DEAD ZONES: a future coastal scenario for climate change

B. Riedel 1*, A. Haselmair 1, M. Stachowitsch 1, M. Zuschin 2

INTRODUCTION

Coastal zones are among the world’s most diverse and productive environments (ref. 1). Global warming – higher temperature, increased stratification, low oxygen concentrations on the sea floor – will make many shallow marine coastal and estuarine ecosystems more vulnerable to low dissolved oxygen (DO) events. Anthropogenic eutrophication will further exacerbate hypoxia and benthic mortalities (ref. 2).

The Northern Adriatic Sea, characterized by epifaunal communities in the form of dense aggregations – so-called multi-species clumps or bioherms (ref. 3) – is also subject to repeated seasonal low DO events, leading to a series of benthic mortalities whose extent and severity appear to be increasing.

We developed a state-of-the-art underwater chamber (EAGU; ref. 4) that documents the in situ behaviour, intra-, and interspecific interactions (e.g. predation) as well as mortality of selected macrofauna assemblages during artificially induced anoxia. This provides information on the sub-lethal effects and the mortality sequence of selected taxa. We expect to better evaluate the status and stability of benthic systems here and elsewhere.

METHOD

The centerpiece of the EAGU (Experimental Anoxia Generating Unit) is an instrumental lid housing a time-lapse camera and flashes with an array of sensors (two oxygen, one temperature-, one pH- and one hydrogen sulfide sensor) and a datalogger. It is positioned atop two different bases:

- first step: EAGU is positioned in its “open” configuration (50 x 50 x 50 cm aluminium frame & lid; Fig. 1 a) over the selected bioherm (24 h). Normoxic situation is documented.
- second step: EAGU is switched to “closed” configuration (plexiglass chamber; Fig. 1 b) over the same bioherm (ca. 48–72 h). Response during hypoxic/anoxic conditions is documented.

Evaluated parameters via image analysis:

- onset of unusual behaviours, i.e. atypical postures
- appearance of cryptic species, e.g. polychaetes, shrimp
- emergence of infauna organisms
- onset and course of mortality
- colour changes of organisms and sediment
- critical O2 and H2S-concentrations on class and/or species level

RESULTS

All experiments yielded a series of distinct behavioural responses to decreasing oxygen concentrations. First indications of stress generally appeared when DO dropped below 2 ml/l (Fig. 2). Some species showed typical stress reduction patterns, i.e. decreased or increased (Fig. 3 a) activity. At 1 ml/l DO, sublethal reactions (ref. 5) included “arm-tipping” of brittle stars (Fig. 3 b) and the emergence of infaunal organisms (i.e. polychaetes or irregular echinoids). Below 0.5 ml/l DO, first mortalities (Fig. 3 c) occurred. Echinoderms and crustaceans were the most sensitive taxa, whereas sea anemones were the most resistant taxa (Fig. 3 d), surviving up to 55 h of anoxia and 120 µM l-1 H2S.

The EAGU enables us to:

1. document natural behaviour of benthic fauna
2. define series of behavioural responses of individual species with decreasing oxygen concentration
3. document inter-specific behavioural interactions
4. determine sequence of mortality
5. help define “tolerant/resistant” and/or indicator species (for oxygen crises)

Acknowledgements

Financial support by the Austrian Science Fund (FWF; project# P17655-B03). Thanks to Valentin Perlinger (workshop), Rudolf Machan (electronics), Gregor Edler (photography), Sabine Maringer (chemistry), Lude Cecolma (font maintenance), Alexandra Haselmair, Philipp Steiner and Ivo Gallmetzer (equipment). All experiments yielded a series of distinct behavioural responses (ref. 5) included “arm-tipping” of brittle stars (Fig. 3 b) and the emergence of infaunal organisms (i.e. polychaetes or irregular echinoids). Below 0.5 ml/l DO, first mortalities (Fig. 3 c) occurred. Echinoderms and crustaceans were the most sensitive taxa, whereas sea anemones were the most resistant taxa (Fig. 3 d), surviving up to 55 h of anoxia and 120 µM l-1 H2S.

The EAGU enables us to:

1. document natural behaviour of benthic fauna
2. define series of behavioural responses of individual species with decreasing oxygen concentration
3. document inter-specific behavioural interactions
4. determine sequence of mortality
5. help define “tolerant/resistant” and/or indicator species (for oxygen crises)

Fig. 1: “Before and after” photos of experiment 12, Piran, Slovenia, 10 – 14 Oct. 2006. Last photo of (a) “open” configuration- and (b) “closed” configuration period. DO and H2S measured 2 cm above sediment surface. Dead emerged polychaete (P), irregular sea urchin (I) and ophiuroid (O); gastropod (G) moved to higher substrate, alive; bivalve (B) gaped and with retracted mantle tissue; hermit crab (H) extended from shell, dead; holothurian (Ho) initially expanded, then collapsed; dead brittle star (Br) on sediment. Serpulid tube worm (S) retracted into tube, dead. Ascidiun (A) “bulldozed” by an emerging irregular sea urchin, alive. Note dark colour of sediment surface.

Corresponding author
bettina.riedel@univie.ac.at

1 Department of Marine Biology, Faculty of Life Sciences, Department of Paleontology, Faculty of Earth Sciences, Geography and Astronomy, AU Univ. of Vienna, Althanstr. 14, 1090 Vienna, Austria

2 Department of Paleontology, Faculty of Earth Sciences, University of Innsbruck, Innsbruck, Austria

References