An aerial view of downtown Hong Kong. Part of the burst of activities in the 1990s in Hong Kong was the expansion of the Central Business area. Land reclamation extended the waterfront, breathing new life into an enlarged Central Business District.

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FORTY YEARS OF MARITIME SOLUTIONS THAT CHANGED THE WORLD
EDITORIAL

Forty years ago this year, sixty of the largest international dredging contractors from seventeen countries decided the time had come to inform the world about the fundamental need for dredging and its benefits. This is how the International Association of Dredging Companies was born. In the following years IADC grew to be recognised as the umbrella organisation for the private dredging industry. With this recognition, IADC was invited to represent its members at supra-governmental agencies and legislative bodies, like the World Bank, the International Maritime Organisation, and the United Nations Environmental Program.

As IADC evolved, its different roles crystallised: it became the guardian of professional standards for the industry; it became the advocate for fair contract conditions and fair competition; it became the facilitator for establishing a platform for dynamic co-operation amongst the diverse parties involved in dredging. Membership in IADC is now, after forty years, seen as a quality label in and of itself.

IADC has grown especially in its role as an educator: organising conferences and seminars, assisting in the development of dredging-related curricula, promoting the field of dredging as a career choice, and presenting awards to students. Most importantly, IADC publishes this magazine, Terra et Aqua, this quarterly technical and scientific journal. It is Terra’s milestone issue #100 that you are holding in your hands. Since 1972 Terra et Aqua has been the flagship publication of the IADC and one of the main means by which dredging information is being disseminated to the world at large.

IADC has adapted to meet the new challenges posed by the evolving needs of clients, of technical innovation in the industry, and of global conditions. You can see this by looking at the activities of the dredging contractors themselves. Forty years ago the emphasis was on protecting the land against erosion and flooding, on maintenance dredging: deepening access channels, canals, rivers, removing sedimentation from ports and harbours. Those activities are still important. But nowadays the emphasis is far more on capital dredging, on maritime infrastructure. Creating new ports, container terminals and LNG harbours. Reclaiming land for housing and industrial parks. Constructing artificial islands as platforms for new airports to alleviate congestion and noise pollution, preparing seabeds for oil and gas pipelines. Indeed, a transformation has taken place: the dredging contractor has become a full partner in the development of maritime infrastructure.

Part of this transformation is the result of the amazing advances in dredging technologies. Jumbo trailing suction hopper dredgers with a capacity of 35,000 tonnes. Drag arms with a reach of over 130 m. Stronger engines and pumps. The advantages of the Global Positioning System. All these innovations and many more have kept the production cost of a cubic metre of sand under control. This in turn opened new maritime infrastructure markets and led to many impressive land reclamation projects.

Global conditions have also influenced changes in the dredging industry. The on-going world trade boom and the need for improved shipping facilities; after all shipping is the least expensive and most environmental friendly means of transportation. The expanding demand for energy and the need for new pipelines, oil rigs and platforms. Global warming and the need for re-enforced coastal protection and intensive beach replenishment. Population pressures in river deltas and along coastlines and the need for sustainable solutions through new maritime infrastructures.

IADC’s slogan is “Dredging Companies that Care”. It defines who we are within our industry. It reflects the careful way in which the member companies approach projects. Aware of the economic and environmental consequences. With respect for professional standards and responsibilities. Full partners in the world’s most exciting maritime infrastructure projects, always searching for innovative solutions. Confident that we can make a difference.

Robert van Gelder
President IADC
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Everywhere on this finite planet Earth, cities and countries seem to be in need of new land. Land for housing, recreation, and industrial purposes. Clearly there seems to be a shortage of living space. Especially at locations close to the water. The private dredging industry is ready and able to make this land.

THIS SPECIAL EDITION CELEBRATES THE 40TH ANNIVERSARY OF IADC AND THE 100TH ISSUE OF TERRA ET AQUA.
Offshore platforms and submarine pipelines are essential links in bringing fuel to onshore customers. The increase in the need for platforms and pipelines means an increased need for dredging – to prepare the seabed, dig the trenches and then protect these pipelines and platforms with sand, gravel and rocks to assure that they stay put.

When the Port of Le Havre made plans for expansion in 2000, it also made plans for Ilot Reposoir, a bird sanctuary. When Hong Kong’s Chek Lap Kok was being built, the corner of Lantau Island where the turtles nest was carefully preserved. These environmental stories are not the exception. For the private dredging and maritime construction industry, they are the rule.

No matter how much real estate development takes place along our coastlines, beaches are part of a natural cycle. They are affected by storms, hurricanes and erosion. Restoring, replenishing and repairing popular beaches, and even creating whole new beaches is an essential activity of dredging and maritime construction.

Each project described here represents the hard work of hundreds, if not thousands of people: engineers, dredging masters and their crews, project managers, scientists, researchers, specialists in all areas of dredging and maritime construction.
FOREWORD

An essential partner in maritime infrastructure construction

What's in a name? Is today's dredging still dredging? In the 21st century the dredging company is first and foremost “an essential partner in maritime infrastructure construction”, as the director of a port authority expressed it. Dredging is an industry in constant transformation. It has evolved dramatically in the last forty years; it has become far more complicated and far more sophisticated. At the same time good-old dredging continues to flourish. Unclogging shipping arteries, clearing sediments from waterways, ports and harbours are still high on the list of a dredging company’s activities. But even so “partner in maritime infrastructure construction” would now be a better name. Or “marine construction specialist”. But that name does not really cover the recent activities in oil and gas related offshore projects that are increasingly important.

For a better name, let’s look at some of the activities of the modern dredging company – or rather, the modern maritime infrastructure company: Winning millions of cubic metres of sand from incredible depths and then transporting them in jumbo hoppers, over hundreds of kilometres to build an enormous artificial island where a new airport will be constructed. Developing strategies for harbour expansion and the revival of surrounding residential areas and industrial parks. Studying demographic trends in the context of hydrographic potentials. Restoring wetlands and helping to solve problems when new sources of energy are being explored. Assisting in the development of new software to find sand deposits on 100 metre deep seabeds and monitor underwater habitats.

When the activities of an industry evolve, the name often changes, and the people in the industry do as well. Traditionally, dredging was for do-ers, for independent, action-oriented people. Yet today’s large land reclamation or port expansion projects often demand years of reflective preparations. Strategic planning, meetings and discussions. Even high-level diplomacy and an understanding of international treaties. Add to that environmental assessments, hydrographic studies, and thorough site investigations. Today’s dredging is part of a knowledge- and information-driven world. It is about sustainable development and ecological and economic feasibility. No wonder that at least half of the employees of IADC member companies have degrees in higher education -- in engineering, geotechnical and environmental studies, in law, navigation and accountancy.

Essential to the industry is self-renewal and key to that is investing in research and development. R&D leads to innovation: larger trailers, longer drag-arms, high-performance pumps, three-dimensional imaging, higher energy efficiency of ships and dredging equipment, stronger geotextiles, and environmentally friendly cutter heads. Together these innovations lead to more efficient, cost-effective production methods, as well as to a safer workplace. Equally essential of course is investing in people: a highly educated and well-trained staff, be it on board a vessel or back at headquarters is of the utmost importance to the success of every project.

This jubilee issue of Terra et Aqua presents a selection of infrastructure projects of the last forty years in which IADC members played a crucial role. Instead of showing how maritime infrastructure construction is done, as is often the case in Terra, this special edition presents the results of the work of IADC members, and the why behind each of the projects, in other words, their “drivers”. For chapter 1, for instance, that is “World Trade”, and for chapter 2, “Coastal Defense”. Other drivers are “Urban and Industrial Development”, “Energy”, “Ecology”, and “Tourism”. The photographs that follow are a testimony to forty years of intensive infrastructure construction. They show the projects that have changed the way we live, the way we work, the way we play. They show how the dredging and maritime construction industry has helped to change the world.
“That container ships were getting larger, that we knew. That as a result we would have to deepen our port, that we knew as well. And we did that. But that the very next day after we finished dredging, one of these huge 8000 TEU vessels would arrive at our port, that came as a real surprise. Of course we are aware of the rapid developments at the Asian side of the Pacific Rim. But we are still not completely prepared for the accelerated speed of the changes. In trade volume, in the size of the ships, in the number of ships”. These were the comments of the director of a major port authority in June 2005.

Call it globalisation, call it outsourcing, the fact is that China and India, the Far East in general, are going through an economic and trade growth spurt that finds the rest of the world not quite prepared for the consequences – despite reports from the financial newspapers and magazines.

The Far East is now, in 2005, the engine of growth for the whole world. China today has seven ports that can handle a freight volume per year of over 100 million tonnes of cargo. The ports in Europe and the U.S. that receive this Asian export rush have to gear up to meet the challenges, to mirror the new modern mega-ports in Asia.

At all sides of the oceans, more trade means a need for extended port and harbour facilities, for improved waterborne transportation. Dredging activities and maritime infrastructure development are fundamental to these expansions and are therefore driven by the acceleration in world trade. But is this the whole picture? Which came first, the chicken or the egg? Is trade driving port development or is port expansion driving trade?

Trade is only possible if the cost of transporting goods to market is kept inexpensive enough so that imported goods remain competitive with local goods. Right now, for most goods, waterborne transportation is more economical, cleaner and more cost-effective than other means of transport, overland or by air. The three main factors in the cost of waterborne transportation are: the sailing distance, the size and speed of the ship, and the capacity and efficiency of departure and arrival ports. So, the construction of state-of-the art maritime infrastructure helps propel world trade by keeping the costs of seaborne transportation low. QED: Port development and waterway maintenance are as much drivers of world trade as the other way around.

Recently the Italian Minister of Transport announced a plan called “Motorways of the Sea”. It is part of an overall European
strategy to get transport traffic off the roads and onto the waterways. With almost 6500 km of coastline, Italy is perfectly situated to replace some of its long-haul trucks clogging up the roads, and polluting the air, and get the cargo on board ships instead. The plan foresees the dredging of a number of ports and inland waterways. This is how dredging, while making transport by water more cost-effective and promoting trade, also contributes to creating a cleaner environment.

This chapter highlights the most important maritime infrastructure projects of the last forty years executed by IADC members, driven by the growth of world trade. Brand new and expanded ports. Improved existing harbours. Both capital and maintenance projects. They are all there, driven by world trade, and driving world trade at the same time.

The Port of the 1990s: Kwai Chung, Hong Kong

After the go-ahead in 1966 from the Hong Kong Government to construct a container terminal at Kwai Chung, both Hong Kong International Terminals (HIT) and Modern Terminals (MIT) were established. The development of the Port of Hong Kong is closely related to these two container terminal operators. With the completion of the first terminal in 1969 the growth of the port has been the highest in the world.

At present Hong Kong is the largest container port. Rapidly following the first terminal in 1969 were: in 1974 dredging and reclamation for Terminal CT 4, Terminal CT 6 in 1986, Terminal CT 7 in 1990, Terminal CT 8 in 1993 and the last one, Terminal CT 9 in 2002. The total berth-length at HIT’s terminals exceeds 4300 m. After only 30 years of operation HIT’s annual turnover exceeded 6 million TEU’s. From 1969 to 2004 they handled 80 million TEU’s.
Ports of India are expanding

Given the extensive coastline of India, the great number of maritime infrastructure projects, both capital and maintenance, should be no surprise. Mumbai on the northwestern coast of India is a prime example. On the eastern side of the Mumbai Estuary a green field container terminal, the first terminal to be privatised, was built in the late 1980s at Nhava Sheva to relieve the congested docks on the western side. Some 6.5 million-m³ soft material and 500,000-m³ hard basalt-rock were dredged, employing one of the most powerful cutter suction dredgers at the time. Mumbai Harbour requires regular maintenance, and water injection dredging is an efficient and cost-effective method. Such an operation is shown near the Gateway to India.

The new Mangalore Port is an artificial lagoon harbour located south of Mumbai on the west coast of India. In its third phase Mangalore was improved to cater to the grass-roots refinery being established near the city of Mangalore. Capital dredging, started in February 1995, included rock dredging utilising underwater drilling and blasting to deepen the existing port.

In 1999 at the port of Tuticorin, south of Mangalore, on the western tip of the Indian continent, significant dredging work was executed. With its natural harbour Tuticorin has been a centre for maritime trade and pearl fishery for more than a century. But to keep up with modern maritime transit needs, deepening the entire port was imperative.
Thailand’s ports keep pace

Two major port construction projects were conducted in the late 1980s, first at Laem Chabang and later at Map Ta Phut. Beginning in 1961 the Royal Thai Government was considering the construction of a new deep seaport which could accommodate larger container ships and bulk carriers to replace Bangkok’s Klongtoey Port which was too shallow. Studies recommended Laem Chabang as a suitable location, with room for later expansion. In February 1988 work commenced at Laem Chabang. This included dredging an approach channel and basin, land reclamation, construction of a rubble-mound breakwater, and slope protection, utilising a state-of-the-art cutter suction dredger.

After completion of the dredging works at Laem Chabang, the cutter suction dredger moved to Map Ta Phut where from September 1989 to January 1992 work on a new deep seaport began. Map Ta Phut is presently the largest industrial port in Thailand.

The port of Map Ta Phut.

The port of Laem Chabang.
The transformation of Tanjung Pelepas (PTP), Malaysia

In just five years, the Port of Tanjung Pelepas (PTP), the newest addition to the port complexes in Johor, has become the largest port in Malaysia, providing ample competition to its rival to the south, Singapore. The port is located at the confluence of major shipping routes at the southern tip of Malaysia and is on track for a five phase development over a 25 year period up to 2020.

The first phase of this new port at a green field site in Johor State was completed in 1998, with 2800 m of waterfront. Dredging and reclamation for the second phase, which will add another 2800 m of wharf, were completed in 2003, allowing the gradual construction of additional container berths, terminals and industrial buildings. Both phases have required mobilising large fleets of trailing suction hopper dredgers. In the second phase more than 40 million m$^3$ of mud and clay were removed and some 35 million m$^3$ of sand were used for reclamation. Major soil improvement works to stabilise the wharf bund and terminal area required some 40 million m of vertical drains to be installed.

PTP has clearly established itself as an important transshipment hub in the region. The excellent port facilities have attracted main world-renowned shipping lines. It is projected to reach the one-million-TEU mark for the first time in August 2005.
Australia mining harbour, Port Hedland

Situated in the rugged, remote Pibara Region on the northwest coast of Western Australia, 1600 km north of Perth, the small mining settlement of Port Hedland has become one of the largest mineral ports in the world. The valuable deposits of iron ore found in the region have fuelled this incredible growth: the port transfers millions of tonnes of iron ore all over the world. To meet these demands, a port extension programme to increase export capacity was initiated in September 2002. The maritime operations comprised dredging the existing berth pocket from –17 m to –19 m, extending this berth pocket, and dredging a new berth pocket and departure area. It required cutting through tough limestone. Work was conducted around the clock, during typhoon season, in temperatures reaching 45 degree Celsius.

Deeper is better at Korean Port Pusan

Situated in southeastern South Korea, on the Korea Strait, Pusan, the nation’s second largest city and largest port, handles most of South Korea’s foreign trade. Lying at the head of the Naktong River basin, it has served as a main southern gateway to Korea from Japan, which helped to develop Pusan’s excellent natural harbour. The city is also the southern terminus of the main railroad line from Seoul. As a leading industrial and commercial centre, in 2001 Pusan port started an intensive programme for port development including deepening the channel and reclamation for a container terminal where sand had to be hauled from borrow areas 100 m deep.
Rehabilitating and expanding European ports

Western European ports like Felixstowe, Dover, Hamburg, Rotterdam and Antwerp have developed over hundreds of years. Port extensions necessary to accommodate growing business were most of the time located outside the city centres where the original old ports were situated. The shipping channel wharfage requirements changed over time. Ports and access channels had to be deeper and wider. Container terminals could not be built close to the populated areas. Logistics, inland transport, transshipment methods were modernised. General cargo handled at the quayside became too costly compared with the fast and economical way of containerisation. Port areas have been expanded, developed and redesigned for ever larger modern cargo ships. Channels and basins were cleaned and filled to form larger areas for more efficient port operations. The modern European ports today are mammoth businesses, with their own Authorities, that operate and maintain all harbour facilities – including dredging and maritime infrastructure construction.

The UK’s largest port

The port of Felixstowe is the largest deep-water container port in the United Kingdom and one of the largest in Europe. Felixstowe reclamation took place in the 1980s and facilities were deepened again in the 1990s. Additional improvements are planned for the near future.
Le Havre Port 2000, France

Nowadays the largest containerised ships that handle the intercontinental commercial exchanges have become so big that they have a limited number of ports of call in Europe. The Port of Le Havre is the only French port able to play an international role in Europe that competes with the main Northern European ports. Situated at the mouth of the Seine, Le Havre is France’s largest port facility and the fifth largest container port in Europe. Port 2000 is an extension to Le Havre port’s facilities for container traffic – there are presently 14 quays. Work going on now is intended to increase capacity for the sustained growth of external trade, increasing jobs and doubling container trade through the port by 2010. The design fosters the use of the most competitive and least polluting means of connection. Infrastructure improvements planned for execution between 2000 and 2005 are the construction of a new container terminal in the outer Port of Le Havre (12 quays planned for outside the locks), the dredging of the access channel (10 km) and turning basin. Two gravel beaches and breakwaters on the North, West and South to protect the new harbour against waves and currents have been constructed.
Rotterdam, the Netherlands, the largest port of Europe

Every year some 30,000 sea-going ships and 110,000 barges call at the Port of Rotterdam. With its ultra-modern Vessel Traffic System (VTS), it can track ships on the radar screen up to 60 km off the coast and 40 km inland. This is one of the advanced systems that keeps Rotterdam competitive in the maritime world. In the 1950s Rotterdam expanded its harbour with the addition of Europort. By 1960 the first oil tanker was moored there. Shortly thereafter the Petroleumnhaven, Beneluxhaven and Dintelhaven were added. The Calandkanaal gave Europort its own connection to the sea. In 1962, with a cargo handling volume of 96 million tonnes, Rotterdam superseded New York as the world’s biggest port. By 1965 the need for more expansion was clear and the Maasvlakte, reclaimed from the sea, was built, tripling the size of the port and industrial area.

The first container ship arrived in Rotterdam on May 5 1966. The container revolution had begun and it led to the establishment of ECT, the Europe Container Terminal. Tonnage increased rapidly and in 1978 the 1 million milestone was achieved. By 1986 2 million containers had passed through the Port of Rotterdam. By 2000, this figure had increased to 6.5 million TEU. Most of these are handled on the Maasvlakte at the ECT Delta Terminals. The projections for 2020 are an increase of throughput up to 40%.

Overview of the harbour of Rotterdam looking at the entrance to the Maas Harbour at Rotterdam.

Construction of the ECT container terminal in 1990.

A cutter suction dredger at work for the expansion of the Amazon Harbour, part of Rotterdam, in 1997.
Hamburg and Bremerhaven, Germany’s premier ports

The Port of Hamburg is Germany’s largest seaport and Europe’s second-biggest container port. It is situated at the upper end of the estuary of the River Elbe and its history goes back more than 800 years. The port has been dredged for hundreds of years so as to maintain water depths for the passage of ships. The port is situated inland on the River Elbe some 100 km from the North Sea. The tidal current has a strong influence on this region. Continual intervention in the river has been necessary to make ship traffic possible and to maintain an adequate fairway depth. The need for dredging measures has been a consequence of the natural sedimentation and the increasingly shallower depths it produced. Nowadays, roughly 3 to 4 million m$^3$ of Elbe sediments are dredged year in and year out.

The northern German Port of Bremerhaven, located on the River Weser, has taken note of the increases in container traffic and is in the midst of a capital investment project to keep up with future demands. At its current rate of growth, Bremerhaven will reach its maximum container handling in 2006 – a good reason to be implementing a new expansion plan. Part of the plan will be ready for use in November 2006. By 2008 Bremerhaven will have the longest quay wall on a riverbank in the world.

Aerial view of Hamburg with intensive work for the extension of the port going on.

Dredging activities at the northern port of Bremerhaven.

Other European ports are also expanding to meet the demands of world trade. At Vuosaari Harbour, Finland between August and November 2004 sand and gravel were dredged from a distant borrow area and transported over 15 km through the future access channel to the new container port.
Belgium ports remain competitive

The Deurganckdock, officially opened in July 2005, is the largest tidal dock in the world, with over 5 km of docking area. The dock has doubled the container transit capacity of Antwerp's Waasland Harbour with 6 million TEU, making Antwerp a serious competitor of Rotterdam. The Waasland Harbour, built on the left bank of the River Scheldt, has its main access through the Kallo Lock.

The America and Albert Docks are part of Antwerp's original port area; recently both docks were thoroughly renovated.

From 1977 to 1989 a huge maritime extension project was realised in the Port of Zeebrugge: the development of a totally new outer and inner harbour. Today Zeebrugge is the major harbour in the Belgian Coastal Area. As do many harbours, Zeebrugge suffers from intense sedimentation by fluid mud entering the harbour during high tide. Annually more than 5 million tonne dry material has to be evacuated, by trailing suction hopper dredgers, to maintain the navigational depth up to 13.5 m.

Ostend (Oostende), some 35 kilometres southwest of Zeebrugge, became important as a harbour in 1722 when shipping over the River Scheldt to and from Antwerp was blocked. Ostend became a transit harbour to England in 1846 when the first (legendary) ferryboat sailed to Dover. Today Ostend, facing the English harbours of Folkestone, Ramsgate and Dover, is still Belgium's largest passenger and car-ferry port.
Zeebrugge fights sedimentation and remains one of Belgium’s major harbours.

Ostend, facing England, is Belgium’s largest passenger and car-ferry port.
Extending the Southern Basin of the Port of Valencia, Spain

Valencia, on the Mediterranean Sea, facing East, is Spain’s commercial port that is nearest to the Suez-Gibraltar axis, the main shipping route connecting Western Europe and Asia. The growth in trade and shipping created the necessity to extend the port’s Southern Basin. It involved the construction of a 3900 m-long breakwater, sheltering the berths and helping to maintain a depth of 16 m. The project was carried out from 1993 to 1996.
Spain’s Seville-Bonanza Canal

Located in southern Spain, Seville is situated on the banks of the Guadalquivir River, 90 km from its mouth. The Guadalquivir is one of Spain’s very few navigable rivers making it an unusually important inland water route. From 1969 to 1976 the river was deepened, the new Guadaira river channel was created, and the docks were lengthened by 2000 m. Besides improving the safety of shipping to and from Seville and enhancing the port facilities, the project also prevented flooding of Seville.

A new deep seaport for Tarragona, Spain

On the Mediterranean Sea, halfway between Valencia and Gibraltar, Tarragona is a transshipment port and plays a major role in the economy of the Spanish hinterland. Increased trade created a need for more quays and a deepening of the port, to 16.5 m. The sediments were used for land reclamation purposes, land where in the second phase of the project the new port was built. The entire project, started in September 2000, was completed in 2001. Tarragona now has another deep seaport accessible to large ocean-going vessels.
Suez Canal and Port Said and Al Sukhna, Egypt

The Suez Canal, which opened in 1869, is the main marine corridor between Europe and Asia, linking the Mediterranean to the Red Sea across 167 km of Egyptian desert. From the beginning it helped increase the flow of world trade. Today it is essential for the petroleum tankers heading to and from Europe. Major canal improvement works started around 1961 (the Ballah Bypass) and again from 1976 to 1980 with the Suez Canal Expansion Project. An enormous dredging fleet including 18 hydraulic dredgers were engaged to widen and deepen the canal. From 1992 to 1994 the depth of the southern part of the canal was increased to –25 m to accommodate larger vessels. Major container hub-ports have been established at both ends of the canal. From 1999 to 2002 at Port Said, the Mediterranean entrance to the canal, a new port was constructed. At about the same time, the Al Sukhna Port was constructed on the Egyptian Red Sea Coast. This was a design-and-build contract for an entire port destined to serve the Cairo region. Al Sukhna Port has been designed chiefly to relieve the Suez Canal by offering shipping from Asia an alternative to Cairo and eliminating the need to transit the Canal.

Widening and deepening of the Suez Canal in the 1970s.

Piles of used cutter-teeth are an indication of the extreme rock layers at the Suez.
Nowadays, container ships traverse the Canal, while the dredging continues.

Dredging goes on day and night. The Suez in 1977.

Dredging at Port Al Sukhna at the southern end of the Suez Canal.
Port construction in the Emirates

In 1968 construction started for a new port at Mina Zayed, in Abu Dhabi, United Arab Emirates. A year after becoming independent in 1971 the first major harbour project was completed. Before this construction, cargo ships had to dock some 8 km away from the coast and unload shipments onto barges and small dhows – the long, flat traditional sailing vessels of the Middle East – to transport the cargo to shore. Presently the port has 21 berths for all types of commercial trans-ocean ships. The ports of Jebel Ali and Port Rashid are the main ports of Dubai. The original dredging for this prestigious man-made port was done from 1976-1982. The basin and inner harbour were dredged with cutters; the 17 km approach channel by the self-elevating offshore dredger Al Wasl Bay, the first of its kind in the world specially built for this purpose. Today Jebel Ali is the largest port of the UAE with 82 berths and a throughput of 6.4 m TEU containers. Initially constructed in the 1970s, Jebel Ali has been extended regularly, most recently from 2002-2004.
Gateway to East Africa

Djibouti, the port city of the eastern African country of the same name, is located on the Gulf of Aden, facing toward the Red Sea and the Arabian Peninsula. The city is an important regional supply centre for the export trade in petroleum, and is the main export route for Ethiopian coffee. Although on the African coast, its importance as a harbour is dependent on its strategic position to the shipping lanes that carry the Suez Canal traffic.

Dredging the Port of Djibouti in 1986.

Cutter suction dredger widening and deepening the Jebel Ali entrance channel.

Aerial view of the extension of Port Rashid.
The four port cities of Saudi Arabia

After the oil crisis of 1973 a construction boom started in Saudi Arabia. The boom lasted for more than ten years. The Royal Commission for Jubail and Yanbu was to oversee the development of the city of Yanbu on the Red Sea coast and of Jubail on the Arabian Gulf. Major petrochemical and related industries were built. But also new modern cities and ports. Initially the ports served to relieve the smaller existing ports, which were totally congested as a result of the import of construction materials and equipment.

Yanbu’s King Fahad Industrial Port is now the largest oil and petrochemical exporting complex on the Red Sea. Completed in 1982 it has 7 terminals with 25 berths.

Jeddah Islamic Port, also on the Red Sea, is the main port for imports into Saudi Arabia.

Jubail King Fahad Industrial Port is the largest port of Saudi Arabia, exporting mainly petrochemicals.

Damman, King Abdul Aziz Port, close to Jubail on the Arabian Gulf, serves as main commercial port for the Eastern and Central Provinces. The ports in these four cities handled a total of 120 million tonnes of cargo in 2004.

Jubail Commercial Port was one of the biggest construction projects in the Kingdom of Saudi Arabia in the late 1970s, requiring the input of major dredging plant of nearly all members of IADC. The port area is 50 km² and the breakwaters have a total length of 10 km. The total dredging volume was over 40 million m³.
From fishing village to port: Bandar Abbas, Iran

From 1976 to 1979 some 11 million m$^3$ of sand, silt and clay were dredged to prepare a huge site for one of the first port-industrial areas in Southern Iran at Bandar Abbas. The new port is strategically located at the Strait of Hormuz, close to the Island of Qeshm. At the start of the project Bandar Abbas was only a fishing village. Nowadays it is one of the largest ports of Iran.

Reaching Africa through Dar es Salaam, Tanzania

The principle port of Tanzania, Dar es Salaam, is a major sea outlet for many African nations including Zambia, Burundi, Malawi, Rwanda, Uganda, Zimbabwe and eastern parts of the Congo. The construction of the eight Deep Water Berths (berths 4 to 11) was the first major marine project in Tanzania after becoming independent in 1963. The project was started in 1969 and completed by 1975. The capacity of the port increased threefold.
Maintenance dredging on the Pacific Coast of Mexico

The western Pacific coast of Mexico is rich in harbours such as Ensenada, Guyamas, Mazatlan, Manzanillo, Salina Cruz, Puerto Madero and Lazaro Cardenas, all of which are in need of regular maintenance dredging. **Lazaro Cardenas Terminal Portuaria de Contenedores** (LCT) is a highly industrial deepwater port. The terminal is significantly closer to Mexico City than Manzanillo, the only other Mexican Pacific port serving this important market. LCT is a single-berth terminal with on-dock rail facilities and the development rights to an 85-hectare deepwater, green field site. From June 1980 to December 1983, the LCT was improved by dredging for the extension of the harbour and for reclamation of industrial areas and a Naval Zone. Maintenance dredging was done from 1994-1996.

Reaching the grain harbours of Argentina

Argentina’s principal water connections for the shipment of grain, the **Rio de la Plata** (River Plate) and Rio Parana, cover a distance of almost 700 km linking the upriver harbours to Buenos Aires and the ocean. They are also connected to the Rio Uruguay through two access channels, the **Canal Mitre** and the **Martin Garcia Channel**. The economic importance of these waterways to Argentina, Uruguay, as well as Paraguay, Brazil and Chile and Bolivia is enormous.

In the 1990s major investments were made to improve these waterways to accommodate PANAMAX and Cape Size Vessels. According to the project plan (1995-2013), the work on the Rio de la Plata from the ocean going 205 km upstream through the Canal E. Mitre and then up the 584 km of the Rio Parana will mean dredging 60 million m³. The total length of the **Martin Garcia Channel** is 106 km of which 76 km is being dredged. This means 40 million m³ in capital and maintenance dredging during the first two years, with the projected quantities for 8 years estimated at 3 million m³ annually.
Modernisation of the Panama Canal

The first complete Panama Canal passage by a self-propelled, ocean-going vessel took place on January 7, 1914. Since then the 80 km long Canal, which crosses the Isthmus of Panama and connects the Atlantic and Pacific oceans, has seen hundreds of thousands of ships. It has been expanded, deepened and widened many times. When in 1999 the Panama Canal was handed over to the Government of Panama, a new episode for this famous canal began. Panama Ports Company (PPC) now operates the ports of Cristobal and Balboa located at each end of the Panama Canal. PPC is committed to transforming these two ports into major hubs. Part of modernising this infrastructure was the capital dredging for deepening and widening the entrance channels on both the Pacific and Atlantic entrances to the Canal done during 2004 and 2005.

Multimodal container terminal at Caucedo, Dominican Republic

The recently built multimodal container terminal in Caucedo on the south coast of the Dominican Republic, not far from the capital city of Santo Domingo, is a new addition to handle the overflow from port Haina. Dredging for this new port construction was especially sensitive, with great care for the coral reefs nearby. A sophisticated monitoring system was established which measures turbidity on a 24/7 basis. The opening of this container transshipment terminal in 2004 gave a tremendous boost to the Dominican economy and employment in the area.

From its inception, the Panama Canal has helped expedite world trade by shortening the travel time for shipping traffic between the Atlantic and Pacific oceans.
The Delta Plan: “closing the gate” is always a suspenseful moment, because of the strength of the currents. Populations have always been attracted to the coastline, to live and work close to water. According to the United Nations, some 3 billion people, or almost half the world’s population, currently live along thousands of kilometres of coastal zones. Expectations are that this number will double in the next half century. In addition more than 80 countries enjoy delta cultures, where large populations are settled at the mouth and along rivers living on fertile, though vulnerable, landmasses. The protection of these delta cultures – be they along the Niger, the Mississippi, the Rhine, the Mekong, or the Meuse – has created a need for dredging activities for hundreds of years and never more so than right now.

The modern era of coastal protection was probably triggered by the events of the night of January 31 to February 1, 1953. That night, high winds combined with high tides created a storm surge that ripped across the southern part of the North Sea. It hit the coasts of the Netherlands, the UK, France, Belgium, Germany and Denmark. The coastal sea defences were completely overwhelmed. And each of the affected countries responded with a burst of research and investments in sea defence. The Netherlands developed the Delta Works, which completely reshaped the southwestern part of the country. In the UK, the Thames Flood Barrier programme was started to secure central London against future storm surges. Belgium introduced the Sigma Plan in the 1970s; France and Denmark also took similar coastal defence measures. In all cases, the innovative thinking and R&D of the maritime construction industry played a major role.

Nowadays the demand for creative solutions in coastal areas and along rivers is as urgent as ever. Add the threat of rising waters from global warming to the shortage of space in these desirable densely populated waterfront areas, and the need for increased and improved protection is clear. And yet despite the changes in sea levels and in rainfall distribution, people continue to flock to the coasts and rivers.

Take the coastal and river areas of Argentina, of Indonesia and Malaysia, and of Europe, areas where wetlands and water culture are woven into the people’s lives and livelihoods. Take the Pearl River Delta which has been one of the most economically dynamic regions of China. It is the fastest growing portion of the fastest growing province in the fastest growing large economy in the world. Or Bangladesh...
The Incredible Eastern Scheldt Storm Surge Barrier

The Delta Plan, which protects the low-lying lands in the southwestern part of the Netherlands, was conceived after the catastrophic floods of February 1953. The closing of the Eastern Scheldt Estuary was planned as the final project of the Delta Plan to bring safety to the surrounding land areas. Originally, the Eastern Scheldt would be a regular closed dam. In fact, in 1967, three artificial islands which would be used to erect the dam had already been raised in the mouth of the river. The 1960s were the years of growing environmental awareness. The Dutch, people as well as politicians, started realising that only working with nature, and not against it, could ensure real safety. In 1975 the Dutch government proposed building an open barrier, instead of a simple closed dam, which could be closed during an emergency but would normally be opened, preserving the ecology of the area. It took till 1979 for Parliament to vote in favour of this project, and the cost at the time seemed enormous. In the last 25 years the Eastern Scheldt Dam has become quite an important tourist attraction, for visitors from all over the world. That makes sense, after all, the open barrier is one of the most impressive and beautiful maritime infrastructure feats ever conceived. And the country has remained protected.

A halfway phase in erecting the storm surge barrier.
A new bay at Cardiff in Wales

The Cardiff Bay Barrage is one of the largest investment and engineering projects to have taken place in the United Kingdom. Completed in 1999 and measuring 1.1 km in length, the barrage impounds two of the main rivers in South Wales, the Taff and the Ely, to create a 2 km² freshwater inland bay, Cardiff Bay, and a new permanent water front of some 12.8 km. The barrage serves not only as a flood defence, but also has helped regenerate the docklands of the Bristol Channel, offering sailors a protected environment.

The completed Barrage at Cardiff Bay literally provides a safe haven.

Work in progress at Cardiff Bay.
The Thames Barrier, flood defence for London

Some forty years ago, it was determined that improved flood protection for the tidal part of the Thames was absolutely necessary. Raising the banks of the river in conjunction with a flood barrier incorporating moveable gates built across the river, was seen as the best solution. Construction of the Barrier started in late 1974. It became operational in October 1982 and it was first used in February 1983. The Thames Barrier is part of a larger system of moveable gates, including Barking Barrier, the gates at old Royal Docks, and Dartford Creek and Fobbing Horse Barrier.

Maeslant Barrier protects Rotterdam and surroundings

As a mirror image to the storm surge barrier in the River Thames protecting London against flooding, Rotterdam is now also protected against storm surges and extremely high tides, by the Maeslant Barrier. The barrier is constructed in the New Waterway, the deep canal that connects Rotterdam to the North Sea. The barrier consists of two floating gates that can be swung into position on hinges and then water-ballasted to seal them into position on a sill. Just like its London counterpart, the Maeslant Barrier, is part of a network of barriers, amongst them the Hollandsche IJssel Barrier and the Hartel Canal Barrier.
Replenishing the coastlines of Europe

Maintaining natural defences against floods is a continuous priority in the low coastal areas of Western Europe. Dunes are a natural defence. The lowlands behind these dunes, especially polders, are risk-exposed areas, which are used increasingly by the population in the coastal regions. At many locations, from the French Atlantic Coast via the North Sea coasts of England, Belgium, the Netherlands and Germany to the shores of the Baltic Sea, beach nourishment projects are executed at regular intervals. An added advantage is that the widened beach, apart from protection, offers additional attractive space for vacationers and gives a boost to the local tourism industry.

The forces that shaped Sylt

The western edge of the German island Sylt is subject to the remorseless pounding of the North Sea, which leads to erosion of the west coast. The eroded material is partially re-deposited, by winds and currents, at the northern and southern extremities of the island, giving it its long, stretched-out shape. But a substantial part, almost 2 million m$^3$, is lost every year to the sea. After careful studies, a decision was reached that beach replenishment, with sand from the seabed from at least 14 m deep and some 8 km offshore, was the simplest and safest way to fight this erosion.

Eierland Dam helps keep sand in place

The coast of Eierland, in the northwestern corner of the Dutch Isle of Texel, has been declining for over a century. A yearly loss of a million m$^3$ of sand was recorded. Since 1979 this has been compensated by sand replenishment of more than 10 million m$^3$. The newly constructed (1996-1997) Eierland Dam, 800 m long, helps keep the replenished sand in place. The dam was built under a strict quality guarantee, a first for a project of this type. Regular replenishment of sand to the coastline takes place up and down the North Sea coast of the Netherlands from Texel in the north to Scheveningen in the middle, and Vlissingen in the southern province of Zeeland.
Protecting the coastline of the UK

As an island nation the United Kingdom is long used to being attacked by the sea. From Hythe to Folkestone Harbour is a dense urban area, important for fishing and popular with tourists. The concrete seawalls that now protect this frontage were originally constructed in the 1930s and are showing wear and tear. The recently completed Hythe to Folkestone Harbour Coast Protection Scheme, including beach replenishment, will reduce the risk of seawall failure and coastal flooding.

The lowlying East Anglian coastline is also subject to intense erosion. To protect the coastline, and a portion of the hinterland from flooding, the Happisburgh to Winterton Flood Defense Scheme using offshore rock reefs has been successfully implemented.
Saldanha Bay, South Africa: waves over 12 m high

South Africa's largest natural anchorage and deepest port, Saldanha Bay is strategically located on the Atlantic coast, some 150 km north of Cape Town. The bay is an ideal place for the transshipment of huge quantities of iron ore, arriving by an 860 km long railway from the Sishen-Orex mines. Before the first shipment of ore was loaded in 1976, the port facilities had to be protected from the attacks of the Atlantic's swell and waves over 12 m high. Construction of the loading jetty was virtually impossible without the closure of a huge spending beach. This 1800-m-long dam had to be made of sand between Marcus Island and Hoedjes Point. Through the forces of nature any sand placed in the dam's profile one day disappeared overnight. Only the combined energy of four private international dredging contractors with extra equipment was able to produce more sand than nature could remove. After placing some 20 million m³ of sand, the gap was finally closed. During this struggle, many seals continuously surrounded the fleet. At fixed times blasting was carried out to remove rock pinnacles. Somehow an hour before the blast the seals always disappeared, returning an hour later to enjoy the leftovers from the Saldanha fish canning industry.

More fish and no more floods in Iztapa, Guatemala

Because of siltation of the Chiquimulila canal, Iztapa, a fishing village along Guatemala's Pacific coast, was often flooded. Moreover, the fishermen could no longer navigate the canal as it had become too shallow. Deepening the canal, the first phase of the project, brought a solution to both problems. The second phase of the project consisted of the construction of two breakwaters at the point where the so-called “barra” or outfall channel to the Pacific Ocean is opened in times of flooding. These breakwaters serve to protect the shore and the banks of the channel.
Training the Jamuna River, Bangladesh

Several rivers such as Ganges, Padma, Megna, Brahmaputra and Jamuna physically divide Bangladesh. These rivers form an obstacle to developing the country’s infrastructure. The 5 km long bridge over the Jamuna, completed in the late 1990s, is an important economic and social link between the underdeveloped, but gas-rich, western part of Bangladesh and the eastern part. Kilometres of river training works were needed to ensure that the waters of the meandering river would flow underneath the bridge between the two abutments and not around them. This was accomplished by constructing a pair of banana-shaped guide bunds and a pair of hard-point islands some 6 km upstream. Work could only be executed during the low-water season, October to April. From May to September strong currents from the melting snow of the Himalayas made work impossible. With no hard rock large enough available in Bangladesh, 1.6 million tonnes of rock were transported over thousands of kilometres, then transferred on barges to the site, where hundreds of local people, rather than machines, carried it in their traditional way to the riverbanks.

For the sake of El Carnaval de Barranquilla

With almost 3 million inhabitants in its metropolitan area, Barranquilla is a major industrial city and modern port on the Caribbean coast of Colombia. It lies at the mouth of the river Magdalena, some 100 km north of the old city of Cartagena. The city is most famous for its carnival, El Carnaval de Barranquilla, second only to the Carnival do Rio de Janeiro in Brazil. In order to protect the shores and port facilities of Barranquilla a sand dam and a rock-fill dam were built and an alternate navigation channel was dredged.
Three breakwaters in Kerteh Bay, Malaysia

For several years the beachfront of the Rantau Petronas Complex, south of Kerteh on Malaysia’s east coast, suffered from severe erosion during the monsoon periods. Without remedial measures the site would partially disappear into the sea. In 1991 a study was undertaken to see how the future safety of the complex and its inhabitants could be ensured. Data and detailed models of the most promising solutions were presented. The most suitable scheme for this situation proved to be the construction of three offshore breakwaters, each 400 m long, curving to become parallel to the coast, with initial beach nourishment.

Jurong, Singapore: revetment of 17 km of new shoreline

In the mid 1990s Singapore decided to create a major oil and chemical platform in the southwest corner of the country. Seven small existing islands were connected to form one large island: Jurong Island. Furthermore, the bordering Tuas Peninsula was extended. In the process some 800 ha of newly reclaimed land was created. To protect the sand of the new land against erosion, some 17 km of new shoreline had to be protected against waves and wind. The revetment involved profiling the reclaimed slopes, covering them with geotextiles and placing two layers of rock.
Protocols 3 billion people living near coasts and rivers

Controlling monsoon damage at Ennore, India

Located 20 km north of Chennai, Ennore is a small village on the east coast of India. Chennai, formerly Madras, is one of India’s major harbours and a centre of economic activity. To supply Chennai and its industries with sufficient power, the new North Madras Thermal Power Station was built. Coal supplied to this power plant originally came through the already congested port of Chennai. From 1997-2001 the new Ennore port was built near the plant, primarily for the import of coal, but also as a multi-functional alternative to Chennai Port. Because India’s east coast is subject to storms and cyclones during the monsoon period and the littoral drift creates significant sand transport along the coast, the new port at Ennore required the construction of two new breakwaters. The two breakwaters are 3.2 km (north) and 1.3 km long. The port has a harbour basin of some 4 km².

Securing the access channel at Pulau Bay, Bengkulu, Indonesia

Bengkulu, a port city on the west coast of Sumatra in Indonesia, had a problem: the access channel to its Pulau Bay Harbour suffered from severe siltation. In order to adjust the water currents and the flow of the sediments, the existing breakwater was lengthened by 300 m and the channel deepened to 12 m. The eroding beach at the northeast side of the channel entrance was nourished with almost 2 million m³ sand and gravel.
The simple question is: Are we running out of land for people to live and work? Ask this question around the world and the answer seems to be a resounding “Yes!”. The global population today is over 6 billion. Predictions are that by the year 2030 it will rise to 8 billion. Everywhere on this finite planet Earth, the governments of cities and countries seem to be in need of new land. Land for housing, recreation, and industrial purposes. Clearly there seems to be a shortage of living space.

Certainly there are vast inland areas available for habitation, but more often than not they are ignored. Locations close to the water act as a magnet. That’s where the better jobs are to be found. Where the climate is more moderate. The result: half of the world’s population lives within 60 km of a shoreline. And this population continues to grow each year, both in an absolute as well as in a relative sense. No wonder that eight of the ten largest cities in the world are located along a coast. Not only does this mean a need for bigger and better ports and coastal defences. Take the whole complex of factors together – an exploding population, people’s desire to live in urban areas and near water, the industrial need for closeness to waterways – and you understand why the coastal areas are so congested, deeply in need of new reclaimed land for industry and residential use, for roads, bridges and tunnels, for work and for play.

The maritime construction of new land, including man-made islands for a multitude of purposes, presents an unprecedented challenge. And the private dredging industry has responded with heavy investments in R&D, with essential technological advances and innovations. With ever larger and more efficient dredging vessels. The size of the trailing suction hopper dredgers has grown exponentially over the last three decades. From the hoppers with less than 6,000 m³ capacity of the 1970s and 80s, to the so-called “jumbo” hoppers with capacity of over 15,000 m³ in the 1990s, to today’s mega-hoppers topping a 35,000 m³ capacity. Thanks in part to these enormous vessels the cost price of a cubic metre of dredged marine sand for reclamation has dropped.

This increase in the capabilities of mega-ships and this large-scale sand-winning has allowed for the construction of mega-projects, significant new landscapes designed literally from nothing: like the areas off the coast of Singapore and Hong Kong, for instance, or the new residential island Hulhumale in the Maldives or the IJburg, north of Amsterdam, the Netherlands. These islands are created from scratch, with sand especially suited to the purpose.
Airports on artificial islands in the water

What to do when your airport is overcrowded, when there are not enough runways, and when noise of planes taking off and landing is bothering the neighbours? Build yourself an airport on an artificial island in the sea. With accelerating speed since the 1980s land reclamation for new airports off the coasts of major cities has become more and more attractive. Japan did it first with Kansai airport near Osaka. Hong Kong gave up on its overcrowded airport squeezed between highrises in downtown and now has Chek Lap Kok. And now it seems all over the world, other cities are following this exciting way of providing high quality, excellent flying services.

Kansai Airport, premier airport of Osaka, Japan

The first phase of Kansai was begun in 1986 and completed in 1991. It is built on a 400 ha artificial island 5 km off the coast and is connected by a doubledecker bridge for trains and vehicles to the mainland. Expansion for the second phase of Kansai is going on now with a new runway being added scheduled to be ready in 2007.

View of the runways and bridge at the first Kansai Airport.

hauled from marine borrow pits. Sprawling urban areas also mean an increased need for improved and expanded transportation networks. Larger and safer airports on artificial islands in the sea, further away from where people sleep. The construction of new bridges, interconnecting highways and roadways, and railway facilities for both passengers and freight. These are part and parcel of the infrastructure development that modern society demands and the private dredging industry provides. Like linking islands in Scandinavia, or building a bridge over the Rio Parana delta in Argentina.

The pictures in the chapter that follow bear witness to the power, the inventiveness and the adaptability of the private dredging and maritime construction industry to meet the needs of the growing world population: space for jobs, for housing, for recreation, new land raised up out of the sea.
“Centrair”, the newest offshore Japanese airport

After extensive planning beginning in 1985, dredging works for the Central Japan International Airport known as Centrair was begun in the year 2000 and the airport officially opened in February 2005. The Central Japan International Airport is located on reclaimed land in the Bay of Ise, approximately 2 km offshore from Tokoname City, some 35 km south of Nagoya. Convenient access from Chubu’s main cities to Centrair will be achieved through the domestic air service network, the Tokaido Shinkansen (bullet train), and the Tomei and Meishin Expressways.

Central Japan Airport opened in February 2005. Planned to operate 24 hours a day, Centrair is expected to be the new gateway to central Japan.

Australian airports in the sea

The Kingsford Smith Airport in Sydney is the hub of Australia’s national and international air traffic network. The airport was first extended on a peninsula from reclaimed sand in Botany Bay in the 1960s, and again in the 1970s. But it continued to outgrow its space. In the 1990s a third runway on reclaimed land was built in the water parallel to the existing runway.

Another maritime infrastructure project, Brisbane International Airport was developed in 1985 on a swampy site north of Brisbane, the capital of the province of Queensland, Australia. Forecasts indicate that the current airport will reach capacity by 2013 and plans are now being made to construct a new parallel runway 2 km to the west of the existing main runway. The construction of the runway will require approximately 15 million m$^3$ of sand fill which will probably be sourced from Moreton Bay.

The completed third runway at Sydney’s airport which was officially opened in 1994-1995.
New site in the water for the New Doha Airport

Qatar is getting ready to build the **New Doha International Airport** (NDIA), some 4 km from the existing facility. The project started in early 2004 with a detailed planning and design phase and is continuing with a massive land reclamation project. A key feature is that 40% of the 1,700-hectare site area will be built on reclaimed land from the Arabian Gulf. The land reclamation is estimated to require about 60 million m³ of sand to be mined from the sea.

The latest in the series of airports on reclaimed land in the sea will be the New Doha International Airport, Qatar.
Flying into Singapore’s Changi Airport is always a treat

Catering to an unprecedented demand for air travel, in 1975 the government of Singapore decided to build a new airport in Changi, on the eastern tip of Singapore. Almost 200 hectares of swampland were cleared for the construction of the airport. More than half of Changi Airport’s total land was reclaimed from the sea using seven cutter suction dredgers 24 hours per day. In the process over 40 million m$^3$ of sand were reclaimed from the seabed. And this was just the beginning. Throughout the 1980s, 1990s and through to the present day, dredging, construction and expansion at Changi Airport continues at a rapid pace.
Chek Lap Kok, Hong Kong; “the dredging project of the century”

The magnitude of the maritime infrastructure work at Chek Lap Kok Airport says it all. Built to the north of Lantau Island in the 1990s, at the peak of construction 14 trailing suction hopper dredgers, 4 cutter suction dredgers, 3 booster pump stations, 7 grab dredgers and some 20 hopper barges were deployed from all over the world. In record time, a small, hilly island Chek Lap Kok was merged with the smaller Lam Chau island and was transformed into one mammoth flat platform as a base for a 1250 ha land reclamation site. The airport officially opened in 1998 and building continues. Other large-scale dredging and maritime construction works around Hong Kong will continue through 2015.
Causeways, bridges, tunnels and other ways of connecting the world

Moving people, traffic, trucks, and trains across great distances is one of the necessities of our urbanised world. Modern techniques of maritime infrastructure construction are making this easier. Creating ways of connecting otherwise unconnected landmasses. Like causeways and bridges and tunnels for road and rail traffic to compete with ferries. In the 1980s as part of the construction boom in the Middle East, a causeway was built between Saudi Arabia and Bahrain. In the 1990s parts of Scandinavia were linked up. And now South America is seeing this kind of bridge. Tunnels also have made it possible to shorten travel distances easily and safely, crossing rivers, estuaries and canals. Just a few of the dredging and maritime infrastructure solutions that bring countries and people closer together.

The Saudi Arabia to Bahrain Causeway

Construction of the King Fahd Saudi Arabia Bahrain Causeway started in 1981 and the Causeway was officially opened five years later in November 1986. This link between the two countries across the Gulf of Salwa was one of the greatest civil engineering challenges at the time. The total length of the causeway is 25 km with seven embankments having a total length of 12.5 km and five bridge sections with a total length of 12.5 km. The embankments are in general located in the shallow parts of the bridge alignment. Some 3.5 million m³ of rock, hauled over 600 km from the Emirates on barges, were used for the outer bunds of the embankments and 8.5 million m³ of sand fill. Rock and sand fill are separated by 500,000 m² of filter fabric. In addition to the sand fill for the embankments, some 5.5 million m³ were dredged and reclaimed for site facilities and the production of concrete.

View of the embankments of the Causeway under construction.

Land reclamation as the causeway takes shape.
Crossing the Rio Parana delta by road

Completed in 2002, the much-needed fixed link project between the cities of Rosario and Victoria in Argentina across the Rio Parana delta provide an essential connection for local and international transports. The two-lane road plus railway connection consists of 13 bridges and 13 embankments covering almost 60 km. Prior to this fixed link the nearest two crossings were 180 km upstream or downstream from Rosario. The new link provides an economic boost to the port of Rosario, and to trade, industry and tourism in the northeastern part of Argentina.
Bridging the Scandinavian waters

Seven thousand years ago during the Ice Age Denmark and Sweden were landlocked to each other. With the opening of the Øresund Fixed Link in 2000 they are linked again. A 17 km bridge, the world’s longest single bridge carrying both road and railway traffic, now goes from Copenhagen, Denmark to Malmo, Sweden. This replaces a 45 minute ferry ride with a 10 minute road trip.

The other monumental Scandinavian connection is the Storebælt (Great Belt) Fixed Link. Opened in 1997-98, it was the biggest construction project Denmark had ever undertaken and created a road and rail connection over the Storebælt, or Great Belt, a wide body of water going into the Baltic Sea, where thousands of cars and people were transported by ferries. It consists of the 6800 m long West Bridge extending from the large Danish island Funen to the little isle of Sprogø, and then from the east to the very large island Zealand with a traffic bridge (6600 m long) and a railway tunnel.

Taken together these phenomenal infrastructure projects are fulfilling one of the goals of the European Union: to create a trans-European rail and road network, another step towards a borderless Europe where individual countries are getting physically and economically closer to each other.
Meeting the challenge of making more land for more people

Reclamation works at Sprogø, Denmark, to create an artificial island in the Storebælt.

An aerial view of the West bridge across the Storebælt.

A closer view of one of the pylons of the Storebælt connection.

Reclamation works at Sprogø, Denmark, to create an artificial island in the Storebælt.
Maritime construction helps sink tunnels

Tunnels in the northern European countries are more a necessity than a luxury. Belgium, the Netherlands and Germany are crisscrossed by rivers. Each country has major cities as hubs in the midst of large areas of water. Sometimes bridges are a solution, sometimes because of navigational considerations tunnels make more sense.

Belgian tunnels give easy access to Antwerp

Built between 1964 and 1968, the Kennedy Tunnel under the River Scheldt linking Antwerp and Ghent was one of the first of the modern Belgian tunnels. First trenching was done for the immersion of the prefabricated tunnel elements and then backfilling to keep the elements in place. As traffic for industry and commerce at the Port of Antwerp increased, the existing tunnels between the Antwerp’s Right and Left Banks of the River Scheldt were not adequate. Planning for future industrial expansion, the Liefkenshoek Tunnel (1989) was added, making sure it could also handle dangerous goods. A large trench was dredged in which the tunnel elements would be submerged. But because of the Scheldt’s sandy bottom and strong currents continual dredging was required up to the very last hours before the actual sinking of the tunnel caissons took place.

An overview of the Kennedy Tunnel near Antwerp in Belgium.

Transporting the tunnel elements to be submerged for the Liefkenshoek Tunnel.

The tunnel elements being placed at the Kennedy Tunnel, ready to be sunk.
The German tunnel connection

The Ems Tunnel, an important connection under the River Ems in Germany, was also constructed in the late 1980s by immersing prefabricated tunnel sections into a trench dredged in the riverbed.

On the far (eastern) side of Amsterdam, the Netherlands

The Piet Hein Tunnel (1997), at the eastern end of Amsterdam’s docklands, is at 1900 m long the longest traffic tunnel in the Netherlands. Some 1250 m was made of submerged sections for which large excavation works were carried out. The tunnel is part of the continuing development of more eastern areas of Amsterdam. It is situated in the midst of several new building projects.

Work on the river bank for the Piet Hein Tunnel, on the east side of Amsterdam, the Netherlands.
Land reclamation reshapes the world

When it comes to land reclamation, “Your wish is my command” seems to be the slogan of the private dredging and maritime construction industry in the last few decades. With new techniques for digging deeper for sand, with larger vessels able to travel greater distances to borrow pits and back, and improved technologies like GPS, there seems to be no limits to what new worlds can be built.

One of the first: Abidjan, Ivory Coast

With the first large scale applications of the centrifugal pump, large sand-winning projects became possible. One of the earliest works was the reclamation works for dyke construction at the new industrial area on the Bay of Abidjan, Ivory Coast.

Japan’s expansion in the 1970s

Major reclamation works in Japan near Kawasaki in Tokyo Bay and Oita Prefecture on the southern island of Kyushu were executed in the 1970s and early 80s to develop large industrial estates. These two projects were special as for the first time sand was extracted from the seabed from depths exceeding 80 m. The deep-suction dredging technique opened the possibilities for large-scale reclamation projects in Tokyo Bay and other places where space for large land-based industrial and residential areas is scarce. Japanese and Dutch dredging companies jointly developed the heavy deep-suction equipment. The deep-suction dredger Dejima, built in 1974, was at the time the first of its kind capable of dredging in open seas, using a novel swell compensation system.
Maasvlakte, artificial land around Rotterdam's harbour

Meanwhile in Europe, expansion around Rotterdam's harbour was also going full speed ahead. The **Maasvlakte** is at the entrance to the Port of Rotterdam, located west of Europort in the North Sea. Since the 1970s an area of some 30 km² have been reclaimed. In ongoing dredging programmes, the Port of Rotterdam has made the infrastructure, terminal areas, roads, quaywalls and waterways with sufficient depth to accommodate the largest vessels. With these huge vessels came an increase in the need in the Europort area for industrial terrains for port related industries such as petro-chemical industries and liquid and dry bulk storage facilities. The huge Maasvlakte built on reclaimed land was the answer. In 1973 the first ships moored in the new port area. By 1990 the area was dotted with a mix of container terminals, liquid bulk loading and storage facilities, dry bulk transshipment, mainly coal and iron ore and a power plant. Gradually this huge “vlakte” or plain is getting fully occupied and plans are well underway to make Maasvlakte II extending further into the North Sea.

Downtown Hong Kong grows too

Part of the burst of activities in the 1990s in **Hong Kong** (besides container terminals and the new airport) was the expansion of the Central Business area. Approximately 20 ha of land north of Central were reclaimed, extending the waterfront up to 350 m beyond the then-existing shoreline and breathing new life into an enlarged Central Business District.

More land for Taiwan

The island of **Taiwan** has not been left behind in the surge in land reclamation. On the heavily populated and industrialised island many large reclamation projects are either being planned or are under construction. For instance, **Keelung Harbour** which was built over 100 years ago and has contributed to the economic development of Taiwan. The dredging programme already completed there includes the main channel, the turning basin and berths that will facilitate larger vessels. Another is the huge reclamation at **Yun Lin** for the new petrochemical plant by Formosa Plastics Group.

Numerous ships can be seen building new land in the Maasvlakte near Europort, Rotterdam.

The ever-growing waterfront of the city of Hong Kong.

Dredging and revetment work at the port of Keelung in Taiwan.
Malaysia keeps pace with its neighbours

The shores of the Malay Peninsula on the Straits of Malacca and the Straits of Johor have one thing in common. They are covered with mangrove vegetation, small meandering rivers and gently sloping muddy flats into the sea. At some places rivers are sufficiently deep to enable local fishermen to moor their fishing boats in protected inland waterways. Only a few entrances have become regular ports, such as Klang the seaport of Kuala Lumpur, Lumut, Butterworth and Pasir Gudang, with the Port of Tanjung Pelepas as the latest major port in Malaysia. Several extensive industrial sites and residential areas have been created close to these ports. Special industrial zones to attract foreign investment were realised close to the north port at Klang in the early 1980s. In 1996 an industrial development area was made near the port of Lumut. Also in the mid-1990s an enormous development scheme was created for Pulau Indah, or Splendid Island as it is translates from Malay. Near the Port Klang area, Pulau Indah comprises an integrated industrial park on 2400 ha, reclamation for roads and for the construction of a marina and residential waterfront project as well as a huge resort.

Reclamation works at Port Klang, the seaport of Kuala Lumpur.

Maritime infrastructure construction (1996) at Lumut, Malaysia.

The enormous land reclamation at Pulau Indah, Malaysia for industry, housing and recreation.
Jurong and Tuas and Singapore just keep on growing

Situated in the southwest corner of the island of Singapore, for three decades Jurong and Tuas have been the site of incredible land reclamation. Jurong started out largely as swamp lands. Gradually starting in the 1980s industry arrived, and success bred success. More industry needed more land. From then until now seven islands were amalgamated into one big island, creating an industrial estate of monumental proportions. A land development that is inextricably tied to Singapore's development into an industrial giant. Ultimately more than 1000 million m$^3$ of sand will be placed. And together the Jurong and Tuas extensions will add 1460 ha to the landmass of Singapore.
IJburg, new land for an old city

Amsterdam may be the capital of a country that is used to making its own land, but the IJburg project just north of this old Dutch city has even amazed the Dutch. Since the 1960s the demand for housing has continued to outstrip the supply and the long-term plan to provide 100,000 new homes by the year 2005 seemed impossible. Time for a novel solution to the municipal strategic policy: the IJburg. Starting with an experiment in 1995, real land reclamation began in 1998. Built on over 10 million m$^3$ of sand, the first two artificial islands have been created, houses are ready, and residents are moving in. Work on more residential and recreational islands has started.
Above and right, gradually filling in the island.

Haveneiland is ready; construction for the Steigereiland is underway.
**Clearing the air at Smokey Mountain, Philippines**

In the mid-1990s a waste site on the overpopulated outskirts of Manila, called Smokey Mountain was transformed. With reclaimed land from the adjoining Manila Bay, an area of 79 ha was rehabilitated and rebuilt into a new residential and light commercial complex. Since then the basin, access channel and other areas have also been maintained.

Smokey Mountain reclamation project is now a new residential area near Manila.

**Clean sand for clean housing at Guayaquil, Ecuador**

Subject to tidal movements and floods, whole parts of this swampy residential area of the port of Guayaquil were unsafe and unhygienic. After blowing huge volumes of sand underneath these dwellings standing on stilts, a complete suburb of this port city was cleaned up. Clean sand made new clean living quarters for some 100,000 indigenous people.

Right, Guayaquil, Ecuador, before the reclamation works; Below, dry ground at Guayaquil, after the reclamation works.
Crowded Maldives builds a new island

Cramped on a coral island cluster in the Indian Ocean? Then build yourself a new island. When the Maldives Housing and Urban Development Board called for the reclamation of an artificial island of almost 190 ha, the dredging and maritime construction industry obliged. Taking great care of the coral reefs, Hulhumale Island is the same size as the capital city Male but 1 m higher, giving the nod to rising sea levels. Male itself has built a seawall around the city for protection. With land reclamation completed in 2002, some 1,500 people have already opted to move into the first houses erected on the new island.

Artificial Hulhumale Island rises from the sea next to Male, the capital of the Maldives.

Singapore gets new residential estates too

All over Singapore maritime construction and land reclamation is visible. So too in the northeastern areas like Pulau Tekong, Pulau Ubin and Punggol where land is being created for housing and commercial estates. Always looking to the future, Singapore is preparing for increasing populations and the maritime construction industry is ready and able to help.

Punggol on the northeastern coast of Singapore is one of several reclamation areas for new housing and recreation.

Stone pitching is part of the revetment works to protect the newly developed land around Pulau Ubin.
Despite attempts to find alternative fuel sources, the *International Energy Outlook 2004* (US Department of Energy) indicates that oil still dominates our energy needs. Consider this: from 1949 to 1972 the demand for oil increased by 5.5 times in the USA, by 15 times in Western Europe and by 137 times in Japan. Fast forward to today: The world market energy consumption is projected to increase by 54 percent over the 24-year forecast horizon from 2001 to 2025.

Where is this fuel to come from? Over the last forty years, oil has been the world’s foremost source of primary energy. In the foreseeable future this is not expected to change. OPEC producers are still expected to be the major suppliers of the world’s ever-increasing energy requirements. However, non-OPEC sources should remain competitive, and offshore resources, especially in the Norwegian Continental Shelf, East Russia (Sakhalin), the Caspian Basin, Latin America, and deep-water West Africa, seem to be likely suppliers. Other recent discoveries, while relatively small, are often located in deep offshore waters or other remote locations.

Offshore platforms and submarine pipelines are essential links in bringing fuel to onshore customers. The increase in the need for platforms and pipelines means an increase in the need to protect them from scouring, and therefore an increased need for dredging – to prepare the seabed, dig the trenches, and then protect these pipelines and platforms with sand, gravel and rock to assure that they stay put in the trench or on the seabed. This service to the offshore industry can be seen along the North Sea coasts of Europe from Norway to France, in the Caspian Sea and on the Northwest Shelf of Australia. Or in the Beaufort Sea and off the coast of Newfoundland, Canada. In these colder climates dredging companies have developed specialised techniques to protect the sub-sea wells and pipelines from iceberg scour.

Given the world’s insatiable thirst for energy, and the limited existing sources of oil, it is easy to predict that new sources of energy will have to be found. Liquefied natural gas (LNG) in particular is becoming more attractive and creating infrastructure demands of its own. LNG plant facilities and ports are growing as the number of LNG carrier vessels increases daily. The expectation is that the specialised fleet for LNG will continue to grow substantially in the next few years. And that the ships will be equal in size to some of the newer very large container ships. Which means a need

Shore approach dredging using a sea-going trailing suction hopper dredger.
Oil, gas, wind: energy for now and the future

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for new or deepened harbours and berths as well as for safe storage areas far from urban centres, for instance, on offshore artificial islands.

No discussion of energy is complete without mentioning alternative sources. These “green” renewable energy sources are being avidly sought. And here too the capabilities of the private dredging industry will be utilised. Wind farms, for instance, are most often placed at sea on pylons or on artificial islands, where maritime construction is required to ensure their stability and safety.

Clearly the techniques of dredging and maritime infrastructure construction are essential to the energy industry. The projects that follow illustrate just a few of the many where the private dredging and energy industries have worked as partners to keep the engines of the modern world running.

The innovative NorFra pipeline system

In 1995 Norway and France agreed to transport natural gas from the Draupner riser platform to Dunkirk on the northern coast of France. The NorFra transportation system comprises a 42-inch diameter, 835 km long high pressure natural gas pipeline of which 575 km had to be buried in the seabed to prevent damage from shipping traffic, anchors and fishing nets.

Using the most up-to-date equipment, offshore pre-sweeping and seabed levelling; pre-trenching in stiff clay; dredging, backfilling and civil works related to the shore approach, beach crossing and pipe pull at Dunkirk were all accomplished safely and securely in record time. At the time NorFra was considered to be the world’s longest submarine pipeline. Delivery of gas to France began in July 1998.
Submarine pipelines bring gas and oil all over Europe

The oil crisis in 1973 launched the search for resources beyond the Middle East, for instance, in the North Sea off the coast of Norway. And indeed enormous discoveries of oil and gas were made. Their impact on European energy supplies has been intense. Instead of dependency on Middle Eastern oil and gas, Europe has had its own supplies. In fact, Norway is sitting on approximately half the remaining reserves of oil and gas in Europe. Norwegian North Sea pipelines go to England, Germany, Belgium and France. What’s more this oil and gas does not have to be transported overland. Submarine pipeline transportation has proven far more cost-efficient.

Much has already been accomplished, like Zeepipe, Europipe I and II, and the NorFra pipeline and in July 2005, Ormen Lange. Some 6600 km of offshore pipelines have already been laid.

From Norway to Belgium via Zeepipe

One of the first North Sea pipelaying projects, Zeepipe, stretches along the Belgian Continental Shelf from the Norwegian gas field Sleipner more than 800 km to Zeebrugge, Belgium. Risky and complex, the project required a year of thorough preparation before the work began. But once started, the pre-sweeping, preparing the seabed, and trenching was accomplished in only four months from March through July 1991. Following that, the pipeline was laid, and then precise and careful post-trenching and backfilling commenced to complete the job.

An artificial peninsula with cofferdam structure was created to allow safe shore approach and pipe pulling.
From Norway to Germany via Europipe

Going 670 km from the Draupner riser platform in the Norwegian North Sea to Emden Germany, Europipe I passes through the protected coastal wetlands of the Wadden Sea National Park. A highly sensitive ecological area, the pipeline had to cross sandbanks, tidal mudflats and coastal dykes with the minimum of environmental disturbance. Ninety ships were involved in dredging, pipelaying and backfilling work through the near-shore zone. Deliveries of gas officially began in October 1995.

At the same time an additional length of pipeline was laid which was connected later to the rest of the Europipe II trunkline. This meant that an important requirement for expanding gas transport capacity to Germany was already in place. The 42-inch Europipe II gas trunkline runs for 660 km from Kårstø north of Stavanger to Dornum on the German coast. Deliveries through the line began in October 1999.

Transmediterranean gaslines

The 2200 km TransMed pipeline was laid in the mid-1970s from Algeria through Tunisia to Italy. In the past decade, shore approaches for the TransMed pipeline between Tunisia and Italy and for the Gibraltar crossing between Morocco and Spain have been safely and precisely laid. With North African gas resources increasingly supplying the European mainland, especially Italy, in July 2005 new pipeline construction between Sicily and Libya was performed.
**Bacton to Zeebrugge energy connection**

Opened in October 1998, and stretching from Bacton in eastern England to Zeebrugge in Belgium, the Interconnector can carry some 20 billion cubic metres of gas per year from the UK to Continental Europe and as much as 8.5 billion cubic metres the other way round. The construction of the Interconnector demanded trenching, backfilling, construction of a landfall and onshore pipelaying.

![Image of Bacton to Zeebrugge energy connection](image1)

The Interconnector is a flexible energy link between the UK and continental Europe.

**Ormen Lange gas field**

**Ormen Lange** is the second largest gas discovery on the Norwegian Shelf and, at water depths ranging from 850 to 1100 m, the first deep-water project there. To secure and protect the pipelines on a highly uneven seabed, rock installations are imperative. Some 2.8 million tonnes of rock transported from quarries along Norway’s coast will ultimately be placed on the seabed by means of a flexible fallpipe method. Work began in 2004 and will continue through 2007.

![Image of Ormen Lange gas field](image2)

Artist’s rendering of rock bunds as pipe supports on the very deep seabed.

![Image of Artist's rendering of flexible fallpipe](image3)

Artist’s rendering of flexible fallpipe.
Re-trenching an old gasline: the Eems sinker

After 30 years on the riverbed between Germany and the Netherlands, the strong currents had a powerful scouring effect on the Eems sinker pipeline. Extreme precision and extraordinary safety measures were necessary to lift up a 500-m section of “live” gasline that was being exposed, and retrench the area and lay it down again. And to do all this without interrupting the energy supplies to Eemshaven’s power stations and the Dutch gas grid.

Support frames held the pipeline while a new and deeper trench was dug.

A close-up of a backhoe working with extreme accuracy to deepen the trench crossing the Eems river.
An offshore pipeline linking north and south Taiwan

Northern Taiwan had a structural shortage of gas; and southern Taiwan had the supplies. Given the predictable difficulties of installing an onshore pipeline through one of the most densely populated coastal plains in the world, Taiwan choose to lay an offshore pipeline from Yung-An, the LNG terminal in the south, to Tung Hsiao halfway up the coast.

The cutter suction hopper dredger at work for the shore approach off the coast of Taiwan.

Deep-water gas from Malampaya to power Philippines

The Malampaya Field Development, a joint undertaking of Shell, Chevron-Texaco and PNOC, serves to produce natural gas for the Republic of the Philippines. Marine installation related activities were executed in 1999 and 2000 and included dredging and seabed preparation, scour protection at 43 m below Chart Datum and the tow-out and installation of the massive 90,000 tonne concrete gravity structure 50 km offshore. From the platform, a 504-km-long pipeline required support berms as well as a stone protection layer. At the end of the line a landfall was made at Batangas. To form the level foundation for the platform and protect the pipeline, large amounts of stone were placed using a high precision flexible fallpipe technique. Gas production started in January 2002.

The tow-out of the massive 90,000 tonne concrete gravity structure for the Malampaya gas field.
Bringing gas from Indonesia to Singapore

Following an agreement between Pertamina, Indonesia’s National Oil Company, and Sembawang of Singapore, the West Natuna Transportation System was begun to supply gas from the Indonesian West Natuna gas fields to Singapore’s industrial complexes. Traversing very rough seabeds with coral and rock outcrops, the 28-inch diameter trunk line, 600-km-long, high pressure gas pipeline required significant seabed rectification works. Over 300 rock supports were laid and over 21 km of pipeline were covered with rock armour. Trenching took place and rock was placed at depths up to 60 m. At about the same time, gas pipelines were laid between Sumatra, Indonesia and Singapore for PowerGas, the sole gas transporter and system operator in Singapore. For some 9.6 km submarine pipeline trenching and placing of protective rock armour were executed in a period of nearly four years. Similar work for another 17.5 km of pipeline was done for the Indonesian PT Perusahaan Gas Negara (PTP GN) in the Indonesian waters bordering Singapore.

Next generation of oil and gas at Sakhalin, Russia

Launched in 1996, Sakhalin II is a world-class oil and gas project off the coast of Sakhalin Island, in the Russian Far East. During Phase 1 in 1999, oil production was begun. Now with Phase 2, the most technologically advanced project on the Sakhalin Shelf, Russia’s first LNG will be exported to the growing economies of Asia. Trenching, backfilling and pipelaying are being done for the 800-km-long pipelines connecting the Luskyoye concrete gravity base structure (CGBS) production platform, located 15 km off the northeast coast of Sakhalin Island, for onward transportation through the onshore pipelines to the LNG plant at Prigorodnoye at the south of the island. The Sakhalin II development represents the largest foreign direct investment project underway in Russia.
Fighting the elements during oil exploration in Canada

Exploration for oil and gas in the icy waters off the Pacific and Atlantic coasts of Canada have presented their own interesting challenges over three decades.

Artificial islands and helipads in the Beaufort Sea

Spurred on by the 1973 oil crisis, areas that had earlier been considered too remote, inaccessible or nearly impossible to operate with economic feasibility, became attractive exploration areas. In addition to the Norwegian North Sea, the Beaufort Sea, part of the Arctic Ocean above the Yukon, was one of these. But heavy floating ice during some 8 months of the year limited activities to only 3 or 4 months a year, insufficient time to complete the drilling of 5000 m boreholes. Temporary solid artificial platforms were required to enable drilling on a continuous basis and small artificial islands were built in shallow waters within 25 km from the shoreline. These islands were built partly in wintertime when the bulk of the sand fill was transported over the frozen sea. When exploration islands at a distance of some 100 km had to be made, sand had to be transported and discharged by trailing suction hopper dredgers. To enable the dredgers to operate 5 months instead of 3 months under Arctic conditions, drastic modifications to the vessels were made to keep them from being crushed by heavy ice. In addition heli-pads were constructed on the vessels to enable crew changes and the supply of food in case the ship got stuck in the ice.

Glory holes for the Canadian White Rose Project

At most offshore gas and oil installations, wellheads and manifolds installed on the seabed are protected against fishing trawlers by a steel structure. For the White Rose Oil exploration in the northern seas, off the eastern Canadian coast, 350 km southeast of Newfoundland, where icebergs are a serious hazard, glory holes offer a solution. A glory hole is an artificial depression in the seabed in which the wellhead and manifold are placed to protect it from ice keels of pressure ridges formed when two floes collide and the ice edges are crushed. This demands extensive and precise excavation works in difficult frozen seas at depths of −120 m.
Finding oil in the extreme climate of Kazakhstan

Important large oil and gas reserves are present below the Caspian Sea in Kazakhstan. In 1998, a consortium of eight large oil companies joined forces to explore these reserves. To conduct these explorations an artificial island was built by placing geotextile fabric on the seabed, topped with gravel to ensure a sufficiently flat foundation for the drilling equipment. Protection against ice and waves was constructed by building an 8 m wide armour rock berm around the core. Working in an environmentally sensitive area, with freezing Siberian winters, and incredibly hot summers is a challenge. But the exploration of the Caspian Sea deposits is of vital importance to the economic betterment of the people of Kazakhstan.

Hot time at the Ras Laffan, Qatar, LNG port

Strategically located at the center of the Arabian Gulf on Qatar’s huge North Gas Field, Ras Laffan Industrial City is a fast growing industrial export location. The North Field is believed by some energy experts to be the single largest non-associated gas field in the world. Discovered in 1971, it covers over 6000 sq km and it is believed to have 20% of the world’s proven gas reserves. The expansion of the Ras Laffan LNG harbour in Qatar in the 1990s for Rasgas, which included dredging and land reclamation, was clearly essential.

Maintaining the LNG port at Skikda, Algeria

The long history of the Port of Skikda, Algeria has a new modern twist. In the 1970s the port was transformed into a mixed port with the inclusion of several oil jetties. In 1981, adjustments were made to increase the harbour’s capacities. Since then the port has never ceased to perform and plans to develop it through 2015 are on the table. Skikda accounts for about a quarter of the LNG from Algeria, the world’s second largest LNG exporter after Indonesia and one of southern Europe’s main gas suppliers.
Richards Bay, Coal terminal, South Africa

Although Commissioner Henry Cloete was not impressed in 1843, when he surveyed the Mhluwe estuary and found it to have little or no potential as a future harbour, today Richards Bay is South Africa’s premier bulk port. Built in 1976 for the export of coal, it has since expanded into other bulk and break bulk cargoes. In 1986 another round of major dredging works were undertaken to further expand the harbour. In less than 30 years the port has handled over 1 billion tonnes of coal, serving major power stations, steel mills, cement plants and heavy industries around the world. In 2004 the port handled 85 million tonnes of cargo. A dedicated railway line links the port with Mpumalanga Province and Gauteng, from which area most of the country’s coal exports are handled. 200-wagon trains deliver coal on a non-stop daily basis.

The many ships at work in Richards Bay, South Africa in 1976.

The new coal port at Ennore, India

On the eastern Coromandel coast of India, 20 km north of Chennai, plans for a new harbour at the small village of Ennore were developed in the late 1990s. The Ennore Coal Port including the port basin and entrance channel were excavated and extensive harbour development was supported by the Asian Development Bank. Envisaged as a satellite port to decongest and improve the environmental quality at the bustling Chennai Port, since its opening in 2001, Ennore Port has evolved into a full-fledged port with the capacity to handle a wide range of products.

A cutter suction dredger vessel working in 1999 at the developing Port of Ennore.
The oil and gas fields of Nigeria

In the heart of the Niger delta is the home of the Nigerian oil industry. All types of dredging, land reclamation, shore protection as well as pipeline and mechanical installation projects are necessary to maintain and explore this important part of Nigeria’s valuable economic resource. In addition, in 2002 work was begun for the Escavros gas to liquid plant project, and the necessary maritime construction activities, for shore approaches and trench digging were undertaken.

Windmills return to Europe’s horizons

They don’t look like the famous windmills of yore that dotted the European landscapes, but the modern versions are providing a sizable amount of renewable energy. More and more often, instead of being placed on land, these elegant wind turbines are being located offshore. The expertise of the private dredging and maritime construction industry is then necessary to install the turbines as well as to provide erosion protection for the cable positions and platforms. Denmark’s Horns Rev Offshore Wind Farm became operational in 2002, with 80 turbines. Other wind farms at Samso in Denmark, Utgrunden in Sweden and Thorntonbank off the Belgian coast have utilized the services of the dredging industry. Ireland’s first offshore wind project, the Arklow Bank Wind Park, located 10 km offshore, became operational in 2003, with future plans for some 200 wind turbines. And other plans for renewable wind energy are blossoming all over the world.
When the Port of Le Havre made plans for expansion in 2000, it also made plans for *Ilot Reposoir*, a bird sanctuary. When Hong Kong’s Chek Lap Kok Airport was being built, the corner of the island where the turtles nest, was carefully preserved. These environmental stories are not the exception. In today’s dredging and maritime construction industry, they are the rule.

Sustainable development. Renewable energy. Remediation. Over the last four decades, dredging companies, like society as a whole, have become more environmentally conscious and responsible. Environmental impact assessments and site investigations are routine procedures preceding any maritime construction. Abiding by international treaties like the London Convention and the OSPAR Convention, by the environmental requirements of the World Bank and European Union, as well as myriad local and regional agreements goes without saying.

But contractors are not just abiding by rules and regulations. They are actively seeking unique techniques to solve difficult environmental problems. Research and development of new types of dragheads, more precise equipment to limit turbidity. Elaborate planning for maritime projects takes into account the seasonal migration of birds, fish and whales. Especially careful methods are implemented when working near coral reefs. This, in fact, only describes the ecological mindset regarding nature. In older cities, remediation from pollution caused by the industrial era is a top priority as well.

“Pollution must be stopped at source” is the basic premise, but sometimes that’s not enough. When the damage has already been done, remedial excavation is often the solution to persistent contamination problems. Take for example, the River Rhine which winds through several European countries and lands up in the Netherlands at a large internal lake called the Ketelmeer. For decades, industrial pollutants from factories along the Rhine and IJssel settled there to form a thick layer of contaminated sludge. With studied dedication, pilot projects were conducted by dredging companies to clean up a mess they didn’t create. And they succeeded, making the Ketelmeer depot probably the world’s largest and most technologically advanced environmental dredging project to date. Other such essential environmental dredging projects are the construction of outfalls, kilometres out to sea, ensuring that clean wastewater is discharged faraway and can cause no health risks.

In emerging nations like Bangladesh or Ghana, good care of the waterways can also have dramatic ecological and economic impacts. Clean and controlled rivers can mean the difference between life-threatening floods and droughts, and a healthy river that ensures good hygiene, safe water for drinking, bathing and fishing. Balancing economy with ecology is the bottom line. Part of that is finding beneficial uses for dredged materials.

Interested people line the river banks of the Gorai to watch the dredging works.
Restoration of the Gorai River,
Bangladesh

For several decades, the Gorai River, a branch of the Ganges in Bangladesh, was drying up, causing difficulties for the people living along its banks. Sand deposits were increasing as was the water’s salinity. This led to harmful environmental conditions, including the destruction of a mangrove forest at the river’s mouth and the lengthening of the dry season. Because the drought was having catastrophic consequences, a dredging project was instituted to try to reverse the situation. As a direct result of this intervention, water is flowing once again through the Gorai, even in the dry season. Villagers use the waters of the Gorai to wash clothes and bathe, and children are playing in its streams. Fish are plentiful as the salinity has been reduced. Boats can be sailed all year round and so goods can be brought from village to village. The restoration of low-water discharge has established the prerequisites for an enduring development. The certainty of sweet surface water all year round creates the basic condition for future irrigation development for agriculture. Surface water also means that with the installation of water purification facilities the river can be used as a source of drinking water. Since the groundwater in Bangladesh is contaminated with arsenic, while the surface water is not, this could be a great boon to general public health.

A cutter suction dredger moving sand to improve the flow of the Gorai River.

Efforts are ongoing to find alternatives for disposal and to utilise clean dredged material for environmental enhancement, habitats and flood defence. In recent years the emphasis has shifted from direct disposal to managing relocation to creating safe confinement areas and dewatering lagoons. As a result, many beneficial use options have evolved where dredged material is regarded as a potential resource for landscaping. Where it can be used to recharge or recreate inter-tidal habitats such as mangroves, estuaries, coastal areas and wetlands.

A look at the projects that follow shows how dredging and maritime construction projects are an essential tool for creating a positive synergy between ecology and economy, for achieving sustainable development, for making the world greener and cleaner.
Remediation of Lake Tunis, Tunesia both North and South

One of the most significant environmental projects undertaken in the southern Mediterranean is the restoration of Lake Tunis. The project has taken two decades to be realised. In 1984 the first plans were made for the remediation of the pollution and stagnation of the shallow North Lake of Tunis and land reclamation for the expansion of Tunis City. With the construction of specialised circulation and pumping systems, the eutrophication of the northern part of the lake was reversed. This laid the groundwork for similar maritime construction to reverse contamination in the South Lake. More than a decade later, in 2000 the clean-up began of the South Lake which was suffering from severe contamination from industry and wastes. Part of the contract was to continue maintenance for 2 years and monitoring for 5 years. Situated in the middle of an urban hub, the restoration of the lake and of water quality were urgent efforts to improve the living conditions of the citizens of Tunis City. In the South Lake some 900 ha were reclaimed to provide public green areas and land for more than 20 thousand apartments.

Korle Lagoon ecological restoration, Ghana

Situated in Accra, the capital city of Ghana, the banks of the Korle Lagoon are densely populated. This caused a multiplicity of problems. Lack of sanitation resulted in heavy pollution, and frequent flooding during the unusually heavy rainy season resulted in unhygienic and unhealthy living conditions, as well as drowning of dozens of people who were swept into the murky waters. A two-year project from 2000-2002, representing numerous disciplines of dredging and maritime construction, such as dyke building, canal digging and constructing a barrage and an outfall, have remedied the dangerously polluted and uncontrollable waters of the lagoon. The new sanitation of Korle Lagoon has drastically changed the social situation for the citizens of Accra and has even saved lives.
Marine pollution in Izmir Bay, Turkey

The River Melez flows into Izmir Bay, one of the largest and most enclosed bays on the Aegean coast of Turkey. The Bay is amongst the most productive water bodies on the Turkish Aegean coast. In the past, the quality of fish caught there was highly valued. In addition prime agricultural areas existed along the northern shores of the Inner Bay and the Middle Bay. But urbanisation and untreated wastewater from industries located along the Arap and Melez Rivers carry pollutants to the Bay. In 1987, a dredging regime was instituted to improve the river flow and clean industrial wastes.

Ecological restoration at the bay of Arcachon, France

A peninsula of sand dunes separates the bay at Arcachon, France from the Atlantic Ocean. On the southwestern side a number of shallow tideways form an open connection with the ocean. As part of a programme to restore the ecological balance in the waters, the fairway channel of Le Cheval de Piquey was deepened in 2003. More sand was removed in 2004 from the Banc Jan Blanc; and in 2005 the access channel was widened. To avoid disturbances to breeding birds and the oyster beds, all work was done between October and March.

Strict environmental standards were observed during all restoration work at the Bay of Arcachon.
Port and harbour rehabilitation in western Europe

Ports are an essential element in the economic story of all coastal countries. They are responsible for goods, services, jobs and a constant stream of activity. They can also be the source of pollution, noise and irritation with the surrounding environs.

The Port of Delfzijl

A typical example of a small regional port, Delfzijl developed over time. The town is located in the northeast of the Netherlands, facing the Dollard-Ems basin, close to the Wadden Sea, a protected area and the most important tidal wetland of Europe. In less than 100 years the small port was not so small any more, growing gradually with industries and shipyards in the area. The latest port extensions were planned in such a way that detrimental effects of port operations for the close-by sensitive nature reserve were limited. Carefully dredging the top layer of polluted material cleaned up the harbour. The harbour entrance was relocated to minimise siltation and sedimentation inside the basin. Old industries were made more environmentally friendly.

The Port of Hamburg

As part of the reconstruction and remediation at the Port of Hamburg a confined and unused harbour basin called Rodewischhafen was used to store fine-grained and contaminated dredged material from Hamburg Harbour. Extensive studies determined that the subaquatic confinement provides a safe storage area for the sediments of the harbour.
Docklands in Dublin, Ireland remediation

Remediation of industrial sites like the Dublin docklands often requires an integrated approach, in which engineering, civil works, geohydrological works, and scientific background are combined. The remediation of derelict sites often requires the combination of several techniques like excavation, in-situ treatment, ex-situ treatment and isolation. After clean-up redevelopment of the area is often an attractive option. Recently a complete clean-up and sanitation of a former gas plant in the Dublin docklands was successfully undertaken.

Restoration of the precious Ria habitat in Avilès, Spain

An environmental clean-up operation in the old heavily industrialised Asturias region of Spain, has turned a contaminated sedimentation basin of a river mouth into an inviting urban green space for the Spanish coastal town of Avilès. The project has restored sound ecological conditions in the sensitive Ría Avilès habitat. The rías of northern Spain are protected tidal inlets, very much like the abers in Brittany or some parts of the big estuary systems along the North Atlantic coast of France and the Low Countries. Some ría’s support very productive ecosystems, which have led to major economic activities such as mussel farming. However, since they provide very good shelter from the ocean as well, important harbour facilities have developed which in turn caused massive pollution. Over the past decades, the Ría Avilès has degraded into an open sewer in between the 90,000 people city of Avilès on the left bank, and a cokes and steel factory and a power plant on the opposite bank. The rehabilitation of this industrial area, required intensive study of the chemical composition and careful treatment and disposal, but it was an important step in converting a brownfield into a clean safe area.
The greening of Belgium’s waterways

With the passage of time, society’s pursuit of industrial advancement has been brought into balance with its need for a cleaner environment. And the private dredging and maritime construction industry has embraced this attitude, applying their skills to an innumerable number of projects.

In Belgium, as elsewhere, new techniques for cleaning dredged slurry from canals and ports are continually being sought. This slurry is often contaminated with heavy metals from urban, industrial and agricultural waste. Sometimes this has meant the development of innovative dredge heads. Sometimes this has meant extensive laboratory studies and modelling. Several ongoing projects are related to the maintenance and clean-up of the River Scheldt and other Belgian waterways. Artificial lagoons and dewatering sites have proven to be an excellent way of disposing of contaminated sediments and, for the material that can be cleaned, re-using it for beneficial land enhancement projects.

For instance, the Kallo Lock connects the Scheldt with the Left Bank of Antwerp Harbour and is a place of accumulating sediment. Recycled soil from the access channel at the Kallo Lock and the adjacent harbour area is now being used for landscaping. Also part of environmental management programmes is the lagooning field at the Ruisbroek site near Brussels, used to process sediment from Brussels port. Other Belgian sites for lagunation, dewatering and sediment treatment facilities are located at Krankeloorn, Couillet and Tubize, to name a few.

Another area for the disposal of dredged material which was developed in the...
1990s, is Fasiver, near Ghent. Here a 42-ha deserted black-point site that was already severely contaminated from industrial overuse was first sanitised, then a confined disposal area was built, and finally a sludge treatment centre with dewatering lagoons will be used to create a greenbelt. An example of ecological and dredging ingenuity: remediating this industrial wasteland into a new useable industrial zone surrounded by a beautified greenbelt.
**Controlled storage of contaminated materials in Rotterdam**

Some 20 or more years ago, industries along the River Rhine and its tributaries, from Basel, Switzerland to Rotterdam the Netherlands, used the river’s water for their production processes. And then pumped it back into the river, often untreated. Luckily, those days are the past. But the polluted sediments in the delta, in the harbour basins and waterways, did not just disappear. The solution for the problem was found in the construction of large disposal sites, on existing land and on newly created man-made islands. One of the first such sites in the Rotterdam Port area was the Papegaaienbek, for the disposal of heavily contaminated dredged materials. The depot has an area of 29 ha and a storage capacity of 1.2 million m³. In 2005 it was decided that the Papegaaienbek would be closed and the contents moved to the far larger and newer depot area of the Slufter. The Papegaaienbek served in many respects as a rehearsal site for the Slufter, which was built in 1986-1987. With a storage capacity of 150 million m³, the Slufter was at the time by far the largest storage depot for contaminated dredged silt in the world. The basin is located at the entrance to the Port of Rotterdam, facing the North Sea. The 2.6-million m² basin is 29 m deep and has a surrounding dam up to 28 m high.

The Slufter facilities include cleaning and extraction plants, so the dredged material can be prepared for beneficial uses. Some of the pollution from the River Rhine bypassed Rotterdam and took a more northern route, carried by the waters of the River IJssel, a branch of the Rhine, that ultimately streams into Lake Ketelmeer. The bottom of the Ketelmeer was covered with a layer of contaminated silt, on average some 50 cm thick. There were serious threats that the much larger Lake IJsselmeer would also become contaminated and pollute the groundwater. The depot IJsselooog (IJssel-eye – the depot is perfectly round) was constructed to create a safe storage space for the contaminated silt. The work started in 2000 and was completed in 2002. Once the clean-up was done, it became possible to deepen the fairway of the Ketelmeer, providing access to the River IJssel for larger ships with a greater draught. Deepening the navigation channel also benefited the environment, by shifting road transportation to cleaner waterway transportation. The deepening of another nearby waterway, the fairway Amsterdam-Lemmer, supplied the material to realise a 70 ha large bird sanctuary De Kreupel, in addition to the 800 ha large wetlands nature reserve IJsselmonding further to the east.

The Slufter, with a storage capacity of 150 million m³.

The Papegaaienbek (Parrot’s Beak) was a rehearsal for the larger depots that followed.
IJsseloog: It was discovered that the circle is the safest shape for a storage depot.

The mouth of the River IJssel is now surrounded by a nature reserve of wetlands.
Habitat restoration, waste disposal and how to solve two problems with one...

Under the name “Port 2000” the Port of Le Havre (France) has realised a major port extension, including the construction of a new container terminal. Part of the “environmental compensation package” of the project is the creation of a bird sanctuary on a newly reclaimed island Ilot Reposoir, at the site of the sandbank Banc du Ratier. Le Havre is at the mouth of the River Seine. Upstream, but still influenced by the tidal movements, there are many silt banks in the river – a great habitat for all types of special fauna, as long as the banks are under water at high tide, and above water at low tide. But because of the steady accrual of sediments over many years the silt banks had risen above the high water line, and did not get immersed any longer. Result: a dying off of many of the rarest species. In order to save the vitality of the silt banks a number of measures were taken: new dams were built to guide the river currents, a storage depot for dredged silt was constructed, and the pillars of the nearby bridge Pont de Normandie were strengthened to withstand the force of the new currents.

Silt banks at the Pont de Normandie in the River Seine. (Port Autonome du Havre)

Tokyo’s solution for waste disposal

Not unlike other large cities with millions of inhabitants, Tokyo, Japan struggles with a severe waste disposal problem. This although the technology of compressing waste or otherwise minimising it, has made great progress in Japan in the last decade. The Shinkaimen Offshore Disposal Facility, constructed in Tokyo Bay, offers a unique solution: storing the waste in several different compartments, each for a different type of waste.

Shinkaimen Offshore Disposal Facility in Tokyo Bay.
Singapore has a solution too

The Pulau Semakau Offshore Landfill, 8 km south of Singapore, is very similar to the Tokyo Bay project, and born out of the same need to store waste. The offshore disposal area links two islands, Semakau and Sakeng, via a 7-km bund enclosing 350 ha. Part of the project, executed in 1995-1999, was to restore the natural ecology by replanting mangroves over a large area. And the mangroves are indeed flourishing.

The Besos Outfall in Barcelona, Spain

In 1994 one of Europe’s largest outfalls was installed in Barcelona, Spain. Following EU guidelines, the Besos outfall was placed in a 55 m deep trench, that stretches 8 km into the sea. The cleaned-up effluent from a primary treatment plant is released at great depth, so as not to disturb the swimming waters.
TIME OUT FOR FUN: OF BEACHES AND BOATS

Consider the strip of land less than five kilometers wide stretching along the entire Spanish coastline: it represents merely 7% of the entire landmass of the country and yet it is occupied by a permanent population of 35% of the inhabitants of Spain. This population rises to 80% in summer, with the Spanish people drawn to it by the sun, sea and sand. And that’s not even considering the large number of visitors from abroad.

From the Gulf of Mexico to the Mediterranean Sea to the Emirates to Australia’s Gold Coast, tourism in or near water attracts millions of visitors annually. With air travel more accessible, beach holidays in faraway places have become a realisable dream. Amongst the most popular destinations for vacationing are the British Virgin Islands, Macao (China), as well as a large number of small island states in the Caribbean and the Pacific, Hong Kong and the United Arab Emirates. Additional destinations such as Cyprus and Malta as well as the coasts and islands of Spain, France, Italy and Greece provide millions of tourist with holiday relaxation. New areas of recreation and fun in the sun can be found in Dubai and its latest, enormous, artificial island building efforts.

This water-related tourism has become an important source of national income for many countries. For emerging nations it is an essential instrument of economic and social development. To appreciate the importance of tourism globally consider the forecasts of the World Tourism Organisation that 1.6 billion tourists will visit the world’s leading destinations by 2020, spending hundreds of millions of euros each day. Such financial forecasts place great emphasis on the economic basis of tourism, and key components of tourism are sun, sea and sand.

Yet no matter how much real estate development takes place along our coastlines, beaches are part of a natural cycle, affected by storms, hurricanes and simple erosion. Restoring, replenishing and repairing popular beaches, and even creating whole new beaches is an essential activity of dredging and maritime construction. Land reclamation for other areas is important too, for instance, for major tourist resorts and amusement parks like the Disney theme park in Hong Kong and the elaborate Laguna Gamagori resort in Japan.

Speaking of which, resort areas like Gamagori and Dubai also need marinas and yacht harbours. But when it comes to “boating” nothing tops the building boom in the cruise industry. Magnificent multi-story million-euro cruise ships are now being readied faster than you can count them.

Bridgetown Port, Barbados, during the deepening operations.
Barbados: cargo and cruise simultaneously

In the early 2000s, several Caribbean countries have undertaken port enhancement projects to attract the new larger class of cruise ships. Barbados is one of these. In the spring of 2002 the Bridgetown Port upgraded its cruise ship facilities with the dredging of the inner basin (to 11.6 m deep), and of the turning circle and entrance channels. The project proceeded under a rigorous environmental monitoring programme, to ensure that the oceanographic and sediment processes, the water quality and the marine communities were not compromised. Sediment from the dredging was used to reclaim 3.6 ha of new land, where additional berths for cargo were planned. The new reclaimed area allows the port to handle cargo and cruise ships simultaneously.

Hard as a rock: Freeport, Grand Bahama

The booming Freeport harbour with more than 25 ships a day coming and going certainly needed expansion. But the rock layers of Freeport’s harbour are so extremely hard that the job was almost impossible. To attack this rock, a new type of cutting head had to be invented. With determination, the cruise ship port was effectively deepened to –16 m in 2004.

This trend in leisure-time cruise tourism is expected to show double-digit growth in the near future. With more than a 1000 rooms and able to accommodate more than 3000 passengers, “mega” cruise ships or “floating skyscraper hotels” are looking for homeports and romantic destinations. As with the trend for super-sized container-ships, the acceleration in the size of cruise vessels has pushed the envelope in developing cruise ship harbours. Harbours that are deep enough and quays that are long enough to handle these luxurious tourist attractions.

Tourism, and nowadays eco-tourism, is a major economic and social force with far-reaching implications. Looking at the photographs of the new beaches and cruise harbours created in the last few years will probably make you start planning your next vacation. Just don’t forget to say “thanks” to the private dredging and maritime construction industry.
A new second pier for Antigua’s St John Harbour

The development of cruise tourism in the Caribbean over the past two decades has been spectacular. What was considered a large cruise ship twenty years ago is rarely seen today. Ships of 15,000 tons carrying 700 passengers have been replaced by mega ships of 140,000 tons carrying 3500 passengers and 1000 crew. These new ships offer their passengers almost all the amenities they require, from theme bars to wall climbing and even ice-skating. The food on board is as good as you can get in any of the world’s better restaurants. In order to cater to the requirements of these ships, an expensive infrastructure must be in place. Antigua, blessed with one of the best natural harbours in the region, invested in its future by bringing its facilities up to par. In 2001-2002 St John’s harbour was dredged to a depth of 11.6 m, the entrance channels were widened, the turning circle deepened so the ships can manoeuvre, Heritage Quay refurbished and extended. A whole new quay was built off Redcliffe Quay so that four large ships can now be berthed downtown.

Extension of Port de la Condamine, Monaco

A large multi-level floating dyke was constructed as part of the extension of the Port de la Condamine in Monaco. The dyke will be used for parking cars and the mooring of yachts. Long 352 m, the dyke is attached to the seabed with anchors, perpendicular to “the Rocher de Monaco”. At the junction of shore and dyke a large concrete caisson has been placed on a backfill of stone. For this precision work a dynamic positioning tracking system was used.

How does one operate a dredger in Monaco’s old port? Very carefully...
Renovation of St Maarten’s harbour facilities

Philipsburg, the capital of the Dutch part of St Maarten, is four parallel streets squeezed between Great Bay, where the cruise ships dock, and Salt Pond, where salt was made many years ago. The picturesque Creole houses on the shore have been restored, providing arriving boats with a glimpse into the island’s past. The larger hotels sit at the edge of town or just around the rocky promontory that separates Great Bay from Little Bay. Being one of the Caribbean’s leading cruise destinations, with over 800,000 cruise visitors a year, was reason enough to upgrade the harbour so that cruise ships could tie up at a new terminal. New port development started in 1998 by dredging a new 10 m deep basin and reclaiming some 1.2-million m³ harbour front area. Container and other cargo facilities were erected. Sand from the dredging was used to replenish Great Bay beach and a boardwalk was built running essentially from Greenhouse Restaurant to the Captain Hodge Pier in the center of town. In the summer of 2004, the boardwalk was extended and Front Street was beautified, adding trees and eliminating parking.
Nourishing beaches from the Mediterranean to the Atlantic to the Gold Coast of Australia

Lapped by the Mediterranean Sea and the Atlantic Ocean, Spain boasts over 1800 km of wonderful beaches in a wide range of landscapes and settings. Its natural wealth and benign climate encapsulate important ecosystems in terms of both flora and fauna. These great features come with demographic consequences. As it is, the narrow strip of 5 km wide along the Spanish coast, which represents no more than 7% of the country’s total land area, is home to 35% of its total population. And in the hottest part of the summer 80% of the Spanish people head to the sea to cool off. This means that the quality of Spain’s beaches is a major factor in the economic and social life of the country. A good reason to take stabilising measures in defence of the beaches, for their regeneration and improvement. Since 1988, nourishment with dredged sand has been found to be the solution in recovering various beaches that were in the process of disappearing. Amongst the nourished beaches were Maresme Beaches (Barcelona Province, 1993-4), Calafell and Vendrell Beaches (Tarragona Province, 1993), Victoria Beach in Cadiz (1991), and earlier the beaches of Malaga (1990) and Alicante (1991). Later beach regeneration projects took place in Mallorca and Huelva, and at Playa de Zurriola in San Sebastian.

Repairing the damage done by a storm at the beach of Huelva, northwest of Cadiz.

Fresh sand for the beaches of Mallorca, largest of the Balear islands.
Of course, other countries along the Mediterranean also nurture and nourish their beaches, such as Ischia, an island near Naples, Italy. And even on the other side of the world in Australia, beach nourishment is an urgent necessity, as witnessed at Currumbin-Tugun Beach, part of Australia’s Gold Coast, known to feature some of the most incredible beaches in the entire world.
Enhancing the beaches of the Lowlands

Looking at a map of Europe it may seem that the coasts of the Netherlands and Belgium are protected from Atlantic storms by the location of Great Britain. That is only partially true. In fact, the Lowlands knows quite well the heavy storms, powerful tidal forces and strong eroding currents of the North Sea, especially in the period from November to March. No wonder that over the last decades many beach enhancement projects have been carried out along the North Sea coastline. Originally these projects emphasised the coastal defence aspects, the protection of the low-lying areas behind the dunes, but later on the recreational aspects, stimulation of the tourist industry, became equally as important. Beach nourishment at Zandvoort (Amsterdam’s sea resort), Den Helder (where the Wadden Sea begins), Delfland (close to Delft and The Hague), Knokke (close to Bruges, Belgium) and Ostend, Belgium’s most famous beach “where Europe’s royals used to go” are just a few of the beaches that get regular sand replenishment.

Nourishment for enhancement of the Delfland beaches.
Time out for fun: of beaches and boats

Repairing the damage a storm caused close to Den Helder. Usually beach nourishment takes place outside the tourist season, but here an exception had to be made.

Ostend is not only Belgium’s premier sea resort but also its main passenger port.

Nourishing the beach of Knokke, today Belgium’s most elegant sea resort.
The Eighth Wonder of the World

The Palm Islands in front of the coast of Dubai, capital of the United Arab Emirates, have been proclaimed the “eighth wonder of the world”, and they are indeed amazing feats of marine engineering and construction; they will most certainly help to maintain Dubai’s position as a premium tourist destination. There will be three Palm Islands: Palm Jumeirah (ready as of 2004), Palm Jebel Ali (to be completed in 2007), and Palm Deira. Construction of the land site of Palm Deira Corniche was started in 2004. The first two Palm islands are being built in the shape of a date palm tree, with a trunk and a crown with 17 fronds. The palm is surrounded by a crescent dam, whose seaside forms the breakwater. The Jumeirah Palm Island is primarily a retreat and residential area for living, relaxation and leisure. It contains all types of hotels, thousands of villas and thousands of shoreline apartments. Palm Jebel Ali will be more an entertainment destination, including six marinas, a water theme park and water homes built on stilts, between the fronds and the crescent. Palm Deira will be the largest of the three islands, 14 km long and 8.5 km wide.
It will have 41 fronds and contain 8000 villas and townhouses. The first two islands will each have taken over 100 million m$^3$ of rock and sand to build. Together the first two islands add 120 km to Dubai’s shoreline. The three Palm islands will be the largest man-made islands in the world, with Palm Deira, once ready, in first place. In the meantime projects similar to the Palm Islands have been undertaken. On either side of the trunk of the Palm Jumeirah, two islands were built in the shape of the logo of the developer. They are private islands, with beaches and yachting facilities. The Logo Islands, including one 200-m quay wall, were completed in February 2005. And then there is The World, a project that involves the reclamation of a conglomerate of artificial islands in the shape of various continents of the globe.
From Dubai to Doha to the Seychelles

The reclamation of The World in front of the coast of Dubai is expected to be completed end of 2005. It will involve the creation of 250 islands within the perimeters of breakwaters, the dredging, transport and placement of 300 million m$^3$ sand, and the building of the largest breakwater ever. The various breakwaters under construction for this project will be some 25 km long in total. Investors can only buy one or more whole islands, not mere lots, and each island ranges between 25,000 and 100,000 m$^2$ in size. Some 400 km west of Dubai one will find Doha, capital of Qatar, where the Pearl of the Gulf project is under development. It is a US$2.5 billion offshore real estate project, a Riviera-style man-made island that will cover 400 ha of reclaimed land. The Pearl will create 30 km of new coastline. The four-phase development will eventually house over 30,000 residents in an up-scale and multicultural community. The reclamation work is underway since mid-2004.
Quite a bit south of Dubai, north of Madagascar, in the Indian Ocean, one will find a group of islands called the Seychelles. Victoria, on Mahe Island, is the capital. The Seychelles are already an important tourist attraction, but will become even more so once the seven newly created man-made islands, comprising in total 352 ha, are fully developed. Five of these islands are located off the eastern coast of Mahe, one off the coast of Anse Aux Pins and one on Praslin Island. Each island is created by constructing bunds in the sea, which then are filled in. This method minimises the impact on the environment. The first island to be developed is Eden Island, some 48 ha large. It will include a 5 star 150 room hotel, luxury apartments and villas, an up-market shopping mall, and a marina. Eventually it should have some 8000 residents. Construction of phase 1 of Eden Island started in the last months of 2004.
Penny’s Bay and Laguna Gamagori, theme parks on new land

Yet another gigantic reclamation project took place in Hong Kong: some 200 ha of new land were reclaimed from the sea in Penny’s Bay to accommodate the building of a new Disney theme park. The work involved the removal of over 42 million m$^3$ of unsuitable soil, 50,000 m$^3$ of which were contaminated, and the supply of some 70 million m$^3$ of sand for the reclamation. Moreover, a sea wall of 2 km long was built and 2 km of access road. The project was executed under the strictest environmental supervision. Water and air quality were measured daily, noise levels were limited, local wildlife and coral were closely monitored. Both soil removal and sand deposits took place within a 4 km silt screen surrounding the site. In 2002 the reclaimed land was handed over to the next set of engineers to start constructing the amusement park. Theme parks are also popular in Japan. Once upon a time Gamagori City, located between Tokyo and Kyoto on Honshu’s southern coast, along Atsumi Bay, used to be a sleepy sea resort. That was until land reclamation started for an enormous new recreation area. Nowadays Gamagori is known for its marine theme park, Lagunasia, at the newly created Lagoon Gamagori. Lagunasia is famed for its thalasso therapy, for its many different pools and high water slides, for its amusement park and its museums. Reclaiming Laguna Gamagori involved the moving of 3 million m$^3$ of soil. The reclamation project was completed in 1999.
Welcome to Lulu Island, Bahrain

In the last decade Bahrain has become a favorite for visitors from all over the world, some 5 million of them every year. The development of Lulu Island in front of the coast of Manama, Bahrain’s capital had a first phase in 1990. The new phase that is ongoing, called the Lulu Abraj project, involves land reclamation, to be completed end 2006, and will eventually encompass the building of a grand hotel, spa, marina, convention center, aquarium, apartment buildings and villas.

View of the results of the first phase of the Lulu Island project, in 1990.

An early stage of the ongoing Lulu Abraj project in 2004.
You’ve come to the last page of an overview of the last forty years of dredging and maritime infrastructure construction. The sheer quantity of projects that have been realised in four decades is slightly overwhelming. As is the magnitude of the projects and how they have changed the world. But even more overwhelming is that each of these projects represents the hard work of hundreds if not thousands of people: engineers, dredging masters and their crews, project managers, scientists, researchers, specialists in all areas of maritime construction. They comprise local people who have been employed and trained on site by the IADC member companies. And our own staffs who, sometimes at the drop of a hat, are deployed all over the world. Each project reflects the expertise, enthusiasm, imagination, and professionalism they bring with them; even more so, each demonstrates the adventurous spirit of these individuals who travel wherever they are needed to do their jobs. They are the ones who make a difference: in creating jobs for others, in improving living circumstances, in providing clean water and better economic opportunities. They are the ones who working together have changed the world. To all those colleagues in the industry, we say thank you.

This special issue of Terra et Aqua was based on the research and creative efforts of many people working many hours. To everyone who dug through their archives and supplied the photographs, who provided the background descriptions, and the enthusiastic stories behind the photographs, to all of you who have contributed time and energy, we say thank you as well.
An aerial view of downtown Hong Kong. Part of the burst of activities in the 1990s in Hong Kong was the expansion of the Central Business area. Land reclamation extended the waterfront, breathing new life into an enlarged Central Business District.

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