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Ecological consequences of dredged material disposal in the marine environment: A holistic assessment of activities around the England and Wales coastline

S.G. Bolam [a,*], H.L. Rees [a], P. Somerfield [b], R. Smith [a], K.R. Clarke [b], R.M. Warwick [b], M. Atkins [b], E. Garnacho [c]

[a] Centre for Environment, Fisheries and Aquaculture Science, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA, UK
[b] Plymouth Marine Laboratory, Prospect Place, West Hoe, Plymouth, Devon, PL1 3DH, UK
[c] Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK

Abstract

This study provides a holistic perspective on the ecological effects of dredged material disposal, both intertidally and subtidally. A number of numerical techniques (univariate, distributional, multivariate and meta-analysis) were used to assess impacts at 18 different disposal sites. The analyses revealed that ecological effects associated with dredged material disposal were dependent on the numerical techniques used, and that impacts were disposal-site specific. Disposal-site communities were generally faunistically impoverished to varying degrees, and impacts following intertidal placement were comparable to those of subtidal placement.

We conclude that any assessment of the consequences of dredged material disposal to the coastal environment must take account of site-specific variation in prevailing hydrographic regimes and in ecological status, along with information on the disposal activity itself (mode, timing, quantity, frequency and type of material). As would be expected, variability in the latter presents a significant challenge in attempts to generalise about environmental and ecological impacts.

Keywords: Dredged material; Environmental assessment; Monitoring; England and Wales

1. Introduction

1.1. Background

In the UK, statutory control of the disposal of wastes to sea from ships is provided by the Food and Environment Protection Act (Great Britain-Parliament, 1985). This disposal route is now largely confined to dredged material, arising from the maintenance of port/harbour facilities and their approach channels and, periodically, from capital projects such as those involving channel deepening or new constructions (Rees et al., 2003). The effective management of the sea disposal option assumes strategic importance in view of the continuing significance of maritime trade for the UK economy.

Supporting monitoring of licensed activity has been conducted by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), an executive agency of the Department for Environment, Food and Rural Affairs (Defra) primarily to ensure that: (i) environmental conditions at newly designated sites are suitable for the commencement of disposal activities; (ii) disposal operations conform with licence conditions, and (iii) predictions for established sites concerning limitations of effects continue to be met. Monitoring outcomes contribute directly to the licensing/enforcement process, by ensuring that action is quickly taken if any evidence of unacceptable changes or practices is found.

* Corresponding author. Tel.: +44 1621 787200; fax: +44 1621 784989.
E-mail address: s.g.bolam@cefas.co.uk (S.G. Bolam).

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There are over 150 sites designated for the disposal of dredged material around England and Wales, not all of which are used in any one year. In total, approximately 40 million wet tonnes are disposed of annually (Bolam et al., 2003), therefore, in terms of quantity, maintenance dredged material far outweighs all other materials disposed of to the marine environment. Quantities deposited at individual sites may range from a few hundred to several million tonnes. The nature of the material may vary from soft silts to boulders or even crushed rock according to origin, although the majority consists of finer material (Anon, 1996; CEFAS, 2003). The majority of disposal sites are situated several miles off the coast of England and Wales, although some are located in estuaries (e.g., Humber and Outer Severn estuaries), and, more recently, a number of intertidal placements for habitat creation/enhancement (i.e., beneficial use) have been initiated (Bolam et al., 2004; Bolam and Whomersley, 2003, 2005). Given the large number of disposal sites around England and Wales and significant variations in year-on-year usage, regular monitoring is targeted at representative sites.

1.2. Rationale for present work

Studies of the impacts of dredged material disposal around England and Wales have previously described impacts at individual disposal sites (Somerfield et al., 1995; Boyd et al., 2000; Rees et al., 1992, 2003; Bolam and Whomersley, 2003, 2005). Combining data from a variety of studies allows their simultaneous comparison, making the detection of any general trends possible. The formulation of a general trend in the ecological effects of dredged material disposal in the coastal environment could lead to the development of a conceptual model upon which a decision-framework could be based, comparable to the Pearson and Rosenberg (1978) model for organic enrichment.

Information concerning the effects of the disposal of dredged material to sea around the England and Wales coastline has been accumulated over a number of years, largely through CEFAS monitoring in support of the Food and Environment Protection Act (Great Britain-Parliament, 1985) (e.g., Rees et al., 2000; Anon, 2004). A comparable body of information also exists on the chemical quality of the dredged material, gathered through the licensing process (CEFAS, 2000). In decisions regarding the disposal of dredged material, 'beneficial use' and sea disposal options tend to be viewed as, respectively, positive and negative in outcome. This is unfortunate, since there is evidence to suggest that the conventional sea disposal route to sea may have environmental benefits as well as costs, e.g., in terms of enhanced benthic productivity and hence food for fish (Rhoads et al., 1978; Bolam and Rees, 2003), or in terms of the creation of new habitat suitable for colonisation by commercial species (Rees et al., 2003), and may therefore be just as amenable to management in order to promote desirable ends.

The aims of the present work are:

- to provide a holistic perspective on the ecological effects of dredged material disposal (both inter- and subtidal) through a combined analysis of existing benthic monitoring data from England and Wales,
- to further our understanding of the factors (dredged material properties and disposal site characteristics) affecting ecological impacts at such sites,
- to allocate the entirety of the activity of dredged material disposal along a continuum of environmental costs and benefits, so as to facilitate sound decision-making across all available options.

2. Methods

2.1. Data sources

Following a review of an extensive archive of data arising principally from the conduct of monitoring surveys at dredgings disposal sites around the England and Wales coastline, a sub-set of suitable quality was identified for inclusion into a database to facilitate analyses of patterns and trends. Data arising from new sampling programmes at estuarine disposal and intertidal 'beneficial use' schemes (Bolam and Whomersley, 2003, 2005) were also included. The data consisted of species abundance matrices for the benthic macrofauna, along with ancillary data on biomass, and sediment particle size distributions and contaminant concentrations, where available. Information on maximum spring tidal current rates in the vicinity of surveys was obtained from Admiralty charts, while water depths and visual sediment descriptions were sourced from field observations at the time of sampling. Table 1 summarises the characteristics of each disposal site and associated data sources.

Accompanying the above field data, information on the concentrations of selected contaminants and on the % solids content of samples of the material prior to dredging and disposal was also used to determine similarities or contrasts between locations. Such information is routinely gathered as part of the licensing process (CEFAS, 2000).

2.2. Sampling methods

2.2.1. Subtidal sampling

At each subtidal disposal site, samples were taken at a number of stations both inside and outside the licensed boundaries. For some sites, annual or intermittent time-series were available, while for most, data for single years have been obtained (Table 1).

A 0.1 m^2 Day grab was employed for the remote sampling of finer sediments. Sub-samples of sediment for particle size analyses were collected with a 2 cm diameter corer prior to extraction on a 1 mm mesh of the macrobenthic infauna, which were then fixed in saline 5% formalde-