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Macrofaunal communities in the habitats of intertidal marshes along the salinity gradient of the Schelde estuary

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ABSTRACT

The macrobenthos is important in benthic remineralization processes; it represents a trophic link and is also often used as a bio-indicator in monitoring programs. Variations of the environmental parameters strongly influence the structure of the macrobenthic communities in the marshes and since macrobenthos is the most important food item for marsh-visiting fish species in the Schelde, the variation in food resources can have a strong effect on the higher trophic level. The present study deals with the variation in macrobenthic communities in different habitats of intertidal marshes along the salinity gradient and the differences between the marsh creeks and the intertidal part of the estuary. The study measured density and species richness together with the biomass, and sampled a large intertidal channel and a smaller creek within five marshes along the salinity gradient of the Schelde estuary every six weeks between May and October in 2000.

The small creeks had a smaller grain size and higher organic matter content than those in the large channel although the differences in the environmental parameters did not explain the different communities in the two habitats. Marshes had distinct macrobenthic communities but the abundance of macrofauna fluctuated along the estuary without an identifiable spatial trend. In contrast, the total biomass increased towards the euhaline area due to the domination of *Nereis diversicolor*. Diversity showed a significant positive correlation with the salinity.

Comparison of the macrofaunal communities in the marsh with those on the intertidal flats of the estuary indicated similar trends in density, biomass and diversity along the salinity gradient. The density was similar in both habitats whereas biomass was much higher in the intertidal habitats of the estuary, partly due to the higher biomass of molluscs and annelids. Diversity indices were higher in the marsh, and the freshwater area had more species than in the estuary.

1. Introduction

The macrobenthos of estuarine intertidal areas are exposed to extreme and highly variable environmental conditions. This includes low oxygen concentration in the predominantly fine-grained sediment and fluctuations in salinity, drying and flooding, suspended sediment etc. with which benthic animals with limited mobility have to cope (McLusky et al., 1993). The colonisation by macrofauna and the subsequent development and modification of their communities therefore depends on several factors (Elliott et al., 1998). In estuaries, the macrobenthos is important in benthic remineralization processes, both directly and indirectly through its process of structuring the sediment (Mazik and Elliott, 2000). Macrofauna represent an important trophic link between producers and fish and crustaceans species in the salt marshes (Sarda et al., 1995) and they are also often used as a bio-indicator in monitoring programmes (e.g. Heip et al., 1992).

The macrobenthos of the extensive US salt marshes has been well studied (Rader, 1984; Sheridan, 1992; Sarda et al., 1995; Szalay and Resh, 1996; Angradi et al., 2001) and macrofaunal communities have been compared between mature and created salt marshes to indicate the development of the newly created area (Alphin and Posey, 2000). Characteristics of macrobenthic fauna communities in three salt marsh successional stages of the Yangtze estuary were studied by Yang et al. (2006). In Europe, Jackson et al. (1985) studied macro-invertebrate populations and production in east

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England and Frid and James (1989) investigated the temporal change of macrobenthos of another English salt marsh in North Norfolk. Tagliapietra et al. (2000) sampled macrobenthos in a marsh pond in the Venetian Lagoon, Italy. Other studies have focused on one or two macrobenthic species such as *Nereis diversicolor* (Emmerson, 2000; François et al., 2002), *Nereis oligohalina* (Alves and Lana, 2000) or *Corophium volutator* (Essink et al., 1989; Hughes and Gerdol, 1997).

The present study was conducted in marshes situated along the Schelde estuary (The Netherlands and Belgium). The subtidal and intertidal benthic macrofauna along the salinity gradient of this estuary has been intensively studied by Ysebaert et al. (1993), Ysebaert and Herman (2002) and van der Wal et al. (2008) however macrobenthic communities in the marsh creeks of the Schelde had not been previously investigated. The fish community of this estuary has been extensively studied (Maes et al., 1997, 1998; Hostens, 2000) which shows that the area's marsh creeks are important feeding grounds for several fish species such as the sea bass *Dicentrarchus labrax*, the flounder *Platichthys flesus* and the common goby *Pomatoschistus microps* (Mathieson et al., 2000; Hampel and Cattrijsse, 2004). These species occur in the marsh creeks in high abundance from spring until autumn (Cattrijsse et al., 1994; Hampel et al., 2004) and sea bass and flounder also have feeding maxima during these months (Arntz, 1978; Kelley, 1987). The diet of the three fish species is mainly comprised of macrobenthic species (Elliott et al., 2002; Hampel et al., 2005). For this reason, the investigation on the change of the macrobenthic communities is required to give better understanding of the functioning of these systems, especially in relation to the food availability of the marsh-visiting fish species. The main aim of the present paper is to investigate 1) whether the two marsh habitats (small and large channel) harbour different macrobenhic communities 2) how macrobenthic communities change in marshes along the salinity gradient and 3) whether there is difference in macrobenthos between the marsh and the intertidal part of the estuary.

2. Materials and methods

Five marshes were chosen along the salinity gradient of the Schelde estuary (Fig. 1). In the tidal freshwater part, one of the largest freshwater marshes is the 'Groot Schoor' or the marsh of Grembergen (G). 'Het Verdronken Land van Saeftinghe' (S) lies in

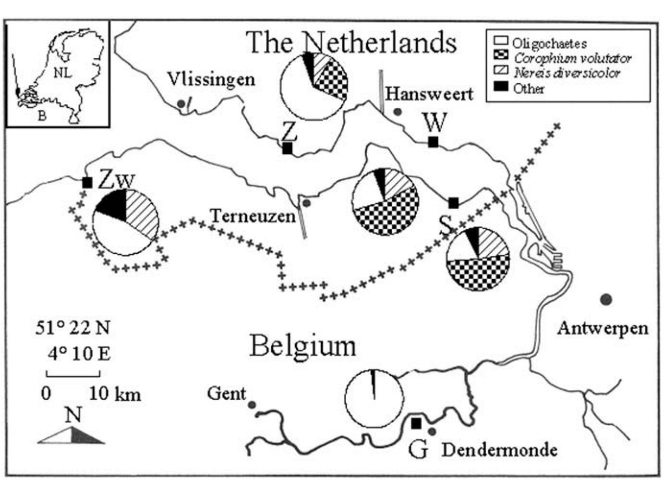

Fig. 1. Location of the five marshes sampled along the Schelde estuary. Marshes labelled by letters: Grembergen (G), Saeftinghe (S), Waarde (W), Zuidgors (Z) and Zwin (Zw). Relative species abundances are indicated next to each marsh.

the oligohaline part of the Schelde estuary. The marsh of Waarde (W) belongs to the mesohaline and the Zuidgors (Z) marsh to the polyhaline zone. Zwin (Zw) is situated at the mouth of the estuary, in the euhaline part. A large intertidal channel and a smaller creek were sampled in each marsh. The small creeks opened from the large channels. The dimensions of the larger creeks varied between 10–20 m wide and 3–4 m deep whereas the smaller creeks were generally 2 m wide and 1–1.8 m deep. Marshes were sampled during the spring tide period when tidal amplitude ranged between 4.5 and 5.5 m NAP (Dutch ground level) in the estuary. The inundation periods in the large channels were 6 h in Saeftinghe, Waarde and Zuidgors, while in Zwin and Grembergen the tide receded within 5 h. In the small creeks the inundation period generally lasted 2 h less compared to the large channels. At low tide the water left the channel and 5 replicate plastic cores (diameter 6.2 cm) were used to sample the macrobenthos to a depth of 15 cm at the centre of the large and small creek channel.

Samples were collected every six weeks between May and October 2000, this period and frequency was considered adequate to indicate the settlement, recruitment, establishment and development of the communities. The five marshes were sampled on consecutive days. In Grembergen, samples could be taken only from the large channel as the small channel became inaccessible after May due to the dense vegetation.

The environmental parameters of water temperature, salinity and dissolved oxygen were measured in the large and small creeks. Measurements were performed in the water column during the ebb period before the macrobenthic samples were taken in order to indicate the conditions experienced by the macrofauna prior to exposure. In each creek, a sediment core of diameter 6.2 cm was taken for the measurement of the medium grain size and organic matter content of the sediment. The values of the environmental parameters in each month were used to calculate the coefficient of variation in each marsh as following: % Coefficient of variation = (standard deviation/mean) × 100 (Jongman et al., 1987).

In the field, samples were preserved in a brackish-water–formalin solution. Samples were washed in the laboratory, sieved using a 1 mm sieve, stained with Rose Bengal and individuals were counted and identified to the lowest possible taxonomic level. The use of a 1 mm sieve after fixing the samples will have collected organisms smaller than the mesh used (pers. obs.). Individuals belonging to the class Oligochaeta were not identified to species level. Density was calculated for each replicate using the surface area of the sampling cores (0.003 m^2) and average densities for each creek. To calculate the biomass the samples (except bivalves) were dried at 60 °C for 4 days and then 2 h at 550 °C. They were placed in a desiccator for 2 h to reach room temperature and ash free dry weight (AFDW) was determined. For bivalves established regressions were used between length and AFDW. To minimise the weighting bias, the 5 replicates from the same creek were measured together.

The Shannon–Wiener function H′ (Pielou, 1966) was used as an indicator of the species diversity and calculated for each replicate and each creek. The non-parametric Mann–Whitney U test was used to test the abundance and diversity differences between the large channels and the small creeks within each site. The non-parametric Wilcox matched pair test was employed to indicate the differences in environmental parameters and sediment characteristics between the small and large creek. Multiple regression models were constructed using forward variable selection, with the software package STATISTICA v6, to identify the environmental variables which best explain the variation in species density, biomass and diversity in the small and large creek. Data from the large creek of Grembergen was excluded from the analyses to make result comparable with the result from the small creek. Temperature, dissolved oxygen