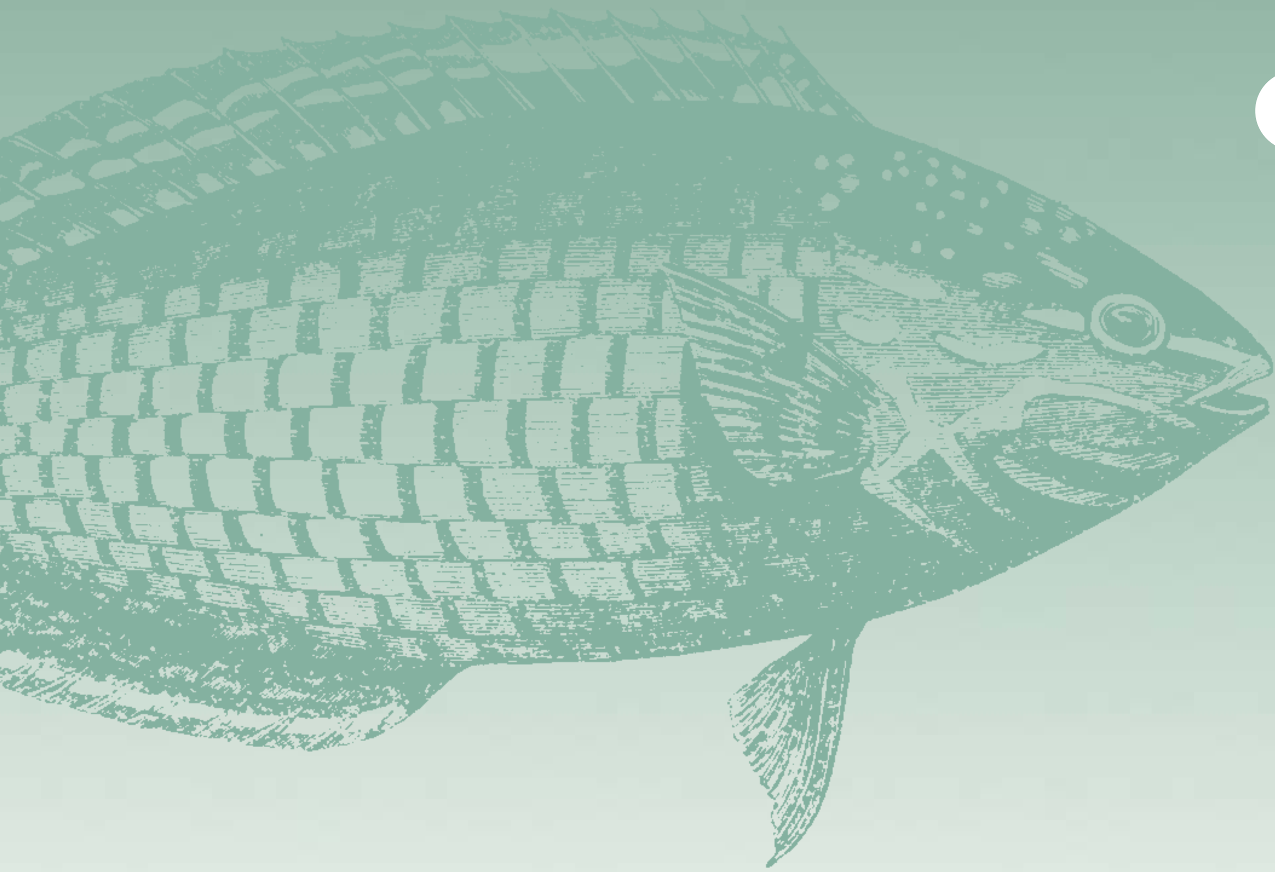
dredging: the facts

Dredging is vital to social and economic development. In particular, dredging is vital to the construction and the maintenance of much of the infrastructure upon which our economic prosperity and social well-being depend. So, when, and why do we dredge?



Dredging for navigation

From the very beginnings of civilisation, people, equipment, materials and commodities have been transported by water. Ongoing technological developments and the need to improve cost effectiveness have resulted in larger, more efficient ships. This, in turn, has resulted in the need to enlarge or deepen many of our rivers and canals, our "aquatic highways", in order to provide adequate access to ports and harbours. Nearly all the major ports in the world have at some time required new dredging works – known as capital dredging – to enlarge and deepen access channels, provide turning basins and achieve appropriate water depths along waterside facilities.

Capital dredging in Hong Kong was undertaken for both the new airport and new container terminals.

Many of these channels have later required maintenance dredging, i.e. the removal of sediments which have accumulated in the bottom of the dredged channel, to ensure that they continue to provide adequate dimensions for the large vessels engaged in domestic and international commerce.

Waterborne transport is vital to domestic and international commerce. It offers the most economical, energy efficient and environmentally friendly transportation of all types of cargo. Navigation projects must keep pace with waterborne transport needs in order to support and maintain local, national and regional economies.

Dredging for construction, reclamation and mining

Dredging is an important way of providing sands and gravels for construction and reclamation projects. In the last two decades, the demand, and the associated extraction rates, for such offshore aggregates have significantly increased.
Dredged aggregates have a wide range of uses including:

- Land reclamation: pressures arising from population growth and port and infrastructure developments in coastal areas have created a need to raise the elevation of low-lying areas and/or to construct new land areas. Such pressures are likely to continue.
- Construction materials: an increasing quantity of marine aggregate is being used in concrete and fill, including fill for reclamation projects.

Beaches in Alicante, Spain, before replenishment (left) and after (right). Beach nourishment is now commonplace in many parts of the world and the demand for dredged materials from offshore borrow areas has consequently increased significantly in recent years.

Dredging is also often undertaken in order to:

- create underwater foundations;
- facilitate the emplacement of pipelines or immersed tunnel elements;
- construct flood control structures such as dams, dikes or levees;
- ensure flood defences (by improving or maintaining the discharge capacity of watercourses);
- create or maintain storage capacity in water supply reservoirs.

In addition, though perhaps less commonly, dredging may be used to recover minerals and precious metals, or to remove the overburden in order to reach these. As with land-based extraction, there are environmental concerns about marine aggregates extraction. Nonetheless, dredging can have distinct economic and environmental advantages in comparison to quarrying.

Dredging for the environment

Dredging can be undertaken to benefit the environment in several ways. Dredged materials are frequently used to create or restore habitats. Recent decades have also seen the increasing use of dredged materials for beach replenishment.
These schemes are designed to prevent – or reduce the likelihood of – erosion or flooding. Such beach nourishment or recharge is achieved by placing dredged sand or gravel on eroding beaches. This represents a "soft-engineering" solution, an important alternative to – often more costly – structural solutions such as rock armour or concrete walls.

Another environmental use of dredging has been in initiatives designed to remove contaminated sediments, thus improving water quality and restoring the health of aquatic ecosystems. This so-called "remediation" or "clean-up" dredging is used in waterways, lakes, ports and harbours in highly industrialised or urbanised areas. The removed material may be treated and used afterwards, or disposed of under strict environmental controls. Under proper conditions a viable alternative to removal is in-situ isolation, i.e. the placement of a covering or a cap of clean material over the contaminated deposit.

THE DREDGING PROCESS

Capital (or new) dredging projects can be both extensive and expensive. Maintenance dredging is often a regular, perhaps annual ongoing, long-term activity. In either case, what are the key elements of dredging? The dredging process consists of the following three elements:

- Excavation: this process involves the dislodgement and removal of sediments (soils) and/or rocks from the bed of the water body. A special machine - the dredger – is used to excavate the material either mechanically, hydraulically or by combined action. The main types of dredgers are described below.

- Transport of excavated material: transporting materials from the dredging area to the site of utilisation, disposal or intermediate treatment, is generally achieved by one of the following methods:
  (a) in self-contained hoppers of the dredgers; (b) in barges; (c) pumping through pipelines; and (d) using natural forces such as waves and currents.
  Other, rarely used transport methods are truck and conveyor belt transport. The method of transport is generally linked to the type of dredger being used.

- Utilisation or disposal of dredged material: in construction projects, dredging is driven by the demand for dredged material. In navigation and remediation dredging, the project is driven by the objective of removing the material from its original place. Thus, the question of "what to do with the removed material?" arises. As a result of growing environmental pressure, finding an answer to this question has become increasingly difficult, especially when the material is contaminated. The main alternatives for the management of the dredged material are described later in this document.

TYPES OF DREDGERS

How do we dredge? With specialised dredging equipment which varies widely, coming in many sizes and types, and including mainly water-based and sometimes land-based machines. Dredging equipment, classified according to the methods of excavation and operation, can be grouped into the following main categories:

- mechanical dredgers;
- hydraulic dredgers;
- special, low-impact dredgers; and
- other types of dredgers.

Within the above categories further subgroups can be identified on the basis of propulsion, i.e. self-propelled versus stationary. The selection of dredging equipment for a particular project will depend upon a combination of factors, including:

- the type of physical environment;
- the nature, quantity and level of contamination of the material to be dredged;
- the method of placement; and
- the distance to the placement site.

Increasingly strict environmental regulations have led to significant developments in dredging equipment. These include automatic control, positioning systems and degassing systems. These innovations aim to reduce potentially adverse environmental impacts.

Mechanical dredgers

Three main sub-groups of mechanical dredger can be identified:

- bucket-ladder dredgers;
- backhoes; and
- grab dredgers.

These dredgers are well suited to removing hard-packed material or debris and to working in confined areas.

Mechanical means are used for excavation – dislodging the material and then raising it to the water surface – in a way similar to dry land excavation methods. Mechanically dredged sediments are generally transported by barges. Cohesive sediments dredged and transported this way usually remain intact, with large pieces retaining their in-situ density and structure through the whole dredging and placement process.

Hydraulic dredgers

Three main sub-groups of hydraulic dredger are:

- stationary suction dredgers;
- cutter suction dredgers; and
- trailing suction hopper dredgers.

These dredgers use hydraulic centrifugal pumps to provide the dislodging and lifting force and remove the material in a liquid slurry form. They usually work well in loose, "unconsolidated" silts, sands, gravels and soft clays. In more cohesive materials teeth or waterjets may be applied for breaking up the material.

Cutter suction dredgers are equipped with a cutting device to increase the dislodging force. These "cutter" dredgers are suitable for use in high strength materials such as clays, packed or compacted sands and rocks.

Transport methods associated with hydraulic dredgers are pipeline and hopper transport. In some cases, hydraulic dredgers may pump the materials into barges for transport.

Hydraulic dredging and transport methods "slurry the sediment", that is, they add large amounts of process water and thus change the original structure of sediments.


Close-up of a cutterhead.


Trailing suction hopper dredgers come in a variety of sizes to suit the task.

Special low-impact ("environmental/restoration") dredgers

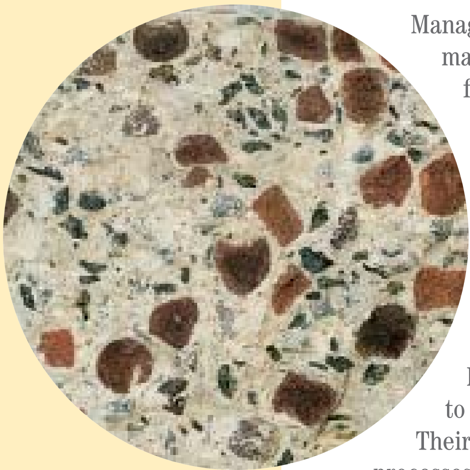
It is increasingly important to dredge contaminated sediments in an environmentally acceptable manner, in particular ensuring that contaminants are not re-mobilised and/or released into the water column where they may detrimentally affect aquatic life.

A new range of equipment has therefore been developed with the aim of increasing precision, i.e by reducing overdredging, and minimising the suspension of bed material. In some cases existing dredger types have been modified; in other cases completely new dredgers have been designed. Examples include the following: encapsulated bucket lines for bucket chain dredgers; closed buckets for backhoes; closed clamshells for grab dredgers; auger dredger, disc cutter, scoop dredger and sweep dredger (all modified cutter dredgers).

Other types of dredgers

There are a number of dredging machines which do not readily fit into the above categories. Many of them comprise specialised tools developed for specific purposes. Of particular note are hydronamic dredging techniques that do not raise the dredged material above the water surface e.g. water injection dredgers.

The encapsulated bucket dredger (above) and the auger dredger (left) are two examples of specially designed environmental dredging equipment.



Artificial gravel, produced from contaminated dredged material, is used in manufacturing concrete.

DREDGED MATERIAL MANAGEMENT ALTERNATIVES

When we dredge, what do we do with the dredged material? In the last thirty years this has become one of the crucial issues of dredging and there has been a continual dialogue amongst many nations and organisations on the subject. With the goal of protecting the environment and still furthering economic development, the parties involved have reached some significant agreements.

Regulatory aspects

Both dredging and disposal are now carefully regulated. In addition to national and regional legislation and policies, the most widely applicable international regulatory instrument is the London Convention 1972 (LC-72), which covers the marine waters of the whole world. LC-72 adopted the Dredged Material Assessment Framework (DMAF), a widely reviewed and accepted approach to the assessment of suitability of dredged material for disposal at sea. The contracting parties to the Convention, some 90 countries, are now expected to adopt the DMAF accordingly. There are also regional conventions such as the Oslo and Paris Convention, the Helsinki Convention and the Barcelona Convention.

Legislation controlling placement on land (and in inland waters) is based on national regulatory systems often involving a great variety of laws prepared for various waste materials, e.g. sewage sludge, agricultural and industrial waste. Some countries are now developing regulations specifically for dredged material.

Some dredging initiatives, particularly those which comprise regular operations such as annual maintenance dredging of a waterway, may not need to be the subject of detailed investigations. Most major/new dredging or disposal projects should, however, have studies carried out in order to ensure that any potential adverse effects are identified in advance and dealt with in an appropriate manner. Such investigations include, for example, technical investigations of dredging and disposal options, physical process studies and environmental impact studies.

Management alternatives for dredged material can be grouped into the following five main categories:

- Sustainable relocation
- Beneficial use
- Open-water disposal
- Confined disposal
- Treatment

Sustainable relocation

Marine or fluvial sediment normaly contribute to the sustainabililty of natural ecosystems. Their role in river, estuarine and costal zone processes should be respected wherever possible. In environmental assessment therefore as a first option the relocation of a estuary in the natural environment should be considered.

Beneficial use

Dredged material is increasingly regarded as a resource rather than as a waste. More than 90% of sediments from navigation dredging comprise unpolluted, natural, undisturbed sediment,

At the Black Swamp, a southern forested wetland in Arkansas, USA, groundwater study measurements are being taken in winter.

which is considered acceptable for a wide range of uses. The DMAF recognises this and requires that, as a first step in examining dredged material management options, possible beneficial uses of dredged material be considered.

Beneficial use may be defined as “any use which does not regard the material as a waste”. A great variety of options are available, and the main types can be distinguished as follows:

- coastal protection, e.g. beach nourishment, onshore/offshore feeding, managed retreat;
- agriculture, horticulture, forestry;
- habitat development or enhancement, e.g. aquatic habitats, bird habitats, mudflats, wetlands;
- amenity development or enhancement, e.g. landscaping;
- raising low-lying land;
- land reclamation, e.g. for industrial development, housing, infrastructure;
- production of construction material, e.g. bricks, clay, aggregates;
- construction works, e.g. foundation fill, dikes.

Operational feasibility, that is, the availability of suitable material in the required amount at a particular time, is a crucial aspect of many beneficial uses.

Open-water disposal

Open-water disposal means that dredged material is placed at designated sites in oceans, estuaries, rivers and lakes such that it is not isolated from the adjacent waters during placement. Placement is generally via release from pipelines, barges or hoppers.

Open-water sites can be either dispersive or non-dispersive (retentive) depending on whether the sediment is transported out of the site or remains within the designated boundaries. Generally, clean or mildly contaminated sediments are disposed of in open-water, although the disposal of highly contaminated material can also be considered with appropriate control measures.

Variants of open-water disposal include:

- unrestricted placement on waterbeds in the form of mounds;
- placement with lateral containment in natural or man-made depressions;
- placement with lateral containment behind constructed berms.

A cap of clean material over the dredged material can provide isolation from the benthic environment. If capping is applied over the mound formed by unrestricted placement, it is called level-bottom capping (LBC). If the capping is applied with lateral containment, it is called contained aquatic disposal (CAD).

The majority of the stored dredged material at the IJsseloog confined disposal facility in Lake Ketelmeer, The Netherlands, comes from the clean-up of the lake.

Confined disposal

Confined disposal means that the dredged material is placed in an engineered containment structure, that is, within dikes or bunds, or in natural or constructed pits, or borrow pits. This isolates the material from surrounding waters or soils during and after placement. Other terms used in the literature for this type of placement include “confined disposal facility" (CDF), “diked disposal site” and “containment area”. CDFs may be constructed in open waters (known as island CDFs), at near-shore sites or on land.

The function of CDFs is to retain the dredged material solids whilst releasing the carrier water. For facilities receiving contaminated material, an additional objective is to provide the efficient isolation of contaminants from the surrounding area.

To achieve this, depending on the degree of intended isolation, CDFs may be equipped with a complex system of control measures such as surface covers and liners, treatment of effluent, surface runoff and leachate.

This separation and dewatering plant consists of several hydrocyclones, which solidify dredged material, thus reducing its quantity.

Treatment

Treatment is defined as the processing of contaminated dredged material to reduce its quantity or to reduce the contamination. Treatment methods range from separation techniques, in which contaminated mud is separated from relatively clean sand, to incineration. Some techniques are well developed but others are still in the early stages of development. The problem is scale: treatment is often expensive, so the treatment of small volumes of contaminated material is more likely than that of large volumes.

Welded sheets of PEHD plastic are laid as a basic seal to prevent dispersion of contaminants, at the Francop land-based CDF in Hamburg, Germany.

A monitoring well is used to test groundwater quality, in the vicinity of the Francop site.

ENVIRONMENTAL ISSUES

What about the environment? Is dredging good or bad? How do we find out? Dredging plays a vital role in the socio-economic development and the environmental health of many countries and regions in the world. Yet any infrastructure or development project can have impacts on the environment, and dredging is no exception.

Effects of the dredging process

Direct or indirect environmental and socio-economic effects may be associated with any element of the dredging process – excavation, transport and disposal. The effects may be positive or negative, short term or long term and may include, amongst others, impacts on:

- water quality, e.g. increase of suspended solids concentration and potential release of contaminants during dredging or disposal; leaching of contaminants from disposal sites;
- habitats and natural areas, e.g. habitat enhancement or creation, removal or destruction of benthos, smothering;
- local communities, e.g. the effects of noise; increased labour opportunities;
- changes to bathymetry or topography;
- physical processes, e.g. waves, currents, or drainage, and hence erosion or deposition;
- archaeological assets, e.g. shipwrecks;
- recreation, e.g. sailing, swimming and beach use;
- economic activities, e.g. commercial fishing; improved infrastructure.

Prior to undertaking dredging and/or disposal projects, a careful assessment to identify potential effects and to determine their significance is necessary. The “environmental impact assessment” (EIA) should highlight both positive and negative, short- and long-term impacts.

Where potentially significant adverse effects are anticipated, management techniques should be implemented, where possible, to reduce concerns; thereafter identification and implementation of practical, cost-effective compensation or mitigation measures will be required for any residual effects. With management practices and effective mitigation, impacts which might otherwise threaten the viability of a particular scheme or initiative can often be reduced to an acceptable level, or avoided altogether.

As part of the ongoing environmental assessment process, the subsequent monitoring of environmental parameters may also be needed in order to:

- measure the magnitude of particular changes;
- compare such changes to those predicted; and
- identify whether, when or where remedial actions are required.

The involvement of interested groups and organisations, consulting with them and reaching a consensus forms an important component in the process of identifying potential impacts and implementing acceptable mitigation measures. It is in the best interests of all parties that the need for the dredging is explained, that the decision-making process is transparent, and that the reasons for the selection of the preferred dredging and/or disposal option(s) are clearly understood.

During dredging for the Øresund Link between Denmark and Sweden, scuba divers take samples of eelgrass every other week to assess impacts.

Source control

Dredging organisations and their clients – ports and harbours for instance – can do their utmost to minimise and monitor the impacts of the dredging activity itself. But what do we do when the continuing input of contaminants to a water body, by a factory or chemical plant for example, presents an ongoing problem in respect of disposing of contaminated dredged material?

Pollution needs to be curtailed at the source. Source control represents a potential long-term solution. Indeed, in some cases, it can be argued that source control should have a higher priority in terms of environmental effectiveness than disposal or treatment of the contaminated sediment.

The organisation responsible for dredging is rarely responsible for the pollution, that is, for the discharge of the contaminants. Achieving source control usually involves substantial collaboration and co-operation between a number of organisations and agencies. These groups must be willing to identify the source and take measures to reduce or prevent further pollution. This is no easy task but it is the only viable way to guarantee a long-term successful outcome.

From Sewer To Fishery

As early as 1950 the countries bordering the Rhine had joined together and set up the International Rhine Commission (ICPR). In 1987, the ICPR presented the Rhine Action Programme (RAP) and the governments of the Rhine bordering countries and the EC Commission supported it unanimously. RAP’s aims included halving the number of discharges into the river by the year 2000. In terms of ecology this was meant to ensure the return of higher species, such as salmon into the river. Emissions of some substances – including a number of heavy metals, organic micropollutants and oil – were to be cut by as much as 90% for the year 2000. Thanks to close cooperation between all the countries involved, the Rhine water today is considerably less toxic than it was only a few years ago.

Scientists visit a study site at a restored wet prairie in Missouri, USA.

FINDING FURTHER INFORMATION ON DREDGING

Responsible dredging and disposal practices are in everybody's interest. The following organisations are actively involved in promoting responsible dredging and disposal practices. Each of these organisations is able to provide further information to help you understand the processes and the facts about dredging and disposal. If you have any questions about dredging or disposal, we encourage you to contact one or all of them.dredging or disposal, we encourage you to contact one or all of them.

IADC – International Association of Dredging Companies
Mission: To inform the world about the fundamental need for dredging and the beneficial economic, social and environmental effects of dredging. To promote fair practice conditions and fair competition within the dredging industry and to improve the international business climate for the private dredging industry.

Contact: IADC Secretariat,
PO Box 80521, 2508 GM The Hague,
The Netherlands. Phone: +31 70 352 3334
Fax: +31 70 351 2654
E-mail: info@iadc-dredging.com
www.iadc-dredging.com

IAPH – International Association of Ports and Harbors
Mission: One of IAPH's missions is to promote the development of the international port industry, by inter alia, helping to define international regulations, standards and guidelines covering the environment, including dredging.

Contact: IAPH Head Office,
7th Floor, South Tower, New Pier
Takeshiba, 1-16-1 Kaigan, Minato-ku,
Tokyo 105-0022, Japan.
Phone: +81 3 5403 2770
Fax: +81 3 5403 7651
E-mail: info@iaphworldports.org
www.iaphworldports.org

PIANC – International Navigation Association
Mission: PIANC aims to be the foremost professional organisation for the promotion, management and sustainable development of navigational inland, coastal and ocean waterways, embracing ports and harbours, logistics, infrastructure and coastal zones, all for the safe and efficient operation of all types of commercial and recreational vessel.

Contact: PIANC Secretariat,
Graaf de Ferraris Building –
11th Floor, Blvd. du Roi Albert II,
20 – Box 3, B-1000 Brussels, Belgium.
Phone: +32 2 553 71 61
Fax: +32 2 553 71 55
E-mail: info@pianc-aipcn.org
www.pianc-aipcn.org

World Organization of Dredging Associations (**WODA**) is composed of Eastern Dredging Association (EADA), Central Dredging Association (CEDA), and Western Dredging Association (WEDA). The three associations share the mission of WODA:

- *To promote the development and exchange of professional knowledge– scientific, technical, regulatory and managerial – in all fields concerned with dredging and handling or placement of dredged material;*
- *To participate in the development of international and national policies, regulations, and guidelines on dredging and related matters;*
- *To balance the environmental, social and economic concerns related to dredging and dredged material handling or placement projects and to encourage open communication between all stakeholders;*
- *To enhance contacts between individuals and various professional entities concerned with dredging and associated matters and between the dredging community and the society in which it works.*

CEDA, Radex Building,
Rotterdamseweg 183c,
2629 HD Delft, The Netherlands,
Phone: + 31 (0)15 268 2575
Fax: + 31 (0)15 268 2576
E-mail: ceda@dredging.org
www.dredging.org

EADA Secretariat,c/o Port Klang Authority, Mail Bag Service 202,
42009 Port Klang, Malaysia,
Fax: + 603 316 70211
E-mail: david@pka.gov.my
www.woda.org

WEDA Executive Offices,
P.O. Box 5797, Vancouver,
WA 98668-5797 USA.
Phone: +1 5360 750 0209
Fax: +1 360 750 1445
E-mail: weda@comcast.net
www.wesda.westerndredging.org

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Dredgeline – the on-line bibliographical reference database on dredging literature, www.dredgeline.net

Paralia Nature, www.imiparalianature.org

European Sediment Network, www.sednet.org

UNEP - Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, www.gpa.unep.org

US Army Corps of Engineers Dredging Operations Technical Support, http://el.erdc.usace.army.mil/dots

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Cover photos:
From top to bottom:
dredger "rainbowing" sand;
skunk cabbage, a typical wetlands plant;
disc cutter.