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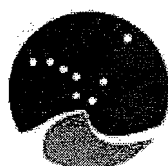
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Effects of of marine sediments the marine environment 1998-2004

Gerry Sutton and Sien Boyd, Editors

Authors

Claude Augris • Wendy Bonne • Sien Boyd • David Carlin
Ingemar Cato • Mike Cowling • Jan van Dalfsen • Jean-Paul Delpech
Michel Desprez • Chris Dijkshoorn • Hans Hillewaert • Kris Hostens
Jochen Krause • Brigitte Lauwaert • Ine Moulaert • Poul Erik Nielsen
Jouko Rissanen • Stuart Rogers • Mark Russell • Ruud Schüttenhelm
Jonathan Side • Mathijs Smit • Ad Stolk • Gerry Sutton • Manfred Zeiler



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development, and no clear examples of such a system were encountered during this research. Technological advances and the ready availability of low-cost, high-power, desktop, Intranet or Internet environments are supporting the development of ERM systems in an efficient and timely manner. The use of component-based architectures is now allowing complex systems to be modelled with multiple and scalable components; however, the use of expert opinion remains a very important factor in the success of such knowledge-based systems. Results obtained from spatial and analytical modelling tools for environmental risk assessment have a variety of uses (e.g. for comparative or relative risk analysis; cost-benefit analysis; scenario analysis; probabilistic analysis; decision matrix; sensitivity analysis). GIS-based software applications will increasingly serve as powerful tools for the assessment and management of effective environmental risk because of their capacity to rapidly and accurately display and analyse huge volumes of spatial and non-spatial environmental data (including hazards and exposure).

5.3 Conclusions

The nature of the sediments being dredged by ICES Member Countries varies, depending on the availability of the natural sediment resources offshore and the national and international market requirement for these materials. The principal markets for marine dredged sediments vary between Member Countries, but in general, they can be broadly identified as construction aggregates, construction fill/land reclamation, and beach replenishment/coastal protection. As a consequence of the variations in resource availability and market demand, some national operations are concerned primarily with sand, whereas others are primarily concerned with gravel.

The use of marine sediments within ICES Member Countries varies greatly, depending to a large extent on the availability of alternative sources of material and of suitable marine sediments within national boundaries.

5.3.1 Resource mapping

There is increasing demand on marine space and resources across ICES shelf sea areas, partly because of the expansion of some maritime industries and also because of newer developments, such as offshore windfarms. These changes in marine use mean that conflicts can arise between different activities. Marine seabed maps provide important information to assist in resolving conflicts arising from multiple uses of the seabed, and they are also an essential underpinning for the sustainable management of offshore resources.

It is evident that, within ICES Member Countries, there is a growing movement towards seabed and resource mapping programmes, driven by several forward-looking and horizon-scanning exercises that have recognized the need to underpin spatial planning and the sustainable use of seabed resources. Developments in survey methods, such as the use of acoustic techniques for accurate discrimination of sediment type, are also proceeding rapidly. This rapid pace of developments in the field of resource mapping, driven by continuous improvements in acoustic techniques (e.g. sidescan sonar, multibeam bathymetry, and acoustic ground-discrimination systems), has radically altered approaches to the assessment of anthropogenic impacts on the seabed. In addition, their extensive use in wide-scale reconnaissance surveys (e.g. in a resource or conservation context) means that they are increasingly being employed by a growing number of ICES Member Countries as part of strategic national seabed mapping programmes. However, large parts of the ICES shelf sea area remain unmapped. Yet, true baseline information is essential to the strategic management of

offshore resources and for the assessment of the broad-scale vulnerability of habitats and species to sand and gravel extraction. Such information is also becoming essential to the identification of potential environmental constraints (e.g. the location of fish spawning areas, sensitive and important species and habitats, archaeological features), allowing sustainable informed development. It is therefore important that seabed-mapping programmes continue to be supported to simultaneously address the needs of governments and marine stakeholders by mapping prioritized areas of the seabed in a strategic manner.

5.3.2 Environmental effects

As noted in Section 4.1, awareness of the impacts of sand and gravel dredging, particularly in relation to the coast, goes back at least a century. However, interest in the environmental impacts of sand and gravel extraction dates back some 50 years and became more significant starting in the 1960s. Initially, concern focused on the potential impacts on the benthic macrofauna and consequential effects on fish resources and commercial fisheries. This interest has expanded over the years to include most components of the marine ecosystem.

Research has demonstrated that sand and gravel extraction can have a number of environmental effects on the seabed, including the removal of sediment and the resident fauna, changes to the nature and stability of sediments accompanying the exposure of underlying strata, increased turbidity, and the redistribution of fine particulates. Typically, this activity is assessed by ICES Member Countries not only from the standpoint of effects on the benthic fauna during and after the extraction event, but also for its effects on the wider resource, including dependent fish and shellfish populations and associated fisheries, coastal processes, and other legitimate interests, such as conservation and recreation. These issues are addressed as part of an EIA or by conducting targeted research.

Dredging can also lead to the production of plumes of suspended material. This material can arise from the mechanical disturbance of the seabed sediment by the drag-head. However, the outwash of material from the spillways of the vessel hopper can generate a far greater quantity of suspended material. A further source of suspended material is the sediment fractions rejected during screening activities.

An increasing number of studies has concentrated on establishing the rates and processes of macrobenthic recolonization upon cessation of dredging. Typically, these studies indicate that marine sediment extraction causes an initial reduction in the abundance, species diversity, and biomass of the benthic community. Available evidence from such investigations, carried out in a variety of environmental conditions, suggests that substantial progress towards seabed "recovery" could be expected within two to three years of cessation of dredging in highly dynamic environments, although this period can be greater in areas that are dredged repeatedly or where the seabed has been significantly altered.

5.3.3 Management of marine aggregate extraction operations

Not all countries have the same approach to the legislation and regulation of marine aggregate extraction, and it is inadvisable to prescriptively formulate a preferred option. However, although countries are free to organize their own legislation and regulation, it is important that they are transparent about their regulations, both to the industry and to NGOs.

Increasingly, the trend in legislation and regulation is to take environmental issues into account in a formal way. The obligation to follow EIA procedures and to include EU directives in the management of marine aggregate extraction is operationalized.

Some countries have an overall marine legislation under which marine aggregate extraction is regulated. However, most countries have national laws on extraction, although it is often regulated by regional authorities.

Regarding the considerations required for regulation, risk assessment is a promising instrument, but in connection with the extraction of marine sediments and the possible effects on the environment, it is still far from mature.

5.4 Recommendations

The Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem (WGEXT) recommends the continued use of the "ICES Guidelines for the Management of Marine Sediment Extraction" (ICES, 2003) by national administrations within domestic consenting regimes for marine aggregate extraction.

- 1) ICES Member Countries and OSPAR contracting parties should continue to supply information about their marine aggregate industries to WGEXT, particularly information relating to annual production rates, the area of seabed licensed, and the area of seabed dredged.
- 2) WGEXT recommends that information on the design, implementation, and use of the results of monitoring programmes associated with aggregate extraction activities be shared with the working group so that best practice can be determined.
- 3) The dredging industry should continue to improve dredging technology and management practices in order to ensure the sustainable development and use of these valuable, but finite sand and gravel resources.
- 4) Use of electronic monitoring systems and black-box monitoring equipment for surveillance of dredging operations in ICES Member Countries is recommended. The analysis of the data from these systems has continued to evolve, significantly improving their value as a management tool.
- 5) Where multiple dredging operations are proposed close to each other, and where the potential exists for cumulative or in-combination effects, a regional approach to development and assessment should be considered, for example, by means of a regional environmental assessment.
- 6) Given the wide range of extraction operations in northern European and Atlantic waters, and the large diversity of seabed habitats, WGEXT continues to recommend that the specific requirements for any particular extraction operation be determined on a case-by-case basis, taking into account information from regional environmental assessments, as appropriate.
- 7) Wherever possible, data and environmental management experience of the regulatory authorities and dredging industry should be made widely and proactively available to facilitate the continued development of best practice. For example, issues such as currency, completeness, and facilitated access should be addressed through web-enabled spatial databases and user-friendly GIS interfaces.
- 8) The aim should be to increase the spatial coverage and resolution of seabed maps and to encourage the adoption of common standards and practices.

- 9) WGEEXT encourages ICES Member Countries to undertake programmes of habitat mapping, in order to provide information to underpin licensing decisions *and/or* marine spatial planning initiatives in relation to the extractions of marine sediment. Such information will also be useful for sustainable management of the marine environment and the identification of features important to nature conservation.
- 10) There is a need for fundamental research into the effects of marine aggregate extraction on meiofaunal populations. Development of new taxonomic keys and further development of quantitative meiofaunal sampling methods for gravel substrates is required in order to permit quantitative sampling of meiofaunal assemblages in and around marine sediment extraction sites. Such research is necessary to inform any future decisions about whether or not to include meiofaunal assessment in monitoring programmes associated with marine aggregate extraction activities.
- 11) Some preliminary research has been conducted on the effects of extraction operations on fish resources and their trophic interactions with other components of the ecosystem. Future investigations should try to develop an understanding of the effects of marine aggregate extraction activities on both commercial and sensitive fish species in relation to changes in marine habitats. Such investigations should attempt to apply the relevance of such research to a wide range of environmental conditions and dredging strategies.
- 12) WGEEXT recommends further development of approaches to risk assessment in connection with the extraction of marine sediments and the possible effects on the marine ecosystem. The completeness and utility of existing approaches need to be examined in detail, together with comparisons with risk-assessment methods employed in other sectors, such as the oil and gas industries.
- 13) A large number of studies have now been undertaken to determine the environmental effects of marine aggregate extraction across ICES Member Countries. WGEEXT emphasizes the need to establish the significance of such effects relative to natural fluctuations in the marine environment (including climate change) and changes caused by other anthropogenic activity. Such an appraisal of the concept of environmental significance in relation to stakeholder perception is long overdue and must include an assessment of socio-economic factors.
- 14) Long-term investigations (over several years) on the recovery of fish resources and benthos should be undertaken to determine, in particular: (i) natural recovery of the structure and function of the biological community, and (ii) any persistent and long-term changes to fish resources and benthic community parameters within the context of natural, spatial, and temporal variability of reference environments.
- 15) There is a need for further research to assess the feasibility and cost-effectiveness of restoring sensitive marine habitats in areas where adverse, persistent, and long-term effects of marine aggregate extraction are evident.

Work to identify suitable indicators of the impacts of marine sand and gravel extraction should continue. Such indicators will need to satisfy the criteria as far as possible

(see *ICES Cooperative Research Report No. 273*; ICES, 2005), as well as attempting to achieve EcoQOs, including those already proposed by OSPAR.