Abstract

Over centuries of human activity at sea various man-made structures e.g. oil platforms, shipwrecks and wind turbines became an inherent element of the marine environment. As a result of rapid development of the offshore wind industry during the last three decades the number of anthropogenic structures at European Seas grew substantially. With its wind potential estimated at approximately 6000 wind turbines by the year 2050 the Baltic Sea may also face a wide-spread construction of man-made structures in a relatively short time. This may affect various components of the marine environment including macrozoobenthos.

The taxonomic composition of macrobenthic assemblage depends on the type of sediment. Soft bottom made of sand or mud provides a suitable habitat for species that live partially or wholly within sediment. On the other hand hard substrate e. g. bedrock, concrete or metal is impenetrable by infaunal species, but provides a solid foundation for sessile epifaunal species to attach to. Hard substrate macrobenthic assemblages are often characterized by higher species richness and density than their soft bottom counterparts. This is caused by high density of sessile filter-feeding species i.e. mussels, barnacles and various cnidarians. They create a multi-layered, three-dimensional structure over an otherwise featureless flat surface. Such structures can be inhabited by numerous mobile species of crustaceans, polychaetes and gastropods.

Considering the significant difference in properties between artificial hard substrate and natural soft bottom, an introduction of man-made structure into an environment made predominantly of soft sediments may significantly alter taxonomic composition of the local macrobenthic assemblage. The following thesis aimed at providing a comprehensive study of potential impacts of man-made structures on macrobenthic assemblages in the Baltic Sea. Three research problems relevant for biodiversity conservation in this brackish, species-poor environment were chosen.

Because of the relatively low species richness and diversity of the Baltic Sea, any process that could potentially enhance local diversity is worthy of investigation. In the first study included in the thesis benthic communities inhabiting natural and artificial hard substrate in the Gulf of Gdańsk were compared in order to test **hypothesis whether an artificial structure presents a surrogate for natural rocky substrate and supports equal benthic communities in terms of**

their taxonomic composition, abundance, biomass as well as structural and functional diversity.

One of the most frequently raised potential negative impacts of man-made structures is that they may facilitate introduction and secondary spread of non-indigenous species. The issue of non-native species is particularly relevant for the Baltic Sea, as it is highly susceptible to biological invasions due to its estuarine character. The study included in the thesis involved a comparison of the abundance and number of non-native species between natural and artificial hard substrates in the Gulf of Gdańsk in order to test the **hypothesis that the artificial substrate offers more favorable habitats for non-indigenous organisms than natural hard bottom.**

Hard bottom benthic communities are often characterized by high abundance and biomass. It has been reported that large density of filter-feeding organisms may result in an increased deposition of organic matter in the vicinity of an artificial structure. To a certain extent it may increase the food source for some macrobenthic species. However an excess of organic matter could lead to diminished oxygen concentration near the bottom and negatively affect benthic organisms. As the Baltic Sea is already strongly affected by hypoxia and anoxia, a potential extension of these phenomena requires investigation. The third study included in the thesis involved a comparison of oxygen concentration and soft bottom benthic assemblages at varying distance from artificial structure in order to test the **hypothesis whether it can lead to a significant decrease in oxygen concentration and in consequence negatively affect benthic invertebrates.**

Sampling was conducted at three sites in the Gulf of Gdańsk from July 2015 to November 2017. Macrobenthic samples were collected at three different types of substrate: artificial hard substrate provided by 70-year old man-made structures, natural hard substrate provided by boulders originating from eroded cliffs and natural sandy bottom near one of the man-made structures. Samples at artificial substrate were collected at several depths (0, 2, 4 and 8 m). Soft bottom assemblages were sampled 1, 7 and 50 m away from a man-made structure. Long-term data on water temperature and oxygen concentration were collected using data loggers at the three distances.

The obtained results revealed that the macrobenthic assemblage inhabiting artificial substrate is not a surrogate for the natural hard substrate community. The assemblage at artificial structure was characterized by lower species richness but higher biomass. Overall functional

diversity of macrozoobenthos was relatively low at both types of substrate due to a high dominance of traits expressed by sessile filter-feeding species.

The direct comparison of assemblages between natural and artificial substrate at the same depth did not indicate that non-native species preferred artificial structure over natural substrate. The average richness and relative abundance of non-native species was higher at natural substrate than at artificial structure. However individual non-indigenous species were found in greater numbers at lower depths where only artificial substrate was present.

An oxygen depletion near the structure was observed. The five-month average at 1 m was 0.6 mg · L^{-1} lower compared to 7 and 50 m away from the structure. The monthly average was lower at 1 m compared to the two other sites by up to 1.0 mg · L^{-1} in September, October and November of 2017. The highest observed difference in single measurements between 1 m and the other sites was 3.7 mg · L^{-1}. However the negative impact on oxygen concentration close to the structure was not reflected in soft bottom macrobenthic assemblage. Taxonomic richness, abundance and biomass of benthic macrofauna were generally similar or higher at the two sites close to the structure compared to 50 m away.

In conclusion the impact of man-made structure on macrobenthic assemblages was reflected mainly by their enhanced density and biomass on the structure itself and at nearby soft bottom. A positive impact on biodiversity is debatable as the community was heavily dominated by few species and did not provide a surrogate for natural hard substrate assemblage. Moreover the provision of suitable habitats for non-native species particularly at lower depths is a potential threat for biodiversity. High density of macrofauna on the structure resulted in an oxygen depletion in its vicinity, but not to such an extent, that would negatively affect the macrofaunal assemblage.