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Differential response of nematode colonist communities to the intertidal placement of dredged material

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Abstract

The use of fine-grained maintenance dredged material for habitat enhancement has increased in recent years, particularly recharge schemes which provide a means of combating the erosion of intertidal flats and saltmarsh. This article investigates the development of meiofaunal nematode communities following a natural experiment in 2003, when fine-grained dredged material was deposited concurrently at four adjacent intertidal recharge sites on the southeast coast of the United Kingdom. A 12-month survey of nematode assemblages was carried out to compare univariate, multivariate, allometric and functional attributes of colonist communities in relation to the different environmental conditions prevailing at the four sites. Developing assemblages were increasingly affected by the spatial differences in the elevation, consolidation and exposure of bed material. The results indicated that the colonisation sequence was the result of random settling of suspended nematodes, sequential reproduction and differential survival and reproductive success of colonising species. For the first time, this experiment provided insights into the development of adaptive and functional types of meiofaunal nematodes following the intertidal deposition of uncontaminated fine-grained dredged material. This, in turn, will contribute considerably to the development of ecological models of the evolution of the large-scale placement of muddy dredged material in the intertidal environment.

Keywords: Dredged material; Intertidal; Meiofauna; Natural experiment; Recolonisation

1. Introduction

Large losses of wetland are occurring along coastlines worldwide due to a variety of natural and anthropogenic factors (French, 1997). Such losses are of real concern because wetlands, particularly intertidal mudflats and saltmarshes, are fundamental components of coastal ecosystems (Snelgrove, 1999). They provide feeding grounds for migratory birds, offer nursery and stock habitat to many commercially important fish species and export energy-rich material to deeper waters. These important functions justify conservation and restoration efforts (Williams and Desmond, 1999; Valiela et al., 2004). In addition to their ecological value, these habitats perform other important roles, including protecting modern sea defences by dissipating wave energy (e.g. Möller and Spencer, 2002).

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On average, 40 to 50 million tonnes (wet weight) of sediment are dredged each year from ports, harbours and waterways in the UK to maintain and improve the nation's navigation systems for commercial and recreational purposes (Bolam et al., 2003). At present, the majority of this material (which is generally fine-grained and relatively uncontaminated) is disposed of at sea (Waldock et al., 2003). In recent years, there has been a growing awareness of the potential for dredged material as a manageable beneficial resource (Sabat et al., 2002). The use of fine-grained maintenance dredged material for habitat enhancement has increased, particularly recharge schemes, which provide a means of combating the erosion of intertidal flats and saltmarsh.

Various potential long-term benefits are associated with recharging fine-grained material to the intertidal. Recharged sediment can be recycled into the intertidal habitat where it replaces lost habitat and supports a productive benthic community following recolonisation by fauna from adjacent areas (ABP Research, 1999; Bolam and Whomersley, 2003, 2005). Small-scale schemes of this kind have been undertaken at over 15 locations along the UK coast (Bolam et al., 2003). These provide ideal sites for a natural experiment on the effects of varying environmental regimes on the development of infaunal colonist communities.

Most biological investigations into the recolonisation of newly created soft-bottom habitat have traditionally targeted the larger macroinfauna that can readily be counted and identified (Moy and Levin, 1991; Sacco et al., 1994; Levin et al., 1996; Lee et al., 1998; Craft et al., 1999; Delaney et al., 2000; French et al., 2004), whereas the smaller-sized meiofauna has been largely neglected. As a result of their ubiquitous distribution in nature, high abundance, intimate association with sediments, fast reproduction and rapid life histories, meiofauna are widely regarded as ideal organisms to study the potential ecological effects of natural and anthropogenic impacts (review by Coull and Chandler, 1992). Although functional attributes of meiofauna communities remain poorly understood, it has been suggested that, in addition to their indicator value, meiofauna play a key role in the functioning of benthic food webs (Warwick, 1989 and references therein). Their importance as food for larger animals such as fish and their potential influence on macrobenthic community structure provide compelling reasons to assess the meiofaunal response to the intertidal placement of dredged material. Published information on the processes affecting the development of meiofaunal colonist communities is currently limited to results from a field manipulation experiment by Schratzberger et al. (2004a).

We have therefore examined, over a 12-month period, the development of nematode assemblages at an experimental intertidal recharge scheme in an attempt to identify the environmental factors that contribute to short-term variation in, and the longer-term maintenance of, meiofaunal populations. Particular emphasis was placed on addressing the following questions:

(1) How do taxonomic, allometric and functional aspects of meiofaunal colonist communities develop in space and time?
(2) What is the role of environmental variables prevailing in the newly created habitat in determining the distribution of species, feeding types and life history groups? and thereby testing the two null hypotheses:

$H_0$1: The rate of development of nematode colonist communities at four distinct recharge areas, recharged concurrently with the same material, does not differ over a 12-month period.

$H_0$2: Nematode assemblages at four distinct recharge areas, recharged concurrently with the same material, do not differ 12 months post-recharge.

2. Materials and methods

2.1. Study area

The study area was located in the Orwell Estuary, close to its confluence with the Stour Estuary, on the southeast coast of England (Fig. 1). The recharge was carried out in phases in distinct areas. All study sites were recharged in September 2003 with uncontaminated fine-grained material from maintenance dredging at Harwich harbour. Each area of placement had a retaining bund or bunds, constructed to hold the pumped muddy material. The bunds consisted of either in-situ bed material (site 1), existing gravelly material (site 2) or clay material arising from a capital dredging operation (sites 3 and 4).

Site 1: an amphibious excavator scraped its bucket in arcs, creating mud banks of approximately 0.3 m height. Four parallel bunds were formed in this way and filled with dredged material.
Site 2: this site was initially bunded in 1999 and, following settlement of recharged material, topped-up in September 2003.
Sites 3 and 4: the upper terrace of this recharge area (site 3) was filled initially and subsequently over-topped while the lower terrace (site 4) was filled.