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EDITORIAL

IMPACT OF EUROPEAN UNION ENVIRONMENTAL LAW ON DREDGING
FREDERIK MINK, WOUTER DIRKS, GERARD VAN RAALTE,
HUGO DE VLIEGER AND MARK RUSSELL
EU environmental law and international conventions are not always compatible. The European Dredging Association makes its case on when and why dredged material should not be considered waste.

TOXICITY ASSESSMENTS FOR DREDGED MATERIAL CHARACTERISATION IN PORTS AFFECTED BY METALLIC POLLUTION
M. CARMEN CASADO MARTINEZ
At the ports of Cartagena and Huelva, Spain dredged materials are affected by mining activities and require careful examination to aid decision making about disposal, as described by the IADC Award winner at the PIANC Conference in Portugal in May.

IMO/UNEP/SOA WORKSHOP ON MARINE POLLUTION PREVENTION AND ENVIRONMENTAL MANAGEMENT
NEVILLE BURT
As part of an ongoing effort to encourage training and discussion of dredging related issues, the IADC/CEDA Environmental Seminar was presented at Dalian, China in late May to delegates from 14 countries.

PORT 2000, LE HAVRE’S NEW CONTAINER TERMINAL: BREAKWATERS AND DREDGING OF THE NAUTICAL ACCESS CHANNEL
JAN VANDENBROECK
Flexibility and ingenuity were required to meet the environmental and economic demands for expanding France's largest port which faces the rough swells of the Channel.

BOOKS/PERIODICALS REVIEWED
Two new books, Dredging in Coastal Waters and Die Küste, examine policies, methods and solutions to dredging in coastal waters around the world.

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A renewed Call for Papers for the upcoming WODCON and three new seminars co-organised by IADC are noteworthy.
EDITORIAL

Clean water is a prime resource for life. The concerns of the world as a whole about the marine environment are concerns deeply shared by the dredging and maritime construction industry. During the multitude of projects which are dependent on the services of dredging, like port expansion and offshore development, environmental impact assessments and remediation operations are prerequisites and they are built into the project planning. In this way the dredging industry strives to comply with international and national guidelines.

Often these rules and conventions, laws and treaties have been developed for general regulation of waterways, rivers and oceans and they do not directly define dredging activities. Yet they do affect how the dredging industry conducts its operations. For instance, the London Convention of the International Maritime Organisation (IMO) and certain European Union Directives have a direct impact on the dredging industry, though the word dredging is not necessarily apparent. Sometimes these regulations result in stimulating R&D for new techniques or in the invention of new equipment. Sometimes they result in costly delays of projects. The need for awareness about current thinking on the issues of disposal, remediation and environmentally sound dredging is of paramount importance and requires a professional approach.

In this issue, Terra considers environmental subjects from a variety of angles. First, the similarities - and differences - between international treaties and European environmental law are examined with the core question, “what is the definition of waste?” being tackled. In addition, a report on a recent environmental workshop organised under the auspices of the IMO and the United Nations Environmental Programme (UNEP) in China demonstrates the positive effects of cooperation amongst international organisations.

And then ports both old and new are profiled. The IADC Award presented to a young author at PIANC’s May meeting in Portugal explains the intense attention spent to the remediation of Spain’s ports from pollution caused by the mining industry. Finally, the story is told of France’s newly expanded Port 2000 at Le Havre with its necessary environmental accommodations such as creating new beaches and re-use of dredged material.

As the global economy increasingly demands new maritime infrastructure, the role of the dredging industry on the world stage becomes more and more significant. Maritime infrastructure is essential for the world’s economic motor. Defining with clarity an economic and environmental framework and finding a good balance for sustainable development of the global infrastructure in and around coastal areas and inland waterways will contribute to the world. To both the improvement of the welfare of mankind and to the preservation of the environment for future generations.

Robert van Gelder
President, IADC Board of Directors
ABSTRACT

In certain aspects of environmental law there is a potential friction between EU Directives and international conventions. In these cases, international conventions have priority over EU law because they constitute treaties between sovereign nations. Thus when the question arises, “Is dredged material waste or not?”, the answer may not always be the same. The European Commission has consistently argued that dredged material is a form of “waste” since the holder attempts to get rid of it. The industry, as represented by the European Dredging Association, maintains that dredged material is foremost a natural resource that should be kept in its environmental compartment. Since this difference is apparently a long way from being resolved, another question arises: Can the dredging community live with the EU waste hierarchy principles as such?

The answer as far as the waste hierarchy is concerned is a mitigated “yes, provided that the national authorities understand the issue”. Moreover, for marine waters where the bulk of dredging takes place anyway, the framework established under the umbrella of the London Convention has priority over EU law and is also more helpful to the sector. Other Directives on environmental protection, in particular the Habitats and Birds Directives, cause administrative nightmares and lead to delays or cancellation of projects and to increased costs.

INTRODUCTION

The European Dredging Contractors established the European Dredging Association (EuDA) in 1994 as a trade association for contacts with European institutions; this includes influencing and tracking EU law that might impact the dredging sector. Amongst the areas where EU legislation affects the industry, environmental law has taken a prominent role. The EuDA Environment Committee has recently prepared a comprehensive review of European environmental rules and their impact on the practice of dredging and dredged material disposal. This article presents a summary of the findings.

ON INTERNATIONAL LAW

The European Union is formed by a community of nations that have agreed by Treaty to transfer legislative and executive competences in a number of domains to a supranational level. Environmental law is an area where EU competences are far reaching because it was recognised early on that environmental problems and pressures do not stop at national borders, but are felt community wide.

EU law is in essence built on three types of instruments:
• Framework Directives (the term of Directive is equivalent to a law in national legislation) define a general approach which sets a number of boundary conditions and constraints and have to be implemented by each member state in accordance with its specific circumstances. Certain provisions of a Framework Directive may also be detailed in a later stage at the European level and made effective by other legal instruments. When the instrument of a Directive is used in such a case, one speaks of a Daughter Directive.
• Directives are equivalent to laws and are binding on the member states, except for
the fact that they first have to be “transposed” into national law. This poses a particular problem: Some member states have a tendency to transpose (environmental) EU law in a very strict and stringent manner, while others tend to follow the minimum requirements of the Directive.

• Regulations are legal decisions taken at EU level that are binding as such for the member states and do not need transposition. They usually concern more technical details on which there is no major disagreement.

It may be clear that the EU law has the potential to deeply influence national legislation; also clear is that the resulting hierarchy of rules and regulations is anything but simple, while the transposition mechanism often results in the opposite effect of what was intended: In several cases transposition creates important differences in national law. Moreover, the impact of a particular EU law frequently has to be tested before the Court of Justice in order to assess its judicial limits.

The next question to be raised is: how do International Conventions and Treaties relate to EU law and to national law?

International Conventions, such as the London Convention which was established under the umbrella of the IMO, but also the Oslo-Paris (OSPAR) Convention for the Atlantic and the North Sea, are agreements between sovereign nations; each nation decides independently whether or not to ratify a particular Convention. When a certain number of countries have ratified a Convention, it can become international law. As the ratification is done by sovereign states, the EU as a supranational body does not play a role. Consequently, International Conventions have priority over EU law. As will become evident, this may lead to friction between the rules at the international and supranational levels.

Figure 1 illustrates the situation and lists also a number of advisory bodies and/or guidance documents that are helpful, but are not legally binding.

**EU law and dredged material**

EU law does not deal specifically with dredged material, nor is there any intent to do so. Nevertheless, a number of EU Directives have an impact on the management of dredged material, either directly or indirectly. Figure 2 presents an overview of the structure of the relevant regulations and the relationship between the various Directives.

The conclusion is that relevant rules can be grouped under the three headings of waste, water and habitat protection. Of these three, the Waste Framework Directive and related Directives occupy the most discussion time, since a great deal depends upon defining what constitutes waste and, subsequently, on the limits of competence of the regional seas conventions versus EU law.

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**Figure 1. Hierarchy of legislation.**

**Figure 2. Overview of the structure of the relevant regulations and the relationship between the various Directives.**
WASTE FRAMEWORK DIRECTIVE

The Directive establishes a hierarchy, a strategy for prioritising management of “waste” as follows:

a) Prevention
b) Re-use
c) Recycling
d) Processing or recovery
e) Disposal

“Waste” is defined as “any substance or object which the holder discards or intends to discard”. Under this very broad definition the European Commission has consistently argued that dredged material is a form of “waste” since the holder attempts to get rid of it. So far this discussion has not been very fruitful: The industry as represented by the EuDA maintains that dredged material is foremost a natural resource that should be kept in its environmental compartment and that this does not in itself cause the material to become a form of waste.

As a clear definition apparently has not yet been found, the question becomes: Can the dredging community live with the EU waste hierarchy principles as such? With this in mind the EuDA Environment Committee has developed an approach in the form of a decision logic diagram in line with the established “waste” hierarchy. A distinction between marine water and fresh water dredging has also been made since the constraints are somewhat different. These distinctions are presented in Figures 3 and 4. In both cases the logic sequence of the waste hierarchy is followed.

Marine water dredging

The fact that the regional sea conventions define their own limits of jurisdiction was

N.-B.: the annual volume of dredged material in the marine environment is estimated at 200-250 million tons/year for the EU. The % in the diagram indicates roughly the estimated breakdown.

Figure 3. Decision logic diagram for dredged material in a marine environment.
carefully considered. For the OSPAR Convention the limit is the tidal influence in the tributaries. Disposal of dredged material is dealt with in essence under the Dredged Material Assessment Framework (DMAF) which was developed for the London Convention and has been reviewed in Terra et Aqua (Burt and Fletcher, nr. 66 March 1997) previously. The OSPAR Convention clearly has no competence concerning upland disposal or for beneficial use applications outside the marine compartment. As the Conventions accept the placement of dredged material back into the marine waters, the conclusion was drawn that EU law has hardly any impact on the dredging process in marine and coastal waters, except when heavily contaminated materials are involved. Figure 3 shows the quantities and the breakdown into categories.

At this point one faces the potential friction between international law under the Conventions and EU law as a supranational body of rules. The first question to ask concerns the territorial limits of competence of EU environmental law. There is no simple, nor single answer to that question, but the Water Framework Directive (see below) claims jurisdiction roughly until one mile beyond the coastline. However, international law supersedes EU law and the jurisdictional boundary of the OSPAR Convention and other regional conventions extends well inland. The EuDA Environment Committee therefore takes the position that for marine dredging the international conventions apply as implemented by national law and EU law only may apply when nothing is foreseen in these conventions. Since the conventions accept that dredged material is put back into the water body, unless it is too contaminated, the Environment Committee concludes that for dredging in marine waters current EU law may only be relevant to the confined disposal of dredged material on land.

Figure 3 shows the quantities of dredged material and the assignment to the categories in the waste hierarchy.

The conclusion is that overall some 5-10% of the dredged material may be so contaminated that it needs to be disposed of in a confined facility. At this point in the review the question arises whether disposal sites fall under any specific EU waste legislation and if so which ones.

The answer is that upland disposal would be covered by the so-called Landfill Directive, which introduces stringent isolation requirements and leads to considerable expense. Landfill sites are typically not intended for the disposal of dredged material, but in some cases there is no alternative available. In most countries concerned this applies only to a minute fraction of the dredged material.

So what about sub-aquatic disposal sites? These are clearly not covered by specific EU rules and must be regulated at the national level. Fundamental to the assessment stated above is the consideration that placing dredged material back into its environmental compartment is a form of re-use that is in principle beneficial for the environment. In fact, it is particularly helpful in maintaining the sediment balance.

**Fresh water dredging**

With respect to fresh water dredging, one must recognise that the Conventions no longer play a role, but that the Waste Framework Directive applies. The same approach can be followed as for marine waters, since in both cases the waste hierarchy is respected. The resulting interaction with other EU legislation such as the Water Framework Directive may be stronger. In terms of the decision logic the following “disposal” modes were considered:

- **Beneficial use:**
  - as fill material
  - as construction material
  - for soil improvement of agricultural land

- **Relocation:**
  Placing dredged material at specific locations in the environmental compartment so that it fulfils its role in the sediment balance.

The annual volume of dredged material in the fresh water environment is estimated at 50-60 million tons/year in the EU. The % indicates the estimated breakdown.
Placement:
The disposal of dredged material at suitable disposal locations.

Processing:
- separation of sand and silt
- manufacturing bricks or basalt
- biological treatment to reduce contaminant level
- dewatering, ripening
- land farming
- and more...

Direct impact of specific waste legislation is in this case limited to the Landfill Directive which establishes the (stringent) provisions for the landfill sites, but which also recognises that disposal of dredged material along waterways, on agricultural land or at suitable subaquatic locations are acceptable solutions, as long as contaminants remain below certain limits. The Landfill Directive thus provides a number of escape routes that help to avoid disposing dredged material in landfills. Some member states have recognised these possibilities in their national rules, but others appear to focus more on the isolation provisions for landfill sites, thus adding to the cost of dredged material disposal.

Contaminants
The last aspect to be discussed under this heading concerns the contaminants.

The European Commission will not set any specific limit values for dredged material; this is left to the member states. The only quantitative values that have been around are limits set in a separate Sewage Sludge Directive; for lack of other standards these have sometimes been quoted in connection with dredged material. However, these values are currently being revised since they are too high and they are not actually suitable for dredged material.
Member states have been requested under the rules of the OSPAR Convention or equivalent, to set limit values for sea disposal of contaminated dredged material. As a consequence one can find a wide range of classification systems and threshold values in some member states, while other countries are of the opinion that dredged material does not lend itself to setting limit values for individual substances and should be assessed on a case by case basis.

**WATER FRAMEWORK DIRECTIVE**

The Water Framework Directive, which became European law in 2000, has as its goal to gradually improve the quality of European waters to some standard which may be called “good”. This objective is very laudable, but the way to get there is still very much under discussion amongst the Commission, the member states and the stakeholders.

The question raised here is: Could this Directive possibly be a constraint for dredging operations? In the implementation process of the Water Framework Directive (which is foreseen to last some ten years), it has been repeatedly emphasised that this law has a long-term goal. It is recognised that water quality varies considerably over time and as a function of physical parameters, chemical conditions, biological and ecological factors as well as hydromorphological boundary conditions. Obviously it is no easy task to cast such a framework into detailed implementation measures and therefore a series of questions arises:

- Will there be constraints on dredging operations in ports where the risk of releasing contaminants from silt cannot be excluded?
- Is short-term deterioration of water quality resulting from operational interventions and maintenance practices an issue?
- How should one deal with the interaction between water and sediment?
- Can one legislate water quality without setting boundary values for sediment?
- How should changes in hydromorphology owing to infrastructure works be assessed in terms of their impact on water quality?

Even though these questions can be considered reasonable, it is too early to provide answers since the relevant River Basin Management strategies and the Daughter Directives are still under development. Much will depend on the consideration of variability over time: does exceedance of established quality standards, e.g. for TBT, matter if the annual average is within the limits? How can the legislator deal with the weak links between chemical quality and hydromorphology?

In the implementation process it has been repeatedly stated that the Directive is not intended to interfere with normal operations and maintenance practices of waterways and ports. This will be translated into guidance for selection of sampling and monitoring points remote from areas of activity and in establishing quality standards that recognise (some) variability in the aquatic environment.

The conclusion of this committee is that maintenance dredging will probably not be affected by this Directive, but that capital dredging may become even more constrained in water bodies falling under its...
scope. One may also foresee new business opportunities for environmental dredging in water bodies where historic contamination needs to be removed in order to meet the ecological objectives (Figures 5, 6 and 7).

**HABITATS AND BIRDS DIRECTIVES**

These two Directives aim to protect biodiversity and rare biotopes and species. The implementation process has led to the establishment of an ecological network across Europe called Natura 2000. Natura 2000 consists of designated “special areas of conservation” under the Habitats Directive and “special protection areas” under the Birds Directive, most of which would be interconnected via corridors or other means of protection. Why would these Directives impact dredging?

The reason is that coastal ports and harbours are very often located at, near or adjacent to Natura 2000 sites. This imposes on ports many restrictions in case they want to expand their site area or when they wish to build new infrastructure. In short port development projects face severe delays and increased costs, in particular when situated at the mouth of estuaries. Similar observations can be made for infrastructure development along valuable stretches of coastline.

The consequences for the dredging sector are likely to be indirect, but significant. The European dredging industry has noticed increasing problems with permits for infrastructure development in the marine environment and it faces increasing monitoring requirements in sensitive environments. A number of important infrastructure development projects have even been cancelled. Other impacts would entail such things as the presence of designated marine sites near ports, where disposal is not permitted; delays in infrastructure projects near designated sites and problems with establishing acceptable forecasts for habitat impact studies.

Again, there are also opportunities: The Habitats Directive foresees the possibility to provide compensation measures if valuable nature would be threatened owing to project development. The dredging sector can often be of considerable help in creating new nature sites near the development area. This can take the form of artificial islands, extended beaches and berms or habitat restoration through the re-creation of mudflats and salt marshes.

**MARINE STRATEGY**

The European Commission published a Thematic Strategy on the Protection and Conservation of the Marine Environment in October 2005 (see http://ec.europa.eu/environment/water/marine.htm). This is currently a document for discussion, but may have repercussions on dredging in a more distant future. The strategy and the resulting proposed Directive aim to achieve “good environmental status” of European marine waters by 2021. It also claims competence to regulate the status of the seabed and its subsoils. Currently, good environmental status is not defined, but by analogy to the implementation of the Water Framework Directive one can assume that it will be established on the basis of a series of parameters, including physical and chemical conditions, biological and ecological processes, physiographic and geographic factors. In the wake of such an approach it is clear that the European Commission attempts to establish jurisdictional competence over the wider marine environment, where currently only international bodies like OSPAR and the respective member states are competent to regulate.

The discussion on the Marine Strategy is in an early stage and it is expected that member states will be reluctant to give up their exclusive...
jurisdiction over marine zones. The following quotes give an indication of the intention of the European Commission on the role it wishes to play in the marine environment:

- “Many of Europe’s regional seas are the subject of international conventions and a number of these have made excellent contributions to the marine protection. However, these conventions have few enforcement powers and this compromises their effectiveness in achieving agreed goals.”
- “In order to build on progress made through the existing institutions, policies and conventions and to take action to make further progress, there is a need to formulate a clear, overarching vision for the marine environment and associated policies. A strong EU policy on marine protection will complement and bolster the current patchwork of institutional arrangements by providing a legally enforceable framework (...).”

CONCLUSION

The conclusion of this assessment by the EuDA Environment Committee is that the impact of EU environmental legislation on the dredging sector is fundamental with respect to the question of dredged material management and priorities, but is restricted when it comes to detailed implementation rules. The main impact results from the Landfill Directive, but even here much depends on the way the member state concerned has transposed this piece of legislation into national law. Especially for marine waters, where the bulk of dredging takes place anyway, the framework established under the umbrella of the London Convention has priority over EU law and is also more helpful for the sector.

The Marine Strategy may in the future undermine the exclusive competence of the international conventions.

The impact of the Water Framework cannot yet be established in full, but it is likely to have mainly indirect effects as a result of complicating project development. Direct effects may result from additional monitoring requirements during projects and after completion as imposed by the respective permitting authorities in member states.

The conclusion with respect to dredging operations in relation to the Habitats and Birds Directives is: their effects will be mainly indirect but not insignificant. The effects of this legislation can lead to significant delays in project approval and also to important increases in costs caused by extended needs for impact assessment. Of particular concern to the industry is the fact that impact assessment for ecological effects in marine waters may be very difficult, since the environment is so dynamic, and thus lead to further delays in the approval process.

CASE STUDY

That lofty definition of “waste” in EU legislation can lead to lengthy and rather useless debates may be illustrated by a recent case involving the Port of London Authority (PLA) and the English Environment Agency (EA).

The PLA intends to carry out dredging in the River Thames Prince’s Channel in view of increasing the navigational depth and it plans to use the dredged sand to improve a nearby construction site. EA has taken the view that the material resulting from dredging is waste according to the Waste Framework Directive and should therefore meet stringent requirements when it is disposed of on land. The EA does not wish to recognise the fact that clean sand can be used beneficially as construction material. The case was submitted to Lord Kingsland for a legal ruling. The Right Honourable Lord, rather than stating something like “don’t be silly”, or “let’s use common sense”, or even “what’s in a name?”, had to review the case law produced by the European Court on these and similar matters and based thereon produced a long argument which concludes that:

1. “the dredged substance [from the Prince’s Channel] is [not waste, but] a product, or at least a by-product;
2. if, nevertheless [the interpretation of the Waste Framework Directive would conclude that] it is initially waste, then it is fully recovered when it becomes physically identifiable as a product (…) once it is in the hopper of the dredger”.

The reader will notice that in the legal sense it makes significant difference at which step in the waste hierarchy one finds oneself. Lord Kingsland draws the conclusion that, once dredged material is targeted for re-use, recycle or recovery, it is no longer waste, or it has never been waste in the first place. These conclusions are in fact based on a very strict reading of the definition (“Waste is any substance or object which the producer or the person in possession of it discards or intends to discard”). The interpretation thus hinges on the meaning attributed to “discard”. Lord Kingsland, after a lengthy review of the jurisprudence, concludes that, as long as the holder of the material intends to re-use or recycle, it never becomes waste on the way; if the material is intended to be recovered there is some leeway for interpretation. Lord Kingsland is of the opinion that it still does not become waste, but even if it is considered to become waste, the part that is recovered turns into a “product” or a “by-product” and is no longer waste.

Only material that the holder explicitly intends to discard, or is forced to discard, is thus “waste” under the definition. A long argument is probably not necessary to conclude that this kind of reasoning is so subtle and sophisticated that the dredging contractor no longer feels at ease. Nor for that matter does the European Dredging Association.
TOXICITY ASSESSMENTS FOR DREDGED MATERIAL CHARACTERISATION IN PORTS AFFECTED BY METALLIC POLLUTION

M. CARMEN CASADO MARTÍNEZ

ABSTRACT

Surface sediments from two ports affected by mining activities (Cartagena and Huelva) were characterised following the traditional physicochemical characterisation based on contaminant concentrations together with laboratory toxicity tests. The toxicity tests included acute and chronic methodologies both on the whole sediment and on the sediment elutriates. As expected, sediments reported remarkable concentrations of metals, some failing the higher limit values for open-water disposal, and organic contamination in some areas affected by industrial and shipping activities.

The toxicity assessment results showed differences amongst the two studied zones: the port of Huelva reported significant toxicities both for the whole sediment and the elutriate tests, while the sediments from the port of Cartagena reported significant toxicity only for some whole sediment bioassays. These sediments provoked little or no adverse effects for other benthic species and similar responses to controls for elutriate tests. These results show that SQGs are not always a good predictor for sediment toxicity, especially for evaluating the risks of elutriate waters.

In this sense the advantages and disadvantages of laboratory toxicity tests for dredged material characterisation and its use in ecological risk assessment for decision-making is further discussed.

The author would like to thank Jesús M. Forja and T. Ángel De Valls, both of the University of Cádiz, Spain for their contributions and support. The paper received the IADC Award at the PIANC Conference in Estoril, Portugal and first appeared in the Proceedings. It is reprinted here in a slightly revised form with permission.

INTRODUCTION

During the last decades a number of international conventions on marine environmental protection have encouraged impact assessment to evaluate potential effects on human health, living resources, amenities and other legitimate uses of the sea owing to dredged material disposal (Burt and Hayes, 2005). Even though the greater proportion of dredged materials is similar in environmental terms to the sediments that are present naturally, a small proportion of sediments is contaminated and may represent a real threat.

The extent of sediment contamination is largely influenced by operations carried out in ports and waterways, such as passenger traffic, freight shipping, “accidental” spills or “intentional” discharges occurring close to navigational routes. Point source control measures have significantly contributed to reducing sediment contamination in recent years. Nonetheless short and long-term sources, as the result of past and present activities, may have contributed critically to worsening the environmental quality of littoral ecosystems.

The anthropogenic substances accumulating in aquatic systems can be distinguished into two groups: nutrients and pollutants (Goossens and Zwolsman, 1996). Amongst other substances, metals, metalloids, oil and grease, hydrocarbons and pesticides are pollutants traditionally found in ports and waterways, though the extent of environmental pollution depends on the nature of the activities performed, the characteristics of the area and the control measures adopted.
A great proportion of dredged materials has to be disposed of into the same aquatic system for economical, technical or logistical reasons. This management option is considered if sea disposal is identified as the least detrimental option according to the characterisation of the sediments to be dredged and after completing the dredged material management framework.

One of the clearest dredged material assessment frameworks was presented by Burt and Hayes (2005) and the subject of pre-dredging investigations for materials characterisation to evaluate the environmental aspects of dredging operations have been addressed in several guides and recommendations set up by different groups of experts, such as the one from the IADC-CEDA series on environmental aspects of dredging (Peddicord and Dillon, 1997) or the one recently published by PIANC (2006). These guides seek to lead the reader through a “highly focussed, cost-effective evaluation of the potential environmental impacts of dredging operations” that can be summarised in four steps (Peddicord and Dillon, 1997):

Step 1: Project planning, including the nature and scope of the activities, the potential dredged material placement options and the regulatory requirements.

Step 2: Initial evaluation, where available data is examined, may lead to the conclusion that no further pre-dredging evaluations are needed is gathered if needed, one proceeds to Step 3.

Step 3: Physical, chemical and biological characterisations of dredged material.

Step 4: Interpretation of results of the data assembled and evaluated.

This study looks at the methodologies and endpoint measurements involved during dredged material characterisation in relation to environmental risk assessment and dredged material management frameworks. Specifically the use of biological tests in the context of navigational dredging is addressed in two case studies consisting of sediments from two areas with known metallic contamination.

An integrated approach, designed to meet the international recommendations on the application of biological tests for dredged material characterisation and management (PIANC, 2006), has been used to characterise harbour sediments and the results are presented to study the uncertainties on the use of the different methodologies involved and to improve confidence in decision-making as gaining experience and knowledge.

Nonetheless the results cannot address the questions related to the project itself (Steps 1 and 2) because of its hypothetical nature. This study is part of the research developed at the University of Cádiz for the implementation of an integrated approach including biological endpoints for dredged material characterisation in Spain (DelValls et al., 2001; 2003).

**STUDY AREAS**

The ports included in this study are located in areas affected by important mining activities: the port of Cartagena and the port of Huelva (Figures 1, 2 and 3).

**Cartagena**

The port of Cartagena is located close to the city of the same name on the southeast coast of Spain. The city of Cartagena has been under the influence of an abandoned lead-zinc (Pb-Zn) mining district, which originates date back to the Roman Empire.

This region became one of the most representative open cast mining areas in Spain after the middle 20th century that led to an intensive movement of metals that ultimate entered the aquatic environment through direct and indirect deposition. The ore vein was mainly composed of
galena (PbS) and sphalerite (ZnS) with other minor elements such as nickel (Ni) and cadmium (Cd) (Marguí et al., 2004). Furthermore, the city experienced some industrial development during the 1960s and nowadays there are several chemical and metallurgical factories located in the surroundings of the harbour facilities – an electrolytic Zn plant, different fertiliser plants, a Pb smelter closed since March 1992, a fertiliser plant closed since 1993, a power plant, an oil refinery and a shipyard.

Huelva

The other area under study is the port of Huelva, located in the South Atlantic coast of Spain. The Ría of Huelva comprises the estuary of the rivers Tinto and Odiel, which form the Padre Santo Channel (Figure 3). The area delimited by these two rivers is characterised by important mining and metallurgical activities dating back three thousand years and based on pyrite (FeS₂) and other sulphuric minerals. This estuary suffered from continuous metal discharges over centuries through acid mine drainage and solid wastes, which represent an important long-term contamination source.

Three industrial areas are present in the Tinto and Odiel catchment areas: the first one upstream in the Tinto River, a second one located in the Odiel River before it joins the Tinto, and a third one just after this confluence. These areas include a cellulose factory in the Tinto River catchment area, which produces high quantities of pyrite ashes, different phosphates and fertilisers plants, a copper and sulphuric acid factory and a power plant, a petrol refinery and different chemical plants are located in the left margin of the channel.

APPROACH

Sediment sampling

The sediment samples were collected in April 2003 with a 0.025 m² Van Veen grab from approximately the top 20 cm. On arrival to the laboratory, sediments were homogenised and stored at 4°C and darkness prior to analysis. For each study area, CEDEX and the University of Cádiz selected four sampling stations (Figure 3). As Figure 3 shows, two inner stations were selected in Cartagena, one on the east (C1) and a second one in the western bay (C2). The other two stations were located on the east and west external part of the bay (C3 and C4, respectively).

In Huelva four different stations were sampled and numbered going seaward along the estuary.
**Physico-chemical characterisation**

The characterisation of sediments was performed on sediments dried at 40°C for 24-h and followed the CEDEX Recommendations for Dredged Material Management (1994). Grain size distribution followed UNE 103 101 and total organic matter content was estimated by loss of ignition (LOI) at 550°C and gravimetric determination, as recommended for small dredged volumes. Metals were determined in microwave acid-digested samples. The concentrations of Cd, Pb, Cu, Zn and Cr were determined using flame or furnace atomic absorption spectrometry, depending on the metal content. Mercury was determined using the cold vapour technique and for As the hydride generation technique was chosen before quantification using atomic absorption spectrometry.

PCB congeners #28, 52, 101, 118, 138, 153 and 180 and polycyclic aromatic hydrocarbons (PAHs) were quantified after extraction with cyclohexane and dichloromethane by means of ultrasound treatment, before concentration and clean-up with column chromatography. Determination of PCBs was made with gas chromatography with electron capture detection (GC-ECD) (EPA 8080) and 12 PAHs (acenaphthylene, acenaphthene, anthracene, benz(a)anthracene, benz(a)pyrene, chrysene, dibenz(a,h)anthracene, phenanthrene, fluoranthene, fluorene, naphthalene and pyrene) were determined with HPLC with fluorescence detection (EPA 8310). Detection limits were 0.8 and 10-30 μg kg⁻¹ dry weight of sediment of PCBs and PAHs respectively. Recoveries of analytes determined ranged from 60% to 120% and all the analytical procedures were checked with reference materials and allow agreement with certified values.

**Ecotoxicological characterisation**

Bioassays are, amongst other things, required for the characterisation of the toxic potential of dredged sediments and for environmental risk assessment of the disposal of dredged material. For that reason marine bioassays are also recommended in several dredged material management guidelines (Peters et al., 2002). These guidelines recommend sensitive and standardised sediment-dwelling or sediment-associated test organisms that are reasonably similar to those found – or expected to be found – at the site (Chapman and Anderson, 2005) to assess acute and chronic toxicity. Generally a set of 2-4 bioassays with different taxa are recommended to assess acute toxicity.

If biological tests are used to clarify gaps of information in decision-making the selection of test species and endpoints should include sensitive organisms (ecological receptors) in the environment that may be exposed to the contaminants and should address all the exposure pathways that may operate to bring contaminants into contact with the receptors. In the particular Spanish case, the framework assumes that the general goal of the assessment is to determine whether a dredged material, proposed for open-water disposal, is likely to cause adverse impacts at the disposal site. Thus, the receptors of concern include invertebrates that live in the sediment, animals and plants living on the sediment surface, bottom-associated fish, pelagic fish and invertebrates, birds and other wildlife, and humans using the site (PIANC, 2006).

The biological tests derived from the assessment hypotheses are summarised in Table I. Direct benthic effects were assessed in the amphipod Corophium volutator, the polychaete Arenicola marina and the irregular sea urchin Echinocardium cordatum. These three organisms are infaunal benthic species in direct contact with the sediment where they are buried. In addition the clam Ruditapes philippinarum was included to assess the potential effects of sediment resuspension events. This commercial clam, also known as the Manila clam, is an infaunal bivalve that lives buried in the sediments. Contrary to the others, this species is a filter-feeder, feeding on the overlying water thus it addresses specifically direct water column effects.

To complete the assessment of direct water column effects the sediment elutriates were tested for toxicity in sea urchin embryos and rotifers. In this way the test set includes both acute and chronic exposure (i.e. acute are the 10/14-d tests and chronic the 7-d rotifer population decay test; the embryogenesis success is considered a sub-chronic endpoint) and lethal and sublethal endpoints (i.e. survival and burrowing activity). In addition bioaccumulation potential of compounds that are known to bioaccumulate and biomagnify in aquatic food webs, such as PCBs or mercury, was evaluated by measuring the residue concentrations in clams after the standard 28-d exposure and lugworms after the 10-d of exposure.

Finally the results of the Microtox® device following the standard protocol for soil and sediments SPT were considered owing to its potential suitability to screen for toxicity in dredged sediment samples.

**Table I. Bioassays developed for the sediment ecotoxicological characterisation.**

<table>
<thead>
<tr>
<th>Test species</th>
<th>Exposure route</th>
<th>Exposure time</th>
<th>Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibrio fischeri</td>
<td>Whole sediment</td>
<td>30-min</td>
<td>Bioluminescence inhibition</td>
</tr>
<tr>
<td>Corophium volutator</td>
<td>Whole sediment</td>
<td>10-d</td>
<td>Survival</td>
</tr>
<tr>
<td>Arenicola marina</td>
<td>Whole sediment</td>
<td>10-d</td>
<td>Survival</td>
</tr>
<tr>
<td>Echinocardium cordatum</td>
<td>Whole sediment</td>
<td>14-d</td>
<td>Burrowing/survival</td>
</tr>
<tr>
<td>Ruditapes philippinarum</td>
<td>Whole sediment</td>
<td>14-d</td>
<td>Burrowing/survival Bioaccumulation</td>
</tr>
<tr>
<td>Brachionus plicatilis</td>
<td>Elutriate</td>
<td>7-d</td>
<td>Population decay</td>
</tr>
<tr>
<td>Paracentrotus lividus embryos</td>
<td>Elutriate</td>
<td>48-h</td>
<td>Embryogenesis success</td>
</tr>
</tbody>
</table>
Data treatment and interpretation
The results of the physico-chemical measurements were studied in relation to the guidelines recommended in Spain for dredged material management. These guidelines follow an action level approach based on the use of two different limit values (the so-called Action Levels –ALs) that are used to classify the sediments in three different management categories. Despite the higher complexity of the classification process the chemical concentrations measured in the sediment samples were compared directly with the national ALs for dredged material characterisation (Table II). In this way it was possible to identify the category for each sediment and the contaminants of concern in each area under study.

The biological endpoints were studied in relation to the negative toxicity controls carried out with each batch of experiments. This control consisted of a sediment free of all contamination and toxicity for the solid phase bioassays and clean seawater for the elutriate tests. A difference of 20% between the controls and the test and reference sediments is neither different nor environmentally relevant in short-term (e.g. 10-d) acute tests. Thus, if all sediment toxicity endpoints are 20% different from the reference, the sediments are not considered toxic even if the difference is statistically significant. As a screening test, the Microtox® results were compared with the Canadian limit value established at 1000 mg/L d.w. for disposal licencing (EC, 2002). Statistical analyses were performed by means of the statistical programme STATISTICA®.

CASE STUDY 1: HUELVA
The sediments from Huelva reported significant differences in the proportion of fines, the organic matter content and the chemical load showing a clear decreasing trend along the estuary (Table III). The inner station (H1) was characterised by the highest proportion of fines and organic matter and also the highest concentrations for most chemical compounds while H4, the station in the external estuary, was a typical coarse sediment free of all contamination. Stations H1 and H2, that are actually more influenced by the rivers, consisted of fine sediments rich in organic matter with As and Cu concentrations higher than the corresponding AL2 for aquatic disposal authorisation and intermediate concentrations of Hg, Pb and Zn (Table IV). The higher concentration of Ni reported for station 3, located close to a petrol refinery, evidenced the importance of addressing point sources in the general assessment framework. The organic micropollutants also identified some enrichment in the inner estuary and PCBs were the only micropollutants detectable in the two inner stations (H1 and H2).

In general the ecotoxicological characterisation of harbour sediments from Huelva was in agreement with the results of the physico-chemical analyses. The IC50 values obtained from the Microtox® device identified the two inner sediments (H1 and H2) as potentially toxic (Figure 4). These sediments reported the highest contaminant concentrations in sediments, although the plot of IC50 values indicates that some factor, for which the proportion of fines or the organic matter content accounts for, may be determining the performance of this endpoint.

The results of the physico-chemical analyses supported the potential toxicity identified for the finer sediments through a first screening. The sediment with a higher proportion of sands, that was not a positive of toxicity for the Microtox® assay, considering the test species and the exposure routes addressed by each endpoint, dredged materials from the

Table II. Contaminants determined in sediments and Action Levels used for dredged material management (CEDEX, 1994). All values expressed in mg kg\(^{-1}\) except PCBs, expressed in \(\mu g\) kg\(^{-1}\).

<table>
<thead>
<tr>
<th>Compound</th>
<th>Action Level 1</th>
<th>Action Level 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>As</td>
<td>80</td>
<td>200</td>
</tr>
<tr>
<td>Cd</td>
<td>1.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Cr</td>
<td>200</td>
<td>1000</td>
</tr>
<tr>
<td>Cu</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Hg</td>
<td>0.6</td>
<td>3.0</td>
</tr>
<tr>
<td>Ni</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Pb</td>
<td>120</td>
<td>600</td>
</tr>
<tr>
<td>Zn</td>
<td>500</td>
<td>3000</td>
</tr>
<tr>
<td>(\Sigma_7)-PCB</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
Ría of Huelva may pose a risk through contact with the whole sediments but also through exposure to the sediment elutriates. Some decrease in elutriate toxicity for the inner sediments (H1) indicates that organic matter may decrease the bioavailability of contaminants by decreasing its solubility to the water phases. Nonetheless toxicity through elutriate and whole sediment exposure was still significant. The sediment organic matter content can be also considered an important confounding factor when using organisms such as rotifers, that should be in starving conditions but may obtain extra food from elutriates, but it is not relevant for echinoderm larvae because they do not need extra food (Apitz et al., 2005).

Tissue concentrations in clams under laboratory exposure indicated that metals bioaccumulate from sediments although a significant elevation in contaminant tissue concentrations in test organisms does not necessarily mean that risks to upper trophic levels are likely. However it is reasonable to conclude from a failure to statistically distinguish the dredged material and reference exposed organisms that risks to upper trophic levels are unlikely (PIANC, 2006). Considering that the extent of bioaccumulation at higher trophic levels in the food chain is unknown, further assessments (e.g., trophic transfer modelling and dose calculations) should also be considered for those compounds with known biomagnification potential (PCBs, mercury).

CASE STUDY 2: CARTAGENA

The sediments from Cartagena were more similar in grain size and organic matter content than the sediments in the previous case study that formed a clear gradient of sediment properties (Table III). The chemical characterisation evidenced that dredged materials from Cartagena are affected by a “cocktail” of contamination consisting of different metallic and organic compounds mixed at different concentrations. Dredged materials from Cartagena would fall into category III with high Cd, Cu, Pb, Hg and Zn concentrations. These sediments also reported high PCBs and detectable concentrations of PAHs. The Microtox® evidenced potential toxicity for all sediments except C3 (Figure 4), that reported the lower proportion of fines, while the rest of tests reported very variable toxicity in the different endpoints measured. All sediments were toxic to amphipods and, at the highest sediment concentrations, toxicity to polychaetes also occurs. On the opposite side, the sediments evidenced neither elutriate toxicity nor lethal and sub-lethal effects on clams.

Considering the results obtained in Huelva it seems that the contaminants bound to sediments from Cartagena are not bioavailable in the water phases although chemical measurements were not performed on the elutriates. Nonetheless, clams bioaccumulate Cd, Cu, Pb, Zn and especially Hg at higher concentrations than clams exposed to a reference sediment, which indicates that bioaccumulation of contaminants can occur even if toxic effects are not evident.

Table III. Grain size and organic content of the sediments (g·kg⁻¹).

<table>
<thead>
<tr>
<th>Sample</th>
<th>% coarse</th>
<th>% sand</th>
<th>% fines</th>
<th>Organic content</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>0.07</td>
<td>9.71</td>
<td>90.22</td>
<td>20.27</td>
</tr>
<tr>
<td>H2</td>
<td>0.19</td>
<td>9.60</td>
<td>90.21</td>
<td>10.64</td>
</tr>
<tr>
<td>H3</td>
<td>0.03</td>
<td>56.02</td>
<td>43.95</td>
<td>6.30</td>
</tr>
<tr>
<td>H4</td>
<td>80.34</td>
<td>19.65</td>
<td>0.01</td>
<td>1.00</td>
</tr>
<tr>
<td>C1</td>
<td>3.95</td>
<td>38.24</td>
<td>57.81</td>
<td>10.54</td>
</tr>
<tr>
<td>C2</td>
<td>5.22</td>
<td>53.59</td>
<td>41.19</td>
<td>9.12</td>
</tr>
<tr>
<td>C3</td>
<td>0.93</td>
<td>67.20</td>
<td>31.87</td>
<td>7.19</td>
</tr>
<tr>
<td>C4</td>
<td>0.90</td>
<td>50.01</td>
<td>49.10</td>
<td>9.87</td>
</tr>
</tbody>
</table>

Table IV. Results of the physico-chemical characterisation. All values expressed in mg kg⁻¹ except PCBs, expressed in µg kg⁻¹.

<table>
<thead>
<tr>
<th>As</th>
<th>Cd</th>
<th>Cr</th>
<th>Cu</th>
<th>Hg</th>
<th>Ni</th>
<th>Pb</th>
<th>Zn</th>
<th>PCBs</th>
<th>PAHs</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>840</td>
<td>4.35</td>
<td>32.9</td>
<td>1938</td>
<td>2.38</td>
<td>34.6</td>
<td>383</td>
<td>2458</td>
<td>200</td>
</tr>
<tr>
<td>H2</td>
<td>531</td>
<td>2.50</td>
<td>24.1</td>
<td>1497</td>
<td>1.99</td>
<td>7.10</td>
<td>385</td>
<td>1857</td>
<td>229</td>
</tr>
<tr>
<td>H3</td>
<td>273</td>
<td>1.32</td>
<td>8.13</td>
<td>772</td>
<td>1.20</td>
<td>129</td>
<td>217</td>
<td>1176</td>
<td>n.d.</td>
</tr>
<tr>
<td>H4</td>
<td>4.70</td>
<td>n.d.</td>
<td>9.70</td>
<td>1.90</td>
<td>0.04</td>
<td>0.80</td>
<td>5.30</td>
<td>20.9</td>
<td>n.d.</td>
</tr>
<tr>
<td>C1</td>
<td>101</td>
<td>98.5</td>
<td>66.6</td>
<td>666</td>
<td>136</td>
<td>29.0</td>
<td>1397</td>
<td>8661</td>
<td>123</td>
</tr>
<tr>
<td>C2</td>
<td>64.7</td>
<td>17.5</td>
<td>45.6</td>
<td>313</td>
<td>32.7</td>
<td>15.3</td>
<td>748</td>
<td>1885</td>
<td>468</td>
</tr>
<tr>
<td>C3</td>
<td>88.0</td>
<td>31.9</td>
<td>57.6</td>
<td>453</td>
<td>115.2</td>
<td>19.3</td>
<td>1397</td>
<td>3310</td>
<td>108</td>
</tr>
<tr>
<td>C4</td>
<td>62.6</td>
<td>6.79</td>
<td>29.5</td>
<td>171</td>
<td>21.6</td>
<td>19.3</td>
<td>487</td>
<td>901</td>
<td>119</td>
</tr>
</tbody>
</table>

*n.d. means not detected or lower than the corresponding detection limit;

Σ₇-PCBs;
Σ₁₂-PAHs.
Three questions can summarise concisely the information needed:
1) Are the contaminants of concern present in the sediment and at which levels?
2) Are these contaminants bioavailable?
3) Are these contaminants causing adverse biological effects?

The information arising from the assessment framework should be able to address these questions. In the two ports studied, the sediments reported high concentrations of different metallic and organic compounds (Table V). Huelva was principally affected by metallic contamination despite that higher concentrations of some organic compounds were reported at the inner sampling sites. Even if it is not possible to identify the causes of toxicity, statistically significant reduction of survival in different benthic organisms occurs. The sediment-bound contaminants were bioavailable according to the high toxic effects registered and, in addition, the gradient of toxicity agreed with the gradient of physico-chemical properties thus it is probable that toxicity is caused by sediment-bound contaminants.

In the second case study, in Cartagena, the relationship between contamination and toxicity is not straightforward, possibly owing to the different sources of contamination in the area and the higher complexity of the sedimentological processes in this harbour. The overall toxicity could be considered significant because multiple endpoints exhibit major toxicological effects, and these effects could be in some way related to sediment-bound contaminants by the decrease in toxicity for the lower sediment concentrations.

Considering these results in the general framework for dredged material management it seems that the ecotoxicological characterisation supports the results of the physico-chemical characterisation. But this type of tests is not probably considered when a tiered-action level approach such as the one recommended in Spain is used. When the chemical concentrations are high, dredged sediments are not afforded further ecotoxicological assessments to decide whether or not they are suitable for open-

Figure 4. Results of the ecotoxicological characterisation of the sediments selected in this study. Toxicity is identified with an asterisk. ET1: rotifer population decay expressed as % effect compared to controls; ET2: percentage of abnormal sea urchin larvae; ST1: Microtox® SPT as IC50 mg/L d.w. basis; ST2: % amphipod mortality; ST3: % polychaete mortality; ST4: % E.cordatum mortality; ST5: % not buried E.cordatum; ST6: % mortality R.philippinarum; ST7: % not buried R.philippinarum.
water disposal, and the corresponding management strategy is selected according to sediment chemical concentrations alone.

Although the physico-chemical approach is useful to identify the contaminants of concern and even identify toxicity “hot spots” (Long et al., 2000; Casado-Martínez et al., 2006), certainly the physical, chemical and biological inter-relations of sediment/water combinations are far too complex to be evaluated through a rather simplistic approach. Dredging simulation by elutriate tests accurately predicted concentrations of metal released to the water column from contaminated sediments and long-term effects of dredging because of deposition of contaminated material (Edwards et al., 1995; Alden III et al., 1982; 1987).

Further validation programmes have demonstrated that effluent and surface water quality predictive methods have good utility for predisposal evaluation of dredged material intended for upland disposal. Thus it can be suggested that laboratory toxicity tests can also be useful methodologies for decision-making when dealing with materials not suitable for open-water disposal.

Table V summarises the information obtained in each of the methodologies used to characterise dredged material.

Table V. Results of dredged material characterisation.

<table>
<thead>
<tr>
<th>Sampling Station</th>
<th>Category CEDEX (1994)</th>
<th>Contaminants of concerna</th>
<th>Toxic effectb Pelagic organisms</th>
<th>Toxic effectb Benthic organisms</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>Illa</td>
<td>As, Cu</td>
<td>–</td>
<td>++++++</td>
</tr>
<tr>
<td>H2</td>
<td>Illa</td>
<td>As, Cu</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>H3</td>
<td>Illa</td>
<td>As, Cu</td>
<td>+</td>
<td>++++++</td>
</tr>
<tr>
<td>H4</td>
<td>I</td>
<td>--</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>C1</td>
<td>IIib</td>
<td>Cd, Cu, Hg, Pb, Zn, PCBs</td>
<td>–</td>
<td>++</td>
</tr>
<tr>
<td>C2</td>
<td>IIib</td>
<td>Pb, Hg, PCBs</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>C3</td>
<td>IIib</td>
<td>Cd, Cu, Hg, Pb, Zn, PCBs</td>
<td>–</td>
<td>++</td>
</tr>
<tr>
<td>C4</td>
<td>Illa</td>
<td>PCBs</td>
<td>–</td>
<td>+++</td>
</tr>
</tbody>
</table>

a Compounds exceeding the corresponding AL2.
b Identified based on one or more toxicity for bioassays.

Table VI. Dredged material categories and management requirements according to Spanish recommendations (CEDEX, 1994).

<table>
<thead>
<tr>
<th>Category</th>
<th>Concentrations</th>
<th>Aquatic disposal</th>
<th>Type of licence</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>C&lt; AL1</td>
<td>Free aquatic disposal</td>
<td>Normal authorisation</td>
<td>Sedimentological studies and biological effects (physical/mechanic)</td>
</tr>
<tr>
<td>II</td>
<td>AL1&lt; C&lt; AL2</td>
<td>Disposal under controlled conditions</td>
<td>Special authorisation</td>
<td>- Controlled disposal and justification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Impact hypothesis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Environmental control management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Corrective measures</td>
</tr>
<tr>
<td>III</td>
<td>C&gt; AL2</td>
<td>Disposal under adequate management techniques</td>
<td>Special authorisation</td>
<td>- Contaminants sources study and source control measures.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Isolation techniques and justification.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Impact hypothesis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Environmental control program.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>- Corrective measures</td>
</tr>
</tbody>
</table>
CONCLUSIONS

If a tiered testing approach is used for dredged material management, the first important step is the compilation of all available information. This can sometimes be enough for decision-making if sound scientific information is available. In Spain, however, previous assessments are only available for a few ports. In such cases the process should be followed to the next tier which includes the physicochemical characterisation of the sediments and possibly some test to screen for toxicity.

Taking account of the advantages of a commercial test the Microtox® offered promising results, offering a different toxicity trend not related to whole sediment toxicity but also not related to elutriate toxicity (Casado-Martínez et al., 2006). The Spanish recommendations for dredged material management (CEDEX, 1994) include a next tier comprising a battery of toxicity tests for those sediments with intermediate contamination or in the case that potential adverse effects are identified. For these intermediate contaminated sediments a battery of tests including solid phase bioassays to assess potential toxicity to benthic organisms and elutriate tests to determine potential toxicity to organisms living in the water column is recommended. In this sense the test using amphipods seems more sensitive than the test using polychaetes and embryogenesis is more sensitive than the test using Amphipods and Blasco, J. (2004). “Chemical and ecotoxicological guidelines for managing disposal of dredged material”. TrAC Trend Anal Chem. 23: 819-328.


REFERENCES


The International Association of Dredging Companies (IADC) and Central Dredging Association (CEDA) joined forces some time ago to develop an Environmental Seminar based on their series of guides Environmental Aspects of Dredging. The aim was to present this seminar upon the request of appropriate organisations. Most recently the seminar was presented under the auspices of the International Maritime Organisation (IMO), UNEP (United Nations Environmental Programme) and State (China) Oceanic Administration.

DALIAN, CHINA

As part of its scientific and technical support programme, every other year the London Convention holds its Scientific Group Meeting outside of its headquarters in London. This year’s meeting was held in Dalian, China, May 29 - June 2. Attached to the meeting is a workshop to identify technical co-operation and assistance needs, not only with member countries, but also with those in each region. The International Association of Dredging Companies (IADC), the Central Dredging Association (CEDA) and the World Dredging Association (WODA), which has observer status at the Convention, supported this endeavour by providing training and opportunities for discussion of dredging related issues. This service has previously been provided at South Africa (1998), Jamaica (2002) and Mombassa (2004). The dredging session of the workshop was well attended by delegates from fourteen countries representing: Cambodia, Canada, China, Democratic People's Republic of Korea, Indonesia, Japan, Malaysia, Netherlands, Philippines, Republic of Korea, Singapore, Thailand, United Kingdom, and the United States. In addition, a delegation of five people from CEDA’s sister organisation the Chinese Dredging Association (CHIDA) was also present.

The facilitators for the dredging part of the workshop were Mr. Neville Burt, Dr. Chris ivian, Dr. Andy Birchenough, Dr. Elizabeth Kim, M. Lex Oosterbaan, Dr. Tom Fredette and M. Jeremy Martinich.

THE SESSIONS

The morning session comprised a series of lectures about various aspects of dredged material management. To further support in these lectures, delegates received free-of-charge the eight volume set of the CEDA/IADC guides, Environmental Aspects of Dredging. At the end of each lecture, there was ample opportunity for questions.

The afternoon session provided an opportunity for presentation of papers by delegates followed by a panel discussion led by the speakers and other invited experts. The main lectures were:
- “Mind the Gap”: Introduction to the Dredged Material Management Working Group: M. Neville Burt
- Application of the London Convention to Dredged Material: Dr. Tom Fredette
- Project Planning and Assessment: Investigation, Interpretation and Impact: M. Neville Burt
- Management of Dredged Material: Re-use, Recycle or Relocate: Dr. Andy Birchenough
- Machines, Methods, and Mitigation: M. Neville Burt
- Beneficial Uses of Dredged Material (a special session requested by CHIDA): Dr. Andy Birchenough
- Environmental Education: Dredged Material Management – Sources of Information: M. Jeremy Martinich and Dr. Tom Fredette

Above, the delegates to the IMO/UNEP/SOA Workshop came from fourteen countries and three continents - Asia, Europe and North America.
Case studies presented by delegates included:
- Assessment procedure and classification for dumping dredged material: Mr Huo Chuanlin (National Marine Environmental Monitoring Centre, SOA, China).
- Dredging Environmental Protection in China: Mr Lin Feng (Shanghai Dredging Corporation and CHIDA).

A Panel Discussion followed, chaired by Mr. Neville Burt, assisted by Dr. Tom Fredette, Dr. Andy Birchenough, Dr. Chris Ivián, Dr. Elizabeth Kim, and Mr. Lex Oosterbaan. Often in these types of international gatherings there is a reluctance – perhaps because of cultural or language problems – to raise questions publicly. To overcome this barrier, a question sheet was prepared and distributed beforehand to delegates. This proved to be a successful way of bridging any cultural divides, and resulted in a number of stimulating discussion points to which the panel was then able to give their attention.

The main points of discussion were:
- How are action lists and action levels set in other countries?
- Are there low-tech solutions to waste characterisation?
- Should a non-member of the convention hesitate to join if they are unable to immediately fully comply with the criteria for ocean disposal activities?
- Would the experts be able to provide assistance to individual countries?

The discussions on all of these points were interesting, but it is noteworthy to reflect on the final question: “Would the experts be able to provide assistance to individual countries?” In a follow-up discussion of all those involved in leading the workshop, general agreement was reached that country-specific workshops could prove very useful. CHIDA in particular is keen on this idea. Overall, there is no doubt that the workshop and the sets of guides were appreciated by the delegations, and that the aim of CEDA and IADC to inform professionals in maritime areas related to dredging is a worthwhile endeavour.

The next similar event sponsored by IADC and CEDA, “Seminar on Environmental Aspects of Dredging”, is scheduled for November 6-7 2006 at the Technical University Delft, the Netherlands (see page 32).
PORT 2000, LE HAVRE’S NEW CONTAINER TERMINAL: REAKWATERS AND DREDGING OF THE NAUTICAL ACCESS CHANNEL

ABSTRACT

The construction of Port 2000, at Le Havre, France marks a significant expansion of France’s largest port and the fifth largest in Europe. To facilitate the elaborate expansion plans, the project was divided into several phases. These included dredging of an access channel, construction a 10 km protective breakwater, building quay walls and dredging a basin on the river side of the port. In addition two beaches were created and two caissons were manufactured, towed and sunk.

Port 2000 is expected to have long-lasting economic impact on the development of container shipping and transshipments in the northern European area.

INTRODUCTION

As the first and the last port of call on the Hamburg, Germany to Le Havre, France shipping route, the French port of Le Havre needs a deep draught for welcoming the newest generation of vessels, for both inbound and outgoing traffic. Located 365 km from Paris at the mouth of the Seine Estuary, the port of Le Havre is the largest container port of France and the fifth largest in northwestern Europe (Figure 1). Existing container terminals at Le Havre have reached their maximum capacity and some are built behind the François I lock making them less accessible for larger ships. The increase of scale of container vessels and the ever stricter time schedules and throughput times prompted authorities to decide to construct a completely new port. The site chosen is south of the existing facilities, and is in a plain estuary subject to tidal movements and directly facing the sea swell.

CONTRACT

In late August 2001, the Le Havre Port Authority (PAH) awarded the main contract for the construction of Port 2000 to a joint venture comprising Dredging International, GTM Terrassement (pilot), Campenon Bernard TP and inci GrandsProjets. The aim of this project, as far as the “wet” side is concerned, was the construction of the inner and external breakwaters and the dredging of the maritime access and internal channel of the new container port. The contract was awarded for an amount of € 218 million including eight options for a total of € 103 million of which four more will be awarded later. The project was initially scheduled for 37 months and was finalised in 47 months, taking into account the elaborate permitting procedures that were encountered and that final dredging operations were postponed in agreement with the Port Authorities.

The original Joint venture offer was withheld owing to the introduction of alternative
port 2000, le havre’s new container terminal: breakwaters and dredging of the nautical access channel

schedules to minimise the environmental impact of the works on the seine estuary. In addition, other optimal economic solutions were sought. In this respect, fine-tuning the phases of execution, the maximising the re-use of dredged material, and the innovative development of the accurate, dynamically positioned and automatically guided spraying pontoon Bayard II have been of crucial importance. Alternative and beneficiary execution methods presented to the client, were clearly decisive in obtaining the contract.

During the first few years of the 21st century, the construction of Port 2000 was the biggest maritime undertaking in Europe. Construction was completed late in 2005 (Figure 2). Remarkably it was exactly a century earlier that the extension of the port of Le Havre had been begun by a number of Belgian-based companies. On March 30 2006, the new port was inaugurated, and reportedly there has been an increase in vessels calling and in container movements per call. Ultimately the new facilities will triple container throughput to 6 million TEU per year.

**Scope**

The nautical access channel to Port 2000 is dredged to a level of -16m CMH which allows a tide-independent access for the largest container vessels. The access route comprises:
- An exterior channel of 4000 m presenting a bottom width ranging from 580 m at its connexion with the existing entrance channel up to 300 m at the entrance of the new harbour.
- An internal channel protected by the southern breakwater, having a length of 4000 m as well and a bottom width of 300 m.
- A turning circle with a radius of 353 m.

Channel slopes vary from 5/1 for the exterior channel and 3/1 for the internal channels.

The total dredged volume was over 45 million m³, principally sand and silex gravel. Where possible dredged material has been reused as reclamation material (11 million m³) and to construct the foundations and the core of over 10 km of breakwaters (6 million m³ of gravel). A disposal site for the rest of the materials was available at the offshore site of Octeville.

**Breakwaters**

The southern breakwater forms the main protection of the new port over a length of 5900 m. It is a sloped dike constructed on a 50-m wide sub-base realised in dredged gravel. The external protection is completed on the north side by the northern breakwater (300 m), which is linked to the existing concrete breakwater of Le Havre (Figure 3).

**Figure 2. A schematic drawing of the completed Port 2000.**
Bunds 3660 m long were realised on the northern side to limit the future platforms behind the quays. These bunds will be replaced in the future by quay walls, as the container terminals are expanded. Four quays were actually constructed over a total length of 1400 m, eight more are to be constructed in future contracts. The construction of the quay wall was part of a specially dedicated contract, assigned to a civil contractor.

Inner bunds and outer breakwaters are essentially composed of a core of dredged gravel, covered by a watertight layer and protected by several layers of quarry rocks. The southern breakwater has in its most exposed sections an outer protection made of Accropodes.

Beaches
As an added, perhaps surprising, plus point the new harbour includes two reclaimed gravel beaches. The first, called “internal beach” is situated just behind the northern external breakwater. Its major purpose is to create an ecologically interesting area to sustain a marine plant called “crambe maritima” which were threatened by the extension works.

The second beach, situated at the outer side of the same northern breakwater, is created to ameliorate the wave climate at the new port entrance. It should absorb a complex superposition of waves created by diffraction in the new channel and reflection on existing vertical walls.

Musoirs
Musoirs is the French word for the two concrete caissons, placed at the entrance of the port, marking the northern and southern sides. These massive structures (surface: 55 m x 21.5 m x height 30 m) were imposed to reduce the opening at the entrance to 300 m so as to limit internal wave action (Figure 4).

Theoretically, a dike formation could have been created to protect of the fairway. Unfortunately this would have required such an acute slope that a much wider port entrance would have been needed. And a wider port entrance would increase wave movements, agitation and turbulence within the inner port that would have decreased port safety beyond acceptable limits. Hence it became clear that a very narrow entrance, which could not be realised without the huge caissons, was preferable.

For the major part the caissons were constructed in a drydock in the inner harbour, and then set afloat, towed and sunk on location onto prepared gravel bases between –17 m and –20 m CMH. This unusual part of the project will be discussed more thoroughly below.

WORKING IN PHASES
From the preliminary studies onwards, the Port Authority was fully aware that the phasing of the works would have a major impact on the sedimentological evolution of the estuary during and even after the completion of the works. The Port Authority had to consider that diminishing the width of the estuary at the height of Port 2000 by 20 percent, would have a significant influence on flood channel displacements and resulting erosions, as well as sand displacement and deposits. In addition, this is an ecologically and also economically valuable area because of the presence of the entrance channel to the port of Rouen 100 km inland on the Seine.

The 776 km long Seine river discharges into one of the largest estuaries of northwestern Europe, a 30,000-ha maritime, industrial and wetland area spanning more than 5 km which includes both the mouth and the fairway to the port of Rouen. The average discharge of 500 m³/s, the important tidal range of up to 8 m, and very strong currents cause a huge sedimentation transport. This, incidentally, moves the mouth of the estuary westward at a rate of 50 m per year.

For these reasons, “phasing the works” was a serious issue for the Joint venture.
JAN VANDENBROECK graduated as a Civil Engineer (MSc) from the State University Ghent, Belgium. He joined DEME in 1989 and has worked as desk operations manager and project manager on numerous projects. From 2001-2005 he was co-project manager Marine Works PO T 2000 Le Havre (France) for the DPAM oint Venture (GTM DI). Since 2005 he is resident Manager of Soci t de Dragage International (SDI), Lambersart, France.

and an alternative solution was proposed to ameliorate the environmental impact. The phasing proposed in this offer is described as follows.

The works would start with dredging the inner basin and creation of the inner bunds. In the first phase this would allow:
- only a very limited deviation of the flood currents, which reach peak values of 5 knots (2.5 m per second at high tide),
- and the ability to take advantage of the presence of gravel in the upper layers, making an immediate construction of the eastern bund possible.

After closing the bund, a reclamation area was made available in which sand could be stocked. The eastern and central sections of the reclamation cover an area of 78 ha and provide a fill of 7.7 million m$^3$. Underneath the dredged sand other gravel layers were situated so that in a second phase further bunds could be realised with this gravel. This was continued till a maximum distance was reached between dredging area and the bund realisation. At a distance of longer than 750 m the economical and technical advantages of directly pumping gravel decreased significantly, because of the massive pump capacity required for the transport of the gravel.

At the same time on the western part of the channel an access channel was created, requiring small hopper dredgers with limited draughts as the area was very shallow. In a later phase the channel permitted the use of bigger (and more economical) hopper dredgers. It also allowed the transport of 3 million m$^3$ of gravel present on the western area to be imported to underwater stock areas as close as possible to the western bunds and dikes to be constructed. This allowed direct pumping from these stocks by cutter suction dredgers into the gravel basement in a second phase.

Once the inner bunds were realised and sufficient gravel stored by the hopper dredgers in the underwater stock areas, a new phase was started: the construction of the western sub-base. The two underwater stock areas had a total capacity of no less than 3 million m$^3$. In order not to obstruct totally the flood currents, only the sub-base was constructed in this phase; the upper dike construction was started several months later.

The sub-base reaching 3 CMH was submerged at high water. This means that only a part of the flood is deviated. The creation of this barrier has as a natural consequence the deviation of the flood stream and the creation of a new flood channel, south of the southern breakwater. The partial deviation combined with a close follow up of this evolution allowed a continuous assessment of the evolution of the estuary and the possibility to adapt the phasing whenever required.

One of the economic risks was the displacement of huge quantities of sediment and their deposit in the navigation channel towards Rouen. Therefore this flood channel creation was “accompanied” by dredging works along its path, removing the sediments in a controlled way and disposing of them outside of the estuary on the site of Octeville. A complementary measure with the same objective was the 750 m elongation to the west of the submersible dikes on the north side of the same navigation channel.

Once the western foundation was realised, the upper dikes were constructed, using a temporary access dike in the middle of the port. This allowed work to be done simultaneously to the east and to the west thus accelerating the construction process. The total length of the protection dikes was 5.9 km, to which another 3.66 km of the closing dike had to be added. On average, width at the top was about 50 m.

The temporary division of the inner waters of Port 2000 made by building this temporary access dike had created separate basins with a length of 1 to 2 km each. Finally, in order to eliminate the strong currents which generate erosion risks, the temporary access dike and the eastern dike were opened and closed in one operation, thereby sustaining the equilibrium between two huge basins.

**DREDGING WORKS**

From the beginning several factors influenced the mobilisation schedule of the equipment and in particular the preparation of the dredgers, especially those designated...
to operate in the gravel areas. These included a very tight schedule, combined with offshore conditions like huge tides up to 8 m and strong currents. For these reasons the following dredgers were deployed.

Cutter suction dredgers (CSDs) were chosen to dig the internal channel, pumping the gravel through the dynamically positioned and guided diffuser Pontoon Bayard II directly into the sub-base of the future bunds and breakwaters. Sandy materials were reclaimed in the areas limited by the inner bunds. Significant investments were made in dredgers like the laanderen I, for instance, by introducing wear-resistant layers in the pipelines and the pump houses before starting the works so as to be prepared for gravel dredging.

Trailing hopper suction dredgers (TSHDs) of different capacities were needed. At first, small and medium dredgers having a limited draught were deployed, so as to initiate a minimum channel in the shallow areas. Thereafter high capacity dredgers as Antigoon (8000 m³), Lange Wapper (13,700 m³) and Uilenspiegel (13,700 m³), to accelerate the creation of the channel and to import the gravel from the western area into the underwater stock areas were introduced. Dipper dredgers such as the Big Boss and enne were brought in for particular operations during archaeological investigations on historic wrecks and assistance with complementary ordnance clearing operations, as well as the lengthening of the submersible dikes alongside the navigation channel to Rouen.

Pontoons with heavy cranes like De Bever plus an armada of tugs, multicats, floating and submerged pipelines as well as crew vessels and a survey boat equipped with latest technologies as multibeam sonars provided general assistance (Figure 5).

Table I presents an overview of the main equipment used. Up to 250 people were mobilised for the operations which continued for three years continuously on a seven days a week, 24 hour a day.

### SUB BASE CONSTRUCTION

The sub-base of the dikes had been designed as a massive construction situated in gravel with a top level at 3 m CMH, directly placed on the seabed. Therefore the construction has a variable height going from 3 m for the shallowest areas up to 6 m for the deepest. On the top, it has a 50-m width, with a mean section of 350 m². With a total length of 10 km, 3,500,000 m³ was thus required to be placed.

Taking these quantities into consideration, combined with the offshore circumstances, a major concern for the joint venture from the beginning was to develop a technique which could manage the quantity of reclaimed materials as well as expedite the progress of the works. This demanded being able to take advantage of favourable weather conditions whenever possible.

To meet these requirements a technique was devised in which the gravel was directly pumped using a CSD as the dredging unit and a dynamically positioned and guided diffuser (DPGD) pontoon as reclaiming unit. The DPGD measures the density and the velocity of the materials delivered by the CSD, calculates the quantity of materials needed on the spot to realise the sub-base, and automatically controls the winches of the unit. These techniques allowed the work to progress at 300 m sub-base per week, compared with progress of less than 100 m using the classic dipper and split-barge techniques.

The DPGD Bayard II was designed to work in the Seine estuary currents of up to 5 knots.

A major concern however remained the stability of the sub-base once realised. A known phenomenon is that at currents of 5 knots small gravel tends to start rolling.

<table>
<thead>
<tr>
<th></th>
<th>CSD</th>
<th>DPGD</th>
<th>THSD</th>
<th>THSD</th>
<th>THSD</th>
<th>THSD</th>
<th>Dipper</th>
<th>Dipper</th>
<th>Heavy Lifting pontoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>laanderen I</td>
<td></td>
<td>Lange Wapper</td>
<td>Uilenspiegel</td>
<td>Antigoon</td>
<td>laanderen I</td>
<td>Charlemagne</td>
<td>Big Boss</td>
<td>Rambiz</td>
</tr>
<tr>
<td>Power</td>
<td>11,728 kW</td>
<td></td>
<td>13,700 m³</td>
<td>13,700 m³</td>
<td>2,065 m³</td>
<td>1,751 m³</td>
<td>1,928 kW</td>
<td>805 kW</td>
<td></td>
</tr>
<tr>
<td>Type</td>
<td>Dredging of gravel material, pumped directly into the sub-base through DPGD Bayard II. Reclamation of gravel beaches</td>
<td>Gravel sub-base construction Ballasting caissons after their installation</td>
<td>Channel dredging</td>
<td>Final Channel Dredging</td>
<td>Minimum channel realisation and accompanying dredging works in the new flood channel</td>
<td>Accompanying dredging works in the new flood channel Gravel dredging for the realisation of the caisson foundations</td>
<td>Wreckage removal and complementary ammunition removal</td>
<td>Installation of the musoirs</td>
<td></td>
</tr>
</tbody>
</table>
As explained in the “phasing” chapter above, the western part of the sub-base was planned to remain unprotected for several months before construction of the upper dike. Furthermore, the gravel layers present in the areas to be dredged contain a significant quantity of sand, which is even more susceptible to erosion.

Using a partnering concept between client, contractor and the engineering company Sogreah, a detailed study programme was set up to search for a solution. Combining mathematical and physical models, as well as experimental try-outs on site, did ultimately help to adapt execution methods aimed at reducing the erosion of sub-base material. Mathematical modelling was followed by physical modelling and trials on site.

The solution found was to anticipate partially the movement the gravel would undergo and to adapt the sub-base design in its first phase. It was estimated that 300,000 m³ of gravel consumption was economised thanks to this adaptation.

VIRGINIE AND STEPHANIE

Two concrete caissons (L x W x H 55 m x 21.5 m x 30 m) were constructed in the drydock “Forme 7” inside the existing harbour. They weighed 13,000 tonnes each and represented, after flooding, a draught of about 13 m. These two caissons marking the entrance of the new port were named after the two site secretaries, Virginie and Stephanie, in tribute to their work.

To stabilise these floating “matchboxes” posed on their side during transport, the heavy lifting pontoon Rambi was used. By lifting about 1000 tonnes, it reduced the draught to 12 m.

Utilising pre-installed anchors, the pontoon could be positioned very accurately allowing a tolerance of a few centimetres. Taking advantage of the outgoing tide and by ballasting the caissons, the sinking was realised in a controlled way. Once touch-down took place on the foundations at -16.50 m CMH, further ballasting was immediately executed by pumping gravel through the DPGD Bayard II especially adapted to this particular situation.

Special attention was paid to the construction of the foundations, which also used dredged gravel delivered by the gravel dredger Charlemagne. Before placing the caissons, the foundation bed at -16.50 m had to be levelled with a precision of 5 cm. To meet the demands of this precision, the CSD laanderen I was equipped with a levelling plate instead of the standard cutterhead and a tension wire for precisely double-checking the exact level of the plate. Good weather conditions prevailed once again, and allowing use of this technique, which proved decisive for the successful completion of construction.

CONCLUSION

There is no doubt that the realisation of a project like Port 2000 demands the combined experience of engineers, superintendents, captains and their crews. On the other hand, a project like Port 2000 results in broadening the experience of all the participants.

Amongst the challenges faced by the Joint venture were the exposure to difficult weather circumstances with heavy sea swells, reckoning with strong tidal and current changes, the safety factors of the possible presence of military ordnance and limiting the displacement of large quantities of sediment and their deposit in the navigation channel of the Seine. This latter item has both economic and ecological consequences.

During the 47 months of work 250 people were continuously on the job and each and every piece of major plant in the Dredging International fleet was occupied. Thus as an economic driver, the development of the Port 2000 project was a significant force. In the future as well this role will continue, as the long-term aim of the new Port at Le Havre is to become a logistics hub for container vessels in northern Europe. In this way, the port of Le Havre will provide the local population with sustainable growth that is environmentally acceptable and beneficial for the development of the region as a whole.

Figure 5. Several of the dredging vessels can be seen working simultaneously to prepare the channel.
It is always exciting to open the pages of a new publication on the subject of dredging. Not only is there the opportunity to forage for information on new techniques, experience from past projects, environmental effects data and other related matters, but for anyone who has ever tried to publish a technical treatise, there is the added interest in how the subject has been handled and the book has been structured. In this case, there could hardly be any doubt about the quality of the information being presented. The list of authors reads like a Who’s Who in the dredging world and, taken as a series of essays on various dredging-related topics, the material is of top quality. Where one could be critical is in the presentation of this material in book format without, apparently, the chapters being merged sufficiently to eliminate repetition. That said, admittedly it is better to have repetition of good quality, than poor quality and there are no examples of the poor quality here. Quite the contrary.

The authors and their contributions are as follows (in the order they appear and as credited in the book):

- Anders Jensen: “Environmental Investigation and Monitoring of the Fixed Links across the Danish Straits”.
- W J Lasblom: “Dredging in the Dutch & Belgian Coastal Waters and the North Sea”.
- Neville Burt: “Dredging in UK Coastal Waters”.
- Robertoidal: “Dredging in Spanish Coastal Waters”.
- Robert E Randall: “Dredging in the United States”.
- Peter D G Whiteside: “Dredging in Hong Kong”.
- Weidong Sun: “Singapore Dredging”.
- Pierellinga: “Dredging in a Changing Environment”.

The book is edited and introduced by D. Eisma who is a retired professor in Marine Sedimentology at the University of Utrecht and the Netherlands Institute for Sea Research, Texel. The book opens with a general appreciation of the nature of dredging projects and dredging processes, together with a description of how these are made more environmentally friendly. This is followed by seven individual chapters relating to dredging works in Denmark, the coastal waters of Holland and Belgium and the North Sea, the United Kingdom, Spain, the United States, Hong Kong and Singapore. The final chapter is a more philosophical perspective of the nature of dredging in an environmental context.

Chapters 1 and 3 both contain a substantial amount of information on dredging processes and together could be described as a current “state of the art” inventory. Chapter 2, curiously located, and Chapters 4, 5, 6, 7 and 8, are more country specific and deal with dredging works in the context of their environmental regulations. There is a wealth of detail here. The way to get the maximum benefit from this publication is probably is to read right through the whole book, noting points of interest and references, rather than dipping into it, as one might do for a standard text book. Many of the “essays” are based on previously published material, but expanded to fulfil the requirements of the book. As a whole they represent a significant contribution to the state of the art and a valuable reference.

Although an index is provided, the nature of the publication does not lend itself to easy access for specific subjects, particularly when they occur on a recurrent basis. However, the knowledge base as a whole is substantial and there is no doubt that the literature of dredging and its environmental context is considerably enhanced by this publication.

The book is available from Taylor and Francis at http://www.taylorandfrancis.co.uk

NICK BRAY
This compendium of state-of-the-art papers on the common strategies to reduce the risk of storm-induced flooding in coastal lowlands in Europe comes at a very appropriate moment. The matter is of particular interest, given the Asian tsunami in 2004 and more recently the storm-induced damages to the Gulf Coast of the United States in the wake of Hurricane Katrina, especially along New Orleans, Louisiana. Much of the disaster planning, education, preparation and mitigation measures that could have been of use in the USA are actually addressed in great detail in this publication. The book is hence a must-have for personnel involved with emergency management and preparedness in coastal areas.

The book, edited by Dr. Jacobus Hofstede, presents a series of papers that address the various topics related to being prepared for coastal flooding. It is estimated that approximately 16 million people live in the 40,000 square kilometer (km²) expanse of coastal lowlands in the North Sea Region (NSR), which encompass the United Kingdom, Belgium, the Netherlands, Germany and Denmark. Although the various national governments spend several hundreds of thousands of euros each year on coastal defence, the authors establish that much larger amounts are needed in the future, and that a coordinated, well-planned effort is needed to optimise utilisation of these resources.

As part of the efforts of the North Sea Coastal Managers Group (NSCMG) to improve cooperation and coordination between national agencies and governments on coastal risk management issues, the "Common strategies to reduce the risk of storm floods in coastal lowlands – COMRISK" was formed. COMRISK, which lasted from 2002 to 2005 focussed on the following aspects:

"(1) to bring together coastal risk management experts from administration, science and private companies from around the North Sea and beyond, (2) to exchange experiences and studies of good practice on coastal risk management, (3) to evaluate and further develop innovative integrated coastal risk management strategies, considering national regulations and responsibilities, (4) to initiate and support transnational cooperation on integrated coastal risk management (networking), and (5) to integrate coastal risk management into strategies for sustainable management of the coastal ones in the NSR".

In April 2005, a workshop was held in Kiel, Germany, to address these aspects and to obtain agreement amongst the various coastal managers. This book essentially summarises the workshop discussions and conclusions into a series of chapters: Chapter 1 provides an overview to the project. Chapters 2-6 address the evaluation of policies and strategies, strategic planning, risk perception and public participation, performance measures, and hydraulic boundary conditions as it applies to coastal risk management. Following this, Chapters 7-10 present four case studies for Flanders and West Flanders (Belgium and the Netherlands), Ribe Area (Denmark), Lincolnshire (UK) and Langeoog (Germany). Finally, the book presents strategies for reducing the risk of storm flood in coastal lowlands and associated integrated risk-based decision-making process in Chapters 11-13.

The authors presents risk management as essentially comprising the following basic steps:
(a) identification of the nature and extent of flood risks, (b) understanding and addressing the relevant public perceptions, (c) establishing goals and standards with respect to the flood risk, (d) establishing strategies and policies to achieve these goals, and (e) minimising the costs of achieving the goals, while ensuring that the risk remains acceptable.

Several challenges were identified in the risk management context – primarily, external challenges (sea level rise, ecological regulation, and development pressure), physical opportunities and threats (large and deep flood prone areas and unprotected natural shorelines), socio-economic challenges (major shoreline cities, designated natural areas, low sense of urgency from citizens), and institutional aspects (limited budget and staff, policy limitations (management as well as planning), and limited integration amongst regions). There were considerable variations in risk management philosophy, approaches and planning
amongst the various NSR countries. For example, the UK places a strong focus on cost-benefit aspects of projects and has permissible legislation (like Denmark), which creates flexibility in funding projects. In Germany, a retreat policy for threatened area may be followed under extreme situations. The concept of flood risk management is well underway in all of the NSR countries, although the specific focus may vary - for example, UK and Denmark stress intervention to mitigate damages, while the Netherlands and Germany focus of flood defence systems.

The authors conclude that, in a global sense, the strategic planning process can be thought to comprise of the following key elements:

(a) problem formulation and management goals (establish appropriate policy aims, identify the flood hazard; consider multi-generational planning, cost-benefit criteria, ecological carrying capacity),

(b) flood risk analysis (assessing present and future trends, identifying hazard, assessing probabilities and consequences of flooding and communication of risk),

(c) alternatives analysis (generation of management options and comparative cost-benefit study),

(d) implementation (i.e., carry out the selected plan - improve or manage the flood defences, develop better warning and forecasting systems, and communications plans), and

(e) monitoring and reviewing (performance monitoring of completed projects, reconsideration of strategies based on lessons learned).

Within the context of alternatives analysis, the authors recommend considering:

(i) key focus aspects of management measures (alternate methods and strategies, local site-specific methods considered, flexibility),

(ii) management measures to reduce probability of flooding (primary and secondary defense systems and emergency planning),

(iii) measures to reduce consequence of flooding (avoid development in flood prone areas, crisis management through forecasting and warning, and evacuation), and

(iv) recovery systems (restoration of affected areas, funding mechanisms).

Thus, key steps in a performance evaluation would be:

(a) evaluating effectiveness and efficiency of existing flood defence systems using future risk as a performance indicator,

(b) evaluating geographic indicators of shoreline position (where is the defence set? is it stable? should we rebuild or retreat?),

(c) evaluating geometric indicators of defence systems (e.g., setting shape, slope and crest elevation criteria for dikes and gates using hind-cast and forecast data, establishing dune volumes that would resist flood events, development of real-time coastal systems to forewarn of imminent danger, and so on),

(d) structural integrity measures (e.g., geotechnical failure mode analysis - visual loss, slope gradients, piping and failure; field inspection, data collection and predictions), and

(e) development of long-term performance criteria and indicators (data needs, present condition assessment, overtopping potential, failure modes).

The primary failure mechanisms considered in the book include: dune breaching (for natural and beach shorelines) and dike breaching (for engineered shorelines). For dune breaching, the equilibrium beach profile can be compared with the pre-storm profile to draw conclusions regarding vulnerability and probability of failure. The performance of the dune is a function of its geometry, water level, waves and grain size of sediments. For dike breaching, primary aspects of interest are wave overtopping, geometry and stability of the dikes, erosion potential and rate for the core, and predicted breach growth rates during floods. These can be simulated with existing hydrodynamic modelling tools such as Mike21 and Delft3D, amongst others. The authors also point out many of the concerns regarding present use of models and future modelling challenges in this arena.

In terms of technical analysis, geometry, hydraulics and geotechnical characteristics control the results. Geometry varies with the type of structure and its functions, and is site specific to a certain extent. From a hydraulic perspective, all of the NSR countries have fairly extensive networks of water level monitoring and wave gauging stations. The data from these are used for hind-cast and forecast applications of various storm events - but the statistical methods employed vary between the various countries. Also, there are differing criteria amongst countries for the return storm frequency and permissible overtopping assumptions, although 2% run up is still considered as good criteria.

For example, while Denmark uses inner structure slope as an explicit criteria for these calculations,
In conclusion, this book presents a wealth of information that is invaluable to emergency planners and managers who work in coastal flood-prone areas. Periodic review of the flood defence systems (identification of weak points in the system and appropriate strengthening measures), evaluation of management strategies (communications plans, evacuation and response plans) and annual review of national emergency response budgets for coastal disasters are vital planning elements. Ultimately, lessons such as the recent New Orleans disaster, can in themselves, be used to develop vital tools for better preparedness in the future – through a failure modes analysis of not only coastal defences, but also the entire policy, planning and response aspects. If such a project were contemplated, this book would be a strongly recommended mandatory first reading assignment.

The authors nicely summarise the intent of the book through their final catch phrase: “risk of all time risk is everywhere and always has been”. It is important that coastal managers and planners recognise and communicate this integral part of the risk management philosophy – “that the absence of occurrence of risk over long periods of time may reinforce the myth that these extreme events are not probable however, they are bound to occur sometime in the future”. The appropriate realisation, communication and reaction to this simple philosophy could have been extremely valuable in New Orleans.

RAM K. MOHAN
SPE RUSSIAN OIL AND GAS 2006

CROCUS E O
MOSCO RUSSIA
OCTOBER

This is a new major international event for the upstream oil and gas exploration and production community organised by SPE and Spearhead Exhibitions Ltd, who also partner to present Offshore Europe in Aberdeen, Scotland. The main objectives of the event are to deliver messages by the industry for the industry, to highlight opportunities in the biggest oil and gas market and to showcase cutting edge technologies to the local government, industry decision-makers and professionals. The conference programme will cover: drilling, well completions, geology and geophysics, reservoir monitoring & testing, well logging and formation evaluation, facilities engineering, production operations, fluid mechanisms and oil-recovery process, reservoir engineering, gas technology, project management, emerging and peripheral technology, and health, safety and environment.

For further information visit: http://www.russianoilgas.com/ or Spearhead Exhibitions Ltd, Oriel House, 26 The Quadrant, Richmond, Surrey, TW9 1DL, UK
Tel: 44 208 439 8900, Fax: 44 208 439 8901
Email: russianoilgas spearhead.co.uk

ROTTERDAM THE NETHERLANDS
OCTOBER

The conference and exhibition, supported by the Port of Rotterdam, is aimed at those involved in the development and operations of port and terminal facilities in the container sector. Participants come from engineering departments of port authorities, terminal operators, consultancy firms, dredging contractors, maritime construction firms and suppliers to the industry. Topics will include: Increasing capacity, efficient port operations, fender systems, terminal security, breakwater design, ports and the environment, maintenance, quay design, concrete repair, dredging, port planning, paving, simulation, port and terminal automation, crane design, new technology in cargo equipment, terminal design, impact of large ships of port infrastructure.

For further information contact:
CEDA-AS Secretariat
Dounia Gharbi or Khadija Legliti
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5, Rue Chajarat Addor, quartier Palmiers, Casablanca 20100, Morocco
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www.dredging.org
This respected event took place in College Station, Texas in the USA in 2002, and then in Singapore in 2004. In 2006, Amsterdam will host this third symposium, ICSE-3, for engineers, scientists, decision makers and administrators working in all areas of hydraulics and geo-engineering, which focuses on Erose, scour and geotechnics, scour anticipated designs, modeling, field measurements and verification tests, and application areas such as river related, offshore, coastal and port structures. Two days of technical sessions will be followed by technical site visits, including to the Delta Works.

For further information contact:
CUR, Cora Hoogeveen
P.O. Box 420 2800 AK Gouda, the Netherlands
Tel 31 182 540 650, Fax 31 182 537 067
Email: mail icse2006.org
www.icse2006.org

The theme of the International Hydrographic Conference 2006, known as Hydro 06, is “Evolutions in Hydrography”. It is organised and hosted by The Hydrographic Society Benelux on behalf of International Federation of Hydrographic Societies. Papers are welcome on all topics related to hydrography such as oceanography, shallow water, inland surveying, charting, dredging support, tides, sediment transport, multibeam, side-scan sonar, positioning, remote sensing, subbottom profiling, and so on.

There will be exhibition stands at the conference, and companies interested in participating should contact the Conference Secretariat for details.

For further information contact:
Hydro 06 c/o Technologisch Instituut vzw Desguinlei 214, BE- 2018 Antwerp, Belgium
Tel. 32 3 260 0840, Fax 32 3 216 0689
Email: info hydro06.com
www.hydro06.com

CALL FOR PAPERS

WODCON VIII
YNDHAM A ACE RESORT
OR ANDO F ORIDA USA
MAY JUNE

This is a Call for Papers for the Eighteenth World Dredging Congress (WODCON VIII) which will be held May 27 to June 1, 2007 at the Wyndham Palace Resort and Spa at Disney World in Lake Buena Vista, Florida. The theme of the conference and exhibition is “Global Dredging: Its Impact on the Economy and the Environment”. This theme will provide a unique forum between worldwide dredging contractors,
port and harbour authorities, government agencies, environmentalists, consultants, civil and marine engineers, surveyors, shipyards, vendors, and academicians who work in the exciting and challenging fields related to dredging. Important discussions on the impact that dredging or the inability to dredge will have on the world economy and its environment will highlight the programme.

The Technical Papers Committee will review all one page abstracts received, select and notify authors of acceptance. Submission of an abstract implies a firm commitment from the authors to present the papers at the conference. Conference deadlines are the following:

Submission of one page abstracts: October 15, 2006
Notification of authors: December 1, 2006
Submission of final manuscript: January 10, 2007

Interested authors should mail their one page abstract to one of the following members of the WEDA Technical Papers Committee:

Dr. Ram Mohan
Blasland, Bouck & Lee, Inc
100 Four Falls Corp Center, Ste 106
W. Conshohocken, PA 19428-2950
Tel: (484) 530 9119 x35, Fax: (484) 530 9118
Email: rkm bbl-inc.com

Dr. Robert E. Randall
Department of Civil Engineering
Texas A&M University
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Email: r-randall tamu.edu

Mr. Steve Garbiciak, Jr.
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200 S. Wacker Drive, Suite 3100
Chicago, IL 60606
Tel: (312) 674 4937, Fax: (312) 674 4938
Email: sdg bbl-inc.com

Interested CEDA and EADA authors should send their abstract to CEDA or EADA Technical Papers Committee, CEDA Secretariat.

PIANC COPEDEC VII
DUBAI UNITED ARAB EMIRATES
FEBRUARY

After its successful start in 1983, it was decided to organise the International Conference on Coastal and Port Engineering in Developing Countries (COPEDEC) once every four years in a different developing country. At the September 2003 meeting in Sri Lanka a merger Agreement between COPEDEC and PIANC (the International Navigation Association) was signed and the tradition will be continued under the auspices of the two organisations. For this reason, the newest conference will be held in five years instead of four.

The theme of the COPEDEC II will be “Best Practices in the Coastal Environment”. Topics will include:
- Port, harbour and marina infrastructure engineering, planning and management;
- Coastal stabilisation and waterfront development;
- Coastal sediment and hydrodynamics;
- Coastal zone management and environment;
- Coastal risk management;
- Short sea shipping and coastal navigation.

Papers should focus on practical applications and managerial and environmental aspects of coastal and port engineering in developing industrialised countries, including documented case studies. Prospective authors should submit two-page abstract either as 5 hard copies or 1 digital copy (emailed Word document). These should be forwarded prior to February 15 2007 to the Paper Selection Committee. Papers will be reviewed by the International Paper Committee in April 2007 and authors will be notified by mid-June 2007. Final versions of the selected papers must be submitted by December 2007.

For further information contact:
International Organising Committee,
PIANC-COPEDEC c/o Lanka Hydraulic Institute Ltd.
177, John Rodrigo Mawatha, Katubedda,
Moratuwa, Sri Lanka
Tel: 94 11 265 1306/ 265 0471
Fax: 94 11 265 0470
Email: copedec lhi.lk
www.pianc-aipcn.org

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Dr. Ram Mohan
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www.pianc-aipcn.org
Organised by the Institution of Civil Engineers (ICE) on behalf of the Central Dredging Association (CEDA) and the International Association of Dredging Companies (IADC) with the support of FIDIC, this two-day conference and workshop will be held in London in October 2006. The successful completion of maritime construction projects requires skilled contractors and consultants and clients, bound by a fair contract, who are willing and able to work together to resolve technical and management difficulties as they arise. The conference aims to develop amongst contracting partners a constructive approach to the planning, design and execution of dredging and maritime construction projects. It will highlight the capital-intensive nature of maritime construction in contrast with other civil works which are predominantly labour-intensive.

The target audience comprises consulting engineers, dredging contractors (especially junior project managers), site engineers, assistant engineers, quantity surveyors, legal counsellors, construction lawyers, insurers, project financiers and advisors to decision makers in dredging and maritime construction projects.

The conference will be divided into eight sessions, each comprising keynote lectures presented by invited specialists from all sides of the international industry. These will be followed by workshop sessions dealing with the following key topics:

- Pre-tender information including ground conditions and investigations, site morphology and bathymetry, metoc conditions and physical obstructions.
- Environmental aspects including environmental impact assessment, the specification of environmental constraints and requirements in tender documents, and the development of appropriate and practical monitoring and mitigation programmes.
- The balance between technical and functional requirements, e.g., unrealistic or unspecified environmental requirements, disproportionate technical requirements, the choice of monitoring benchmarks (zero base measurements).
- Identification of appropriate forms of contract (e.g. FIDIC D&R contract, innovative contract forms, D&C, BOT, PPP) and risk allocation in contracts.
- Tender procedures including early involvement of consultants and contractors to gain maximum benefit from their knowledge and experience, achieving a price-quality balance, preparation time, evaluation criteria, transparency and equity within the process and fair competition.
- Project finance phasing e.g., cash flow planning, just-in-time’, and the time and finance assigned to the preparation stage.
- Liability issues such as liquidated damages, consequential damages, gaps between insurance covers, professional indemnity and general liability insurance.
- Dispute resolution including forms of dispute resolution, pragmatic approach to dispute resolution and arbitration and the speed of dispute resolution.

Attendance at the conference will attract Continuing Professional Development points.

For further information contact the IADC Secretariat: info iadc-dredging.com or visit www.iadc-dredging.com or conferences ice.org.uk Online registration is opened at: www.iceconferences.com

This two-day Environmental Seminar is a joint effort of the International Association of Dredging Companies (IADC) and the Central Dredging Association (CEDA). It gives an overview of the environmental aspects of dredging and state-of-the-art dredging techniques.

Dredging is a necessary activity in man’s development. In the right circumstances, it may also be a very useful tool for remedying past environmental interference. However, by its very nature, the act of dredging and relocating dredged material is an environmental impact. It is, therefore, of the utmost importance that we should be able to determine whether any planned dredging will have a positive or negative impact on our environment. Evaluation of environmental impact should examine both the short- and long-term effects, as well as the sustainability of the altered environment. Besides
presentation of the subjects, participants are challenged in case studies to apply the principles discussed in order to get a full understanding of the scope and importance of the environmental aspects of dredging projects, the management of dredged material and the effects of environmental guidelines. The seminar is aimed at consultants in dredging related industries and professionals from different governmental bodies, whether municipalities, district water boards, ports and harbour authorities or central government.

The course fee is € 775. The leaders of the course are Gerard van Raalte, Engineer, Hydronamic and Nick Bray MSc, Dredging Research Ltd. All lecturers are professionals working in the dredging industry or dredging consultancy. Course material includes the 7 part series of guides entitled 'Environmental Aspects of Dredging'. For more information about the guides see the attached IADC publication order form or www.iadc-dredging.com or http://www.dredging.org/content.asp?page 48.

For further information and registration, please contact PAO, Tel: 31 15 278 4619 or by Email: info pao.tudelft.nl

For (future) decision makers and their advisors in governments, port and harbour authorities, offshore companies and other organisations that have to execute dredging projects, the International Association of Dredging Companies (IADC) has organised for more than a decade the International Seminar on Dredging and Reclamation. Since 1993 IADC, often in co-operation with local technical universities, has provided this week-long seminar especially developed for professionals in dredging-related industries. These intensive courses have been successfully presented in Delft, Singapore, Dubai and Buenos Aires. This year's choice of Bahrain as a venue is a logical outgrowth of the extensive maritime infrastructure construction going on in the Middle East region. As is appropriate to a dynamic industry, the seminar programme is continually updated. In addition to basic dredging methods, new equipment and state-of-the-art techniques are explained. The seminars reflect IADC's commitment to education, to encouraging young people to enter the field of dredging, and to improving knowledge about dredging and land reclamation throughout the world.

To optimise the chances of the successful completion of a project, contracting parties should, from the start, fully understand the requirements of a dredging project. This five-day course strives to provide an understanding through 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.

Some of the subjects covered are:
- port development and maintenance;
- project phasing (identification, investigation, feasibility studies, design, construction, and maintenance);
- descriptions of types of dredging equipment and boundary conditions for their use;
- state-of-the-art dredging techniques as well as environmentally sound techniques;
- pre-dredging and soil investigations, designing and estimating from the contractor's view;
- costing of projects and types of contracts such as charter, unit rates, lump sum and risk-sharing agreements.

An important feature of the seminars is a trip on a trailing suction hopper or cutter to visit a dredging project being executed in the given geographical area. Each participant receives a set of comprehensive proceedings with an extensive reference list of relevant literature and, at the end of the week, a Certificate of Achievement.

The cost of the seminar will be € 2450; this fee includes all tuition, seminar proceedings and workshops and a special participants dinner, but is exclusive of travel costs and hotel. A group accommodation agreement has been made with the seminar hotel. Representatives of port authorities, companies, and individuals, with an education level equivalent to at least a BSc or comparable work experience, interested in attending are requested to contact the IADC Secretariat, Mr. Frans-Herman Cammel (cammel iadc-dredging.com) as soon as possible but prior to October 1st 2006, as the number of participants is limited to 25.
The European Dredging Association has recently prepared a review of European environmental rules, how they interact with international regulations and the impact of both on dredging and dredged material disposal (see page 3).