Geophysical Research Abstracts
Vol. 12, EGU2010-5781, 2010
EGU General Assembly 2010

Marine anoxia: quantifying short- and longer-term responses in situ

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Hypoxia and anoxia are key threats to modern shallow coastal ecosystems worldwide and both their frequency and intensity have increased dramatically over recent decades. In the Adriatic Sea, hypoxic events may affect up to 3000 km^2 of the seafloor, leading to extensive mass mortalities of the benthos. The onset of these catastrophic events, however, is hard to predict. Our research group therefore deployed an experimental anoxia generating unit (EAGU), a benthic chamber that creates and fully documents small-scale anoxia in situ. The instrument combines photo-documentation with detailed chemo-physical analyses (sensor array) and allows the analysis of the behaviors and mortalities of benthic organisms during and after oxygen depletion.

We focus here on three aspects:
· reactions to hypoxia/anoxia
· the effect on a key species
· immediate post-anoxia processes

The responses to declining oxygen values and/or to increasing duration of anoxia were the emergence of infauna, atypical or escape behaviors of epifauna, and mortalities. The documented behaviors and mortalities of the selected species were correlated to five oxygen categories: normoxia (>2.0 ml O2 l-1), beginning hypoxia ($\leq$2.0-1.01 ml O2 l-1), moderate (1.0-0.51 ml O2 l-1) and severe hypoxia (0.5-0.01 ml O2 l-1) and anoxia. The results show considerable differences in tolerance to oxygen depletion from species to species.
The key organisms chosen here are hermit crabs. They play a crucial role in the benthic community, in particular through their symbioses with other organisms: their heavily overgrown shells represent mobile aggregations of benthic organisms. The crabs help structuring the overall community because the encrusting species survive when the crabs exchange old for new shells. Hermit crabs changed their behavior during decreasing oxygen concentrations and most of them ultimately abandoned their shells.
The sequence of post-anoxia events revealed that, analogous to commercial trawling damage, the moribund/dead organisms attracted predators/scavengers, which removed most of the dead material within days. Fish (Gobius niger; Diplodus vulgaris, Serranus hepatus) were the first post-anoxia visitors (after 9 min); their numbers gradually decreased during the deployment, suggesting that most of the suitable dead material was consumed early. The second and third groups arriving were hermit crabs and gastropods, respectively. They fed mainly on remains not utilized by fishes (e.g. sponges, ascidians).
The results provide an opportunity to better interpret benthic responses to anoxic events in Earth's history.