websites run by NGOs

- Ocean acidification literally dissolves the shells of young crabs. Cause: CO_2 emissions – smoglab.pl (source)

Video about ocean acidification:

- Dangerous ocean acidification – TVN METEO, Increasing carbon dioxide emissions threaten animals living in the Arctic Ocean.
- Acidity test Global ocean acidification - Natural Resources Defense Council. Translation: Aleksandra Kardaś, Marcin Popkiewicz, NaukaOKlimacie.pl

News:

- The Great Barrier Reef has been fading for the third time in five years. Researcher: As if I saw the Louvre burning + video about danger for aquatic animals
- The UN warns: 2020 is crucial for the protection of the seas and oceans - *Since the beginning of industrialization, the world's sea waters have become more and more acidic, which hinders the existence of sea vertebrates and molluscs* - Special Envoy of the UN Secretary General for Oceans Peter Thomson, onet.pl

Research

Current work:

Project - Integrated monitoring of carbon and trace gases in the Baltic Sea, Program BONUS- In the project, the eight partners of BONUS INTEGRAL from five different nations (a) integrated the different data streams of ICOS and related infrastructure for the pan-Baltic area, (b) provided better charts of seasonal carbon dioxide and greenhouse gas (GHG) flux over the Baltic Sea, (c) integrated the carbon system variables into a high resolution 3D-model, which will contribute to a better description of the biogeochemical coupling of eutrophication and deoxygenation, (d) demonstrated the added value for a better biogeochemical ecosystem status description of the Baltic Sea, (e) advised the implementation of ICOS in the southeastern countries of the Baltic, in particular promoting components that strengthen the value for Baltic Sea ecosystem status assessment, and (f) developed in close interaction with stakeholders, strategies for a better, cost-efficient monitoring approach for the Baltic Sea by integrating and aligning with ICOS.
Two annual reports of are available on the website; in the figure 1, the results from two cruises are presented.

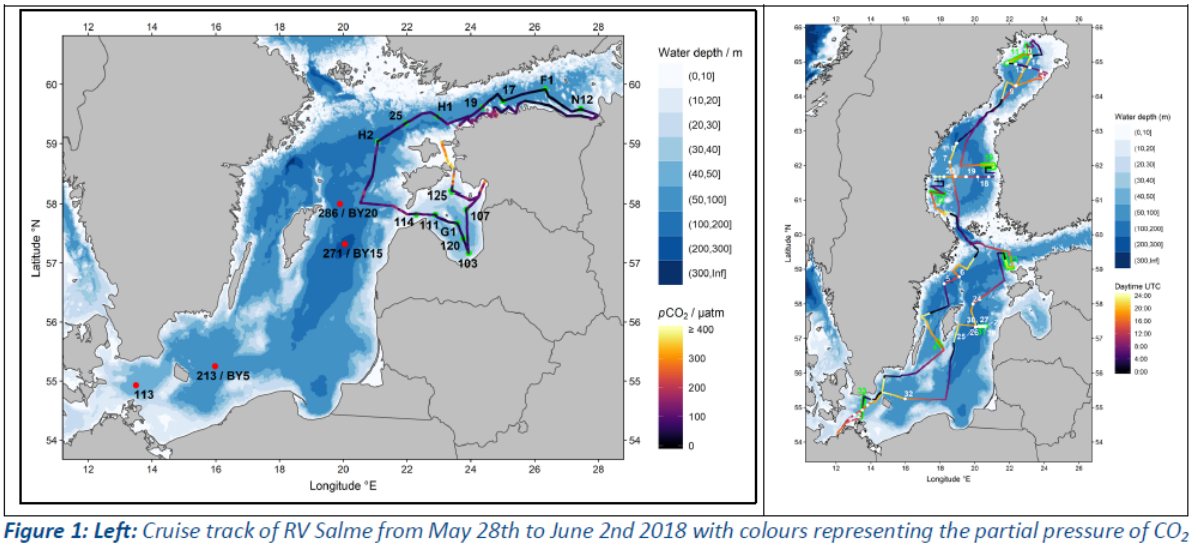

Figure 1: Left: *Cruise track of RV Salme from May 28th to June 2nd 2018 with colours representing the partial pressure of CO_2 in the surface, and stations of trace gas and carbon system sampling indicated by the red and green dots.* ***Right:*** *Cruise Track for the BONUS INTEGRAL summer cruise. The colour code of the track indicates the time of day (UTC). CTD sampling stations are indicated as white dots, ScanFish transects as green lines. Both maps with underlaying bathymetry.*

The Institute of Oceanology of the Polish Academy of Sciences is a partner in this project

Past projects:

POLNOR - The Changing Ocean of the Polar North - The Institute of Oceanology of the Polish Academy of Sciences - The aim of the project was to assess how the Arctic ecosystem will respond to the variable levels of environmental stressors as a result of the ocean warming, and the change of seawater chemistry due ocean acidification (OA) (Website of the project)

BONUS PINBAL - *Development of a spectrophotometric pH-measurement system for monitoring in the Baltic Sea.* High accurate measurements of pH in combination with other parameters are invaluable to fully describe the marine CO_2 system, to study biogeochemical processes, and to trace "ocean acidification" - Within BONUS PINBAL, a consortium of the Leibniz Institute for Baltic Sea Research, the German SME CONTROS Systems & Solutions GmbH, the University of Gothenburg and the Institute of Oceanology of the Polish Academy of Sciences will cooperatively fulfill the still required fundamental chemical work, system and software design and field testing to realize a prototype of a spectrophotometric pH-measurement system for continuous underway measurements as well as for discrete samples.

Structure and functioning of the acid-base system in the Baltic Sea - project financed by the National Science Center. The project had two basic goals:

- Improving accuracy in the calculation of pH and pCO2 for the Baltic Sea by taking into account all important peculiarities / anomalies occurring here, which will reduce the uncertainty of predicting future potential changes in the Baltic Sea pH
- Experimental study and parameterization of biogeochemical processes that may affect the functioning of the acid-base system.

Publications:

The influence of dissolved organic matter on the acid–base system of the Baltic Sea

Karol Kuliński, Bernd Schneider, Karoline Hammer, Ulrike Machulik, Detlef Schulz-Bull, The influence of dissolved organic matter on the acid–base system of the Baltic Sea, Journal of Marine Systems, 132 (2014) 106-115

PhD work of Magdalena Anna Jakubowska on *Impact of acidification of water with carbon dioxide on the physiological processes of Baltic invertebrates* from Gdańsk University, Faculty of Oceanography and Geography. These studies confirmed the hypothesis that Baltic invertebrates are resistant to water acidification with carbon dioxide. The tested species turned out to be even better adapted than expected, because in most of them no changes in measured parameters were observed.

Coral skeleton crystals record ocean acidification – research done in the Institute of Paleobiology in Warsaw (Poland) was published in the journal Nature Communications, for the first time, the relationship between physiological changes caused in corals living in the acidified ocean and changes in the organization of their skeleton on an atomic or crystallographic scale.
Ismael Coronado, Maoz Fine, Francesca R. Bosellini, Jarosław Stolarski. **Impact of ocean acidification on crystallographic vital effect of the coral skeleton**. *Nature Communications*, 2019; 10 (1) DOI: 10.1038/s41467-019-10833-6