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7 DREDGING AND DISPOSAL OF DREDGED MATERIAL

7.1 DESCRIPTION

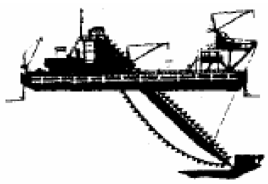
7.1.1 Dredging

In order to maintain access to Belgian seaports, dredging is required along the Belgian coast, in the estuary of the Western Scheldt and in the seaports (Zeebrugge, Oostende, Nieuwpoort and Blankenberge).

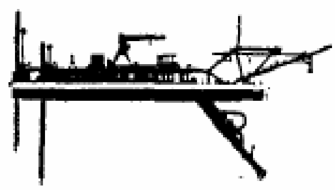
There are two types of dredging activities: dredging required for the initial construction, deepening and broadening of ports and shipping channels; and maintenance dredging to maintain the required depth of existing infrastructure (Maes et al. 2000). Maintenance dredging on the BPNS is the most important activity that takes places the whole year round. The deepening of the fairways also takes place during certain periods of the year.

To dredge the navigation channels and harbours the following techniques are being used in Belgium (De Brauwer 2003) (definitions and figures from Donze (1990):

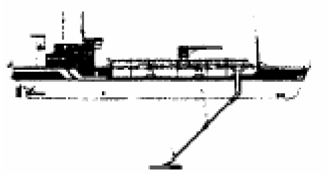
- **bucket dredger**: stationary dredger, with an endless chain of buckets that scrape material from the bottom. The dredged material is loaded in barges.



- **cutter suction dredger**: stationary dredger with a cutter head to loosen the material on the bottom to be dredged. The dredged material is pumped via a pipeline ashore or into barges.



- **trailing suction hopper dredger**: self-propelled ship which fills its hold or a hopper during dredging, while following a pre-set track. The hopper can be emptied by opening the bottom doors or valves (dumping) or by pumping its load ashore. This kind of dredging is mainly used in open water. It is this kind of dredger that is mainly used in the harbour of Zeebrugge.



7.1.2 Dredge disposal

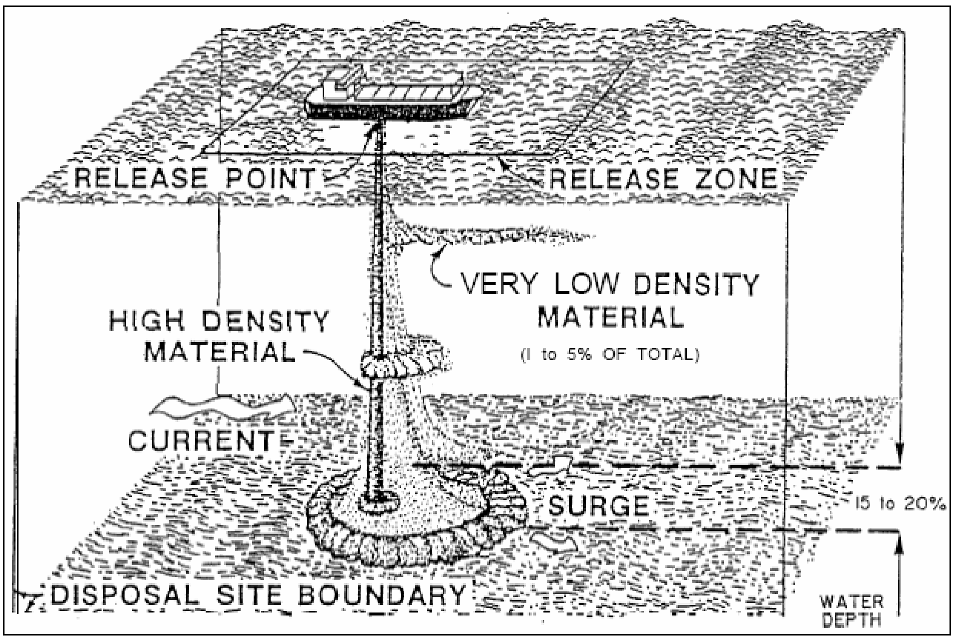
Most of the dredged material is dumped back into the sea or in the Westerscheldt. It is difficult to choose the best place for disposal. The cheapest way is to dump the material in a dumping site close to the place where dredging takes place (e.g. Bruggen en Wegen Zeebrugge Oost is close to the harbour of Zeebrugge). But the closer to the location of dredging, the more chance on re-circulation of the material.

The dredged material from maintenance dredging consists of fine sediments that are deposited from sedimentation. The material originating from deepening works contains a higher sand fraction (Fettweis et al. 2003).

The quality of dredged material is assessed every 10 years as part of a large-scale monitoring programme, executed by the Flemish region (Lauwaert 2002). The results show that the dredged material from the harbours is contaminated to a higher extent than the material that is dredged from the navigation channels. This is due to the higher content of fine fraction and organic matter in the harbour sediments. However, the concentrations measured in 2000 were not higher than the sediment quality criteria, except for tributyltin (Seys 2002).

The dumping of the dredged material generally occurs underneath the transport vessel (Figure I.3.7a). During dumping the majority of the material is caught within a vertical density current. Near the seabed this current transforms into a horizontal one, influenced by the direction of the tidal current and the seabed slope (Malherbe 1991; Van Parijs et al. 2002; The Scottish Office Agriculture 1996).

Figure I.3.7a: Transport processes during open water disposal (from The Scottish Office Agriculture (1996) after Collins (1990), Truitt (1988) and earlier authors)



7.2 SUBUSES AND DESCRIPTION

Monitoring

The monitoring of dredging activities is necessary and can be executed from both a survey vessel or onboard the dredging vessel. Those monitoring activities include several measurements from the sea bottom and the water column.

Depth measurements

Depth measurements are necessary before and after the dredging. This can be done with several techniques. In the past a *lead line* was used, whilst nowadays echo-sounding techniques like *singlebeam* and *multibeam* are used.

Density measurements

(Van Craenenbroeck et al. 1998).

The presence of fluid mud layers in maritime access channels and ports results in unpredictable changes in the registered depth, which is mainly caused by hydrometeorological conditions and seasonal variations. Deep-draughted vessels can navigate through this fluid mud, if the density of the mud remains below a certain level. Therefore, the concept of **navigable depth** in muddy areas has been developed. This corresponds with a physical level within the fluid-mud layer indicating a safe navigation limit for deep-draughted vessels. Each port has to determine this density level, because the physical properties of the mud are different. The port of Zeebrugge considers the **1.15 t/m³ density level** a safe limit for navigation. In Zeebrugge, the Navitracker system is daily used to measure this density level: a towed density probe that automatically tracks a pre-determined density level within the fluid mud in order to allow the production of navigable depth charts. An H-shaped inclinometer-equipped Vertical Density Profiler was added to the basic system to allow the collection of data throughout the mud column.

7.3 LEGISLATIVE FRAMEWORK

(updated by Cliquet A.)

7.3.1 Spatial delimitation

Competent authority

The Flemish Region (Ministry of the Flemish Community - Maritime Access Division) is responsible for the dredging activities in the Belgian coastal zone. The Water- and Seaways Administration of the Ministry of the Flemish Community commission dredging activities. The material dredged from the harbours and fairways is dumped back into the sea in large quantities. This material can be polluted in varying degrees. The federal government is responsible for the monitoring of the effects of dumped dredged material. The management of the dredging activities and the dredged material to be dumped is a shared responsibility. The Belgian State and the Flemish Region signed a **cooperation agreement** on 12 June 1990, as modified by a co-operation agreement signed on 6 September 2000.

Legislation

(Cliquet et al. 2004; Maes and Cliquet 2005)

The management of the dredged material in Belgium follows international obligations under the **OSPAR Convention** (regional) and the **London Convention** (world). The London Convention is the worldwide equivalent of the OSPAR Convention. Belgium follows the 'Waste-specific Guidelines for Dredged Material' of the London Convention. International dumping of dredged material is regulated by the OSPAR '**1998 Guidelines for the Management of Dredged Material**'. In the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR, Paris, 1992), dumping of waste is prohibited in principle, except for certain categories such as dredged material. No such material can be dumped without a permit or regulation by the competent authorities (Maes et al. 2000).

In accordance with the Law of **20 January 1999** on the Protection of the Marine Environment in the Marine Areas under Belgian Jurisdiction (*BS* 12 March 1999), the dumping of dredged material into the sea requires an authorization. The Flemish Region must obtain such an authorization from the Belgian State, pursuant to the Royal Decree of 12 March 2000.

International legislation and Belgian implementation on dredge disposal:

- Convention for the Protection of the Marine Environment of the North-East Atlantic ("OSPAR Convention"), Paris, 22 September 1992.
- OSPAR Guidelines for the Management of Dredged Material (OSPAR 98/14/1-E, Annex 43).
  - <u>Implementation in Belgium:</u>
    - Law of 11 May 1995 on the approval of the Convention for the Protection of the Marine Environment of the North-East Atlantic, *BS* 31 January 1998.
    - Law of 20 January 1999 on the Protection of the Marine Environment in the Marine Areas under Belgian Jurisdiction, *BS* 12 March 1999.
    - Cooperation Agreement of 12 June 1990 between the Belgian State and the Flemish Region on Preventing Adverse Environmental Effects on the Marine Environment due to Dumping of Dredged Material, *BS* 22 August 1990.
    - Royal Decree of 12 March 2000 for defining the procedure for the authorization of dumping certain substances and materials in the North Sea, *BS* 4 April 2000.
    - By four Ministerial Orders of 29 March 2000, the Ministry of the Flemish Community (Department of Infrastructure and Environment, Waterways and Maritime Affairs Administration, Ports, Waterways and Maritime Affairs Policy Division) has the authority to dump dredged material into the sea, *BS* 26 May 2000.

National legislation on dredging:

- Special Law of 8 August 1980 on the state reform, *BS* 15 August 1980, as amended.
- Royal Decree of 4 August 1981 on a Police and Shipping regulation for the Belgian territorial sea, the ports and beaches of the Belgian coast, *BS* 1 September 1981; as amended.

7.4 EXISTING SITUATION

7.4.1 Spatial delimitation

7.4.1.1 Dredging

In order to maintain accessibility to the Belgian seaports, dredging is required along the Belgian coast, in the estuary of the Western Scheldt and in the seaports themselves (Zeebrugge, Oostende, Nieuwpoort and Blankenberge) (Map I.3.7a).

7.4.1.2 Dredge disposal

Most of the dredged material is dumped back into the sea or in the Westerscheldt. It is difficult to choose the best place for disposal. The cheapest way is to dump the material in a dumping site close to the place where dredging takes place (e.g. Bruggen en Wegen Zeebrugge Oost is close to the harbour of Zeebrugge). But the closer the dumpsite is to the location of dredging, the more chance there is of re-circulation of the material (Map I.3.7a).

There are seven official **dumping zones** on the BPNS:

- Bruggen en Wegen Zeebrugge Oost
- Bruggen en Wegen Oostende
- S1
- S2
- S3
- R4
- Nieuwpoort disposal

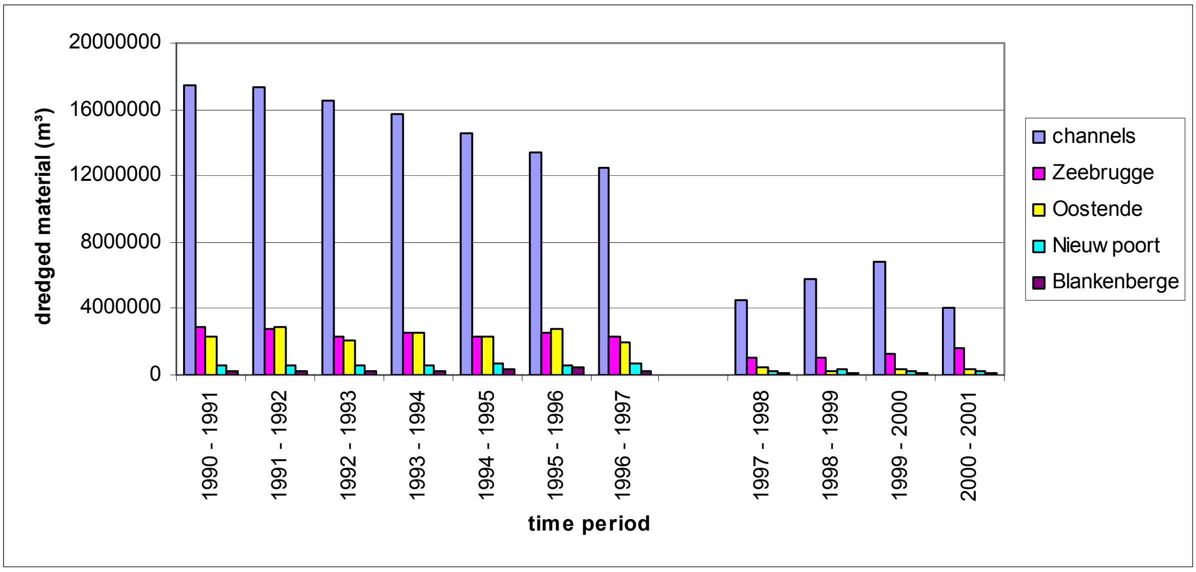
It is envisaged there will be two new zones for dumping dredged sand (zone 3a and 3b). These zones will probably be recognized as sand extraction zones, as the sand that is dumped could be recycled (Communication press, December 30, 2003). Scientific aspects related to this are discussed in Du Four (2004).

7.4.2 Type and intensity

7.4.2.1 Dredging

Dredging activities are of two types: dredging required for the initial construction, deepening and broadening of ports and shipping channels; and maintenance dredging to maintain the required depth of existing infrastructures (Maes et al. 2000). Maintenance dredging on the BPNS is the most important activity and takes places the whole year round. The deepening of the fairways also takes place during certain periods of the year. Annually about 9 to 10 million tonnes of dry material (TDM) has to be dredged from the Belgian coastal zone (De Brauwer 2003). On average 75% originates from the harbour of Zeebrugge, its access channel (Pas van 't Zand) and the access channel to the Westerscheldt (Scheur). This high amount is likely due to the presence of a turbidity maximum in front of Zeebrugge (Fettweis et al. 2003). The other dredged material comes from the harbours and access channels of Oostende, Blankenberge and Nieuwpoort (Figure I.3.7b) (Map I.3.7b).

Figure I.3.7b: Quantities of dredged material from the Belgian harbours and their access channels in (m³) from 1990 to 2001. Quantities before 1997 were measured on wet material, whilst from 1997 onwards the material was measured as tonnes of dry matter. Due to this different methodology, both measurements cannot be compared directly (source: Ministry of the Flemish Community (Maritime Access Division)

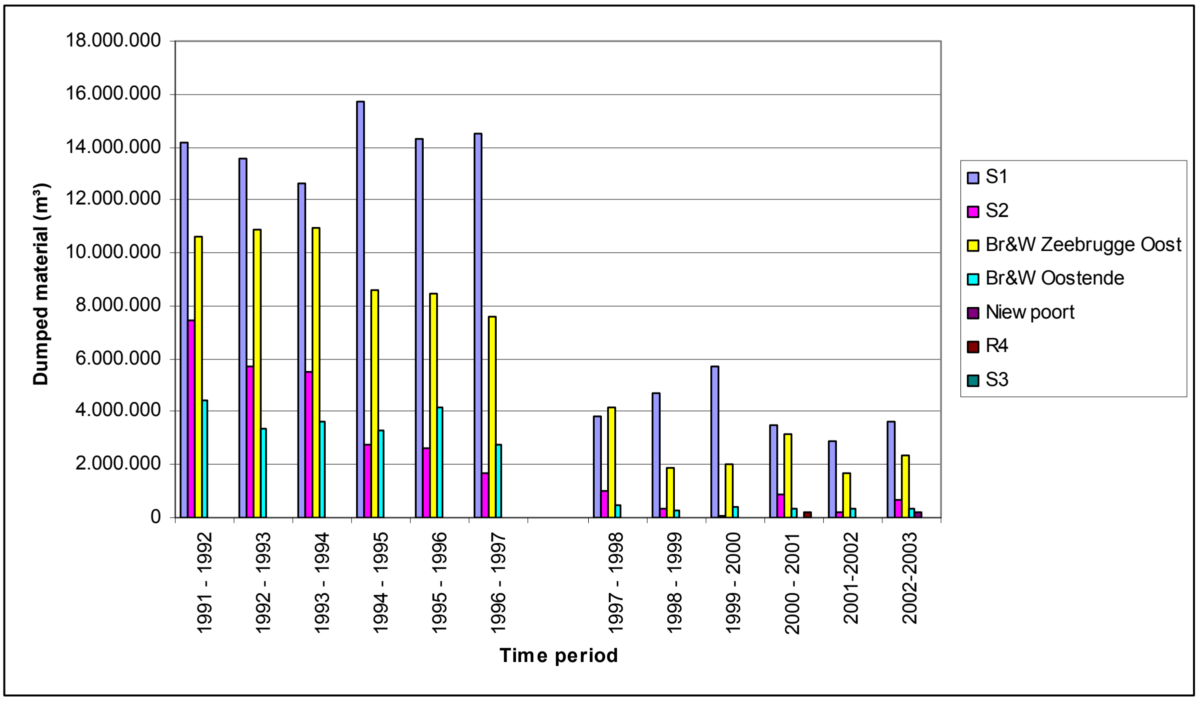


7.4.2.2 Dredge disposal

The most important dumpsites are S1 and Br&W Zeebrugge Oost ('Bruggen en Wegen'). The dredged material of maintenance dredging consists of fine sediments that are deposited from sedimentation. The material originating from deepening works contains a higher sand fraction (Fettweis et al. 2003) (Map I.3.7c).

The quality of dredged material is assessed every 10 years as part of a large-scale monitoring programme, executed by the Flemish region (Lauwaert 2002). The results show that the dredged material from the harbours is contaminated to a higher extent than material dredged from the navigation channels. This is due to the higher content of fine fraction and organic matter in the harbour sediments. However, the concentrations measured in 2000 were not higher than the sediment quality criteria, except for tributyltin (Seys 2002).

Figure I.3.7c: Quantities of dredged material dumped at sea (m³) from 1991 to 2003. Quantities before 1997 were measured when the material was still wet, while from 1997 onwards the material was measured as tonnes dry matter. So due to this difference in measurement methods we cannot compare both. (source: MUMM)



Dredged material is generally dumped under the transport vessel (Figure I.3.7a). During dumping the majority of the material is caught within a vertical density current. Near the seabed this current transforms into a horizontal one, influenced by the direction of the tidal current and the sea-bed slope (Malherbe 1991; Van Parijs et al. 2002; The Scottish Office Agriculture 1996).

7.5 INTERACTION

7.5.1 Suitability for user

Details – if applicable – can be found in the chapter that is specifically dedicated to "Suitability".

7.5.2 Impact on other users

Details – if applicable – can be found in the chapter that is specifically dedicated to "Interaction among users".

Beneficial use of dredged material

(Paipai 2003)

Biological uses:

- habitat restoration, enhancement and/or creation
- aquaculture
- agriculture
- horticulture

- forestry

Geological/physical uses:

- relocation within the natural ecosystem
- beach nourishment
- sediment cell maintenance
- construction and other engineered uses
- construction material
- replacement fill
- shoreline stabilization
- erosion control

Spatial conflict

There is a spatial conflict between dredging and dredge disposal on the BPNS and:

- cables and pipelines
- military exercise areas
- future electricity cable
- fisheries
- nature protection

7.5.3 Impact on environment

Biological

Impact on benthos:

The impacts of sediment disposal on benthic communities vary depending on many factors including the amount, frequency and nature of the disposed sediment, water depth, hydrography, time of year, the types of organisms inhabiting the disposal area and the similarity of the dredged sediment to that of the disposal area (Harvey et al. 1998).

Turbid plumes of suspended sand and silt can cause substratum removal and alteration of the bottom topography, resulting in the destruction of infaunal and epifaunal biota (De Groot 1996).

Harvey et al. (1998) came to the conclusion that the benthic community structure changes drastically shortly after the open-sea deposition of dredged materials. Less opportunistic families had a decreasing density and the most opportunistic families tended to have an increasing density. Both the burial with dredged sediments and the enhanced food-supply are responsible for the changing densities. However, studies carried out by the Sea Fisheries Department (DvZ) from 2001 till 2004 showed that there was no long-term change in the amount, density or diversity of species between the dumping sites on the BPNS and the reference sites. The only parameter that changed from station to station was the species composition, which is strongly dependent of the soil composition (Lauwaert et al. 2004).

The Scottish Office Agriculture (1996) gives an overview of responses of benthic communities to different waste types. Their conclusions were the following: '*Most dredged material, irrespective of its nature, will be rapidly re-colonised by benthic species following disposal. The rate of recolonisation will clearly depend on the frequency of disposal, and the nature of the receiving area. The timing of disposal in* *relation to seasonal peaks of recruitment of juveniles from the plankton will also affect recolonisation rates. However, adults may arrive immediately, either through vertical migration if undamaged and only lightly buried, or horizontally (passively or actively) from unaffected areas nearby. Factors influencing time-scales for "recovery" on cessation of disposal include the dispersive properties of the receiving environment, the degree of similarity of the deposited substrate with that naturally prevailing in the area and the age composition of "key" species in unaffected populations'.*

Impact on fish/birds/flora:

Dredging activities can have beneficial impacts on fish and fish habitats (e.g. increased water column oxygen content, re-oxygenation of sediments, re-suspension of nutrients, removal of polluted sediments) (Hopkins and White 1998).

In the Mobag 2000 project, initiated by the Flemish Government, the physical, chemical and ecotoxicological impact of dredging and relocation in the harbour of Nieuwpoort was investigated. The maintenance dredging and relocation operations only cause a visual effect near the relocation area, but have no adverse environmental effect and do not impact the local ecosystem as such (De Groote et al. 1998). Also the results of DvZ studies showed no important changes in the demersal fish stocks due to dumping activities (Lauwaert et al. 2004).

When dredging activities take place in spawning grounds, a deposition of fine material from the plumes (which can extend in a larger area than the actual dredging area) can smother eggs laid on the bottom (De Groot 1996).

Geological/physical

A turbid plume of suspended material (sand and silt) is formed when the displaced water of the hopper flows back into the sea. Removal of substratum, alteration of the bottom topography, the formation of temporary plumes in the water column and re-deposition of material are the most common physical impacts of dredging (De Groot 1996; Burt and Hayes 2005). However dredging activity is not the only factor that affects the turbidity. Other causes are storm and tides. Therefore the relative contribution of dredging should be quantified in order to assess the surplus impact of dredging (Van Parys et al. 2002).

Dumping of dredged material will change the bathymetry and the nature of the bed sediments, if it is of a different particle size. It also influences a larger area due to the formation of a turbid plume during the dumping process. If bedforms are present they will likely disappear during the period of dumping. However, if the sediment composition is restored after the dumping has ceased the chances of recovery are high (Knaapen and Hulscher 2002). Bedforms have reappeared in the old dumping site of the Sierra Ventana area (S1) after the site was closed for dumping. This has been well demonstrated by Du Four (2004).

Hydrological

Increased turbulence due to vessel movements and dumping may re-suspend sediments, which can have an impact on bank stability (e.g. erosion of banks), dislodge macro-invertebrates and disturb fish eggs and larvae in the edges of a waterway (Hopkins and White 1998).

Chemical

De Groote et al. (1998) did not find a change in the quality of seawater owing to the relocation of dredged sediments in the near shore zone near the harbour of Nieuwpoort. Pieters et al. (2002) concluded that the mobility of contaminants in dredged material changed during dredging. This change is different for every examined contaminant. For some contaminants the mobility decreases; for others it increases. However it is important to note that the change in mobility is very low for all the considered contaminants and for both dredging techniques. There are indications that arsenic is liberated to the surrounding seawater at the disposal area. However, the concentrations remain very low and in the laboratory no negative effects could be detected for the organisms tested.

The Belgian Sea Fisheries Department investigated the impact of dumping activities on the concentrations of organic and inorganic contaminants in the fine sediment fraction. However the fluctuating concentrations could not be brought in correlation with the dumping activities (Lauwaert et al. 2004).

7.5.4 Impact of on socio-economy

Economic

An estimate of the turnover of dredging in the Belgian part of the North Sea (and its coastal ports) can be given by extrapolating the budgets invested. In 2000-2001 this was an amount of 57 million euros. There seemed to be a gradual increase of turnover over the last 10 years mainly due to investment in dredging works during the period 1998-2001 (Maes et al. 2002).

Social

Making use of information from the "Temporary Union" of dredgers, an estimate of about 240 employees for the year 2000 could be given. More than 65% of these people worked on the vessels whereas the others worked in the office, on the berth or in the work places (Maes et al. 2002).

It is extremely difficult however to give an estimate since most companies have huge activities abroad. In the past 5 years for example, De Nul alone already invested 580 million euro. The employment increased from 1600 to 2400 persons. There is an ongoing recruitment of engineers, technical people and vessel staff. De Nul's activities however go beyond the Belgian part of the North Sea.

The number of employees of the Ministry of the Flemish Community authorized for dredging works should also be taken into account:

- 29 staff monitoring dredging activities
- 2 engineers
- 1 civil engineer

7.6 REFERENCES

Burt, N. and Hayes, D. F., 2005. Framework for research leading to improved assessment of dredge generated plumes. Terra et Aqua, 98, p. 20-31.

Cliquet, A., Lambrecht, J. and Maes, F., 2004. *Juridische inventarisatie van de kustzone in België, 2e update*. Studie in opdracht van de Administratie Waterwegen en Zeewezen, Afdeling Waterwegen Kust, (Departement Leefmilieu en Infrastructuur, Ministerie van de Vlaamse Gemeenschap), Gent, Maritiem Instituut/Vakgroep Internationaal Publiekrecht, 88 p.

Collins, M., 1990, The behaviour of cohesive and non-cohesive sediments. Alzieu, C. and Galenne, B. eds. Proceedings of the international seminar on the environmental aspects of dredging activities. Nantes, Port Autonome de Nantes Saint-Nazaire, p. 15-32.

De Brauwer, D., 2003. Baggeren. Oral presentation on information session 'De Zee en haar gebruikers'.

De Groot, S.J., 1996. The physical impact of marine aggregate extraction in the North Sea: ICES Journal of Marine Science, v. 53, p. 1051-1053.

De Groote, J., Dumon, G., Vangheluwe, M. and Jansen, C., 1998. Environmental monitoring of dredging operations in the Belgian nearshore zone, Terra et Aqua, 70, p. 21-25.

Donze, M., ed., 1990. Shaping the environment: aquatic pollution and dredging in the European Community. The Hague, Delwel, 136 p.

Du Four, I., 2004. Pysical characterization of the Sierra Ventana region, in view of the rehabilitation of a dumping site of dredged material into a potential area for marine aggregates extraction. Unpublished Msc Thesis, Universiteit Gent, Gent, 56 p.

Fettweis, M., Francken, F., Pison, V. and Van den Eynde, D., 2003. Dredging Location and dumping sites in relation ot bottom sediments, hydrodynamic conditions and sedimentation rates. In. Lanckneus et al., 2001. Management, research and budgeting of aggregates in shelf seas related to end-users (Marebasse). Scientific Report Year 1. Federal Office for Scientific, Technical and Cultural Affairs (OSTC), 39 p.

Harvey, M., Gauthier, D. and Munro, J., 1998. Temporal changes in the composition and abundance of the macro-benthic invertebrate communities at dredged material disposal sites in the Anse a Beaufils, Baie des chaleurs, Eastern Canada, Marine Pollution Bulletin, 36, p. 41-55.

Hopkins, E. and White, M., 1998. Dredging, extraction and spoil disposal activities: departmental procedures for provision of fisheries comments, Queensland Department of Primary Industries, Fish Habitat Management Operational Policy FHMOP 004, 79 p.

Knaapen, M.A.F. and Hulscher, S.J.M.H., 2002. Regeneration of sand waves after dredging: Coastal Engineering, v. 46, p. 277-289.

Lauwaert, B., 2002. Het beheer van de niet-levende rijkdommen op het Belgisch continentaal plat. pp 1-4. In Van Lancker et al. (eds). Colloquium 'Kustzonebeheer vauit geo-ecologische en economische invalshoek'. Oostende (B), 16-17 mei 2002. Genootschap van Gentse Geologen (GGG) – Vlaams Instituut van de Zee (VLIZ). VLIZ Special Publication 10: Oostende, Belgium. ISSN 1377-0950

Lauwaert, B., Fettweis, M., Cooreman, K., Hillewaert, H., Moulaert, I., Raemaekers, M., Mergaert, K. and De Brauwer, D., 2004. Syntheserapport over de effecten op het mariene milieu van baggerspeciestortingen. 52 p.

Maes, F. and Cliquet, A., 2005. Codex wetgeving kustzone, Brugge, Vanden Broele, vol. 2.

Maes, F., Cliquet, A., Seys, J., Meire, P., and Offringa, H., 2000. Limited Atlas of the Belgian part of the North Sea.

Maes, F., Douvere, F. and Schrijvers, J., 2002. Ontwikkelen en evalueren van maatregelen die de overheid dient te nemen om een geïntegreerd beheer en duurzaam gebruik van de Noordzee te bevorderen. In: *Beoordeling van mariene degradatie in de Noordzee en voorstellen voor een Duurzaam Beheer*, DWTC, PODO I, p. 335-557.

Malherbe, B., 1991. A case study of dumping dredged material in open areas. Terra et Aqua, 45, p. 5-31.

Pieters, A., Van Parys, M., Dumon, G. and Speleers, L., 2002. Chemical monitoring of maintenance dredging operations at Zeebrugge, Terra et Aqua, 86, p. 3-10.

Seys, J., 2002. Een 'diepgravend' onderzoek naar de milieu-impact van baggerspecielossingen op zee. Vliz Nieuwsbrief, Focus, juni 2002, p. 3-8.

The Scottish Office Agriculture, E.a.F.D., 1996. Monitoring and assessment of the marine benthos at UK dredged material disposal sites, 35 p.

Truitt, C.L., 1988. Dredged material behaviour during open water disposal, Journal of Coastal Research, 4, p. 389-397.

Van Craenenbroeck, K., Duthoo, J., Vandecasteele, M., Eygenraam, J.A. and Van Oostveen, J., 1998. Application of modern survey techniques in today's dredging practice, Terra et Aqua, 72, p. 3-9.

Van Parijs, M., Dumon, G., Pieters, A., Lanckneus, J., Van Lancker, V., Vangheluwe, M., Van Sprang, P., Speleers, L. and Janssen C., 2002. Milieugerichte monitoring van baggerwerkzaamheden: MOBAG 2000.

Web sites:

MUMM, 2003, http://www.mumm.ac.be/NL/index.php