John Riddell

Dredging: Opportunities and Challenges for 2000 and Beyond

Abstract

Dredging today is a service industry, yet it has often been underestimated or misunderstood. The main concerns have been environmental issues such as the disturbance of contaminated sediments, turbidity while dredging, and disposal of dredged materials. Today's dredging industry has met the challenge and has carefully addressed these issues with large investments in technology and equipment. Consequently, at the start of the new millennium, the opportunities for environmentally sound dredging are increasing steadily. This article is adapted from the Keynote Address presented by the author at the Coasts & Ports '99 Conference, held in Perth, Western Australia, in April 1999. The Conference was organised by the Institution of Engineers Australia and was followed by a dredging short course which attracted many participants from throughout Australia and New Zealand.

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Introduction

There are many aspects to both coastal and port and harbour engineering. All are important. It has to be recognised, however, that few of today's ports would have been developed, or indeed would continue to exist, without the activity of the dredger. Whether it be involved in creating a new harbour, maintaining a channel or creating new land for port development, the dredger plays a vital role (Figure 1). Yet the modern dredger and the dredging industry of which it is the most visible part is relatively rarely regarded as favourably as might be expected from the benefits it brings. The public perception of dredging is low and when dredging does attract media attention it may well be in an adverse light. Even among port professionals – including civil engineers – dredgers are little understood, their capabilities not fully recognised and their potential not always appreciated.

Yet the dredging industry of today is one of the most dynamic and innovative areas of the modern construction industry. Over the last two to three decades the industry has faced huge challenges – challenges both to provide increased benefits and services to its customers and challenges to its perceived impact on an increasingly fragile and sustainable-vulnerable environment. The industry has risen to these challenges. By very substantial investment in plant and equipment, by the development of new methods and techniques, by research and training, and through a growing realisation of the importance of communication, the world's dredging industry is well placed to enter the new millennium.

Like ports, dredging is a service industry. Its developments and innovations are thus largely responses to the needs of its customers and in turn the pressures put on these customers by other external influences. The dredging industry of today is truly international. Its customers and their needs are constantly changing. The type, scale, location and purpose of dredging projects are far from uniform, and may not even be predictable more than a few years ahead. What then are the opportunities and challenges for the dredging industry beyond 2000?

Figure 1. The premier project of the last decade of the last century was most likely the massive development of the container terminal and airport platform of Hong Kong.

The Environment

It is difficult in any discussion of dredging today not to start with the challenges presented by a world with an increasing awareness of and concern about the environment. Our seas and waterways constitute a very large part of that environment. The potential of the oceans for all forms of future advances – medicine, food, minerals – is far from understood, while recreational use of the sea continues to grow. Dredging by definition takes place in that water. Thus the opportunities for dredging to disturb, interrupt and even destroy the water environment are high.

Figure 2. Close up of a specially developed environmental sweephead.

Concern about the environmental impact of dredging can be divided into three main areas. The first is the disturbance of contaminated material, the second turbidity and the third is material disposal.

Contaminated sediment

Contamination of the sediments lying on the bottom of a harbour or channel is not caused by the dredging industry, or even in most cases by the ports. It is caused by industry, by agriculture and by human beings. It is the result mainly of historic ignorance and sometimes of greed and negligence.Yet these contaminated sediments often require to be dredged. The resulting disturbance may then produce the potential for the pollutants to re-enter the water column or otherwise spread.

The recognition of contaminated sediment and its problems is relatively recent. Whether it be tin from antifouling paints in a marina or chromium from some long-abandoned tannery, the impact of disturbance can damage both the marine environment and human health.

The dredging industry has responded most effectively

to the challenge of removing and disposing of contaminated sediments. It has funded research and developed new techniques and equipment (Figure 2). It can now clear, relocate and, if required, treat most forms of contaminated sediment. It has developed expertise of a high professional standard. In the process it has also created a new and valuable business opportunities.

Turbidity

Although most concern still relates to the quality of dredged material, there is growing awareness of the possible physical impacts of the dredging and disposal operations. The sediment dredged may be quite pristine in terms of quality, but its loosening, lifting and transporting can result in significant amounts of material entering the water column. Both through light reduction and subsequent settling, this can have an adverse impact on marine life – and on public perceptions. The smothering effect of fine sediment on coral is perhaps the most obvious example, but there are many short-, medium- and long-term changes – some possibly beneficial but all changes – which may follow the disturbance caused by dredging activity.

The challenge of minimising the production of suspended solids has been accepted by the dredging industry. There are now numerous examples of projects where sensible and informed discussion between those with environmental concern and responsibility, those wishing to dredge, and the dredging industry has resulted in spillage being controlled to agreed parameters. Spill management and monitoring formed a significant part of recent major dredging projects in Hong Kong, in Victoria, Australia, and on the new Øresund crossing between Denmark and Sweden (Figure 3).

Again, meeting the challenge has resulted in new knowledge, new techniques and new equipment. Enclosed, "no spillage" grabs are now commonplace while sophisticated turbidity measurement and monitoring equipment able to give real time data to the dredger is in regular use. As with contamination, the dredging industry is not always unhappy with tight environmental controls. So long as the rules of the game are clearly established in the contract, the additional costs of control and monitoring can offer enhanced business opportunities.

Such is the investment in environmental technology by the dredging industry that some may say that the industry now has a considerable interest in maintaining environmental awareness. This is coupled with an increasing projection of a "green image" by many of the companies and organisations involved in dredging, as evidenced by their advertisements and other promotional material.

Environmental concern in relation to dredging, like most environmental concerns, is a luxury which the developed world can now afford. The care and concern of the dredging industry when operating in that world may be something of which all involved can be proud. But is it too much of a challenge for the industry to apply the same standards of care in those many countries where the environment is still far down the list of basic concerns? If turbidity is controlled in Rotterdam, New York and Sydney, should it not also be controlled in all locations where the dredging industry now finds its work?

Material disposal

The disposal of dredged material has traditionally been achieved by dumping in the sea. But the environmental acceptability of ocean disposal of even clean sediment is being increasingly questioned and opposed. There is also a growing awareness that dredged material can be regarded as a resource rather than a waste, with possible beneficial uses. With maintenance dredging, the removal from the estuarine or coastal circulation zone of large volumes of natural sediment inflow is also now regarded as unsustainable.

Figure 3. Research vessel Maritina monitored the effect of dredging on the ecological conditions in the Øresund.

Figure 4. The cutter suction dredger Castor, at work in the Øresund, is equipped with innovative anchoring systems and precision excavation control.

Figure 5. Cutting through hard rock demands specially developed cutter heads that can withstand incredible wear and tear.

For all the foregoing reasons increasing attention is being given to the acceptable disposal or relocation of dredged material. With granular material there are many satisfactory alternatives to sea disposal. Beneficial uses include the obvious reclamation and beach nourishment. Less clear is what can be achieved with the finer cohesive sediments which form a large proportion of many maintenance dredging projects. Where rapid drying can be achieved the possibility of use for reclamation may exist, but otherwise the options to date have generally been limited to some form of environmental enhancement. The creation or recharging of mangrove areas and saltmarshes using dredged muds is now well established, but there are obvious limits to how much dredged material can be used in such ways.

Opportunities

The dredging industry is primarily reactive. The development of specialist equipment and techniques for tackling contaminated sediments was a response to the recognition of contamination in material which needed to be dredged. The construction of heavy-duty rock cutter dredgers for port projects in the Middle East and Australia was a reaction to the physical and financial characteristics of these locations. The development of highly efficient maintenance dredgers was a response to the need to contain port operating costs.

World trade continues to develop. No viable alternative to the sea transport of thousands of containers and tens of thousands of tonnes of bulk cargoes are yet in prospect. Ships may for the present have stopped expanding in terms of draft, but the need for new harbours and the expansion and maintenance of existing ones does and will continue. Such development is totally dependent upon dredging. Thus what might be termed conventional harbour dredging – whether of a marina, ferry terminal, fishing harbour or container port – is likely to continue steadily if not dramatically.

Construction activities

Where the greatest opportunities now exist in dredging is work to support construction activity. There are numerous examples of such activity and each has presented new challenges for the dredgers involved. Below-water tunnel construction, for example, is now predominately achieved by immersed tube techniques. These involve the accurate excavation of the containing trench, often in hard material. The Øresund Tunnel trench required the use of a large cutter suction dredger with innovative anchoring systems and precision excavation control (Figures 4 and 5).
The lessons learned in such projects will be applied by both designers and contractors to future immersed tube tunnels.

Pipelines and cables

The increasing number of pipelines and cables laid on the sea bed also provides new dredging opportunities. These lines have to be placed in a trench, backfilled and protected. Water depths are frequently far in excess of any required for safe navigation. Routes are often in the most exposed and hostile seas. How do you dig a

trench for a 1 m pipe in 80 m of water, bury the pipe and then cap the trench with stone? The dredging industry has provided the solution by the development of very deep dredging hopper dredgers and stone placement vessels.

Land reclamation

The greatest opportunities for the international dredging industry are in land reclamation. The creation of new land for industry, transport, housing and recreation are now priorities for many countries. Singapore, for example, can only expand if its land area expands; the only possibility is to create new land from the sea. The reclamation projects currently under discussion around the world are staggering in their magnitude. They include a new airport for Holland in the North Sea and major industrial sites off the coasts of most Far Eastern countries.

Reclamation is fine so long as a sufficient volume of suitable material can be found to create the platform. It is here that the problems start. Sand deposits conveniently located to the reclamation areas are being dredged out. Thus the need to go further afield, to go to deeper water, or to reach for sand lying below mud or clay. These problems are tackled by new equipment. Deep suction dredgers able to recover sand from 100 m water depths or from below overlying cohesive layers are one solution. Where the material lies at some distance from the fill area the design criteria not only look at the recovery but also the transport and placement.

Dredgers

At the start of the twentieth century the bucket ladder dredger still ruled supreme. It could be found in virtually every harbour in the world engaged in both capital and maintenance dredging. Today the bucket ladder dredger is a quite rare machine. It has been replaced by cutter suction and trailer suction hopper dredgers able to dredge greater volumes of material in shorter times and at lower costs. In the development of the dredger these twin goals of increased production and reduced unit costs have resulted in major changes in both the predominant types of dredger and within the types themselves.

Trailing suction hoppers

The most obvious change has been in the development of the trailer or hopper dredger. This type of dredger is now used for all forms of capital and maintenance dredging, and particularly for land reclamation. The requirements of the latter for vast volumes of sand, often mined from deep water far away from the fill site, have resulted in the rapid expansion in size of the hopper dredger. This growth has been most spectacular in recent years with the advent of a number of so - called "jumbo" trailers with hopper capacities in excess of 20,000 cubic metres. Developed to recover material, haul it long distances and place it ashore at the lowest possible cost, these large and sophisticated vessels now dominate the international dredging scene. In just over a decade their maximum capacity has more than doubled, and is set to treble in 2000 with the introduction of a 33,000 cubic metre "mega" trailer (Figure 6).

The development of the large hopper dredger was a response to the increasing scarcity of easily-won fill material. In meeting that challenge, however, the vessels have also presented opportunities. The dredging industry is now able to undertake reclamation projects requiring hundreds of millions of cubic metres of material, and to undertake such projects in realistic time scales and at affordable prices. This was simply not possible twenty years ago. Thus developers, from national governments to financial institutions, can now conceive of and realise reclamation projects which in the past would have occupied every dredger in the world for many years. In the large trailer hopper dredger the dredging industry has provided a powerful new construction tool for the world's civil engineers to use.

Specialised equipment

Other developments in dredging equipment have been at the opposite end of the scale. Here the need has

Name of Dredger	Company	Year Built	Hopper capacity (m^3)
Lelystad	Ballast Nedam	1988	10,000
JFJ De Nul	Jan De Nul	1992	12,000
Pearl River	Dredging International	1994	17,000
Gerardus Mercator	Jan De Nul	1997	18,000
Amsterdam	Ballast Nedam	1997	17,000
WD Fairway	Boskalis Westminster	1997	23,000
Volvox Terranova	Van Oord ACZ	1998	20,000
Queen of the Netherlands	Boskalis Westminster	1998	23,000
Queen of Penta-Ocean	Penta-Ocean Construction	1999	20,000
Vasco Da Gama	Jan De Nul	2000	33,000

Figure 6. Trailing suction hopper dredgers have doubled — and will soon treble — in capacity from those of some 10,000 cubic metres capacity built only a decade ago, such as the Lelystad (left under), to the jumbos of today (clockwise): Gerardus Mercator, Pearl River, Amsterdam, (opposite page) Queen of the Netherlands and WD Fairway. Right under, the Vasco da Gama (33,000 cubic metres capacity) is scheduled to be delivered this year.

been for specialist dredgers to handle relatively small quantities of material. This may be contaminated sediment from a canal or former dock which needs to be removed without releasing sediment to the water column. Thus the development of such machines as auger and scroll dredgers which can feed in-situ material into a suction mouth at high concentrations and with minimum solids resuspension (Figure 7).

Advances in instrumentation

For any dredging to be efficient it is imperative that the dredger removes only that material which needs to be removed, or which the contractor is being paid to remove. This has resulted in very great advances in surveying and positioning techniques.

Differential global positioning systems using satellites and shore stations are now standard in dredging and surveying for horizontal control, and increasingly for vertical control. Positional accuracies of better than 0.5 m for not only the dredger but more importantly the dredging equipment – grab, cutter head or draghead – ensure that unwanted and unpaid dredging is reduced to a minimum.

Advances in underwater surveying have also been dramatic. The conventional echosounder with its single trace of at times smudgy black lines has given way to multi-beam, movable beam sonars with full colour displays. These provide three-dimensional views of the sea bed and can guide the dredger in real time through the work area.

Further advances in instrumentation mean that every aspect of a dredger's performance can be monitored. This allows production to be maximised, minimises the causes of disputes and enables researchers and designers to optimise loosening, lifting and transporting techniques. Today the performance of a dredger can even be monitored in real time from within the dredging office on shore.

Players and Privatisation

The very large capital investment required to construct and operate modern dredging equipment has resulted in a steady consolidation of the companies and organisations able to play the game. This has happened on three levels, albeit for the same reasons.

The most obvious contraction has been in the direct labour dredging organisations. Fifty years ago it was common for most ports to own and operate their own dredger or dredgers. The numbers doing so in 1999 have fallen substantially as the investment required for new plant has been diverted to more revenue earning developments such as quays, container cranes and bulk terminals. Thus contract dredging has become the norm with the dredger only being hired in when deepening or maintenance is required.

A second level of consolidation has been in the national fleets. This is most noticeable in the United States where much of the dredging formerly undertaken by dredgers owned by the US Army Corps of Engineers is now carried out by private (but US only!) contractors. Other countries, most notably India and China, still retain large national dredging fleets, but it would not be unreasonable to predict that beyond 2000 will see the privatisation of even these extensive state organisations.

Figure 7. Specialist dredgers such as this auger dredger at work in the harbour of Delfzijl, The Netherlands handle smaller quantities of sediment but are equally important.

The third level of consolidation is within the large international contractors. These companies are the true professionals of dredging. They operate throughout the world and will tackle all kinds of dredging projects. To do so they must invest in new dredgers and new technology. The vast cost of such investment has meant that only the strongest, or those considered to be the strongest, have survived. There has thus been a series of amalgamations, takeovers and both agreed and forced mergers so that today only a few large companies dominate the international dredging market. How long these will continue to remain independent will be interesting; already most have to go into joint venture to resource and fund the mega reclamation projects on offer today.

Learning

For many years dredging was a somewhat secretive industry. The private sector contractors saw little to gain by informing others of their projects, problems or new techniques. The industry was also insular and inward looking. Those involved tended to stay within their companies and there was little interchange between contractors, clients and consultants.

Much of this has now changed. Contractors now appreciate that an unprepared client is not a blessing, but a source of endless conflict. There is still commercial confidentiality, especially about production methods and rates, but the availability of knowledge now extends rapidly. The Western, Central and Eastern Dredging Associations, for example, have done much to encourage conferences, workshops, publications and courses. The International Association of Dredging Companies, while clearly promoting the interests of its contractor members, supports educational and training courses and funds a quarterly publication as well as books and pamphlets on dredging.

Conclusions: 2000 and Beyond . . .

The dredging industry at the start of the twenty first century can be considered to be in excellent shape and in good heart. The recent investment in new equipment and technology has meant that dredging costs, adjusted for inflation, have held steady, bringing great benefits to world trade. The industry now has the capability to undertake the full range of work which may be required in coastal engineering construction, in harbours and in inland waterways. These developments have opened up new opportunities and enabled projects to be tackled which a few decades ago were just dreams.

The environment will continue to present challenges and opportunities for the dredging industry. Dredgers do not make harbour muds contaminated, nor does the demand for efficient and competitive international trade come from the dredging industry. If sediments from underwater have to be removed and relocated, a balance has to be struck between the potential benefit and the potential adverse impact. The dredging industry is happy to participate in that debate and continues to develop its experience, knowledge and technology to provide acceptable solutions.