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Restriction of *Spartina anglica* (C.E. Hubbard) marsh development by the infaunal polychaete *Nereis diversicolor* (O.F. Müller)

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Abstract

Spartina anglica has been planted around the coast of SE England, and throughout the world, to help stabilise sediments and reduce wave erosion of sea defences. Recently the areas of *S. anglica* have declined on this coast, contributing to the overall loss of saltmarsh area, in contrast to the north and west coasts of the UK where expanding *S. anglica* marshes have had to be controlled to maintain mudflat feeding areas for birds. Field experiments were established in two old coastal realignment areas in the Blythe Estuary (Suffolk) and on open mudflats in the Blackwater Estuary (Essex), in which surface deposit feeding by *Nereis diversicolor* was prevented by laying porous mats on the mudflat surface. These mats promoted sediment deposition and quickly became buried. *S. anglica* colonised these infauna exclusion areas by growth of rhizomes from adjacent plants, to a significantly higher degree than in control areas. In one of the Blythe sites this occurred when the adjacent *S. anglica* marsh was retreating. These results support the conclusions of Paramor and Hughes (2004, 2005), that the infauna are responsible for much of the loss of saltmarsh in SE England, and that managed coastal realignment will not necessarily lead to saltmarsh creation. The experiments point to an alternative means of managing saltmarsh creation and sediment accretion on existing mudflats, with consequent benefits for coastal defence and conservation.

Keywords: *Spartina anglica*; *Nereis diversicolor*; saltmarsh erosion; UK; Suffolk; Essex

1. Introduction

A major change to some coastal ecosystems around the world has been the deliberate and accidental introduction of *Spartina* species to saltmarsh and mudflat habitats outside their natural distribution range. For example four species of *Spartina* have been introduced into San Francisco Bay (Ayres et al., 2004). Deliberate introductions of *Spartina alterniflora* and *Spartina anglica*, for example, have been to enhance coastal flood defence, as *Spartina* plants promote sediment accretion, stabilise sediments and reduce wave erosion of sea walls (Adam, 1990; Gray et al., 1991; Ayres et al., 2004; Chen et al., 2004). Another consequence of some introductions has been the creation of new species, as *Spartina* species readily hybridise. These hybrids often have a high fecundity and are fast growing, which increases their beneficial consequences. In the UK, *S. anglica*, a polyploid hybrid between *S. alterniflora* introduced from the USA and the native *Spartina maritima*, can colonise mudflats at lower elevations than the other native pioneer zone species (Gray et al., 1991). This led to an appreciation of its potential importance in reducing coastal erosion and from the 1920s *S. anglica* was planted on mudflats around the UK, especially on the subsiding coastline of SE England, and around the world (Gray et al., 1991).

The invasive nature of some *Spartina* species may have detrimental consequences too; they can reduce the areas of mudflat that are feeding areas for birds (Goss-Custard and Moser, 1990; Percival et al., 1998; Chen et al., 2004), outcompete native species (Chen et al., 2004) and prevent the desired

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outcome of coastal restoration schemes (Callaway, 2005). When controlling invasive *Spartina* becomes the priority it proves difficult and expensive (Frid et al., 1999; Taylor and Hastings, 2004) and may cause increased sediment erosion (Swales et al., 2005).

The saltmarshes on the subsiding coast of SE England have been disappearing rapidly for the past half-century (Burd, 1992) with detrimental consequences for conservation and flood defence interests (see Hughes, 2004; Hughes and Paramor, 2004). These losses have been mainly of the pioneer zone vegetation, but erosion at the saltmarsh face and internal creek widening also has caused loss of vegetation from higher levels. These losses of vegetation have been attributed, in part, to bioturbation and herbivory by the infaunal polychaete *Nereis diversicolor* (Paramor and Hughes, 2004, 2005; Hughes and Paramor, 2004). The worms destabilise the sediments by surface deposit-feeding on microphytobenthos (Smith et al., 1996) and reduce colonisation of mudflats by eating the seeds and seedlings of annual pioneer zone species (Paramor and Hughes, 2004). This investigation complements the studies of Paramor and Hughes (2004, 2005) on annual pioneer zone species and tests the hypothesis that by excluding surface deposit feeding by the infauna (mostly *N. diversicolor*) in field experiments, perennial *Spartina anglica* can be stimulated to grow out onto mudflats.

The effects of *Nereis diversicolor* may be particularly acute in SE England because they have a high vertical distribution range that overlaps that of saltmarsh vegetation, but seemingly not so in the north and west (Hughes and Paramor, 2004). *Spartina anglica* has been declining in area in the south and east of the UK (contributing to the overall loss of saltmarsh area), while expanding its range in the north and west of the UK (Charman, 1990; Gray et al., 1990), a geographical difference similar to that of saltmarshes generally. The causes of this dieback of *S. anglica*, and the dieback of *Spartina* elsewhere, are unknown but changes to sediment characteristics caused by the plants themselves may contribute to their decline (Gray et al., 1990, 1991; Ogburn and Alber, 2006). In this study the possibility that *N. diversicolor* may also contribute to this regional scale decline of *S. anglica* area is examined. *Spartina anglica* can colonise mudflats from seeds or fragments of plants and once established may spread laterally by vegetative growth of rhizomes, often leading to sudden rapid increases in coverage (Gray et al., 1991). Hughes et al. (2000) demonstrated that *N. diversicolor* restricted similar vegetative colonisation of mudflats by *Zostera noltii* and observed *N. diversicolor* burying *S. anglica* seeds, by grasping them and dragging them into their burrow, often to depths greater than 4 cm which reduces their germination success (Groenendijk, 1986).

Restoration of saltmarshes in SE England is an urgent conservation and coastal defence priority (Hughes and Paramor, 2004). Saltmarsh has been declared a Biodiversity Action Plan habitat (United Kingdom Biodiversity Group, 1999), and the UK Government is committed to restoring and maintaining the area of saltmarsh present in 1992. The main strategy is to use managed realignment, where in selected areas of the coast breaching the sea defences will allow saltmarsh to develop on agricultural land which has become intertidal. This policy is controversial (Hughes and Paramor, 2004; Morris et al., 2004;Wolters et al., 2005) because it is based on the assumption that saltmarsh loss in SE England is due to sea level rise leading to coastal squeeze, which Hughes and Paramor (2004) argued was a false assumption. Further, Paramor and Hughes (2005) argued that low-lying realignment sites would not develop saltmarsh vegetation because the infauna that colonise accreting sediments would prevent it. This may be why older low-lying unmanaged realignment areas remain as unvegetated mudflats.

These conclusions were based on studies with annual pioneer zone species in recent managed realignment areas. In this investigation with *Spartina anglica* one of the study areas includes two realignment sites on the Blythe estuary, which after more than 50 years are still mainly mudflats. If these experiments successfully promote colonisation of mudflats by *S. anglica* this would reinforce the conclusion of Paramor and Hughes (2005) that managed realignment cannot be relied upon to create sufficient areas of new saltmarsh, and, more importantly, would point to a cheap practical alternative management technique for increasing saltmarsh area without realignment. For infaunal exclusion to be of significant management potential it would have to work with *S. anglica*, because with the loss of so much of the annual pioneer zone vegetation in SE England *S. anglica* is often the only pioneer zone plant species remaining.

2. Methods

The experiments were conducted in the Blythe Estuary, Suffolk, and at Maldon, Essex, at the head of the Blackwater Estuary (Fig. 1). In the Blythe Estuary infauna exclusion was

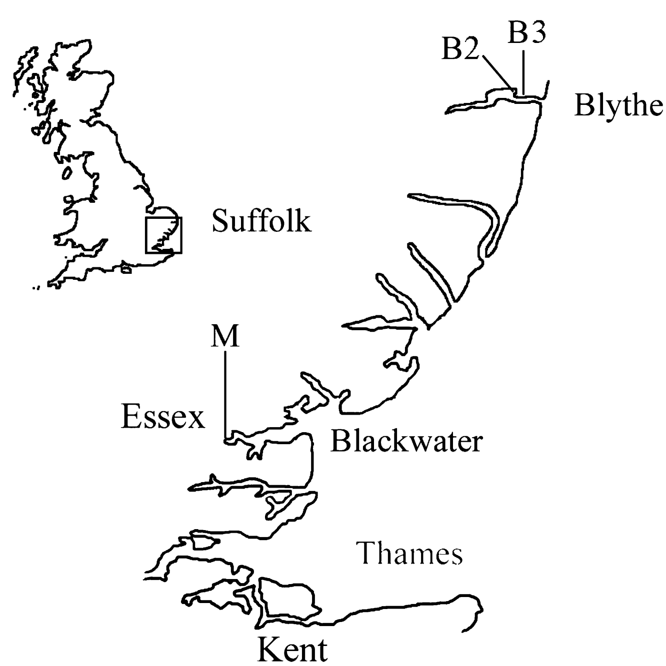

Fig. 1. The locations of the experimental sites on the Blythe Estuary (B2, B3) and at Maldon on the Blackwater Estuary (M).