OSPAR COMMISSION

Protecting and conserving the North-East Atlantic and its resources

OSPAR Guidelines for the Management of Dredged Material at Sea

(Agreement 2014-06)

OSPAR Guidelines for the Management of Dredged Material

1. Introduction

1.1 Dredging is essential to maintain navigation to, within and from ports and harbours and for the development of port facilities, as well as for remediation, flood management and to maintain the carrying capacity of marine and coastal systems. Much of the material removed during these necessary activities requires deposit at sea. Most of the material dredged from navigation channels within the OSPAR maritime area is, by its nature, either uncontaminated or only slightly contaminated by human activity (i.e. at, or close to, natural background levels). However, a smaller proportion of dredged material is contaminated to an extent that major environmental constraints need to be applied when developing management options.

1.2 Dredged sediments are recognised as part of the natural sediment cycle. Therefore, when considering suitable management options, it is generally the preferred option to retain dredged material within the same aquatic sedimentary system from where it originated, if it is environmentally, technically, socially and economically feasible to do so.

Overview of Dredging Activities

1.3 The different types of dredging activities are outlined below:

a. Dredging for water-based infrastructure, includes:

- Capital (or new-work) dredging for navigation involves enlarging or deepening existing channel and port areas or creating new ones; and for engineering purposes includes constructing trenches for pipes, cables, immersed tube tunnels, and removal of material unsuitable for foundations or for aggregate extraction, and for hydraulic purposes this involves increasing the flow capacity of the waterway;
- Maintenance dredging to maintain channels, berths or construction works, etc. at their designed dimensions (i.e. to counteract sedimentation and changes in morphology);
- Dredging for coastal protection: use of sediments for such activities as beach nourishment and construction of levees, dykes, jetties, etc.

b. Dredging for the purposes of ecosystem enhancement:

- Environmental dredging to remove contaminated sediment for the purpose of reducing risks to the environment and to human health;
- Restoration dredging to restore or create environmental features or habitats to establish ecosystem functions, benefits, and services; e.g., wetlands creation, island habitat construction/nourishment, construction of offshore reefs and topographic features for fisheries enhancement, etc.; and
- Dredging to support local and regional sediment processes retaining sediment within the natural sediment system to support sediment-based habitats, shorelines, and infrastructure.

2. Background and Scope

2.1 These Guidelines were adopted at the 201X Meeting of the OSPAR Environmental Impact of Human Activities Committee and are in accordance with the London Convention and Protocol Revised Specific Guidelines for Assessment of Dredged Material. Contracting Parties should take these guidelines into consideration in their authorisation or regulation procedures for dredged material.

2.2 The *OSPAR Guidelines for the Management of Dredged Material* outlined in this document are designed to assist Contracting Parties in the management of dredged material in ways that will prevent and eliminate pollution in accordance with Annex II to the 1992 OSPAR Convention, and protect marine species and habitats in the OSPAR maritime area in accordance with Annex V. Dredged materials have been listed in Article 3.2 of Annex II as being permitted to be dumped at sea, as an exception from the general prohibition from dumping in Article 3 (2).

2.3 Any deposit into the maritime area of dredged materials, independently of whether it is considered as “dumping” or “placement” within the OSPAR Convention (cf. Article 1(f) and Article 1(g)(ii) respectively), should be assessed on a case-by-case basis in order to ensure that it complies with the objectives of the Convention, as outlined in these Guidelines.

2.4 The Guidelines address the management of dredged material in the maritime area subsequent to any dredging technique including hydrodynamic and sidecast dredging. In addition to preventing and eliminating adverse effects the guidelines, where appropriate, seek to maintain or enhance the existing environmental conditions and to create new opportunities.

2.5 The guidelines are primarily a scientific and technical framework for assessing dredged material proposed for deposit at sea. While economic considerations are acknowledged, they are not dealt with in detail in these guidelines. This implies that the detailed procedures described in the guidelines will not be applicable in all national or local circumstances.

2.6 In the context of these guidelines, dredged material is deemed to be sediments or rocks with associated water, organic matter etc. removed from areas that are normally or regularly covered by water, using dredging or other excavation equipment.

2.7 It is recognised that both removal and deposit of dredged sediments may cause harm to the marine environment. Contracting Parties are therefore encouraged to exercise control over both dredging and dredged material management using a Best Environmental Practice (BEP) approach designed to minimise both the quantity of material that has to be dredged and the impact of the dredging and deposit activities in the maritime area - see Technical Annex V. Contracting Parties are encouraged to develop local, regional and national dredged material management plans in order to minimize the possible impacts and maximizing possible benefits from dredging and deposit. Advice on environmentally acceptable dredging techniques is available from a number of international organisations e.g. the Permanent International Association of Navigation Congresses (PIANC) and the Central Dredging Association (CEDA).

2.8 The schematic shown in Figure 1 presents the steps involved in the application of this Guideline where important decisions should be made. In general, national authorities should use this schematic in an iterative manner (revisiting steps in the processes as needed) to ensure that all steps receive appropriate consideration, including consideration of BAT and BEP, before a decision is made to issue or decline a permit. The following sections of this document describe the steps and activities relevant to the Guideline.

2.9 As a significant number of the Contracting Parties are under the European Union regulations, the Guidelines are also conceived as a tool assisting them in the management of dredged material that is subject to current European Directives (e.g. Water Framework Directive 2000/60/EC, Marine Strategy

Framework Directive 2008/56/EC, Natura 2000 areas under the Birds and Habitat Directives 2009/147/EC and 92/43/EEC). Also, the *Directive 2008/98/EC of the Parliament and of the Council of 19 November 2008 on waste*, (hereinafter the Waste Framework Directive), has been identified by Contracting Parties as having implications on the management of dredged material. Which implications those are exactly, and how this affects national legislation, remains in many cases unclear. Annex II attempts to offer clarifications regarding the relationship between the existing national interpretations in the application of the Waste Framework Directive to dredged material and the dredged material management guidelines shared in OSPAR maritime area.

3. Requirements of the 1992 OSPAR Convention [1]

3.1 Article 2.1a requires Contracting Parties to take all possible steps to prevent and eliminate pollution and to take the necessary measures to protect the maritime area against the adverse effects of human activities so as to safeguard human health and to conserve marine ecosystems and, when practicable, restore marine areas which have been adversely affected.

3.2 Article 4 requires Contracting Parties to take all possible steps to prevent and eliminate pollution by dumping or incineration of wastes or other matter in accordance with the provisions of the 1992 OSPAR Convention, in particular as provided for in Annex II.

3.3 With regard to the dumping of wastes or other matter at sea that are permitted under Article 3(2) of Annex II of the 1992 OSPAR Convention, Article 4 (1)(a) of Annex II requires Contracting Parties to ensure that no such materials are dumped without authorisation or regulation by their competent authorities. In addition, Article 4 (1)(b) of Annex II requires Contracting Parties to ensure that such authorisation or regulation is in accordance with the relevant applicable criteria, guidelines and procedures adopted by the Commission.

3.4 Furthermore, Article 4 (3) of Annex II requires Contracting Parties to keep records and report to the Commission on the nature and quantities of wastes or other matter dumped at sea in accordance with Article 4(1) of Annex II and the locations and methods of dumping used. To this end, OSPAR has agreed on reporting formats for the submission of data on dumping operations at sea.

3.5 Article 2 of Annex V to the OSPAR Convention, requires Contracting parties to protect and conserve the ecosystems and the biological diversity of the maritime area, and to restore, when practicable, marine areas which have been adversely affected and cooperate in adopting programmes and measures for the control of the human activities identified by the application of Appendix 3. To this end, Article 2 (2)(d)(ii) of the OSPAR Strategy on Biological Diversity and Ecosystems, includes dredging for navigational purposes other than within harbours on the candidate list of human activities to be further assessed and controlled by the Commission.

4. Preliminary Considerations for Dredged Material Management

4.1 Before beginning a full assessment of the material and the deposit options the first considerations should be the scale and need for the dredging project. In the event of a subsequent full assessment indicating no acceptable options for deposit it will be necessary to re-address this issue in a broader context.

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[1] All Article or Annex references mentioned in this chapter refer to the 1992 OSPAR Convention as amended by the 1998 inclusion of Annex V and Appendix 3.

4.2 Reducing adverse effects on the marine environment can be accomplished through the following three activities:

.1 Controlling and reducing sources of contamination;

.2 Maximizing the use of dredged material for beneficial purposes;

.3 Minimizing the volumes of sediment that must be dredged by using improved Best Environmental Practices (BEP), as discussed in Technical Annex III

4.3 Contamination of the aquatic environment, both as a consequence of historical and present day inputs, presents a problem for the management of freshwater, estuarine, and marine sediments. High priority should be given to the identification of sources, as well as the reduction and prevention of further contamination of sediments from both point and diffuse sources. Successful implementation of prevention strategies will require collaboration among competent authorities with responsibility for the control of contaminant sources. Sources of contamination include:

.1 industrial and domestic discharges;

.2 storm water;

.3 surface runoff from agricultural areas;

.4 sewage and waste-water treatment effluents;

.5 transport from upstream contaminated sediments.

.6 accidental pollution

4.4 In developing and implementing a source control strategy, competent authorities should take into account:

.1 the risks posed by contaminants and the relative contributions of the individual sources to these risks;

.2 existing source control programmes and other regulations or legal requirements;

.3 best available techniques (BAT) and BEP as defined in Appendix 1 of the 1992 OSPAR Convention, inter alia, as regards the technical and economic feasibility;

.4 evaluations of the performance or effectiveness of measures taken

.5 consequences of not implementing source control.

4.5 In cases where control measures are not fully effective in reducing contamination and high levels of contamination persist then specific dredged material management options may be required, for example confined disposal facilities or treatment methods.

4.6 Sediment is a valuable natural resource. Beneficial uses of dredged material (which are described further in Chapter 7) should be pursued to the maximum extent practicable. Beneficial use of sediments includes retaining sediments that meet national assessment criteria within freshwater, estuarine, and marine systems.

4.7 There is a need to minimize the release of contaminants to the environment while maximizing the re-use of sediment for beneficial purposes. Progress toward more sustainable practice in respect to sediment management (including dredged material management) can be seen in initiatives being undertaken by Contracting Parties (such as Building with Nature) and Observers to the Convention (such as Working with Nature, (PIANC 2011).

4.8 In addition, attention needs to be given to ensuring that the quantities of material needing to be dredged are minimised as far as is practicable. Application of BEP (technical annex III) to dredging operations minimises the quantity of material that must be dredged and deposited at sea thereby reducing the environmental impact of dredging activities (e.g., PIANC 2009 and CEDA 2010).

Sampling for the purpose of issuing a permit

5.1 Dredged material that is not exempted under paragraph 6.3 will require analysis and testing (cf. Technical Annex I) to obtain sufficient information for permitting purposes. Judgement and knowledge of local conditions will be essential when deciding what information is relevant to any particular operation.

5.2 A survey of the area to be dredged should be carried out. The distribution and depth of sampling should reflect the size and depth of the area to be dredged, the amount to be dredged and the expected variability in the horizontal and vertical distribution of contaminants. Core samples should be taken where the depth of dredging and expected vertical distribution of contaminants suggest that this is warranted. In other circumstances, grab sampling will usually be sufficient. Sampling from deposit vessels or barges is not advisable for permitting purposes.

5.3 The following table gives an indication of the number of separate sampling stations required to obtain representative results, assuming a reasonably uniform sediment distribution in the area to be dredged:

Amount dredged (m^3)	**Number of Stations**
Up to 25 000	3
25 000 - 100 000	4 – 6
100 000 - 500 000	7 – 15
500 000 - 2 000 000	16 – 30
>2 000 000	extra 10 per million m^3

The number of sample stations can also be determined on the basis of the area to be dredged. Contracting Parties are encouraged to use the Guidelines for the Sampling and Analysis of Dredged Material Intended for Disposal at Sea (IMO, 2005).

5.4 Normally, the samples from each sampling station and different depths in the sediment should be analysed separately. However, if the sediment is clearly homogenous with respect to sediment texture, it may be possible to analyse composite samples from two or more adjacent sampling stations at a time, providing there are no distinctly different contaminant concentrations in different sub samples and care is taken to ensure that the results allow derivation of valid mean contaminant values. The original individual samples should, however, be retained until the permitting procedure has been completed, in case further analyses are necessary.

Frequency of sampling

5.5 If the results of the analyses indicate that the material meets national assessment criteria (*e.g.* below lower action level), sampling in the same area need not be repeated more frequently than once every 3 years, provided that there is no indication that the quality of the material has deteriorated.

5.6 It may be possible, following assessment of the results of an initial full survey, to reduce either the number of sampling stations or the number of determinants and still provide sufficient information for permitting purposes. If a reduced sampling programme does not confirm the earlier analyses, the full survey should be repeated. If the list of determinants is reduced, further analysis of the complete list of determinants is advisable every 5 years.

5.7 In areas where there is a tendency for sediments to exhibit high levels of contamination, analysis of all the relevant determinants should be frequent and linked to the permit renewal procedure.

6. Dredged material characterisation

6.1 Characterisation should take into consideration physical, chemical and biological characteristics. A list of the data to be collected and analysed during the characterization process should be developed on a project-specific basis. This data should be sufficient to describe and assess possible impacts as a basis for management decisions (e.g. PIANC 1996; 1998a and b). Guidance on the selection of determinants and methods of contaminant analysis, together with procedures to be used for normalisation and quality assurance purposes, will be found in the Technical Annexes.

6.2 If dredged material is so poorly characterised that proper assessment cannot be made of its potential impacts on human health and the environment, it shall not be deposited at sea.

Exemptions from detailed characterisation

6.3 Dredged material may be exempted from the testing referred to in paragraphs 6.5 to 6.10 of these Guidelines (but note that the information listed in paragraph 6.4 below will still be required) if any of the criteria below are met:

a. it is composed of previously undisturbed geological material; or

b. it is composed almost exclusively of sand, gravel or rock; or

c. in the absence of appreciable past and present pollution sources and when the quantity of dredged material from operations does not exceed 10 000 tonnes per year.

In relation to 6.3b and 6.3c the exemption from testing should be supported by local information so as to provide reasonable assurance that the dredged material has not been contaminated.

Dredged material that does not meet at least one of these requirements will need further stepwise characterisation to assess its potential impact (*i.e.* see paragraphs 6.5-6.9).

Physical characterisation

6.4 The following information is required:

a. the amount of material;

b. anticipated or actual loading rate of material at the deposit site;

c. sediment characteristics preferably by grain size analysis (laser or sieving methods) or exceptionally on the basis of visual determination (*i.e*. clay/silt/sand/gravel/boulder).

Evaluation of the physical characteristics of sediments for deposit is necessary to determine potential impacts and the need for subsequent chemical and/or biological testing (cf. Technical Annex I for further guidance).

Chemical characterisation

6.5 Sufficient information for chemical characterisation may be available from existing sources. In such cases new measurements may not be required of the potential impact of similar material in the vicinity, provided that this information is still reliable and has been obtained within the last 5 years. Details of the substances recommended to be determined are listed in Technical Annex I.

6.6 Considerations for additional chemical characterisation of dredged material are as follows:

a. major geochemical characteristics of the sediment including redox status;

b. potential routes by which contaminants could reasonably have been introduced to the sediments;

c. industrial and municipal waste discharges (past and present);

d. probability of contamination from agricultural and urban surface runoff;

e. spills of contaminants in the area to be dredged;

f. source and prior use of dredged materials (e.g., beach nourishment); and

g. natural deposits of minerals and other natural substances.

6.7 Further information may also be useful in interpreting the results of chemical testing (cf. Technical Annex I).

Biological characterisation

6.8 If the potential impacts of the dredged material to be deposited cannot be adequately assessed on the basis of the chemical and physical characterisation and available biological information, biological testing may be conducted. Further detailed guidance on biological testing is provided in Technical Annex I.

6.9 Biological tests should incorporate species that are considered appropriately sensitive and representative and should determine, where appropriate.

a. acute toxicity;

b. chronic toxicity;

c. the potential for bioaccumulation; and

d. the potential for tainting.

6.10 Assessment of habitats communities and populations may be conducted in parallel with chemical and physical characterisation, *e.g.* triad approach. It is important to ascertain whether adequate scientific information exists on the characteristics and composition of the material to be deposited and on the potential impacts on marine environment and human health.

Action List

6.11 The Action List is used as a screening mechanism for assessing properties and constituents of dredged material with a set of criteria for specific substances. It should be used for dredged material management decisions, including the identification and development of source control measures as described in Section 4 above. The criteria should reflect experience gained relating to the potential effects on human health or the marine environment.

6.12 Action List levels should be developed on a national or regional basis and might be set on the basis of concentration limits, biological responses, environmental quality standards, flux considerations or other reference values. They should be derived from studies of sediments that have similar geochemical properties to those from the ones to be dredged and/or to those of the receiving system. Thus, depending upon natural variation in sediment geochemistry, it may be necessary to develop individual sets of criteria for each area in which dredging or deposit is conducted. With a view to evaluating the possibilities for harmonising or consolidating the criteria referred to above, Contracting Parties are requested to inform the OSPAR Commission of the criteria adopted or revisions, as well as the scientific basis for the development and refinement of these criteria.

6.13 An Action List should include upper and lower levels giving these possible actions:

a. material which contains specified contaminants or which causes e.g. biological responses, in excess of the relevant upper levels should generally be considered unsuitable for normal sea deposit but suitable for other management options, see paragraphs 7.4 – 7.6 below;

b. material of intermediate quality, below the upper level but exceeding the lower level, should require more detailed assessment before suitability for deposit at sea can be determined ; and

c. material which contains contaminants below the relevant lower levels should generally be considered of little environmental concern for deposit at sea.

6.14 Action levels should be established at least for determinants on the Primary List in Technical Annex I.

6.15 If, as an option of least detriment, dredged material is deposited at sea when one or more criteria exceed the upper level, a Contracting Party should:

a. where appropriate, identify and develop source control measures with a view to meeting the criteria - see paragraphs 4.3 – 4.5 above;

b. utilise management techniques, including confined disposal or treatment methods, to mitigate the impact of the dumping operation on the marine environment see paragraphs 7.4 - 7.5 below; and

c. report the fact to the Secretariat, including the reason for permitting the deposit, in accordance with the format for the annual report.

7. Dredged material management options

7.1 Generally it is preferable to keep the sediment in the aquatic, estuarine, or marine system, however the results of the physical/chemical/biological characterisation will determine the dredged material management options. Examples of management options include beneficial use, unrestricted, open-water deposit, confined aquatic disposal or confined disposal facilities. In some cases the best option may be to leave the material in-situ.

Options for material assessed to be uncontaminated[2]

7.2 There is a wide variety of management options for dredged material depending on the physical and chemical characteristics of the material. Generally, a characterization carried out in accordance with these Guidelines will be sufficient to determine possible management options in water and at the shoreline. Examples include:

.1 Sustainable Deposit by retaining sediment within the natural sediment system to support sediment-based habitats, shorelines, and infrastructure.

.2 Habitat Restoration and Development using direct deposit of dredged material for enhancement or restoration of natural habitat associated with wetlands, other near-shore habitats, coastal features, offshore reefs, fisheries enhancement, etc.

.3 Beach Nourishment using dredged material (primarily sandy material) to restore and maintain beaches.

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[2] according to national assessment criteria

.4 Shoreline Stabilization and Protection through the deposit of dredged material with the intent of maintaining or creating erosion protection, dike field maintenance, berm or levee construction, and erosion control.

.5 Sea deposit (see Chapter 8)

.6 Engineering uses (e.g. as capping material or for land reclamation).

7.3 Additional information about beneficial uses of dredged material, including case studies, can be found at the Central European Dredging Association's (CEDA) website (http://www.dredging.org). PIANC (2009) provides technical information on the assessment of options for beneficial use and recommendations on how to overcome constraints based on "lessons learned" from numerous cases studies in different situations in various countries.

Options for material assessed to be contaminated [3]

7.4 Where the characteristics of the dredged material are such that normal sea deposit would not meet the requirements of the 1992 OSPAR Convention, treatment or other management options should be considered. These options can be used to reduce or control impacts to a level that will not constitute an unacceptable risk to human health, or harm living resources, damage amenities or interfere with legitimate uses of the sea.

7.5 Treatment, such as separation of contaminated fractions, may make the material suitable for a beneficial use and should be considered before opting for sea deposit. Deposit management techniques to reduce or control impacts may include e.g. deposit on or burial in the sea floor followed by clean sediment capping, or methods of containing dredged material in a stable manner. Advice on dealing with contaminated dredged material is available from PIANC and CEDA (see references).

7.6 The practical availability of means of deposit, other than at sea, should be considered in the light of a comparative risk assessment involving both dumping and the alternatives.

8. Sea deposit site selection

8.1 The selection of a site for sea deposit involves considerations of an environmental nature and also economic and operational feasibility. Site selection should try to ensure that the deposit of dredged material does not interfere with, or devalue, legitimate commercial and economic uses of the marine environment nor produce undesirable effects on vulnerable marine ecosystems or species and habitats on the OSPAR List of Threatened and/or Declining Species and Habitats (Reference number 2008-6).

8.2 For the evaluation of a sea deposit site information should be obtained and assessed on the following, as appropriate:

a. the physical, chemical and biological characteristics of the seabed (e.g., topography, sediment dynamics and transport, redox status, benthic organisms);

b. the physical, chemical and biological characteristics of the water column (e.g., hydrodynamics, dissolved oxygen, pelagic species);

c. proximity to:

   (i) areas of natural beauty or significant cultural or historical importance;.

   (ii) areas of specific scientific or biological importance (*e.g.* Marine Protected Areas);

   (iii) recreational areas;

   (iv) subsistence, commercial and sport fishing areas;

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[3] according to national assessment criteria

(v) spawning, recruitment and nursery areas;

(vi) migration routes of marine organisms;

(vii) shipping lanes;

(viii) military exercise zones;

(ix) past munitions dump sites;

(x) engineering uses of the sea such as undersea cables, pipelines, wind farms

(xi) areas of mineral resources (*e.g.* sand and gravel extraction areas); and

d. the capacity of the site should be assessed, taking into account:

(i) the degree to which the site is dispersive;

(ii) the allowable reduction in water depth over the site because of mounding of material.

(iii) the anticipated loading rates per day, week, month, or year;

Such information can be obtained from existing sources, complemented by field work where necessary.

8.3 The information on the characteristics of the sea deposit site referred to above is required to determine the probable fate and effects of the deposited material. The physical conditions in the vicinity of the sea deposit site will determine the transport and fate of the dredged material. The physico-chemical conditions can be used to assess the mobility and bioavailability of the chemical constituents of the material. The nature and distribution of the biological community and the proximity of the site of sea deposit to marine resources and amenities will, in turn, define the nature of the effects that are to be expected. Careful evaluation will allow determination of environmental processes that may dominate the transport of material away from the sea deposit site. The influence of these processes may be reduced through the imposition of permit conditions.

8.4 In some cases, depositing of dredged material can augment existing effects attributable to inputs of contaminants to coastal areas through land runoff and discharge, from the atmosphere, resource exploitation and maritime transport. These existing stresses on biological communities should be considered as part of the assessment of potential impacts caused by the deposit operation. The proposed method of deposit and potential future uses of resources and amenities in the marine receiving area should also be taken into account.

8.5 Information from baseline and monitoring studies at already established deposit sites will be important in the evaluation of any new deposit activity at the same site or nearby.

8.6 For contaminated material the use of open-sea sites at distant off-shore locations or in deep waters is seldom an environmentally desirable solution to the prevention of marine pollution.

8.7 The dredged material which is acceptable for sea deposit and the sediments at the chosen site, or in case of a dispersive site for the sediments of the receiving area, should be of similar characteristics as far as possible.

9. Assessment of potential effects

Deposit sites

9.1 Assessment of potential effects should lead to a concise statement of the expected consequences of the deposit option (*i.e.* the Impact Hypothesis). Its purpose is to provide a basis for deciding whether to approve or reject the proposed deposit option and for defining environmental monitoring requirements.

9.2 This assessment should integrate information on the characteristics of the dredged material and the proposed deposit site conditions. It should comprise a summary of the potential effects on human health, living resources, amenities and other legitimate uses of the sea and should define the nature, temporal and spatial scales and duration of expected impacts based on reasonably pessimistic assumptions.

9.3 In order to develop the hypothesis, it may be necessary to conduct a baseline survey which describes not only the environmental characteristics, but also the variability of the environment. It may be helpful to develop sediment transport, hydrodynamic and other models, to determine possible effects of deposit.

9.4 For a retentive site, where the material deposited will remain within the vicinity of the site, the assessment should delineate the area that will be substantially altered by the presence of the deposited material and what the severity of these alterations might be. At the extreme, this may include an assumption that the immediate receiving area is entirely smothered. In such a case, the likely timescale of recovery or re-colonisation should be projected after deposit operations have been completed as well as the likelihood that re-colonisation will be similar to, or different from, the existing benthic community structure. The assessment should specify the likelihood and scale of residual impacts outside the primary zone.

9.5 In the case of a dispersive site, the assessment should include a definition of the area likely to be altered in the shorter term by the proposed deposit operation (i.e., the near-field) and the severity of associated changes in that immediate receiving environment. It should also specify the likely extent of long-term transport of material from this area and what this flux represents in relation to existing transport fluxes in the area, thereby permitting a statement regarding the likely scale and severity of effects in the long-term and far-field.

9.6 If applicable, the "Council Directive 2011/92/EU of 13 December 2011 amending Directive 97/11/EC on the Assessment of the Effects of Certain Public and Private Projects on the Environment" of the European Community should be taken into account when assessing potential impacts of dredged material deposit. Where applicable, the EU-Habitats Directive (92/43/EEC) may require an appropriate assessment and the EU-Landfill (99/31/EC) and Water Framework Directives (2000/60/EC) may have implications for dredging and deposit operations. Additionally the Marine Strategy Framework Directive (2008/56/EC) specifies the deposit of dredged material as a possible pressure with regard to physical loss or damage which needs to be considered when assessing the status of the marine environment.

9.7 The Convention on Biological Diversity has produced guidance on biodiversity issues in relation to Environmental Impact Assessment that should be taken into account, when appropriate.

Nature of the impact

9.8 All dredged materials have a significant physical impact at the point of deposit. This impact includes covering of the seabed and local increases in suspended solids levels. Physical impact may also result from the subsequent transport, particularly of the finer fractions, by wave and tidal action and residual current movements.

9.9 Biological consequences of these physical impacts include smothering of benthic organisms in the deposit area and potentially in the surrounding area. In comparatively rare circumstances, the physical impacts can also interfere with the migration of fish (*e.g.* the impact of high levels of turbidity on salmonids in estuarine areas) or crustaceans (*e.g.* if deposition occurs in the coastal migration path of crabs).

9.10 The toxicological and bioaccumulation effects of' dredged material constituents should be assessed. Deposit of sediments with low levels of contamination is not devoid of environmental risk and requires consideration of the fate and effects of dredged material and its constituents. Substances in dredged material may undergo physical, chemical and biochemical changes when entering the marine environment and these changes should be considered in the light of the eventual fate and potential effects of the material. It should also be taken into account that deposit at sea of certain substances may disrupt the sensory capabilities of the fish and may mask natural characteristics of sea water or tributary streams, thus confusing migratory species which e.g. fail to find spawning grounds or food.

9.11 In relatively enclosed waters, such as some estuarine, archipelagic and fjordic situations, sediments with a high chemical or biological oxygen demand (*e.g.* organic carbon-rich) could adversely affect the oxygen regime of the receiving environment while sediments with high levels of nutrients could significantly affect the nutrient flux.

9.12 An important consequence of the physical presence of dredged material deposit activities is interference with fishery activities and in some instances with navigation and recreation. These problems can be aggravated if the sediment characteristics of the dredged material are very dissimilar to that of the ambient sediment or if the dredged material is contaminated with bulky harbour debris such as wooden beams, scrap metal, pieces of cable etc.

9.13 Particular attention should be given to dredged material containing significant amounts of oil or other substances that have a tendency to float following re-suspension in the water column. Such materials should not be deposited in a manner or at a location which may lead to interference with protected species and habitats, fishing, shipping, amenities or other beneficial uses of the marine environment.

10. Permit or regulation by other means

10.1 If sea deposit is the selected option, then a permit or regulation by other means (which is in compliance with these guidelines) authorising sea deposit must be issued in advance. In granting a permit, the immediate impact of dredged material occurring within the boundaries of the deposit site such as alterations to the local, physical, chemical and biological environment is accepted by the permitting or supervising authority. Notwithstanding these consequences, the conditions under which a permit for sea deposit is issued should be such that environmental change beyond the boundaries of the deposit site are as far below the limits of allowable environmental change as practicable. The deposit operation should be permitted subject to conditions which further ensure that environmental disturbance and detriment are minimised and benefits maximised.

10.2 The permit is an important tool for managing sea deposit of dredged material and will contain the terms and conditions under which sea deposit may take place as well as provide a framework for assessing and ensuring compliance.

10.3 Permit conditions should be drafted in plain and unambiguous language and will be designed to ensure that:

a. only those materials which have been characterised or considered exempted from detailed characterisation according to paragraph 6.3, and found acceptable for sea deposit, based on the impact assessment, are deposited;

b. solid waste[4] contained within the dredged material should be separated and managed on land;

c. the material is deposited at the selected deposit site;

d. any necessary deposit management techniques identified during the impact analysis are carried out; and

e. any monitoring requirements are fulfilled and the results reported to the permitting or supervising authority.

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[4] as defined in the glossary

10.4 A permit to deposit dredged material that is assessed to be contaminated according to national assessment criteria shall be refused if the permitting authority determines that appropriate opportunities exist to reuse, recycle or treat the material without undue risks to human health or the environment or disproportionate costs.

11. Management of the Deposit Operation

11.1 This section deals with management techniques to minimise the physical effects of dredged material deposit. The key to management lies in careful site selection and an assessment of the potential for conflict with other interests and activities. In addition, appropriate methods of dredging and of deposit should be chosen in order to minimise the environmental effects. Guidance is given in Technical Annex III.

11.2 Where appropriate, deposit vessels should be equipped with accurate positioning systems and the activity of the vessels may be reported to the permitting or supervising authority. Deposit vessels and operations should be inspected regularly to ensure that the conditions of the deposit permit are being complied with and that the crew are aware of their responsibilities under the permit. Ships' records and automatic monitoring and display devices (e.g. black-boxes), where these have been fitted, should be inspected to ensure that deposit is taking place at the specified deposit site.

11.3 In most cases, blanketing of a comparatively small area of seabed is considered to be an acceptable environmental consequence of deposit. To avoid excessive degradation of the seabed as a whole, the number of sites should be limited as far as possible and each site should be used to the maximum extent that will not interfere with navigation or any other legitimate use of the sea.

11.4 Effects can be minimised by ensuring that, as far as possible, the dredged material and the sediments in the receiving area are similar. Locally, impacts may also be reduced if the deposition area is subject to natural physical disturbance. In areas where natural dispersion is low or unlikely to be significant and where reasonably clean, finer-grained dredged material is concerned, it may be appropriate to use a deliberately dispersive deposit strategy to prevent or reduce blanketing, particularly of a smaller site.

11.5 The rate of deposition of dredged material can be an important consideration since it will often have a strong influence on the impacts at the deposit site. It may therefore need to be controlled to ensure that the environmental management objectives for the site are not exceeded.

11.6 Engineering controls, such as method of dredging and deposit, remediation of contaminated materials, infilling of depressions, deliberate capping or other confinement methods for dredged material deposits may be appropriate in certain circumstances to avoid interference with fishing or other legitimate activities.

11.7 Operational controls can include temporal restrictions on deposit activities, such as tidal and/or seasonal restrictions to prevent interference with e.g. nature protection, anthropogenic uses, migration, spawning or seasonal fishing activity.

12. Monitoring

12.1 Monitoring in relation to deposit of dredged material is defined as measurements of compliance with permit requirements and of the condition and changes in condition of the receiving area to assess the Impact Hypothesis upon which the issue of a deposit permit was approved.

12.2 The effects of dredged material deposit are likely to be similar in many areas, and it would be very difficult to justify (on scientific or economic grounds) monitoring all sites, particularly those receiving small quantities of dredged material. It is therefore more appropriate, and cost effective, to concentrate on detailed investigations at a few carefully chosen sites (e.g. those subject to large inputs of dredged material) to obtain a better understanding of processes and effects.

12.3 It may usually be assumed that suitable specifications of existing (pre-deposit) conditions in the receiving area are already contained in the application for deposit.

12.4 The impact Hypothesis forms the basis for defining the monitoring programme. The measurement programme should be designed to ascertain that changes in the receiving environment are within those predicted. In designing a monitoring programme the following questions must be answered:

a. what testable hypotheses can be derived from the Impact Hypothesis?

b. what measurements (e.g. type, location, frequency, performance requirements) are required to test these hypotheses?

c. what should be the temporal and spatial scale of measurements?

d. how should the data be managed and interpreted?

12.5 The permitting or supervising authority is encouraged to take account of relevant research information in the design and modification of monitoring programmes. Measurements should be designed to determine two things:

a. whether the zone of impact differs from that projected; and

b. whether the extent of change protected outside the zone of impact is within the scale predicted.

The first of these questions can be answered by designing a sequence of measurements in space and time that circumscribe the projected zone of impact to ensure that the projected spatial scale of change is not exceeded. The second question can be answered by the acquisition of measurements that provide information on the extent of change that occurs outside the zone of impact after the deposit operation. Frequently, this latter suite of measurements will only be able to be based on a null hypothesis - that no significant change can be detected.

Feedback

12.6 Information gained from field monitoring, (or other related research studies) can be used to:

a. modify or terminate the field monitoring programme;

b. modify or revoke the permit; and

c. refine the basis on which applications to deposit dredged material at sea are assessed.

12.7 Concise statements of monitoring activities should be prepared. Reports should detail the measurements made, results obtained and how these data relate to the monitoring objectives. The frequency of reporting will depend upon the scale of deposit activity and the intensity of monitoring.

13. Reporting

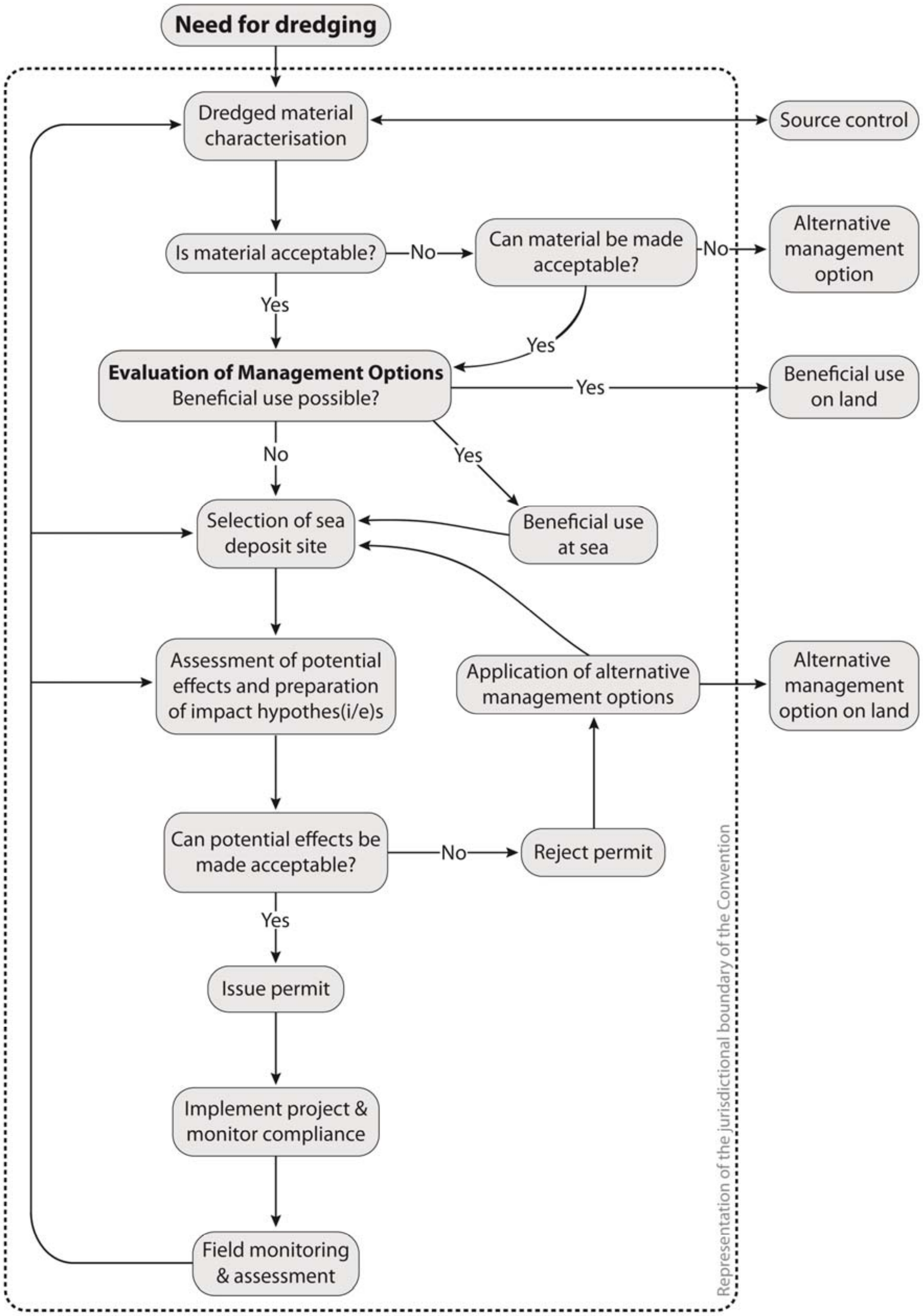
13.1 Reporting of permits issued and amounts of dredged material, deposited together with the associated contaminants, is required according to the 1992 OSPAR Convention - see paragraph 3.4 above. The characterisation process is designed to provide information for permitting purposes. However, it will also provide some information on the contribution of dredged material to total inputs and, at the present time, it is considered the only approach available for this purpose. It is assumed that materials exempted from analysis represent insignificant inputs of contaminants and therefore it is not necessary to calculate or report contaminant loads. See paragraph 3.4 for the basis of this reporting requirement.

13.2 Together with contaminant data, information on the methods of determination and on quality assurance of analyses of deposited material should be provided as requested in the Reporting Format (Agreement 2014/07).

13.3 Contracting Parties should also inform the Secretariat of their monitoring activities and submit reports when they are available.

Figure 1

Steps to be considered in assessing permits application for sea deposit



Annex I

Glossary and Acronyms

These terms are define for the purpose of these guidelines

Glossary and Acronyms

Action levels	Guidance values used to trigger action
Anoxic	Without oxygen.
Anthropogenic	Originating from the activity of humans.
Benthic	Of, relating to, or occurring at the bottom of a body of water.
Best Available Techniques (BAT)	The latest stage of development (state of the art) of processes, of facilities or of methods of operation, which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. (Appendix 1 (2) of the OSPAR Convention 1992)
Best Environmental Practice (BEP)	The application of the most appropriate combination of environmental control measures and strategies. (Appendix 1 (6) of the OSPAR Convention 1992)
Bioaccumulation	Accumulation of environmental contaminants in living tissue.
Bioassay	Tests in which organisms are exposed to dredged materials to determine their effects or toxicity.
Biological testing	Testing via bioassays.
Biota	Living organisms.
Building with Nature	New approach to maritime infrastructure projects using the dynamics of the natural system as a starting point.
Capital dredging	Capital dredging includes geological material dredged from previously unexposed layers beneath the seabed and surface material from areas not recently dredged.
CEDA	Central Dredging Association, one of the three autonomous sister organizations, along with WEDA and EADA, that constitute WODA.
Clay	Sedimentary mineral particles 0.2 to 2.0 µm in size, usually with a negative charge (anion); the size and charge have profound implications for sediment chemistry and other physical interactions.

Contaminated dredged material	Dredged material not meeting national assessment criteria (e.g. exceeding upper action levels).
confined disposal	Disposal in a structure planned and designed to contain dredged material and safely contain any released contaminants, preventing their re-entry into the aquatic environment.
Dredged material	Material arising from dredging operations.
Dredged material management	Is an overarching term describing a variety of handling methods of dredged materials including, inter alia: dumping (deliberate disposal), re-use, beneficial use, re-location, placement and treatment.
Eco-toxicological testing	Biological testing via bioassays.
Fractions	Categories of sediments using grain size.
Gravel	Unconsolidated rock fragment > 2mm to < 63mm
Harbour	Harbours include enclosed and semi-enclosed docks, docks entrances, marinas, wharves and unloading jetties
Inert material of natural origin	Inert material of natural origin,that is solid, chemically unprocessed geological material, the chemical constituents of which are unlikely to be released into the marine environment. The type of inert material including the reason for its classification as inert should be indicated;
Maintenance dredging	Maintenance dredging is the dredging required to maintain berths and navigation channels at advertised depth. It includes material dredged from recently deposited by sedimentation processes in harbour or sea areas
Oil	Total petroleum hydrocarbons (total oil and grease) C10 – C40
Σ PAH9	anthracene; benzo[a]anthracene; benzo[ghi]perylene; benzo[a]pyrene; chrysene; fluoranthene; indeno[1,2,3-cd]pyrene; pyrene; phenanthrene
Σ PAH16	acenaphthene, acenaphthylene, anthracene, benzo[a]anthracene, benzo[b]fluoranthene, benzo[k]flouranthene, benzo[a]pyrene, benzo[ghi]perylene, chrysene, dibenz(ah)anthracene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene,
Σ ICES 7 PCB	CB 28; CB 52; CB 101; CB 118; CB 138; CB 153; and CB 180
Permitting authority	The official department or agency that has the legal authority to permit or refuse deposit in the marine environment and to prosecute violations of deposit regulations.

PIANC	The International Navigation Association.
Practicable	Idea that a project, or scheme that can be realized, with the available resources and within the given constraints of cost and time.
Sand	Mineral particles > 63 µm and < 2 mm in size.
Sediment	Naturally occurring material that is produced through the processes of weathering and erosion of rocks, and is subsequently transported by the action of fluids such as wind, water, or ice, and/or by the force of gravity acting on the particle itself.
Silt	Mineral particles between 2.0 µm and 63 µm in size;
solid waste	Any persistent, manufactured or processed solid material or items discarded, disposed of or abandoned in the marine and coastal environment
toxic	Has lethal or debilitating effects when ingested or contacted externally, such as exposure to gill membranes during respiration or to skin.
treatment	The processing of (contaminated) dredged material to reduce its quantity or to reduce the contamination.

Annex II

Clarifications regarding the relationship between the existing national interpretations in the application of the Waste Framework Directive to dredged materials and the dredged material management guidelines shared in OSPAR region

1. There are different approaches between CP's to regard "dredged material" generally as "waste" or only under certain circumstances, depending on the national interpretation of the Waste Framework Directive when dealing with dredged material.

2. Despite these different interpretations on how the Directive may apply to dredged material there is a shared management framework in the OSPAR region provided by the Guidelines presented in this document.

3. The management framework contained in these Guidelines is consistent with the provisions of the Waste Framework Directive. Despite the use of different terminology, the Waste Framework Directive and the OSPAR Convention all have the same purpose and objective, that is the protection of the marine environment and human health.

4. Consequently, the present Guidelines are applicable to the existing approaches undertaken by the CP's and summarised below[5]:

    (i) Dredged material is regarded as waste, irrespective of the quality, and national waste legislation is applied.

    (ii) Dredged material is excluded from the scope of the Directive if it is proven that the sediments are non-hazardous (exemption in article 2.3 of the Waste Framework Directive). Article 2.3 requires the Member State to prove the non-hazardousness of the dredged sediments, not being demanded to apply the Directive in cases complying with the mentioned requirement. Therefore, CP's need to develop a consistent methodology that assures the non-hazardousness of the sediments. If it is determined to be hazardous by this methodology, the material must not be exempted and hazardousness related to the Waste Framework Directive has to be checked.

    (iii) Dredged material is either interpreted to not be waste or excluded from the scope of the Waste Framework Directive. The regulation is principally based on water legislation as long as it is proven that it is non-hazardous which is defined also within the scope of water legislation. If it is determined to be hazardous related to water legislation, then it is generally regarded as waste and hazardousness related to the Waste Framework Directive has to be checked.

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[5] It is not the aim of the document to reflect a unique position but to show the existent diversity which is not in contradiction with the aims of the OSPAR Convention and in particular of this document.

(iv) Dredged material is regarded as a resource for the aquatic systems, quality is determined and if it meets the criteria, national water legislation can be applied for the recovery of waste. This approach allows the Member State to have legislation in place for the recovery of waste. If the Waste Framework Directive directly applies to the management of dredged material, the Directive allows for the recovery and re-use of wastes, as defined in Annex II of the Waste Framework Directive. For those activities listed Member States may exempt dredged material from permit requirements (article 24). Article 25 then states that the Member State then shall lay down general rules specifying conditions and methods used. Starting point for this point of view is that sediments (dredged material) are an important resource for aquatic systems**.**

(v) Dredged materials are excluded from the scope of the Waste Framework Directive if they are not managed on land.

For more clarification, the present Guidelines apply to:

(a) dredged sediments not considered excluded from the scope of the Waste Framework Directive by the competent authority but classified as non-hazardous waste accordingly to it.

(b) dredged sediments considered excluded from the scope of the Waste Framework Directive by the competent authority under Article 2.3 of the Waste Framework Directive (proved to be non-hazardous sediments),

(c) dredged sediments not considered as waste according to national interpretation of this term and therefore consequently regulated by national and European water legislation.

Annex III

Background information and supplementary literature to the OSPAR Guidelines for the Management of Dredged Material

CBD, 2006. Guidelines on biodiversity - inclusive Environmental Impact Assessment (EIA).

CEDA & IADC, 2008: Environmental Aspects of Dredging, Edited by R. N. Bray. Taylor and Francis. ISBN 978-0-415-45080-5

CEDA, 2010: Information Paper - Dredged Material as a Resource. Options and Constraints.

CEDA, 2011: Information Paper: Environmental Control on Dredging Projects – Lessons Learned from 15 Years of Turbidity Monitoring.

CEDA, 2012: Position Paper: Climate Change Adaptation as it Affects the Dredging Community.

IMO, 2005. Sampling of Dredged Material. Guidelines for the sampling and analysis of dredged material intended for disposal at sea. IMO publication I537E.

USACE/EPA/CE, 1992, Revised 2004. Evaluating Environmental Effects of Dredged Material Management Alternatives - A Technical Framework, EPA 842-B-92-008.

PIANC, 1992. Beneficial Uses of Dredged Material: A Practical Guide, Report of Working Group No. 19.

PIANC, 1996. Handling and Treatment of Contaminated Dredged Material from Ports and Inland Waterways, Report of Working Group No. 17 of the Permanent Technical Committee 1 - Supplement to PIANC Bulletin No. 89.

PIANC, 1997. Dredged Material Management Guide. Special Report of the Permanent Environmental Commission – Supplement to Bulletin no.96.

PIANC 1998: Management of Aquatic Disposal of Dredged Material.- Report EnviCom WG 1; Brussels.

PIANC, 2002: Environmental Guidelines for Marine, Near shore, and Inland confined Disposal Facilities (CDF's) for Contaminated Dredged Material.- Report EnviCom WG 5; Brussels.

PIANC,2006: Generic Biological Assessment Guidance for Dredging and Disposal.- Report of EnviCom WG 8; Brussels.

PIANC, 2006: Environmental risk assessment in dredging and dredged material disposal.- Report of EnviCom WG 10; Brussels.

PIANC, 2009: Dredging Management Practices for the Environment.-Report no.100, EnviCom WG 13; Brussels.

PIANC, 2009: Dredged Material as a Resource" .- Report no.104, EnviCom WG 14; Brussels.

PIANC, 2009: Long term management of Confined disposal facilities.- Report no.109, EnviCom WG 11; Brussels.

PIANC & UNEP,2010: Environmental Aspects of Dredging and Port Construction Around Coral Reefs.- Report no.108, EnviCom WG 15; Brussels.

PIANC, last update: 2011: Position Paper: Working with Nature philosophy

Technical Annex I

Analytical Requirements for Dredged Material Assessment

1. This Technical Annex covers the analytical requirements necessary to implement paragraphs 6.5-6.10 of the OSPAR Guidelines for the Management of Dredged Material.

2. A tiered approach to testing is recommended. At each tier it will be necessary to determine whether sufficient information exists to allow a management decision to be taken or whether further testing is required.

3. As a preliminary to the tiered testing scheme, information required under section 6.4 of the Guidelines will be available. In the absence of appreciable pollution sources and if the visual determination of sediment characteristics leads to the conclusion that the dredged material meets one of the exemption criteria under paragraph 6.3 of the Guidelines, then the material will not require further testing. However, if all or part of the dredged material is being considered for beneficial uses, then it will usually be necessary, in order to evaluate these uses, to determine at least some of the physical properties of the material indicated in Tier I.

4. The sequence of tiers is as follows:

   - assessment of physical properties
   - assessment of chemical properties
   - assessment of biological properties and effects

A pool of supplementary information, determined by local circumstances may be used to augment each tier (cf. section 6.6 of the Guidelines).

5. At each stage of the assessment procedure account must be taken of the method of analysis. Analysis should be carried out on the whole sediment (< 2mm) or in a fine-grained fraction. If analysis is carried out in a fine-grained fraction, the results should be appropriately converted to whole sediment (< 2 mm) concentrations for establishing total loads of the dredged material. Additional information (e.g. as regards storage and pre-treatment of samples, analytical procedures, analytical quality assurance) can be obtained in the JAMP Guidelines for Monitoring Contaminants in Sediments (Agreement 2002/16).

6. The physical composition of samples, and therefore the chemical and biological properties, can be strongly influenced by the choice of sampling sites, the method of sampling and sampling handling. These possible influences should be taken into account when evaluating data.

Tier I: Physical properties

Physical analyses are important because they help to indicate how the sediment may behave during dredging and deposit operations and indicate the need for subsequent chemical and/or biological testing. It is strongly recommended that the following determinations be carried out:

Determinant	Indicating
• grain size analysis (by laser or sieving methods) • percent solids (dry matter)	• Cohesiveness, settling velocity/resuspension potential, contaminant accumulation potential
• density/specific gravity	• Consolidation of placed material, volume *in situ* vs. after deposit
• organic matter (as total organic carbon)	• Potential accumulation of organic associated contaminants

When dredged material is being considered for beneficial uses, it will also usually be necessary to have available details of the engineering properties of the material e.g. permeability, settling characteristics, plasticity and mineralogy.

Tier II:Chemical properties

Primary List

The following trace metals should be determined in all cases:

Cadmium (Cd)	Copper (Cu)	Mercury (Hg)	Zinc (Zn)
Chromium (Cr)	Lead (Pb)	Nickel (Ni)	

The following organic/organo-metallic compounds should be determined:

Polychlorinated biphenyl (PCB) congeners - IUPAC nos 28, 52, 101, 118, 138, 153 and 180 (ICES 7).

Polycyclic aromatic hydrocarbons (PAHs). ΣPAH9 is the sum of the following PAHs: anthracene; benzo[a]anthracene; benzo[ghi]perylene; benzo[a]pyrene; chrysene; fluoranthene; indeno[1,2,3-cd]pyrene; pyrene; phenanthrene.

Tri-Butyl tin (TBT) compounds and their degradation products

Arsenic (As).

As a minimum requirement, national action levels should be established for the primary list above.

However, the determination of PCBs, PAHs and Tri-Butyl tin compounds and its degradation products will not be necessary in circumstances where the sediments are very unlikely to be contaminated with these substances. The relevant circumstances are:

a) sufficient information from previous investigations indicating the absence of contamination is available (cf. §§ 5.5 - 5.7 in the OSPAR Guidelines for the Management of dredged Material); or

b) - there are no known significant sources (point or diffuse) of contamination or historic inputs; and
   - the sediments have very low amounts of fine material; and/or
   - the content of total organic carbon is low.

Secondary List

Based upon local information of sources of contamination (point sources or diffuse sources) or historic inputs, other determinants may require analysis, for instance:

Other chlorobiphenyls	organophosphorus pesticides	petroleum hydrocarbons
Organochlorine pesticides	other organotin compounds	Polychlorinated dibenzodioxins (PCDDs)/polychlorinated dibenzofurans (PCDFs)
	other anti-fouling agents	

In deciding which individual organic contaminants to determine, reference should be made to existing priority substance lists, such as those prepared by OSPAR[6] and the EU[7]

Normalisation

It is recommended that normalised values of contaminants should be used to enable a more reliable comparison of contaminant concentrations in dredged material with those in sediments at deposit or reference sites, as well as with action levels. The normalisation procedure (see Technical Annex II) used within a regulatory authority should be consistent to ensure effective comparisons.

Therefore in order to be in the position to anticipate the effects of contaminants adsorbed on sediment particles on deposit or filter feeders it is important to have information on the contaminant concentration of the relevant fine fraction (*e.g*. less than 63 µm or 20 µm).

Analytical Techniques

Reference should be made to the Technical Annexes of the JAMP Guidelines for Monitoring Contaminants in Sediments (Agreement 2002/16) and ISO/EN methods for recommended analytical techniques.

Tier III: Biological properties and effects

In a significant number of cases the physical and chemical properties described above do not provide a direct measure of the biological impact. Moreover, they do not adequately identify all physical disturbances and all sediment-associated constituents present in the dredged material. If the potential impacts of the dredged material to be deposited cannot be adequately assessed on the basis of the chemical and physical characterisation, biological measurements should be carried out.

The selection of an appropriate suite of biological test methods will depend on the particular questions addressed, the level of contamination at the dredging site and the degree to which the available methods have been standardised and validated.

To enable the assessment of the test results, an assessment strategy should be developed with regard to granting a permit authorising deposit at sea. The extrapolation of test results on individual species to a

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[6] OSPAR List of Chemicals for Priority Action (Up-date 2007); Reference Number: 2004-12

[7] Water framework directive. DIRECTIVE 2013/39/UE amending Directives 2000/60/EC and 2008/105/EC as regards priority substances in the field of water policy. Decision No. 2455/2001/EC of the European Parliament and of the Council of 20 November 2001 establishing the list of priority substances in the field of water policy and amending Directive 2000/60/EC The daughter directive to WFD on chemical compounds: Directive 2008/105/EC of the European Parliament and of the Council of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequent repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council.

higher level of biological organisation (population, community) is still very difficult and requires good knowledge of assemblages that typically occur at the sites of interest.

1. Toxicity bioassays:

   - The primary purpose of toxicity bioassays is to provide direct measures of the effects of all sediment constituents acting together, taking into account their bioavailability. For ranking and classifying the acute toxicity of harbour sediment prior to maintenance dredging, short-term bioassays may often suffice as screening tools.
   - To evaluate the effects of the dredged material, acute bioassays can be performed with pore water, an elutriate or the whole sediment In general, a set of 2-4 bioassays is recommended with organisms from different taxonomic groups (e.g. crustaceans, molluscs, polychaetes, bacteria, echinoderms);
   - In most bioassays, survival of the test species is used as an endpoint. Chronic bioassays with sub-lethal endpoint (growth, reproduction etc) covering a significant portion of the test species life cycle may provide a more accurate prediction of potential impact of dredging operations. However, standard test procedures are still under development;

   The outcome of sediment bioassays can be unduly influenced by factors other than sediment-associated chemicals. Confounding factors like ammonia, hydrogen sulphide, grain size, oxygen concentration and pH should therefore be determined during the bioassay.

   - Guidance on the selection of appropriate test organisms, use and interpretation of sediment bioassays is given by e.g. USACE/EPA (1991/1994) and CEDA & IADC (2008) while guidance on sampling of sediments for toxicological testing is given by e.g. ASTM (1994) or PIANC (2006).

2. Biomarkers:

   Biomarkers may provide early warning of more subtle (biochemical) effects at low and sustained levels of contamination. Most biomarkers are still under development but some are already applicable for routine application on dredged material (e.g. one which measures the presence of dioxin-like compounds - Murk *et al*., 1997) or organisms collected in the field (e.g. DNA strand/breaks in flat fish).

3. Microcosm experiments:

   There are short-term microcosm tests available to measure the toxicant tolerance of the community e.g. Pollution Induced Community Tolerance (PICT) (Gustavson and Wangberg, 1995)

4. Mesocosm experiment:

   In order to investigate long-term effects, experiments with dredged material in mesocosms can be performed, for instance to study the effects of PAHs in flatfish pathology. Because of the costs and time involved these experiments are not applicable in the process of authorising permits but are useful in cases where the extrapolation of laboratory testing to field condition is complicated r environmental conditions are very variable and hinder the identification of toxic effects as such. The results of these experiments would be then available for future permitting decisions.

5. Other biological properties:

   Where appropriate, other biological measurements can be applied in order to determine e.g. the potential for bioaccumulation and for tainting.

Supplementary information

The need for further information will be determined by local circumstance and may form an essential part of the management decision. Appropriate data might include: redox potential, sediment oxygen demand, total nitrogen, total phosphorus, iron, manganese, mineralogical information or parameters for normalising contaminant data (*e.g.* aluminium, lithium, scandium – cf. Technical Annex II). Consideration should also be given to chemical or biochemical changes that contaminants may undergo when deposited at sea.

Literature References related to Technical Annex I

ASTM, 1994. Standard guide for collection, storage, characterisation and manipulation of sediment for toxicological testing. American Society for Testing and Material, Annual Book of Standards. Vol. 11.04, E1391-96.

CEDA & IADC, 2008: Environmental Aspects of Dredging, Edited by R. N. Bray. Taylor and Francis. ISBN 978-0-415-45080-5

EPA/CE, 1991. Evaluation of Dredged Material Proposed for Ocean Disposal: Testing Manual EPA-503/8-91/001. US-EPA Office of Water (WH-556F).

EPA/CE, 1998. Evaluation of Dredged Material Proposed for discharge in Waters of the US. Testing Manual (Draft): Inland Testing Manual EPA – 823-B-98-004.

EPA, Office of Water, 2001. Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual EPA-823-F-01-023.

International Maritime Organization (IMO) 2003. Waste Assessment Guidance - Selection and analysis of physical and chemical parameters for the assessment of dredged material quality, Report of the Scientific Group of the LONDON Convention.

IOC - UNEP - IMO, 2000. Global Investigation of Pollution in the Marine Environment (GIPME 2000): Guidance on Assessment of Sediment Quality, Pub. No. 439/00.

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HELCOM, 1997. Manual for Marine Monitoring in the Cooperative Monitoring in the Baltic Marine Environment (COMBINE Programme) of HELCOM. Part C - Programme for Monitoring of Eutrophication and its Effects. Annex C-4: Directives for sampling and analysis of hydrographic, chemical and biological variables. Annex C-8: Soft bottom macrozoobenthos.

Murk *et al.*, 1996. Chemical-activated luciferase gene expression (CALUX): a novel in vitro bioassay for Ah receptor active compounds in sediments and pore water. Fund. & Applied Tox. 33: 149-160.

OSPAR, 1997 (available from the OSPAR website):

> JAMP Eutrophication Monitoring Guidelines: Benthos - Technical Annex 1 (Hard-bottom macrophytobenthos and hard-bottom macrozoobenthos) - Technical Annex 2 (Soft-bottom macrozoobenthos)

OSPAR, 2002

> JAMP Guidelines for Monitoring Contaminants in Sediments (Agreement 2002-16)

PIANC 2006 Biological assessment guidance for dredged material, EnviCom report of WG 8 Rees, H.L., C. Heip, M. Vincx and M.M. Parker, 1991. Benthic communities: use in monitoring point-source discharges. ICES Techniques in Marine Environmental Sciences No. 16.

Rumohr, H.,1990. Soft-bottom macrofauna: collection and treatment of samples. ICES Techniques in Marine Environmental Sciences No. 8.

Technical Annex II [8]

Normalisation of Contaminants Concentrations in Sediments

This annex provides guidance on the application of methods to normalise contaminant concentrations in sediments

1. Introduction

Normalisation is defined here as a procedure to correct contaminant concentrations for the influence of the natural variability in sediment composition (grain size, organic matter and mineralogy). Most natural and anthropogenic substances (metals and organic contaminants) show a much higher affinity to fine particulate matter compared to the coarse fraction. Constituents such as organic matter and clay minerals contribute to the affinity to contaminants in this fine material.

Fine material (inorganic and organic) and associated contaminants are preferentially deposited in areas of low hydrodynamic energy, while in areas of higher energy, fine particulate matter is mixed with coarser sediment particles which are generally not able to bind contaminants. This dilution effect will cause lower and variable contaminant concentrations in the resulting sediment. Obviously, grain size is one of the most important factors controlling the distribution of natural and anthropogenic components in sediments. It is, therefore, essential to normalise for the effects of grain size in order to provide a basis for meaningful comparisons of the occurrence of substances in sediments of variable granulometry and texture within individual areas, among areas or over time.

When analysing whole sediment (*i.e.* < 2mm fraction) for spatial distribution surveys, the resulting maps give a direct reflection of the sea bed sediments. However, in areas with varying grain size distributions, a map of contaminant concentrations will be closely related to the distribution of fine grained sediments, and any effects of other sources of contaminants, for example anthropogenic sources, will be at least partly obscured by grain size differences. Also in temporal trend monitoring, differences in grain size distribution can obscure trends. If samples used for a spatial survey consist predominantly of fine material, the influence of grain size distribution is of minor importance and may probably be neglected.

2. Normalisation procedures

Two different approaches to correct for variable sediment compositions are widely used:

a. Normalisation can be performed by relating the contaminant concentration with components of the sediment that represents its affinity for contaminants, i.e. binding capacity. Such co-factors are called **normalisers** (cf. section 4). Normalisation can be performed by simple contaminant/normaliser ratios or linear regression. Another procedure takes into account that the coarse sediment fraction contains natural metal concentrations in the crystal structure before the normalisation is performed (see section 5). Combinations of co-factors, possibly identified from multiple regression analysis, can be used as normalisers.

b. Isolation of the fine fraction by sieving (e.g. <20 µm, <63 µm) can be regarded as a physical normalisation to reduce the differences in sediment granulometric compositions and is

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[8] Technical Annex 5 - Normalisation of contaminant concentrations in sediments - to the JAMP Guidelines for monitoring contaminants in sediments

applicable to both metals and organic contaminants (Ackermann et al. 1983; Klamer et al. 1990). Consequently the coarse particles, which usually do not bind anthropogenic contaminants and dilute their concentrations, are removed from the sample. Then, contaminant concentrations measured in these fine fractions can be directly compared. Subsequently, the differences in sediment composition due to geochemical nature remaining after sieving can be further corrected for by the use of co-factors. Thus, sieving is a first powerful step in normalisation.

3. Limitations of normalisation

Clearly, normalisation procedures may not apply equally well to all elements at all sites; especially important in this respect are elements that participate in diagenetic reactions. In cases where there is a lack of full understanding of the geochemical processes operating care should be taken when normalising for grain size differences. These processes can create important natural enrichment of metals at the sediment surface, as a result of the surficial recycling of oxihydroxides or deeper in the sediment as the result of co-precipitation of the metals with sulphides (cf., e.g., Gobeil et al. 1997), which cannot be accounted for by normalisation.

There is no evidence that normalised data are more appropriate for ecotoxicological interpretation than non-normalised data. However, the matter deserves further investigation.

4. Normalisation with co-factors

a. The binding capacity of the sediments can be related to the content of fines (primary factor) in the sediments. Normalisation can be achieved by calculating the concentration of a contaminant with respect to a specific **grain-size fraction** such as <2 µm (clay), <20 µm or <63 µm.

b. As the content of fines is represented by the contents of major elements of the clay fraction such as **aluminium** (Windom et al. 1989) or an appropriate trace element enriched in that fraction such as **lithium** (Loring 1991), these can also be used as co-factor (secondary). Both, aluminium and lithium behave conservatively, as they are not significantly affected by, for instance, the early diagenetic processes and strong redox effects frequently observed in sediments. Problems may occur in when the sediment is derived from glacial erosion of igneous rocks, with significant amounts of aluminium present in feldspar minerals contributing to the coarse fraction. In such cases, lithium may be preferable (Loring 1991).

c. Organic matter, usually represented by organic carbon, is the most common co-factor for organic contaminants due to their strong affinity to this sediment component. Trace metals can be normalised using the organic carbon content (Cato 1977) but would require further explanation due to the non-conservative nature of organic matter.

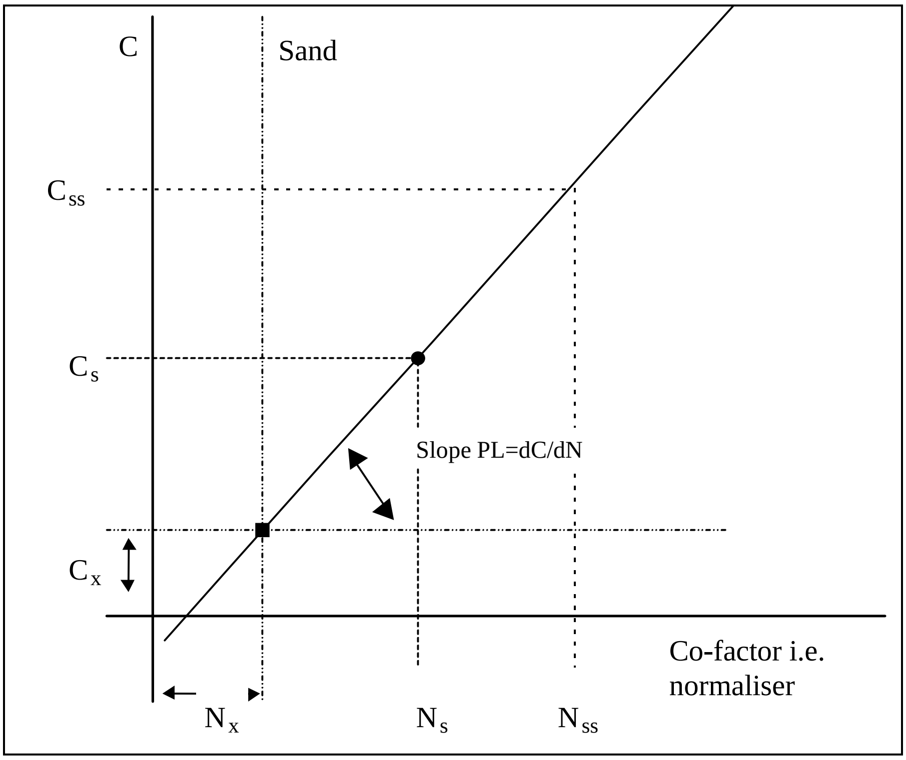

Figure 1: Relation between the contaminant C and the cofactor N (see text).

5. Theory

The general model for normalisation taking into account the possible presence of contaminants and cofactors in the coarse material is given in figure 1 (Smedes et al.1997). C_x and N_x represent the co-factor and the contaminant contents, respectively, in pure sand. These "intercepts" can be estimated from samples without fines and organic material. The line of regression between the contaminant and co-factor will originate from that point. That means that regression lines of sample sets with a different pollution level and consequently different slopes will have this point in common (i.e. pivot point). When this pivot point is known only one sample is required to estimate the slope. This allows determination of the contaminant content for any agreed (preselected) co-factor content (N_{ss}) by interpolation or extrapolation. The slope for a sample with a contaminant content C_s and a cofactor content of N_s can be expressed as follows:

$$PL = \frac{dC}{dN} = \frac{C_s - C_x}{N_s - N_x} \quad \text{.....(1)}$$

The extrapolation to an agreed co-factor content, N_{ss}, follows the same slope:

$$PL = \frac{dC}{dN} = \frac{C_s - C_x}{N_s - N_x} = \frac{C_{ss} - C_x}{N_{ss} - N_x} \quad \text{.....(2)}$$

Rewriting gives the contaminant content, C_{ss}, that is normalised to N_{ss}:

$$C_{ss} = (C_s - C_x)\frac{N_{ss} - N_x}{N_s - N_x} + C_x \quad \text{.....(3)}$$

Results of different samples normalised to the agreed N_{ss} can be compared directly.

Normalisation by this model can be applied with different cofactors. Here primary and secondary cofactors can be distinguished. A primary cofactor like clay or organic carbon is not present in the coarse fraction and consequently has no intercept (N_x=0). Al and Li are present in the coarse fraction and therefore are considered to be secondary cofactors. Provided N_x and C_x are known, the model allows recalculation of total samples to a co-factor content usually found in sieved fractions, either <20 or <63µm. However such an extrapolation for a coarse grained sample will be associated with a large error due to the uncertainty of the intercepts and the analysed parameters. For a more fine grained sample, the uncertainty of the normalised result is much lower than for normalisation of a sieved fraction to the agreed cofactor content and will result in a more accurate result. The model presented also applies to the normalisation of organic contaminants using organic carbon but in that case the intercepts N_x and C_x will not differ significantly from zero.

Principally, the result allows comparison of data of total and sieved samples, irrespective the sieving diameter but the error has to be taken into account. Through propagation of errors the standard error of the result can be calculated from the analytical variation and the natural variation of the intercept N_x. Results can therefore always be reported with a standard deviation.

6. Considerations on co-factors

The **clay mineral content** is the most important cofactor for trace metals. In the model above the N_x will be zero for clay and only the intercept due to the content of the trace metal in the coarse fraction (C_x) has to be taken into account. However, current intercomparison exercises do not include this parameter. Presently other parameters such as aluminium or lithium are used to represent the clay content.

The **aluminium** content in the sandy fraction may vary from area to area. For some areas aluminium contents in the sandy fractions are found at the same level as found in the fines (Loring, 1991) and therefore the intercept N_x becomes very high. In equation (3) this implies that the denominator is the result of subtracting two large numbers, that is the normaliser content in the sample (N_s) and the normaliser content in only sand (N_x). Consequently, due to their individual uncertainties, the result has an extremely high error. Obviously, normalisation with low intercepts is more accurate. Much lower intercepts are found if partial digestion methods are used that digest the clay minerals, but not the coarse minerals. Using partial digestion, the spatial variability of the results of aluminium analyses in the sandy fraction has been found to be much smaller than with total methods. Although normalising concentrations of contaminants in fine grained material will always give more accurate results, an error calculation will identify whether using coarse samples (and total methods, e.g. HF, X-ray fluorescence) allows the requirements of the program to be met.

For most areas the **lithium** content in the sandy fraction is much lower than in the fine fraction. In addition, results from partial digestion and total methods do not differ significantly. There is only little spatial variability of the lithium content in the sandy fraction. Generally, compared to aluminium, more accurate normalised data can be expected using lithium.

As for clay, no intercept (N_x) applies for organic matter, which is usually represented by **organic carbon**. Organic matter also occurs in the coarse fraction but is even then a cofactor that contributes to the affinity for contaminants, whereas the aluminium in the coarse fraction does not. Furthermore, organic matter in a sample is not always well defined as it can be composed of material with different properties. The most variable properties will be found in the organic matter present in the coarse fraction, i.e. that not associated with the fines. In **fine sediments** or in the sieved fine fractions the majority of the organic matter is associated with the mineral particles and it is assumed to be of more constant composition than in the total sample. In addition, the nature of the organic matter may show spatial variation. For samples with low organic carbon content close to the detection limit, normalisation using this cofactor suffers from a large relative error. This results from the detection limit and the insufficient homogeneity that cannot be improved due to the limited intake mass for analysis.

For further interpretation of data the **proportion of fines** determined by sieving can be useful. Provided, there are no significant amounts of organic matter in coarse fractions, the proportion can be used as normaliser. The error in the determination of fines has to be taken into account and will be relatively high for coarse samples.

7. Considerations on contaminants

Almost all trace metals, except mercury and in general also cadmium, are present in the coarse mineral matrix of samples. The metal concentrations show a spatial variability depending on the origin of the sandy material. In sandy sediments, partial digestion techniques result in lower values than are obtained from total digestion techniques. This implies that partial digestion results in lower intercepts (pivot point is closer to the zero). However, the partial digestion must be strong enough so the clay will be totally digested (as is the case with HF digestion techniques), and the measured aluminium content remains representative for the clay. It was demonstrated that analyses of fine material gave similar results for several trace elements using both total and strong partial methods (Smedes et al. 2000, QUASH/QUASIMEME intercalibrations).

In general, correlations of organic contaminants with organic carbon have no significant intercept. Obviously a normalised result from a coarse sample will show a large error as due to the dilution by sand the concentrations are often close or even below the detection limit. Presently, organic carbon is usually applied for normalisation of PAHs. It should be recognised that due to the possible presence of undefined material, for example soot or ash, elevated PAH concentrations may occur in specific fractions that might have limited environmental significance. Although this needs further investigation, existing results indicate that PAH concentrations in the sieved fractions are not affected significantly.

8. Isolation of fine fractions for analyses

The Sample preparation

Samples must be sieved at 2 mm as soon as possible after sampling to remove large detritus and benthic organisms. Otherwise during further sample handling like storage, freezing or ultrasonic treatment, biotic material will deteriorate and become part of the sediment sample. Until the final sieving procedure that isolates the fines, the sample can be stored at 4°C for about a week and up to 3 months when frozen at –20°C, although direct wet sieving is preferred. For prolonged storage freeze-drying of samples can be considered. In this case contamination and losses of contaminants during freeze-drying have to be checked. Air-drying is not appropriate due to high contamination risks. Besides, samples may be difficult to be disaggregate and mineral structures may be affected.

Requirements for Sieving

A wet sieving procedure is required to isolate the fine-grained fractions (<63 µm or <20 µm). Wet sieving re-suspends fine particles that would otherwise remain attached to coarser particles in the sample. Sediments should be agitated during sieving to prevent to disaggregate agglomerates of fines and to prevent clogging of the mesh. Freeze-dried samples need to be re-suspended using ultrasonic treatment. Seawater, preferably from the sampling site, should be used for sieving as it reduces the risk of physico-chemical changes in the sample i.e. losses through leaching or contamination. Furthermore seawater assists the settling of fine particles after the sieving. If water from the sampling site is not available, then seawater of an unpolluted site, diluted with deionised water to the required salinity, can be used. The amount of water used for sieving should be kept to a minimum and be reused for sieving subsequent batches.

To minimise or prevent contamination it is recommended to use large sample amounts of sediment for sieving. No significant contaminant losses or contamination was detected when at least 25 g of fine fraction is isolated. (QUASH).

Methodology

Both automated and manual methods are available for sieving. A video presentation of these methods can be provided by the QUASH Project (QUASH 1999).

- The automatic sieving method pumps seawater over a sieve that is clamped on a vibrating table (Klamer et al. 1990). The water passing the sieve is lead to a flow-through centrifuge that retains the sieved particles and the effluent of the centrifuge is returned to the sieve by a peristaltic pump. Large sample amounts, up to 500 g, can be handled easily.
- The second method is a manual system sieving small portions 20-60 g using an 8-cm sieve in a glass beaker placed in an ultrasonic bath (Ackermann et al. 1983). Particles are isolated from the water passing the sieve by batch wise centrifugation. The water can be reused for a subsequent batch of sediment. In case of sandy samples, when large amounts of sediments have to be sieved, removal of the coarse material by a pre-sieving over e.g. 200-µm mesh can facilitate the sieving process.

Isolated fine fractions have to be homogenised thoroughly, preferably by a ball mill, as centrifugation produces inhomogeneous samples due to differences in settling speed of different grain-size fractions.

9. Recommendations

1. For both temporal trend and spatial monitoring, it would be ideal to analyse samples with equal composition. This could be confirmed by determination of co-factors Al, Li, OC and parameters of the grain size distribution (e.g. clay content, proportion <20um, proportion <63um). However, this situation will not always occur, particularly in the case of spatial surveys.
2. New temporal trend programs should be carried out by the analysis of fine sediments or a fine-grained fraction, isolated by sieving. Existing temporal trend programs could be continued using existing procedures, provided that assessment of the data indicates that the statistical power of the programs is adequate for the overall objectives.
3. Contaminant concentrations in whole sediments can be subjected to normalisation using co-factors for organic matter, clay minerals etc., taking into account the presence of both co-factors and target contaminants in the mineral structure of the sand fraction of the sediment. Taking into account these non-zero intercepts of regressions of contaminant concentrations with co-factors, normalisation to preselected co-factor content will reduce the variance arising from different grain sizes. Normalised values for sandy sediments will have greater uncertainties than for muddy sediments. The propagated error of the variables used for normalisation may be unacceptable high for sandy sediments, if both contaminant and co-factor concentrations are low, particularly when approaching detection limits. In that case, in order to draw reliable maps, alternative procedures, such as sieving, need to be used to minimise the impact of this error structure.
4. Variance arising from grain size differences can be reduced in a direct way by separation of a fine fraction from the whole sediment. Spatial distribution surveys of the concentrations of contaminants in separated fine fractions can be used to prepare maps which will be much less influenced by grain size differences than maps of whole sediment analyses. There will still be some residual variance arising from differences in the composition (mineralogy and organic

carbon content) of the sediments.

5. The natural variance of sample composition will be smaller in the fraction <20 µm than in the fraction <63 µm. Therefore, the fraction <20 µm should be preferred over the fraction <63 µm. However, separation of the fraction <20 µm can be considerably more laborious than the separation of the fraction <63 µm and might be an obstacle to its wide application. For this practical reason, the fraction <63 µm is an acceptable compromise for both temporal trend and coordinated large scale spatial surveys.
6. The preferred approach for preparing maps of the spatial distribution of contaminants in sediment consists of two steps: analyses of contaminants in fine sediments or in the fraction <63 µm, followed by normalisation of analytical results using co-factors (see section 4). Current scientific knowledge indicates that this procedure minimises the variances arising from differences in grain size, mineralogy and organic matter content. Application of this two-tiered approach to fractions <20 µm gives results that can be directly compared to results found by normalisation of concentrations measured in fractions <63 µm. This approach should give consistent and comparable data sets over the ICES/OSPAR area. Maps of contaminant levels in fine sediments should be accompanied by maps of the co-factors in the whole sediments.
7. In order to clarify aspects of data interpretation, analytical data for field samples should be accompanied by information on limits of detection and long term precision. In order to contribute to environmental assessment, data for field samples should include the grain size distribution, as a minimum the proportion of the analysed fraction in the original whole sediment.

10. Literature References related to Technical Annex II

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Appendix

Testing normalisation methods

As normalisation should correct for sediment composition, a criterion for an adequate normaliser is that after normalisation of equally polluted sediment samples with different grain size distributions, the results should not differ significantly. However, sample sets to test normalisation approaches for this criterion are scarce. An alternative approach is to take one sample and to produce subsamples with varying grain size distributions (Smedes 1997, Smedes et al. 1997, Smedes et al. 2000). Both the fine and coarse subsamples are analysed for contaminants and potential normalisers. In this way a higher variability for the normaliser concentrations, i.e. a worst case than ever will occur in nature, can be obtained which provides a sensitive test for the usefulness of potential normalisers.

Technical Annex III

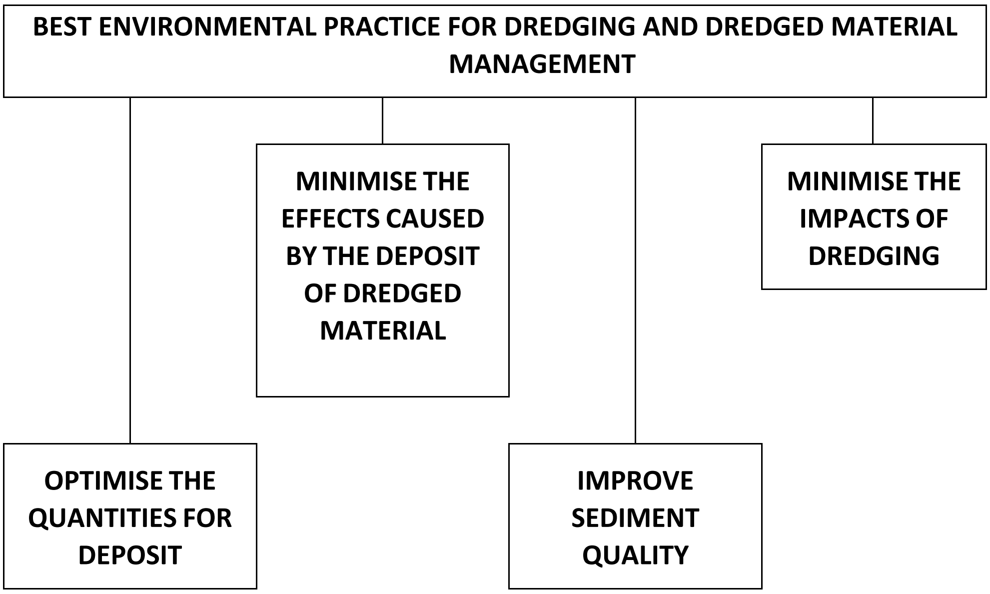
Best Environmental Practice (BEP)

Introduction

This Technical Annex was prepared bearing in mind that, although the guidelines strictly only apply to the deposit of dredged material, Contracting Parties are encouraged also to exercise control over dredging operations.

This Technical Annex has as its aim to provide guidance to national regulatory authorities, operators of dredging vessels and port authorities on how to minimise the effects on the environment of dredging and deposit operations. Careful assessment and planning of dredging operations are necessary to minimise the impacts on marine species and habitats.

The items given as BEP under the different headings of this Technical Annex are given as examples. Their applicability will generally vary according to the particular circumstances of each operation and it is clear that different approaches may then be appropriate. More detailed information on dredging techniques and processes can be found in CEDA & IADC (2008).



Point A - Minimisation of the effects caused by the deposit of dredged material - is comprehensively described in the main body of these guidelines. An example is the Building with Nature philosophy[9]

Point B ‘Optimisation of the quantities for deposit’, Point C ‘Improvement of sediment quality’ and Point D ’Minimise the Impacts of Dredging’ are requirements resulting from Annex V to the OSPAR Convention (see § 3.5 of the OSPAR Guidelines for the Management of Dredged Material), and, in addition, are very relevant to the prevention adverse affects on the marine environment resulting from the deposit of dredged materials. Descriptions of BEP in relation to these activities are given at Appendices I and II.

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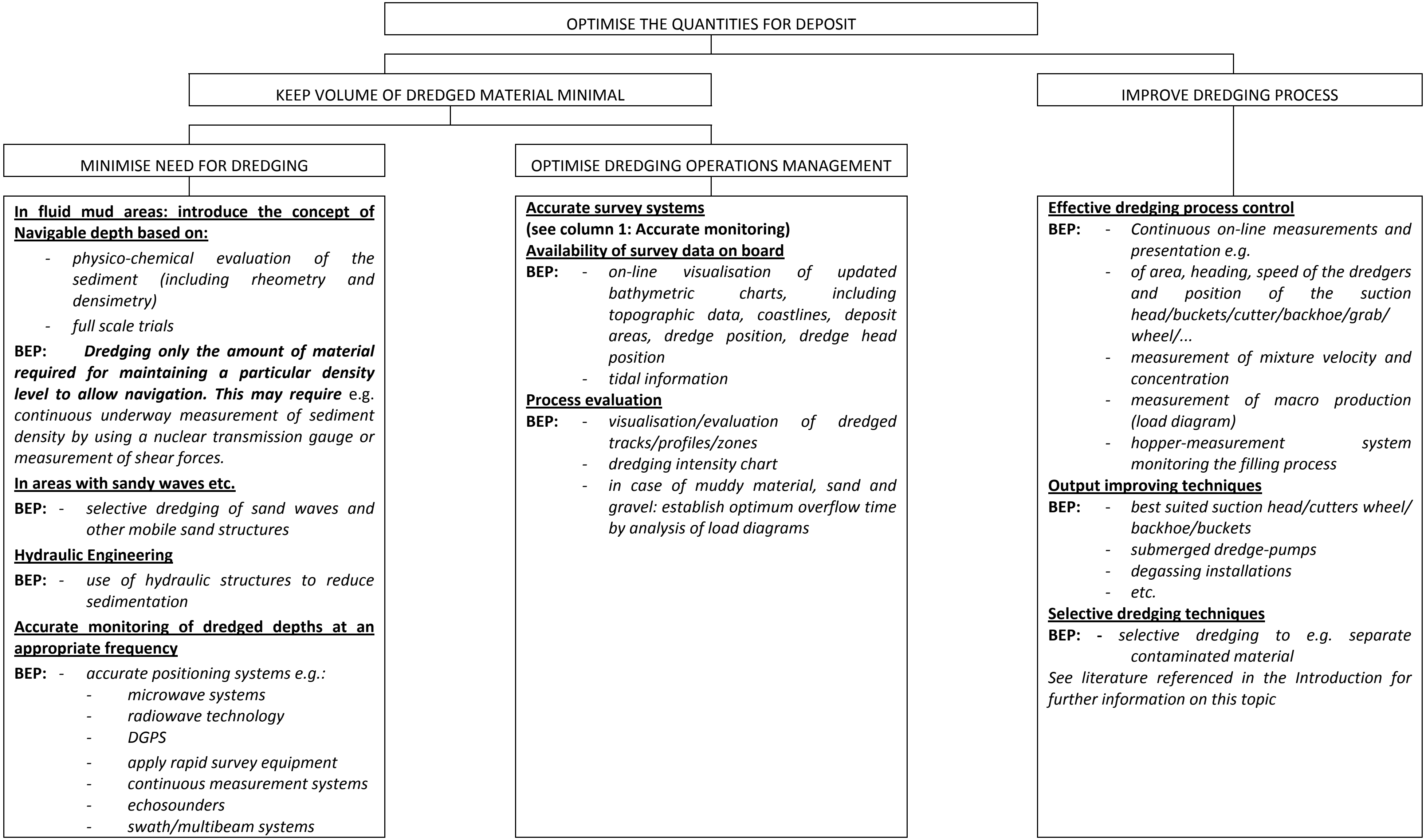
[9] www.ecoshape.nl

APPENDIX I



OPTIMISE THE QUANTITIES FOR DEPOSIT

KEEP VOLUME OF DREDGED MATERIAL MINIMAL

IMPROVE DREDGING PROCESS

MINIMISE NEED FOR DREDGING

OPTIMISE DREDGING OPERATIONS MANAGEMENT

In fluid mud areas: introduce the concept of Navigable depth based on:

- *physico-chemical evaluation of the sediment (including rheometry and densimetry)*
- *full scale trials*

BEP: ***Dredging only the amount of material required for maintaining a particular density level to allow navigation. This may require*** e.g. *continuous underway measurement of sediment density by using a nuclear transmission gauge or measurement of shear forces.*

In areas with sandy waves etc.

BEP: - *selective dredging of sand waves and other mobile sand structures*

Hydraulic Engineering

BEP: - *use of hydraulic structures to reduce sedimentation*

Accurate monitoring of dredged depths at an appropriate frequency

BEP: - *accurate positioning systems e.g.:*

  - *microwave systems*
  - *radiowave technology*
  - *DGPS*
  - *apply rapid survey equipment*
  - *continuous measurement systems*
  - *echosounders*
  - *swath/multibeam systems*

Accurate survey systems

(see column 1: Accurate monitoring)

Availability of survey data on board

BEP:
- *on-line visualisation of updated bathymetric charts, including topographic data, coastlines, deposit areas, dredge position, dredge head position*
- *tidal information*

Process evaluation

BEP:
- *visualisation/evaluation of dredged tracks/profiles/zones*
- *dredging intensity chart*
- *in case of muddy material, sand and gravel: establish optimum overflow time by analysis of load diagrams*

Effective dredging process control

BEP:
- *Continuous on-line measurements and presentation e.g.*
- *of area, heading, speed of the dredgers and position of the suction head/buckets/cutter/backhoe/grab/ wheel/...*
- *measurement of mixture velocity and concentration*
- *measurement of macro production (load diagram)*
- *hopper-measurement system monitoring the filling process*

Output improving techniques

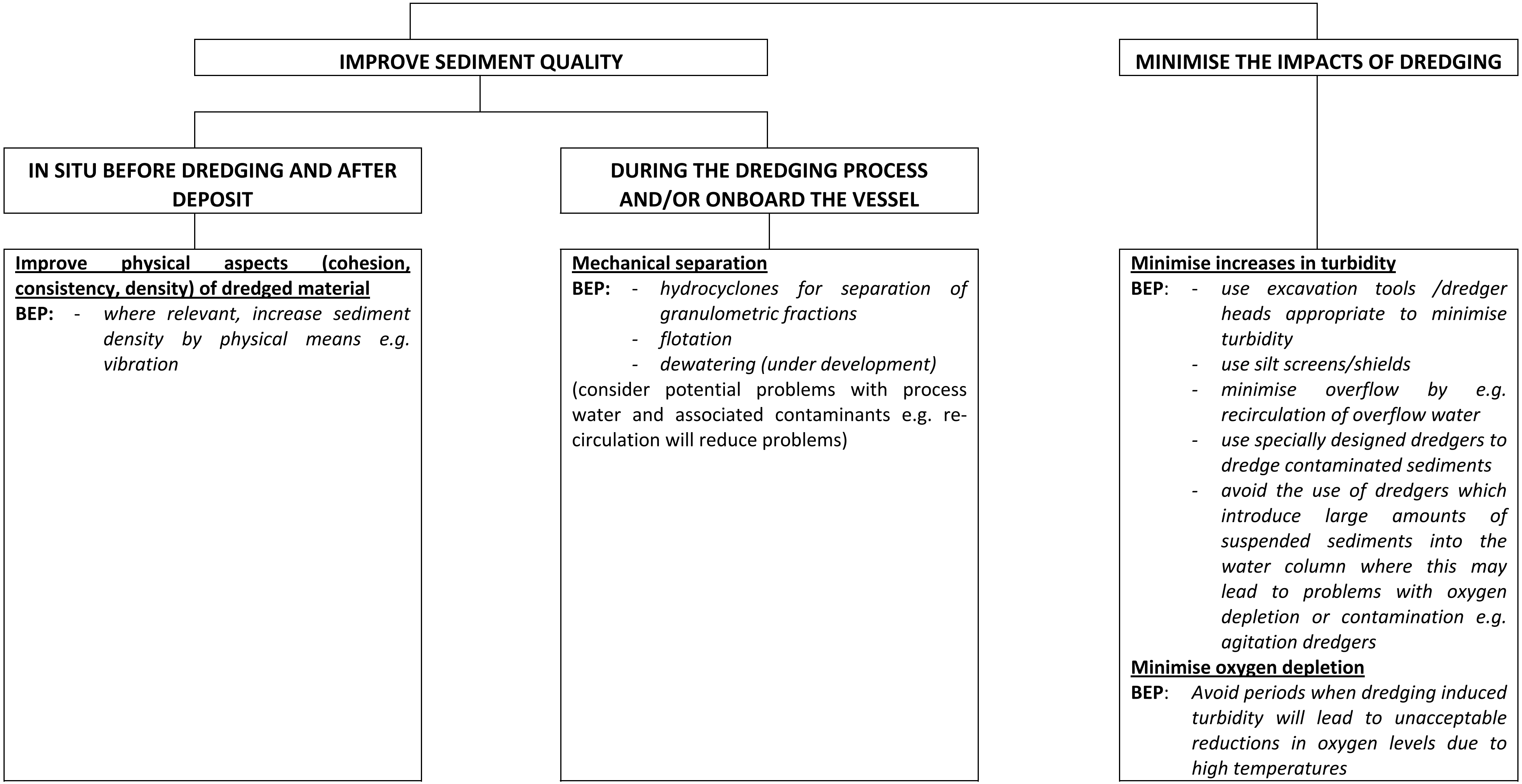
BEP:
- *best suited suction head/cutters wheel/ backhoe/buckets*
- *submerged dredge-pumps*
- *degassing installations*
- *etc.*

Selective dredging techniques

BEP: - *selective dredging to e.g. separate contaminated material*

See literature referenced in the Introduction for further information on this topic

APPENDIX II



IMPROVE SEDIMENT QUALITY

MINIMISE THE IMPACTS OF DREDGING

IN SITU BEFORE DREDGING AND AFTER DEPOSIT

DURING THE DREDGING PROCESS AND/OR ONBOARD THE VESSEL

<u>Improve physical aspects (cohesion, consistency, density) of dredged material</u>

BEP: - *where relevant, increase sediment density by physical means e.g. vibration*

<u>Mechanical separation</u>

BEP:
- *hydrocyclones for separation of granulometric fractions*
- *flotation*
- *dewatering (under development)*

(consider potential problems with process water and associated contaminants e.g. re-circulation will reduce problems)

<u>Minimise increases in turbidity</u>

BEP:
- *use excavation tools /dredger heads appropriate to minimise turbidity*
- *use silt screens/shields*
- *minimise overflow by e.g. recirculation of overflow water*
- *use specially designed dredgers to dredge contaminated sediments*
- *avoid the use of dredgers which introduce large amounts of suspended sediments into the water column where this may lead to problems with oxygen depletion or contamination e.g. agitation dredgers*

<u>Minimise oxygen depletion</u>

BEP: *Avoid periods when dredging induced turbidity will lead to unacceptable reductions in oxygen levels due to high temperatures*