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Water conditions and geochemistry in northern Adriatic anoxia-prone areas and response of benthic faunas to oxygen deficiencies

Martin Zuschin (1), Bettina Riedel (2), Michael Stachowitsch (2), and Branko Cermelj (3)

(1) Department of Palaeontology, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria (martin.zuschin@univie.ac.at), (2) Department of Marine Biology, University of Vienna, Althanstrasse 14, A-1090 Vienna, Austria, (3) Marine Biology Station, National Institute of Biology, Piran, Slovenia

One predicted effect of global climate change, specifically global warming, is the increase in the temperatures and stratification of shallow coastal and estuarine systems. This, coupled with ongoing anthropogenic eutrophication, will exacerbate hypoxia and benthic mortalities, significantly damaging these critical marine ecosystems. These phenomena are particularly severe on sublitoral soft-bottoms such as the poorly sorted silty sands at the study site in the northern Adriatic Sea. We deployed a specially developed underwater chamber to artificially induce anoxia in situ. Our Experimental Anoxia Generating Unit (EAGU) is a large plexiglass chamber that combines a digital camera with oxygen/hydrogen sulphide/pH sensors along with flashes and battery packs. The unit can be deployed for up to five days to autonomously generate oxygen crises and quantify both physico-chemical parameters and benthic responses. The system is initially positioned in an "open" configuration (open-sided aluminium frame) over the benthic fauna ("control" experiment). After 24 h the EAGU is switched to its "closed" configuration (plexiglass enclosure) and repositioned over the same assemblage. In this contribution, we focus on the natural oxygen content, temperature and pH of bottom waters during summer, the course of oxygen decrease during our experiments and the onset of H2S development. Oxygen content of the bottom water, a few centimetres above the sediment-water interface, ranges from $\sim$3.5-8 but is mostly between 4-6 ml l-1 during July to September of the study periods (2005 and 2006) and decreases to zero within $\sim$1-3 days after initiation of our experiments. In parallel, H2S starts to develop at the onset of anoxia. Water temperatures at the bottom were stable during experiments and ranged from 18.5°C to 21.4°C, but pH decreased from 8.3 to 8.1 at the beginning to 7.9 to 7.7 at the end of the experiments. Sediment profiling indicates that the diffusive benthic boundary layer is approximately 2.5 mm thick and that oxygen values decrease from $\sim$2 ml l-1 3.5 mm above the sediment water interface to virtually zero at the interface. PH-values in 2 mm depth decrease from 8.15 to 7.6 within the first 10 h of the experiment. This indicates that the most reactive organic matter is decomposing in the uppermost few mm of the sediment. These data can be related to behavioural responses and mortality sequences of benthic faunas, including echinoids, crustaceans, molluscs and anemones. Beginning hypoxia ($\leq$2.0 ml l-1 DO) elicited escape patterns such as increased horizontal and vertical locomotion of animals. Moderate hypoxia ($\leq$1.0 ml l-1 DO) triggered species-specific sublethal effects such as arm-tipping in ophiuroids or extension from the sediment in sea anemones. At severe hypoxia ($\leq$0.5 ml l-1 DO) infaunal organisms began to emerge and first mortalities occurred. Some crustaceans and echinoderms are among the first to die, but sea anemones and large gastropods can even survive the onset of hydrogen sulfide.