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Seasonality in vegetation biometrics and its effects on sediment characteristics and meiofauna in Baltic seagrass meadows

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ABSTRACT

Seagrass meadows can act as ecosystem engineers, i.e., organisms that modify the availability of resources to other organisms. However, their possible positive impacts depend on the characteristics of the vegetation, and these can vary strongly seasonally. This study assesses seasonal variability in macrophyte taxonomic composition and seagrass biometrics in the temperate Baltic Sea eelgrass meadows. We hypothesize that the anticipated strong seasonality in vegetation cover induces parallel seasonal changes in seagrass engineering effects as indicated by changes in sediment characteristics and meiozoobenthic abundance, composition and diversity. Macrophytes, sediments, and fauna were sampled at two locations in the Puck Bay from vegetated bottoms and bare sands five times in one year. *Zostera marina* vegetation occurred throughout the year and showed strong seasonality with the highest values of shoot density, leaf length, and biomass in July (202.3 ± 30.0 95% CI shoots m^{-2}) and the lowest in March (55.4 ± 15.0 shoots m^{-2}). POC was significantly higher in vegetated sands, and these effects were evident throughout the study period regardless of variability in macrophyte vegetation. The density and diversity of meiofauna did not differ between the seagrass beds and bare sands even in summer months when vegetation was best developed. The lack of an effect of the seagrass meadows on the meiofauna can be explained by the relatively low shoot density and biomass of the studied seagrass meadows and/or higher macrobenthic predation on the vegetated bottom compared to bare sands. However, both the canopies of macrophytes and the effects of the vegetation on benthic systems could increase substantially over the course of the gradual, natural restoration of the seagrass meadows.

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1. Introduction

Ecosystem engineers are defined by Jones et al. (1994) as 'organisms that directly or indirectly modulate the availability of resources to other species, by causing changes in physical state of biotic or abiotic materials'. A classic example of a marine ecosystem engineer is seagrass that can modify water flow regimes and sedimentation of particles thus influencing food supplies for benthic organisms (Hemminga and Duarte, 2000). Seagrasses also play a role as habitat-forming organisms since they create three-dimensional structures in the seabed architecture, provide shelter and substrata for benthic species, and are a direct food source for grazing invertebrates. Seagrass beds are one of the most productive and diverse systems in marine coastal waters (Hemminga and Duarte, 2000). In European waters, as well as on a global scale, seagrass meadows are regarded as one of the most endangered marine habitats (Airoldi and Beck, 2007). In the southern Baltic, the severe decline in *Zostera marina* meadows was observed in the second half of the 20th century. Recently, the natural recovery of eelgrass-dominated underwater meadows has begun in several places in the Gulf of Gdańsk.

Seagrasses and associated faunal communities have been the subject of a number of studies performed in the northern basins of Swedish, Finish and Estonian Baltic Sea waters (e.g., Bostrom and Bonsdorff, 1997; Herkul and Kotta, 2009; Baden et al., 2010). These studies focus on long-term changes in macrophyte communities, sediment accumulation by seagrass, colonization processes, environmental variables explaining macrofauna community structure, spatial variation of epi- and infauna, as well as trophic interactions. Apart from historical reports on *Zostera marina* distribution, there is no information on the structure and variability of the seagrass meadows or their effects on sedimentary systems in Polish coastal waters. To the best of our knowledge, all of the Baltic Sea seagrass system studies published to date were performed in

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summer when environmental conditions are optimal for the plant growth. It remains unknown if the seagrass structures in the Baltic persist during the winter when the benthic biota are faced with very low water temperatures and low radiation that is often additionally reduced by ice cover. We aim to explore seasonal variability in macrophyte vegetation taxonomic composition (at the species level) and seagrass canopy biometrics. We hypothesize that the expected strong seasonality in vegetation cover induces parallel seasonal changes in seagrass engineering effects. More specifically, we expect that ecosystem engineering effects, as indicated by change in sediment grain size, organic matter concentration, and meiofauna biomass, will be the strongest in the season when the vegetation is best developed. To the best of our knowledge, this is the first study of the meiobenthic component of seagrass benthic systems in the Baltic Sea.

2. Materials and methods

2.1. Study area

The samples were collected in the Puck Bay, which is a shallow embayment in the southern Baltic Sea that is separated from the open sea by the elongated Hel peninsula (Fig. 1). Seagrass meadows in the Polish part of the Baltic Sea have been shown over the past 60 years to significantly decrease in the area of *Zoster marina* occurrence (*Z. marina* area (ha): 1969 – 5120.3 (Klekot, 1980), 1987 – 16.0 (Kruk-Dowigallo, 1991), 2007 – 320.0 (Gic-Grusza et al., 2009)), mainly because of eutrophication and replacement by filamentous algae. A recent inventory of Polish Exclusive Economic Zone seabed habitats indicated that increasingly large areas are covered by *Z. marina* meadows in the Puck Bay (http://iopan.gda.pl/hm/atlas/Atlas_all.pdf). Therefore, it is important to identify the possible impacts of expanding seagrass meadows on the marine ecosystem in this area.

2.2. Sampling and laboratory analysis

Samples were collected at two stations in the Puck Bay (Fig. 1): 1) in the inner part of the bay close to the Ryf Mew sandbar (RM, depth of 3 m); 2) in the outer bay east of Jastarnia (JAS, depth of 1.5 m). Two sampling sites were designated at each station: one on the vegetated seabed and one on the bare sandy bottom. Samples were collected five times throughout the year in October 2010 (October 10), March 2011, June 2011, July 2011, and October 2011 (October 11). The sampling was planned to include different seasons in the southern Baltic Sea. Seasonality in the functioning of the southern Baltic Sea coastal ecosystem is defined by changes in water temperature and shifts in the dominant phytoplankton producers: spring starts with diatom blooms (usually in March, Witek, 2010); summer is defined by the mass occurrence of cyanobacteria and high water temperatures (exceeding 18–23 °C, Witek, 2010); autumn is characterized by the dominance of diatoms and dinoflagellates (Witek, 2010). Sampling started in autumn 2010 (10–13 October 2010). Winter in 2011 was relatively cold, and ice covered the Puck Bay until 20 March (http://www.smhi.se/oceanografi/iceservice/is_prod_en.php), making sampling not possible. The sampling that was intended to represent the winter conditions took place on 30–31 March 2011, just after the ice cover disappeared. However, high chlorophyll *a* concentrations in the surface sediments collected on these days suggest that the diatom bloom could have already started. Thus, samples were collected in early spring (30 and 31 March 2011), late spring (1 June 2011), summer (19 July 2011), and autumn (8 and 15 October 2011).

Five replicates per station were collected by SCUBA divers. Each replicate comprised five cores. The first 15 cm diameter core was sampled for macrophyte measurements (upper 10 cm). The four other 2 cm diameter cores were taken for meiobenthos counts (upper 10 cm), granulometry measurements (upper 10 cm), particulate organic carbon (POC) and total nitrogen (TN) concentrations (upper 2 cm), and photosynthetic pigment concentration (upper 2 cm).

Samples for macrophytes were sieved through a 0.5 mm size sieve, and all plants and algae were collected carefully and fixed in 4% formaldehyde. Samples of meiofauna were fixed in 4% buffered formaldehyde and stained with Bengal Rose. Sediments collected for POC and TN measurements as well as granulometric analyses were frozen at −20 °C. Samples collected for photosynthetic pigment analysis were frozen at −80 °C.

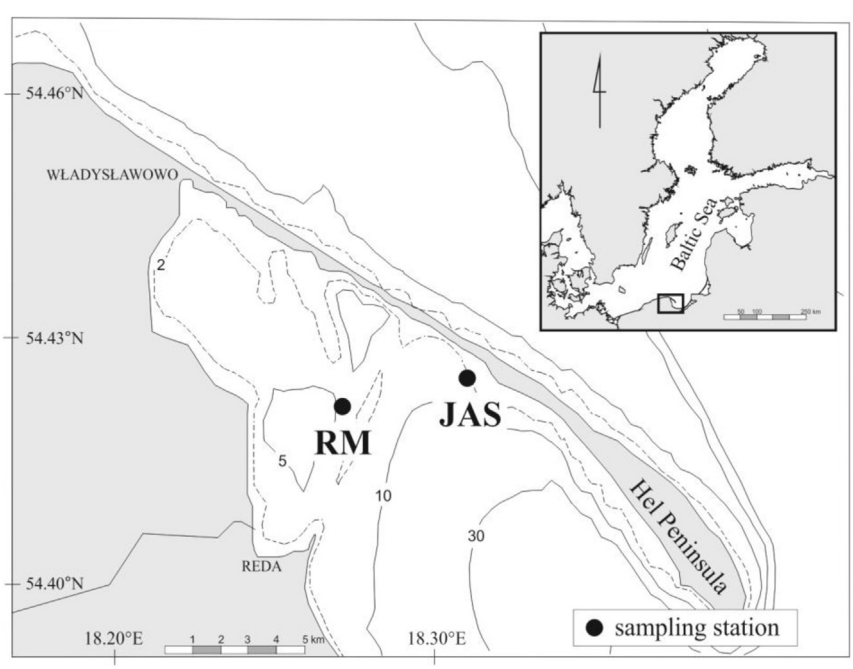

Fig. 1. Location of sampling stations in the Puck Bay.

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