R. Nick Bray

A Review of the Past and a Look to the Future

Abstract

The paper reviews the changes that have taken place in dredgers, dredging fleets and dredging technology over the past two decades in the light of the changing market for dredging works.The influence of global development in trade and constraints imposed by environmental legislation are also considered.
An attempt is made to determine whether the market leads development or whether development leads the market.
The potential future market for dredging work is also reviewed and the possible developments which might be seen in technology. It is concluded that dredger evolution is generally Darwinian, but that some innovative technological advances may create new markets.The way forward is for the major players to take the environmental aspects of development proactively and integrateengineering and environmental solutions.

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He was the keynote speaker at the CEDA Dredging Days, November 1997.

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Introduction

The international dredging industry operates in a continually evolving global market-place. This is a market where the stalls change in size and type from year to year, and from decade to decade, where at one moment you may find a flurry of activity in one corner and a short time later the activity has shifted somewhere else. Meanwhile, the day-to-day trading steadily continues.

For a dredging company to be successful, it must keep a keen eye on the market-place. It must adapt its dredging fleet and technology to keep pace with the trends in the market, or even to precede them, and it must avoid the pitfalls of fleet over-capacity, over-specialisation and over-generalisation. To achieve this fine balancing act is no easy task when you are dealing with such a large and diverse market. It takes good management and a fair degree of luck. Detecting trends and reacting to them is somewhat akin to designing for the effects of global warming. All things are predictable in a deterministic way if we understand the rules that govern the changes. Unfortunately, there are usually too many rules and we only understand a few of them!

However, it may be possible to gain some insight into the future by reviewing the past; perhaps to discover some pointers to the art of survival; a few broad principles which could be used in decision-making. Maybe to answer some basic questions, such as “Does the market lead the technology or does technology lead the market?”, and “Can Darwinian theory be used in the study of dredger development?”

In this paper, the changes which have occurred in dredging technology over the last 20 years or so are reviewed. The background against which these changes have occurred is investigated and some thoughts about the future are postulated.

One area which has not been covered is the North American market. Here, owing to certain legislative measures and a monopolistic regime, for much of the period under study, competition and development were stifled. However, in an effort to break free from the environmental stranglehold, the US dredging industry has shown some signs of freeing itself up for development.

General Changes Over the Past 20 Years

That fundamental changes have taken place in dredger size and type over the last two decades there is little doubt. For example, Figure 1 shows the size distribution of trailing suction hopper dredgers in 1977 compared to that in 1997. Although the sources from which the numbers in this figure are derived are generally inaccurate and incomplete, it is clear that there has been a massive increase in hopper capacity of individual vessels. However, the true effect of this on the marketplace is not easy to see until one examines the fleet capacity. Incidentally, the number of smaller trailers has probably not fallen. The 1977 figures contain some dredgers which worked exclusively in one port and have not been included in the 1997 figures.

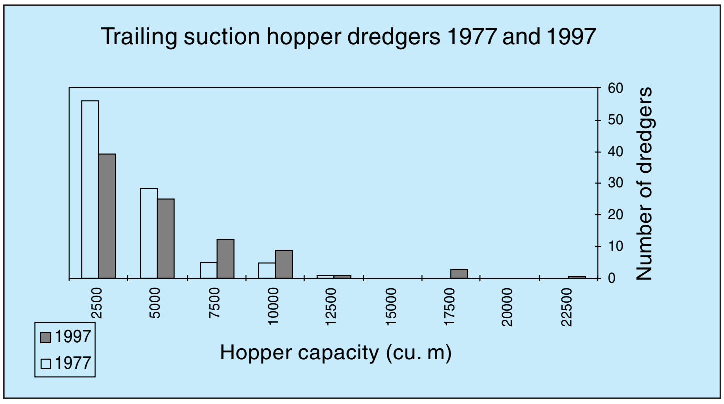
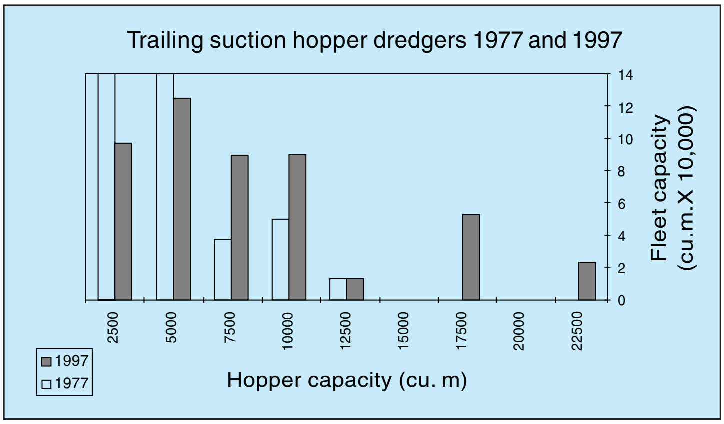


Figure 1. Numbers of trailing suction hopper dredgers in 1977 and 1997.

Figure 2. Capacity of the trailing suction hopper dredger fleet in 1977 and 1997.



Fleet capacity is defined here as "number of dredgers x hopper capacity" for any particular size category of dredger. The results of this are shown in Figure 2.
As can be seen from this figure, the two largest categories (around 17,500 m^3 and 22,500 m^3) represent nearly 20% of the total available fleet capacity.
The large vessels under construction and still to be launched will increase this percentage even further (Figures 3, 4, 5, 6).

It can also be seen from Figure 2 that the total fleet capacity has increased overall since 1977. This increase is not quite as large as appears from the graph, because in 1977 most hoppers were designed for a load density of around 1.8 Mg/m^3, whereas now many of the hoppers are designed on a load density of 1.4 to 1.6 Mg/m^3. For any additional capacity to be usefully employed, either the total amount of work has to increase or the trailers have to obtain a larger share of the market at the expense of other types of dredger.

One way in which the trailers can increase the total amount of work is for them to be capable of carrying out dredging in conditions hitherto not possible for this type of vessel. This aspect is examined later.

Other dredger types also exhibit a marked change in their distributions over the same period. Figure 7 shows the comparison of the numbers of backhoe dredgers available in 1977 and 1997. Here, there has been a marked increase in numbers overall, particularly in the smaller sizes. In terms of the total fleet, the backhoe dredger has probably trebled its capacity.

The bucket chain dredger numbers are shown in Figure 8. The smaller sizes of dredger have fallen in numbers to about a third of their original fleet. However, as the dredgers become larger so the numbers have been maintained, until one reaches the 800 to 900 litre bucket size where the capacity has changed little over the intervening years. This is probably owing to the fact that the larger bucket dredgers are used for dredging appreciable volumes of strong soils, which they are capable of doing at economic rates compared with backhoes.

Grab or clamshell dredgers have suffered the same fate as the bucket dredger (see Figure 9). Here the numbers of the smaller sizes have reduced considerably, whilst the larger grabs have increased in numbers. There is even a 200 m^3 capacity grab dredger in Japan, which has not been shown. Clearly, use has been found for the larger sizes of grabs whilst the smaller

Figure 3. The Pearl River (17,000 m3), built in 1994, is one of the largest TSHDs in the world.

grabs have been largely superseded by another type of dredging method.

It is difficult to draw firm conclusions from the numbers shown above, because of the numerous factors involved and the unreliability of the reporting of numbers. However, it is probable that, in some respects, they may be explained by the following:

a) Dredging of weak soils
   The trailer dredger has become much more efficient at dredging weak soils and has extended its capability into soils of greater strength. When working in harbours in a maintenance capacity, and particularly when used in conjunction with a bed leveller, it has replaced the grab dredger and the bucket dredger.
b) Dredging of strong soils
   The bucket dredger still dredges strong soils, when volumes are large. When volumes are small the backhoe is more likely to be economic. Very large grabs may also be used for firm soils, particularly when sea conditions prevent bucket dredgers and backhoes from working.

It will be noticed that cutter suction dredgers have not been mentioned in the above analysis. This is because the number of cutter suction dredgers has not changed significantly over the last 20 years. However, their characteristics have changed and are described below.

Trailing Suction Hopper Dredgers

The main changes in trailer dredgers over the last two decades, apart from the considerable increase in hopper capacity, are as follows:

a) On the suction side, degassing systems have become more reliable and have enabled higher density mixtures to be dredged during maintenance dredging. Pumps in the dragarm have also contribu-

Figure 4. The 18,000 m3 TSHD Amsterdam, launched in May 1996, is shown here at work in Hamburg Harbour, Germany.

Figure 5. The jumbo trailer Gerardus Meractor (also 18,000 m3) was launched in September 1996.

Figure 6. In June 1997 the WD Fairway became the world's largest trailer with a hopper capacity of 23,425 m3.

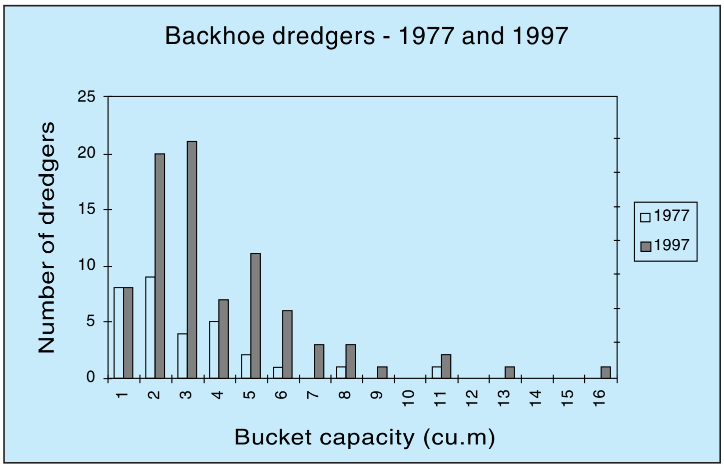
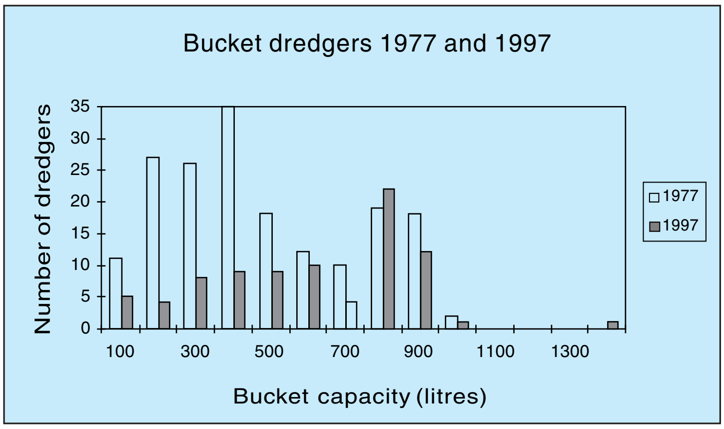


Figure 7. Numbers of backhoe dredgers in 1977 and 1997.

Figure 8. Numbers of bucket dredgers in 1977 and 1997.



ted to higher density mixtures and dredging at much greater depth.

b) In the hopper, overflow weirs have become adjustable, allowing vessels to change their characteristics to suit either sand or silt/mud dredging, and to adopt more sophisticated loading techniques. There has been a marked decrease in the ratio of hopper carrying capacity to hopper volume.
c) Discharge systems have become more adaptable. Many trailers now have a pump ashore or rainbowing capability as well as the conventional bottom discharge. Some are able to discharge through the suction pipe for such operations as covering pipelines. More environmentally acceptable methods of overflowing have been developed.
d) On the bridge, considerable improvements in monitoring and control have been introduced. Positioning, tracking and draghead control are now sophisticated operations. Dynamic positioning systems have improved efficiency in temporary positioning situations.
e) Overall, costs have been reduced by reducing manning levels and making machinery more efficient.

Figure 10 shows the current normal characteristics of trailer dredgers. It is interesting to note that, in spite of the large increases in hopper capacity, the laden draughts of the larger vessels are not appreciably greater than the smaller trailers. This is partly explained by the lower load carrying capacity of the hopper.

Cutter Suction Dredgers

Cutter suction dredgers went through some evolutionary changes in the later 1970's and early 1980's, mainly as a result of the boom in the Middle East, where many projects involved the dredging of sands, silts and rocks, to be used in reclamation. The effect of this market is illustrated in Figure 11. In this graph, the massive increase which occurred in cutterhead drive and pump power may be seen. These powers are necessary for the dredging and pumping of rock.
Also noticeable in the graph is the increase in dredging depth achieved by the use of ladder pumps in the larger dredgers. Unfortunately, as the Middle East activities slowed down, very little cutter suction work emerged elsewhere. This resulted in an overcapacity of the heavy duty rock cutters.

The main changes in cutter suction dredgers over the last 20 years may be summarised as follows:
a) the introduction of self-propelled cutter suction dredgers for the larger sizes, which considerably reduced mobilisation costs;
b) the introduction of ladder pumps to improve concentration in the deeper dredging depths;
c) the introduction of anti-abrasion materials in pump and pipeline systems to reduce wear and tear;
d) the development of faster cutter tooth changing, cutterhead changing and spud movement owing to improved systems;
e) automation of the dredging controls to improve accuracy and productivity (some dredging systems can now anticipate the soil conditions by remembering the conditions on the previous cutting swing); and
f) reducing costs by reducing crew numbers and making the mechanical and electrical systems both fuel- and maintenance-efficient.

Backhoe Dredgers

Twenty years ago the custom-built backhoe was relatively rare. It is now treated as one of the main classes of dredger and has emerged as a suitable workhorse for strong soils, such as glacial tills, and for dredging fragmented or friable rocks.
There has not been much development in the basic excavator and its support platform. Power has increased and controls have become centralised. Positioning and control of the bucket have improved

because of electronic positioning and bucket location systems. Land-based backhoes, used for dredging inland waterways, have been developed to improve reach and a number of low-ground pressure and amphibious versions are now available.

Other Developments

The above sections have described the changes which have taken place in the numbers and designs of the traditional items of dredging equipment. However, as one would expect in an innovative and competitive industry, there have been a number of new developments and designs which have been introduced in the last two decades. It would be impossible to describe all of these. A few of particular note are illustrated here.

Water injection dredging

The water injection dredger, a proprietary design, is fundamentally different from other items of dredging plant. This dredger, illustrated in Figure 12, fluidises material on the sea or river bed, thereby encouraging the material to form low level density currents which move into deeper water. The system has found many applications and is one of the few really novel designs to have proved of wide practical use for the dredging of "clean" materials.

There may well be environmental problems to be overcome in the use of the water injection system for the maintenance dredging of large volumes of material. However, it is possible that its low cost may encourage the development of more frequent and environmentally

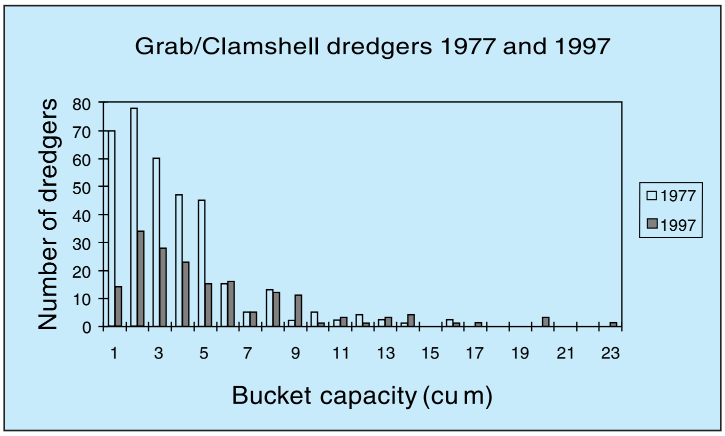


Figure 9. Numbers of grab/clamshell dredgers in 1977 and 1997.

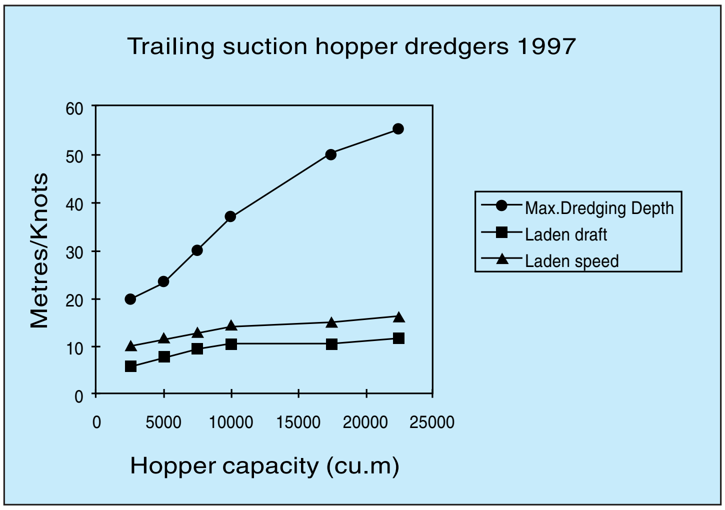


Figure 10. Characteristics of trailing suction hopper dredgers in 1997.

Figure 11. Characteristics of cutter suction dredgers in 1977 and 1985.

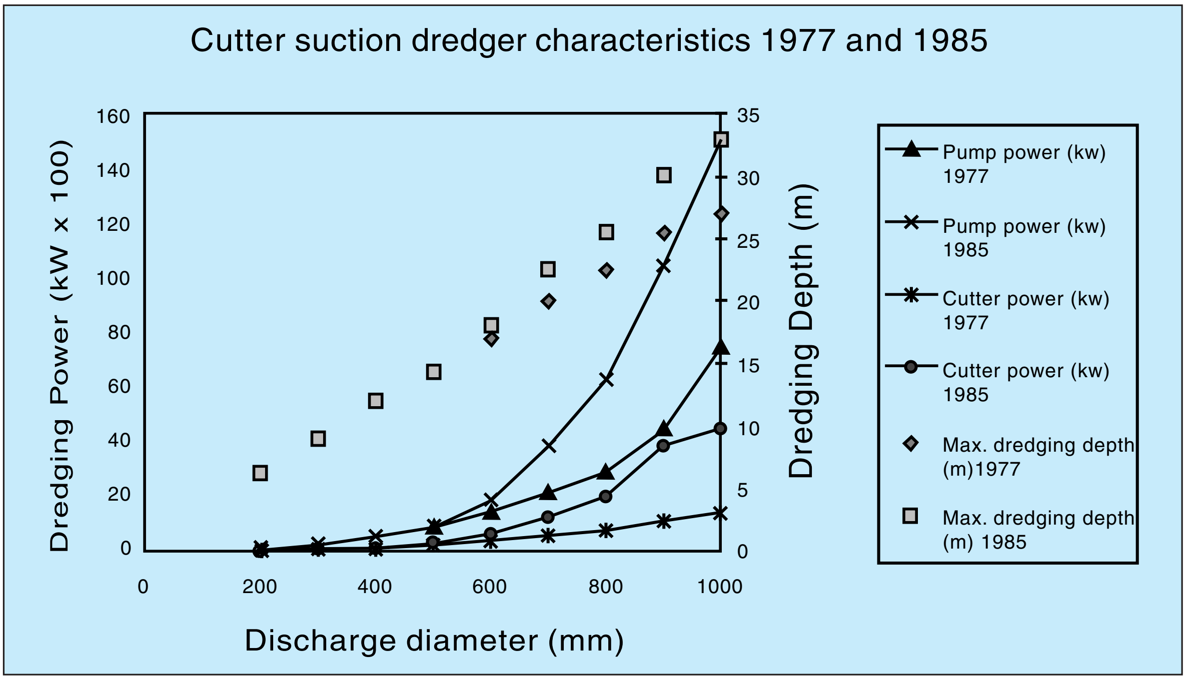


Figure 12. Through this artist's rendering underwater, the unique design of the water injection dredger Jetsed can be seen.

friendly maintenance dredging campaigns which involve the fluidisation of small and more acceptable volumes of sediment for dispersal into the local environment.

Much of the success of this system will depend on the ability of engineers to establish the baseline environmental characteristics of their dredging sites in a comprehensive manner and to predict and monitor the effects of the water injection works.

Environmental/restoration dredgers

The other area which has seen a proliferation of innovative ideas, driven by necessity, is in the field of environmental/restoration (or remedial) dredging. In this field it was soon recognised that benefits accrued to the company which could produce a dredger that was accurate (thereby reducing overdredging) and minimised the suspension of bed materials. A great variety of developments has emerged, many as attachments to standard items of plant. A number of these are mentioned below:

a) Backhoe dredgers: Closed buckets such as the Visor Grab, which closes the bucket, thereby preventing loss and compression of the material. Also the screening bucket which coarse screens the dredged material as it empties.
b) Grab dredgers: The Cable-Arm closure clamshell bucket, which minimises overdredging and prevents overflowing of the bucket.
c) Bucket chain dredgers: Sound-proofing, enclosing the ladder, valved buckets to prevent air escaping at bed level, bucket cleaning.
d) Suction dredgers: Environment-friendly cutterheads, the Matchbox suction head, the Scoop- and Sweepheads (Figures 13 and 14), the disc cutterhead (Figure 15), the closed auger (Figure 16), all designed to minimise turbidity generation.
e) Positive displacement pumps: All designed to pump dredged material at its in situ density, thereby reducing volumes for transport and disposal.
f) Trailing suction hopper dredgers: The re-circulation of overflow water by feeding to jets at the draghead, thereby reducing the quantity of overflow being discharged to the site. This is a proprietary system developed by Royal BosKalis Westminster.

The Dredging Market

The world dredging market is huge and diverse and it is not possible to analyse it in detail in a paper such as this. However, a few broad points can be made.

Over the last five years the dredging market has been

Figure 13. The scoophead reduces turbidity during dredging.

Figure 14. The cutter dredger Vlaanderen XV has been rebuilt with a sweephead, an environmentally friendly dredging system.

dominated by activities in South East Asia, particularly in Hong Kong, where reclamation works associated with the Port and Airport Development Strategy and Metroplan have involved the movement of around one billion cubic metres of dredged material. Developments such as these show no sign of tailing off in Hong Kong or in the region as a whole. Already, there are plans for further massive land reclamation works in Singapore, Malaysia and Taiwan, with one such project requiring around 200 million m^3 of fill. With figures like this in mind it is not difficult to see why dredging contractors are confidently building large trailers.

To demonstrate the reason for this confidence, it is merely necessary to examine the costs of dredging sand, transporting to a site and dumping. Figure 17 shows the results obtained for a mythical project for various sizes of trailer. It also shows the costs associated with dredging by stationary dredger and transporting by barges. There are two key points shown by this figure; the larger trailers are cheaper than barge transport and the larger trailers are making the supply of sand cheaper in absolute terms. Hence, to compete with conventional equipment (dustpan/grabs and barges) it is essential to have trailers of over 14,000 m^3 capacity.

It is also possible that the reduction in absolute sandfill cost will increase the market volume, as the marine dredged sand becomes more acceptable than that from an equivalent land-based source. The graph in Figure 17 might be very different under different circumstances, where for instance total sand volume, water depths, environmental constraints and other factors varied, but it serves to illustrate the points.

In the Middle East, where activity has been relatively steady over recent years, there still seems to be a modest base load of dredging and reclamation works, generally associated with industrial ports and waterside leisure developments. This work has traditionally been executed by heavy-duty cutter suction dredgers and there is no reason to doubt that these machines will continue to carry out the bulk of the future work of this type.

In western Europe the market is likely to be dominated by coastal engineering works and port developments. So-called "soft engineering" solutions to coastal problems, involving the re-charge of beaches with sand or

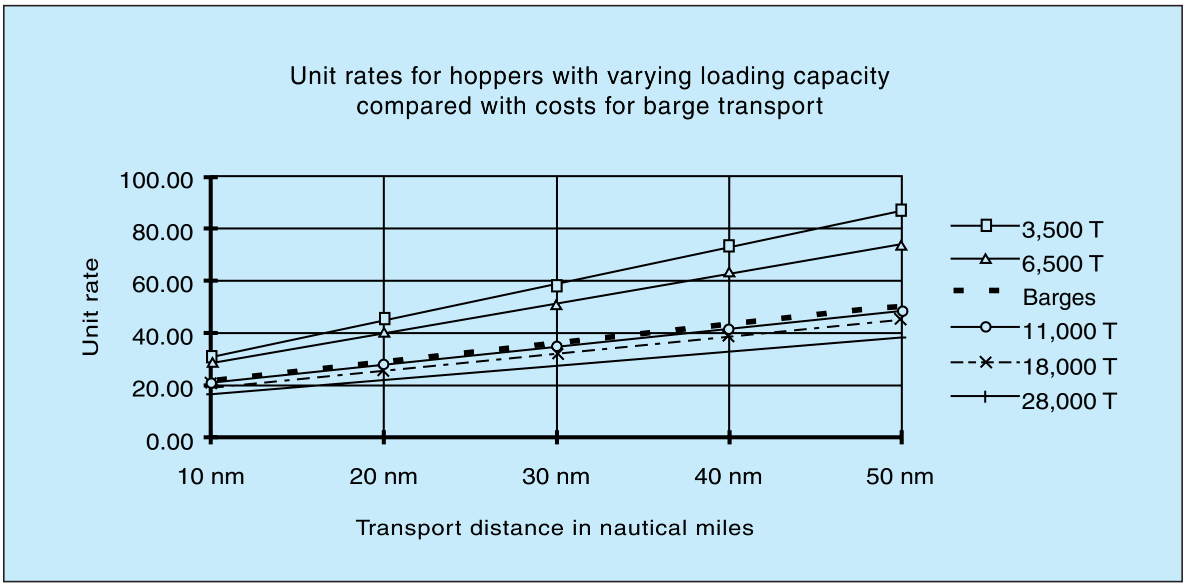
Figure 15. Close up of the environmental disc cutter installed on the Vecht.

Figure 16. The closed auger, Willem Bever, has been used to dredge in highly contaminated waters.

gravels, have been the fashion for a few years now and are likely to continue for the foreseeable future. Although not massive, the volumes of dredging involved add an appreciable workload for trailer dredgers. European ports are beginning to deepen their access channels and berths again to maintain competitiveness, particularly in the container trade. Adding another 2 metres to an existing navigable depth frequently represents a sizeable dredging project; work which may be carried out by trailer, backhoe and bucket dredger. The deepened ports may also require additional maintenance. More work for trailers! If European container terminals are getting deeper, it is probable that container ports in the rest of the world will be developing in a similar fashion and that more capital dredging will occur.

Some of the South American economies have seen formidable growth rates in the past five years. Although the west coast of South America is not likely to generate massive dredging works, there being few substantial rivers on that side of the continent and deep water relatively close inshore, the situation on the east coast is very different. Large rivers and estuaries exist and a

Figure 17. Cost of dredging, transporting and dumping : trailer dredgers 1997



considerable amount of trade depends on river transport, estuarine ports and dredged channels. It is likely that trailer dredgers could be gainfully employed in these areas for some time to come.

In summary, therefore, it would appear that, in the short to medium term there is sufficient work for trailing suction hopper dredgers and backhoe dredgers. Cutter suction dredgers will not be in huge demand, but a base load of work will probably continue. Innovative dredgers for special projects and remedial dredging will continue to be in demand.

Future Trends

The evidence from the above discussion of dredger types and changes over a 20 year period is that, in general, dredger development has followed the market. The one development which might be seen to have not been market-led is the introduction of water injection dredging. This dredger may, to some extent, be making its own market.

The dredging market itself is affected by two major, but often opposed, factors; trade and the environment. Almost all dredging projects relate to one or both of these factors. Trade encourages people to move goods around the world and leads to the need for new ports, deeper ports, industrial ports, infrastructure, new land and leisure facilities. Environmental legislation affects the way projects are carried out. It controls use and disposal of dredged material. It affects the methods of dredging. It affects the way engineering is carried out and this, in turn, may determine whether dredging is required or not, and how it may be executed.

For example, the whole question of development in estuaries. How is it best to modify an estuary?
By dredging large volumes over short time periods and taking the dredged material to sea, or dredging small volumes over very long periods and trickle feeding the material back into the estuary?
In coastal engineering, should we build "hard" or "soft" defences? Should we build ports out to sea or dredge basins inland?

If we want to predict the future volume of dredging we need to look at world trade. If we want to predict the form of dredging projects, we need to look at trends in the way that the engineering world is adapting to the requirements set by our environmental legislators. These will give us pointers towards the types of dredgers we need in the future.

Historically, there have always been two main driving forces behind innovation in dredging; reducing dredged volume and reducing unit costs. These two forces remain. Speculating about what might happen to dredgers in the next few years might lead to the following suggestions:

For trailers:
- the development of on-board mixture handling processes designed to increase the density of the dredged material in the hopper
- the introduction of more devices to reduce overflow plumes
- greater control over draghead position.

For cutter suction:
- systems for reducing the amount of low density water passing down the pipeline.

Generally:
- further increases in pump and engine efficiencies
- more automation
- possible return to simpler "agitation" type dredging methods, if baseline measurement of site and environs is improved.

Conclusion

In general, it may be said that the evolutionary process of dredger development is Darwinian, i.e. companies which adapt their fleets to have the most suitable plant and the right mix of plant will survive. However, it is possible to create a new market and the water injection dredger may be just beginning to show us this.

Further innovative dredger designs may yet appear to enable other new markets to be developed. But the question which arises is "how do you identify the potential markets?" This may be answered by studying the two driving forces; trade and environment. In particular, the environmental solutions to developments necessitated by trade may give some useful pointers to where we should be looking in the future.

If one accepts this, then it might not be too strange in the future to find environmental scientists in the research and development departments of major dredging companies. This would then enable teams to put forward comprehensive solutions to development needs, by introducing new techniques which have been evolved against an environmentally sound background. It has already happened in the field of dredging for inland waters.