Status of ecological assessment of dredging and relocation sites in Germany and The Netherlands

Dutch-German Exchange (DGE) on Dredged Material

– Part 4 –

Status of ecological assessment of dredging and relocation sites in Germany and The Netherlands

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1 Introduction

The Dutch German Exchange (DGE)

The Netherlands and Germany have large river systems such as Danube, Rhine, Meuse, Elbe, Weser and Ems, which have important hydrological and shipping functions and where dredging is essential. In case of the rivers Rhine, Meuse and Ems, both countries have a common interest in the sound management of the sediments, because these river basins are shared by both countries. Finally, both Germany and The Netherlands have large (sea) harbours such as Hamburg, Bremen/Bremerhaven, Rotterdam and Delfzijl, which receive large amounts of sediment both from the sea by tidal processes and from the hinterland by rivers. Therefore, both countries are equally subject to the cross-national (European) dimensions of dredging.

Against this background, the competent governmental authorities in The Netherlands and Germany have started a Dutch-German Exchange on Dredged Material (DGE) in the year 1999. This DGE was started as an informal bilateral platform for exchanging knowledge, information and experiences in the field of sediment management. Since its start, several meetings have been organized, in which subjects such as legislation, risk assessment, sediment treatment, hazardous substances, ecotoxicological and ecological assessment were discussed. The results of these discussions were put down in thematic reports. The DGE has thus achieved an increased understanding of the management of dredged material both at policy level (national) and practical (project) level.

First having set the basis on the bilateral situation and second several developments in the international scene require a broader perspective for the exchange of information on sediment and dredged material. These developments are:

- Implementation of the WFD
- Climate change, leading to increased risk for flooding, therefore increasing the need for dredging waterways
- Integration of river management in other policy-making processes, such as Marine Strategies and Soil Protection Strategies.

For this reason, the Dutch and German participants in DGE have invited other countries to participate. The exchange is intended to be on the level of authorities that deal with the management of our rivers and ports. Most participants represent regulatory organizations (governments / port authorities). The exchange is informal, meaning that no official governmental statements will be prepared. However, the exchange will help to feed the contributing organizations with better knowledge and experience of sediment and dredged material management.

Demands from the Water Framework Directive and International Conventions for the protection of the marine environment (OSPAR, HELCOM, LC) enforce the use of ecological methods for sediment- and dredged-material management. The possible impact of dredged-material handling on the animal communities in the aquatic environment (sediment and water) is an important aspect of ecological (risk) assessment. DGE aims to compare the current tools and procedures in Germany and The Netherlands particularly regarding the impact of dredged-material management on fauna and the ecological assessment of potential relocation sites. Great emphasis is put on macrozoobenthos, as this is the group of organisms with most direct effects caused by dredging and relocation/disposal. Macrozoobenthos is an often used in-situ indicator of ecological changes in waters.

Ecological field investigations are made to describe how organisms react or will react in their environment. In the frame of DGE the most representative aspects are in closer focus. These are physical sediment properties, chemical pollution and ecological aspects such as oxygen consumtion and nutrient as an indicator of pelagic production/eutrophication, ecotoxicology and benthic organisms. Other aspects as fish, mammals, birds, vegetation and nature protection can be additional parts of the scope of the investigation. The part of chemistry is described in the DGE-report 3 (Hazardous substances in dredged material, 2005), ecotoxicology is treated in the DGE-report 5 (Status of the ecotoxicological assessment of sediment and dredged material).

The report describes the rules and legal framework and the use of ecological investigations in the context of dredged material quality assessment of polluted sediments and of physical effects of its relocation. Regulation interactions with EU-WFD will be an important future topic.

The DGE ecology report starts with the description when ecological aspects have to be considered in the wider context of dredged material or polluted sediments (Chapter 2). It explained which aspects have to be investigated and/or assessed. In Chapter 3, the methods are described on the basis of case studies, because the „guidelines“ do not require specific methods. Therefore the spectrum of adequate solutions in single cases is shown. Details of guidelines and methods are placed in the Annex.
In Chapter 4 the results of some background studies are given to show the knowledge that is necessary to use sound methods and to make proper assessments.

2 Current Legal Situation and Policy: Ecology Used within Risk Assessment

Dredged material is produced by maintenance or capital dredging, in case of a need for sediments (beach nourishment, dike construction etc.) and if remediation of the beds of the waters is necessary. Internationally guidelines have been agreed for the handling of dredged material for marine and coastal waters (LC, OSPAR, HELCOM).
The equivalent German implementation in the corresponding national guideline for federal coastal waters focusses therefore on assessing effects at the disposal site and includes investigation in dredging areas as the source for the "dredged material".
Due to the soil protection act [Wet bodembescherming; Wbb] in The Netherlands, sediments have to be removed in case of severe pollution. Therefore, The Netherlands also concentrate on the investigation and the evaluation of the remediation (=dredging) sites.
Both countries maintain that the effects on the ecosystem must be assessed, where dredged material is involved.
The requirement to carry out ecological investigations is partly laid down by law. This chapter deals with the laws and regulations that are applied in the various situations in Germany and The Netherlands. Some relevant policy frameworks are also discussed.
European policy greatly influences the policies and the laws and regulations in the two countries. Because possible effects and their assessment are not yet fully known, this subject is a main part of the discussion in Chapter 5 (Future Perspectives).

2.1 European Legislation

Protecting the environment is essential for the quality of life of current and future generations. European Union environment policy is based on the belief that high environmental standards stimulate innovation and business opportunities. Economic, social and environment policies are closely integrated. EU rules provide a broadly equivalent level of protection throughout the EU, but the policy is flexible enough to take local circumstances into account. (http://europa.eu.int)

Directives influencing national law exist already, like the water framework directive (WFD), the habitat directive (Natura2000) or the directive on the environmental impact assessment (EIA). Beside these directives, there is the marine strategy as a new directive in preparation. All these directives influence or will influence the handling of dredged material.

2.1.1 Water Framework Directive (WFD)

The European Water Framework Directive (WFD) was adopted in 2000 (2000/60/EC). The objectives of the Framework Directive are such that results are mandatory. This means that Member states will have to comply with the environmental objectives of the WFD; otherwise, a sanction will follow. The water management within the WFD is organised on the scale of river basins. This forces countries to work together.
The WFD has a strong ecological character, with the focus on the well-being of the water ecosystems. Together with the chemical objectives it supports the main objective: to reach a "good ecological and chemical status". For the ecological objectives "Quality elements" have been formulated. The quality elements include fish, phytoplankton, phytobenthos, macro-

phytes and macro-invertebrates. A distinction is also made between categories (e.g. natural, artificial and heavily modified waters) and types (e.g. slow flowing rivers on sand). The assessment is carried out per type of water system. The aquatic sediment is not mentioned separately in the WFD, but it is an integral part of the system. Also the handling of dredged material is not addressed directly in the WFD. But as the handling of DM has an effect on the environment - at least physical effects like sedimentation and raised turbidity - it belongs to anthropogenic activities with a possible impact on the good ecological status of water bodies. Therefore in future the WFD will affect the handling of dredged material, if the generated impact will be responsible for not reaching the good ecological status or in case of endangering the good ecological status. For future perspectives see Chapter 5.

2.1.2 Directive on Environmetal Impact Assessment (EIA)

In projects with environmental consequences, an Environmental Impact Assessment (EIA) has to be carried out in order to give the environmental interests due consideration in the matter.
This has been laid down in the Directive 85/337/EEC, amended 97/11/EC, a directive of the European Union about environmental impact assessment. This directive includes construction activities as parts of projects and thereby also the handling of dredged material in case of e.g. capital dredging.

2.1.3 Birds and Habitats Directives

Within its aim to protect the nature, the EU resolved upon the Birds Directive in 1979 and the Habitat Directive in 1992. The plan is to construct a coherent network of protected areas. The birds and habitat directives as well as the EIA directive function as complementary tools, the EIA has its focus on human activities to minimise adverse effects on nature, and the two other directives have their focus on areas of specific value for nature ore ecosystems to minimise effects from human activities. With these instruments, the EU took action towards the conservation and sustainable use of biodiversity. This led to the formulation of a policy principle, when in 1998 the European Commission adopted a Communication on a European Biodiversity Strategy. As a part of the European Biodiversity Strategy, this strategy aims to anticipate, prevent and attack the causes of significant reduction or loss of biodiversity at the source. The birds and habitats directives are the mandatory regulations to reach this aim.

2.2 German Legislation

According to HELCOM, OSPAR and London Convention (LC), the related German guideline HABAK describes the frame of aspects and questions to be investigated. There is no detailed programme of methods to be used (generally accepted scientific methods). The HABAB, the related German guideline for federal inland waters with no international requirements, gives also a general description of the frame of aspects to be investigated. In Germany, the Federal Government is responsible for the larger waters as federal waterways. The regulations HABAK and HABAB were set up for the administration of these waters. There exists no comparable regulation from the “Länder” (SRU 2004). A common guideline for coastal waters of the federal government and the 5 “Küstenländer” is in preparation.
The implementation of EIA into national law leads to develop decision-making processes, which are based on ecological assessments. This is necessary in advance of permission for

construction and thus also for capital dredging, sand extraction, construction of confined disposal areas, etc. The assessment methods are preset only in a very general manner. The investigation concept and the choice of evaluation tools etc. were part of the decision upon the investigation design within the investigations of the single cases.
The WFD with its focus on improvement of the ecological status of waters will also have an influence on the handling of dredged material. This EU-guideline will lead to preset methods and evaluation tools in the very detail.

2.2.1 Directive for Dredged Material Management in Federal Inland Waterways

With the “Handlungsanweisung für den Umgang mit Baggergut im Binnenland” (HABAB) Germany has set up regulations for the administration of the inland federal waterways, as to which ecological aspects have to be considered when handling dredged material.

Basis for the determination of a placement site is an inventory of the quantity and properties of the dredged material. The properties of the dredged material are to be tested according to physical, chemical, biochemical and ecotoxicological criteria. In the case of maintenance dredging, characterization of the fauna and flora in the dredging area is not necessary. This would only be considered necessary for hydraulic engineering projects. In this case, the faunistic aspect is to be tested and assessed at the dredging site and placement site, however, exclusively for the purpose of an investigation of the intervention within the framework of the environmental impact assessment in accordance with the Environmental Impact Assessment Act (UVPG) (see Chapter 2.2.3).
Dredged material that is to be relocated and consists mostly (> 90%) of sand, gravel or pebble, need not be further tested, insofar as there is no suspicion of contamination, or if results of previous investigations show no or negligible contamination.

For all other cases, the tests named below are to be carried out:

Physical and sedimentological tests (see Annex 1)
Testing for contaminants (see DGE report III)
Biochemical tests (oxygen, nutrients) (see Annex 1)
Ecotoxicological tests (see DGE report V)
Fauna and vegetation (see Annex 1)

In this guideline no methods are preset regarding sampling methods, sampling design and assessment methods. This is part of the case-to-case decision.

2.2.2 Directive for Dredged Material Management in Federal Coastal Waterways

In the “Handlungsanweisung für den Umgang mit Baggergut im Küstenbereich” (HABAK) Germany has set up regulations for the administration of the coastal federal waterways (eligible area as defined by HELCOM and OSPAR), as to which ecological aspects have to be considered when handling dredged material. This guideline resulted from different international agreements (HELCOM 1992, LC 1972, OSPAR 1992). There exists no comparable regulation from the “Länder” (SRU 2004).
According to the international regulations from LC, OSPAR and HELCOM, effects of disposing dredged material in the marine environment have to be described. Severe impact, as far as it is predicted or described, has either to be minimised or it has to be checked, whether another way of handling is possible.

Dredged material that is to be relocated and consists mostly (> 90%) of sand, gravel or pebble, need not be further tested, insofar as there is no suspicion of contamination, or if results of previous investigations show no or negligible contamination.

Tests named below are to be carried out:

Physical and sedimentological tests (see Annex 2)
Testing for contaminants (see DGE report III)
Biochemical tests (oxygen, nutrients) (see Annex 2)
Ecotoxicological tests (see DGE report IV)
Fauna and vegetation (see Annex 2)

In any case, the disposal of dredged material has a physical impact on the area of disposal. The physical process can cause effects on bed organisms by smothering the surface or changing the grain size, if the composition of the dredged material greatly differs from that of the sediment found at the site of disposal. The physical process can also adversely affect the migration of fish and crustacea (e.g. salmon in estuaries, crabs in coastal regions).
When selecting suitable disposal sites, disturbance of environmental conditions and marine ecosystems (fauna and flora) have to be taken into consideration. It has to be examined in detail whether there is a conflict with the following aspects:

- benthic biocoenosis,
- spawning, breeding and feeding grounds,
- migration routes of marine organisms,
- landscape or conservation areas,
- areas of special importance for science or conservation (e.g., bird sanctuaries, seal resting places, eelgrass marshes).

In this guideline no methods are preset regarding sampling methods, sampling design and assessment methods. It is a case-to-case decision on the choise of the methods used for each investigation.

2.2.3 Environmental Impact Assessment (EIA)

The adoption into German law (UVPG 1990ff) adresses among other topics ecological effects of capital dredging and by that also the handling of dredged material. All essential impacts within the environment have to be described, minimised and compensated, so that at the end no severe impact will remain.
For the administration of the German Federal Waterways in an administrative instruction it is laid down in a more detailed way, what and how has to be investigated and assessed (EIA-Investigation Guideline for Federal Waterways in VV-WSV 1401).

The administrative instruction is a guidance for the Federal Waterways and Shipping Administration in applying the EIA in the legal preparation of waterway construction projects. It includes assessment criteria for the different protected assets (*Schutzgüter*) on a more general level which have to be adjusted from case to case.

2.2.4 Environmental Risk Assessment (ERA)

The Federal Transport Infrastructure Plan of the German government is a framework investment plan and a planning tool.

"The FTIP 2003 follows the guiding policy principle of "development of Eastern Germany and upgrading in Western Germany". Alongside their evaluation on the basis of benefit-cost analysis, all projects have been subjected to an environmental and nature conservation assessment and were classified in terms of the ecological risks they pose. In addition, the regional planning significance of the projects was identified more comprehensively than in the past by means of a spatial impact assessment." (http://www.bmvbw.de/artikel,-17080/Federal-Transport-Infrastructu.htm)
"New features of the ERA are a methodologically comparable application for all modes of transport and the greater account it takes of cultivated landscapes, highly sensitive sites and unsevered areas with a low density of traffic. It distinguishes risks that are relevant in terms of the environment and nature conservation. The results of the ERA are classified on a scale from 1 to 5 (very low environmental risk to very high environmental risk)." (http://www.bmvbs.de/Anlage/original_17121/Federal-Transport-Infrastructure-Plan-2003.pdf)

2.2.5 Nature Protection (Habitats Directive, Birds Directive)

These directives were implemented by modifications of the German Federal Nature Protection Act (Bundesnaturschutzgesetz, BNatSchG from 2002, last modification 21. June 2005). Germany has named the areas of protection to the EU. The methodology of assessing possible impacts of planned projects on protected areas or species is still in progress.

2.3 Dutch Legislation

Dredged materials have to be dealt with in accordance with the various policy frameworks and laws and regulations. These have been laid down, among other things, in the 4th Policy Document on Water Management, the Pollution of Surface Waters Act [Wet verontreiniging oppervlaktewater; Wvo], the Pollution of Saltwater Act [Wet verontreinigingen zee; Wvz], the Environmental Management Act [Wet milieubeheer; Wm], Soil Protaction Act (Wet bodembescherming; Wbb] and the Building Materials Decree [Bouwstoffenbesluit; Bs] (DGE, 2003). Testing is usually applied on environmental quality objectives that were drawn up on the basis of ecotoxicological data. The ecological assessment of the dredged materials and sediment quality plays only a minimal role in this.
An assessment of the effects on ecology is, however, required for a number of activities, e.g. the ecological assessments for remediation issues (prioritisation) (Soil Protection Act, Guideline for risk assessment of contaminated sediments [Richtlijn Nader Onderzoek]).There is a need to evaluate the effects of the measures on the basis of ecological assessment methods. The distribution of dredged material in marine systems requires an evaluation of the ensuing ecological effects (Key National Spatial Planning Decision Wadden Sea). An overview of the relevant statutory and policy frameworks in which ecological assessment plays a role is listed below.

2.3.1 Key National Spatial Planning Decision Wadden Sea (PKB-Wadden Sea)

A few general guidelines for open-water disposal are given in the Key National Spatial Planning Decision Wadden Sea (PKB Wadden Sea) and the Nature Conservation Act [Natuurbeschermingswet]. The rules regarding ecology are most clearly worded in the Management Plan Wadden Sea, which is derived from the PKB Wadden Sea:

Only dispose of material in channels in which currents can disperse this material;
Do not dispose of material within a distance of 1000 m from areas with rich benthic flora and fauna, among which mussel banks and culture lots;
Depending on the site, dispose only during low or high tide;
Careful disposal location planning will preclude dredging problems elsewhere.

The above rules are partly drawn up to minimise any possible ecological effects. The evaluation of the ecological effects will be carried out when a licence is applied for under the Nature Conservation Act [Natuurbeschermingswet]. The Ministry of Agriculture, Nature and Food Quality (LNV) is responsible for the evaluation and for issuing this licence (see Nature Conservation Act).

2.3.2 Soil Protection Act

If the intervention value for one or more substances in a volume of at least 25 m^3 is exceeded, the Soil Protection Act (Dutch: Wbb) speaks of a serious instance of contamination. In such a case, a decision must be made whether remediation is urgently required. For this purpose the actual risks for man and the ecosystem, and the risks of spreading in respect of the groundwater will be examined in a Further Inquiry (Elswijk et al, 2002). In determining the actual risks for the ecosystem, the Further Inquiry makes reference to the TRIADE approach (Maas et al, 1993). The TRIADE approach comprises assessments based on chemistry, ecotoxicology and ecology. Ecology is assessed with the help of the TRIADE field component based on benthic animals (macrozoobenthos) (Annex 5).

2.3.3 Active Sediment Management of Rivers

The policy document Active SedimentManagement of Rivers (dutch: ABR) relates to the remediation of diffusely contaminated floodplain beds resulting from restoration measures in the summer and winter beds of the rivers branches (Rhine and Meuse). The ABR was drawn up to avoid stagnation in major civil projects due to the lack of uses for large quantities of dredged floodplain soil. It is based on existing statutory frameworks, among them the Soil Protection Act, and sets requirements as to the quality of both the receiving sites and the used sediment. What must be done to acquire knowledge about the ecological soil quality of water systems is/will be laid down in the guideline for floodplain beds.

2.3.4 Environmental Impact Assessment (EIA)

The Netherlands has fulfilled the task of implementation in the Environmental Management Act [Wm] and the Environmental Impact Statement Decree 1994. The environmental impact assessment should comprise an identification, a description and an assessment in respect of, among other things, man, flora and fauna (art. 3). This also includes the assessment of ecological aspects, although the method has not been defined. One example of a large project whereby the ecological effects have been assessed is the filling of pits with dredged material in the Afferdensche en Deestsche Waarden (RWS 2006).

2.3.5 Nature Conservation Acts

There are a number of important laws and regulations in respect of nature conservation. The EU has the Birds and Habitats directives. In the Netherlands these directives have been implemented in the Flora and Fauna Act and in the Nature Conservation Act.

These laws spotlight the protection of species, areas or habitats. Within these laws there is the possibility to apply for exemption (licence) in a number of individual cases, i.e. if a great social interest is at stake.
The Ministry of Agriculture, Nature and Food Quality (LNV) is responsible for evaluating and granting such a licence. The Ministry of LNV can ask the applicant to carry out a study of the ecological aspects, although it does not prescribe a particular method of study. Current legislation does not include any preconditions or parameters. The evaluation of the method and results of the field study is the responsibility of Ministry of LNV staff, who normally ask for expert advice.

2.3.6 Additional Acts

The Pollution of Surface Waters Act [Wet verontreinigingen oppervlaktewater], the Environmental Management Act [Wet milieubeheer], the Pollution of Saltwater Act [Wet verontreinigingen zee] and the Building Materials Decree [Bouwstoffenbesluit] are very important in legislation concerning dredged materials and sediment quality; ecological assessement plays no role.

2.4 Chapter Conclusions

- International agreements about ecological investigation, evaluation and assessment of dregded materials exist, however the methods and quality criteria to use them are not given.
- Both coutries implemented the international agreements into their national laws and regulations.
- In Germany, ecological assessment of sediment is mainly done for dregded materials, which has to be relocated.
- In The Netherlands, ecological assessment of sediment is also done on sites to determine whether remediation is necessary.

3 Ecological methods of assessment in use

3.1 Introduction Case Studies

In this chapter the ecological assessment methods are described using case studies. These methods comprise all methodological aspects of ecological investigations (sampling design and method, evaluation and final assessment methods).
Within representative case studies the aims of the studies are specified i.e. whether it is investigated in the context of a dredging operation or in case of remediation. Within the different frames of laws and regulations named in Chapter 2, it is specified which aspects for which reasons/questions have to be investigated. As the methods in detail depend on the single case circumstances, these methods were modified from case-to-case, and consequently they have therefore – up to now – not yet been generally preset. Exceptions are the methods developed in the frame of soil legislation in The Netherlands. Also the methods for the EU-WFD will be preset in future. The general implementation procedure requests an international intercalibration to assure comparable assessment results.

3.2 Germany

The German situation is explained by the help of three cases illustrating the procedure of the HABAK as the guideline for waters within the scope of OSPAR/HELCOM, the procedure of the HABAB as an national guideline for the inland area of the Federal Waterways and Shipping Administration, and the procedure of the EIA in the coastal area.

Example of HABAK Application: Jade
In the Jade area (the district of the Waterways and Shipping Office (WSA) of Wilhelmshaven) 7 disposal sites are in use. The investigation of the environmental effects caused by relocation activities were carried out according to the HABAK guideline.
Example of HABAB Application at Iffezheim
Material from above of the barriage of Iffezheim had to be disposed downstream of the barriage. The HABAB forms the frame of the topics to be dealt with according to the prognosis and the monitoring of possible environmental effects.
EIA „Inner and Outer Weser Estuary"
It is planned to deepen the Weser Estuary. Therefore a plan approval is neccessary and in this context an EIA is obligatory to describe all permanent or serious environmental impacts.

3.2.1 Example of HABAK Application: Jade

Introduction
In order to maintain the guaranteed water depth within the approach to the port of Wilhelmshaven regular dredging is necessary. As main dredging areas are defined: the outer part of the harbour, the inner part of the Jade north of the harbour and the part of the Jade approach north of the island of Wangerooge.
Three different types of dredged material are handled:

1. Fine and medium sand from the outer Jade approach is disposed of in the North Sea at the disposal site "01",

2. Fine sand mixed with fines from the inner Jade is relocated to a disposal site north of the island Wangerooge (Jade-Weser) and
3. Mud (1.3 million m³/a) from the outer port of Wilhelmshaven is disposed of in the Jade Bay (Vareler Fahrwaser, Südreede) and north of the island Mellum (Mellum-plate).

Sediments of the disposal sites consisted mainly of sand, partly mixed with cobble/pebble and in the case of the “Südreede” of mud. The map in Fig. 3.2-1 shows the positions of the dredging and disposal sites.

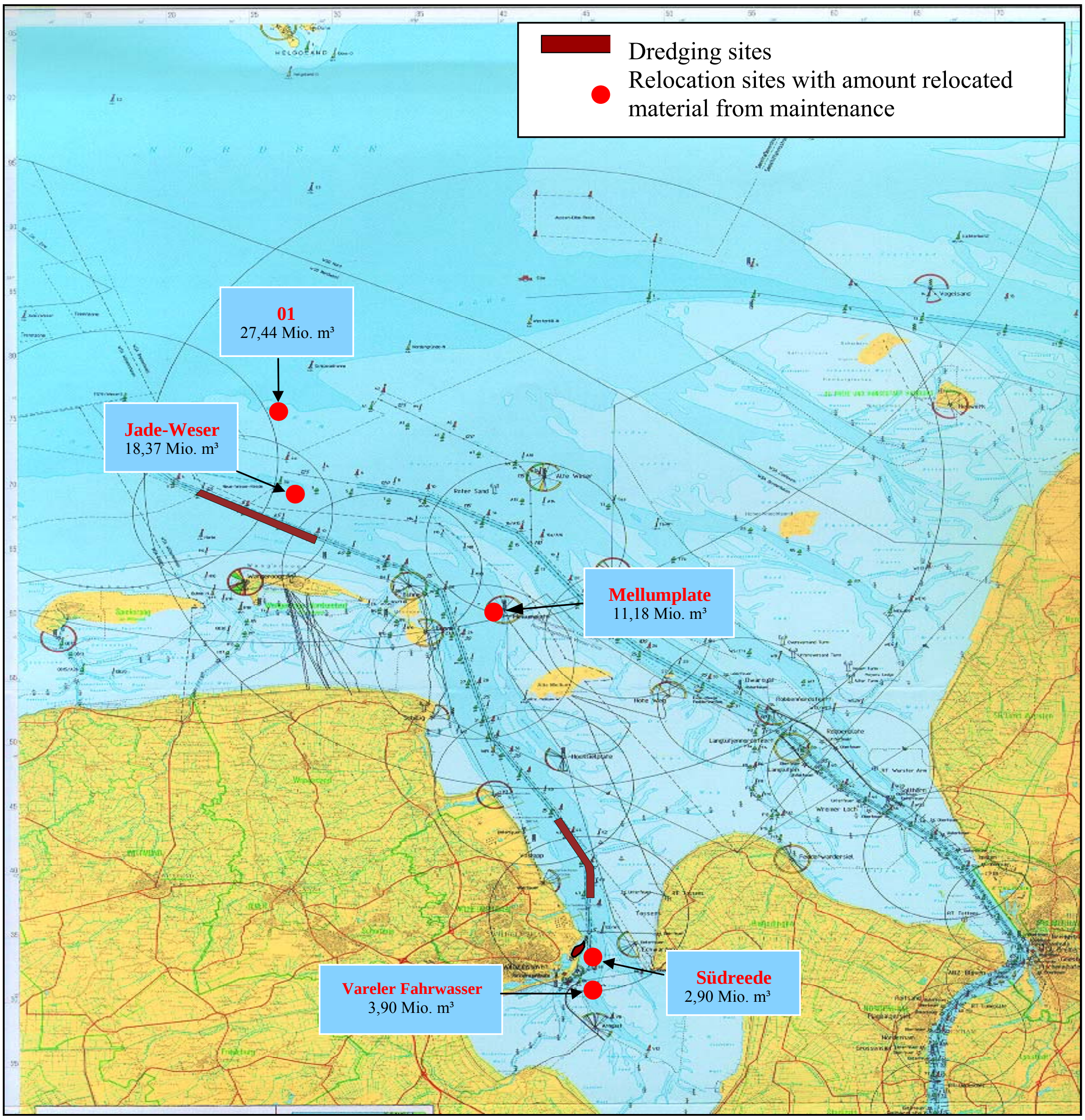


Figure 3.2-1: Positions of the dredging (red lines) and relocation areas (red dots) in the Jade district.

Legal framework and regulations

In order to fulfil international agreements on the handling of dredged material (OSPAR 1998) and related German guidelines (HABAK, BfG 1999), the dredged material and the sites where it was diposed of had been investigated in 2000 and 2001 within the „Jade-district“ of the Waterways and Shipping Office of Wilhelmshaven. The disposal sites have been in use for many years already. The aim was to describe and assess the effects of disposing the dredged material and, if there were serious impacts, to recommend mitigation measures.

Scope of investigation
Investigations comprised sediment to be dredged and sites of disposal. The sediment or dredged material was investigated regarding grain size, chemical components, nutrients, ecotoxicological effect and oxygen budget. At the disposal sites, morphological, chemical, ecotoxicological and biological investigations and assessments were made. The biological investigation included oxygen budget, macrozoobenthos, fish/fisheries and seals. Additionally, possible impacts on nature-protection areas were described.

Methods used
Macrozoobenthos
Macrofauna sampling was carried out at each disposal site according to a specially developed sampling design where the stations are divided into 3 groups: the disposal site, a transect of the assumed sediment plume, and a reference site, where no influences of disposal are assumed. The reference site was always selected as close as possible to the disposal site in order to minimize other potential gradients than those caused by dredged-material disposal. At each station, 3 replicate samples (van Veen grab 0.1 m^2) were collected. Macrozoobenthic specimen retained on a 1 mm mesh sieve were preserved in 70 % ethanol, sorted and identified to the lowest taxonomic level possible using a dissection microscope. Biomass estimates (wet weight, dry weight, ash-free dry weight), were determined using the ethanol-preserved specimens (Wetzel et al. 2005). Sediment properties (grain size, relative composition) were determined according to standard procedures (DIN 4022, DIN 18123) and classified (mud, medium-, fine-, and coarse sand, etc.). For each station, the number of individuals of each specimen, the number of species, and the biomass of each specimen were recorded.

Data were analyzed using different statistical, mathematical, and ecological assessment techniques, because it is often difficult to separate natural variability and man-induced influences: Methods used were:
univariate techniques (analysis of variance, H-test, etc.),
ecological assessment techniques (comparisons of Shannon-Wiener diversities and evenness, abundance biomass comparisons, species number, number of individuals, biomass, a modified amoebae approach, abundance biomass plots), as well as
multivariate tests (multidimensional scaling, analysis of similarities, principal component analysis, correspondence analysis, canonical correspondence analysis).
The environment in the surroundings of the disposal sites is very dynamic regarding varying water currents in amplitude and direction, salinity, turbidity, sediment morphology, etc. The specimens are adopted to this dynamic environment. So, the disposal of dredged material is "only" one of several disturbances, which makes it difficult to identify disposal-caused effects and to separate them from natural variance. Therefore, the results of the species composition analyses are checked for plausibility, if the result of an assessment technique showed a difference between a disposal site and the reference.

Summarizing all results of all these analyses comparing disposal and reference sites led to three different categories (no difference, clear difference, difference but not clearly caused by dredged-material disposal).

Fish
The description of effects on fish is based on an exemplary investigation of the relocation site "Südreede" and the experiences of other "HABAK"-investigations. Investigations of fish and shrimps were carried out with shrimp cutter with two trawl nets over two periods of 3 days each in October and November 2001 within the relocation site and in two reference areas.

Fish and shrimps were determined and the length of the individuals was measured. The investigation at the relocation site was carried out 5 to 10 min after dredged-material placement. In total, data sets from 12 single nets for each area were analysed separately. Additionally, parameters such as temperature, conductivity, oxygen, pH and turbidity were recorded.

The assessment comprised the number of species in total and per trawl, the species composition, the dominance, the number of individuals in total and per species and the distribution of the length of specimens. Box-and Whisker-Plots were use to test for significant differences.

Seals
The environmental administration of Lower Saxony organized 5 to 8 flights per year to count juvenile and adult seals. The results from those flights were used to describe and assess possible disturbances through dredged-material disposal activities. Shooing distances from 500 to 1000 m are discussed as assessment criteria.

Nature protection
The positions of disposal sites in relation to different protection areas were checked to identfy possible direct or indirect impairments of the aims of the protection areas. The results of the biological studies were taken into consideration.

Results
Chemistry
The placement of dredged material with low nutrient concentration showed no acceleration of eutrophication and no significant oxygen depletion with the exception of the material from the outer port. This had a higher redox-potential (oxygen demand) but disturbance of the oxygen budget at the placement site within and after disposal was not found.
All ecotoxicological measurements showed no effects.
No threshold regarding chemistry, nutrients, oxygen budget and ecotoxicology was exeeded, so that disposal was permitted without any restrictions.

The examinations of the macrozoobenthos communities at the placement sites 01 and Jade-Weser identified differences between the biocoenoses at the placement sites, on the one hand, and the communities in the reference areas or within a “plume area” that was secondarily influenced by drifted suspended solids, on the other hand. The dredged material that had been placed at the Site 01 in the previous years (1992-1995) caused significant elevations of the seabed, what influenced the faunal composition in addition to the effects of the placement operations in the year 2000. Sedimentological and faunistic changes were observed in some parts of the placement site Jade-Weser that were due to the large volumes of material (>1 million m^3) placed in the year 2000 until the time of sampling. No indications of effects due to dredged-material placement were found at the sites “Mellumplate Mitte + Nord 2” and “Mellumturm”. Probably, the zoocoenoses had recovered in the period between the last placement action and the time of sampling. Because of the high heterogeneity of the station groups at the placement sites “Südreede” and “Vareler Fahrwasser”, a final assessment of placement effects on the fauna there was not possible. Analysis of results from HABAK investigations of more than 20 relocation sites in the Ems and Weser estuaries and the Jade showed that differences could be detected only at relocation sites where more than 500,000 mio m^3 per year were disposed of (Leuchs et. al 2004).
The exemplary fish-biological studies performed at a placement site of the inner Jade (“Südreede”) showed that temporary effects of dredged-material relocation may occur in form of short-term evasion of fish and shrimps and prawns. This response was shown only by a very small portion of the fish and shrimp communities, while the majority of the animals re-

mained at the placement sites even immediately after the relocation activity. Long-lasting and/or significant impairments need not be expected, because the habitats that are vital for fish and shrimps are not or only slightly changed, the disturbance of food supply is not lasting, and the placement areas including the affected surroundings constitute only relatively small parts of the habitats of these species.
For these reasons, the fishing industry need not fear decreasing stocks of target species like shrimp and flatfish. Impairments of fishing operations due to soiled/muddy catches and nets may happen, especially at the placement sites of the inner Jade, where more silt was disposed. Because this affects usually only a very small portion of the fishing ground of the individual fishery, the impairment remains very modest.
Nearly all resting places of seals are in sufficient distance from the placement sites in the Jade River, and no significant or lasting impairment through dredged-material relocation was noticeable.

Except the site Vareler Fahrwasser, all placement sites considered were outside protected areas (reserves). In legal terms, the relocation activities of the “WSA Wilhelmshaven” within reserve areas are governed by federal legislation. Regarding nature conservation, the results of the studies suggest, at most, only slight impairments but no threats to protected areas.

In summary, it can be noted that the studies made so far found that the impacts of the current practice of dredged-material placement do not entail significant ecological impairments. Consequently, there is no need to change the existing placement-site management.

3.2.2 Example of HABAB Application at Iffezheim

Introduction
The River Rhine at Iffezheim carries annually one to two million cubic metres of suspended solids. With an annual sedimentation rate of some 1,500,000 m^3 of suspended solids, over the past two years about 3,300,000 m^3 of material have accumulated in the headwater channel of the impoundment weir of Iffezheim. This material must be removed in order to ensure the drainage of water and to avoid or reduce rising water levels in the impounded reach. Moreover, the freeboard guaranteed in German-French contracts must be ensured, and the stability of dams during flood events must not be threatened. In order to check whether the accumulated material may be discharged into the river downstream of the weir, analyses were made to characterize the material to be dredged and to assess potential impacts on the environment.

HABAB is the applicable planning and decision-aiding tool here. Following the HABAB procedure, the material to be dredged and relocated must be examined first in sedimentological, chemical (contaminants), biochemical (oxygen budget and nutrients), and ecotoxicological regards. In a second step, sedimentological, chemical, faunistic, floristic, biochemical, and ecotoxicological studies must be made at the site of the intended placement to assess possible impacts there.

Since a scientifically substantiated method for evaluation of analytical data of dredged material regarding the impacts of its relocation within the water is still lacking, the principle that the project must not cause durable disturbances of the present status is applied (principle of no-deterioration). To make the project ecologically acceptable, the interests of nature conservation and of the European Water Framework Directive have to be considered along with HABAB.

The maintenance-dredging activities at Iffezheim were carried out under consideration of possible impacts on the environment in nature reserves, bird sanctuaries, and FFH areas within the following set boundary conditions:

-Dredged material is discharged only when streamflow is above 700 m³/s and below 1,500 m3/s in order to avoid impairments of the life communities in the River Rhine and/or to prevent material from drifting into the lateral river zones and to avoid the inundation and silting of the floodplains.

- Such relocation is practised for ecological reasons only outside the growth period.

-The action should be stopped whenever the HCB concentration in the relocated material in the pipeline exceeds the value of 255 µg/kg (= the three-fold long-term annual average of HCB concentrations in suspended solids at Plittersdorf in the tailwater of the Iffezheim impoundment). This agrees with a binding rule in the German Federal Waterways and Shipping Administration (WSV) for the relocation of dredged material in inland waters and helps to observe the principle of no-deterioration).

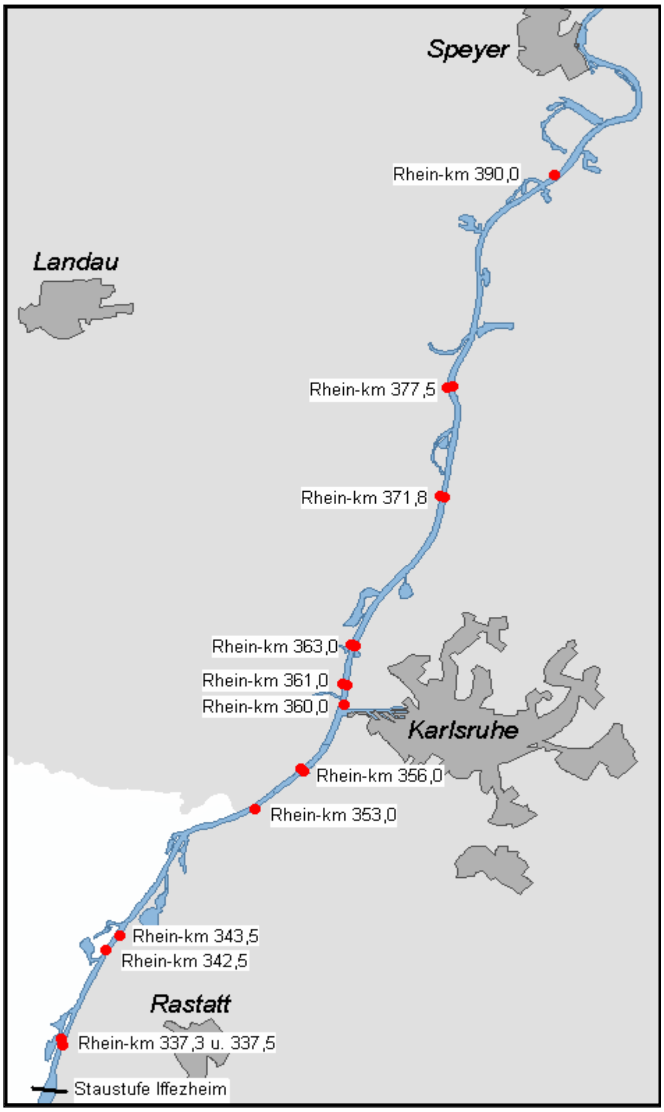


Fig. 3.2-1: Investigated area of the river Rhine from Iffezheim to Speyer

-Dredging with a mean performance of 5,250 m3 per day.
-Discharge of the material downstream of river-km 335.8, preferentially mid-stream.
The works should be stopped when one or several of the above criteria are not met.

Legal framework and regulations
The guideline for the handling of material dredged from inland waters (HABAB) intends to contribute to the economic handling of dredged material under observance of ecological concerns. Accordingly, the HABAB Directive is a planning and decision-aiding tool that leads to time and cost reductions in the considered overall project.

Since a scientifically substantiated evaluation of analytical data of dredged material regarding the impacts of its relocation within the water is still lacking, the principle that the project must not cause persistant disturbances of the present status is applied (principle of no-deterioration). To make the project ecologically acceptable, the interests of nature conservation and of the European Water Framework Directive have to be considered along with HABAB.

Because the planned dredged-material relocation is a maintenance project of unprecedented dimensions on inland waterways, additional investigations were made beyond the requirements of HABAB in the permitting process to obtain the consent of the District Administration of Rastatt.

Scope of investigations
This investigation is a surveillance programme which accompanies the disposal of sediment from the backwater of the barriage of Iffezheim into the water downstream. (see Fig.: 3.2-1) This maintenance measure may have an influence on the river systen due to raised HCB-concentrations.
Below the ecological investigations regarding water quality and fauna are described.

Methods
Water Quality
Although no effects of the measure are expected regarding the hydrological or ecological situation of the oxygen budget or the water quality, a monitoring programme was carried out. Close to the disposal site, oxygen concentrations had been measured while profiling the turbidity in cross sections. Additionally, oxygen consumption and nutrient concentrations were measured.
Two measuring campaigns were made for water-quality surveys (oxygen and nutrient content) before and after the beginning of the relocation. The first measuring cruise took place on 23 November 2004 before the relocation works started, and the second one monitored the beginning of the operation on 20/21 January 2005. The measurements were made 0.1 to 7 km downstream of the point of dredged-material discharge along five cross profiles in depths of 0.5 and 2 m.

Macrozoobenthos
In order to identify impacts of the relocation of fine sediment on the macrozoobenthos downstream of the Iffezheim impoundment weir, surveys were made at 48 stations between the Rhine river-km 337.3 and 390.0 36 days before (14/15 December 2004) and six days (23/24 February 2005) and 54 days (12/13 April 2005) after the action. River-sediment samples were collected by means of a dredge. The organisms were separated from the substrate by repeated flotation and sieving through a mesh size of 0.3 mm and were then preserved in 98% ethanol. The qualitative and quantitative taxonomic analyses were made in the laboratory using a stereoscopic lens. The data evaluation covered the species number, the density, the differentiation for species as r-strategists or K-strategists, as well as other ecological and biological criteria. Evaluation methods were: the ratio between r-strategists and K-strategists, the dominance ratio, the potamon-type index , the saprobic index, and the correspondence analysis.

Birds
Bird monitoring examined the impacts of the prolonged turbidity period on waterfowl species preying preferentially on fish by daylight at sight. The studies on the occurrence and behaviour of different bird species before, during, and after dredging and relocation into the flowing water began on 27 December 2004 and ended after ten counting campaigns on 20 April 2005.

The study area begins south of the Iffezheim impoundment weir at river-km 329 and extends towards Karlsruhe-Rappenwörth (river-km 358.5).

Counting and behaviour studies took place on the River Rhine and its lateral waters upstream (for reference) and downstream of the point of dredged-material discharge.

Results

Water Quality

Generally the impacts of dredged-material relocation on the oxygen balance are locally concentrated. Already seven kilometres further downstream, the impacts on the oxygen budget were negligible. Oxygen concentrations were never critical.

Macrozoobenthos

No lasting deterioration of the macrobenthic community due to the dredged-material relocation was observed. On a large-scale, the life community and the natural development typical for the degraded River Rhine remained preserved. The minor differences in the biocoenoses before the relocation and six days as well as two months afterwards are within the natural range of biocoenotic variability, as it is frequently observed in the River Rhine. Only locally were short-term impairments due to sediment deposition observable.

Birds

No impacts of the relocation project on the behaviour of waterfowl were found.

3.2.3 EIA Fairway Deepening Weser Estuary

Introduction

It is planed to deepen the navigation channel of the the Weser estuary. The sizes of the modern container ships are enlargening their draught. Therefore the waterway has to be adjusted. For the outer estuary of the River Weser further deepening of the fairway by about 1 m is planned. The fairway of the inner estuary is planned to be deepened between 0.6 and 0.9 m. This goes along with several minor adjustments. Here, two different pathways of impact are forseen. These are the direct impacts caused by dredging and disposal of sediments and the indirect effects resulting in changed hydrology and thereby possible shifts in biotope distribution (e.g. enlarging tidal flats). Information about this project and investigations is given in German language on the web site: „www.weseranpassung.de“.

Legal framework and regulations

In advance of further deepening of the Weser estuary a plan approval is necessary. This includes an EIA, a NATURA 2000 impact assessment and a landscape conservation support plan.

Scope of investigations

All protective assets named in the EU EIA-guideline are covered. The area of investigation covers the Weser estuary and the tributaries up to the tidal barrages, to the watersheds to the Elbe in the north-east and the Jade in the west and to the German Bight Approach (see Fig. 3.2-2). The part describing the possible impacts caused by dredging and disposal includes sediment characteristics (grain size and chemistry, ecotoxicology), water quality, macrozoobenthos and fish.

This paper presents the investigation of the macrozoobenthos and describes the methods of assessment in the framework of an EIA. Further investigations are not shown within this DGE-report.

Methods

Macrozoobenthos investigations (in the inner estuary = Unterweser)
Sediment samples were taken by Van-Veen grab and dredge along 13 cross transects for surveys of endobenthic and epibenthic fauna;
198 sediment samples (Van-Veen grab, 0.1 m², 70 kg):

(1) Benthic macrofauna, abundance (1 mm sieving), biomass (measurement of fresh weight and ash-free dry weight);
(2) Meiofauna from a sub-sample (core sampler Ø 4 cm, 250 µm sieve)
(3) Dredge (frame width 1 m; mesh size 0.5 cm; trawling length about 100 m);
(4) Sediment assessment (identifying the dominating surface sediment, estimating the percentage-composition of the substrate, consistency, peculiarities etc.)
(5) Sediment analysis of a sub-sample (core sampler Ø 4 cm) for grain-size analysis, including elutriation analysis (according to DIN).

Fig. 3.2-2: Map of the Weser estuary from Bremen towards sea. Green and red boxes mark relocation sites, the grey line the shipping channel and the red line the border of the investigation area.

The 45 passages of the dredge consisted of three to four moves along each of the cross transects, what gives - under the assumption of permanent, constant bottom contact and a dragging length of 100 m - a survey area of about 100 m² (0.01 ha).

Assessment
The present state of the benthos is assessed by means of criteria that are derived from the principles and categories proposed by the BfG for the assessment of federal waterways in Germany (BfG 1996). In this approach, aquatic fauna communities are rated in five levels that had been developed for assessments in the context of Environmental Impact Studies (EIS). The basic assessment criteria used here are:

- Naturalness of the species composition (comparison with historical reference);
- Representativity of ecological groups, indicators;
- Degree of anthropogenic impairment;

- Capacity of rehabilitation, regeneration period.

The following facts make the assessment of estuarine habitats by means of the benthos communities' generally difficult (cf. Witt 2004):

- High dynamics in benthic communities due to the hydromorphological and climatic variability in the estuary;
- Dominance of few, often unspecific species (e.g. euryhaline marine species);
- High portion of neozoa (mainly anthropogenically introduced species);
- Intensive anthropogenic modification (technical structures and buildings, land and water uses);
- Scarcity of data on the status quo (uninfluenced reference conditions);
- Open questions about the (functional) significance of estuarine species (interactions, food web).

Results
The impacts on the macrozoobenthos of the planned fairway deepening in the Weser estuary result mainly from the dredging and relocation of sediment and the disposal of the dredged-material. These impacts remain usually within the limits of the direct project areas. There, they cause significant impairments of the affected coenoses, especially in previously unaffected areas and there where hard-substrate coenoses prevail. Against the background of dredging and relocation impacts, the consequences of the fairway deepening for the velocity of currents, the tidal range, and consequently the expansion of mudflat areas are of minor importance. The tributaries are only slightly affected. However, the trends that were initiated by previous development projects will continue in all landscape units.

3.3 The Netherlands

The Dutch situation is illustrated with 3 cases; the first deals with relocations (Loswal North and Northwest), the second with prioritation of remediation (Kanaal door Walcheren) and the third with evaluation of remediation and restoration (Hollandsche IJssel).

Loswal North and Northwest
Disposal facility (Loswal) in the North Sea. Within the framework of an environmental impact assessment procedure, the ecological effects of the distribution of dredged material were mapped out here. Rehabilitation after disposal was also examined.
The Kanaal door Walcheren.
A brackish water system. The actual ecological risk in respect of remediation has been drawn up on the basis of the Guideline for risk assessment of contaminated sediments.
The Hollandsche IJssel
A freshwater tidal river. An evaluation of ecological rehabilitation was following remediation and river restoration measures here.

3.3.1 Disposal of Dredged Material "Loswal North and Northwest" (North Sea)

Introduction
Sedimentation takes place continuously in the port of Rotterdam and in the fairway leading towards the city; this process is the result of, among other things, the waves, the tide and discharge from the river. Because shipping is hampered by this sedimentation, the material must

be removed regularly. Since 1961 large volumes of this dredged material have been deposited in a disposal facility in the North Sea (Loswal North). Dumping in this disposal site ended in 1996, because Loswal North was full. A new disposal site was then put into use north of the old Loswal North (Loswal Northwest). The disposal sites are shown in Figure 3.3-1.

Statutory framework

The Environmental Management Act (Wm) stipulates that for certain activities, which may cause considerable harm to the environment, an Environmental Impact Assessment (EIA procedure) must be carried out. In respect of the discharge of dredged material into the sea, the Environmental Impact Assessment procedure is applied on a voluntary basis (MER rapport, 1995). The environmental impact report is submitted together with the application for exemption pursuant to the Seawater Pollution Act to discharge dredged material in the North Sea.
The EIA procedure includes an obligation to carry out an evaluation. The objective is to determine whether the behaviour and effect of Loswal Northwest sufficiently reflects the expectations, assumptions, and prognoses of the EIA.
Besides on the transport of dredged material, and the ecotoxicological effects, this evaluation study also focuses on the ecological effects of the dumping of dredged material. The following questions are highlighted:
What damage is caused to the ecosystem in the new Loswal (environmental effects)?
What is the rehabilitation of the ecosystem in the old Loswal (recovery)?

Method used

Sampling
Macrobenthos samples were taken with a box core (6,8 dm^2) in December and June/July. 10 (separate) sub-samples where taken in an area of 20 by 20 meters. The box core penetrated 30-50 cm into the sediment. The samples where rinsed over a sieve (1mm) a preserved with 96% ethanol. Exact at the same location a sample was taken also for chemical analyses (1 liter of top layer).
Megabenthos samples are taken with a Triple-D soil slicer (Bergman et al, 1994) in June and July. This slicer is equided with a knife (width 20 cm), which reaches 10 cm into the soil. Behind the slicer, a net (mess 7 x7 mm) collects the megabenthos. Stretches (80 –200 m) were taken upstream at speed of circa 6 km per hour (3 knots). The megabenthos (including fish)

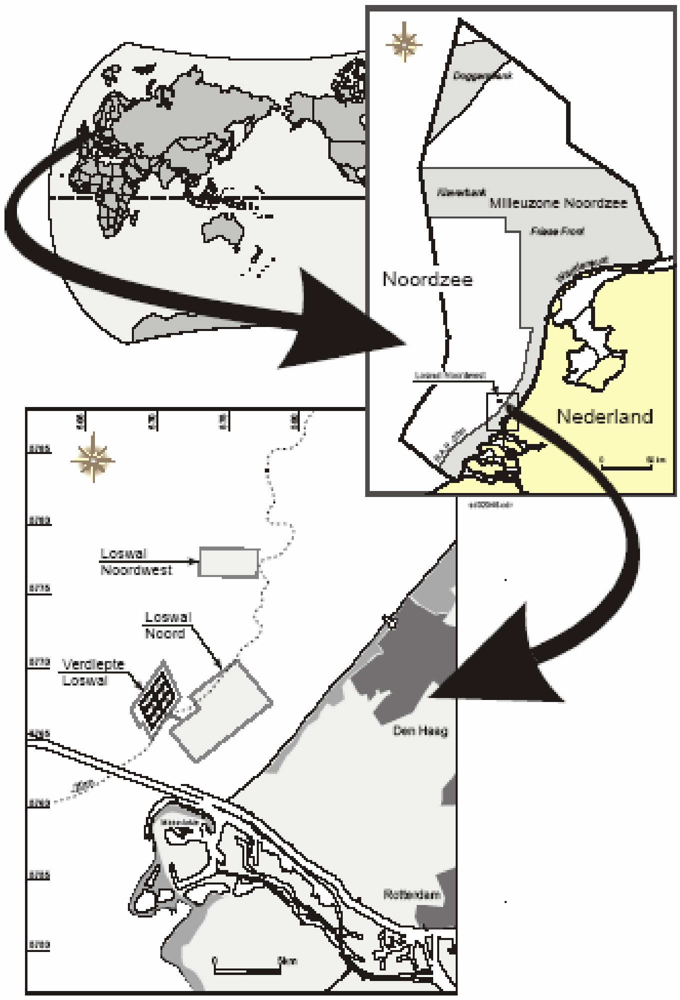


Figure 3.3-1: Overview location Loswal North (Noord), Loswal NorthWest (Noordwest) and Verdiepte Loswal (not furter mentioned in this case-studie)

was sorted and measured on board.

Analyses
Macrobenthos was separated from the samples by sorting under a binocular. Identification took place at species level. For macro-invertebrates samples, a method description is used (RIZA werkvoorschrift W 8140.2.112). Ash-free dry weight (mg/m2) was obtained by drying the samples for 3 days (70 °C) and calcinating for 4 hours (520 °C). Chemical analyses comprised total concentrations (metals, PAH, PCB, OCB) a physical parameters (loss on ignition, organic C, etc.).

Assessment
To assess the ecological effects, the macrobenthos (organisms < 1 mm) and megabenthos (organisms > 1 mm) were checked. Assessment focused in particular on the quality aspects of the benthic communities. The study also investigated the ecotoxicological and morphological aspects of the dredged material disposal (Sandeh Stutterheim, 2002).

Quality
The quality of the macrobenthos community was assessed on the basis of the number of species, densities, biomass, dominance and the spatial patterns in the benthic community (cluster analysis).
The megabenthos community was assessed on the basis of the total number of species and the number of fishes.

Results
Loswal North (rehabilitation)
The effect of the disposal in Loswal North until 1996 is obvious: extremely low values of diversity of species, density of biomass, macro- and megabenthos were locally found. After disposal ended, ecological rehabilitation was evident from an increase in numbers of species, density and biomass (see Fig. 3.3-2a). Stagnation in development occurred after two years. Species that have returned to Loswal North are mostly the more mobile ones – usually crustaceans and fish – while the benthic species such as the echinoderms and shellfish have not returned, or only in small numbers. These species depend for their rehabilitation mainly on colonisation by larvae. It is possible that the silt content of the sediment obstructs a successful colonisation and/or metamorphosis of these larvae.

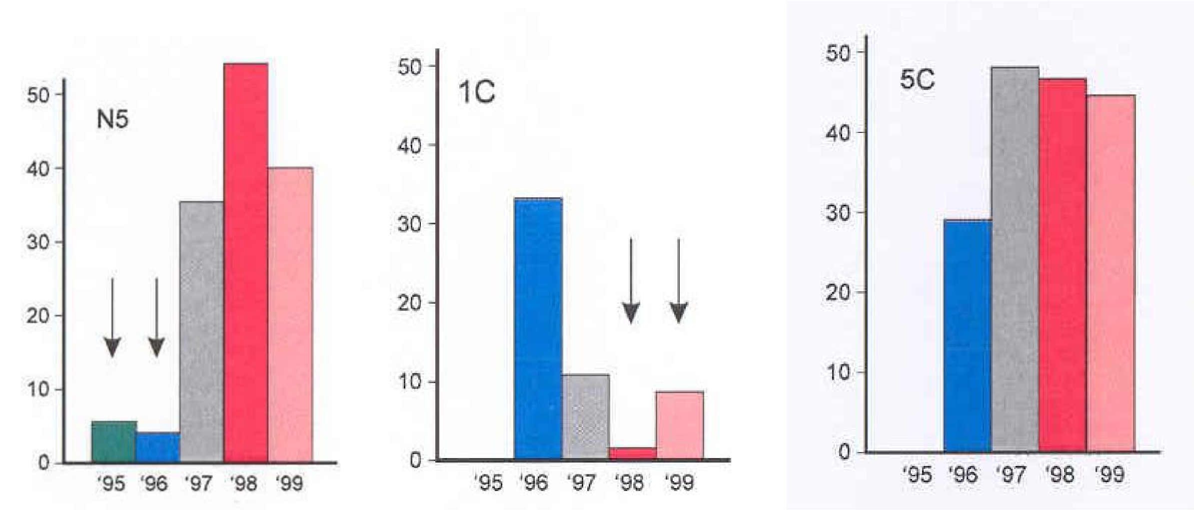


Figure 3.3-2: Number of species (Macrobenthos) on Loswal North (N5); Loswal Northwest (C1); reference site (C5). Arrow = year of sediment disposal at the sample site.

Loswal Northwest
Disposal (1997) has an enormous damaging effect on the numbers of species, the density and the biomass of the macro- and megafauna benthic community. Disposal at site C1 started in 1998. The number of species after disposal was minimized. One year after the disposal (1999), the number of species increased, but still suffers from the desposal activities (65% of the number of species before disposal in 1996). Results are found in Figure 3.3-2. Moderate knock-on effects are found as far as one kilometre from the disposal sites in the form of poorer diversity of species, density and biomass.

3.3.2 Kanaal door Walcheren

Introduction
The Kanaal door Walcheren is a brackish canal that connects the Veersche meer with the Westerschelde (see Fig. 3.3-3). The sediment in this canal is locally highly contaminated by previous industrial usage along the canal. Copper and PAHs, in particular, were found in high concentrations.

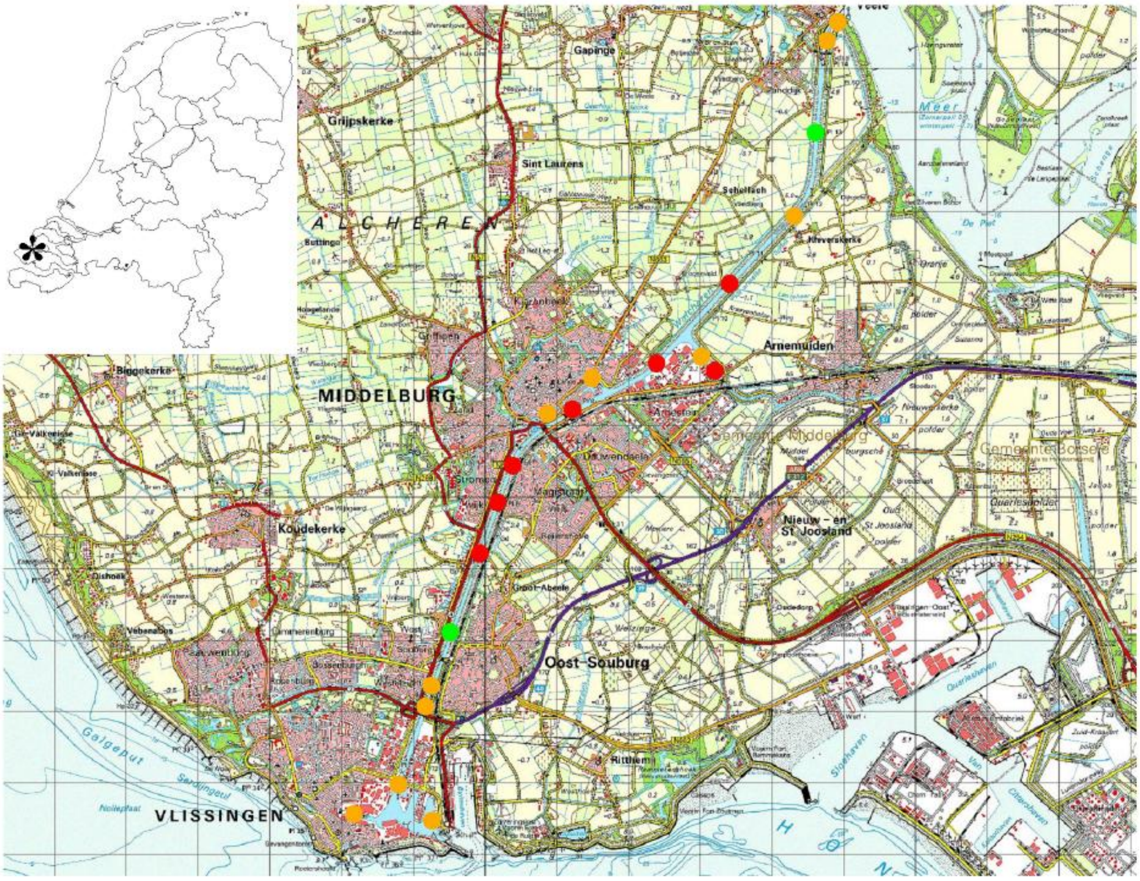


Figure 3.3-3: Overview of sampling sites. Green: no actual risks; Orange: moderate actual risks; Red: severe actual risk for macrobenthos communities.

Statutory framework

The implementation of remediation work on severely contaminated sediment requires decision-making based on the Soil Protection Act. In order to assess the actual risks for man and the ecosystem and the risks of spreading in respect of groundwater, a Further Inquiry (Elswijk et al, 2002) was carried out. To map out the effects of contamination on the ecosystem, a study was carried out into the present macrofauna benthic community in the spring of 2004 (Oosterbaan et al, 2003).

The remediation work was also based on the Pollution of Surface Waters Act [Wvo], the Building Materials Decree [Bsb], the Environmental Management Act [Wm] and the Earth Removal Act. No ecological aspects were included in these assessments.

Method used

Sampling

Samples were taken with an Eckman-grab in early spring. For macro-invertebrates 5 sub-samples were taken from the top layer (10 cm) and pooled together. The samples were rinsed over a sieve (500 µm) a preserved with 96% ethanol. Exactly at the same location a sample was also taken for physical and chemical analyses (1 liter of top layer).

Analyses

Macro-invertebrates where separated from the samples by sorting them out under a binocular. Identification took place at species level. For macro-invertebrate samples a method description is used (RIZA werkvoorschrift W 8140.2.112). Chemical analyses comprise total concentrations (metals, PAH, PCB, OCB) and physical parameters (grain size, organic C, etc.)

Assessment
The setup of the assessment follows the TRIADE field component (Maas et al, 1993). However, no methods have been developed yet for brackish water systems such as the Kanaal door Walcheren. The following principles were considered when adopting a method to assess the Kanaal door Walcheren:

The benthic community must be assessed on various aspects;
The various assessments must be integrated into a site-specific final assessment;
Statements on the actual risks for macro-invertebrates must be made on the basis of the final assessment.

To achieve a balanced assessment, three different aspects of the benthic community will be assessed:
Ecological quality;
Ecological functioning;
Effects of contamination.

A tie-up has been sought with methods that are currently being developed for assessing coastal and transitional waters within the European Water Framework Directive (Lorenz et al, 2003).

Quality
In respect of quality, a check was made as to whether unique species and indicators, including the Stowa assessment (Stowa, 2002), were present. At benthic community level, diversity (Shannon-Wiener, 1949) and patterns in the benthic community were checked using TWINSPAN (Hill, 1979). The ratio between the number of individuals and the biomass was assessed with the ABC method (Warwick, et al. 1994).

Functioning
Each species is part of a functional feeding group. In a well-functioning ecosystem, functional feeding groups are proportionally represented. When one or more functional feeding groups are no longer present, the system lacks equilibrium, and this may lead to an accumulation of organic material in the soil. The Infaunal Trophic Index is based on the distribution of functional feeding groups (Lavaleye, 1999). This index is used to assess the functioning of the benthic community.
Effects of contamination
The OMEGA model (Optimal Modelling for Ecotoxicological Assessment) was used to determine how many and which organisms are at risk as a result of existing contamination (Durand-Huiting, 2004). It was then checked whether these effects could indeed be traced in the field. The Biotic Index provides insight into how the benthic community reacts to toxic and other types of stress (Borja, et al 2000).
The situation at the Kanaal door Walcheren was assessed on the basis of clean and non-disturbed reference sites (Noordzeekanaal and Hartelkanaal).

Together with the results regarding the quality and the functioning of the benthic community it was checked whether a link could be found between the physical and the chemical characteristics of the sediment. To get a good picture of the correlation between contamination and the benthic community, the following interactions were examined:

Sediment - contamination;
Sediment - benthic community parameters;

Contamination - benthic community parameters;
Benthic community parameters - contamination - assessment methods.

The following benthic community parameters were included: density, biomass and the number of aquatic worms, bristle worms, shellfish, bivalves and diversity (Shannon-Weiner).

Effects
The results of diversity analysis, Stowa assessment, ABC method, Infaunal Trophic Index and Biotic Index of all the sites (the reference sites included) were divided into 3 categories. The category gives the following indications: "no disturbance", "moderate disturbance" or "severe disturbance". This division was made on the basis of existing criteria. No score was specified for diversity (Shannon-Wiener) as no clear criteria were available.
For the final assessment, the scores over the categories in terms of percentage were calculated per site. Altogether of 5 categories were assessed. If, for example, 2 parameters score a severe disturbance, 2 score a moderate disturbance and 1 has no disturbance, this is shown as 40%, 40% and 20% respectively.

The following criteria are used to estimate the risks for the benthic community:

- No actual risk for macro-invertebrates: Sites, where the assessment methods indicate more than 25% "no disturbance" and less than 25% "severe disturbance".
- Moderate actual risk for macro-invertebrates: Sites, where the assessment methods indicate less than 25% "no disturbance" and less than 25% "severe disturbance".
- Severe actual risk for macro-invertebrates: Sites, where the assessment methods indicate more than 25% "severe disturbance".

Results
On the basis of the benthic community, a moderate to severely disturbed benthic community was found in the entire Kanaal door Walcheren. Figure 3.3-3 presents the conclusions in respect of the actual risks for macro-invertebrates per site. The northern part of the canal (Kanaal North and Outside harbour Veere) harbours a diverse and varied benthic community. In spite of that, severely disturbed benthic communities were found, in particular in respect of their functioning.
The central part of the Kanaal door Walcheren (Kanaal Central, Kanaal door de Oude Arne) shows a severely disturbed benthic community. Species that have become tolerant to contamination are found here. No bivalves are found in Kanaal Central or in the port of Middelburg. This concerns species that are hampered by high copper concentrations (OMEGA).
Kanaal South shows a not-disturbed to severely disturbed benthic community. Densities and diversity of species lag behind in Kanaal North, but are higher than in the other subsectors.
The port of Vlissingen has a moderately disturbed benthic community (moderate risks).
Besides local contamination of the soil, the quality of the suspended matter also has a harmful effect on the benthic community.

3.3.3 Hollandsche Ijssel

Introduction
The Hollandsche IJssel is a tidal river in the southwest of the Netherlands, between Gouda and Rotterdam (see Fig. 3.3-4). Due to its canal-like character, the river has no dynamic tidal zones. The riverbanks had been raised with contaminated waste material. In addition, intensive shipping has caused erosion of the sediment layers and the riverbanks.

To create a cleaner and more natural Hollandsche IJssel again, it was decided in 1995 to clean up the river entirely and to restore the riverbanks (Doze, 1999; Doze et al. 2005).

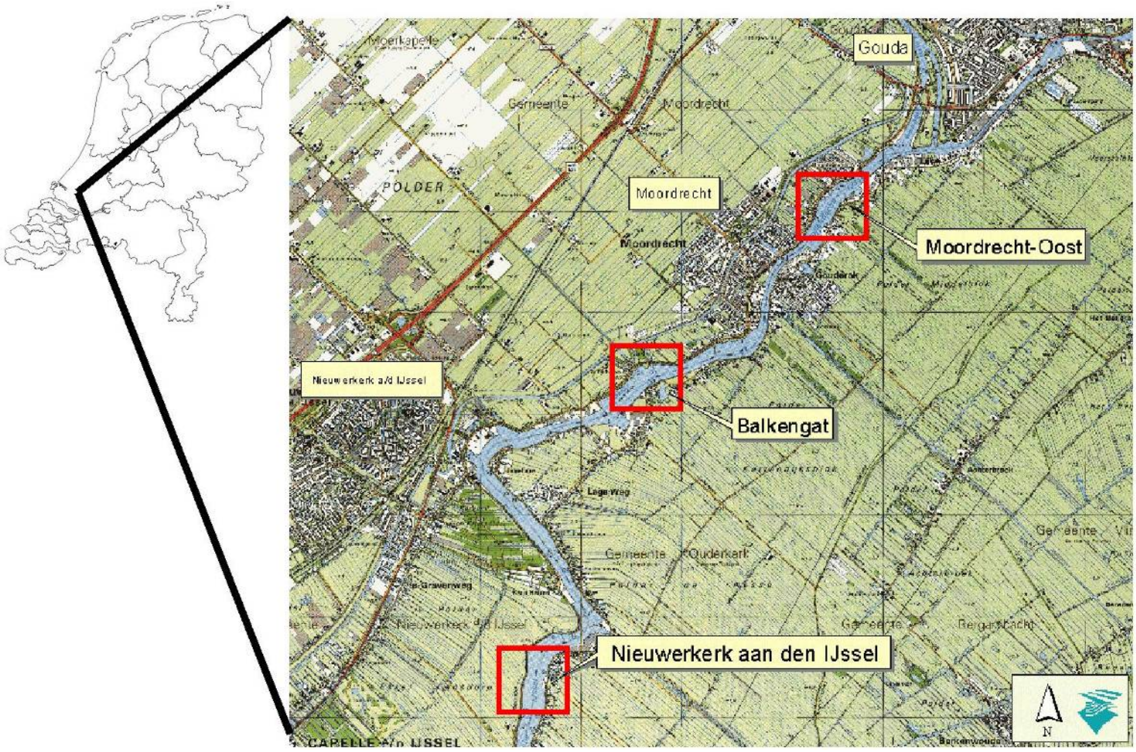


Figure 3.3-4: Sampling site Hollandsche IJssel

Statutory framework

Remediation and restoration used to be not obligatory under the Environmental Impact Statement (EIS). Besides, the banks of the Hollandsche IJssel were not designated under the habitats and birds directives. However, a Quickscan was carried out within the framework of the Flora and Fauna Act in 2003 in respect of the development of comparable riverbanks (Hunink et al, 2003). The presence of breeding birds, mammals, amphibians, fish and plants was examined. The above mentioned obligation (Flora and Fauna Act) did not yet apply to the case described in this paper (it became effective in April 2002).
Under the terms of the Pollution of Surface Waters Act (Wvo), licences had been issued for remedial and restoration work, but the ecological aspects were not assessed. Although legislation did not demand assessment in respect of ecological aspects, a decision was made to monitor the development in the area for a period of 5 years (Doze, 1999). The aim was to learn from these developments for future projects and to change the practise if an undesirable turn of events should occur.

Method used

Sampling

Samples are taken with a box core in spring. For macro-invertebrates, 3 (separate) sub-samples were taken from the top layer (10 cm). The samples were rinsed over a sieve (500 µm) a preserved with 96% ethanol. Exactly at the same location a sample was also taken for nematods and chemical analyses (1 liter of top layer). For nematodes, a standard method was used (Kerkum, 2005). From shallow waters (depth maximum 3 meter), samples were taken using a small core (diameter 5 cm). The overlying water in the core was removed and 5 cm of the sediment core were put in a polyethylene jar. The samples were preserved with 20 ml of 40% formalin. At each location, 5 sub-samples were taken and treated separately. In deep

waters (more than 3 meters), a box core was used to collect a large undisturbed sediment sample. From this sample, sub-samples were taken as described above.
To estimate the fish stock, two methods were used: electric fishing and net fishing. Fishes were identified to species level and measured (length).
Avifauna
Birds have been counted in 1x1 km plots in spring and autumn.

Analyses
Macro-invertebrates were separated from the sample by sorting them out under a binocular. Identification took place at species level. (RIZA work instructions W 8140.2.112). For nematodes, fresh samples were extracted with the Oostenbrinkfunnel ('s Jacobs & Bezooijen, 1986). The fixed samples were centrifuged in Ludox during two minutes and decanted over a 10 µm sieve. For counting and identification, the nematodes were mounted on slides and observed under a light microscope. Chemical analyses involves total concentrations (metals, PAH, PCB, OCB) and physical parameters (grain size, organic C, etc.).

Assessment
To evaluate the effects of both remediation and restoration, a 5-year monitoring programme was started in 1999. For the purposes of this study, three sites were designated to represent "the goings on" in the Hollandsche IJssel. Data were collected in accordance with the following ecological parameters: macro-invertebrates, nematodes, vegetation, birds and fish. Data were also collected about ecotoxicology, river bed and sediment quality, morphology and water quality.

Macro-invertebrates
The assessment of the benthic community was carried out with the help of the TRIADE method field component. This method (TRIADE field component) tests whether the benthic community differs from what would be a clean and not disturbed sediment. Per sediment type, ranges are established for macroinvertebrate parameters (such as density and number of taxa), which indicate severe, moderate, or no risk. Concurrently, densities, number of taxa, division of the taxonomic groups, dominance, and the spatial division (TWINSPAN and CACOCO) were calculated, and tested against the Water Framework Directive for natural waters.

Nematodes
The Maturity Index (Bongers, 1990) is used to assess the quality of the nematode community. This Index indicates the condition of the nematode community. Nematode taxa are divided according to their ability to colonise a disturbed habitat. Species, which can colonise in a rapid tempo, have a short life cycle and are therefore known as colonisers. Species that have long life cycles are better able to compete with other species; they occur in stable habitats which change very little. These species are known as persisters. The composition of the taxa is expressed as the Maturity Index, hence indicating the degree of ecological disturbance of the soil ecosystem. The higher the value of this index, the more stable the habitat.

Fish, vegetation and birds
Although there is no direct relation between dredged-material and fish, vegetation and birds, there is an indirect influence on them. This occurs, among other things, via secondary pollution in the food chain (see Chapter 4). Rehabilitation greatly depends on the way restoration is carried out but, if the sediment is contaminated, the objectives of restoration may never be achieved.
The objective of the fish study is to establish whether fish stocks in the cleaned and restored locations differ from those where these remedial works have not taken place. Because these

works included establishment of new mating and spawning possibilities for fish, it is expected that many more young fish will be found at these locations. Moreover, it was expected that the species composition could change as a result of these new mating and spawning grounds. Fish were monitored in respect of number of species (in the spring and in autumn).

Botanical monitoring is based on observations in respect of the vegetation developments in the restored parts of the Hollandsche IJssel at the various design measures. The overall number of species and vegetation cover was monitored, as were the specific target species.

The restored locations are expected to attract larger numbers of marsh birds and waders. Birds were monitored in 1x1 km plots. A comparison was made between plots with and without cleaned and restored sites.

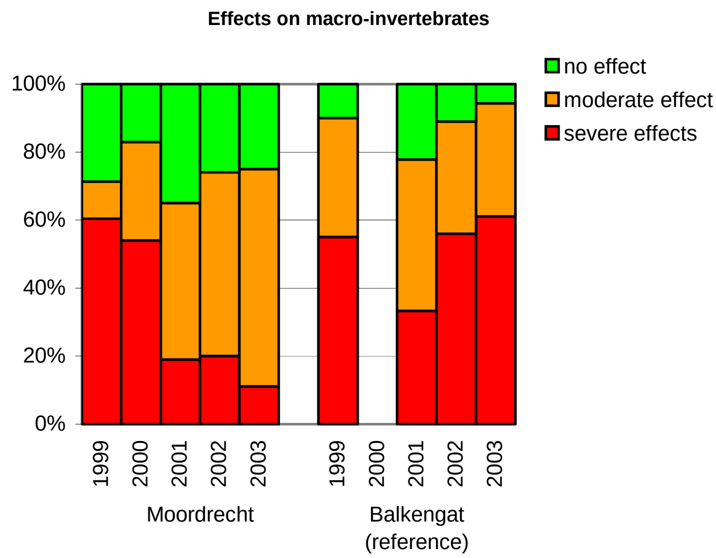


Figure 3.3-5: The effects of the contaminated sediment on the macro-invertebrates near Moordrecht (remediation and restoration sites) and Balkengat (reference site) in the period 1999-2003. No macro-invertebrates sampling took place at Balkengat in 2000.

Results

Macro-invertebrates

Figure 3.3-5 shows the results of the TRIADE field component. Altogether 8 parameters were assessed in the TRIADE field component. If 4 score severe disturbance, 2 moderate disturbance and 2 no disturbance, this is shown as 50%, 25% and 25% respectively. Figure 1 also shows that after the remedial works at the Moordrecht site, the strong effects (red) are clearly decreasing. Remediation is therefore having a positive impact on the benthic community. The decrease is not shown for the Balkengat reference site, because no monitoring took place there. The development of the density of the characteristic macro-invertebrates at the freshwater-tidal area at the Moordrecht site, which was cleaned up and restored in 2000, and the Balkengat reference site is shown in Figure 2 (Balkengat was not measured in 2000). It is clear that remediation and restoration have brought about an improvement at Moordrecht, because the characteristic species of the freshwater-tidal area have returned.

Nematodes

The Hollandsche IJssel study shows that nematode populations react positively to their new habitat after remedial and restoration work on some embankments, and they are therefore an indicator of whether the sediment is functioning properly. This is shown in Figure 3.3-6 for the cleaned Moordrecht site and the non-cleaned Balkengat site. A position top left in the diagram suggests eutrophic conditions, a position bottom left suggests contaminated conditions and a position bottom right suggests optimum conditions. No changes were found at the Balkengat site. The Moordrecht site, however, first turned eutrophic (nutrient-rich), afterwards the change to optimum conditions commenced.

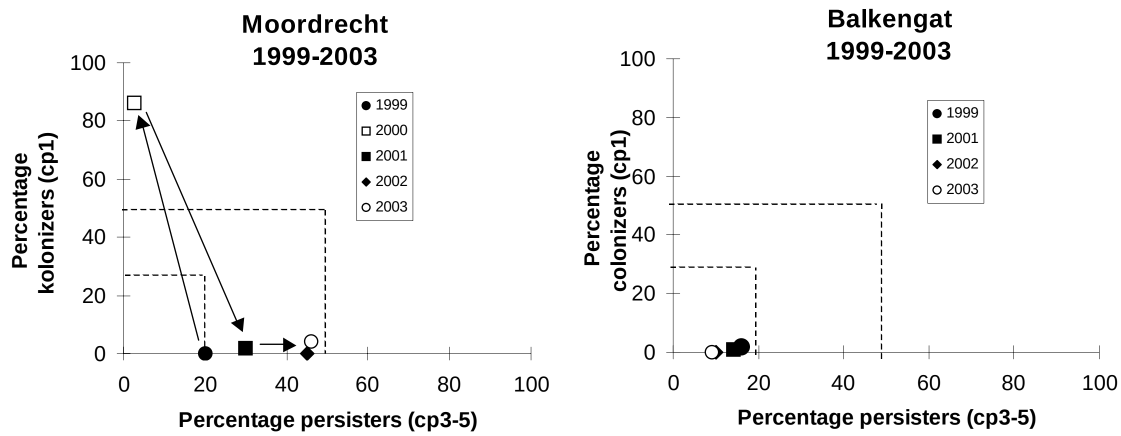


Figure 3.3-6: Diagram of the changes in habitat conditions at the remediation and restoration site (Moordrecht) and the non-cleaned site (Balkengat). The black dot represents the situation before remediation. The arrows represent the sequential habitat conditions.

3.4 Chapter Conclusions

- Both countries do not have a list with standard methods for ecological assessment; not for sampling, not for parameters to be used and not for interpretation the results. Case-specific methods are set up. In this respect the guideline “Futher Inquiry” [Nader Onderzoek; NaOz] for prioritating remediation sites in The Netherlands is the most explicit one.
- For assessing risks, the Netherlands has set up quality criteria. In Germany such criteria are lacking.
- Regarding organisms The Netherlands focuses most on macroinvertebrates and nematodes. Germany also includes vertebrates and plants if necessary.
- Regarding abiotic parameters, the Netherlands assess mainly sediment characteristics (grain size), organic mater, salinity and micro pollutants. Germany includes also nutrient concentrations (ortho phosphate and nitrogen) and oxygen depletion.

4 Background Research for Optimal Assessments

4.1 Germany

The methods implemented at the time being are not sufficient to assess contaminated sediments in a comprehensive way. Chemical analyses can assess only what is measured, and this is only a part of the chemicals present in the waters. Moreover, only information about the concentration of contaminants but nothing about the bioavailability of contaminants is provided. Within the implemented assessment tools, ecotoxicology adds tests with a few species more or less ideally representing the different trophic levels. But this is far from knowing the synergistic effects of contaminants within biocoenosis in nature.

Therefore, in Germany university groups are working in optimizing the assessment possibilities. At the universities of Heidelberg and Hamburg-Harburg scientists are working on an integrated concept of sediment assessment covering up to 5 components: chemical sediment analyses, sediment toxicity tests, tissue residue analyses, pathological investigations and biocoenotic investigations (e.g. Ahlf 1995; Hollert 2001; Karbe 1994). Every single component is important in assessing the sediment quality. The complex investigations contain 3 or more of these components. The sediment triad (chemical, ecotoxicological and biocoenosis components) is an often-used combination.

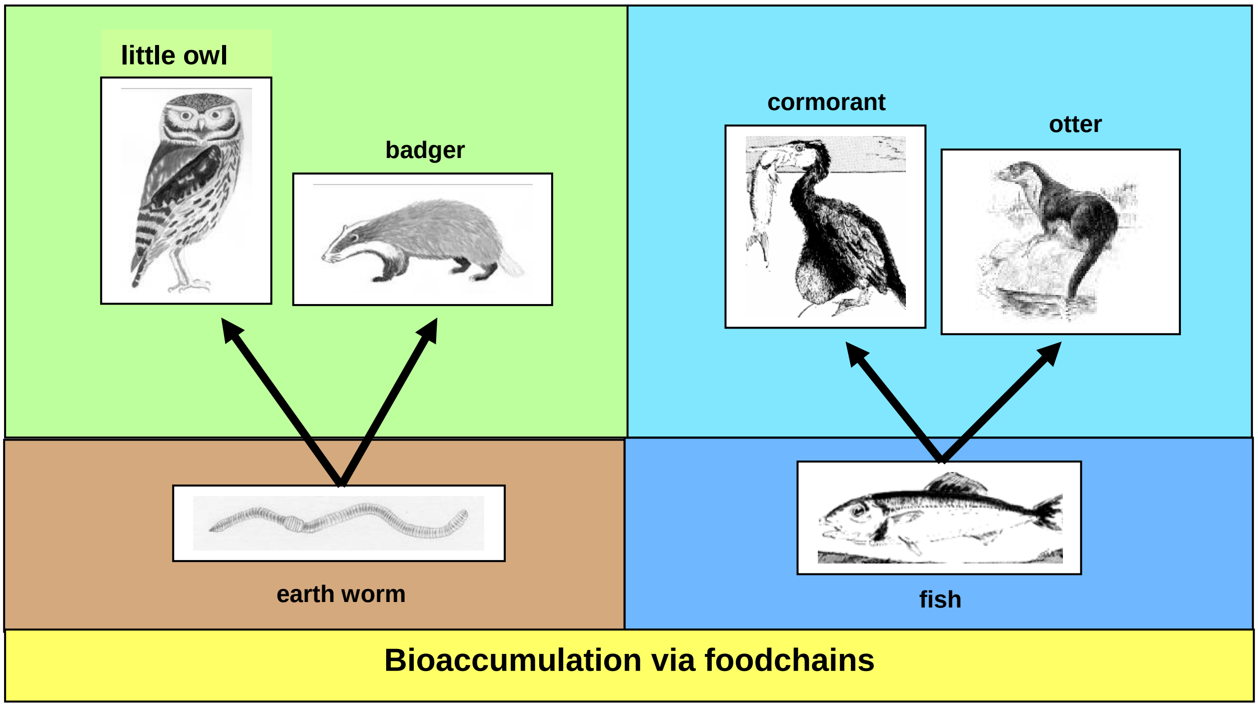
Hollert (2001) investigated River Neckar sediments using the sediment assessment triad. For the biocoenotic part, the macrozoobenthos was selected and the saprobic index, the RETI (rhitron-feeding-type-index, Schweder 1992), the diversity and evenness, the “acidification steps” (Brauckmann and Vobis 1998) and the “ecotoxicology-index” (Camargo 1990, Böhmer et al. 1999, 2000) were tested. Hollert showed that only the combination of different bioindices gives a good and complex picture of the situations at the different sites.

4.2 The Netherlands

To develop solid ecological assessment methods for aquatic sediments and (potential) dredged material and to interpret the results accurately, it is necessary to have sufficient knowledge about the benthic organisms and their predators. Moreover, there is a need to know how that contamination may affect these organisms. Managers also need this knowledge in order to ensure that nature develops sustainably in contaminated river systems. Laws and regulations provide no detailed guidelines in this respect, but they do give the opportunity to nature development when contamination has little or no effect (RIZA, 2004).

A great deal of knowledge about the effects of contamination comes from laboratory experiments combined with knowledge about properties and modes of action of substances. However, a few detailed studies have been carried out in the past few years to find out whether expected effects are measurable in real-world ecosystems, as to monitor the effects of the total toxic burden. The latter is not easily possible in a laboratory. Contamination of sediment can have a direct effect on bottom dwelling organisms, or it can affect predators higher in the foodchain through bioaccumulation. Two foodchains in and along aquatic systems are important in this respect: from benthic organisms via fish to fish-eating birds (e.g. cormorants) or fish-eating mammals (e.g. otters), and from earthworms in the floodplains to worm-

eating birds (e.g. little owls) or worm-eating mammals (e.g. badgers). Fish, and especially earthworms, can accumulate contaminants to high levels without having a problem themselves, but as staple food for top-predators they will affect those.
In ecotoxicological risk-assessment methods, concentrations of contaminants are being translated into effect-levels for organisms in sediment and water, and into effect-levels for top-predators, using Biota-Sediment Accumulation Factors (BSAF). Ecological field research can contribute to the validation of these effect-levels.



Summary of some study results
In a 4-year study, the impact of the veil of sediment contamination in the branches of the rivers Meuse and Rhine on the biodiversity and the productivity of benthic invertebrates was studied to investigate whether this has had any consequences for the carrying capacity for fish and waterfowl populations. The relation between the effects of contaminants and food abundance also formed part of the study.
The main conclusions were:
1/ The veil of sediment contamination has led to a lower diversity of benthic invertebrates. Midge larvae and worms dominate the benthic community, whereas in relatively clean eutrophic sediments other groups like molluscs, crustaceans and mayfly larvae are also present.
2/ The reproduction of midge larvae and worms is not negatively influenced by the present contamination levels, while reproduction of other groups, mainly snails, is.
3/ The carrying capacity for non-selective predators does not seem to be affected by the contamination veil; the carrying capacity for selective predators may be negatively affected.
4/The food abundance seems to compensate the negative effects of sediment contamination on the production of worms and midge larvae. (De Lange et al, 2004; De Lange et al 2005)

The breeding biology of a population of little owls (Athena noctua vidalli, a worm-eating bird) having the polluted floodplains along the river Waal as its habitat was studied. Internal concentrations of contaminants were monitored and compared with a population in a non-polluted area. This showed that the little owls in the Dutch river floodplains are at risk due to the presence of PCBs and cadmium. Levels of these pollutants in little owls from floodplains were significantly higher than those found in Little owls from a reference site. PCBs can de-

crease the success of breeding, and cadmium attacks the kidneys and can shorten the life span of these birds substantially. The eggs of little owls in the polluted floodplains were found to develop in a different way compared to those in the clean reference sites. This may be the result of chicks needing more energy to combat the pollution. (Van den Brink et al 2003: Groen et al 2005)
A study was conducted along the River Meuse addressing the effects of contamination on badgers (Meles meles). Badgers are known to feed on earthworms a great deal. Organs and fatty tissue from traffic casualties were analysed, faeces was collected and analysed and food patterns studied. It was shown that the PCB and cadmium concentrations in badgers had decreased significantly as compared to the time 20 years ago. However, the concentrations in worms are still very high. An explanation for this is that badgers appear to have changed from worms as their staple food to maize that contains only a fraction of the contamination in worms. When preparing new areas for nature development, badgers must be encouraged to eat food like maize instead of contaminated worms. (Boudewijn et al 2003)

Study into a population of fish-eating cormorants in the heavily polluted Biesbosch area during the 90s showed a relation between the presence of PCBs, DDT metabolites and dioxins in fish on the one hand and a reduced reproductive success on the other. The reduced reproduction success was the result of a number of factors: there were fewer eggs, the eggshells were thinner and broke more easily, and there was a high mortality among embryonic young and a high mortality among the chicks in the first two weeks after hatching. Reproductive success has been on the increase in recent years, a change that can be explained by a decrease in contamination levels in fish (Dirksen et al 1995).
A connection between reduced reproduction and PCBs in food was also found in otters. The otter is now being reintroduced in the Netherlands, but only in areas where the PCB concentrations in fish are so low that no effects need be expected. These concentrations are still too high in the Rhine and Meuse basins (Linde 1996; Leonards et al 1998).

This type of long-term field studies is important for the validation of applied risk analyses and methods to assess contaminated sediments and soils. There is no long-term study currently ongoing into the immediate or secondary pollution effects of contamination in aquatic sediments.

4.3 Chapter Conclusions

- To develop, validate and evaluate ecological assessment methods, field studies are carried out to gain more knowledge about the impacts of toxicants on food chains and ecosystems.

- In Germany, field studies are carried out to develop, validate and evaluate methods combining chemistry, ecotoxicology and ecology in order to set up a TRIADE method.

5 Future Perspectives

The EU influence on the administration of the handling of dredged material will continue to grow. Besides the WFD, the marine strategy – at the time being "under construction" – will say something about the "not WFD-covered" marine areas. Additionally the EU- Habitat Directive, NATURA 2000, and the Bird Directive will have influence on measures or projects concening dredged material. But the fixation of the aims to reach the good ecological status of the WFD and to ameliorate the situation for target species of the Habitat Directive will possibly have an indirect effect.

5.1 Water Framework Directive

The aquatic sediment is not mentioned separately in the WFD, but it is an integral part of the system. The WFD will be indicative in the future for determining the urgency of remediation, for example. This means that wherever the ecological and/or chemical objectives of the WFD are not achieved, the situation is one of remedial urgency. In addition, the WFD can result in limitations for the aquatic disposal of dredged material, if the generated impact will be responsible for not reaching the good ecological status. Consequently, it is of importance that assessment of sediment quality / dredged material is included in the objectives and the assessment of the WFD.
In this chapter a description is given how Germany and The Netherlands will deal with sediment/dredged material within the WFD.

5.1.1 Germany

As in Germany there is no corresponding soil protection act for aquatic soils as it exists in The Netherlands, the WFD may lead to forced measures of remediation in case of strongly polluted aquatic sediments in Germany.

The German implementation of the WFD led to modifications of the national laws "Wasserhaushaltgesetz" (Water Act, WHG 2002) and the corresponding "Landeswassergesetze".

Investigation and assessment methods are still under development. There is a first decision to use two different methods: a system combining single habitat sampling and multimetric index assessment for large rivers ("PTI", Schöll and Haybach 2005) and AQEM, a system which combines multi-habitat sampling and multimetric index assessment for smaller waters (Hering et al., 2004).
For transitional and marine waters the developments are not so far, but it seems that also index-based methods will be chosen. For transitional waters, the AeTI (Krieg 2005) was developed basing on the PTI. For the German marine area of the Baltic Sea the MarBIT (Reincke (MariLim), in development) uses biological and ecological parameters characteristic for each species. This system is worked on to be optimised, and it is on the way to be modified to be usable for the German North Sea Region. These assessment methods are still on the way to be optimised and a result is announced for the second half of 2006.
Results of the German implementation process of the WFD are presented in the Internet on the page: www.wasserblick.net (in German language).

The status of the assessment of more than half of the waters in Germany is at risk: rivers - 62%, lakes - 38%, transitional and coastal waters - 91%, a result of the inventory of 2004. (http://www.bmu.de/files/gewaesserschutz/downloads/application/pdf/wrrl_ergebnisse2004.pdf) The results of the inventory rely mainly on an estimation, as the development of assessment methods and data collection has not been finished yet.

5.1.2 The Netherlands

In the Netherlands, the sediment quality assessment that so far has been part of the legal framework of the soil protection act, is now restructured in order to prioritise sediment remediation locations from the ‘WFD perspective’. This means that the main question of the risk assessment will shift from “Are there unacceptable risks for the ecosystem?” to “Is sediment quality the main limiting factor for reaching ecological objectives?”. In the Netherlands, this will be achieved by introducing a stepwise approach with two steps (see also the DGE report on ecotoxicology):

1. A calculation of the toxic pressure on aquatic organisms with the model OMEGA with bioavailable concentrations of contaminants in the sediment as model input.
2. In case toxic pressure is expected on the basis of bioavailable contaminant concentrations, the thirds step consists in a Triad sediment quality assessment.

For freshwater, however there is a discrepancy between the metrics for assessing the ecological objectives of the WFD and methods for assessing sediment quality (prioritising remediation). The metrics for the natural waters (metrics for artificial and heavy modified waters are under construction) are based on indicator species and distinctive/characteristics species. For deriving indicator species and distinctive/characteristics species from references, the focus was put on good habitats and waters quality of the assessments by using metrics focus mainly on the diversity of the system. Other aspects like the functioning of the ecosystem remain unknown. This is enhanced by the sampling method, where multi-habitat samples are taken as a mixed sample. Since the WFD becomes an important factor influencing the priority of sediment-remediation urgency, it becomes important that the metrics for artificial and heavily modified water assesses these aspects. In other words, the sediment quality has to be included in the construction of these metrics. For this reason a sediment-quality methods based on normal ranges of ecological parameters (macro-invertebrates and nematodes) is in development. (Kerkum 2005; Oosterbaan 2005). This method can be used in WFD-metrics although nematodes are no part of the WFD; they are also part of the sediment assessment method. Nematodes have a very close relation to the chemical quality of the sediment (pore water); this group is very useful for identifying toxic pressures. (see case study Hollandsche IJssel, chapter 3.3.2.)

For marine water systems, sediment quality is part of the assessment of the objectives of the WFD. Metrics like AMBI (AZTI Marine Biotic Index; Borja et al, 2000, 2003 & 2005), BENTIX (Simbouro et al, 2002) and BQI (Benthic Quality Index; Rosenberg ey al, 2004) are used.

5.2 TRIADE

The development of the TRIADE approach in Germany is not ready to be used as a standard application. Therefore, development has to proceed in future, especially regarding the marine area there is hardly any work done on the development of the TRIADE approach. As this is an important aspect of assessing sediment quality, much effort has to be put in research of the cause-and-effect net of chemistry, ecotoxicology and biocoenosis.

5.3 Models

Ecological models are in an early stage of development. Overviews on the status of model development are described in Moll & Radach (2001) for the North Sea within the SYCON project. For the limnic area Lek et al. (2005) published a book on "Modelling Community Structure in Freshwater Ecosystems". Another source for information are the yearly reports of the ICES Study Group on Modelling of Physical/Biological Interactions (SGPBI; www.ices.dk).

"The major problems we are facing (like climate change, anthropogenic input of matter in the oceans) are interwoven with each other, and we cannot, e.g., investigate eutrophication by model studies any more without taking account of the effects of climate change at the same time. This complicates the treatment of the problems considerably. The complexity of all models, except perhaps of ERSEM-type models, needs to be enlarged to cope with the currently pending problems.
Steps towards the needed ecological models
To reach these aims many special problems have to be solved and many deficiencies have to be eliminated. The following list emphasises the tasks which we judge to be important for making progress in ecological modelling; their sequence is not meant to denote a temporal priority to be worked down.
…
Ecological modelling with complex trophic structure
Major problems for setting up models for species, size classes or functional groups are caused by both the lack of data for the rates and of data sets for the state variables. Therefore, it is still an open question whether the approach by species, by size classes or by functional groups is the most appropriate one for special problems. Case studies are necessary where all approaches are compared using the same data sets.
…
When summarising the steps necessary to finally reach operational models for the greater North Sea system, it becomes clear that very much work has still to be done in the fields of model development, model validation, model comparison and model forcing to get to the stage where ecological models can be used by authorities in the same manner as weather prediction is done nowadays. However, we think this is principally possible." (Moll & Radach, 2001)

Ecological relationships such as the structure of a community depending on a set of physical constraints "are usually complex. Linear or unimodal responses that are the basis for most statistical approaches are seldom observed. On the contrary, complex non-linear relationships are often involved, and this is probably the more important reason for the success of new modelling strategies" such as artificial neuronal networks (Lek et al. 2005). The development of these approaches has significantly increased within the past 10 years.

In Belgium and The Netherland, the Institute of Nature Conservation (INB, fused to INBO), Brussel, the Netherland Institute of Ecology (NIOO) and the Rijksinstituut voor Kust en Zee (RIKZ) had developed a statistical model to predict the occurrence of macrozoobenthic species on the basis of different physico-chemical factors. Further aims are to extend the predict-ability to abundance and biomass in space patterns and to extend the applicability to other estuaries. (Ysebaert et al. 2002).

In Germany, for limnic rivers and canals models for the prediction of effects caused by changed morphology on the cycles of nutrients and oxygen nce exist (QSim, Eidner et al. 2002). “DELTA” is a model combining physicochemical factors and the reactions of macro-zoobenthic species (BfG 2006).

Furtheron, great effort in scientific research is needed in order to develop a “tool” usable for the forcast of effects caused by the handling of dredged material.

5.4 Chapter Conclusions

- The WFD can affect the handling of dredged material, if the generated impact will be responsible for not reaching the good ecological status.
- When the objectives of the WFD are not achieved and there is sufficient proof that the sediment quality is the cause of the problem, the situation is one of remedial urgency. Consequently, it is of importance that ecological sediment parameters are included in the objectives and the assessment.
- For assessing sediment quality, a sediment-specific method based on normal ranges for macro-invertebrates and nematods is useful.

- In Germany, the TRIADE has to be developed furtheron. In the Netherlands, it is at application level, however, improvements regarding the assessment of ecological aspects are recommended.
- Ecological models are worked on with great pressur, but due to complexity still a lot has to be developed.

6 General Conclusion and Recommendation

The description of the situation regarding ecological aspects within the handling of dredged material in Germany and The Netherlands shows similarities but also great differences. Similarities are found in the existing assessment within the EIA procedure and development of WFD-methods. But the procedure and the assessment as a result of the soil protection act in The Netherlands finds no equivalent in Germany and - vice versa - the guidelines for the handling of dredged material in Germany have no direct equivalent in The Netherlands.
It would be helpful to get more insight in the ecological assessment methods. This could be a part of the future work of DGE.
Therefore it is recommended to assess one limnic and one marine case with both the German and the Dutch assessment methods. This should include methods which are still in the developmental phase (e.g. TRIADE, WFD-metrics and assessment methods).

Regarding the ecological assessment of sediments, the implementation of the water framework directive (and of the marine strategy) is of great importance for dredged-material management. The development of assessment methods will have to be compared with methods describing the ecological quality of polluted sediments/dredged material.

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8 Abbreviations

ABR	Active sediment management of rivers
AMBI	AZTI marine biotic index
ARGE Elbe	Working Group for the Advancement of Water Quality of the River Elbe
AVEU	Arbeitshilfe für die Vergabe von Entnahmen und Untersuchungen von Boden-, Schwebstoff- und Wasserproben sowie von Bestandserhebungen der Fauna der Gewässersohle (Working Aid fort the Placing of Special Orders)
AZTI	Investigación Marina y Alimentaria (spanish institute)
BfG	Bundesanstalt für Gewässerkunde (German Federal Institute of Hydrology)
Bentix	Biotic index on the basis of the AMBI
BQI	Biological quality index
BSAF	Biota-ediment Accumulation Factors
Bsb	Building Materials Decree [Bouwstoffenbesluit]
DDT	Dichlordiphenyltrichlorethan
DIN	German Organization for Standardization
DM	Dredged Material
EIA	Environmental Impact Assessment
EIAA	Administrative Provision on the Implementation of the Environmental Impact Assessment Act (EIAA)
EIS	Environmental Impact Study
EN	European Organization for Standardization
ERA	Environmental Risk Assessment
GV1/2	Guide value; below GV1 means natural variability, above GV2 high contamination/toxicity
HELCOM	Helsinki Commission (www.helcom.fi)
LC	London Convention (www.londonconvention.org)
ICES	International Council for the Exploration of the Seas
OCB	Organic Chloro Benzenes
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PTI	Potamon-Type-Index
QSim	BfG-Gewässergütemodell (http://www.bafg.de/servlet/is/7455/) (BfG-model for water quality)
OMEGA	Optimal Modelling for Ecotoxicological Assessment
OSPAR	Oslo-Paris-Commission (www.ospar.org)
RIKZ	Rijksinstitut for Kuust en Zee
RIZA	Rijksinstitut for
SEA	Strategic Environmental Assessment
SGPBI	Study Group on Modelling Physical/Biological Interactions
SRU	Sachverständigenrat für Umweltfragen der deutschen Bundesregierung (www.umweltrat.de) (Council of Experts for Environment of the German Federal Government)
SUP	Strategische Umweltprüfung (Strategic Evironmental Assessment)
URE	Umweltrisikoeinschätzung (Environmental Risk Assessment)
UVP	Umweltverträglichkeitsprüfung (Environmental Impact Assessment)
UVPG	Gesetz über die Umweltverträglichkeitsprüfung und Strategische Umweltprüfung (Environmental Impact Assessment Act and Strategic Evironmental Assessment)

UVPVwV	Verwaltungsvorschrift zum Gesetzes über die Umweltverträglichkeitsprüfung (Administrative Fiat fort the Environmental Impact Assessment Act)
UVU	Umweltverträglichkeitsuntersuchung (Environmental Impact Investigation)
VV	Verwaltungsvorschrift (Administrative Fiat)
Wbb	Soil Protection Act [Wet bodembescherming]
Wm	Environmental Management Act [Wet milieubeheer]
Wvo	Pollution of Surface Waters Act [Wet verontreinigingen oppervlaktewater]
Wvz	Pollution of Saltwater Act [Wet verontreinigingen zee]

9 Annexes

Annex 1: HABAB
Annex 2: HABAK
Annex 3: Methods and indices used by The Netherlands

Annex 1

HABAB

In the HABAB, Germany has set up regulation for the administration of the federal waterways, as to which ecological aspects have to be considered when handling dredged material.

Dredged material
Basis for the selection of a placement site is an inventory of the quantity and properties of the dredged material. The properties of the dredged material are to be tested according to physical, chemical, biochemical (cycles of nutrients and oxygen) and ecotoxicological criteria. In the case of maintenance dredging, characterization of the fauna and flora in the dredging area is not necessary. This would be considered necessary only for hydraulic engineering projects. In this case, the faunistic aspect is to be tested and assessed at the dredging site and placement site, however, exclusively for the purpose of an investigation of the intervention within the framework of the environmental impact assessment in accordance with the Environmental Impact Assessment Act (UVPG).
Dredged material that is to be relocated and consists mostly (> 90%) of sand, gravel or pebble need not be further tested, insofar as there is no suspicion of contamination, or if results of previous investigations show no or negligible contamination.

For all other cases, the tests described below are to be carried out.

Physical and sedimentological tests
Testing for contaminants
Biochemical tests (oxygen, nutrients)
Ecotoxicological tests

Physical and sedimentological tests

The dredged-material samples are to undergo the following minimum test criteria:
Colour, odour
Type of material
Grain-size distribution
Water content (solid material content)
Organic composition as TOC or weight loss

Biochemical tests (oxygen, nutrients)

Oxygen distortion/depletion
For sediments showing a high fine-grain fraction, the degree of potenial oxygen-consuming depleting substances must be tested for. For this, the 3-hour consumption is measured under defined conditions in the laboratory. Following that, it is to be estimated by using computer models whether dumping in the respective area would lead to oxygen depletion or not.

Nutrients
A relocation of dredged materials often results in only slight increases in the nutrient content of the respective waterway. Generally, therefore, it is not necessary to measure these nutrients, however, an overall assessment can become necessary in individual cases of unfavourable hydological and hydro-chemical conditions. In such cases, a determination is to be car-

ried out for the following substances in the eluate or interstitial water of the sediments for estimating the potential of eutrophication:

Ortho-phosphate	(o-PO_4)
Nitrate nitrogen	(NO3-N)
Ammonium nitrogen	(NH4-N)

Assessment of placement sites
The composition of grain sizes at the dredging site must be known. The hydrodynamic changes and their impacts on the morphology of the riverbed must be assessed as well in order to judge the effects on the ecology and on water managment.

Faunistic and vegetation testing
If the ecological conditions in the area of the placement site are unknown, the corresponding tests must be conducted. In this case, testing procedures include benthic populations, fish and substrate conditions (here, also submersed vegetation).

Results of the test include population tables and information on the site (e.g. spawning grounds), which provide assessments concerning naturalness of the species population, whether the species deserve protection or individual animal species as well as anthropogenic detrimental ("previous loading", "quality of life").

Sampling and sample preparation are thoroughly described in the AVEU (1994). Grain-size conditions can be concluded from the substrate conditions.

Biochemical criteria

Oxygen distortion/depletion
Indicating threshold values for oxygen depletion is not useful. Rather, it is generally accepted that relocation must not lead to critical oxygen concentrations in the waterway. That means, there must always be sufficient oxygen concentrations to ensure survival of the water organisms. The threshold values to be observed (e.g., 4 , 5, or 6 mg/l) depend on the type of waterway and on the sensitivity of its organism communities and, if necessary, should be defined by a team of experts.

Changes in structural conditions can help to reduce loading. For example, by dumping during high streamflow or lower water temperatures, by reducing the number of dumping operations per time unit, by choosing other placement sites or by measures to reduce drifting of the dredged material during dumping.

Nutrients
Currently, there are no special recommended values for ortho-phosphate, ammonium nitrogen and nitrate nitrogen in interstitial water or eluate of river sediments. An analysis of these nutrients useful for plants which are found in sediments should be carefully conducted in order to recognize a eutrophication potential of the respective waterway resulting from relocation of dredged material.

Faunistic criteria

When relocating dredged material in the waterway, the ecological impact should be minimized by the selection of the most suitable placement area. This can be done by considering the habitat requirements of the animal communties of the riverbed.

The dredged material should be placed at a site that shows very low or low merit in its population. The evaluation is made according to the value table Fauna of VV1401. Median- and high quality-regions, in particular, areas with submersed vegetation should generally not be used for dredged-material placement. Areas of very high quality and protected biotopes should not be used as placement areas at all.

The benthic poplulation is closely bound to the colonizable substrate. Basically, negative effects on benthic organisms are minimized through the substrate, so that similar substrate classes can be layered on the existing substrate in unstable areas. As a rule, "only grains of similar sizes belong together". Otherwise, long-term disruption of the ecological equilibrium may occur.

Fish spawning gounds are never suitable for placement sites.

Annex 2

HABAK

In the HABAK Germany has set up regulations for the administration of the federal waterways, as to which ecological aspects have to be considered when handling dredged material. This guideline resulted from different international agreements (s.a.). There exists no comparable regulation of the "Länder" (SRU 2004).
According to the international regulations from LC, OSPAR and HELCOM, effects of disposing dredged material in the marine environment have to be described. Severe impacts, as far as they are predicted or described, have either to be minimised or it has to be checked, whether another way of handling is possible.

Water Quality

Extent and methodology of testing
Oxygen consumption and nutrient contents should be measured when the dredged material consists of a finely grained fraction:

- Oxygen consumption of dredged material — in mg/kg dry m.
- Content of total phosphorus (P_{total}) — in mg/kg dry m.
- Content of total nitrogen (N_{total}) — in mg/kg dry m.
- Fractions of ortho-phosphate and ammonium — in mg/l in interstitial water

If extremely oxygen-consuming sediments are to be dumped in areas where, owing to previous constraints or little water exchange, low oxygen contents can be expected, concentrations in the water body should be examined in order to take the ecologically necessary precautions.

If dredged material with high nutrient contents is to be placed in areas with high fine-grained fractions, nutrient contents in the interstitial water and/or eluate of the sediments should also be determined at the site of disposal.
The extent of testing can be reduced, if

- the dredged material, similar to the natural relocations of sediments, will be relocated only within the respective section of the water body,
- no additional nutrients or oxygen-consuming material e.g., from harbour basins are discharged, and
- the volume of dredged material to be disposed of is insignificant in comparison to the volume of sediment that is moved under natural conditions.

Methods of sampling, storage, transport and measurement for determining the oxygen consumption are described in the AVEU (internal guideline for the German Federal Waterways and Shipping Administration). The recommendations given there for the handling of the samples are also applicable for the measurements of nutrients. The corresponding DIN procedures should be used.

Evaluation of test results

Oxygen consumption

As there are no generally recognised guide values for oxygen depletion of sediments, and none have been yet stipulated for the HABAK, whenever sediments consist of a finely grained fraction, the potential of oxygen-consuming matter in the dredged material should be examined.

Based on the relevant hydrological conditions, quantitative computations show whether in the respective area an oxygen deficiency can occur.

Nutrients
As guide values GV_1, the following values for phosphorus and nitrogen in solid matter and eluate should be used provisionally (in accordance with the dredged-material concept of the Federal State Schleswig-Holstein (1996):

GV1:	Total phosphorus	< 500 mg/kg dry m.	and < 2 mg/l eluate, and
	Total nitrogen	< 1500 mg/kg dry m.	and < 6 mg/l eluate

Currently, there are no special guide values for ortho-phosphate (PO43-) and ammonium (NH4+), although these ions are easily remobilised.

Introducing guide values GV2 for nutrients is not necessary for the purpose of dredged material disposal, as, for elevated concentrations the required constraints laid down in Section 2.5.3 are sufficient to minimise negative impacts on the marine environment.

Fauna and Flora
The minimum testing includes the benthos and fish populations. Additionally, it must be examined whether there is a possibility of endangering other valuable biota (e.g. eelgrass, birds and seals). A basis for this can be matching data on species populations in the region of the disposal site with the protected species catalogues, such as the red lists. In this case, the extent of testing is to be enlarged. Following HABAK – Coastal Dredged Material Management-testing and evaluation of flora and fauna have to be carried out according to generally accepted scientific methods. Field studies provide data on the combined impact of physical disruptions and chemical contamination.

In any case, the disposal of dredged material has a physical impact on the area of dumping. The physical impact can cause effects on bed organisms through smothering or, if the composition of the dredged material greatly differs from that of the sediment found at the site of disposal, adversely affect the migration of fish and crustacea (e.g., salmon in estuaries, crabs in coastal regions).
When selecting suitable disposal sites, disturbances of environmental conditions and marine ecosystems (fauna and flora) have to be taken into consideration. It has to be examined in detail whether there is a conflict with the following aspects:

- benthic biocoenosis,
- spawning, breeding and feeding grounds,
- migration routes of marine organisms,
- landscape or conservation areas,
- areas of special importance for science or conservation (e.g., bird sanctuaries, seal resting places, eelgrass marshes).

In this guideline no methods are preset regarding sampling methods, sampling design and assessment methods.

Annex 3

Methods and indices used by the Netherlands

TRIADE field component

The field-component tests whether the bentic community at the dumping site differs from what would be expected on clean and undisturbed sediment. Per sediment type, ranges are established for macro-invertebrate parameters (such as densities and numbers of taxa), which indicates severe, moderate, or no risk (Table 1).

Table 1: Normal ranges (class boundaries) for classification of field parameters (for field studies in tidal river areas). Order of classes: severe effect/moderate effect/no effect.

Parameter	**Type of sediment**[1)]						
	stable or consolidated silt (shallow)	stable or consolidated silt (deep)	instable silt in high dynamic areas (deep /shallow)	moderate consolidated (instable) silt in low dynamic areas (deep/shallow)	fine sand (shallow)	Coarse sand in lothic systems	fine sand (deep)
Numbre of Chironomid species	0-4 / 5-10 / $11	0-4 / 5-10 / $11	0-2 / 3-5 / $6	0-2 / 3-7 / $8	0-4 / 5-7 / $8	0 / 1-3 / $4	0-2 / 3-6 / $7
Numbre of *Oligochaeta* species	0-4 / 5-9 / $10	0-4 / 5-9 / $10	0-2 / 3-5 / $6	0-2 / 3-7 / $8	0-2 / 3-4 / $5	0-2 / 3-4 / $5	0-2 / 3-4 / $5
Numbre of *Bivalva* species	0-3 / 4-8 / $9	0-3 / 4-6 / $7	0-2 / 3-5 / $6	0-2 / 3-5 / $6	0-3 / 4-8 / $9	0-5 / 6-9 / $10	0-3 / 4-6 / $7
Total numbre of *Ephemeroptera, Plecoptera* and *Trichoptera* species	0 / 1-2 / >3	Not applicable	Not applicable	0 / 1-2 / >3 (only in shallow water zones)	0 / 1-2 / >3	Not applicable	niet toe-pas-baar
Desity Chironomids	< 500 / 500-1500 / $ 1500	< 500 / 500-1500 / $ 1500	< 100 / 100-500 / $500	< 100 / 100-1500 / $ 1500	< 100 / 100-500 / $ 500	< 100 / 100-500 / $ 500	< 100 / 100-500 / $ 500
Density Oligochaeta	< 300 / 300-1000 / $ 1000	< 300 / 300-1000 / $ 1000	< 300 / 300-1000 / $ 1000	< 300 / 300-1000 / $ 1000	< 200 / 200-1000 / $ 1000	< 50 / 50-200 / $ 200	< 200 / 200-1000 / $ 1000
Density Bivalva	< 200 / 200-800 / $ 800	< 200 / 200-800 / $ 800	< 5 / 5-100 / $ 100	< 5 / 5-100 / $ 100	< 200 / 200-1000 / $ 1000	< 700 / 700-2000 / $ 2000	< 200 / 200-1000 / $ 1000
Population part Chironomids (%)	< 10 / 10-75 / $ 75	< 10 / 10-75 / $ 75	< 10 / 10-75 / $ 75	< 10 / 10-75 / $ 75	-------------------	-------------------	-------------------
Population part Bivalva (%)	----------------------	----------------------	--------------------	--------------------	< 15 / 15-30 / $ 30	< 15 / 15-30 / $ 30	< 15 / 15-30 / $ 30
Ratio Chironomus/Chironomus+ Procladius (CCP index;)	< 0,3 / 0,3-0,8 / $ 0,8	< 0,3 / 0,3-0,8 / $ 0,8	< 0,3 / 0,3-0,8 / $ 0,8	< 0,3 / 0,3-0,8 / $ 0,8	--------------------	--------------------	--------------------
Ratio Chironomids/Chironomids + Tubificidae (CCT index)	< 0,1 / 0,1-0,5 / $ 0,5	< 0,1 / 0,1-0,5 / $ 0,5	< 0,1 / 0,1-0,2 / $ 0,2	< 0,1 / 0,1-0,2 / $ 0,2	< 0,2 / 0,2-0,6 / $ 0,6	< 0,2 / 0,2-0,6 / $ 0,6	< 0,2 / 0,2-0,6 / $ 0,6
Percentage Menthum deformation Good/Moderate/bad	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20	< 10 / 10-20 / $ 20

1) Classification of sediments:

A - sand: fraction < 63 µm less than 10%.
- silt: grain size fraction <63 µm equal or more than 10%.

B subdivision of silt in stable/instable silt: stable silt if water contents < 50%, or sediments with more than 50% water, but Ks < -1 and regression coefficient 0.7; Instable silt if water contents > 50% and Ks > -1 and/or the regression coefficient < 0.7.

C Coarse sand grain size fraction >210 µm is more than 50%.

D Shallow < 2m;

E Deep >2m.

Biotic Index (macro invertebrates: brackish waters and marine)
By using the Biotic Index (BI) the toxic stress (pollution) can be determine (Borja *et al*, 2000). The index is based on how species use different strategies to cope with (toxic) stress. Five different strategies (categories) are distinguished. Every species is assigned to one of these categories. The BI is calculated by the following formula:

$$BI = [\ (0 \times \%Gr1) + (1{,}5 \times \%Gr2) + (3 \times \%Gr3) + (4{,}5 \times \%Gr4) + (6 \times \%Gr5)\ ] / 100$$

BI = Biotic index
%Gr1..5 = Percentage of category 1 till 5

The BI score varies from 0 (not polluted) to 7 (extremely polluted) and can be calculated by using the computer program AMBI.

ITI (macro invertebrates: brackish waters and marine)
The Infaunal Trophic Index (ITI) (Word, 1978; 1990) was originally developed as an aid to identify changed and degraded environmental conditions as a result of organic pollution in coastal waters. The approach is based on the allocation of species to one of four groups based on the type of food consumed by the animal and where the food is obtained from. As such it is a strictly trophic index. However, Word (1990) demonstrated a relationship between the total abundance of animals in each of the four groups and sediment BOD values, so that the ITI could be used to indicate pollution.
The ITI is calculated by determining the total abundance of the taxa belonging to each of the four groups and combining them in the following formula:

ITI = 100 – {[33.33x [(0n1 + 1n2 + 2n3 + 3n4) / (0n1 + 1n2 + 2n3 + 3n4)]}

where n1-4 is the number of individuals in the groups 1-4 and the coefficients in the numerator are simply scaling factors. Values of the index vary from 0-100 with low values indicating degraded conditions. ITI values were used to classify areas of the seabed into either "normal" (ITI values 100-60), "changed" (60-30) or "degraded" (30-0) (Bascom et al., 1978).

ABC method (macro invertebrates: brackish waters and marine)
The Abundance Biomass Curve (ABC) method is based on the assumption that in the event of environmental disturbance, the distribution of numbers of individuals among species in macrobenthic assemblages behaves differently from the distribution of biomass. Under stable undisturbed conditions, the biomass will become increasingly dominated by one or a few large species, each represented by rather few individuals that are in equilibrium with the available resources. However, the numerical dominants are smaller species which are not in equilibrium with the resources, and thus an undisturbed state is indicated if the biomass k-dominance curve lies above the abundance curve throughout its length. As disturbance becomes more severe, macrobenthic communities become increasingly dominated numerically by one or a few very small species, and few larger species are present although these will contribute proportionally more to the community biomass in relation to their abundance than will the small numerical dominants. A strongly disturbed state is therefore indicated if the abundance k-dominance curve lies above the biomass curve throughout its length.

Maturity index (nematodes: freshwaters)
The Maturity Index (MI) indicates the condition of the nematode community. Nematode taxa are divided according to their ability to colonise a disturbed habitat. The composition of the taxa is expressed as the Maturity Index, hence indicating the degree of ecological disturbance of the soil ecosystem.
Nematode taxa are classified on a scale of 1-5, with colonisers (inter alia: short life-cycle, high reproduction rates, high colonisation ability) weighted as one and persisters (inter alia: long life-cycles, low colonisation ability, few offspring, sensitive to disturbance) weighted as five. The MI is calculated as the weighted mean of the constituent nematode taxa values. The maturity index is calculated by the formula:

$$MI = \frac{\sum_{i=1}^{n} (v(i).a(i))}{\sum_{i=1}^{n} a(i)}$$

where $v(i)$ is the *c-p* value assigned to taxon *i* and $a(i)$ is the abundance of taxon I in sample *a*.

Water framework directive
For several types of waters (such as tidal river systems, slow-running waters on sand) a reference condition is established. A metric (based on this reference conditions) is developed using 3 indicators (positive dominant species, characteristic species and negative dominant species). Each water type has a list of indicators with abundance classes.

The metric is build up of 3 sub-metrics:
DN% = percentage of individuals of negative indicator species
KM% = percentage of characteristic species
KM% + DP% = percentage of individuals of positive indicator species and characteristic species

After calculating the values of the 3 sub-metrics, the final judgment can be calculated by using Tables 2 and 3 (as a sample for slow-running waters with sandy sediment). Assessment results in a final judgement (bad, inadequate, moderate, good, very good).

Tabel 2 Overview of sub-metrics with accompanying values and scores

Sub-metrics	values	score
DN % (density)	≥ 41	0.1
	< 41	0.2
KM % (number of taxa)	≤ 10	0.1
	>10 - < 28	0.2
	≥ 28 - < 50	0.3
	≥ 50	0.5
KM % + DP % (density)	< 5	0.1
	≥ 5 - < 25	0.2
	≥ 25	0.3

Tabel 3 Final judgement (quality classes)

totale score	Quality class	
≤ 0.3	bad	
> 0.3 - < 0.5	inadequate	
≥ 0.5 - < 0.7	moderte	
≥ 0.7	good +	very good

Dutch-German Exchange
on dredged material