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Cover:
Satellite photos helped to monitor the progress of the construction of Palm Island (pictures shown at three-month intervals, see page 14).

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International Association of Dredging Companies
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EDITORIAL

The growth and expansion of dredging activities in the last decade, and the concern for ecological issues, have been mirrored in the breadth of articles in Terra et Aqua. In recent issues our pages have been filled with reports on environmental concerns at the Port of Brisbane, the need for more public awareness about dredging, the beneficial uses of dredged material, and new projects such as the Hong Kong airport, Singapore land reclamation, the new land IJburg in The Netherlands, and the Palm Island project in Dubai. These articles reflect the wide realm of the International Association of Dredging Companies (IADC). Whilst member companies are active from Asia to Australia to Europe to the Americas and Africa, the role of their umbrella organisation has also broadened.

As the voice of the private dredging industry, IADC has sought cooperation with CEDA, WEDA, IAPH, PIANC and other maritime institutions. The IADC seminar is in its eleventh year and will be given for the first time in the Middle East, in Dubai. A new Environmental Seminar, under development with CEDA, is ready to be launched by year’s end, and work with the London Convention through CEDA continues, as does participation in several PIANC working groups. In coordination with OPL, the initiative to publish Dredgers of the World was undertaken and the fourth revised edition will appear in September. The new edition of another publication, a joint venture with IAPH, Dredging for Development should be ready by the end of the year.

At the forefront of these developments has been Peter J.A. Hamburger, Secretary General of the International Association of Dredging Companies. Having spent better than a decade at the helm of the IADC during this exciting era, he is now ready to move on to new challenges elsewhere in the maritime industry. As of 1st October 2003, he will be handing over the reins of IADC to Constantijn Dolmans, who has been Deputy Secretary General for the last 5 years. With recognition of their past contributions, we sincerely wish both men success in their future endeavours.

Rob van Gelder
President, IADC Board of Directors
should be subject to a robust and rigorous study, but equally the suitability of the dredged material for some sort of beneficial use must be part of the same study. Why? Because the vast majority of dredged material around the world is not significantly different from the sediment found naturally in rivers, estuaries and seas. Natural processes bring soil down the river and into the estuaries and seas, and natural processes bring weathered rock material along the coast and up the estuary. In other words, this material is basically a natural resource and should not be regarded as a waste material that has to be disposed of. Much of that material therefore must be suitable for relocation within the natural ecosystem and/or some other form of beneficial use with or without treatment.

Abstract

Contrary to popular beliefs, the vast majority of dredged material around the world is not significantly different from the sediment found naturally in rivers, estuaries and seas. Since the 1980s, a number of NGOs including CEDA, PIANC and IAPH, as well as several Contracting Parties to the London Convention, have been arguing the case that dredged material generally should be regarded as a resource and not a waste. Therefore much of the dredged material is suitable for relocation within the natural ecosystem and/or some other form of beneficial use with or without treatment. This paper attempts to re-define the word “beneficial” and gives a survey of present beneficial use activities and suggestions for future options.

The paper was prepared under the auspices of CEDA by Eleni Paipai, presently of Halcrow Consulting Engineers, UK, with invaluable assistance from Axel Netzband (Germany), Polite Laboyrie (The Netherlands), Lindsay Murray (CEFAS, UK), Antonio Navarres (Spain), Caroline Fletcher (HR Wallingford, UK) and Neville Burt (HR Wallingford, UK). It was presented on behalf of WODA at the London Convention, Scientific Group meeting, April 2003 in London, UK.

Introduction

The great majority of the world’s goods are transported over water. Ports and inland waterways are therefore major revenue earners and creators of employment. Many waterways have recreational value and provide amenity uses to the general public. Thus waterways have considerable socio-economic value, which brings prosperity to thousands of communities around the world. In the majority of the world’s waterways dredging is essential to provide safe navigation routes to ports and harbours. Undoubtedly, the effects of dredging and operations on environmental resources should be subject to a robust and rigorous study, but equally the suitability of the dredged material for some sort of beneficial use must be part of the same study. Why? Because the vast majority of dredged material around the world is not significantly different from the sediment found naturally in rivers, estuaries and seas.
The phrase “beneficial uses of dredged material” first began to appear in dredging conference proceedings in Europe in about mid 1980s although it had begun to be used in the USA before that. To some extent it was a response to the London Convention (LC). In those days it was called the London Dumping Convention — which implied that any dredged “spoil” was a waste. A number of NGOs including CEDA, PIANC and IAPH, as well as several Contracting Parties to LC, began to argue the case that dredged material generally should be regarded as a resource and not a waste.

The London Convention’s Dredged Material Assessment Framework (DMAF) recognises that dredged material is increasingly regarded as a resource and it requires possible beneficial uses to be considered before a licence for sea disposal may be granted. The principle of “dredged material is a resource not a waste” was embodied in the first draft of the Dredged Material Assessment Framework produced in the Los Angeles inter-sessional working group in the early 1990s and has been generally adopted by Contracting Parties. Sadly, because the procedure is called “specific guidance for dredged material” under the “Waste Assessment Framework” the word “waste” has reappeared in its title. It is to be hoped that this does not inhibit constructive thought about beneficial uses of this plentiful resource.

Types of Beneficial Use of Dredged Material

The disposal of dredged material, whether from capital dredging or maintenance dredging, provides opportunities for a number of environmental, economic and aesthetic uses, including a number of innovative beneficial uses mainly with the fine grained dredged material. The following is a list of beneficial uses of dredged material:

- Sediment cell maintenance (more applicable to maintenance dredging);
- Construction and other engineered uses (e.g. land reclamation for port/airport development, residential development, redevelopment of confined disposal facilities);
- Construction material (e.g. dredged material mixed with cement, manufacturing of bricks);
- Replacement fill;
- Shoreline stabilisation and erosion control
  - beach nourishment
  - coastal realignment
  - muddy shore profile engineering
  - offshore berms (e.g. feeder berms, hard and soft berms);
- Amenity
  - beach nourishment
  - derelict land restoration
  - recreation (e.g. hills for walks and picnic areas)
- landscaping (parks and other commercial and non-commercial landscaping applications)
- Capping (one of the early beneficial uses of clean dredged material was to cap contaminated dredged material in offshore disposal sites)
- Habitat restoration, enhancement and/or creation (e.g. saltmarshes, mudflats, wetlands, bird islands, gravel bars, oyster sandy/gravelly beds) (Figure 1)
- Aquaculture
- Agriculture (e.g. cotton fields)
- Horticulture (e.g. orchards, ornamental plant nurseries)
- Forestry
- Strip mine reclamation and solid waste management

In the early days there was a widely held perception that beneficial uses would only ever be applied to small quantities in tailor-made situations. However, with increasing pressures under the regulatory systems, the use of some creative thinking, and the development of new technologies there is now widespread use of dredged material for beneficial purposes. It might also be said that there has been some re-definition of the word “beneficial”.

Beneficial Use Options by Material Type

Rock is a valuable construction material and whether or not it can be used economically depends on its quantity and size.

Gravel and sand are generally considered the most valuable material for reuse that a dredging project can provide. They can find wider application as a resource material to a number of engineered uses, and most frequently without the need to sort (or pre-wash) the material prior to being used. The engineered uses mainly are land reclamation, construction material, replacement fill, land improvement, capping, beach nourishment, and offshore berms. “The range of engineering applications for dredged material is diverse, being limited only by the ingenuity of the designer” (PIANC, 1992).

Clay and silt are the most common materials acquired from maintenance dredging in rivers, canals and ports. Consolidated clay can find more engineered uses than soft clay, whereas silt in particular is more suitable for agricultural/horticultural purposes and all forms of habitat creation and/or enhancement. The economical use of clays and silt differs from that of rock mainly in terms of preparation work prior to their beneficial use; silt and soft clay needs dewatering unless appropriate dredging equipment removes them almost in-situ density. Also, silt, being fine-grained sediment, can contain contaminants in quantities, which necessitate a certain degree of pre-treatment prior to a beneficial use.
transport modelling studies and ecological models are some of the tools, which nowadays can facilitate the
decision-making process for beneficial uses of dredged material. Environmental legislation requires the use
of such tools for all dredging and disposal projects particularly when they are located in or near sensitive
natural resources. It also emphasises the importance of
timing of such studies early on in the project in order to
prevent and/or reduce negative environmental impacts
and maximise the potential for mitigation measures.
Early consideration of beneficial use options in a dredging
project can have the dual benefit of a successful
beneficial use application and minimum environmental
impact.

Science alone, however convincing, cannot guarantee
the successful application of beneficial use options for
dredged material. The main reason for this is the large
number of interests of an equally large number of
stakeholders involved in a dredging project, who are
trying to reach a consensus particularly in terms of
timing and costs. Such difficulties can be overcome by
long-term planning. The key to success for the beneficial
use project planner is to identify how, when and where
dredged material from a navigation project can fulfil an
economic need, whilst paying due regard to environ-
mental considerations and limitations. Identification of
economic and/or social benefits may help overcome
some environmental opposition to the use of dredged
material. A multi-criteria analysis where ecology, geology,
hydrogeology, economy and society are considered is
the route to an effective screening down to an appro-
priate number of beneficial use options.

A large number of countries are already engaged in
such type of projects, however the beneficial use of
dredged material is not as widely applied as many in
the dredging industry would like. Why not? There are

Figure 1. Wetlands restoration is a beneficial use option which encourages long-term habitat development.

Pre-treatment of dredged material to facilitate and
optimise their beneficial uses can, however, be costly
and co-ordination and cost sharing may be very difficult
to achieve. These difficulties, however, can be over-
come by discussion between the interested parties
and stakeholders from policy-makers to the dredging
industry who are left to do the work. Co-operation is
more likely where a defined regional policy exists
which positively encourages the beneficial use of
dredged material (PIANC, 1992).

Decision-making Considerations for
Beneficial Uses of Dredged Material

Defining “beneficial” is not easy. “The context in
which the phrase was coined has probably emphasised
beneficial to the environment rather than beneficial to
man in particular. It still poses the question of what will
benefit.” (CEDA/IADC, 1999).

Indeed, the construction of offshore berms for purposes
of improved coastal protection may be regarded by
many as a serious threat to shellfisheries resources.
A serious threat it may be, but a comprehensive
investigation of the physical, chemical and biological
characteristics of the dredged material, of the way it is
expected to behave after placement and of the hydro-
dynamic regime, which will determine its behaviour
can significantly contribute to a successful beneficial
use. Such information is essential for evaluating
the suitability of the dredged material for numerous
beneficial use applications, as well as for the identifica-
tion of preventative measures to ensure the minimum
environmental impact and maximum beneficial use
chance.

Environmental impact assessment studies, sediment
a number of reasons including:
- Dredged material is legislated in a “peripheral” way; disposing of dredged material on land is subject to legislation on soil;
- First and foremost there is different legislation for dredged sediment management between rivers and coast;
- Unless a use is identified, dredged material in the eyes of environmental law is a waste;
- Where dredging is most frequently required (i.e. where low-energy hydrodynamic regimes allow settling of suspended sediment) is where contaminants entering watercourses upstream tend to settle down along with the fine sediments.

**Beneficial Use Options for Contaminated Dredged Material**

Obviously, the degree of sediment contamination, being a decisive factor in any management process for dredged material, plays an even bigger part when considering beneficial use. Without treatment, highly contaminated sediments will normally not be suitable for most proposed beneficial use applications, particularly where wildlife habitat development projects are proposed. The exception to this may be the processing of highly contaminated sediment for the purpose of creating a usable construction product (e.g. ceramic, aggregate, and such) or the beneficial end-use of a confined disposal facility (CDF) where contaminated dredged material is disposed. However, moderate and slightly contaminated sediments may be appropriate for many beneficial uses, possibly after pre-treatment and/or covering with clean material. What determines whether or not contaminated dredged material can be used beneficially is the compatibility between the physical, chemical and biological properties of the dredged material and those of the intended beneficial use, as well as the potential for impacting on sensitive natural resources.

PIANC in its Working Group 17 report on “Handling and Treatment of Contaminated Dredged Material from Ports and Inland Waterways” has come up with the Contaminated Dredged Material Technical Framework (CDMTF) (Figure 2). This framework is an “international road map” for nations to follow when developing and evaluating the appropriate options for dredging and management of contaminated dredged material, including the options for a beneficial use. CDMTF comprises a number of functional steps, aiming to assist project developers and regulators to approach, in a systematic and logical way, the development of alternative uses of dredged material, that are both environmentally and economically feasible.

“The assessment of the potential for a beneficial use of dredged material that is contaminated is a functional step early on in the CDMTF, demonstrating the significance of regarding dredged material as a resource rather than as a waste” (PIANC, 1996).

In both The Netherlands and Germany, dredged material, which cannot be relocated in the water system or be used directly as a soil substitute, is regarded as waste. European legislation sets the priority on the beneficial use option but pre-treatment (e.g. dewatering) is almost certainly required. If the costs for pre-treatment are prohibitive or it proves to be technically not feasible, the only option left is disposal either offshore or in confined disposal facilities. Management of such sites nowadays includes the re-use of dredged material from within the confined disposal facility, after some form of treatment and/or the identification of an end use for the site.

In The Netherlands in particular, dredged material has always been regarded, and in many cases, used as a resource. At present, relatively clean material is returned to the North Sea where from they move north and feed the Waddensea in areas where soft sediment is needed for benthic productivity. Its usefulness was first realised well over 30 years ago when farmers used it as a growing medium, and polders were filled up with it. Later on houses were built on land where dredged material was used as engineering fill. Dried sediment from rivers was used to make building blocks.

All that, however, was stopped when in the 1980s the seriousness of the contamination levels in the sediments was realised. In response to this significant problem and in realisation of the potential of such a resource, the Dutch Government decided to address the problem at its root and targeted the industrial discharges into the waterways, which were the major culprit for the sediment contamination. In addition, confined disposal facilities were built and research into treatment technologies was becoming increasingly active. The ultimate goal of this conscious activity was to reduce contamination levels in dredged material as much as it was necessary to enable their beneficial use.

In 1995, the Dutch Government set a target of 20% of dredged material to be used beneficially. Dutch policy now aims to increase the amount of contaminated dredged material to be treated and reused as construction materials in order to save on disposal capacity in confined disposal facilities and to produce new building materials. Although research and active projects demonstrated that technically, chemically and biologically treatment of contaminated sediment could enable its beneficial use, the target percentage has not yet been reached because the biggest problem was public perception. In order to make the public aware of what is possible with contaminated dredged material, people had to learn about contamination and its implications. The result was that people were still suspicious of treated dredged material.
At present, the Dutch Government subsidises the beneficial uses of contaminated dredged material. The subsidy scheme and pilot project are part of a more comprehensive programme to encourage treatment, which also includes an environmental tax on the disposal of easily treatable contaminated dredged materials and promoting the sale of these products (Hakstege and Heynen, 2003).

**Beneficial Uses of Fine-grained Dredged Material**

Over the last 10 years or so, dredging and disposal licensing authorities, conservation and environmental protection authorities in the UK have largely contributed in the change in view that only sand and gravel may be used beneficially. Fine-grained materials are now seen...
as a valuable resource, and this was evident by the number of opportunities to use capital and maintenance dredged material. In 1992, 0.07% of fine-grained dredged material was used beneficially in the UK, whereas in 2000 0.47% was used beneficially. In 1998, when Harwich Harbour Approach Channel in the east coast of England was deepened, the amount of fine-grained material used beneficially went up to 0.78%. Fine-grained dredged material is mainly used for flood and coastal defence, sediment cell maintenance and habitat conservation or enhancement (Table I).

The soft coastlines of various parts of the UK, particularly in the southeast of England are eroding, some of them at an alarming rate. These soft coastlines comprise saltmarshes and mudflats, which help protect and stabilise sea walls by buffering wave action. The Environment Agency, which is responsible for the flood protection measures in the UK, see two alternative solutions to the coastal erosion problem: either maintain and build bigger sea walls, at huge costs, or adopt a sustainable approach of working with coastal processes such as using beneficially fine-grained maintenance dredged material (DECODE, 2002). Dredged material has been shown to successfully combat erosion and even create new saltmarshes, which eventually become capable of functioning like natural systems. In a similar way, fine-grained maintenance dredged material can be used to create mudflats or, more usually, to enhance biologically poor mudflats and in time turn them into much more productive systems than before.

**Innovative Beneficial Uses of Fine-Grained Dredged Material**

The recent success of beneficial use schemes has significantly contributed to an increasing willingness to identify novel methods of intertidal placement of fine dredged material. One of the main drivers was the assurance of the regulators and nature conservation bodies that the retention of the material within an estuarine system is one of the more appropriate applications for beneficial use.

In many tidal estuaries there is a net balance between the amount of material being deposited and eroded. It is a dynamic and self-regulating process for excessive erosion and accretion. The balance it achieves may be disturbed as a result of dredging. Continuous removal of fine material by dredging may eventually lead to the permanent loss of intertidal banks and saltmarshes. Fine-grained maintenance dredged material can be (this is the current practice in the UK) returned to a tidal estuary in order to minimise perturbations to an estuary’s cell maintenance of soft sediment during essential dredging works.

Between October 1998 and April 2000 the approach channel to Harwich Haven Ports, in southeast England was deepened. The Department of the Environment, Transport and the Regions issued consents for the works under the Coast Protection Act, 1949, part of which was the “Mitigation and Monitoring Package”. One of the detailed objectives for mitigation defined in the “Mitigation and Monitoring Package” was to create 16.5 hectares of intertidal habitat in the Stour and Orwell Estuaries Special Protection Area (SPA) (protected under the European Directive for the Protection of Birds) and to prevent the loss of up to 5 hectares per annum of intertidal habitat owing to the increased rate of erosion. This objective is to be achieved through the implementation of a sediment recycling initiative associated with maintenance dredging campaigns in the Stour and Orwell Estuaries and is being implemented by several means of returning fine-grained sediment in the estuarine system. These involve direct subtidal

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**Table I. Quantity of silt deposited at sea and beneficially between 1992 and 2000 in England.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Total tonnage disposed in England and Wales</th>
<th>Beneficial use tonnage</th>
<th>% used beneficially</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>28,976,381</td>
<td>20,800</td>
<td>0.07</td>
</tr>
<tr>
<td>1993</td>
<td>28,487,422</td>
<td>20,800</td>
<td>0.07</td>
</tr>
<tr>
<td>1994</td>
<td>39,132,395</td>
<td>40,950</td>
<td>0.1</td>
</tr>
<tr>
<td>1995</td>
<td>40,247,625</td>
<td>26,000</td>
<td>0.06</td>
</tr>
<tr>
<td>1996</td>
<td>51,251,367</td>
<td>36,140</td>
<td>0.07</td>
</tr>
<tr>
<td>1997</td>
<td>41,241,324</td>
<td>80,600</td>
<td>0.2</td>
</tr>
<tr>
<td>1998</td>
<td>28,849,142</td>
<td>226,000</td>
<td>0.78</td>
</tr>
<tr>
<td>1999</td>
<td>57,305,868 (Harwich Haven Approach Channel first deepening)</td>
<td>426,000</td>
<td>0.74</td>
</tr>
<tr>
<td>2000</td>
<td>52,274,543</td>
<td>245,000</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Source: CEFAS (Centre for Environment, Fisheries and Aquaculture Science), Burnham Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA, tel: +44 (0)1621 787200, fax: +44 (0)1621784138. E-mail: s.j.bolam@cefas.co.uk, http://www.cefas.co.uk
The effects of sediment placement on bird and fish populations. This is particularly important as the majority of beneficial use schemes are in estuarine intertidal habitats, areas important for sustaining such populations (Bolam, 2000).

The impacts of sediment disposal on benthic communities vary depending on many factors including the amount, frequency and nature of the disposed sediment, water depth, hydrography, time of year, the types of organisms inhabiting the disposal area and the similarity of the dredged sediment to that of the disposal area (Harvey et al., 1998). Where dredged material has been placed, for instance for habitat enhancement, and temporary upsetting or localised loss of benthos has followed, the sequence of changes towards recovery appeared to be dependent upon many factors, including:

– the availability of colonisers;
– the characteristics of the deposited sediment;
– the survival of the disposal site community and/or exotics (species introduced with the disposed material); and
– the timing of any later depositions.

The complex nature of the intertidal communities makes prediction of their post-placement behaviour inherently difficult. However, the observed succession patterns have been shown to be similar following many types of disturbances, even though the actual mechanisms operating during the succession dynamics of fine-grained sediments remain uncertain. In general, following the local elimination of the macrofaunal community, the re-colonisation process begins with the

Figure 3. Schematic presentation of subtidal placement and water column recharge of fine-grained dredged material

placement, increased overflow during dredging operations and water column recharge (sprinkling). The latter is the most novel of the recharge techniques being applied in the Stour and Orwell estuarine system. The process is subject to ongoing refinement as field data is obtained and used to improve the knowledge of sediment budgets within the system (Figure 3).

The Challenge to Wider Application of Beneficial Uses of Fine-Grained Material

Compared to capital dredged material, which typically comprises relatively coarse material, the behaviour of deposited fine-grained maintenance material tends to be less predictable. It is possible to reduce this unpredictability by engineering the placement site so that it confines the deposited fine dredged material.

At present, the beneficial placement of maintenance dredged material within the UK is limited to small-scale trials. There are several reasons for this. Firstly, there are concerns over subsequent movement and hence the potential for interference with other uses/users of the sea. These concerns arise from our current lack of understanding of the biological processes following deposition: phyto- and zoo-benthic re-colonisation may have profound effects on the stability of sediments, and hence, the fate of deposited material in both the short and long term. Secondly, our lack of knowledge of the rates of invertebrate recovery, and how they are affected by other factors, limits our ability to predict the effects of sediment placement on bird and fish populations. This is particularly important as the majority of beneficial use schemes are in estuarine intertidal habitats, areas important for sustaining such populations (Bolam, 2000).

The impacts of sediment disposal on benthic communities vary depending on many factors including the amount, frequency and nature of the disposed sediment, water depth, hydrography, time of year, the types of organisms inhabiting the disposal area and the similarity of the dredged sediment to that of the disposal area (Harvey et al., 1998). Where dredged material has been placed, for instance for habitat enhancement, and temporary upsetting or localised loss of benthos has followed, the sequence of changes towards recovery appeared to be dependent upon many factors, including:

– the availability of colonisers;
– the characteristics of the deposited sediment;
– the survival of the disposal site community and/or exotics (species introduced with the disposed material); and
– the timing of any later depositions.

The complex nature of the intertidal communities makes prediction of their post-placement behaviour inherently difficult. However, the observed succession patterns have been shown to be similar following many types of disturbances, even though the actual mechanisms operating during the succession dynamics of fine-grained sediments remain uncertain. In general, following the local elimination of the macrofaunal community, the re-colonisation process begins with the
recruitment of opportunistic species, typically small, tube-dwelling polychaetes and oligochaetes, which may reach very high densities. Their near-surface activities act beneficially as they gradually “condition” the sediments allowing the successful colonisation of less opportunistic species. Consequently, later succession species are able to survive and the community functionally resembles the one prior to disturbance (Figures 4, 5 and 6).

THE FUTURE

Understanding the factors influencing the colonisation of fine-grained sediment after intertidal disposal

In the UK, CEFAS, the Centre for Environment, Fisheries and Aquaculture Science, is heavily engaged in research work to better understand the factors influencing the colonisation of fine-grained sediment after intertidal disposal. There is a fundamental need to develop a better predictive ability at the community level in order to assess the ecological consequences of disturbances, and design successful beneficial use schemes (Bolam, S., 2000). In general, from the very few studies in the intertidal zone, invertebrate community responses to the deposition of maintenance dredged material occur much more slowly than those reported for subtidal (particularly estuarine) systems. The fine sediments relocated during beneficial use schemes tend to be very unconsolidated with very high water contents and it is possible that this may inhibit initial re-colonisation. Invertebrate community responses are likely to depend on factors such as the frequency and intensity of dredged sediment deposition, type of material deposited and the nature of the recruiting assemblage.

There are, however, still important questions that need to be addressed in order to improve our understanding of the biological processes following deposition, our knowledge of the rates of invertebrate recovery, and how they are affected by other factors. Answers to the following questions should enable successful applications of large-schemes of beneficial uses of fine-grained dredged material (Waldock et al., 2002).

These questions include:

– How does the nature of dredged material (particle size distribution, organic content) affect survival of species at the deposition site and succession dynamics following deposition?
– Does the degree of consolidation of relocated sediments affect the initiation of re-colonisation?
– How does the rate of deposition of the dredged material affect survival of species and succession dynamics?

Wider application of beneficial uses of fine-grained (muddy) dredged material

There is undoubtedly a fundamental need to improve our understanding and predicting ability of how factors influence the rate of colonisation of fine-grained material after intertidal placement in order to increase the degree of success of beneficial use schemes, and particularly with fine-grained dredged material. At present, the beneficial placement of fine-grained dredged material within the UK is still limited to small-scale trials because of the largely unknown factors that

Figure 4. In 1998 and 1999 fine-grained dredged material was placed at Titchmarsh Marina in the UK to create mudflats and saltmarshes. Seen here, the placement stage.
Sediment management

The primary limitation of more beneficial use application, in the experience of Germany and The Netherlands, is the contamination levels of dredged material. Those responsible for dredging are not responsible for the contaminants in the waterways, which is why source control to reduce contamination input must be seen as the only effective future solution to the ongoing problem of dredged material disposal. Germany believes that source control can solve the problem of contaminated sediments. The International

Contribute to the colonisation by plants and animals of the disposal site after placement.

In the meantime, however, visible results mainly from small-scale schemes in a relatively short time, increase our confidence in beneficial use schemes using fine-grained material in intertidal areas, and drive attempts to identify new techniques in retaining such material within sediment cells. Large-scale schemes of beneficial use of fine-grained material, which provide the opportunity to closely observe and understand the factors influencing the re-colonisation process at the disposal site, should also contribute to further widening the spectrum of beneficial uses of dredged material and give confidence to regulators that such schemes are feasible.

Such a scheme has recently been commissioned by DEFRA (the Department for Environment, Food and Rural Affairs) in the southeast of England. The physical, chemical and biological processes of this large-scale scheme will be monitored by HR Wallingford and CEFAS. In addition, the practicalities of large-scale placement of fine-grained dredged material will be part of the study as well as lessons learned from other similar projects worldwide.

The water column recharge (sprinkling) in the Stour Estuary in the UK is an innovative and promising technique that uses fine-grained material. Ongoing studies will show whether this is an effective method of returning material to the intertidal areas despite its negative, yet short-lived, aesthetic impact. Up until now, observations indicate that it is likely to be the most efficient way of returning fine sediment to the intertidal areas.

Beneficial Uses of Dredged Material: Yesterday, Today and Tomorrow

11

Figure 5. Titchmarsh Marina: Growth starting to appear.

Figure 6. Titchmarsh Marina: Diverse saltmarsh vegetation has colonised the recharged area successfully.

Sediment management

The primary limitation of more beneficial use application, in the experience of Germany and The Netherlands, is the contamination levels of dredged material. Those responsible for dredging are not responsible for the contaminants in the waterways, which is why source control to reduce contamination input must be seen as the only effective future solution to the ongoing problem of dredged material disposal. Germany believes that source control can solve the problem of contaminated sediments. The International
Commission for the Protection of the River Elbe foresees that the sediments shall be clean by the year 2010 in a way that they can be used beneficially, for example, for agricultural purposes.

For a greater emphasis and more effective application of beneficial uses of dredged material, handling of sediments (including treatment and confined disposal) has to be more effectively recognised and represented in the legal framework (Dutch-German Exchange on Management of Dredged Material, 2002). On the European level this is not the case. For example, the Landfill Directive does not take into account the special properties of dredged material and the sub-aquatic confined disposal is not accepted as an effective way of storing and confining contaminants.

Contrary to conventional waste, fine-grained dredged material, which has a very low permeability, when stored in anoxic and sub-aqueous environment, provide its own “sealing capacity” (both in terms of physical and geo-chemical properties) and thus groundwater protection. Yet the Landfill Directive requires that confined disposal facilities for contaminated dredged material should be lined with artificial liners. There is however no known artificial liner with more than 25 years of lifetime; in other words effective ground and groundwater protection is guaranteed up to a maximum of 25 years. Thus wider recognition of the properties of dredged material and its post-disposal behaviour, as well as legislative harmonisation in terms of how and where dredged material can or cannot be disposed of on land, is required for a more successful application of beneficial uses of dredged material and particularly fine-grained dredged material.

**Conclusions**

The development of beneficial use options for dredged materials contributes to a sound economy and ecology. Yet these options remain acutely underdeveloped. In general, relatively coarse, capital dredged material is more easily utilised because it is more predictable. For the intertidal placement of fine-grained maintenance dredged material, however, a fundamental need remains to identify innovative methods. This means developing a better predictive ability to assess the ecological consequences of disturbances caused by fine-grained sediment. Recent small-scale schemes in the UK and elsewhere give reason for optimism. In addition, large-scale pilot studies are in the planning or under way.

The primary limitation of more beneficial use applications is the contamination levels of dredged material. Those responsible for dredging are not responsible for the contaminants in the waterways, which is why source control to reduce contamination input must be seen as the most effective future solution to the ongoing problem of dredged material disposal. In addition, the handling of sediments, including treatment and confined disposal, has to be more effectively recognised and represented in the European and international legal framework.

**References**

IADC International Seminar on Dredging and Reclamation

More than eleven years ago, the International Association of Dredging Companies (IADC) and the International Institute of Hydraulic and Environmental Engineering (IHE) joined forces to develop the first International Seminar on Dredging and Reclamation in Delft, The Netherlands. The Seminar, presented by professionals from IADC member companies, formed a complete unit within a year-long graduate level study programme at IHE.

Since then the Seminar has become one of the main elements in the IADC’s efforts to reach young people all over the world and help them understand the need for dredging, the process by which the decision to dredge is reached, and how a dredging project is implemented. Building on the success at IHE Delft, it has since been held in Singapore, Buenos Aires and Egypt. Now, with the same enthusiasm, a request has been made to present the Seminar at still another location, and thus in October 2003 it will be given for the first time in Dubai, UAE (see page 32).

 Needless to say, as dredging is a growing, dynamic industry, the Seminar programme has been updated continuously and the manual has been revised to include the newest equipment and state-of-the-art techniques. The basic principle, however, remains unchanged: A well-executed dredging project results in positive developments for an area’s economy, for its environment and for the quality of life of its residents. Also unchanged is IADC’s commitment to education, to encouraging young people to enter the field of dredging, and to improving communications and understanding about dredging throughout the world.

The Seminar in Brief
To optimise the chances of the successful completion of a dredging project, it is important that from the start contracting parties fully understand the requirements of the project. The five-day course seeks to establish this and is divided into two types of presentations:
- lectures by experts in the field, and
- workshops, partly conducted on-site in order to give the "students" hands-on experience.

An important feature of the Seminar is a trip on a trailing suction hopper or cutter to visit a nearby dredging project in the local geographic area. This gives the participants the opportunity to see dredging equipment in action and to gain a firsthand view of the extent of dredging activities.

As part of the course, participants receive a comprehensive manual which includes a reference list of relevant literature in the field. At week’s end, attendees are presented with a Certificate of Achievement from the IADC in recognition of their completion of the course.

Education about dredging, both within the profession and for others who come in contact with dredging, continues to be a necessity. Even today too often misunderstandings arise between the public, dredging companies and government agencies. Raising the level of knowledge about the dredging industry is an important responsibility of the industry itself. Ignorance is not bliss, and only by providing accurate information can we ensure that dredging, with the highest quality and adherence to international guidelines, treaties and safety standards, will continue.

The Seminar will next be given October 11-15 2003 in Dubai. For further information about the venues for courses in 2003 and 2004 please contact the IADC Secretariat in The Hague by telephone (+31 70 352 3334) or by email (info@iadc-dredging.com).
Abstract

The construction of an artificial island in the shape of a palm tree with a diameter of approximately 5 km in front of the coast of Dubai is nearing completion. To protect the island against wave attack, an offshore crescent breakwater surrounding the island with a total length of 11 km was constructed at the same time. After completion, the island will be developed into virtually self-contained communities including marinas, shopping centre, theme parks, restaurants and so forth.

The Client is Dubai Palm Developers, a subsidiary company of the Dubai Ports, Customs & Free Zone Corporation. The main contractor for the reclamation works, totalling some 70 million m³ of sand, is Van Oord ACZ. The breakwater construction was carried out under a separate contract awarded to Achirodon Overseas. The contract was awarded to Van Oord ACZ at the end of 2001 and works have to be completed end 2003.

One of the main challenges was constructing the sand fill for the island, which had to be carried out partly in unprotected sea conditions, since the breakwater was under construction simultaneously because of the tight time schedule. Therefore an execution methodology was developed aiming at an optimal schedule in terms of speed of construction and minimal risks of damage and sand losses.

First an inventory was made of the different sand transport mechanisms i.e. long-shore, cross-shore and wash-over transport and how this would effect the work under construction taking into account a number of possible execution strategies. From this study, the optimal execution methodology was derived. Also optimal logistics in terms of cycle times and combination of placement/rainbowing has been achieved, by implementing day-to-day survey results into the DGPS tracking system. In this way underwater filling is made possible, leaving open sufficient space to manoeuvre the ships.

Figure 1. Artist impression of Palm Island 1.
Introduction

Jebel Ali Properties is developing a prestigious housing and recreation project on new land to be reclaimed in the Gulf between Dubai City and Mina Jebel Ali. The project, aptly named Palm Island Project, comprises an artificial palm-shaped island protected at the seaward side by an armoured semi-closed oval crescent (Figure 1). The area under consideration has water depths ranging between 8-10 m below Jebel Ali CD (tidal range is approximately CD+0.5 m to CD+1.5 m) and an almost horizontal to very mild foreshore. The island itself is built from locally dredged sand. The dimensions of Palm Island are impressive: the perimeter of the crescent is approximately 11 km long, the surface to be reclaimed is about 650 ha and the net sand volume is about 70 million m³. The total time allowed to construct the island is two years. The required sand is acquired by hopper and cutter dredgers and is deposited in the lee of the oval crescent surrounding it. The contractor Archirondon Overseas is main contractor for the construction of the rock armour protected crescent, where Van Oord ACZ is the main contractor for the construction of the actual island (Figure 2).

Since the crescent breakwater and sand-filled island were built simultaneously due to time restrictions, the island was partly unprotected during the first stages of the construction. This means that during this construction period the integrity of the island was endangered by the incoming waves, making the progress and success of its construction strongly dependent upon the progress of the crescent construction providing a sheltered area.

Therefore an optimal execution schedule in terms of maximum speed of construction and minimal risks (of damage) was developed by cleverly scheduling the works taking into account and combining the increasing sheltering effect of the crescent under construction, the relevant sediment transport processes and the vessel characteristics and movements.

Sheltering Effect of the Crescent

The wave climate can be characterised as generally mild. The most frequent and most intense storms come from a narrow range of directions in the W-NW sector throughout the months November to April. These are locally referred to as “Shamal” events. Typically wave events with significant wave heights (Hs) of 1-2 m occur rather frequently in this season. Storms with return periods of 5-10 year will produce waves in the order of 3.25 m whilst the 1:100 years design conditions have been set at Hs=4 m. Storm surges are limited to approximately 0.5 m above tidal level (MHHW = CD+1.6 m).

Rob de Jong obtained his Master Degree in Civil Engineering from the Technical University Delft in The Netherlands (2001). Thereafter, he joined the Van Oord ACZ Engineering Department where estimating sand loss during the construction of Palm Island was his first major project.

After graduating in Civil Engineering, Mark Lindo joined FC de Weger International Consultants, where he was involved in the design and review of several large-scale hydraulic and civil engineering projects such as storm-surge barriers and breakwater rehabilitation projects. From 1986-1990 he was Head of the R&D Department of ACZ Marine Contractors and also part-time Scientific Officer at Technical University Delft. Since 1990 he is Head of the Engineering Department VOACZ.

Saeed A Saeed is Director of Projects at Palm Island Developers, Dubai.

Jan Vrijhof is head of the Estimating & Engineering Department at VOACZ since 1999. After obtaining his degree in Civil Engineering (Coastal Construction) at the Technical University Delft (1979), he joined the dredging industry. Over the last 24 years he has worked in many positions and locations. As project manager he was responsible for a number of major dredging projects including one of the Airport Core Projects in Hong Kong, the West Kowloon Reclamation Project. In 2001/2002 he was appointed interim Project Manager during the start-up of the Palm Island Project.
To determine the sheltering effect of the crescent under construction numerical wave computations have been carried out with the 2-dimensional numerical wave model SWAN. Since diffraction equations are not yet modelled in SWAN, an increased directional wave spreading has been applied in the SWAN wave computations. The solution was tuned using the diffraction examples provided in the Shore Protection Manual [1] and gave satisfying results for this situation.

The wave computations were carried out for a combination of 6 different wave directions, 6 different wave heights and 18 different lengths of the crescent under construction. Thus a total of 36 (6 x 6) wave computations have been performed for 18 crescent lengths, hence a total of 648 computations. The completion dates for the various crescent chainages and thus crescent lengths were derived from the planning of the breakwater construction (Figure 3).

The ratio between the computed wave height and the boundary wave height give so-called transformation ratios. These transformation ratios were combined with the nearshore monthly wave climates to determine the monthly wave climates for the various stages of the crescent construction. For each phase of the crescent construction it was thus possible to estimate the sheltering effect on the average wave conditions by comparing the wave climate as computed with and without the crescent (for each specific location, relevant month and accompanying crescent length).

SEDIMENT TRANSPORT PROCESSES

When waves attack the partially completed sand island, they will move sand out of the predefined boundaries of the fronds and trunk (Figure 1). Especially the ends of the fronds will experience losses, since they will lose sand by a combination of littoral (long-shore) and perpendicular (cross-shore) sand transport, whilst they are the least protected by the crescent during the construction phase and are more vulnerable to adverse 3-dimensional effects. Furthermore, there is no natural sand supply. The removed sand is thus permanently lost. This means that either the lost sand must be brought back into the profile or more sand must be borrowed. It is therefore very important to estimate how much sand will be transported outside the final profiles by these waves.

To be able to give a rough assessment of the anticipated sand losses, the sand transport generated by waves was quantified using simple but transparent morphological models. It is emphasised that these models (cross-shore and long-shore) were made for uniform straight beaches and sandbars are not valid for areas such as the end-section of the fronds. These morphological models are discussed below making a distinction between two fundamentally different situations:

1. Crest level lower than the wave run-up level (wash-over transport).
2. Crest level above the wave run-up level (cross- and long-shore transport)

For the calculations use has been made of the expertise and/or models of WL | Delft Hydraulics, Alkyon, Professor Bijker and VOACZ’s in-house expertise and models.

WASH-OVER TRANSPORT

When the crest level is lower than the wave run-up level, waves will wash over the created berm, that can than be seen as a sand bar. This sand bank will reshape in time due to sand transport by waves and currents. Three sub-mechanisms for this wash-over transport can be distinguished. For each of those systems the sand grains are mainly stirred up by the wave-induced
orbital flows. The origin of the current that is required to transport the stirred-up sand grains, however, differs. These currents are:
1. Tidal current parallel to the shore
2. Down-slope directed density currents
3. (Breaking) wave-induced current

For the assessment of the wash-over transport the local bathymetry and the complete submerged Palm Island was taken into account. Two levels of the submerged island were considered: CD – 4 m and CD – 6 m. The breakwater under construction was not taken into account. A 3D flow model was used to get an indication of the increased tidal flow velocities over the partially constructed fronds. These increased flow velocities, in combination with the expected local wave climate were then used to estimate sediment transport rates at various locations in the project area. These sediment transport rates were determined using formulations of Van Rijn [2], which have been implemented in the profile model UNIBEST-TC by WL Delft Hydraulics.

The calculations showed that the sand losses during the winter are dominated by the most severe storms. Especially when breaking of the wave starts the transport rates increase considerably. The actual duration and severity of these storms may differ considerably.

Figure 3. Typical results SWAN wave transmission calculations for 6 execution stages of the crescent (offshore significant wave height 2.25 m, mean wave direction as indicated by the arrow).
from one winter to the other. Changing the incoming wave height +/–10% resulted in a +/– 300% change in the calculated transport rates. This means that the associated sand loss may differ dramatically from one winter to the next.

The berm level also influences the number of waves that are forced to break. Accordingly, the calculated transport rates for the berm level of CD–6 m were considerably lower (order 10 times) than for the berm level of CD–4 m.

The calculation also showed that the sand losses are dominated by cross-shore transport. Not the tidal current parallel to the shoreline, but the wave driven currents (perpendicular to the coastline) over the partially constructed fronds are dominant for the expected sand losses. Unfortunately these transport rates are very sensitive for the calculated near-bottom flow velocities, which in their turn depend on the modelled (sand) bed roughness. The bed roughness was not exactly known. When the bed roughness was varied between 1 cm and 10 cm, the calculated cross-shore current velocity varied between 1 m/s-1.5 m/s.

For this range in current velocity the calculated sediment transport rates differed a factor 10. The magnitude of the sediment transport is however principally not equal to the losses, since part of the transported sediment will resettle in the eventually required profile.

During the construction, the reshaping of the submerged sand bars were monitored. The measurements indicated that reshaping in case of a crest level of about CD-4 m only occurs during extreme conditions conform theory. The reshaping for this crest level is far less than in case of a crest level above the water level.

The calculated transport rates are very dependent on the wave height. The real wave climate outside the breakwater during the first winter period (2001-2002) was milder than average. This mild winter wave climate would result in considerably lower calculated sand transport since the losses are dominated by the highest waves with only a small probability of occurrence. These low transport rates were indeed recorded.

### Long-Shore Transport

For the berm with a crest level higher than the run-up level of the waves, the waves are blocked. Two transport directions are distinguished for this situation: transport parallel to the berm (long-shore) and transport perpendicular to the berm (cross-shore). Three methods to calculate the long-shore transport rates were compared.

#### CERC

The CERC formula is commonly used to estimate the long-shore sediment transport. It is an empirical relation between the waves and the long-shore transport for relatively long and straight beaches, where the along-shore differences in the breaking waves are small. The CERC formula can be given as:

\[
S = A \cdot H_{\text{sig}}^2 \cdot n \cdot c_n \cdot \cos (\varphi) \cdot \sin (\theta) \cdot \text{[m}^3\text{/s]} \tag{1}
\]

- \(S\) : long-shore sand transport [m³/s]
- \(A\) : dimensionless coefficient [-]
- \(H_{\text{sig}}\) : significant wave height [m]
- \(c\) : wave celerity [m/s]
- \(c_g\) : wave group velocity [m/s]
- \(n\) : ratio \(c_g\) to \(c\) [-]
- \(\varphi\) : angle between the wave crests with the shoreline [°]

Subscript “1” indicates that the dimensions at a water depth of 10 m are used. Subscript “br” indicates that the dimensions at the breaker line are used.

In the Shore Protection Manual, a value of \(A = 0.050\) is derived based on measurements on beaches which can be characterised by a \(D_{50}\) of about 200 $\mu$m. At the Palm Island project location sand of about 400 $\mu$m is present. Larger grain result in lower transport rates, the value of \(A\) was therefore adapted for the project location.

The effect of tidal current on the transport rates cannot be incorporated in the CERC formula. The tidal current velocities at the project location are however limited to extremes of 0.25 m/s to 0.30 m/s, so the error of neglecting them may be limited here.

The beach slope strongly effects the distribution of the long-shore transport across the breaker zone. The effect on the total long-shore transport is however limited, since a steeper slope means a narrower breaker zone, but on the other hand a more (energy dissipating) intensive breaker zone. The net effect is a slight increase in the long-shore transport in case of a steeper slope (Bijker [3]). The effect of neglecting the slope at all is therefore expected to be limited as well.

#### BIJKER (1971) AND VAN RIJN (1993)

Alkyon calculated the long-shore transport for several incident wave directions with respect to the normal on the coastline using the transport model UNIBEST-LT. The following input data was used:
- Slope of 1:4
- Constant tidal current of 0.1 m/s
- A constant water level of CD+1 m
- \(D_{50} = 400\) $\mu$m
- Bed roughness = 0.05 m

For the computations the Bijker [3] and Van Rijn [2] transport formula for sand were applied.
For several significant wave heights (Hs) with a wave approach angle of 45° the long-shore sand transport as calculated using the CERC, Bijker and Van Rijn formulation are shown in Figure 4.

The long-shore transport rates calculated with CERC and BIJKER are of the same order of magnitude (within the morphological accuracy factor of 2 to 3).

The VAN Rijn transports are approximately 100 times higher than the transports calculated with the other two formulas. For more gentle slopes lower transport rates are found with VAN Rijn, which is in contradiction with the measurements by Bijker [3] that indicate that the slope has very little impact on the total long-shore transport.

As the long-shore sediment transport rates as calculated with CERC and BIJKER are in good agreement and the CERC formula is simpler and faster, the CERC formula has been used for the determination of the resulting monthly long-shore sediment transports.

**Cross-Shore Transport**

In case the crest level is above wave run-up level not only long-shore transport occurs, but also cross-shore

![Figure 4. Calculated long-shore transport rates for a 45° wave approach angle.](image-url)

![Figure 5A. Typical cross-profile before exposure to waves.](image-url)

![Figure 5B. Typical cross-profile after exposure to waves.](image-url)
transport. In case of cross-shore transport (perpendicular to the coastline) sand will be moved from the slope downward (and to a lesser degree upward) and thus a gentler slope will develop in time. The crest line will shift in shoreward direction and sand will deposit outside the required profile.

With several cross-shore transport models, the shape of the foreshore (slope) for various wave conditions and sand characteristics can be estimated. Also a prediction of the time-dependent development of the profile can be made. Eventually a more or less equilibrium profile will develop.

In case of exposure to waves, the coastal zone can be divided in 3 different zones as shown in Figure 5B. The active zone is the zone that is directly influenced by wave action. The transition and backshore zones are not directly influenced by the waves.

The upper boundary for the active beach profile $h_m$ theoretically equals the wave run-up level above still water level. As a result of the (tidal) variation of the still water level, the active zone varies in time.

In the breaker zone a lot of sand is in suspension and considerable changes in the profile may take place within hours or days. Seaward of the breaker zone seasonal profiles can occur as a result of seasonal changes in the wave climate. Therefore, the actual lower boundary ($h_m$) for the active zone is dependent on the time scale that is considered.

The cross-shore transport in the active zone is difficult to quantify. Three models have been applied to estimate this cross-shore transport:

**SWART’S MODEL**

In the model of Swart it is assumed that for a certain sand grading (characterised by its median grain diameter $D_{50}$) and for certain wave conditions (characterised by the wave height and wave period) an equilibrium profile will develop (as shown in Figure 5B). It takes some time to develop this equilibrium profile. The rate of change of the profile is proportional to the difference in shape of the existing and the equilibrium profile. The larger this difference in shape, the faster initial profile changes take place.

Swart’s model (see [4], [5] and [6]) gives empirical relations to determine the equilibrium beach profile and cross-shore sand transport as a function of the wave height, the wave period and the grain size. These relations are mainly based on a large number of small-scale (mainly regular wave) model test studies but are validated with prototype measurements.

In [5] also an empirical relation for the speed at which the equilibrium profile is reached, is given.

For the Palm Island project a translation was made from the regular wave relations as presented by Swart to irregular wave conditions. Moreover, the impacts of the (tidal) still water variations were taken into account by extending the range of the active zone (see Figure 5B). This modified Swart’s model enabled the calculation of the time-dependent beach profile development.

**DUROSTA**

The estimated erosion of the cross-shore profile was also calculated by Alkyon using the DUROSTA model. This model was developed for computing the offshoredirected sediment transport of a (steep) dune profile during storm conditions. The DUROSTA model is therefore assumed suitable for computing the erosion process along the steep initial slopes of the Palm Island.

**UNIBEST-TC**

Unibest-TC is the cross-shore sediment transport module of the Unibest Coastal Software Package, a software program developed by WL | Delft Hydraulics. It is designed to compute cross-shore sediment transports and the resulting profile changes along any coastal profile of arbitrary shape under the combined action of waves, long-shore tidal currents and wind. The model allows for constant, periodic and time series of hydrodynamic boundary conditions to be prescribed.

Indicative calculations were made using the modified SWART, DUROSTA and UNIBEST-TC model to compare the results. In this indicative calculations the following profile was modelled:

- Crest level CD+3 m
- Flat seabed level CD−9 m
- SWL at CD+1 m (no tidal variations were taken into account)
- Initial profile was assumed to have a 1:4 slope
- $D_{50} = 400 \mu m$

In Figure 6 the calculated time-dependent regression of the crest line (see Figure 5A) for all three models is plotted.

From Figure 6A it can be seen that especially the estimated regression speed during the first few days differs considerably. The reason for this might be that both the UNIBEST-TC and the SWART models are not derived for the steep initial slopes as are present at the Palm Island project. Swart [4] mentioned that the time dependent calculation is inaccurate in the situation of very steep slopes, but without quantifying when an initial slope is too steep. In the situation of steep slopes in combination with smaller waves, the horizontal dimension of the breaker zone becomes small which also results in instabilities in the UNIBEST-TC calculations. DUROSTA was developed to model dune regression in case of severe storms. During this regression steep slopes are present. The initial slope for the modelled conditions will however normally be
far smoother (beach profile) than present here, so it cannot be guaranteed that the model is suitable for this situation.

From Figure 6B, it can be seen that the UNIBEST-TC model results in a far smaller regression speed than the DUROSTA and MODIFIED SWART model. During the erosion, parts of the steep fronds will slide into sea due to the (too) steep slopes and wave run-up. This process is not modelled in UNIBEST. Therefore the erosion rate for high waves (where this sliding occurs frequently) can be expected to be underestimated by UNIBEST-TC.

The results for the DUROSTA and MODIFIED SWART are within a margin of a factor 2-3 that is usually applied for the accuracy for sediment transport calculations. Both methods show considerable sand loss. For practical reasons the MODIFIED SWART model was used to calculate the profile changes as a result of the local wave climates as calculated using the SWAN wave model. These calculations show that the smaller waves are not of importance for the ultimate beach profile which develops after a month. This profile is primarily determined by the higher waves (Hs > 0.5 m).

As soon as the first frond emerged and a storm took place, the profile deformations were measured to verify the models used and update the dump strategy if required. The effects of the storm (about 6-8 Beaufort) as occurred on April 4th 2002, with an estimated duration of 12 hours and with a significant wave height near the central top branch of about 1.25 m, was used for this. The disadvantage of this early measurement was that the frond length above the water was limited to a few hundred metres. This means that no long straight uniform beach was present, resulting in head effects (see next section). Moreover, the frond of investigation was still under construction so that newly deposited sand also influenced some of the cross-shore profiles. Nevertheless, the real cross-shore sections before and after the storm could be schematised as presented in Figure 7. The profiles after the storm were also calculated using the MODIFIED SWART model (with tidal water level variation included) for the first two situations with no overtopping this model can be used for (Figure 7A and 7B).

The measured cross-sections after the storm show that the amount of sand transported from the profile for a crest level at the still water level (Figure 7C) is far larger than when this crest level is brought up higher before the storm occurs (Figure 7A and 7B). The measurements show that considerable regressions of the crest line can indeed be expected in relative short time spans. The real deformations were in good agreement with the predicted ones. The measured regression exceeded the calculated regression a little. This was probably caused by the fact that the measured profiles were taken from relative short

(a few hundred metres) fronds, which are affected by head effects (see next section). This seems to be confirmed by the fact that the sand that was washed away from the higher parts of the slopes was not deposited at the lower part of the slope, but was totally removed from the profile. The MODIFIED SWART model assumes a long strait frond with constant longshore transport. Therefore the sand balance is closed for this model, resulting in more sand down slope.

**Sediment Processes Around End Sections of Fronds**

As mentioned before the sand transport models have been applied for uniform, straight slopes; no boundary effects have been incorporated. With some engineering judgement the models can be applied for the gently curved fronds, taking into account the changing incident wave angle. However the erosion pattern for the unprotected ends of the palm tree fronds is more complicated.
Figure 7A. Typical measured and calculated profile deformations for crest level at CD+2.5 m.

Figure 7B. Typical measured and calculated profile deformations for crest level at CD+2.0 m.

Figure 7C. Typical measured and calculated profile deformations for crest level at CD+1.0 m.
Frond ends that were not sheltered by further offshore-located fronds were subjected to all three erosion phenomena: cross-shore, long-shore and wash-over transport (see Figure 8). The wash-over transport takes sand from the far frond ends to the frond back slope where some kind of sand spit will be formed. The obliquely incoming waves will generate cross-shore and long-shore transport although it is expected that long-shore transport from the far frond tip will be minimal. First a certain beach length is required for sand to be suspended over the water column before transport takes place. Therefore, it was expected that the frond-tips would be mainly subjected to wash-over and cross-shore transport. The result thus will be that the frond tips will be lowered and stretched. Further towards the spine where long-shore transport picks up, the width of the frond will be reduced as sand is transported away and deposited in more sheltered waters behind the previous frond.

It may be clear that those sections are very vulnerable to losses, which in turn are hard to predict. Therefore these ends were constructed only when protected sufficiently.

**Execution Philosophy**

From the combined results of wave propagation studies and cross- and long-shore computations it became clear that when building up the sand body above the waterline in unprotected water, the cross- and long-shore transport would result in unacceptable sand losses. During a rough winter, unprotected fronds could even break through. The profile deformations are dominated by the (short term) extreme conditions they are exposed to.

![Figure 8. Erosion phenomena frond ends.](image)

![Figure 9. Optimum production and safety are obtained by keeping corridors and space open for manoeuvring and constant monitoring of the progress.](image)
When keeping the crest level sufficiently deep below the water level, the deformations only occur during extreme storm conditions. When staying sufficiently deep, the overall profile deformations owing to wave action will be far more limited than in case of a crest above water.

Since repair of damaged sections would have been disproportionately expensive, an execution methodology was developed which was first of all based on minimising the sand transport by waves and currents. In addition to this also the following requirements were taken into account:
- The inevitable sand transport should resettle within the final profiles as much as possible.
- Optimal logistics should be achieved in terms of cycle times and combination of dumping and rainbowing taking into account ship restrictions (draft, maximum rainbow distance).
- Production capacity and planning should meet the time of delivery.
- Safety of the operations should be ensured.

**Execution Methodology**

Based on the combined results of wave propagation studies and cross- and long-shore computations, the client could be convinced that the construction of Palm Island itself should be closely related to the progression of the breakwater, since the protection provided by it, was essential. Therefore the following execution methodology was developed based on the requirements mentioned above, the computation results and the progression schedule of the breakwater.

During first winter
- Especially at the beginning of the first winter, starting at the end of 2001, the sheltering of the partly constructed breakwater was very limited (see Figure 10). The profiles therefore remained below the CD–4 m during the first winter, since this results in lower transport rates then when coming above water.
- The width of the fronds at this stage was kept slightly smaller than required to allow some reshaping without material ending up outside the eventual required profile.
- In between the sand bars, corridors and space for manoeuvring is kept in order to allow the dredgers to operate in a safe and efficient manner during the construction of the fronds.
- The TSHD had such dimensions that this sand could be dumped and did not have to be rainbowed.

After first winter
- Based on scheduled progress of the breakwater and offshore wave climate, the wave and cross- and long-shore sand transport model were used to determine which fronds were sheltered enough at what stage. This way the fronds were given free to construct above water one by one, starting at the most protected top end of the Palm.
- The sequence of the filling was anti-clockwise from

*Figure 10. Satellite pictures of Palm Island showing the progress at approximately 3-month intervals.*
Van Oord ACZ determined the right strategy of staying underwater the first winter and only raised those fronds above water which had sufficient protection from the crescent breakwater from then on.

References


This small volume is the result of a workshop established by the National Research Council to explore the decision-making process used to establish environmental windows for dredging projects, as well as consistency in the windows-setting process.

Environmental windows are those periods of the year when dredging and disposal activities may be carried out because regulators have determined that the adverse impacts associated with dredging and disposal can be reduced below critical thresholds during these periods. The first environmental windows in the United States were established more than 30 years ago. Today environmental windows are applied to over 80 percent of all federal dredging projects according to the U. S. Army Corps of Engineers (USACE).

The cumulative impacts of the application of environmental windows are significant and costly. For this reason, the USACE requested that the National Research Council’s Transportation Board-Marine Board conduct a workshop to explore the decision-making process used to establish environmental windows, as well as the consistency of the windows-setting process.

The report is organised into seven parts, beginning with an Executive Summary and ending with appendices and biographical information of the study committee.

Specifically, the report is divided as follows:

Executive Summary

1. Introduction
2. Workshop Preparations, Design, and Major Points of Discussion
3. Process for Setting, Managing, and Monitoring Environmental Windows
4. Key Findings and Recommendations

Appendices

Study Committee Biographical Information

The Executive Summary and the Key Findings and Recommendations capture the essence and value of the report. The report itself is fairly repetitive and those two sections appeared to be of the most interest, both to the casual reader as well as to those with a more intimate involvement with environmental windows and their effects.

Environmental windows restrict or prohibit dredging and disposal activities during those periods when perceived harm to aquatic resources is above a determined critical threshold. They are an intuitively simple means of reducing risks to biological resources from stressors generated during dredging and disposal activities. The use of windows has significant cost implications for both the USACE and the local sponsors of dredging projects and thus the taxpayers. They can prolong completion of dredging projects, delay project deadlines, and increase the risk to dredging personnel by shifting dredging to periods of inclement weather and sea states.

The report documents the windows-setting process and sets a template by which the process can be summarised. The workshop involved a broad spectrum of stakeholders in the dredging of marine projects and intended to synthesise these diverse perspectives into a set of findings that serve as basis to place the issue of environmental windows on a more objective and consistent framework and practice.

The study resulted in eight recommendations, summarised as follows:
1. The decision-making process for managing dredging and disposal operations to achieve sustainable waterways and to protect natural resources, both living and nonliving, should be broadly based.

2. All tools, including windows, should be considered in designing a management plan for carrying out dredging and disposal operations.

3. The proposed process for assessing the need for windows and for managing and monitoring windows when selected should be tested in a small number of districts.

4. All existing scientific data and information should be exploited in evaluating and setting windows as part of an overall management strategy for dredging and disposal activities.

5. Cross-training opportunities should be created for resource manager and dredging operators.

6. A special effort should be made in identifying existing tools for structured decision-making in complex socio-political situations and to evaluate their applicability to the process of setting, managing and monitoring environmental windows for dredging. One or two of the most promising tools should be selected for additional testing, research, and refinement aimed at enhancing their acceptability and use in the window-setting process.

7. Additional funding should be allocated to resource agencies to ensure full, thorough, and active participation in the window-setting process.

8. The windows-setting process should reflect the principle of adaptive management. That is, as new data and information are acquired and experience is gained, they should be fed back into the process.

If these recommendations sound a bit vague and ambiguous it is because, as is often the case when a report is generated by a committee of stakeholders with opposing disciplines and perspectives, they are.

Certainly, the report adds to the literature on environmental windows, but some specific guidelines and a framework by which to answer the basic questions and issues stated in its purpose and objective would have been welcome. In spite of this, it does give a valuable insight into the issues and the process by which such contentious matters are studied and how reports are then written by such prestigious organisations as the National Research Council.

The report is available from:
Transportation Research Board Business Office
National Research Council
2101 Constitution Avenue NW
Washington, DC 20418

or through the Internet at:
www.national-academies.org/trb
email: TRBsales@nas.edu

http://education.usace.army.mil

The effort to encourage young people to enter the field of dredging as well as attempts to educate the public about the positive aspects of dredging have been of major concern both in Europe and in the United States. After many years of planning, the United States Army Corps of Engineers (USACE) has recently launched a new educational website. Though the site is obviously US oriented, it provides an enormous amount of information for any science teacher or pupil with computer access, anywhere in the world.

USACE’s Education Center, as it is called, is aimed at kindergarten through secondary school (K–12+) students, teachers, librarians and other educators. Its stated objectives are: to promote an understanding of the USACE, create a Corps Classroom connection; and spark interest in applied sciences. Subjects covered in general are Engineering and Construction, Navigation, Water Resources Management, Disaster Response, Environmental Protection, R&D and Recreation.

Its main components are:
– a Young Engineer’s Club, designed for elementary age children;
– Classroom Resources, with a wide range of resources, lesson plans, activities, and education links;
– Corps Classroom Connection with stories about engineering, environmental biology, chemistry, physics, geography and other relevant science subjects;
– Mission Lessons with classroom activities, interactive quiz games, puzzles, glossaries and references;
– Fun science experiments (over 250), with 30 topic categories utilising simple materials; and
– Navigation lessons, emphasising the importance of ports and navigation channels, hydrographic surveys, dredging and beneficial uses of dredged material.

This website is a monumental work, and marks the beginning of a much-needed ongoing effort to educate the public from the ground up (that is, from youth onward) to the important role that dredging plays in our modern society. Anything that helps people understand the positive aspects of dredging and does not encourage knee-jerk negativity is worth taking a look at. The creators of this website deserve a round of applause.

It is available at: http://education.usace.army.mil.
Like most of the Internet, it’s free of charge, just log on.
Seminars/Conferences/Events

Coasts and Ports Australasian Conference

This is the 16th Australasian Coastal & Ocean Engineering Conference and 9th Australasian Port & Harbour Conference. The theme of the conference is "Coastal Development – A Quest for Excellence" and the issues it covers include: models for "good" coastal development; change in port infrastructure and efficiency; costs of regulation and compliance; managing conservation and development; assessing impacts of coastal structures on the natural system; and changes in science and technology in modelling and monitoring coastal change.

For further information contact:
The Conference Managers
The Conference Company
PO Box 90040
Auckland, New Zealand
tel. +64 9 360 1240, fax +64 9 360 1242
e-mail: coasts and ports@tcc.co.nz

International Conference on Port and Maritime R&D and Technology

The 2nd International Conference on Port and Maritime R&D and Technology will be held in Singapore in September. It is organised by a broad base of universities, technological institutes and maritime academies from Singapore, as well as the Association of Consulting Engineers Singapore, and supported by the Maritime and Port Authority of Singapore as well as many international organisations such as the IMO, IAPH, PIANC, EADA, IHO and IALA.

The theme of the conference is "Challenges for the Next Decade" and papers will be presented on: Port development, management and operations; coastal/hydraulics engineering; marine environment; innovative ship designs and operations; and navigation and maritime training.

In conjunction with the conference, an exhibition featuring the latest R&D and technological products, systems and services in the port and maritime industries will take place.

For further information contact:
The Conference Secretariat
Ace:Daytons Direct (International) Pte Ltd
2 Leng Kee Road #04-02, Thye Hong Centre
Singapore 159086
tel. +65 6379 5251/ 6475 9377
fax +65 6475 2077/ 6475 6436
e-mail: admin@acedaytons-direct.com
www.mpa.gov.sg/homepage/conferences/RDT/main.html

COPEDEC VI

The theme of the sixth International Conference on Coastal and Port Engineering in Developing Countries (COPEDEC) will be "Engineering the Coastal Environment".

Subjects include: Port and harbour infrastructure engineering in developing countries; port and infrastructure planning and management in developing countries; coastal sediments, hydrodynamics and control; coastal zone management in developing countries; and coastal and port environmental aspects.

For further information contact:
The Local Organising Secretariat
COPEDECVI-COLOMBO 2003
c/o Ace Travels & Conventions (Pvt) Ltd.
315, Vauxhall Street, Colombo 02 Sri Lanka
tel +94 1 300 589/300 590, fax +94 1 331 816
e-mail: acetravel@aikenspence.lk
www.copedec.lk
General Dredging Course 2003  
Training Institute for Dredging  
Kinderdijk, The Netherlands  
September 29-October 10 2003

The Training Institute for Dredging (TID), founded in 1982, is dedicated to the education of dredging crews and operational management in order to improve the efficiency of dredging operations. The General Course is aimed at managers and technical and operational staff at dredging companies, port authorities and consultants. The course is held at the training facilities in Kinderdijk, The Netherlands. Subjects include: soil characteristics and their effect on dredging; definition of important dredging parameters; site investigation and hydrographic surveying; trailing suction hopper dredgers; plain suction dredgers, cutters and bucket wheel dredgers; centrifugal pumps and slurry transportation; instrumentation and automation; practical and management aspects of dredging; costs; maintenance aspects.

The fee for the course is Euro 3285. TID assist in securing accommodations.

For further information contact:  
Training Institute for Dredging  
Att: Monique Rogaar  
P.O. Box 8, 2960 AA Kinderdijk, The Netherlands  
tel. +31 78 691 0500; fax +31 78 691 0331  
e-mail: training@mtiholland.com  
www.mtiholland.com/tid

International Conference on Remediation of Contaminated Sediments  
Palazzo del Cinema, Venice, Italy  
September 30-October 3 2003

Contaminated freshwater and marine sediments are a significant environmental problem worldwide. Since disposal of contaminated dredged materials can be a major financial issue, further research for better technologies, and practicable and cost-effective sediments-management practises must be designed. To provide a forum for understanding the nature of contaminated sediments and for finding potential solutions, Battelle, with the support of 12 international organisations active in management and remediation of sediments, organised a conference in October of 2001. Based on the positive response to that event, Battelle is organising a second conference focussing on all aspects of remediation and management of contaminated sediments.

For further information on the technical scope of the programme or registration or other matters please contact:

Marco Pellei, Batelle-Geneva Research Centre  
fax +41 22 827 2094  
email: sedimentscon@battelle.org  
or visit the website: www.battelle.org/sedimentscon.

Camels, Sand and Water, the Suez Canal in Sliedrecht  
National Dredging Museum  
Sliedrecht, The Netherlands  
July 25 2003-January 2004

This unusually interesting exhibition is on display at the dredging museum, which is opened Tuesday through Saturday from 14:00 till 17:00 hours. Group visits are possible outside official opening hours by appointment.

For further information contact:  
National Dredging Museum, Molendijk 204,  
Sliedrecht, The Netherlands  
tel. +31 184 41 41 66 or +31 184 42 56 15.  
www.baggermuseum.nl

Ports India 2003  
Mumbai, India  
October 8-11 2003

The conference “Trade, Shipping and Port Strategy” will focus on transport efficiency and infrastructure development, which are the key to India’s trade sustainability. The event will also include a one-day conference on shipbuilding and finance, and a two-day conference on dredging. The conference theme is “Dredging for Development” and is being organised in conjunction with the International Maritime Exhibition (INMEX) by the Eastern Dredging Association (EADA)-India.

For further information contact:  
Millennium Conferences International Ltd.  
Chantry House, 156 Bath Road,  
Maidenhead, Berkshire SL6 4LB, UK  
tel. +44 1628 580 246, fax +44 1628 580 346  
e-mail: INDIA2003@millenniumconferences.com  
www.millenniumconferences.com

INMEX  
Mumbai, India  
October 8-11 2003

INMEX (Maritime Exhibition-India International Maritime Expo) is India’s premier maritime exhibition featuring state-of-the-art equipment available for shipping, shipbuilding, port development, dredging and offshore industries. It will showcase various material components for effective maintenance of existing fleets, both defensive and commercial.

During the exhibition a Dredging Symposium is being organised EADA (see also above).
Topics for discussion include: dredging of waterways and ports, dredging for conservation of water resources, and for mineral wealth, environmental aspects of dredging, R&D efforts, pipeline sediment transport, and the economics of dredging and training.

For further information contact:
Tebma Shipyards, Ltd.
III Floor, Khaleeli Centre, 149 Montieth Road,
Egmore, Chennai 600 008, India

For further information about INMEX contact:
Yogesh Srinivasan, PDA Trade Fairs
PDA House, no. 32/2, Spencer Road
Freazer Town, Bangalore – 560005, India
tel. +91 80 554 7434, fax +91 80 554 2258
e-mail: pdaexpo@vsnl.com
www.pdatradefairs.com

Europort 2003

The Europort Exhibition is one of the largest trade shows for the international maritime industry and is held every two years in Amsterdam. The trade exhibition covers all sectors of the maritime industry such as seaborne shipping, inland shipping, offshore industry, dredging and ports. Many countries have once again made arrangements for national pavilions where their companies can join forces and exhibit together.

Various maritime trade associations such as IRO (Dutch Association of Suppliers to the Oil and Gas Industry), KNVTS (Royal Dutch Association of Naval Architects), KVNR (Royal Association of Netherlands Shipowners), VNSI (Netherlands Shipbuilding Industry Association) and VIV (Association of Importers of Combustion Engines) are organising their (annual) meetings and seminars at Europort. In this way Europort acts as a national and international forum for the maritime industry.

As is customary, the CEDA Dredging Days will also be held during Europort 2003 from November 20-21, and the IADC Award for the best paper to a younger author will be presented. The CEDA conference will focus on the use of dredged sediments as primary and secondary construction material.

For further information contact:
Farouk Nefzi, Europort 2003, RAI
P.O. Box 77777, 1070 MS Amsterdam,
The Netherlands
tel. +31 20 549 1212, fax +31 20 549 1889
e-mail: europort@rai.nl
www.europort2003.com

CEDA Dredging Days

“Specialist dredging techniques, inspiring dredging solutions” is the theme of the next CEDA Dredging Days to be held during the Europort Exhibition in November 2003. Dredging activities cover a wide range of applications, some of which are unfamiliar even to the well-seasoned dredging professional. The variety of dredging functions combined with the diversity of the natural environments provides the profession with new challenges and the need to develop specialised techniques.

Topics of interest include, but are not limited to the use of specialised solutions in: coastal and flood protection; sea and river mining (sand and gravel, minerals, precious metals); offshore oil and gas industry; environmental improvement; land reclamation; dredging in shellfish waters; waterway re-naturalisation; cockle and scallop fishing; and salvage.

At this conference an IADC Young Authors Award will be presented to the best paper by an author younger than 35 years of age recommended by the Paper Committee.

Announcement

All members of CEDA, EADA and WEDA are invited to CEDA’s 25th Anniversary Reunion Reception at 17:30 hrs on Thursday 20 November 2003 during CEDA Dredging Days (20-21 November) and the Europort Exhibition at the Europa Restaurant of the Amsterdam RAI Congress Centre, Amsterdam, the Netherlands.

The Anniversary Committee is preparing an exciting program including CEDA’s “Hall of Fame” in the form of a “wall” with printed photographs about dredging and CEDA in the past 25 years and of a slide show running on plasma screens.

A unique opportunity for dredging friends to meet.
Contact the CEDA Secretariat for your personal invitation card.

For further information contact:
CEDA Secretariat, Anna Csiti
Radex Building,
Rotterdamseweg 183c
2629 HD Delft, The Netherlands
tel. +31 15 268 2575, fax +31 15 268 2576
e-mail: ceda@dredging.org
www.dredging.org
Call for Papers

World Dredging Congress XVII
CCH - Congress Centrum, Hamburg, Germany
September 27-October 1 2004

Every three years leading experts meet in a different part of the world for the World Dredging Congress (WODCON). The congress is held under the auspices of the World Dredging Association which is comprised of the WEDA, CEDA and EADA. In 2004 it will take place in Hamburg, organised by CEDA on behalf of WODA, and co-sponsored by the Ministry of Economic Affairs, Free and Hanseatic City of Hamburg, and the Department of Port and River Engineering and the Shipbuilding, Machinery & Marine Technology International Trade Fair (SMM 2004) which will run simultaneously. The theme of the conference will be “Dredging in a Sensitive Environment”.

Prospective authors are requested to submit titles and abstracts (maximum 300 words) by October 1 2003. If possible they should be sent by email in either RTF, PDF or ASCII formats. If submitting hard copy five copies are needed. Authors will be notified by the Technical Paper Committee by December 1 2003 and final papers are due by July 15 2004.

The programme will consist of Technical sessions with high quality peer-reviewed papers and a special Environment Day focussed on environmental challenges and solutions. An Academic session, with contributions by young scientists, continues CEDA’s support of young professionals. Technical visits in and around Hamburg including views of the Port of Hamburg are planned.

GTZ, the German Technical Co-operation on behalf of BMZ, the German Fedreal Ministry of Economic Co-operation and Development sponsors participation at WODCOON XVII for delegates from: China, Indonesia, Bangladesh, Ghana, Cameroon, Namibia, Romania, Uruguay, Chile, Argentina, Guatemala, Honduras and Costa Rica. Application details and conditions are available from the CEDA Secretariat

For further information contact:
Anna Csiti, CEDA Secretariat,
Radex Building, Rotterdamseweg 183c, 2629 HD Delft, The Netherlands
tel. +31 15 268 2575, fax +31 15 268 2576
e-mail: ceda@dredging.org
www.dredging.org

Oceanology International 2004
ExCel, London, UK
March 16-19 2004

This is one of the largest and busiest international events in the global marine science and ocean technology fields. It has hundreds of exhibitors and attracts thousands of international visitors including policy makers, industrialists, government representatives, decision makers, researchers, directors, managers and manufacturers involved in every aspect of oceanography. They meet to address the present and future trends of the industry and to view the launch of new technologies, equipment and services.

It is sponsored and supported by the Society for Underwater Technology, European Oceanographic Industry Association, World Meteorological Organization, Intergovernmental Oceanographic Commission, The Hydrographic Society and Hydro International.

The following disciplines are representative of the scope of OI:
Marine environmental science; ocean observing and modeling; measurement and instrumentation; data harvesting; marine survey and engineering; diving and ROV; navigation and remote sensing; marine pollution monitoring and control; hydrography; marine R&D; maritime defence; dredging and coastal engineering; renewable energy; resources from the sea; marine civil engineering and more.

For further information contact:
Spearhead Exhibitions Ltd
Apex Tower, High St, New Malden, Surrey, KT3 4DQ, UK
www.spearhead.co.uk

Lesley Ann Sandbach, Conference Director
e-mail: lesley-ann.sandbach@spearhead.co.uk
tel. +44 208 949 9837

Craig Moyes, Project Director
e-mail: craig.moyes@spearhead.co.uk
tel. +44 208 949 9840
International Seminar on Dredging and Reclamation

Place: J.W. Marriot Hotel, Dubai City, UAE
Date: October 11 - 15, 2003

This year the IADC is pleased to announce that its well-known seminar will be presented for the first time in Dubai, UAE. The course has been held for several years in Singapore, Delft and Buenos Aires with great success. Recent enquiries from the area about dredging have led the IADC to select Dubai as this year’s venue.

The intensive one-week seminar on dredging and reclamation will be held from October 11-15 2003. The costs are € 3895.00 and include accommodation for six nights at the conference, hotel, breakfast and lunch daily, one special participants dinner, and a general insurance for the week.

The seminar includes workshops and a site visit to a dredging project. Highlights of the programme are:

Day 1: Why Dredging?
The Need for Dredging/Project Phasing

Day 2: What is Dredging?
Dredging Equipment/Survey Systems
(includes a Site Visit)

Day 3: Cost/Pricing and Contracts

Day 4: Preparation of Dredging Contract

Day 5: How Dredging?
Dredging Projects

Representatives of port authorities, companies, and individuals interested in attending are requested to complete the preliminary registration form below as soon as possible and prior to September 15, 2003, and return to:
IADC Secretariat, Duinweg 21,
2585 JV The Hague, The Netherlands
tel. +31 70 352 3334, fax +31 70 351 2654
e-mail: info@iadc-dredging.com

Place: J.W. Marriot Hotel,
Dubai City, UAE
Date: October 11 - 15, 2003

This year the IADC is pleased to announce that its well-known seminar will be presented for the first time in Dubai, UAE. The course has been held for several years in Singapore, Delft and Buenos Aires with great success. Recent enquiries from the area about dredging have led the IADC to select Dubai as this year’s venue.

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IADC Secretariat, Duinweg 21,
2585 JV The Hague, The Netherlands
tel. +31 70 352 3334, fax +31 70 351 2654
e-mail: info@iadc-dredging.com

Bitte senden Sie diese Form und Ihre Einzahlung in Höhe von € 500 in Rechnung, um sicherzustellen, dass Ihre Teilnahme an diesem Seminar gesichert ist. Wir werden Ihnen dann die endgültigen Registrierungsbögen und die Rechnung für den vorgesehenen Betrag senden.

Without your deposit we cannot guarantee your place and accommodations at the seminar.

Please send this form and your deposit by cheque or credit card for € 500 in order to guarantee your place at the seminar. Upon receipt of this form and your deposit your place in the seminar is confirmed. We will then send you further detailed information, final registration forms, and an invoice for the correct amount.

Without your deposit we cannot guarantee your place and accommodations at the seminar.

☐ A Cheque is enclosed.
☐ Please charge my credit card:
☐ American Express ☐ Eurocard/Master Card ☐ Visa ☐ Diners Club

Account no.: ____________________________ Expiry date: ____________________________ Card validation code: ____________________________

Signature: ____________________________ Date: ____________________________
Membership List IADC 2003

Through their regional branches or through representatives, members of IADC operate directly at all locations worldwide.

Africa

Ballast Ham Dredging (Nigeria) Ltd., Ikeja-Lagos, Nigeria
Nigerian Westminster Dredging and Marine Ltd., Lagos, Nigeria

The Americas

ACZ Marine Contractors Ltd., Brampton, Ont., Canada
Ballast Ham Sucursal Argentina, Capital Federal, Argentina
Ballast Ham Dredging do Brazil Ltda, Rio de Janeiro, Brazil
Draganex SA de CV, Coatzacoalcos, Mexico

Asia

Ballast Ham Dredging India Private Ltd., Mumbai, India
Ballast Ham Dredging by Singapore Branch, Singapore
Dredging International Asia Pacific (Pte) Ltd., Singapore
Hyundai Engineering & Construction Co. Ltd., Seoul, Korea
Jan De Nul Singapore Pte. Ltd., Singapore
TOA Corporation, Tokyo, Japan
Van Oord ACZ B.V., Dhaka, Bangladesh
Van Oord ACZ B.V., Hong Kong, China
Van Oord ACZ B.V., Singapore
Van Oord ACZ Overseas B.V., Karachi, Pakistan

Middle East

Boskalis Westminster M.E. Ltd., Abu Dhabi, UAE
Gulf Cobla (Limited Liability Company), Dubai, UAE
Jan De Nul Dredging, Abu Dhabi, UAE
Van Oord ACZ Marine Contractors Gulf FZE, Abu Dhabi, UAE

Australia

Ballast Ham Dredging Pty. Ltd., Brisbane, QLD, Australia
Dredeco Pty. Ltd., Brisbane, QLD, Australia
Van Oord ACZ B.V., Victoria, NSW, Australia

Europe

ACZ Ingeniører & Entreprenører A/S, Copenhagen, Denmark
A/S Jebens ACZ, Bergen, Norway
Atlantique Dragage S.A., Nanterre, France
Baggermaatschappij Boskalis B.V., Papendrecht, Netherlands
Ballast Ham Dredging bv, Rotterdam, Netherlands
Ballast Ham Dredging Ltd., Camberley, United Kingdom
Ballast Ham Nederland bv, Gorinchem, Netherlands
Boskalis B.V., Rotterdam, Netherlands
Boskalis International B.V., Papendrecht, Netherlands
Boskalis Westminster Aannemers N.V., Antwerp, Belgium
Boskalis Westminster Dredging B.V., Papendrecht, Netherlands
Boskalis Westminster Dredging & Contracting Ltd., Cyprus
B.V. Bedrijfsholding L. Paans en Zonen, Gorinchem, Netherlands

Draflumar SA., Neuville Les Dieppe, France
DRACE (Grupo Dragados S.A.), Madrid, Spain
Dravo S.A., Madrid, Spain
Dredging International N.V., Zwijndrecht, Belgium
Dredging International (UK), Ltd., Weybridge, United Kingdom
Heinrich Hirdes GmbH, Hamburg, Germany
Jan De Nul N.V., Aalst, Belgium
Jan De Nul Dredging N.V., Aalst, Belgium
Jan De Nul (U.K.) Ltd., Ascot, United Kingdom

Mijnster Beheer B.V., Gorinchem, Netherlands
N.V. Baggerwerken Decloedt & Zoon, Oostende, Belgium
Sociedad Española de Dragados S.A., Madrid, Spain
Sodranord S.A.R.L., Le Blanc-Mesnil Cedex, France
Terramare Oy, Helsinki, Finland
Tideway B.V., Breda, Netherlands
TOA (LUX) S.A., Luxembourg

Van Oord ACZ B.V., Gorinchem, Netherlands
Van Oord ACZ Ltd., Newbury, United Kingdom
Wasserbau ACZ GmbH, Bremen, Germany
Westminster Dredging Co. Ltd., Fareham, United Kingdom