MERCURY FROM THE WRECKAGE OF A SUNKEN ANCIENT MERCHANTMAN (GNALIC, BIOGRAD NA MORU, CROATIA): A LONG-TERM DANGER TO THE MARINE LIFE

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Abstract
In the cargo of the ship that sank in the sixteenth century near the islet of Gnalic, Croatian Eastern Adriatic, mercury (500 - 1000 kg) was present in various forms: elemental mercury, ore cinnabar (HgS), and vermillion powder (HgS, opaque red pigment). In order to determine the potential impact on the marine life mercury was analysed in different organisms (fishes, shellfishes, molluscs, crabs and echinoderms) collected and caught around the wreck. Elevated to extremely high mercury concentrations in the investigated organisms indicate the high risk of mercury loads to the marine environment and the need to remove it from the archaeological site.

Keywords: Adriatic Sea, Mercury, Pollution, Fishes, Mollusca

Introduction
In November 1583 a merchant ship *Gagliana Grossa* transported a variety of merchandise from Venice (Italy) to Constantinople (Istanbul, Turkey) [1]. For an unknown reason (fire or severe weather) the ship with the full cargo sank at twenty-five meters of depth near the islet of Gnalic (Fig. 1). It is assumed that surprisingly large quantity of mercury in the ship's cargo were meant for medical and cosmetic purposes. Also, powdered sulphur in cargo indicates the possibility of its use in the vermillion production process by chemical coupling of Hg and S. The wreck was discovered in 1967, while the study of mercury impact on the environment began in 2013.

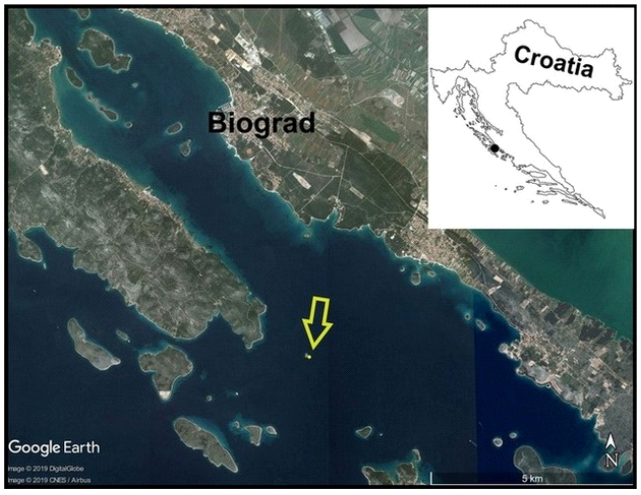

Fig. 1. Study area

Methods
Mercury was analysed in nine organisms (Fig. 2) caught at the site of the archaeological excavation. *Scorpaena scofa, Scorpaena notata, Scorpaena porcus, Sepia officinalis* and *Maia squinado* were caught in the fishing net, while *Echinaster sepositus, Holothuria tubulosa, Paguristes eremita and Murex trunculus* were collected by scuba divers at the sea floor. As a reference, the same species from the other localities that were not burdened with mercury, were taken and analysed. Moreover, the degree of mercury pollution of the examined organisms was determined by comparing the results obtained to the results of organisms from the Kaštela Bay, well known for large quantities of mercury which have been discarded for decades in the sea in the close vicinity of the former chlor-alkali plant [2]. All samples were digested with a mixture of nitric and perchloric acid by a hot plate method. Mercury analyses were performed by cold vapour atomic absorption spectrometry (CVAAS) with detection limit of 0.001 mg kg^{-1}, for solid samples [3].

Results and conclusions
The level of mercury content in organisms clearly shows their contamination, which was noticed in *Scorpaneidae* especially, as they are predators of sedentary and solitary behaviour. In *Scorpaena notata* (11 cm, 64 g) 170 and 45 mg kg^{-1} of Hg was found in liver and muscle, respectively. That was two order of magnitude higher compared to the corresponding organism of similar biometric characteristics from Šibenik archipelago (Croatian middle Adriatic). Identical relationship was also found with *Murex trunculus* and *Maja squinado* compared to the same species from unpolluted part of Šibenik Bay. Hg amounts in *Echinaster sepositus* and *Holothuria tubulosa* from Gnalic location were up to 60 times higher compared to those from Dubrovnik pristine localities. It is very significant that the results of mercury analyses in these organisms show even higher values than the values found in various organisms from Kaštela Bay, notorious regarding mercury pollution. As a part of the sunken ship's cargo, mercury has been a threat to the marine environment for centuries. Recently, mercury has been driven even more by archaeological excavations, that have transferred it from the deeper layers of the sea floor toward surface from where Hg is spreading further. That is why removing of mercury from the Gnalic site is an imperative.

Fig. 2. Studied organisms: *A Scorpaena porcus, B Scorpaena notata, C Sepia officinalis, D Scorpaena scrofa, E Echinaster sepositus, F Murex trunculus, G Maja squinado, H Holothuria tubulosa, I Paguristes eremita*

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