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BRIESE Prize 2018: Focus ocean acidification – Great progress in Baltic Sea pH monitoring and more

Jens Daniel Müller from the Leibniz Institute for Baltic Sea Research Warnemünde has been awarded this year's BRIESE Prize for Marine Research. The jury honours his research on the distinctive features of ocean acidification in marginal and coastal seas. Müller used the Baltic Sea as an example to show that acidification takes place under fundamentally different conditions there than it does in the open ocean. With the advancement of a high-precision optical pH measuring method, which until now could only be used at high oceanic salinities, but which now can also be applied in less salty water, he also created the basis for making pH changes in brackish water comparable worldwide.

The BRIESE Prize for outstanding doctoral theses in marine research, which is donated by the German shipping company Briese Schiffahrts GmbH & Co. KG and is endowed with 5000 euros, has now been awarded for the 9th time at the IOW. Today's laureate Jens Müller, who came to marine research via chemistry, explains his commitment to his doctoral research topic as follows: "Already during my undergraduate studies, it became clear to me that I was particularly interested in chemical processes in nature. In addition, as an enthusiastic sailor and diver, the intactness of the oceans is close to my heart." He is therefore very keen to apply his scientific passion and curiosity to a field that focuses on how human influence on marine environments can best be observed and what kind of solutions can be found for the problems that emerge. "I am all the more pleased that this work is now being honoured with the BRIESE Prize," says Jens Müller.

Ocean acidification, which Müller investigated, using the example of the Baltic Sea, is also referred to as "the other CO_2 problem". The excessive emission of carbon dioxide caused by humans is not only a problem for the climate: CO_2 dissolves in seawater, forms carbonic acid and thus releases hydrogen ions, which lead to acidification. The decreasing pH influences almost all biochemical and biological processes in the sea. Mussels, for example, react very sensitively because the formation of their calcareous shells is more difficult in an increasingly acidic environment. Other calcareous organisms are also affected. Although ocean acidification has been the subject of research for about 20 years, it is difficult to observe: long-term measurements have shown that the pH value in the open ocean only decreases by about 0.002 units per year. In oceanography, optical pH measurement has been established to detect such small changes. It is based on the addition of the dye m-cresol purple to the water sample and its pH-dependent colour shift from violet to yellow. The colour can be determined very precisely with a photometer and converted into pH units depending on ambient salinity and temperature.

But what about the Baltic Sea? "Working together with various colleagues, I have not been able to detect an acidification trend in the data of the past 20 years – a rather remarkable result in view of the already proven acidification of the open ocean," says Jens Müller, describing the initial starting point for his doctoral project. In order to understand this, he examined two possible causes for this observation: 1) There is actually no decreasing pH trend in the Baltic Sea. 2) The data quality is inadequate with regard to measurement precision. Müller was able to show through extensive analyses of alkalinity, i.e. the acid binding capacity of seawater, that there are indeed processes in the Baltic Sea that counteract acidification. Alkalinity has been increasing since 1995, probably due to continental rock weathering, the products of which are washed by rivers into the Baltic Sea. How long alkalinity will

continue to rise and buffer acidification, however, is unknown. “It is therefore also important to rule out that the detection of acidification simply fails due to methodological shortcomings,” Müller emphasises. Currently, the routine determination of pH in Baltic Sea monitoring is based on glass electrode measurements, a method with a measurement uncertainty too large for a reliable detection of acidification trends in highly dynamic brackish water environments.

“We have therefore advanced the optical pH measurement method, which was previously only applicable for salinity levels between 20 and 40, so that it can also be used in Baltic Sea brackish water with low salinities of 5 to 20.” To this end, Jens Müller collaborated with Germany’s national metrological institute PTB (Physikalisch-Technische Bundesanstalt) in order to compare optical pH measurements taken in corresponding artificial seawater standards with measurements taken according to the metrologically defined primary method. In a next step, he tested whether hydrogen sulphide and larger amounts of organic material, both typical for brackish water ecosystems such as the Baltic Sea, are interfering with the new measurement method – which was not the case. In order to make the optical method ready for routine use at sea, the IOW researcher, together with a marine technology company and two scientific partner institutions, developed a compact operational device that has already been tested successfully and is now on the market. Müller spent a good 7 weeks at sea during 5 ship expeditions to test prototypes and subsequent generations of the instrument. By now, the Helsinki Commission for the Protection of the Baltic Sea (HELCOM) is considering to include the adapted pH measurement method into the international Baltic Sea monitoring as an official acidification indicator.

A further chapter of Jens Müller's doctoral thesis was devoted to the possible effects of acidification on mussels, which in the Baltic Sea often settle in the middle of coastal sea grass beds. He carried out this work at the GEOMAR – Helmholtz Centre for Ocean Research in Kiel. In sea grass beds, the pH-value fluctuates strongly during the day due to photosynthesis. Müller found out that the mussels are able to use the time windows with high pH to build up their calcareous shells without any problems, despite being exposed periodically to unfavourably low pH. First, this basic insight makes clear how important it is to take such natural fluctuations into account when investigating the consequences of ocean acidification. Second, the results suggest that sea grass beds should be specially protected as valuable habitats that protect many organisms from global acidification.

“Jens Müller has not only gained important new insights into acidification in the Baltic Sea; he has also succeeded in establishing an excellent integration of his research into the major international issue of ocean acidification, a highly relevant aspect of Earth system and climate change impact research,” commented Prof. Dr. Karin Lochte, member of the BRIESE Prize Jury, on this year's award ceremony. “The further development of the optical pH measurement method will be of interest to researchers worldwide. Together with Jens Müller’s excellent publications and conference contributions, his performance is absolutely compelling,” the spokeswoman of the German Alliance for Marine Research continues. “Jens Müller’s work impressively demonstrates that meticulous scientific work in the Baltic Sea can lead to results that will also be of international significance. We are delighted to be able to honour a young scientist this year, who has developed his scientific ambition through his passion for the sea. We would like to thank the jury for the careful selection of the 9th winner of the BRIESE Prize for Marine Research,” adds Klaus Küper, Head of the Research Shipping Department at the Briese shipping company.

The **BRIESE Prize for Marine Research** is awarded by the German shipping company Briese Schiffahrts GmbH & Co. KG (Leer/Ostfriesland), which is responsible for the management of medium-sized German research vessels such as ELISABETH MANN BORGESE and HEINCKE, as well as the large research vessels METEOR and SONNE. The IOW scientifically curates the award procedure. Since 2010, outstanding doctoral theses in marine research are awarded annually, which are closely related to the use of research vessels and/or the use and development of technology for data collection at sea.

Information on the winner of the BRIESE Prize 2018:

Dr. Jens D. Müller received his doctorate in June 2018 from the Faculty of Mathematics and Natural Sciences at the University of Rostock. Original title of the thesis: "OCEAN ACIDIFICATION IN THE BALTIC SEA: INVOLVED PROCESSES, METROLOGY OF pH IN BRACKISH WATERS, AND CALCIFICATION UNDER FLUCTUATING CONDITIONS" (available at: https://doi.org/10.18453/rosdok_id00002303) *Grade: with distinction ("summa cum laude"); Supervisor: Prof. Dr. Gregor Rehder, Professor of Marine Chemistry and Deputy Head of the IOW Marine Chemistry Section*

Jens Daniel Müller (born 1986) turned to marine research only after his bachelor's degree in chemistry at the University of Marburg. He studied Biological Oceanography at the GEOMAR in Kiel (2010 – 2012) and completed his master thesis on the ecology of Chilean mussels at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven. In his PhD thesis (2014 – 2018) at the IOW he focused on the Baltic Sea and the biogeochemistry of its CO2 cycle. In this context, in addition to publications in scientific journals, he jointly wrote the monograph "Biogeochemical transformations in the Baltic Sea: Observations through carbon dioxide glasses", together with his IOW colleague Dr. Bernd Schneider, which was published in 2017 by the renowned Springer science publishing house. Since July 2018, Müller has been a postdoctoral fellow in the IOW working group "Trace Gas Biogeochemistry". In the course of his career he has received various awards and scholarships, most recently the Early Career Grant of the National Geographic Society.

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