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Spatial patterns in community structure of motile epibenthic fauna in coastal habitats along the Skagerrak – Baltic salinity gradient

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ABSTRACT

Patterns in community structure and functioning of motile epibenthic fauna were investigated in shallow (0–1 m) sediment habitats along the Skagerrak–Baltic estuarine gradient (salinity range from 4 to 34). The study area was divided into five regions, reflecting different sea-basins along the 1260 km coastline, and fauna was collected at six sites within each region. Ten replicate samples of motile epibenthic fauna were taken randomly at each site with a portable drop trap (bottom area 1 m^2) in June and September in 2004.

All together, 110 taxa were found, of which 45 had a marine and 65 a limnic origin. The marine species decreased along the salinity gradient while the limnic showed the opposite pattern. Number of species and abundance of epibenthic fauna exhibited considerable local and regional variation, with a trend of increase with decreasing salinity. Fauna biomass, on the other hand was significantly higher (six times) in the Skagerrak–Kattegat area compared to the Baltic. There was a significant difference in fauna composition among regions and season, but with high similarity within the five regions, which implies that management of such coastal habitats should preferably be based on scales of a region (ca. 100 km) or smaller. Predators were the dominant functional group in all coastal regions, with a species shift from Crustacea to Insecta along the salinity gradient and with gobid fish occurring in all regions. Grazers were the second most important group in the Skagerrak–Kattegat area, but planktovores were more important in two of the Baltic regions. The importance of shallow sediment bottoms as feeding and nursery grounds for coastal fish assemblages is discussed and compared throughout the investigated area.

1. Introduction

Estuaries are highly dynamic habitats with steep gradients in environmental settings from river conditions at the top to almost oceanic conditions at the head of the estuaries. Tides cause rapid changes in salinity and interact with seasonal fluctuations in river flow to cause more long-term variations in salinity (Remane and Schlieper, 1971; McLusky and Elliot, 2006). Organisms may have different ways to adapt to this harsh environment, and there are numerous studies describing changes of community structure in estuaries in response to gradients and fluctuations in environmental conditions (e.g. Thorman, 1986; Bonsdorff and Pearson, 1999; Ysebaert and Herman, 2002; Gimenez et al., 2005).

The Baltic Sea system, including the Kattegat and the Skagerrak, can be considered as one of the largest brackish seas in the world. It is micro-tidal and has limited seasonal fluctuations in salinity and does therefore lack some of the most characteristic elements in shaping the environmental conditions experienced by animals commonly found in estuaries (McLusky and Elliott, 2006). However, the Baltic has estuarine features in salinity with almost limnic conditions at the head in the northern part of the Gulf of Bothnia to almost oceanic conditions at the mouth in the Skagerrak, but the lack of tides make the salinity stable over large geographical scales (Bonsdorff and Pearson, 1999). The large geographic extension of the Baltic makes it difficult to compare studies from other estuaries world-wide. Therefore, reviews on estuarine ecology generally are restricted to include parts of the Baltic Sea or exclude it as an inland sea together with the Black Sea (e.g. Barnes, 1994; Pihl et al., 2001; Franco et al., 2008). The fauna assemblage and function of coastal habitat is likely to change along estuarine gradients and results from studies made in fully marine waters or tidal estuaries with heavily fluctuating salinity is unlikely to be directly transferable to the quite stabile estuarine waters of the Baltic.

A comparison among 25 estuarine and coastal areas in Europe revealed that shallow sediment habitats were by far the most

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common biotope, with extensive distribution in most areas (Pihl et al., 2001). Many marine as well as fresh water species utilise the sediment substratum during one or several stages of their life cycle and these habitats have shown to have the highest richness of fish species in the coastal zone (Pihl et al., 2001; Elliott et al., 2007). Understanding the structure and functioning of coastal systems is crucial since the coastal zone is not only important as nursery and feeding grounds for aquatic animals, but these habitats also provide several other ecosystem services for the society (Zijlstra, 1972; Wennhage et al., 2007; Stål, 2007; Rönnbäck et al., 2007). There is commonly a conflict of interest since these shallow habitats are also economically valuable and ecological information is important in the management process.

Investigations in the Skagerrak–Kattegat area (Swedish west coast) have examined the fauna assemblage and its key species in some shallow (0–1 m) sediment systems in terms of population dynamics, production and energy flow (Pihl and Rosenberg, 1982; Evans, 1983, 1984; Möller et al., 1985). Results from these studies show that motile epibenthic fauna living in these habitats have high annual production (>5.0 g AFDW m^{-2}) of which 90% is produced during the summer season, from June to September (Pihl and Rosenberg, 1982). Estimates by Möller et al. (1985) show that up to 90% of the epibenthic fauna production is transported to deeper water systems through seasonal migration or consumption by coastal fish. In this way, the shallow productive system support deeper less productive areas with fish and fish food organisms. In contrast, the epibenthic fauna assemblage in shallow coastal areas in the Baltic has rarely been studied before and the function of these habitats has not been compared between different geographical regions. Therefore, comparisons of these shallow systems in the Skagerrak–Kattegat and the Baltic will increase the ecological understanding and create an important base for management along the coast.

Thus, shallow sediment habitats in the Skagerrak–Baltic system have received very different attention and the methods used have rarely allowed for comparisons across studies. In this study, we investigate the fauna assemblages in sediment habitats in a spatial context comparing five sea-basins along an estuarine gradient with focus on the structure and functioning of the coastal systems. The overall aim of this study was to investigate patterns in the distribution and biodiversity of epibenthic fauna assemblage and relate these patterns to processes acting over different spatial scales along an estuarine gradient. The Skagerrak–Baltic estuary was therefore sampled at a regional level (five sea-basins) to describe changes in community structure and ecosystem function along the Swedish coast.

2. Materials and methods

2.1. Area investigated

Motile epibenthic fauna was collected in 30 shallow (0–1 m) coastal sites distributed along a 1260 km estuarine gradient, 4–30 (salinity is expressed in Practical Salinity Units, PSU, throughout the paper), of the Swedish coast in the Baltic–Skagerrak area (Fig. 1).

We here define motile epibenthic fauna as non-sessile fauna larger than 1 mm living on or above the sediment and we include smaller fish like gobies and fish commonly known to be resident in these habitats during at least some months of their life e.g. flatfish (<10 cm), eels (<14 cm) and pipefish.

The sampled area was divided into five regions reflecting the sea-basins in the area, with six sites in each. The regions were labelled A–E (where A represent the Skagerrak 20–30, B the Kattegat 15–20, C the Southern Baltic Proper, 8–15, D the Central Baltic Proper, 6–8 and E the Northern Baltic Proper, 4–6) (Appendix 1).

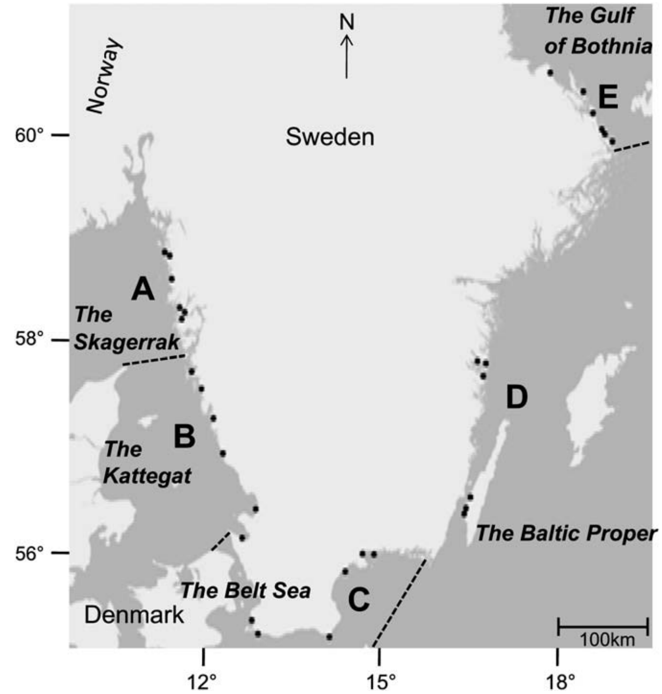

Fig. 1. Map showing the investigated area and the labelling of the sea-basins, A–E. The sampled sites are shown as black dots within the regions.

These regions and sites were also used by Rosenberg et al. (1985), in a study that examined the faunal assemblage of shallow habitats covering a range from sheltered to exposed bays. The Central Baltic Proper which was not fully included in the earlier study was complemented with three additional sites. Ten replicated samples were taken at each site on each occasion within an area of 7000–10 000 m^2 and all sites were sampled within a month in June and in September 2004. Samples in June mainly represented faunal composition among over-wintering individuals of the epibenthic assemblage and in September samples were normally dominated by individuals recruited during the summer season (Pihl and Rosenberg, 1982). Surface water temperature during the sampling periods varied between 14 and 20 °C. During spring and autumn, temperature typically varies between 5 and 10 °C, and in the winter the shallow areas could be ice covered for some weeks (Pihl and Rosenberg, 1982). The sampled coastal area is micro-tidal with an amplitude of <0.2 m.

2.2. Sampling of epibenthic fauna

Ten replicate samples of motile epibenthic fauna were taken at each site on each occasion with a portable drop trap (bottom area 1 m^2) (Pihl and Rosenberg, 1982; Modin and Pihl, 1994). Motile epibenthic fauna were extracted from the drop trap with a bag net (mesh size 1 mm) and preserved in 70% ethanol. Vegetation cover within each drop-trap was recorded and, the vegetation was removed from the drop trap by hand and/or with the bag net after carefully checking it for the presence of animals. All sampled fauna were enumerated, measured for length and weight, and determined to the lowest taxonomical levels possible (in most cases species level, but Chironomidae, Ephdridae and Pyralidae were not identified to lower taxonomical level). Because of uncertain identification of young and small individuals, species within the families of Hydrobiidae, Gammaridae and Idoteidae were grouped together in the statistical analyses. Taxonomic literatures used were: Muus and Dahlström, 1972; Nilsson, 1996; Sahlén, 1996;