UDEMM: ÖkoToxEMM - Blue mussels (*Mytilus spp*.) transplanted at a German munition dumping site in the Baltic Sea for biomonitoring of TNT and degradation products

Jennifer S. Strehse, Daniel Appel, Hans-Jörg Martin and Edmund Maser

Institute of Toxicology and Pharmacology for Natural Scientists, University Medical School Schleswig-Holstein, Campus Kiel, Brunswikerstr. 10, D-24105 Kiel, Germany

introduction

The seas worldwide are threatened by a new source of pollution. Millions of tonnes of all kind of munitions that have been dumped after World War II will corrode and start to leak toxic explosives like trinitrotoluene (TNT) and metabolites, e.g. 2- and 4-aminodinitrotoluene (2- and 4-ADNT) and 2,4-diamino-6-nitrotoluene (2,4-DA-6-NT). Conventional explosives represent a hazard not only for marine ecosystems but also for humans. Besides the risk of detonation with increased human access (fisheries, cable constructions, wind farms and pipelines), TNT and its metabolites may enter the marine food chain and directly affect human health. In TNT-exposed humans, notable toxic manifestations have included aplastic anaemia, toxic hepatitis, cataracts, hepatomegaly and liver cancer. Importantly, these explosives are also known for their carcinogenicity. Since free water concentrations of explosive chemicals at dumped munition sites are low, we use the mussel *Mytilus edulis* as a biomonitoring system (Fig. 1). Mussels are active filtrators and may bioaccumulate nitroaromatic compounds. As part of a national consortium that is funded by governmental sources (BMBF), the mussels were exposed by divers directly at the sea mines in a burdened area (Kolberger Heide, Germany) (Fig. 2).

material and methods

Two bags filled with 20 mussels each were placed in different distances to a mine mound (Fig. 3) or at 0 m and 1.0 m above loose hexanite (Fig. 4). After 3 months of exposure time, the mussels were collected and immediately put on dry ice. In our lab, whole mussel tissue was homogenized, extracted with acetonitrile, and analyzed for explosive chemicals by GC/MS-MS analysis.

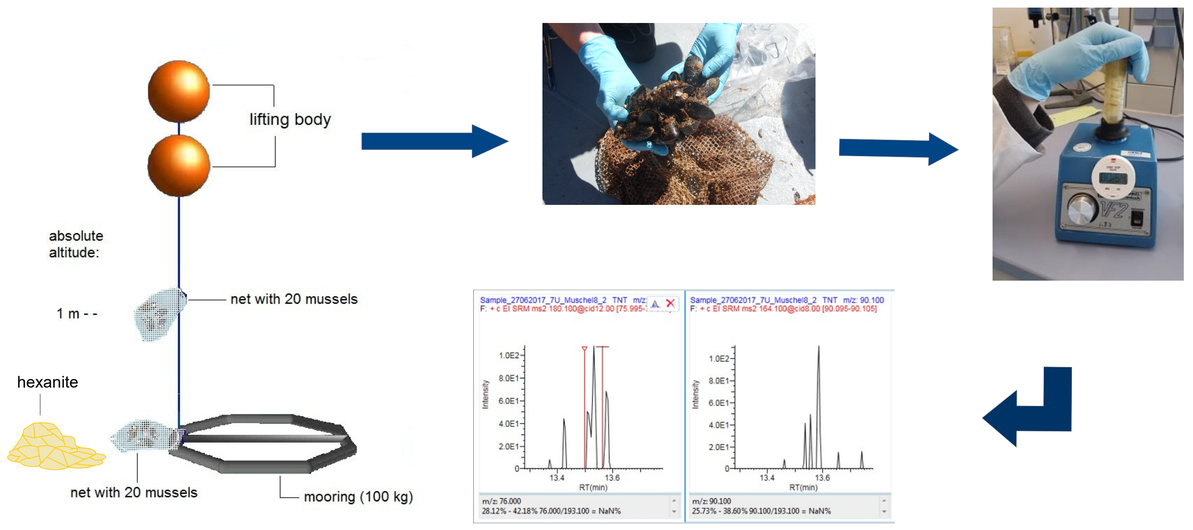


Figure 1: Working steps. Design of the used mooring with deployed mussels, blue mussels after recovery, processing of the samples in the laboratory (on the picture: extraction of mussel tissue with acetonitrile), qualitative and quantitative analyzing with GC/MS-MS.

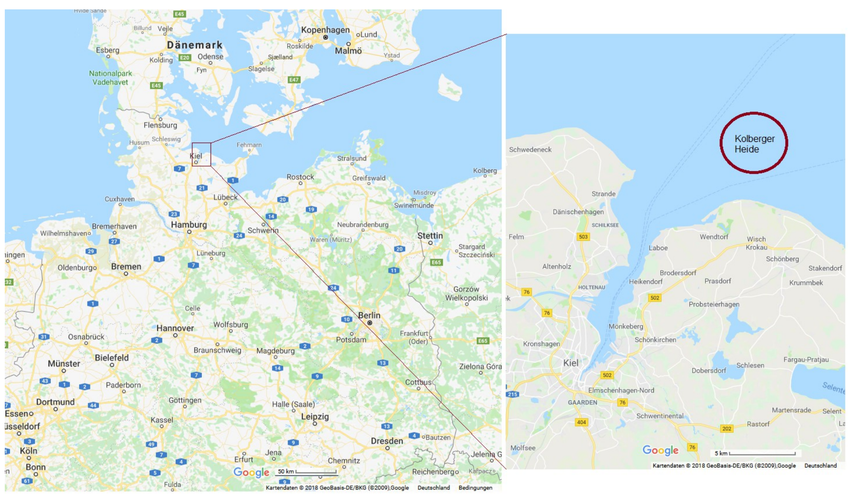


Figure 2: The study area Kolberger Heide is a section of the western Kiel Bight at the entrance to Kiel Fjord, Germany, with a size of approximately 1.260 ha, located in a distance of three to five nautical miles to the shoreline.

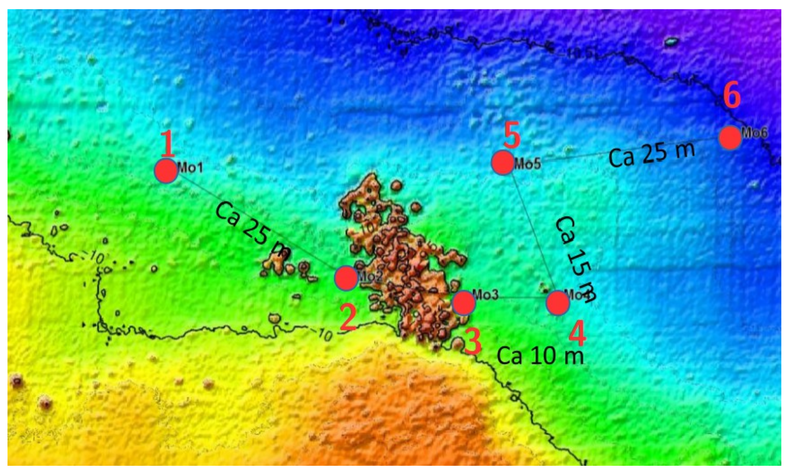


Figure 3: Mound of app. 120 moored mines in the study site. Red dots indicating mooring positions. © M. Kampmeier/Geomar

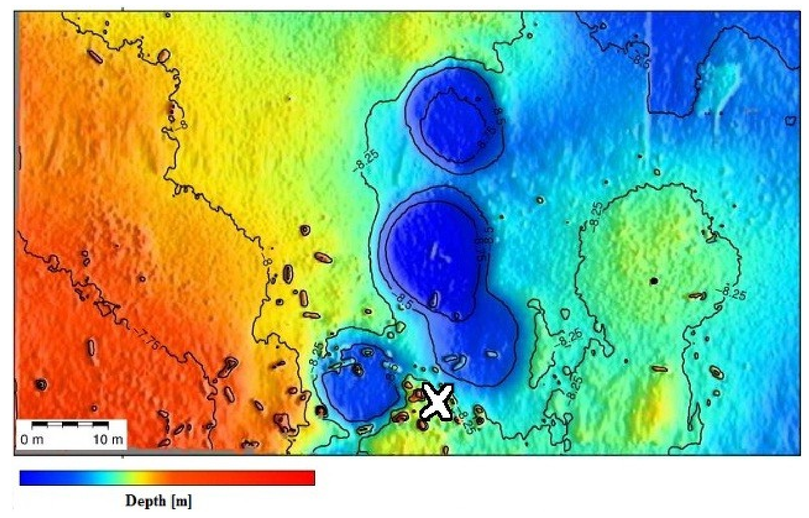
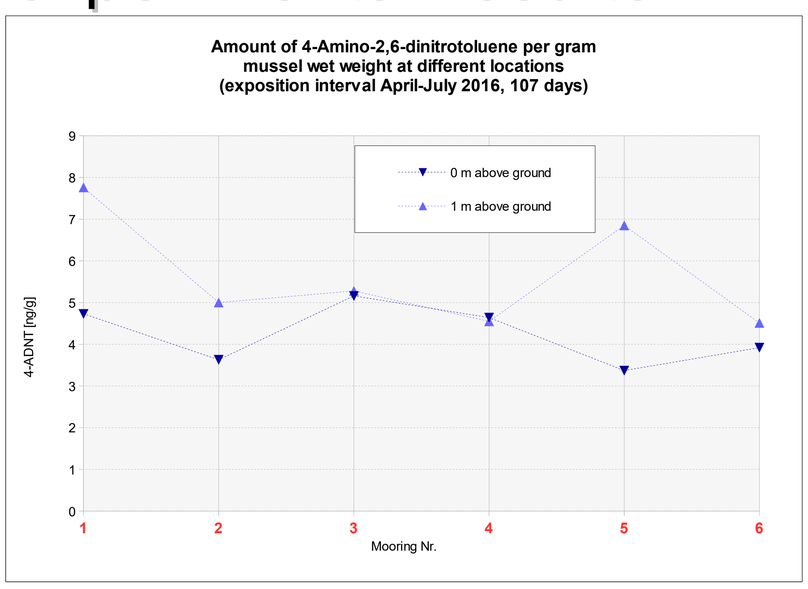


Figure 4: Position of the mooring (indicated by a white cross) near craters caused by controlled detonations during delaboration work in the southern part of the study area. In addition to discarded military munitions, unexploded ordnances like hexanite have been spread in this area. © M. Kampmeier/Geomar

experimental results



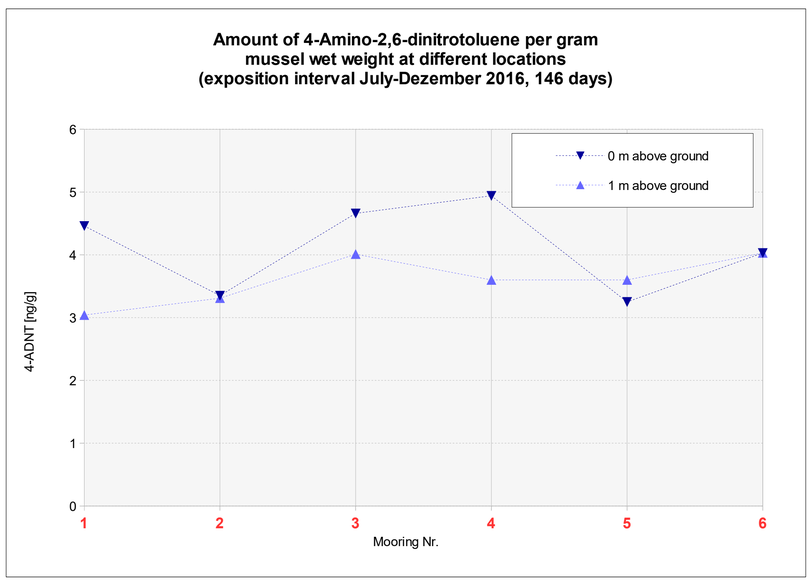


Figure 5a+b: Mean values (n = 3 – 6) of 4- ADNT measured in the tissue of *Mytilus spp.* at different mooring positions around the mine mound at the Kolberger Heide (see Fig. 3) from the first and second exposure period.

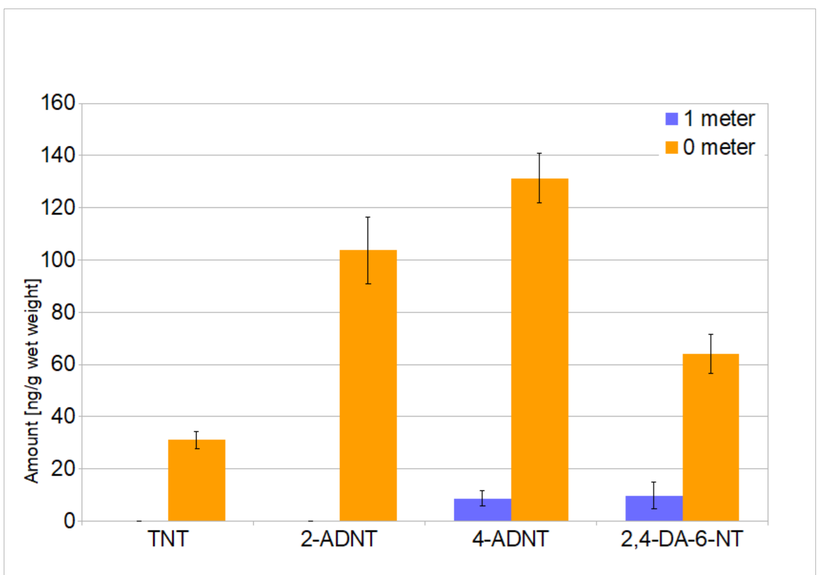


Figure 6: Mean values (± SD) of TNT, 2-amino-4,6-dinitrotoluene (2-ADNT) and 4-amino-2,6-dinitrotoluene (4-ADNT) measured in the tissue of exposed *Mytilus spp.* (n = 8 from 0 meter, n= 7 from 1 meter) and 2,4-diamino-6-nitrotoluene (2,4-DA-6-NT) (n= 9 from 0 meter, n = 12 from 1 meter) above the explosive material (Fig. 4).

summary

- This is the first study using blue mussels M. edulis as an active biomonitoring system for TNT and its metabolites in a free field experiment in a burdened area (Strehse et al., 2017; Appel et al., 2018).
- With this biomonitoring system, we show that blue mussels accumulate TNT and the metabolites 2-ADNT, 4-ADNT and 2,4-DA-6-NT in their tissues (Fig. 5+ 6).
- Our results indicate that these toxic explosives accumulate in the marine biota resp. in the marine food chain, thereby posing a possible risk to the marine ecosphere and human sea food consumer.

J.S. Strehse, D. Appel, H-J. Martin, E. Maser, Biomonitoring of 2,4,6-trinitrotoluene and degradation productsin the marine environment with transplanted blue mussels (*M. edulis*), Toxicology 390 (2017), 117-123.

D. Appel, J.S. Strehse, H-J. Martin, E. Maser, Bioaccumulation of 2,4,6-trinitrotoluene (TNT) and its metabolites leaking from corroded munition in transplanted blue mussels (*M. edulis*), Marine Pollution Bulletin 135 (2018), 1072-1078.

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