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Can 'farting' copepods affect the climate?
IOW expedition on methane production of zooplankton

Methane is an important greenhouse gas with a strong potential to impact climate development on earth. There are, however, huge gaps in the knowledge concerning individual sources of methane and to which extent they have an actual impact on the atmosphere. On August 6, 2016, a research team under the lead of the Leibniz Institute for Baltic Sea Research Warnemünde (IOW) set out aboard the research vessel ALKOR for a 3-week cruise into the central Baltic Sea to examine for the first time systematically, whether certain, at times very abundant copepods and their microbial gut flora produce substantial amounts of atmospherically effective methane.

IOW geologist Oliver Schmale is the expedition's chief scientist. He is an expert in marine methane cycles and exchange processes at the ocean-atmosphere interface. "Even though methane only occurs in traces in the atmosphere, it is 25 times as potent as the greenhouse gas CO2. Therefore it is very important to identify methane sources and to understand in as much detail as possible, how much is generated under which conditions and how much actually reaches the atmosphere," says Schmale. Methane is produced by certain microorganisms in anoxic environments, usually during the degradation of biomass. About half of the global methane is generated by decomposition processes in swamps and bogs, which are the largest known methane source. But also microbial processes in the gut of herbivores contribute substantially: Ruminants, especially farming livestock such as cattle and sheep, as well as termites produce about 30 % of the world's total methane production of 500-600 billion kilograms per year.

"We are far from knowing all sources of atmospheric methane, which is relevant for climate development. The role of marine environments, for instance, still is considered to be small," explains expedition leader Oliver Schmale. There is methanogenesis in anoxic sediments at the seafloor, but due to several physical and biological processes the total amount of methane that reaches the water surface and is emitted into the atmosphere is small, the IOW scientist clarifies. "However, on earlier research cruises we discovered conspicuously high concentrations in comparably shallow, very well oxygenated areas of the Baltic Sea," says Schmale. The phenomenon is also known from other oceans and has been called the "oceanic methane paradox" as no definite explanation exists to date. Precisely, where the elevated methane concentration occurred, the IOW researchers detected high densities of zooplankton, especially of the copepod *Temora longicornis*, typical for the Baltic Sea but also common in other marine environments. Natalie Loick-Wilde, the project's zooplankton expert and also aboard the ALKOR, adds: "Earlier research suggests, that this species excretes methane and that the amount is influenced by its algal food. Now we want to find out, whether we have identified – at least for the Baltic Sea – the 'culprit' behind the methane paradox." Furthermore, copepods probably are the most numerous multicellular organisms on earth with an annual global carbon biomass exceed-

ing that of termites by a factor of two. “It is therefore very worthwhile, to take a good look at these tiny crustaceans to find out, if they indeed produce substantial amounts of methane – especially since they release the greenhouse gas in comparatively shallow water depths, where it can reach the atmosphere and become relevant for climate processes,” Oliver Schmale concludes.

As chief scientist, Schmale is coordinating the 11-member research team of the ALKOR expedition, which consists of nine IOW scientists and two biogeochemists from the University of Göttingen. The cruise, which started in Warnemünde, will circumnavigate the island of Gotland and will return to its departure point on August 25, passing 11 work stations on the way. Its scientific program includes extensive sampling, on-board experiments as well as subsequent genetic analyses. One focal point of the scientists is to get an overview, on how common the methane paradox is in the Baltic Sea. The ship’s course therefore will deliberately pass areas with different environmental conditions, for instance one of the intensive cyanobacterial blooms that are typical for this time of year. Other cruises will do follow-up investigations regarding this phenomenon during other seasons. Furthermore, the scientists want to check systematically, if the methane anomalies are indeed correlated with certain zooplankton species. Incubation experiments with natural zooplankton samples sorted by species will be carried out, to see whether other species besides *Temora longicornis* excrete methane and if algal food influences the amount of their methane production. By means of matter flux balances, the researchers want to find out, if zooplanktonic methane production is high enough to explain the detected elevated concentrations at the methane paradox sites. As methane production in animal guts always depends on their microbial gut flora, detailed genetic studies will be carried out, to find out, which methanogenic microbes inhabit zooplanktonic intestines and whether there are species-specific differences in gut flora and their methanogenic activity.

The ALKOR expedition is part of the three-year project “Zooplankton associated methane production (ZooM, DFG SCHM 2503/5-1)”, which started in December 2015 and is funded by the German Research Association (DFG). Principal investigators at IOW besides Oliver Schmale are Matthias Labrenz (microbiology) and Natalie Loick-Wilde (zooplankton).

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