Nicola Sullivan

The Use of Agitation Dredging, Water Injection Dredging and Sidecasting: Results of a Survey of Ports in England and Wales

Abstract

The Centre for Environment, Fisheries and Aquaculture Science (CEFAS) carries out a diverse range of scientific research, advice and monitoring into aspects of the marine environment. The Regulatory Assessments Team work within CEFAS to provide expert scientific advice to the Ministry of Agriculture, Fisheries and Food on the impacts of the disposal of dredged material at sea. Disposal of material at sea in the United Kingdom, is regulated by the Food and Environment Protection Act (FEPA) Part II 1985. The day-to-day provision of advice is informed by research and monitoring programmes. Presently, dredging methods that involve relocation of sediment by means other than physical removal and deposition elsewhere are not regulated under FEPA. This paper presents the results of a recent review into the use of hydrodynamic dredging techniques in England and Wales.

A questionnaire was sent to 250 ports, harbours and marinas in the study area. The response was encouraging, with 42% of consultees submitting completed questionnaires. The responses were both geographically widespread, and representative of the study area.

More than a quarter of respondents claimed to employ hydrodynamic dredging techniques. However, only 11% of respondents use these techniques as their sole method of dredging. All but one of these ports are situated on the south coast of England. The Review also queried which conventional dredging methods were employed, what consultations were undertaken, and the environmental impacts of these activities. Several site visits provided a practical aspect to the review and allow the presentation of case studies.

The author wishes to thank Dr Lindsay Murray who has been working in the field of the environmental impacts of human activities on the oceans for 25 years. Dr Murray currently works for the CEFAS — an Agency of the Ministry of Agriculture Fisheries and Food (MAFF) — where she heads the Regulatory Assessments Team, whose responsibilities include advising MAFF on the issue of licences for the disposal of dredged material at sea for England and Wales, and development of policy on dredged material disposal. In addition to the above, the paper draws on CEFAS's experience of marine construction operations and presents views on the impacts of sidecasting.

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Introduction

At the present time, the disposal of dredged material at sea in the UK is regulated under the Food and Environment Protection Act (FEPA) 1985. In England (and on behalf of the National Assembly for Wales), FEPA is implemented by the Ministry of Agriculture, Fisheries and Food, who operate a licensing procedure. FEPA does not cover the dredging operation per se. There is no single act regulating dredging operations in the UK, although control of some (but not all) operations is exerted the Harbours Act 1964 or its local equivalents and the Coast Protection Act 1949.

To require a FEPA disposal licence, sediment has to be removed from the seabed and re-deposited from a

Nicola Sullivan (center) was presented the IADC Award by Mr Peter Hamburger (right), Secretary General of the IADC, with W Dieter Rokosch of CEDA assisting.

IADC Award 1999

Presented during CEDA Dredging Days '99, at the Europort '99 Exhibition Amsterdam, The Netherlands November 18-19 1999

At the CEDA Dredging Days, from November 18-19 1999, Ms Nicola Sullivan was presented with the annual IADC Award for young authors. Ms Sullivan graduated from Imperial College, London in 1997 with a first class honours degree in Environmental Geology. She subsequently gained employment with CEFAS (Centre for Environment, Fisheries and Aquaculture Science) where she works within a team performing risk assessment on the deposit of materials at sea and providing scientific advice to the Ministry of Agriculture, Fisheries and Food (MAFF). She is also studying part-time for a MSc in Coastal and Estuarine Management.

Each year at a selected conference, the International Association of Dredging Companies grants an award to a paper written by a young author. The Paper Committee of the conference is asked to recommend an author who is younger than 35 years of age and whose paper makes a significant contribution to the literature on dredging and related fields.The purpose of the award is "to stimulate the promotion of new ideas and encourage younger men and women in the dredging industry".The IADC Award consists of US$1,000, a certificate of recognition and publication in *Terra et Aqua.*

vessel, floating container or pump. There are a number of dredging methods which result in the relocation of sediment by physical pushing or agitating, but which do not involve deposit directly from a vessel. Dredging and disposal of sediment using these methods is not covered by the existing legislation.

The aim of this paper is to provide an indication of the current practice regarding dredging in ports, harbours and marinas located on the coasts of England and Wales. The extent of use of the different types of conventional dredging methods will be discussed, but the main focus of the discussion will be the extent of the use of dredging methods from which the disposal of material is not licensable under FEPA. The original survey of ports referred to these techniques as "non-FEPA-licensable dredging techniques"; however, for the purpose of this paper, the term hydrodynamic dredging (CEDA, 1998) is appropriate.

A questionnaire "A Review of Dredging Techniques" was sent to 250 ports in England and Wales. Recipients were selected using existing records of past and present holders of licences to deposit dredged material at sea, published lists of UK ports and other resources such as Yellow Pages. To ensure that the results were an accurate representation of the use of hydrodynamic dredging techniques, it was important to include ports that do not hold licences to deposit dredged material at sea.

The response to the questionnaire was positive with 42% of ports submitting completed questionnaires. The data was compiled and analysed with the aid of databases, spreadsheets and a geographic information system.

Presentation of Results

The questionnaire was divided into four sections. The results of each section are presented below.

Section 1: Background information about respondents

Section 1 aimed to establish the location of the responding port and details of current licensed dredging quantities.

Of the respondents, 55% claimed to hold a current licence to dispose of maintenance dredgings at sea. These licence holders were well distributed representing all sections of the coast. Disposal licences are for varying quantities, from 1,000 wet tonnes (Minehead) to >19,000,000 wet tonnes (ABP Humber). Figure 1 shows the quantities of material disposed of by responding ports. The major ports of the Tyne, Humber, Harwich, Cardiff, Bristol and Liverpool are immediately obvious from the map. The map also suggests that many ports on the south coast require relatively little dredging.

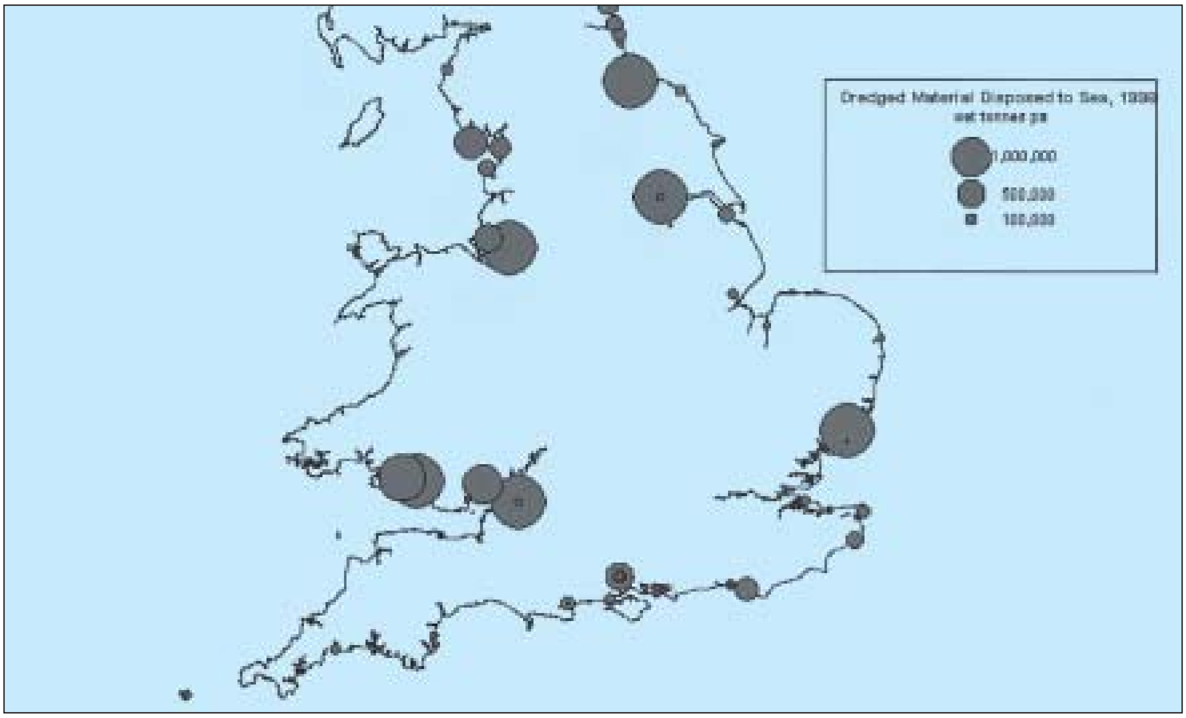


Figure 1. The location of responding ports and quantities of material disposed of to sea.

At the time of the enquiry, few ports held current licences to dispose of material at sea from capital dredging operations. The main respondent was Cardiff Bay Development Corporation with a quantity of >500,000 wet tonnes.

The survey of material types found that silt was the most common surface sediment in ports, although on the south and west coasts, sediments also consisted of fine sands and shingle. The material found at depth was variable according to location and included silt, stiff clay, gravel, boulder clay and rock.

Section 2: The use of conventional dredging techniques

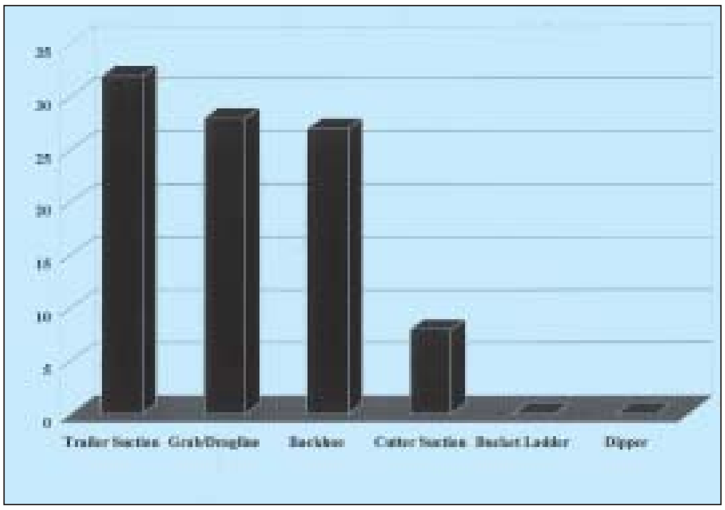
The questions in Section 2 covered conventional dredging methods employed by ports.
The most popular conventional dredging method employed by ports is the trailer suction dredger; closely followed by the backhoe and grab dredgers. None of the port operators replying to the Review employ a dipper or bucket ladder dredger and only a small number make use of a cutter suction dredger (Figure 2).

There were three main reasons cited for the choice of dredging plant employed:

- Water depth: Backhoe and grab dredgers are limited to relatively shallow waters whilst trailer suction dredgers can remove material from deeper water.
- Accessibility of area: Trailer dredgers are used to dredge large areas as they require adequate working space to complete a turning circle. For use in restricted areas, backhoe and grab dredgers are most suitable.
- Availability of contractor/vessels: The dredging operation needs to be timed to coincide with the availability of the contractor. Smaller ports tend to use local contractors in order to minimise costs.

The majority of responding ports (55%) employed a contractor to carry out the dredging process, against 20% of ports operating their own vessels (Figure 3). A small number of ports (9%) own a vessel for daily upkeep, whilst employing a contractor for large-scale maintenance campaigns.

Figure 2. Popularity of conventional dredging plant.



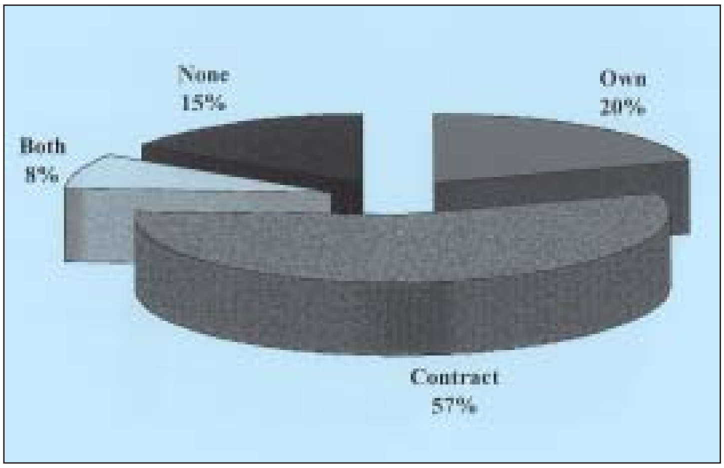
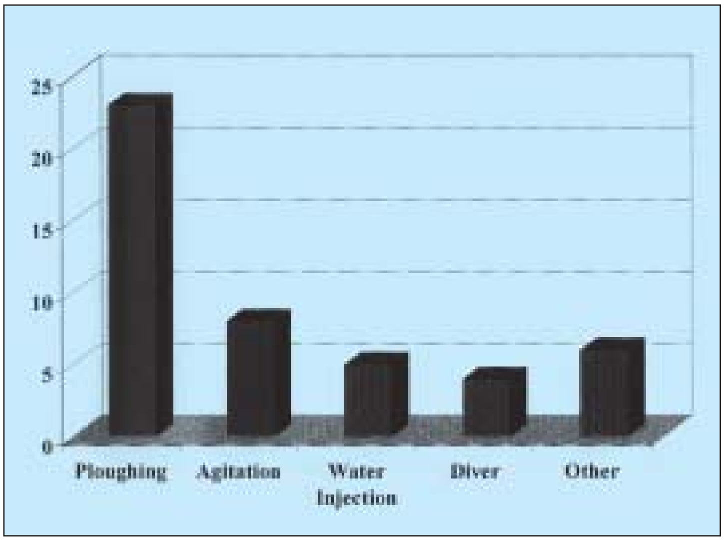


Figure 3. The percentage of respondents using contractors and/or port-owned vessels.

Figure 4. The types of hydrodynamic dredging techniques used by respondents.



Nearly all of the responding port operators stated that there were no noticeable environmental effects associated with, or following, the dredging campaign. Only 15 port operators (14%) stated that turbidity increased during the dredging campaign.

Section 3: The use of hydrodynamic dredging techniques

This section obtained information on the use of hydrodynamic dredging techniques.
Twenty-seven percent of respondents to the Review claimed to use hydrodynamic dredging techniques, with the plough/bed leveller being the most popular (Figure 4). The ports employing these techniques are widely distributed around the coast (Figure 5).

The main uses of the bed leveller are to move material from inaccessible areas into the path of the main dredging plant and to level the peaks and troughs caused by trailer suction dredgers. Most port operators found it difficult to define the quantities of material involved, but where estimates have been made, these are shown in Figure 5. ABP Goole and Fleetwood both redistribute significant quantities of material, >50,000 wet tonnes pa, using bed levellers in addition to licensed (dredging and) disposal operations.

Hydraulic dredging methods, which include vessel propeller agitation and water injection dredging (Figures 7 and 8), were used by 10% of respondents.

Some port operators (10% of respondents) use hydrodynamic techniques as their sole means of dredging. Most of these are located on the south coast of England and the quantities involved are small, <5000 wet tonnes pa. The other area that employs only hydrodynamic dredging techniques is the Burnham Yacht Harbour on the River Crouch, Essex with redistribution of >30,000 wet tonnes pa.

Experience indicated that the major limitation of hydrodynamic dredging techniques is a loss in effectiveness with increasing quantities of material removed.

Encouragingly, 80% of respondents stated that they would, in the future, perform some form of environmental impact study and consultation prior to commencing dredging using hydrodynamic techniques. The scale of the studies would depend upon the scale of the proposed dredging activity, as EIA is expensive and one incentive for using hydrodynamic dredging methods is their relatively low cost.

Section 4: Comments

Section 4 provided the opportunity for comparison of conventional and hydrodynamic dredging techniques and for any further comments.
A third of respondents declined to comment, feeling that they had no experience of one or other dredging types. The majority of larger ports indicated that hydrodynamic techniques are less successful as a lone method of dredging, but can be most useful when used in conjunction with conventional methods.

For many small ports, it is claimed that hydrodynamic dredging is the only cost effective way of maintaining water depths. Many small operators commented that they would be forced to close if any restrictions were placed on techniques such as ploughing.

A comment made by many ports was that hydrodynamic dredging techniques can be successful with the level of success depending on the operation and the many variables associated with a port (area, geography, topography, material and so on).

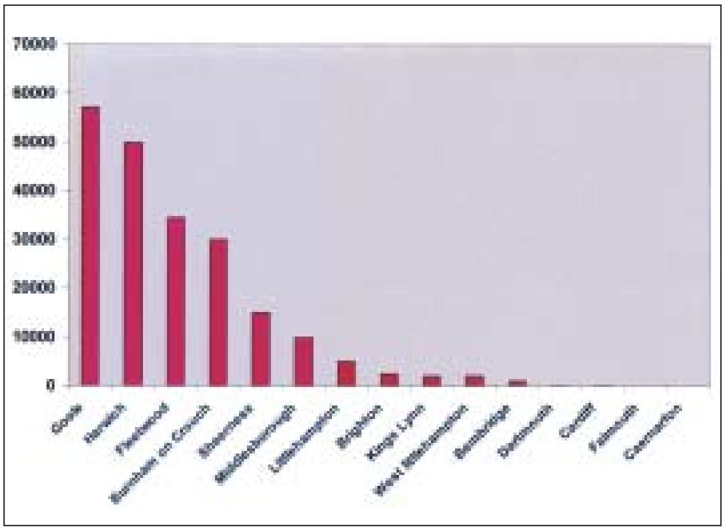


Figure 5. The location of ports using hydrodynamic techniques (left) and estimated quantities moved (above).

Many ports recognised the financial savings associated with hydrodynamic dredging techniques and indicated that their use was being considered for the future. However, as for current users, the quantities involved will probably be small and the areas localised. Ports that already use hydrodynamic dredging techniques plan to continue using them in the future, with quantities removed remaining similar to present.

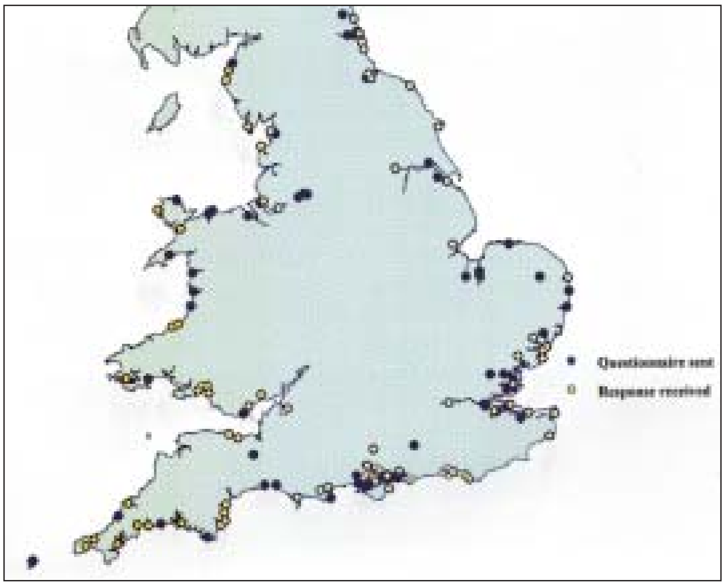
Discussion

The questionnaire "A Review of Dredging Techniques" received a good response with 42% of recipients returning completed questionnaires. In addition, the responses were geographically widespread, which enabled us to gain an understanding of dredging practices throughout the study area (Figure 6).

Of the responses received to the questionnaire, 27% indicated the use of hydrodynamic dredging techniques. Whilst this implies that a large number of ports do not employ these techniques, there are some ports using hydrodynamic dredging methods that did not respond to the survey. The ports that do use hydrodynamic dredging techniques are located all around England and Wales, suggesting that their use is not limited to a particular sedimentary regime. The sediments relocated by these techniques are mainly of silt grade, but some port operators successfully relocate fine and medium sand. However, as the particle size of the sediment increases, the success of most hydrodynamic dredging techniques tends to decrease.

This is to be expected, as most of these techniques rely, at least in part, on water flow to relocate the sediment.

Figure 6. Respondents to the questionnaire



The use of hydrodynamic dredging techniques can be classified into two groups:
1) sole use and
2) use in conjunction with conventional dredgers.

In general the smaller ports tended towards sole use, whilst larger ports used hydrodynamic techniques to dredge areas inaccessible to their main dredging plant, or to level areas following a dredging campaign (Figure 7).

One further use of hydrodynamic dredging techniques is by ports that have been refused a licence to dispose of dredged material at sea. There are a few ports that have highly contaminated sediments, but nevertheless have a requirement to dredge if the port is to continue to operate. If a sea disposal licence is refused, there are

Figure 7. The water injection dredger Jetsed working close to the Thames Barrier Clearance.

a number of options open to a port (such as use of sediments in land reclamation, transfer to a confined marine disposal facility, removal to landfill, application of sediment remediation techniques) but the easiest and cheapest option is often the use of a plough, or vessel propeller agitation. Such techniques in areas of contaminated sediment will inevitably result in the spread of the contamination.

The use of hydrodynamic dredging techniques can be very attractive in commercial terms for small ports, however the lack of legislative control could result in serious adverse impacts on areas of fisheries or conservation importance if the techniques are used without a suitable assessment of the consequences. The main issues of concern are the lack of knowledge of the destination of the sediment, and the possibility of chemical contamination within the sediments being redistributed. The sensitivity of the site is also of key importance. For example, the use of a plough dredger within a port already using a trailer suction dredger will have a minimum additional physical impact on the environment. In such situations, the sediments will have been chemically and physically characterised prior to the issue of a disposal licence, and hence a prediction of impacts can be readily made.

In contrast, the use of a plough or hydrodynamic techniques in an area located close to shellfish beds or a conservation site has the potential to yield adverse environmental effects from physical smothering. If the material is contaminated, then subsequent uptake of contaminants by filter feeders, or release of contaminants into the water column, may give rise to toxicological impacts on marine organisms and potentially to impacts on higher trophic levels through transfer up the marine food chain. Although many port operators did state that they would consult with appropriate bodies prior to commencing dredging using "non-FEPA-licensable" techniques, these statements were qualified by comments relating to the cost of such consultation.

This is particularly notable, as cost reduction is one of the prime reasons given for the use of hydrodynamic dredging techniques in small ports.

There are a number of other considerations associated with the use of these techniques: "hotspots" of contamination could be spread to give a higher background level with consequences for conventional licensed disposals. There is some difficulty in estimating the quantities of sediment relocated, and in identifying the subsequent deposition sites of the sediments.

Any evaluation of the potential impact of the use of such techniques should take account of the environmental sensitivity of the site, the nature of the sediments and the hydrodynamic regime. In making such an assessment, it is also appropriate to put it into the context of the impact of conventional dredging and of natural events including storms.

Case Studies

The following case studies present three different situations involving the use of dredging techniques with "non-FEPA-licensable" sediment disposal.

Dartmouth, Devon

The Dart Harbour Navigation Authority (DHNA) are responsible for maintaining navigable channels within the River Dart in Devon, England. Owing to relatively low levels of siltation (compared with other areas in England) there has not been a requirement to dredge the main channel and Dartmouth Harbour since 1955. However the River Dart is an important and popular area for sailing and the smaller channels, creeks and berths do require dredging to maintain access.

To meet this dredging requirement, DHNA commissioned the construction of an agitation dredger. The technology is based on offshore (e.g. pipeline) dredgers but DHNA developed the navigation dredging method (Barren). The agitation dredger, Neptune is flat bottomed and approximately 8 m in length with a width of <3 m. The propeller (diameter of ca. 1 m) can operate in water depths of up to 5.5 m but is most effective in shallower water. DHNA operate the vessel by swinging about an anchor in an arc of about 2.5 m, or moving the vessel through the berths and channels. The quantities of sediment relocated are not precisely known but DHNA estimate a quantity of between 150 and 1000 wet tonnes per annum (Figure 8).

DHNA do not carry out sampling or chemical analysis of the river sediments prior to dredging an area but it is known that, in the late 1980s, high levels of tributyl tin (TBT) were present in the water column (Waite and Waldock). It is likely that TBT will also be present in the sediments. Since the ban on the use of TBT on boats under 25 m in 1987, water column sampling (the most recent in 1992) has shown a significant decrease in TBT levels (Waite and Waldock). However, the decomposition of TBT in sediments is a very slow process and there may still be TBT present in concentrations that would harm marine life. Detailed research has shown TBT to have a wide range of harmful effects on marine organisms both sub-lethal and lethal with the scale of the effect dependent upon the species and the TBT concentration in the sediments (Alzieu). Hence TBT concentrations in sediments are a critical factor in deciding the suitability of dredged material for sea disposal in FEPA licence assessments (Murray *et al.*).

No formal investigations have been carried out into the destination of the disturbed sediment, but on the low tide following a dredging operation it is possible to see the newly deepened areas and a new layer of silt (1/4 inch thick) upon the surrounding mudflats (Barren).

The Dart, like many estuaries in England and Wales, is subject to an environmental management project (DEEM) which encourages and facilitates consultation between all groups involved with the estuary. The DEEM is supportive of the use of the Neptune and knows of no adverse effects of its use. The upper reaches of the River Dart contain a designated shellfish harvesting area. These shellfish would be sensitive to increases in the suspended solid content of the river water and TBT contamination in the sediments. It should be noted that at present the dredging is not performed in the immediate vicinity of this fishery.

Figure 8. The agitation dredger Neptune alongside the quay, with its propeller down, agitating the sediments to allow silt to be dispersed by the tide.

Burnham Yacht Harbour, Burnham on Crouch, Essex
The River Crouch in Essex, England is an important centre for sailing. During the summer months, the many river moorings in front of the town of Burnham on Crouch and the Burnham Yacht Harbour are filled with small yachts and sailing boats.

In addition, the relatively high siltation rates on the east coast of England produce a need for frequent maintenance dredging. Under the guidance of the Crouch Harbour Authority (CHA), the small marinas and harbours on the River Crouch employ a plough dredger to relocate sediment from the channels and berths. Approximately 30,000 wet tonnes of sediment (mostly silt) is relocated each year. During a visit to the Yacht Harbour to see the plough in action, a large plume of silt was observed in the dredged areas. The CHA continuously monitors the environmental impacts of ploughing, and has not observed any adverse effects to date. In addition, the Burnham Yacht Harbour has carried out its own investigation into the dispersal of the dredged material.

In early 1996, trials were carried into the use of water injection dredging in the yacht harbour. Presently, the use of the plough is the preferred dredging method. In recent years, Essex Marina at Wallasea Island has held a licence to dispose of dredgings at sea. The disposal site used was Bridgemarsh Island in the River Crouch where the material was deposited to help slow the erosion of saltmarsh from the island. Owing to a change of ownership of the marina, the licensed disposal has now ceased with the new marina operators intending to plough instead. This technique is said to have the support of the harbour authority, English Nature and the Environment Agency.

As a result in part of the location of the CEFAS Laboratory in Burnham, there have been a large number of studies and research projects carried out into various aspects of the river. These include investigations into the impacts of TBT from the yachts on the benthic communities in the river, and chemical analysis of sediments for contaminant levels. Very high levels of TBT in water and sediments were observed in the 1980s and these have since reduced following the ban on the use of TBT on small vessels in 1987 (Waite *et al.*). As a consequence, a marked biological recovery of the river is in progress (Waldock *et al.*). The sediments of the Burnham Yacht Harbour, analysed in support of applications for FEPA sea disposal licences, contain concentrations of contaminants similar to those in sediments from the river. However, with the cessation of FEPA licensed disposals, the dredged sediments are no longer subject to routine analyses under that procedure.

An environmental management project is proposed for the River Crouch that will encourage communication between users of the river. It seems that continued assessment of the impacts of dredging, and of the contaminant content of the sediments, would be an appropriate component of that management programme.

Harwich, Essex
In contrast to the two small operations discussed previously, the Port of Harwich in Essex, England, holds a FEPA licence to deposit at sea approximately 3 million wet tonnes of maintenance dredged silt and sand. The dredged areas include the approach channel to the important Ports of Felixstowe and Harwich.

The sediment is removed using a trailer suction dredger and is then transported out to the disposal site (Figure 9). In addition to the trailer suction dredger, Harwich also employ a plough dredger. The plough is used to relocate sediment from the berths and other restricted areas into the operating area of the trailer suction dredger. The plough may also be used to flatten out the peaks and troughs produced by the operation of the trailer suction dredger. Approximately 50,000 wet tonnes of sediment is moved from the restricted areas to be picked up by the trailer suction dredger and removed to sea.

Harwich Haven Authority (HHA) use turbidity meters to monitor the turbidity caused by both the plough and trailer suction dredgers, in addition to surveying the impacts on benthic organisms and fisheries. HHA are presently deepening the approach channel, and are involved in projects to beneficially use the dredged sediments in the local estuaries. One of these beneficial uses involves placing dredged silts into the water column to provide a sediment source with the aim of facilitating deposition on the mudflats. The increases in the suspended solid content of the water column in the deposit areas will mask any effects of using a plough.

Since the survey was completed, licences have been issued to Harwich Haven Authority for the disposal of approximately 27 million wet tonnes of material dredged as part of the capital project to deepen the approach channel. This disposal is in licensed dumping sites offshore, in additional to the near-shore and estuarial beneficial deposits.

The Use of Sidecasting in the UK

The following comments are not derived from the survey of dredging techniques, but are drawn from CEFAS's experience in relation to assessing application for FEPA licences.

In addition to the disposal of dredged material at sea, the deposit of material below mean high water springs in relation to marine constructions is also regulated

Figure 9. Trailing suction hopper dredger at work in the Harbour of Felixstowe, deepening the approach channel to make the harbour more accessible to the new generation of container ships.

under FEPA. The recent changes in European and UK legislation relating to the quality of marine discharges has prompted an increase in the number of applications for the construction of new outfalls. The following paragraphs describe the approach CEFAS use when advising the Ministry of Agriculture, Fisheries and Food of the impacts of outfall construction.

The most common method (currently) of outfall construction involves the dredging or excavation of a trench, and the placing of the excavated material on the seabed to one or both sides of the trench. This process is termed sidecasting. The dredging/excavating of the trench is not regulated by FEPA, but a FEPA licence is required to deposit the material onto the seabed. There are a number of generic issues of concern related to the environmental effects of sidecasting, however the importance of each issue will depend upon the specific characteristics of the construction site. Each application for sidecasting is assessed independently according to the sensitivity of the site but using a common set of guidelines.

Physical impacts

The main reason for sidecasting is to provide a temporary deposit site for material that will be required to infill a trench after placement of the outfall pipe. In many cases only a proportion of the sidecast material will be suitable for trench infilling. The rest of the material should be removed from the seabed on completion of the project and disposed of either to land, or to licensed marine disposal sites. The implications of not removing the excess material depend upon the site and the nature of the sediment, but may include damage to fishing equipment, provide a long-term source of suspended sediment or interfere with natural sediment transport processes. In some cases, there may be a potential for more damage to result from the removal of the material than leaving it in situ, so this must considered in the assessment

The physical impacts of sidecasting include:

– Direct smothering of benthic habitats by deposition onto the seabed.
– Increase in suspended sediment loads during trenching, deposition onto the seabed and the possible transport of suspended material to other areas.
– Once sidecast, the deposit will provide a source of sediment to be transported away from the construction site and deposited in other (possibly more sensitive) areas.
– Further release of sediment during replacement in the trench, or removal of excess material from the site.

The importance of these impacts will depend upon the type and quantity of material to be sidecast (recent applications have ranged from <1000 wet tonnes to

>250,000 wet tonnes), and the sensitivity of the construction site and surrounding areas. All of these factors must be considered during the assessment of an application.

Chemical impacts

The potential chemical impacts of sidecasting include:

– Contaminated material, if present at depth, may be brought to the surface and deposited on surrounding areas.
– Contaminants may be released into the water column.
– Disturbance of the sediments and the consequent changes in physicochemical parameters may increase the bioavailability of contaminants.

Unlike dredged material that is to be disposed of at sea, sidecast material is not routinely sampled and analysed prior to a FEPA licence being issued. However, where an area is likely to be contaminated or concerns are raised by consultees, samples are analysed. In many cases, chemical analysis is carried out during the production of an Environmental Assessment, and hence the data are available to CEFAS to inform the licensing process.

Conclusions

Hydrodynamic dredging techniques are used both alone and in conjunction with conventional dredging techniques at a number of ports and harbours throughout England and Wales

Most ports or harbours which use hydrodynamic techniques as their sole method of dredging move relatively small quantities of sediment, typically <5000 wet tonnes per annum, but up to 30,000 wet tonnes per annum can be moved in some cases.

Chemical and physical impacts associated with the use of hydrodynamic dredging techniques are seldom fully evaluated. There appears to be little if any requirement for such assessments under existing legislative controls

Potentially adverse environmental impacts can occur from the use of hydrodynamic techniques. A site-specific assessment should be made to ensure that measures are taken to minimise such impacts. Key factors are the environmental sensitivity of the site, the quantity and nature of the dredged sediment and the hydrodynamic regime.

When used in conjunction with conventional dredging from which sea disposal of the material has been licensed, additional adverse impacts from hydrodynamic dredging are likely to be minimal.

A few ports may take advantage of the lack of legislative control of hydrodynamic dredging techniques and employ them if refused a licence to dispose of dredged material at sea. If the licence has been refused because of high contamination of the sediment there is a strong likelihood of adverse environmental consequences resulting from the operation.

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