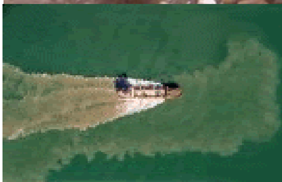

Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

1 PREFACE AND INTRODUCTION

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ACKNOWLEDGEMENTS

The Posford Haskoning project team would like to thank the following members of the Expert Panel, established for this project, for all their invaluable advice and comments:

Dr Alan Brampton (HR Wallingford Ltd)	Dr Tony Firth (Wessex Archaeology)
Professor Richard Newell (Marine Ecological Surveys Ltd)	Ali McDonald (Anatec UK Ltd)
Dr Tony Seymour (Fisheries Consultant)	Dr Ian Selby (Hanson Aggregates Marine Ltd)

In addition to this expert panel, key sections of the report were contributed by the following, to whom thanks are again extended:

- Dr Peter Henderson (Pisces Conservation Ltd)
- Dr Paul Somerfield (Plymouth Marine Laboratory)
- Dr Jeremy Spearman (HR Wallingford Ltd)

The project has also benefited considerably from an initial review by the following organisations. The time and assistance of these reviewers was greatly appreciated:

Tracy Edwards (Joint Nature Conservation Committee)	David Carlin, Dr Sian Boyd, Dr Stuart Rogers, Dr Chris Vivian, Dr Hubert Rees (Centre for Environment, Fisheries and Aquaculture Science)
Victoria Copley (English Nature)	Carolyn Warburton (Welsh Assembly Government)
Nicola Rimmington (Countryside Council for Wales)	Mark Russell (British Marine Aggregate Producers Association)
George Lees (Scottish Natural Heritage)	

Key input was also provided by a range of experts within the field of marine aggregate extraction and environmental assessment through their attendance and input at a series of Technical Workshops held in September 2003. Thanks are given to the representatives of the following organisations that attended:

Anatec	HR Wallingford Ltd
British Geological Society	Marico Marine Ltd
British Marine Aggregates Producers Association	Marine Biological Association of the United Kingdom
CEFAS	Maritime and Coastguard Agency
Defra Sea Fisheries Inspectorate	National Federation of Fishermen's Organisations
Dredging Research Ltd	Pisces Conservation Ltd
EMU Ltd	Royal Yachting Association
Hanson Aggregates Marine Ltd	Sussex Sea Fisheries Committee
IECS, University of Hull	University College London

PREFACE

BACKGROUND

Over the past three to four decades the marine aggregates dredging industry has grown to become a vital and integral part of the materials supply chain for the construction industry (Posford Haskoning, 2003). This contribution is significantly higher in south-eastern England (over 30%) due to the exhaustion of land-based supplies and because the advantages of relatively low marine transport costs apply. In densely populated south-eastern England, the benefits of landing large aggregate tonnages close to the point of demand from distant sources and without the need for road transport are clear. Of equal significance nationally are the benefits to be gained through the reduction in the pressure to quarry land of residential, agricultural or conservational significance, avoiding disturbance, noise, dust and loss of amenity value (Bellamy, 1998).

Another key aspect of the UK marine aggregate industry is that, while it is recognized that marine aggregate resources are finite, as are resources that are worked on land, there is no likelihood of a shortage of marine aggregate reserves for the foreseeable future, provided that licences are forthcoming at a rate consummate with maintaining the required extraction to meet the demands of the market (Hollinsworth, 1997).

Associated with the extraction of marine aggregates is a range of environmental effects. The body of knowledge that exists with respect to these potential impacts is ever increasing and a small number of best practice documents have been produced by various organisations to provide information on assessing the impacts of aggregate extraction on selected environmental parameters. However, it is recognised that there is a need to co-ordinate existing guidance.

The goal of this document, therefore, is to provide and disseminate good practice on assessing the potential impacts of aggregate (sand and gravel) extraction on the marine environment. The document **does not** deal with the issues of maerl extraction.

This document also aims to introduce increased consistency to the impact assessment process and to assist decision-makers in determining applications and agreeing appropriate mitigation, management and monitoring measures. All of this should contribute to ensuring that the impacts associated with marine aggregate extraction are limited as far as possible and that environmental management practices continue to improve.

PROJECT OBJECTIVES

The specific project objectives of this document are:

- To improve the consistency of impact assessment with regard to marine aggregate extraction, through the consideration of good practice in data collection and collation, the definition of robust assessment criteria and techniques, and impact mitigation;
- To support the improvement of environmental management practices;
- To ensure that decisions and actions taken at the strategic level are cognisant and reflective of working procedures and issues at the project level;
- To widely disseminate best practice to stakeholders and encourage participation; and
- To enable sound decisions to be made that minimise the impact of aggregate extraction on the marine environment and ensure the future sustainability of the physical and biological resource.

PROJECT FUNDING

The contract for this project was awarded to Posford Haskoning Ltd (PH) by the Office of the Deputy Prime Minister (ODPM). It was funded through the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme[1], an aggregate minerals research programme established under the terms of reference of the Aggregate Levy Sustainability Fund (ALSF). This contract was managed by the Mineral Industry Research Organisation (MIRO) on behalf of the ODPM.

The Sustainable Land-won and Marine Dredged Aggregate Minerals Programme has been established by ODPM as a mechanism to provide funding for aggregate minerals research that is consistent with the objectives of the ALSF and is broadly in line with the aims of the construction aggregates component of the ODPM's Planning Research Programme.

The specific aims of the Programme are defined as follows:

- To improve the information base on aggregates and environmental constraints, onshore and offshore, so that more sustainable options can be identified in the future;
- To support the improvement of environmental management practices so that impacts can be reduced; and
- To assist in providing information and examples of good practices to stakeholders in the process including the encouragement of better liaison between mineral operators and neighbouring communities.

The Programme operates through five research themes, which are defined below:

Theme 1	Impacts of aggregates dredging on the marine environment
Theme 2	Basis of regional and local environmental assessments of aggregates policies
Theme 3	Dissemination of good practices for community involvement and liaison in respect of aggregate operations
Theme 4	Preparation and dissemination of training information for stakeholders in the aggregates planning process
Theme 5	Development and initial implementation of advice on good practices in environmental management

This particular project falls under Themes 1 and 5.

POSFORD HASKONING PROJECT TEAM

This project required the review of all aspects of the Environmental Impact Assessment (EIA) process related to marine aggregate extraction, namely:

- Data collection, analysis and presentation;
- Impact identification;
- Methods of impact assessment and derivation of significance criteria;
- Mitigation; and
- Monitoring.

In order to ensure that the wide skills present within PH were utilised, an internal project team was established, comprising specialists in the key parameters relevant to this project. The structure of the internal project team is shown below:

[1] ***http://www.odpmaggregatefund.co.uk***

Role/Parameter	Staff
Project Director	Sian John
Project Manager	Jonny Lewis/Chris Adnitt
Project Review and Quality Management	Dr Richard Cottle
Geomorphology and Coastal Processes	Dr David Brew Alun Williams
Marine Ecology	Chris Adnitt Richard Stocks
Fish and Shellfish Resources	Jonny Lewis Richard Stocks
Commercial Fisheries	Jonny Lewis Richard Stocks
Archaeology and the Historic Environment	Pete Thornton
Navigation, Recreation and Other Uses	Rob Staniland
GIS and Information Management	Tim Jeffries-Harris Ian Holmes

EXPERT PANEL

In addition to the internal PH project team, an 'Expert Panel' was established, comprised of a number of specialists with detailed knowledge of the key issues related to aggregate dredging and the marine environment. The members of the Expert Panel are shown below:

Parameter	Member	Organisation
Geomorphology and Coastal Processes	Dr Alan Brampton	HR Wallingford
Marine Ecology	Professor Richard Newell	Marine Ecological Surveys Ltd
Fish and Shellfish Resources & Commercial Fisheries	Dr Tony Seymour	Independent Consultant
Archaeology and the Historic Environment	Dr Tony Firth	Wessex Archaeology
Navigation, Recreation and Other Uses	Ali MacDonald	Anatec Ltd
Policy, Legislation, Operations	Dr Ian Selby	Hanson Aggregates Marine Ltd

The objective of this panel was to ensure that the document produced was effective, clear, useful, relevant and, of key importance, practical. The panel was involved in the regular review of sections of this report as it progressed and in providing expert advice as and when required. They also attended, and in some cases, facilitated the technical workshops held as part of this study.

LINK WITH UNITED STATES MINERALS MANAGEMENT SERVICE RESEARCH STUDY

In addition to using the expertise of PH staff and the expert panel, this study has also benefited from involvement with a research study commissioned by the United States Minerals Management Service (MMS). This project, entitled "*A Review of Existing and Emerging Environmentally-Friendly Offshore Dredging Technologies*", is being undertaken by a group led by Baird & Associates (US) and including Dredging Research Ltd (UK) and Marine Ecological Surveys Ltd (UK). It aims to review new and emerging technology and techniques designed to reduce the adverse environmental impacts of dredging sand and gravels in offshore borrow areas.

In order to increase the cross-working between US and UK aggregate dredging research, an agreement was reached whereby the questionnaire for the MMS project was distributed to European stakeholders under the banner of this MIRO project.

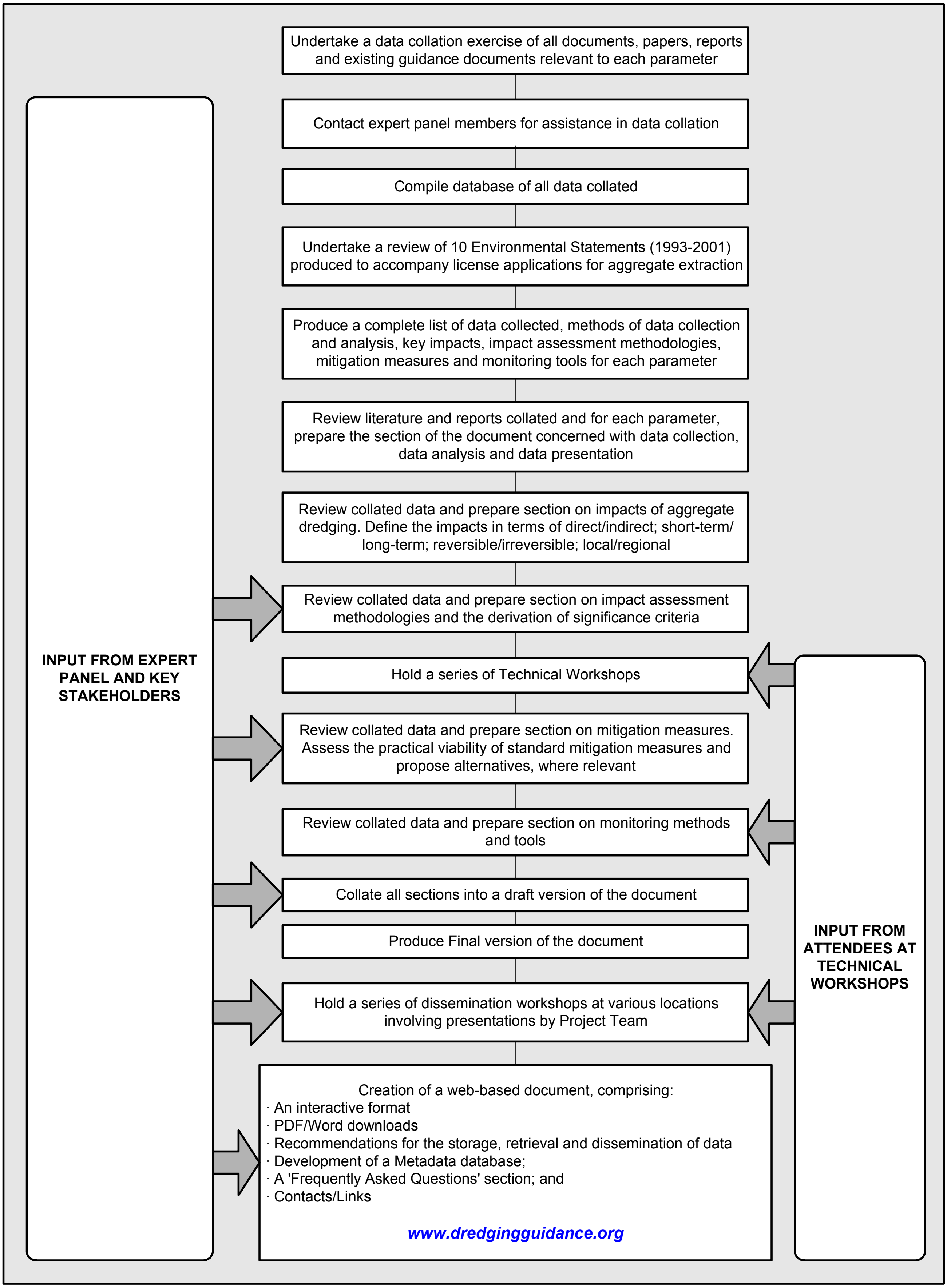

Figure A **Key stages and overall approach to the project**

USER GUIDE

This section of the document provides information to the user, with respect to:

- The target audience;
- The benefits of using this document; and
- The structure of the document.

This document is designed to support the improvement of environmental management practices in marine aggregate extraction. It also aims to ensure that sound decisions are made in the future that minimise, as far as possible, the impact of extraction on the marine environment.

Please note that although the document focuses on marine aggregate extraction, it is anticipated that some aspects could be applied to the assessment and management of other offshore projects, such as those in the oil and gas industry, as well as to offshore wind farms and other renewables initiatives. However, any direct extrapolation of this guidance should be undertaken critically and in the context of existing guidance for these sectors.

WHO IS THE TARGET AUDIENCE?

The core target audience for this document is those individuals, organisations and government bodies involved in undertaking, planning and regulating offshore mineral extraction. In addition, it is also addressed at those bodies or organisations that are affected by the dredging industry, such as commercial fishermen and recreational users.

Thus, the target audience comprises:

- Dredging companies;
- Industry trade associations (i.e. British Marine Aggregates Production Association (BMAPA));
- Environmental consultants (i.e. the ‘assessors’);
- Other sub-contractors or specialist consultants involved in the EIA procedure;
- Regulatory authorities (e.g. ODPM, (Department for the Environment, Food and Rural Affairs (Defra), Local Authorities, English Nature, CEFAS);
- Land-owners (e.g. the Crown Estate, Duchies of Cornwall and Lancaster, private landowners);
- Research institutions, universities and other learning establishments;
- Other marine users, such as the fishing industry (and their respective regulating authorities) and recreational boating users; and
- Non governmental organisations (NGOs), for example, The Wildlife Trusts and the Marine Conservation Society.

WHAT ARE THE BENEFITS OF USING THIS DOCUMENT?

The benefits of good practice are well recognised, as are the consequences of poorly managed and planned activities. It is the principal aim of this document to ensure that those involved in marine aggregate dredging are aware of these benefits and, in addition, informed as to the techniques and measures that will ensure that they are achieved.

There are a number of benefits associated with the adoption of good practice during the assessment of impacts, they are:

- **Environmental protection –** Reduced damage to the marine and coastal environment through better use of suitable and accepted impact assessment methodologies;

- **Consistency of assessment –** Through the comprehensive collation and discussion of assessment methodology, it is hoped that good practice will be advocated and, hence, used more commonly within the industry. If so, the consistent use of similar techniques will aid (decision-makers) in understanding both individual and multiple licence applications, as well as the differences between them. It will also assist assessors when examining cumulative impacts and in the creation of dredging related information databases;

- **Time and money –** If undertaken correctly, the methodologies and approaches put forward within this document will ensure that the impacts of a proposed activity are comprehensively and effectively assessed. By following these recommendations it is also predicted that a developer could encounter significant time and money savings, principally by providing the information required by the competent authority at the first request (i.e. thus avoiding planning delays and requests for further information);

- **Market image and relations –** If a developer and their assessors are seen to be using good practice, both by the competent authority and stakeholders, then the results and the final ES will be perceived to be of higher quality. Through the utilisation of current methodologies and active consultation, image and relations will hopefully improve and benefits will be achieved;

- **Reduction/elimination of risks –** Through the use of good practice, it is more likely that all impacts will be identified and efficiently evaluated, thereby reducing risks principally for the benefit of stakeholders and the competent authorities awareness. The identification of all impacts will ensure that fewer surprises arise for the developer, thus reducing the risk of not gaining planning permission or of incurring significant costs (and time delays) in gaining that permission.

STRUCTURE OF THE DOCUMENT

The document is divided into 7 main Sections (excluding the preface and appendices), as shown in **Figure B**. A brief overview of each section is provided below.

Section 1 Introduction

This section provides an introduction to the project, the marine aggregate extraction industry and EIA. This section also details the legislative and policy framework in which marine aggregate extraction and EIA operate within England and Wales, along with an overview of the development of other guidelines produced that have aimed to promote good practice when undertaking marine aggregate extraction.

Section 2 Data Collection, Analysis and Presentation

At the start of this section, there is a generic overview of good practice in relation to data collection that will apply to all of the various environmental parameters considered. This initial section discusses the importance of scoping, the need to accurately define the extent of the study area and the design of baseline surveys, amongst other things. This is followed by individual sections for each parameter, within which details of data requirements and methods of data collection, analysis and presentation are provided.

To distinguish each parameter, a series of parameter-specific colours is used throughout the document. These parameters, along with the colours used to represent them, are shown below.

Box A Parameters covered within the document
Physical Processes
Marine Ecology
Nature Conservation
Fish and Shellfish Resources
Commercial Fisheries
Archaeology and Cultural Heritage
Navigation, Recreation and Other Uses

Section 3 Generic Impacts of Aggregate Extraction

At the start of this section, there is a generic overview of good practice in relation to identifying and describing impacts, followed by specific sections that describe key impacts related to each of the parameters listed above. This review of impacts has been based largely on previous work by other authors but has been complemented by discussion and consultation with key experts and stakeholders.

Section 4 Methods for Impact Assessment and Derivation of Significance

Generic information with respect to methods for impact assessment and the derivation of significance are presented at the start of this section, followed by specific sections relevant to each parameter. A series of good practice recommendations are made and a framework for deriving the significance of impacts is also presented. Detail is then provided on how physical impacts associated with marine aggregate extraction are assessed and defined. The aim of this section is to introduce an element of consistency to how the impacts of aggregate extraction on the marine environment are assessed and how significance criteria are derived.

Section 5 Mitigation

Following on from Section 4, this section presents both generic and parameter-specific good practice recommendations relating to impact mitigation. Within this section, standard mitigation measures currently adopted are reviewed to assess, as far as possible, the practicality, suitability and success of these measures in real-life situations.

Where appropriate, alternative mitigation measures are proposed, which are based on discussions with key representatives of the industry, regulatory authorities, consultancy and academia.

Section 6 Monitoring

This section provides details relating to good practice in monitoring. It differs from others within the guide because only generic information is provided. This is because many of the key principles and good practice recommendations related to monitoring apply to all relevant parameters and can, therefore, be summarised within a generic overview. Details are provided on the need for monitoring, the importance of setting clear, measurable objectives and reporting and management issues.

Section 7 Summary of Good Practice Recommendations

In all of the preceding sections, boxes marked "Good Practice Recommendation" are present, that is:

GOOD PRACTICE RECOMMENDATION (Example)
The decision as to which data requirements should be investigated in the greatest detail, should be taken in the scoping stage.

In this section of the document, all of these recommendations are brought together to provide a summary of good practice related to individual aspects of EIA, i.e. data collection, impact identification, impact assessment, mitigation, etc. In considering these recommendations, it should be recognised that many of them are already undertaken by the aggregate industry, through their normal day-to-day practices.

APPENDICES

A number of appendices are included that provide details on various aspects of the project.

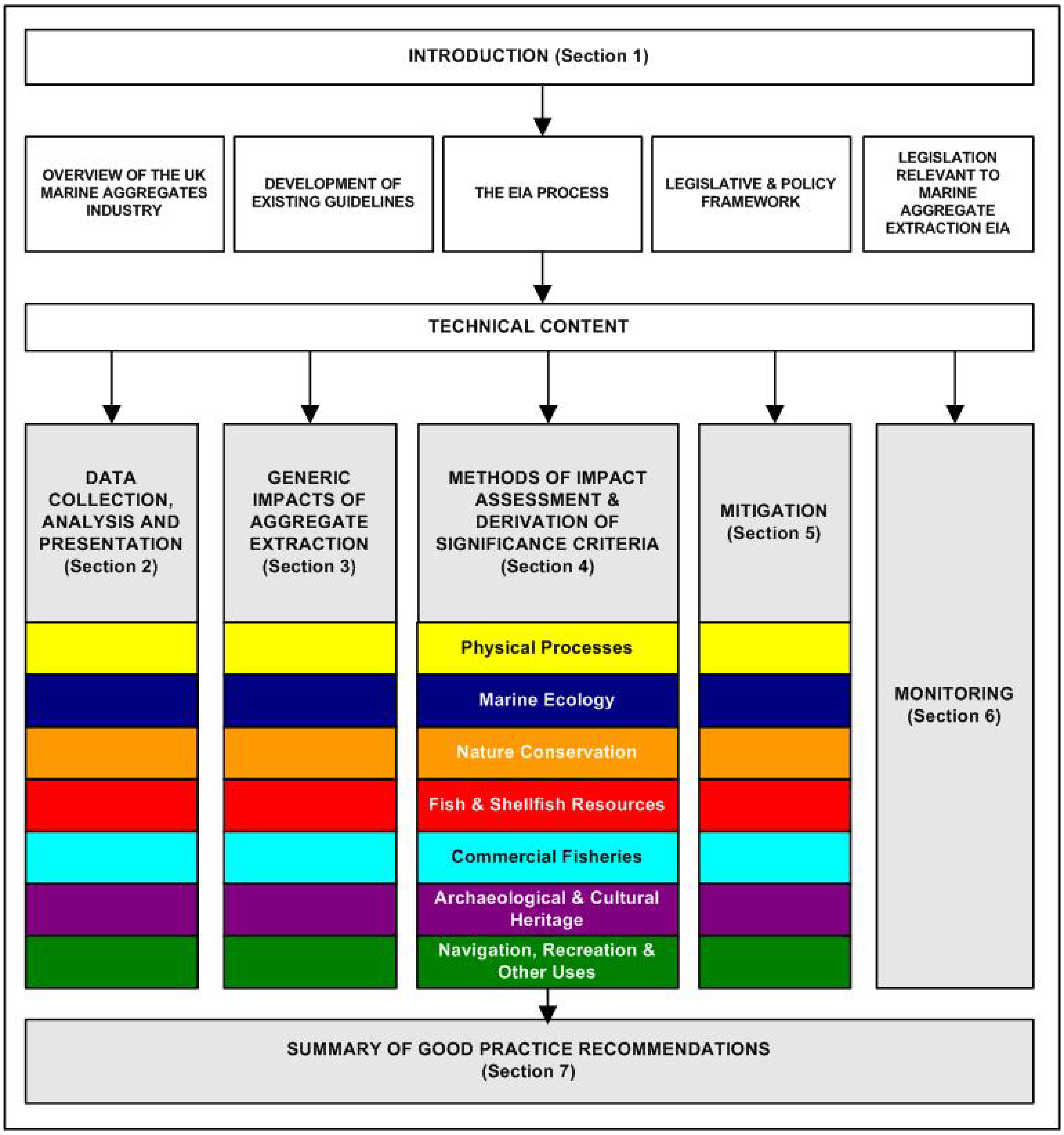

Figure B User's guide to the layout of the Report

REFERENCES

Bellamy, A.G. (1998). The UK marine sand and gravel dredging industry: an application of Quaternary geology. In: LATHAM, J-P. (ed.) 1998. *Advances in Aggregates and Armourstone Evaluation.* Geological Society, London, Engineering Geology Special Publications 13, pp.33-45.

Hollinsworth, C.C. (1997). The Marine Option. *Quarry Management,* February, 1997. pp. I7-22.

Posford Haskoning (2003). Eastern English Channel Regional Environmental Assessment. Report on behalf of East Channel Association. January 2003.

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INTRODUCTION

SECTION 1.1 OVERVIEW OF THE UK MARINE AGGREGATE INDUSTRY

1.1.1 OVERVIEW

Around 20-25 million tonnes (Mt) of marine aggregates (sand and gravel) are extracted each year from 72 licensed areas in UK waters. These areas are licensed by the Crown Estate, under advice from the ODPM in England, the Welsh Assembly Government in Wales and the Scottish Office in Scotland. Further details on the legislative framework for the issuing of these licenses is provided in **Section 1.4**.

This rate of extraction represents approximately 20% of the total sand and gravel production in the UK (Crown Estate/BMAPA, 2000). Sand and gravel dredged from the seabed makes an important contribution to the nation's demand for aggregates, with construction projects being the primary end-use supplied by the industry.

The quantity of marine aggregates landed in the UK between 1982 and 2000 is shown in **Figure 1.1**. It can be noted that following a peak in marine aggregate extraction in the late 1980's, annual extraction from licensed areas then fell, to as low as 18.4Mt in 1991. However, in recent years, production figures have risen again and stabilised at roughly 23Mt.

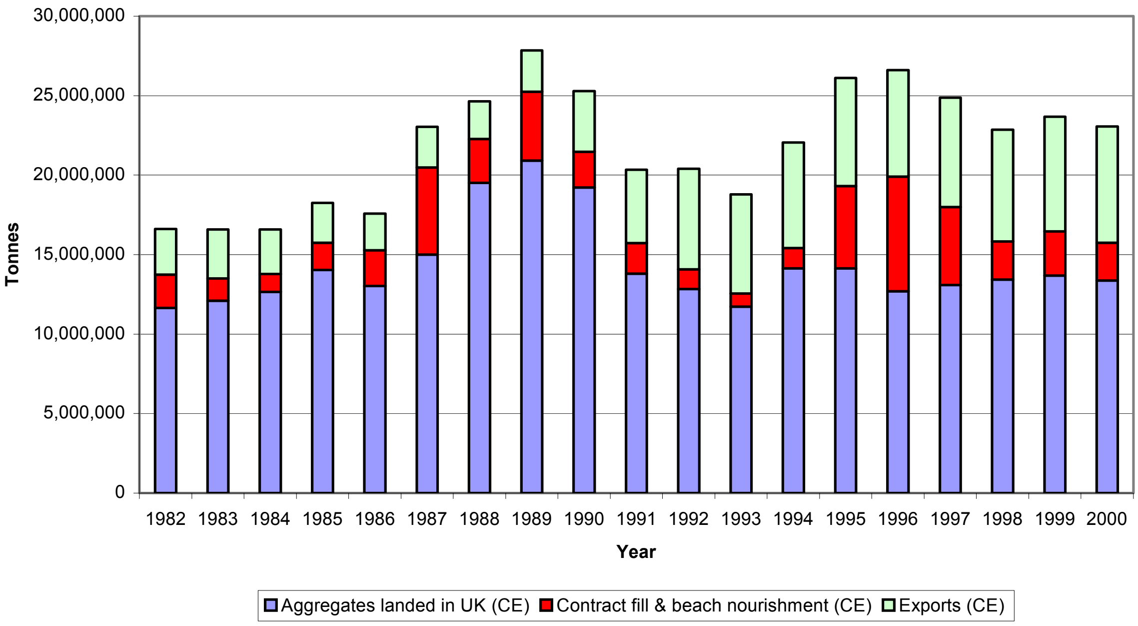

Figure 1.1 UK marine aggregate production 1982-2000 (Source: Crown Estate)

1.1.2 METHODS OF MARINE AGGREGATE EXTRACTION

Working methods for marine aggregate extraction have developed from the use of grabbing cranes mounted on pontoon barges or small vessels, to centrifugal pumps handled by hydraulically or electrically controlled gantries (Gubbay, 2003).

Trailing suction hopper dredging

Trailing suction hopper dredgers (TSHD) are used for the majority of marine aggregate extraction (see **Figure 1.2**). During trailer dredging the TSHD lowers one or two suction pipes and trail them across the seabed at slow speeds (3 knots). At the end of the suction pipe a 'draghead' is in contact with the seabed. The majority of UK vessels use a `California` style draghead. The draghead can be raised or lowered from the seabed to alter the density of the pumped mixture. The draghead may also be lifted clear of the seabed to avoid obstacles or known `resource-poor` patches. The loading pipes may be fitted with dump valves that allow the pumped mixture to be instantly dumped overboard, before entering the hopper, should it be clear that the mixture is contaminated with clays or silts.

Photo 1.1 Trailer Suction Hopper Dredger
Source: BMAPA photo library

The collected sediment-water mixture is pumped aboard the vessel and discharged into a large cargo hold (the hopper). In the hopper, dredged sand and/or gravel settles and the excess water flows overboard. A small percentage of the dredged sand and/or gravel may flow back overboard with the excess water (John *et. al.*, 2000).

Typically the vessel will operate within a prescribed dredge run that is dictated by geological and operational constraints (such as known clay or silt pockets, wreck debris, exclusion zones etc.) and will rarely encompass the whole licensed zone.

One of the key aspects of marine aggregate extraction is screening. Screening is the process by which the proportion of sand in the cargo is adjusted to meet customer requirements. Varying quantities of sand are rejected overboard into the water column by screens located either in towers mounted on the vessels side decks or over the hold as dredging is occurring. The required gravel to sand ratio for construction aggregates is typically between 50:50 and 60:40 (Posford Haskoning, 2003).

Static dredging

During static dredging, the vessel lies at anchor whilst operating (see **Figure 1.3**). The use of static dredgers for aggregate extraction within the UK is currently undertaken by one vessel. Such static operations are used where the resource represents more localised, spatially restricted deposits, e.g. terrace deposits or channel infills (BMAPA, 2004). During these operations, pipes are rearward facing and the dredged aggregate is retained directly into the hopper.

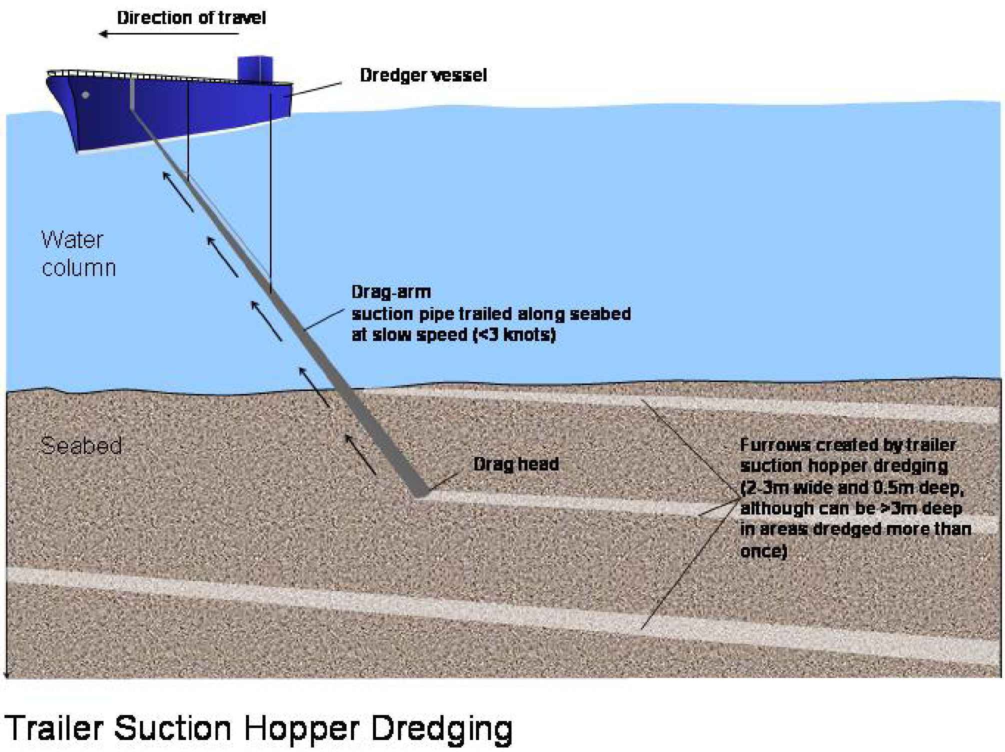

Figure 1.2 Schematic representation of trailer suction hopper dredging

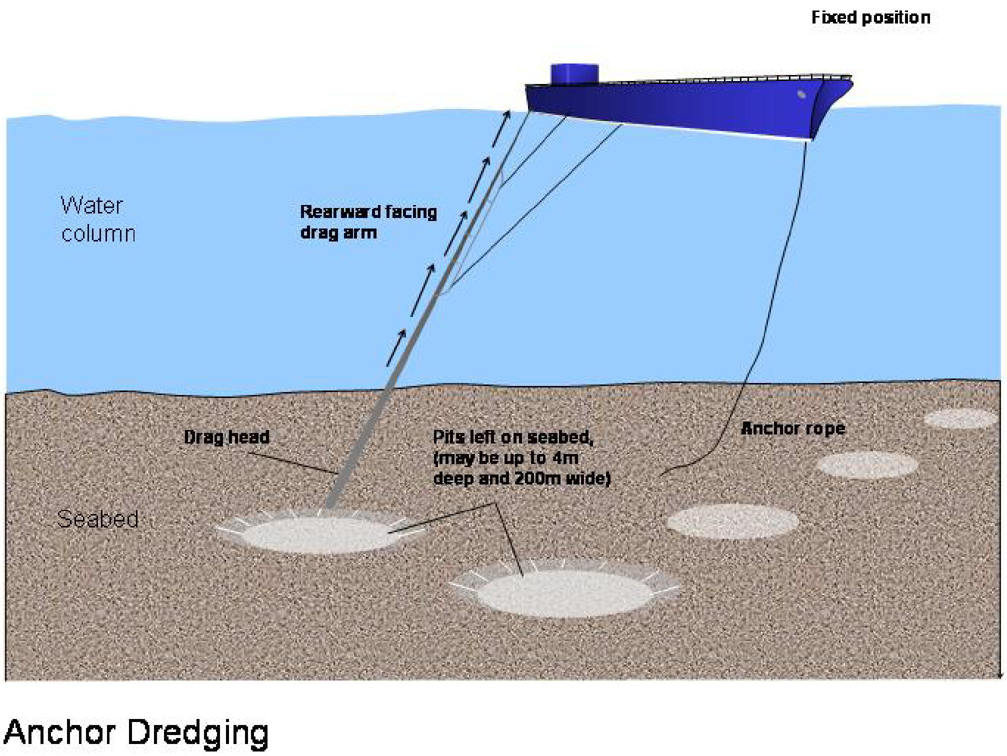

Figure 1.3 Schematic representation of anchor dredging

1.1.3 LICENSED AREAS

In 2003, there were 72 production licences in existence around the shores of the UK. These dredging licences cover just over 1,300km^2. During 2002, the total area actually dredged was 150km^2. Details on licensed areas and actual areas dredged can be obtained from `The Area Involved` reports, produced by BMAPA and The Crown Estate (see ***http://www.bmapa.org***).

Predominantly and historically, the main areas of extraction activity have been off the eastern and southern coasts of England, but licences also exist in the Bristol Channel and Liverpool Bay. There are also two licences in Scotland, one in the tidal section of the River Tay and one in the Firth of Forth. The East Coast region (those licences from Winterton to Southwold off East Anglia) has provided a large proportion (approximately 47%) of the marine won aggregate in the past decade. The second most important marine aggregate producing region is the South Coast, or that area between Bournemouth and Littlehampton (and including a licence area off Hastings). **Figure 1.4** indicates the location of existing licensed extraction areas within English and Welsh waters, whilst **Figure 1.5** indicates the proportion of total marine aggregate extraction from each of the six extraction regions during the period 1989 to 2002.

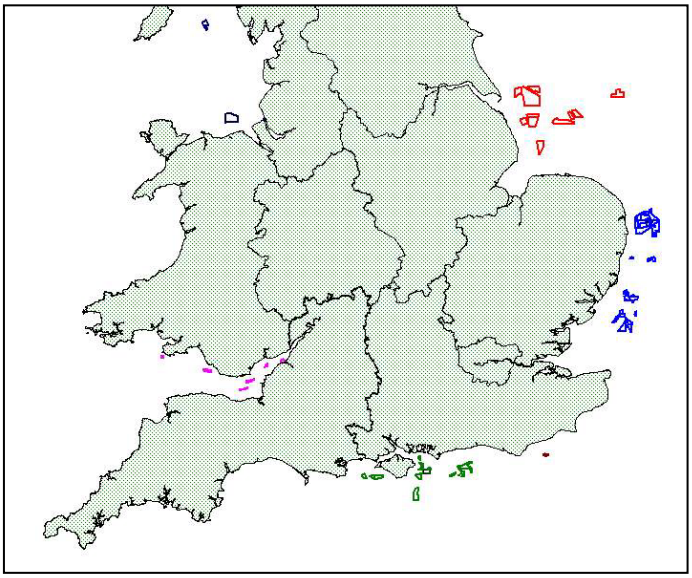

Figure 1.4 Location of dredging licences in England and Wales

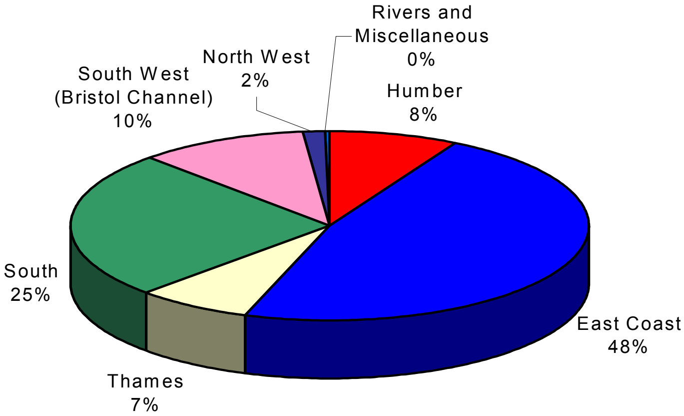

Figure 1.5 Proportion of marine aggregates extracted from various English and Welsh coastal regions; based on regional dredging statistics, 1989-2002

SECTION 1.2 DEVELOPMENT OF GUIDELINES FOR THE ENVIRONMENTAL ASSESSMENT OF MARINE AGGREGATE EXTRACTION

1.2.1 INTRODUCTION

As the marine aggregate extraction industry has developed over the last 30 years, so have a range of guidance documents related to best practice and environmental assessment. Many of these guidance documents have built directly on the content of preceding versions, therefore, there has been a natural evolution of guidance documents over time. In order to illustrate this evolution, and to place this current document into context, an overview of key guidance documents is presented in **Appendix A (i)**. These documents are presented in chronological order, with the earliest guidance discussed first.

A summary of the development of key guidance associated with marine aggregate extraction and EIA is provided in **Figure 1.6**.

SECTION 1.3 THE ENVIRONMENTAL IMPACT ASSESSMENT PROCESS

1.3.1 INTRODUCTION

This section provides detail on the EIA process, including general information relating to the legislative framework for EIA. Specific details on impact assessment methodologies and the derivation of significance criteria, the formulation of mitigation measures and monitoring are provided in **Sections 4**, **5** and **6** respectively.

1.3.2 THE PROCESS OF EIA

Essentially, EIA is a tool that is designed to proactively examine, identify and assess the likely impacts that may arise from developments and activities before they proceed (i.e. are granted consent). If used correctly and to its full potential, EIA will anticipate the consequences of development actions and provide a framework for resolving them, as appropriate. EIA is also cyclical in nature, given that its many steps continuously interact and feedback is provided at all stages. Not only that but it is:

- Systematic - i.e. there are established procedures;
- Holistic - i.e. provides a complete picture of all events; and
- Multi-disciplinary - i.e. EIA deals with natural, physical, human and built parameters.

GOOD PRACTICE RECOMMENDATION 1.1: THE TIMING OF EIA
EIA should commence as early in a projects design or planning as possible, and then should continue well into a projects lifetime (i.e. monitoring of operations, if applicable) and up to the cessation of activities or decommissioning of the development.

A summarised illustration of the EIA process is provided in **Figure 1.7**.

1.3.3 THE PURPOSE OF EIA

The main purpose of EIA is to ensure that the impacts of a development or activity are identified. However, it is designed to fulfil many more objectives and these should be taken into account throughout the EIA process, especially during the preparation of the Environmental Statement (ES). That is:

- **An aid to decision-making** – EIA is a legislative requirement for many large developments, particularly those that occur in sensitive locations. The reason for this being the need to provide the decision-maker (i.e. the competent authority) with enough reasoned and detailed information upon which to make a decision about the future value of the project (i.e. the granting of planning permission). In essence, the EIA process, and the ES in particular, represents the basis for negotiation between the developer and the competent authority (and stakeholders) with regard to the balance of the interests of the project and the environment as a whole;

- **Benefits to design and planning –** If undertaken at an early stage in the design and planning of a project, EIA can be of significant assistance in the formulation of development actions (i.e. location and timing) and early identification of significant impacts or concerns. With respect to the EIA of aggregate dredging projects, this could be the early identification of other projects planned for the area (i.e. telecommunication cables) or the development of progressive communication with key stakeholders with an interest in the study area;

- **Sustainable development –** Following the Earth Summit in Rio, the concept of sustainable development has come to the fore within development planning around the world. That is, development that 'should not cost the earth' and the vision of an environment for future generations that is similar to or even better than the one that we ourselves have inherited. The UK Government, has established four objectives with regard achieving sustainable development[2]:

    - Social progress that recognises the needs of everyone (social);
    - Effective protection of the environment (environmental);
    - Prudent use of natural resources (environmental); and
    - Maintenance of high and stable levels of economic growth and employment (economic).

EIA represents one of the principle tools in the sustainable development of projects, both at an individual level and also at a regional/national level. It places economic and social development in an environmental context and allows decision-makers and stakeholders to draw a parallel between them.

1.3.4 THE SCOPING REPORT

As detailed within **Figure 1.7**, the primary aim of the scoping stage of the EIA process is to identify the potentially significant effects of the development proposal (off and on-site) at an early stage. Scoping is one of the most important stages in the EIA process as it fulfils one of the major purposes of EIA, namely, ensuring that significant impacts are identified early in the planning and design process and allowing the identification of those issues/potential impacts that do not require further consideration. The overall objectives of a scoping study are shown in **Box 1.1**:

Box 1.1 Overall objectives of scoping
• To identify the potential impacts that could arise with respect to each relevant environmental parameter, and thereby exclude others, and to determine and define the level of assessment that will be required in the EIA; • To identify all relevant sources of information relating to the existing environment and define the requirements for further data collection; • To ensure early input from key consultees in the identification of potential impacts and to the EIA process; and • To define the preliminary scope of the EIA (and possibly a Coastal Impact Study)(see **Section 2.3**) to ensure both adequate coverage of potential impacts and appropriate targeting of resources.

[2] *A Better Quality of Life: A Strategy for Sustainable Development for the UK* (Department for the Environment, Transport and the Regions (DETR) (1999)

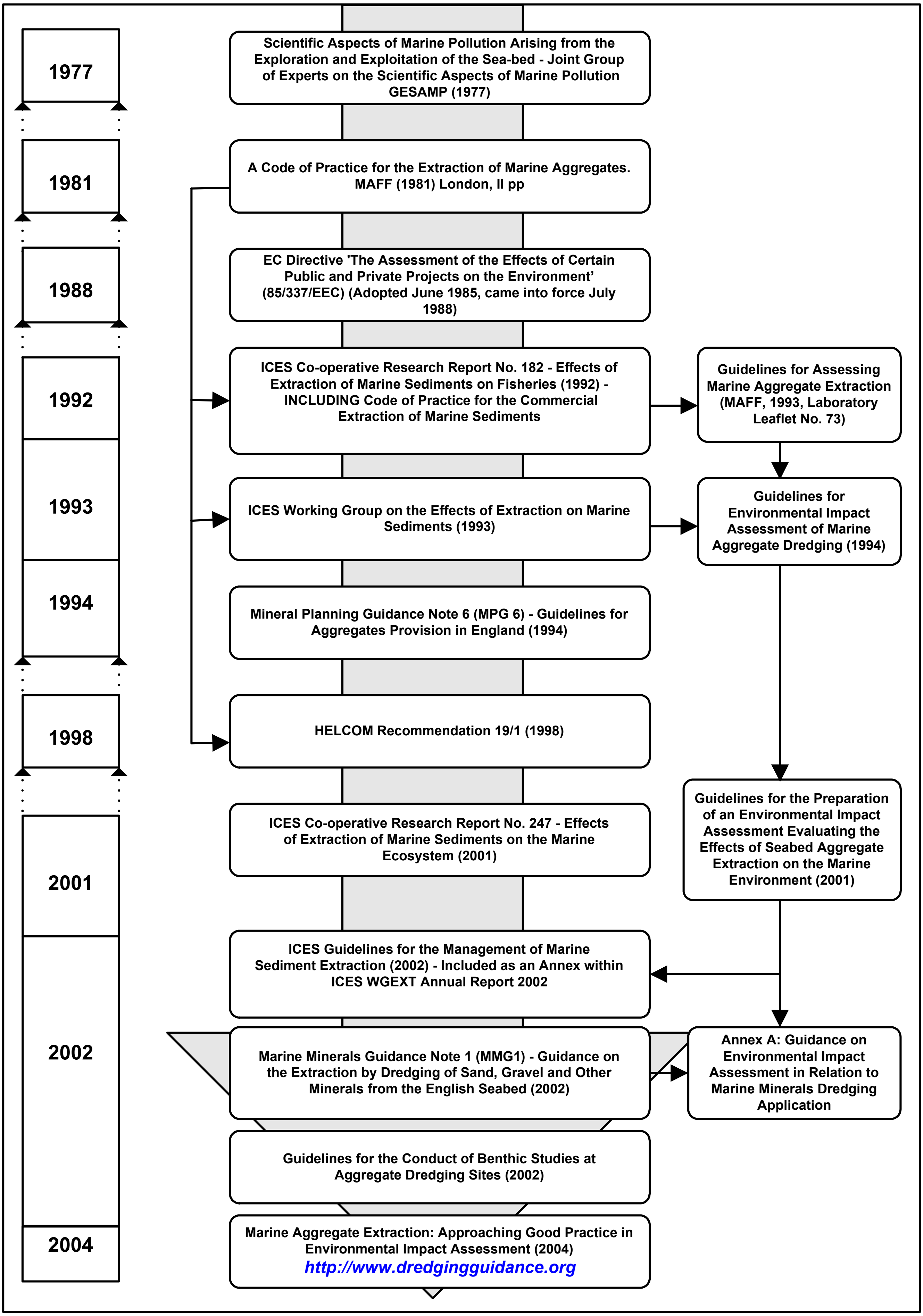

Figure 1.6 Development of guidance related to marine aggregate extraction and EIA

Stage	Task	Aim/Objective	Work / Output (Examples)
Project Screening	Screening	The need for EIA is identified, usually through regulatory determined thresholds	A Screening Opinion is provided by the competent authority
Scoping	Scoping Study	To identify the potentially significant effects of the development proposal (off and on-site) at an early stage	Preliminary consultation with key consultees. Scoping Report. A Scoping Opinion
Production of the Environmental Statement (ES)	Consultation	Consult with statutory and non-statutory organisations (the 'stakeholders') with an interest in the area	Local knowledge and information Transparent process
	Primary Data Collection (see Section **2**)	To identify the baseline/ambient/background/ existing environment	Fisheries data, sediment samples etc.
	Specialist Studies	To further investigate those environmental parameters which may be subject to potentially significant effects or where data gaps/uncertainty lies	Specialist reports on benthic communities, hydrodynamic processes, marine archaeology etc.
	Impact Assessment & Derivation of Significance (see Section **4**)	To evaluate the baseline environment in terms of sensitivity. To evaluate and predict the impact (i.e. magnitude) upon the baseline. To assess the resultant effects of the above impacts (i.e. determine significance)	Determination of significant adverse and beneficial impacts
	Mitigation Measures (see Section **5**)	To identify and design appropriate and practicable mitigation and enhancement measures	The provision of solutions to adverse impacts (e.g. sensitive scheduling to avoid sensitive periods). Feedback into the design process, as applicable
	ES	Production of the ES in accordance with EIA Guidance	ES – the main report of the EIA process
Post-ES Project Management and Analysis	Monitoring (see Section **6**)	Undertake monitoring of sensitive parameters as indicated within the ES. Undertake continued consultation and communication with affected parties	Monitoring on a co-ordinated and regular basis. Meetings with stakeholders, newsletters, web sites etc.
	Review of Monitoring	Review of monitoring results against ES predictions and required mitigation	Modifications to operations, if appropriate

Figure 1.7 Summary of the EIA process and methodology

Box 1.2 Benefits of scoping
• The resources required for the main EIA investigations focussed on real issues, rather than on insignificant matters. This saves time and money and ensures a better result for the developer; • Scoping helps to identify the project option(s) as well as alternatives (i.e. location, timing, processes to use etc.); • Scoping can help to identify likely mitigation and enhancement measures early on, allowing more time to develop them and ensure that they will work; • Scoping provides an early opportunity to consult with key stakeholders and to identify concerns and issues that may require modifications to the design; and • Uncertainty is removed from the ES, which allows for a more robust and assured decision-making tool, thus providing the competent authority with the required detail required throughout the planning process.

In England and Wales, EIA legislation provides the applicant with an opportunity to request a scoping opinion from the competent authority. This opinion should identify the data to be included within the ES and, in particular the key concerns to be addressed. To facilitate this opinion, it is recommended that a Scoping Report be prepared and issued to the competent authority. This Scoping Report should aim to provide the competent authority with the information necessary for the development of their scoping opinion and to facilitate discussion during the initial information gathering stage of the EIA.

1.3.5 APPROACH TO UNDERTAKING THE SCOPING STUDY

The approach to undertaking a scoping study should involve the following:

1. A review of available literature to identify information sources on both the existing environment and potential impacts;
2. A consultation exercise with key data holders and organisations potentially either affected by the scheme or likely to hold site-specific information relevant to the site (or both); and
3. The production of a scoping report for issue to key organisations that will act as the 'foundation' for later investigations.

The final scoping report should focus on the following issues[3]:

- Brief description of the project including any timescales, ancillary features and maps/photos to aid the decision-makers in understanding the proposal;
- Feasible alternatives and others that have been discounted;
- Strategic background, including development plans and other projects;
- List of stakeholders and how they might be involved in the EIA process;
- Methodologies to be adopted for the assessment of each issue;
- The extent of study area considered for each issue;
- The time horizon for which predictions are made;
- Key environmental constraints and opportunities;
- Likely key impacts, both positive and negative;
- Gaps in information and identified uncertainties;
- Proposed further surveys;
- Preliminary mitigation and enhancement measures; and
- Proposed EIA programme, including timescales and milestones.

[3] Taken from *A Handbook for Scoping Projects* by the Environment Agency (2002).

GOOD PRACTICE RECOMMENDATION 1.2: SCOPING
A scoping study should be undertaken as the first stage of a 2-stage approach to EIA (the second being the production of the ES). This represents the most cost-effective approach to EIA. **Consultation with organisations likely to be affected by the proposals AND organisations that may hold relevant baseline data is critical to this stage.** **The scoping study should review existing data and enable a decision to be made as to the need for more detailed baseline studies.** **The scoping study should also highlight key issues, enabling time and resources to be targeted towards these issues within the ES.** **If producing a scoping study as part of a wider EIA study, consultants should allocate a reasonable proportion of the overall project budget to preparing and producing the scoping report. By spending time and effort at the start of the EIA process, many of the key issues will be identified at an early stage and resources can be re-directed appropriately.**

1.3.6 CONSULTING STAKEHOLDERS

In England and Wales, statutory consultees for planning projects subject to EIA are stipulated in the EIA Regulations. This relates to the decision-making process following submission of the ES alongside the planning application. These organisations are consulted with regard the planning proposal and are provided the ES in order to better understand the implications of the project and to provide direct advice to the competent authority on the eventual planning decision.

With respect to aggregate dredging, consultation with key stakeholders forms an integral part of the Government View procedure (see **Section 1.4** for further details). Extraction licenses are not given a 'positive view' unless all the consultees are satisfied that the impacts on the environment and other uses of the sea are acceptable.

As such, given the importance of the role that statutory consultees play in the EIA and planning process, it is important to ensure that they are involved in the process from its outset. In addition, it is also important that other organisations with a direct interest in the scheme or the study area itself are contacted at this time. The main reasons for consulting with key stakeholders during the EIA process are summarised in **Box 1.3**.

Box 1.3 Reasons for consultation

- **Data collection** – Often, a vast database of knowledge exists within the wider community, particularly those people who live and work in the area. Data may already exist for certain parameters following previous studies, perhaps undertaken for other schemes or for general research purposes. It is important to identify what background data already exists and to see whether it might be available/relevant for the EIA;

- **Experience and local knowledge** – Not all data is neatly provided in documents or computer databases. Sometimes, the most important data can be found in the combined knowledge of the people who live and work in the area. With regard to aggregate dredging, this might be fishermen who have worked the study area for several generations who can provide both qualitative and quantitative information on fish stocks, natural variations and spawning grounds;

- **Transparency and bias** – The ES should be an unbiased and clear document, which reports on the project and its implications from a neutral perspective. To achieve this, it is important that interested parties are allowed to provide input into the preparation of the ES and its findings. Through regular consultation and feedback, views and concerns can be incorporated and dealt with, and most importantly, prior to the decision-making process ;

- **Awareness and education** – Consultation increases awareness of a scheme and its likely implications. Potential impacts can be openly discussed and solutions agreed prior to the preparation of the ES. Not only does this prevent speculation and rumour over a project, especially contentious ones, but it allows for a more reasoned and aware decision-making process;

- **Relations** – Consultation and continuous communication with interested parties helps to establish and maintain good working relationships, especially in industries where planning applications might be made on a regular basis. By asking for input and providing project-related information in return, developers will help to improve their own credibility and image.

1.3.7 CONSULTATION METHODOLOGY

Consultation is more than the simple one-way provision of information to interested parties, although this is an important aspect. Consultation should include, as a minimum, dialogue with key stakeholders, perhaps through regular telephone conversations and meetings or less frequent workshops and exhibitions.

Initially, the assessment team should identify the consultees for a particular development. To do this they need to ask:

- Who the statutory consultees are?
- Who would be affected?
- Who thinks they would be affected?
- Who would promote the project?
- Who would oppose the project?
- Who has been involved in this area or this type of scheme previously?
- Who has not been involved previously? and
- Who is influential in the community/industry?

The developer, the licensing authority and other relevant authorities (e.g. Defra) can assist in this. Requirements for consultation are also set down under the GV procedure (see **Section 1.4.2**). The method of consultation should then be established. This could comprise appropriately timed newsletters or consultation documents, which provide both information on the project and its progress, and can ask for feedback and input from the consultees. If scoping has been undertaken, or following the identification of potentially significant impacts, the main affected parties should be identified and necessary dialogue established. This would certainly include telephone calls (i.e. finding out who the relevant contact is and talking to them) and potentially face-to-face meetings to discuss the project and its effects. Other consultation methods such as a web site, newspaper adverts and exhibitions might also be used.

For certain parameters, in particular commercial fisheries, specific consultation is essential in order to collect accurate baseline data and to help to ensure that any potential impacts on this industry as a result of aggregate dredging are minimised. For this reason, dedicated good practice guidance on consulting with this industry is provided in **Section 2.7**.

It is important to recognise that consultation does not end with the publication of the ES. The ES itself becomes the subject of consultation under the GV procedure and, in the longer term, if mitigation such as monitoring is recommended, then results may need to be communicated and discussed. Indeed, continued consultation, perhaps through meetings, the Internet or telephone 'hotlines' might be a requirement of the planning permission.

1.3.8 GENERIC CONSULTEE LIST FOR MARINE AGGREGATE EXTRACTION EIAs

A recent review of five ESs, undertaken by MER Ltd, on behalf of The Wildlife Trusts and World Wildlife Fund-UK Joint Marine Programme (MER, 2003), highlighted a number of issues relevant to consultation. Specifically, the review raised questions about the adequacy and consistency of consultation with stakeholders.

The issue of consultation was discussed further at the "Marine Aggregates and Biodiversity" conference, held on March 6th 2003 in London and within the post conference briefing, published in August 2003 by Coastal Management for Sustainability (CMS). The recommendation was made that "*…the issue of a standard consultee list should be addressed since some key organisations seemed to be missing from the current process*".

Therefore, this section of the document aims to establish a standard consultee list that sets out the key organisations that may need to be consulted during the EIA process (see also **Section 1.4.2**). This list has been compiled from previous consultation lists used by Posford Haskoning and through discussions with representatives of key organisations. It is partitioned based on key National, Local and International consultees.

The full lists are presented in **Appendices A (ii)–(iv).**

Within each of the parameter-specific sub-sections of Data Collection, Analysis and Presentation, further details on consultation, along with contact details for key consultees, are provided.

GOOD PRACTICE RECOMMENDATION 1.3: CONSULTATION
Consultation is an essential part of EIA and should be undertaken in all projects and during all stages of the process. **All views and concerns expressed to the assessment team should be adequately dealt with, either through discussion or within the ES itself.** **For transparency and clarity, it is good practice to include the key comments made by consultees within the ES.** **Specific specialist consultation should be undertaken with key industries, i.e. commercial fishing.** **Consultation should not end with the ES and should continue throughout the project's life and until abandonment.** **Good consultation will save time and money, build relations and improve the image of the developer and the project. Bad consultation will extend the planning process whilst grievances are resolved, will reduce the level of assistance received (particularly in terms of available data) and could tarnish a developer's image in future applications.**

1.3.9 THE ES

One of the most important stages in the EIA process is the preparation of the ES. The ES is the main product or report of the EIA and documents of the information and impacts derived from the various stages of the process. Its importance lies in its purpose, the requirement to make the reader aware of the value of the project and also to advise on the consequences of development and the mitigative solutions that would be put in place should permission be granted. As the ES is designed to report on the EIA process (to date), the typical contents of an ES would be as follows:

Stage	Content
Non-Technical Summary (NTS)	EIA terminology and impact science can be complex and the NTS should be provided in order to improve communication with those unfamiliar with the intricacies or indeed the subject itself.
Introduction and background	Introductory text covering the requirement for EIA, the legislative background of the project and EIA, and the process itself.
The development	A description of the development proposal, including detail on the development actions, timing and processes involved (see **Section 2**). In addition, it is a requirement of EIA legislation for alternative development options considered to be discussed in the ES (i.e. why has this option been chosen and others discarded).
The environment	A description of the baseline environment of the study area. What are the sensitivities of the local environment and what natural, physical, human and built parameters is the development likely to affect? With regard to aggregate dredging, detail on data collection and the presentation of results has been provided in **Section 2**.
The impact assessment	The prediction, evaluation and specification of impacts upon the environment that might arise from the development. These can be qualitative or quantitative descriptions but in all cases a determination of significance should be made. With regard to aggregate dredging, detail on the prediction of impacts and the derivation of significance has been provided in **Section 4**.
Mitigation (and monitoring)	The prescription of mitigation measures to avoid, reduce or remedy the identified effects. In addition, any monitoring or future management measures necessary to the sustainable operation of the project (see **Section 5**).

Under the GV procedure for aggregate dredging, the completed ES is issued to all statutory consultees and made available for public inspection at the offices of Local Authorities. Following a period of consultation on the content of the ES, a revised ES may be produced.

GOOD PRACTICE RECOMMENDATION 1.4: THE ES

Given the importance of the ES to decision-making and the general raising of awareness amongst all readers, the presentation and appearance of the ES should be of high quality. The use of maps, drawings and photographs is encouraged in order to reduce the amount of text required and to allow greater understanding of the development, the environment of the study area and the identified impacts.

As far as possible, the ES should be concise and concentrate its discussions and assessment on those key impacts identified during the scoping stage.

The NTS will be the preferred document for non-specialists or for readers requiring an overview before concentrating on their own specialisation. As such, ensure that it is not too complex, avoids technical jargon and, above all, is clear and easy to read.

The final ES should be issued to consultees either in hard format, digital format (CD, PDF) or made available on the internet.

1.3.10 THE STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) DIRECTIVE

Overview

When considering EIA, it is also important to make reference to EC Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment; the Strategic Environmental Assessment (SEA) Directive. A review of the role of SEA in marine aggregate extraction has recently been undertaken as part of a study to consider whether a development plan approach, possibly based on that used within the land-use planning system, or an alternative, could provide a suitably strategic and sustainable approach to the identification and allocation of areas for marine aggregate dredging in English marine waters. The following text is taken largely from this document (Posford Haskoning *et al*, 2003), to which the reader is referred for a more comprehensive review.

The SEA Directive is expected to effect many changes in the way that the environment and wider sustainability issues are considered. The main objective of the Directive is "*to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development*". An important point to note is that the responsibility for undertaking SEA lies with the Government regulator and not the developer.

The SEA Directive lays down only a minimum environmental assessment framework, relying on existing EIA Regulations that have been established by Member States (in the UK these are The Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999).

Benefits of SEA

With regard to benefits, SEA provides a tool for overcoming the principal limitation of EIA, the fact that it is undertaken at the project specific level, well after many key environmental decisions have already been made. By undertaking an SEA of higher level plans and programmes, the principle of sustainability can be implemented in a increasingly phased and consistent manner.

SEA and Marine Aggregate Extraction

In relation to marine aggregate extraction, the purpose of producing SEAs for the aggregate industry would be to consider the environmental implications of proposed actions and alternatives and the potential areas that could be used for prospecting and extraction activities.

The SEA would consider the following:

- The environmental objectives and standards established for the area relevant to the proposed action;
- Potential activities in the area (i.e. in addition to aggregate extraction);
- The main mitigation measures and alternatives investigated;
- An assessment of the likely significant environmental consequences of the proposed action and its alternatives, including the potential for cumulative, synergistic and transboundary effects;
- Proposed arrangements for monitoring the environmental effects of the proposed action and post decision analysis of its environmental consequences; and
- Difficulties encountered in compiling the information and a discussion of the uncertainty associated with impact predictions.

The wider policy issues of extraction activities from the UK Continental Shelf and sustainable development of the overall resource would also need to be considered.

SECTION 1.4 LEGISLATIVE AND POLICY FRAMEWORK

1.4.1 THE EXISTING REGULATORY REGIME

Decisions on development proposals below mean low water mark are generally outside the scope of the UK planning system. This arises because all mineral rights, with the exception of coal, oil and gas are vested in the Crown which own most of the seabed around the coasts of the British Isles from mean low water out to the limits of territorial waters (12nm). With regard to regulation within English waters, the marine aggregate extraction industry is strictly regulated by ODPM whilst Defra provide advice in their role as a statutory consultee.

In Welsh waters, the Welsh Assembly Government are the key regulatory body and any decisions on licences in Welsh waters will be taken by the Assembly Government's Environment Minister, not by ODPM. A separate Marine Aggregates Dredging Policy has, therefore, been developed by the Welsh Assembly Government and is due to be published in early 2004. This document is summarised in **Section 1.4.5**.

With respect to Scotland, although marine dredged sand and gravel has not contributed to the supply of aggregates in Scotland to date, the Scottish Executive recognises that it may do so in the future. Therefore, the National Planning Policy Guidelines 4 (NPPG 4) - Land for Mineral Workings - includes a paragraph on marine minerals exploitation which states that:

"*…the potential to do so exists. Proposals are subject to the 'Government View' procedure which is co-ordinated by The Scottish Executive Environment Department. If favourable, licences are granted by the Crown Estate. Dredging of sand and gravel may be acceptable, provided it can be done without unacceptable damage to sea fisheries and the marine environment or the stability of the coastline. The operation of the 'government view procedure' is currently under review*."

Ultimately, any decision on the granting of licenses in Scottish Waters will be the responsibility of the Scottish Executive Minister for Communities, whose remit includes the Scottish planning system.

1.4.2 GOVERNMENT VIEW PROCEDURE

Historically, there has never been statutory control of marine dredging activities in the UK. The only form of control was that issued by relevant Harbour Authorities and Coast Protection Authorities within 3 miles of the coast. Otherwise, the only legal control on dredging operations has been exercised by the Crown Estate, which owns the majority of the seabed within the 12 mile limit and possesses ownership rights to all minerals within the UK share of the rest of the Continental Shelf[4].

The GV procedure was introduced in 1968 amidst a general growth in the awareness of environmental issues. From this point the Crown Estate would not issue a dredging license unless the Government expressed a favourable view on the proposed dredging operation's environmental implications. Responsibility for providing the GV within the UK is outlined below in **Box 1.4**.

Box 1.4 Responsible Bodies for GV within UK waters
• England: Office of the Deputy Prime Minister • Wales: Welsh Assembly Government • Scotland: Scottish Executive

A favourable GV is issued only if major stakeholders (such as Defra) are content that the proposed dredging is environmentally acceptable, or can be made so by the imposition of appropriate conditions. The Crown Estate is then requested to impose those conditions through its dredging licence (Marker, 2003). The GV is a voluntary procedure with which all operators have complied since its inception. Since 1989, EIA has also formed part of the GV process (Marker, 2003).

Under the GV procedure, the operating company lodges an application with ODPM which, in turn, provides a list of organisations that should be consulted during the application process. This list includes Government agencies with responsibility for fisheries, habitats, navigation and marine

[4] http://www.sandandgravel.com/extraction/united_kingdom2.htm

heritage issues. The operator is then required to compile an ES, and associated Coastal Impact Study (CIS), and distribute these documents to all consultees, in addition to making them available for public inspection at the offices of Local Authorities. Advertisements are also placed in suitable newspapers, informing interested parties of the publication of these documents. Where trans-boundary effects are believed possible (i.e. effect on the interests of other states in the European Economic Area), the states concerned are consulted directly by ODPM.

Meetings and discussions are held with those consultees who raise concerns in order to identify, where possible, ways in which they might be overcome. This may include the provision of extra monitoring and/or mitigation measures. This second stage process results in the production of a report, which can include a revised ES and suggested dredging conditions, which the applicant believes will mitigate any potential environmental impacts.

ODPM approaches all individuals and organisations that raised objections during the first stage, to determine whether they consider that their representations have been dealt with adequately. The Secretary of State then determines whether a favourable or unfavourable GV should be given.

The GV procedure was amended in 1998 with the introduction of `Interim Procedures` to make the application and determination process faster and more transparent (DETR, 1998). Under this procedure, extraction licenses are not given a positive view unless all the consultees are satisfied that impacts on the environment and other uses of the sea are acceptable.

A scheme of conditions is attached to each favourable GV (Marker, 2003). Examples of appropriate conditions are presented in **Box 1.5.**

Box 1.5 Examples of conditions attached to a favourable GV
• Working within defined sub-areas; • Optimising the distance between dredging areas; • Delaying implementation of the permission until dredging in adjacent areas has ceased; • Restricting the times at which dredging is allowed; • Limiting rates of extraction; • Limiting the total quantity of material that can be removed; • Restricting the type of dredger that is used; and • Prohibiting the screening of sediments at sea.
Source: Marker, 2003

A scheme of monitoring and review may be required to assess the effectiveness of any conditions that are applied. With respect to ensuring that dredgers work within defined areas, Electronic Monitoring Systems (EMS), which remotely and automatically records the location, time and activity of dredgers, have been a mandatory requirement for vessels dredging on Crown Estate licence areas since 1993.

The GV process, although successful, has a number of inherent disadvantages.

Box 1.6 Disadvantages of the current GV process
• The process is voluntary. Although all operators currently comply with it, they are under no legal obligation and, therefore, collaboration may not always take place. There is a need for statutory control; • The ES is submitted after the application for the GV. These steps need to be synchronised in order to efficiently inform the GV process; • The GV is a very slow process of negotiation, which can, in effect be open ended and take many years; and • The Crown Estate has a potential conflict of interests since it licenses dredging for minerals and also collects royalties in respect of minerals extracted.
Source: Marker, 2003

1.4.3 PROSPECTING LICENCES AND PRODUCTION LICENSES

The Crown Estate issues two types of licence: a **Prospecting Licence** and a **Production Licence**.

Box 1.7 Prospecting and Production Licences
Prospecting Licences: are awarded by the Crown Estate through a tender process. This provides a successful tenderer with a fixed time in which to carry out the necessary prospecting to assess the geology of the seabed, the occurrence of potential aggregate deposits, the nature and quality of the deposits and their extent and depth. Prospecting commonly involves the use of sidescan sonar and other seismic techniques to determine seabed topography and structure. Grab sampling is also done in areas of potentially exploitable deposits plus vibracore sampling to determine the depth and granulometry of the deposits through a core sample of up to 4 metres.
Production Licences: are areas that have been licensed to be dredged. Each licensed area is split into several dredging zones (confirmed through discussion with the regulators and the fishing industry), one of which is worked at any one time, to reduce disturbance to other users of the area. Production licences are presently controlled in England and Wales by the interim non-statutory GV procedure, as issued in May 1998 by the DETR (now ODPM).

The key stages and components of each stage of the Production Licence application are summarised in **Appendix A (v)**.

GOOD PRACTICE RECOMMENDATION 1.5: PROSPECTING SURVEY
Prior to undertaking a prospecting survey, the licence holder should consult statutory nature conservation agencies over information held on the area in question. This will remove the risk of grab sampling being undertaken in sensitive habitats. This consultation will have been undertaken as part of the Coast Protection Act consenting process, required for minerals prospecting.

1.4.4 STATUTORY APPROACH

The current system, described above, is in the process of transition from a non-statutory regime to statutory regulation. The UK Government has been working on the introduction of statutory control for marine aggregate extraction since 1997, but no regulations have been made as yet (although draft Regulations exist). The new regulations will replace the Interim GV procedure when they come into force (Vivian, 2003) and will transpose into UK legislation, in so far as marine dredging is concerned, the provisions of EC Directive 85/337/EEC, as amended by EC Directive 97/11/EC, on the assessment of the effects of certain public and private projects on the environment. They will be the Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations.

The new regulations will separate the Crown Estate from the environmental consideration of dredging proposals; in England, the Crown Estate will still issue commercial licenses but these will become distinct from the dredging permission issued by the ODPM (Marker, 2003). Similarly, in Wales, the new regulations being developed by the Welsh Assembly Government will separate the Crown Estate licenses from dredging permissions that will be granted by the Welsh Environment Minister. In Scotland, no such regulations are yet in development, but it is likely that they will be produced in the near future, following the production of ODPM guidelines (Scottish Executive, *pers. comm.* 2004). The differences between the draft Regulations and the Interim GV are shown in **Box 1.8**.

Box 1.8 Differences between the draft Regulations and the Interim GV
• The draft Regulations will require the application to be submitted accompanied by the full ES and to be determined as submitted; and • While the Secretary of State could proceed to decide applications directly if no objections were raised, in all other cases there should be provision for determination on the advice of an independent inspector obtained after examining the application through written representations, a hearing or a public inquiry, as appropriate.
Source: Marker, 2003

The draft Regulations include clear rules for the submission of written representations, hearings and inquiries. They also define clearly the position in respect of variation to conditions, revocation of permissions and compensation in the event that monitoring reveals environmental problems that cannot be adequately resolved (Marker, 2003).

1.4.5 MARINE AGGREGATE EXTRACTION POLICY DOCUMENTS

Minerals Planning Guidance 6 (1994)

MPG6 is the central planning policy document for aggregate production in England. MPG6 anticipates the contribution that marine sources will make to the national supply. The inclusion of marine resources in MPG6 is an indication of the close relationship between land and marine aggregates as a source of supply.

Marine Minerals Guidance Note 1 (2002) "Guidance on the Extraction by Dredging of Sand, Gravel and Other Minerals from the English Seabed"

The Department of the Environment, Transport and the Regions (now the ODPM) developed a policy framework within which the development of marine sand and gravel resources in English territorial waters can take place in a way that is consistent with the Governments approach to protecting the environment and achieving sustainable development. This was published as MMG1 in July 2002. The framework will be accompanied by procedural guidelines (to be called MMG2) when they come into force.

The proposed policy objectives are to provide the dredging industry with sufficient access to suitable long-term resources to meet its varied and fluctuating markets, so as to provide the industry with sufficient confidence to invest in new ships and wharves, while ensuring that the extraction of the mineral does not have an unacceptable impact on the marine or coastal environment, or on other legitimate uses of the sea.

MMG1 gives more detailed advice than in the past on the environmental standards that must be met; and criteria against which applications will be considered and determined. Annex A also gives guidance on the scope and content for Environmental Statements and forms the basis of much of this current report. MMG1 also sets out the Government's policy objectives for marine mineral extraction, under a number of headings, all under the umbrella of sustainable development. These policy objectives include:

- Minimising the area authorised for dredging at any one time;
- Identifying new areas for dredging; and
- Safeguarding resources for specific uses (i.e. beach nourishment).

Some attention is paid to the possibility of cumulative and in-combination effects arising from a number of extraction areas. It is suggested that the Government will seek to "zone" some areas, through co-operation with the Crown Estate and the industry, to limit the extent of groups of workings and (at the same time) minimise the impact of concentrated dredging where necessary.

Marine Aggregates Dredging Policy (South Wales) (2004)

The Bristol Channel is currently the main source of fine aggregates for South Wales, and particularly South East Wales. In May 2001, the Welsh Assembly Government issued the Draft Marine Aggregates Dredging Policy (South Wales) for consultation. This document set out the Assembly's strategic policy to enable objective and transparent decisions to be taken about the most appropriate locations for dredging marine aggregates in Welsh waters; that is, the Bristol Channel, Severn Estuary and the River Severn. Following an extensive consultation process, a final version is to be published early in Summer 2004.

Once adopted, all decisions on planning applications relating to sandbanks that extend into the estuary, but which are determined by local planning authorities because the banks are above the mean low water mark and are contiguous with the foreshore, must be considered in accord with the policies in the Marine Aggregates Dredging Policy.

SECTION 1.5 LEGISLATION RELEVANT TO MARINE AGGREGATE EXTRACTION EIA

This section provides a summary of the main international and national legislation that should be considered when undertaking an EIA in relation to a marine aggregate extraction licence application. A fuller overview of each piece of legislation is provided in **Appendix A** (**ix**).

1.5.1 INTERNATIONAL LEGISLATION – NATURE CONSERVATION

- Convention on Biological Diversity (CBD)
- EC Directive 85/337/EEC on the Assessment of the Effects of Certain Private and Public Projects on the Environment (as amended by EC Directive 97/11 and Regulated according to Statutory Instruments 1999, No. 293); The EIA Directive
- EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna; The Habitats Directive
- EC Directive 79/04/EEC on the Conservation of Wild Birds; The Birds Directive
- EC Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment; the Strategic Environmental Assessment (SEA) Directive

1.5.2 INTERNATIONAL LEGISLATION – OTHER

- EC Directive 2000/60/EC for establishing a framework for community action in the field of water policy; The Water Framework Directive
- International Convention for the Prevention of Pollution from Ships, 1973, as modified by the 1978 Protocol relating thereto (MARPOL 73/78)
- EU Directive 76/60/EEC Concerning the Quality of Bathing Waters
- EC Directive 79/923/EEC The Shellfish Waters Directive
- Draft EC Environmental Liability Directive

1.5.3 NATIONAL (UK) LEGISLATION – NATURE CONSERVATION

- Draft Offshore Marine Conservation (Natural Habitats, &c) Regulations 2003
- Draft Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2001
- Wildlife and Countryside Act 1981
- Conservation (Natural Habitats, &c) Regulations 1994
- Conservation (Natural Habitats and etc) Regulations (Northern Ireland) 1995

1.5.4 NATIONAL (UK) LEGISLATION – OTHER

- Coast Protection Act 1949 (as amended by the Merchant Shipping Act 1988)
- Protection of Wrecks Act 1973
- Ancient Monuments and Archaeological Areas Act 1979, Chapter 46
- Protection of Military Remains Act 1986

REFERENCES

Crown Estate/British Marine Aggregates Producers Association (2000). Marine Aggregate Dredging: The Area Involved – Report 2000**.** The Crown Estate, London.

Gubbay, S (2003). Marine aggregate extraction and biodiversity. Information, issues and gaps in understanding. Report to the Joint Marine Programme of the Wildlife Trusts and WWF-UK.

DETR (1998). Government View: New Arrangements for the licensing of Minerals Dredging Crown Copyright, London. Department of the Environment Transport and the Regions.

DETR (1999). *A better quality of life*: a strategy for sustainable development in the United Kingdom. DETR, CM4345, ISBN 0-10-143452-9

Environment Agency (2002). *A Handbook for Scoping Projects*. Scoping guidelines for the Environmental Impact Assessment of projects (May 2002). Environment Agency

Marker, B.R. (2003) Marine minerals dredging in English waters. Policy and consent procedures. EMSAGG Conference, Delft University, Netherlands, February 2003.

MER Ltd (2003) Marine Aggregate Extraction: a review of selected Environmental Statements. Report to the Joint Marine Programme of the Wildlife Trusts and WWF-UK.

Posford Haskoning Ltd, David Tyldesley Associates, CEFAS and HR Wallingford Ltd (2003). A Development Plan for Marine Aggregate Extraction in England: A Scoping Study. Report to the Office of the Deputy Prime Minister, November 2003.

Posford Haskoning (2003). Eastern English Channel Regional Environmental Assessment Report on behalf of East Channel Association. January 2003.

Scottish Executive (2004). Personal Communication with Planning Department.

Vivian, C.M.G (2003). UK approach to environmental assessment of sand and gravel dredging proposals. EMSAGG Conference, Delft University, Netherlands, February 2003.

Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

2 DATA COLLECTION, ANALYSIS AND PRESENTATION

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SECTION 2 DATA COLLECTION, ANALYSIS & PRESENTATION

SECTION 2.1 GENERIC GUIDANCE

This section of the document sets out the following:

- Baseline data requirements;
- The need to collect baseline data;
- Methods of baseline data collection;
- Baseline data analysis and presentation; and
- Reporting baseline data.

For each relevant environmental parameter, information and good practice recommendations are provided relating to the above headings. Good Practice Recommendations are also provided within each parameter-specific section. The data requirements and methods of data collection detailed within this section are based on the following set of existing guidelines:

- Details on the baseline information that should be provided within an ES are provided in MMG1 and the draft Marine Aggregate Dredging Policy (South Wales). Further detail is provided within the International Council for the Exploration of the Sea (ICES) Guidelines for the Management of Marine Sediment Extraction. These guidelines were published in the 2003 Report of the Working Group on the Effects of Extraction on Marine Sediments (WGEXT) (ICES, 2003).

- Previously published work by MAFF (1993) and ICES (ICES, 1992), plus more recent guidance by HELCOM (HELCOM recommendation 19/1, 1998), have also been taken into account in preparing this document. The final ICES guidelines presented in the 2003 ICES WGEXT report, are designed to be an update to *both* the previous Code of Practice (ICES, 1992) and guidelines on EIA produced in ICES Co-operative Research Report No. 247 – Effects of Extraction of Marine Sediments on the Marine Ecosystem (ICES, 2001).

A full review of guidance documents related to marine aggregate extraction, and how these have developed over time, is provided in **Section 1.2.**

GOOD PRACTICE RECOMMENDATIONS 2.1: BASELINE DATA
The collection and subsequent analysis of baseline data for all parameters should be undertaken by suitably qualified staff. **Discussion should be ongoing between investigators preparing the baseline environment descriptions for related parameters (e.g. physical processes and benthic ecology; fish and shellfish resources and commercial fisheries) to avoid unnecessary replication and to ensure that the ecosystem approach is developed. The ecosystem approach relies on the integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of resources and maintenance of ecosystem integrity.** **If specialist surveys are required, then these should be undertaken by well-qualified companies with experience of carrying out similar surveys.**

2.1.1 SCOPING STUDY

One of the most important stages in the EIA process is the scoping stage**.** The overall objectives of scoping a projects impacts would be to:

- Identify the potential impacts that could arise for each environmental parameter in order to determine the level of assessment that will be required in the EIA. This process is undertaken to ensure that all relevant issues are considered at the appropriate level during the EIA;

- Identify all existing sources of information that relate to the baseline environment. Conversely, to identify all data gaps and uncertainties, and to determine a methodology to resolve these; and

- Ensure early interaction with key consultees in the identification of potential impacts, thus promoting the active flow of information at the project level and ensuring a transparent and unbiased process. It is recommended, that a list of consultees is attached to the scoping document, along with a request that consultees identify any other relevant or interested parties who should be contacted.

Further details on Scoping, and how this fits within the wider framework of EIA, are provided in **Section 1.3**.

2.1.2 CONSULTATION

Consultation is one of the key components of EIA and is essential to data collection. Consultation with stakeholders ensures that project assessors maximise the opportunity to find previously unknown sources of data, thus potentially avoiding the need for detailed surveys.

Generic good practice with respect to consultation is provided in **Section 1.3**. The reader is referred to this section for a more comprehensive review of the key objectives and approaches of consultation. Parameter-specific guidance with respect to consultation is also provided within relevant sections (e.g. commercial fisheries).

2.1.3 DEFINING THE STUDY AREA

Overview

One of the most important aspects of any data collection exercise is to accurately define the spatial extent of the area over which data should be collected. At the simplest level, data should be collected over the area within which impacts are anticipated (the 'zone of influence'). However, data also needs to be collected from areas outside of the zone of influence in order that control sites might be established. Without control sites, subsequent monitoring of affected areas will not be valid as no direct comparison will be able to be made between 'impacted' and 'non-impacted' areas in order to enable allowance to be made for natural variations.

Data should also be collected from outside the predicted area of impact in order to place the baseline data into context with the surrounding environment. If certain resources are only recorded within the area of impact, and not within the wider study area, then the importance of these resources is greater and any impacts on them are likely to be more significant. Conversely, if the affected parameter is prevalent throughout the region, then the impact would be of less significance.

The zone of influence varies between different environmental parameters and can extend as far as adjacent coastlines (i.e. Continental Europe) with regard to changes in physical processes or be much more local in terms of ecological effects. Parameter-specific guidance on defining the study area is provided in each of the sections below. However, there are some generic principles that can be used to help define the extent of the study area around a marine aggregate extraction site.

Developing 'Conceptual Plans' to define the zone of influence

Recent CEFAS guidelines for benthic surveys (DTLR, 2002) advise that a distance of at least one tidal excursion from the limit of the proposed dredging should be the minimum extent of the survey area. However, it should not be assumed that sediment dispersion in the water column would be limited to the area within a single tidal excursion. The potential movement of re-deposited sediment as bedload also needs to be considered and it should be borne in mind that many areas exhibit asymmetrical currents, which transport sediments unequal distances on the ebb and flood tides.

It is, therefore, recommended that site specific conditions be taken into account on all occasions. Where available, the results of any existing numerical models that predict changes in water movements and the fate of suspended sediments should be used to refine the extent of the study area and the design of the survey. Where such models are not available, Admiralty Charts should be used as the basis for any decisions on survey extent, along with consultation with local stakeholders.

By collating relevant data related to local physical and hydrographic conditions, dominant sediment types and the proposed dredging operations, it is possible to develop basic, conceptual plans that show the predicted zone of influence associated with the aggregate extraction. One of the few such conceptual models that currently exist was developed by dredging contractors in conjunction with the assessment team for the Eastern English Channel Regional Environmental Assessment (REA) (Posford Haskoning, 2003). Details of this particular model plus guidance on how similar conceptual models can be developed and used within EIA are provided in **Section 4.2**.

GOOD PRACTICE RECOMMENDATIONS 2.2: STUDY AREA
The study area should be defined as early as possible within the EIA process. **The overall spatial extent of the study area should include the zone of influence and also a wider area where no impacts are predicted. By extending the study area, it will be possible to (a) select potential control sites and (b) determine the `uniqueness` of resources within the zone of influence compared to the wider study area.** **Information on the potential zone of influence can be obtained through the use of conceptual models. A framework for developing such conceptual models is provided in Section 4.2.** **Whilst promoting the use of such models in the definition of study area, it should be recognised that these models are currently based only on a sound understanding of the key processes. There are clear data gaps in the quantification of the processes and fluxes, which demands a cautious approach.**

2.1.4 DATA QUALITY, CONFIDENCE LIMITS AND NATURAL VARIATION

One of the key aspects of any data collection exercise is ensuring that full descriptions of the quality of the data obtained and also the confidence limits associated with these data are provided. The quality of data collected as part of baseline studies can vary significantly, as can the confidence in these data. Without recognition within the ES of these key factors, the reader will not be able to make a judgement as to where assumptions have been made or where findings are based on data in which there is very high confidence. It is also vital that natural variability, both spatial and temporal, is fully explored within a description of the baseline environment of an area.

In terms of temporal variation in ecological communities, this manifests itself over a number of time-scales. Variation typically exists both intra-annually (seasonally) and inter-annually (between years), with different trends apparent at both these levels. For example, at the intra-annual (seasonal) level, abundance and distribution varies quite significantly for populations of fish and epi-benthos. In particular, many fish species exhibit marked migratory patterns in and out of specific areas during times of feeding and spawning. As a further example of seasonal variation, following spawning events, the abundance of juveniles in nursery areas of many species increases significantly, albeit for a relatively short time-scale (ranging from a few hours to a few months).

At the inter-annual level, larger scale variation is often noted, with distinct trends in the overall abundance and distribution of certain species. A good example of this is the decline in many North Sea fish stocks over the last 10 years or so. This trend has been observed through a continuous series of surveys over this longer time-scale.

With regard to natural spatial variation, ecological communities are rarely distributed evenly across the seabed. The density of a certain organism may differ greatly within a few metres. Consequently, when attempting to describe baseline conditions, the amount of spatial variation needs to be determined. Another important consideration when assessing the implications of aggregate extraction are the natural perturbations that exist within any environment. It is important to determine what these may be for each individual site in order to distinguish natural changes from those caused by the extraction activity. It is for this reason that baseline data collection should cover a wide temporal scale and that control sites should be monitored in order to record changes to an area outside the influence of the extraction activity. Natural changes could occur as a result of storm events, cyclical processes of erosion and accretion or natural successional changes in benthic community structures. For example, reefs built by *Sabellaria spinulosa* undergo natural cycles of erosion. Therefore, it is important to determine whether a reef is eroding naturally prior to undertaking extraction activities.

GOOD PRACTICE RECOMMENDATION 2.3: DATA QUALITY
The quality of data and any confidence limits associated with these data should be fully described within the ES. The question of natural variability should also be addressed, as far as is possible, within any baseline studies.

2.1.5 GEOGRAPHICAL INFORMATION SYSTEMS

Through Section 2 reference is made to the use of Geographical Information Systems (GIS) for the presentation and reporting of baseline data. The role of GIS in EIA, an overview of GIS capabilities, the software market, data integration and metadata are all discussed in more detail in **Appendix B (i)**.

REFERENCES

DTLR (2002) Guidelines for the conduct of benthic studies at aggregate dredging sites. Report produced by CEFAS on behalf of the Department for Transport, Local Government and the Regions. May 2002. 117pp.

Helsinki Commission (HELCOM) Recommendation 19/1 (1998).

ICES (1992). Effects of Extraction of Marine Sediments on Fisheries. *ICES Co-operative Research Report No: 182.* ICES, Copenhagen.

ICES (2001). Effects of Extraction of Marine Sediments on the Marine Ecosystem. *ICES Co-operative Research Report No: 247*. ICES, Copenhagen.

ICES (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM2003/E:07. Ref. ACME, ACE, D.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). Scoping the assessment of sediment plumes from dredging. *Construction Industry Research and Information Association.*

MAFF (1993) Guidelines for assessing marine aggregate extraction. Laboratory Leaflet, MAFF Directorate of Fisheries Research, Lowestoft, 73: 12pp.

ODPM (2002). *Marine Minerals Planning Guidance Note 1 (MMG1): Guidance on the extraction by dredging of sand, gravel and other minerals from the English seabed*. Office of the Deputy Prime Minister. The Stationery Office, London.

Posford Haskoning (2003). Regional Environmental Assessment for Aggregate Extraction in the Eastern English Channel. Report on behalf of East Channel Association. January 2003.

SECTION 2.2 DESCRIPTION OF THE PROPOSED ACTIVITY

2.2.1 THE NEED TO COLLECT BASELINE DATA

Once the Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations come into force, there will be a statutory requirement to provide information that describes the proposed dredging activity. The exact information required in relation to this issue, is set out in Schedule 1 to the Regulations and briefly summarised in **Box 2.1**.

Apart from statutory requirements, it is also essential that information on the proposed dredging activity is provided within an ES so that an assessment of the potential impacts of this activity can be made. Without details on the scale, nature, spatial extent and timing of the dredging activity, it will not be possible to accurately predict any potential impacts on the physical, biological and human environment.

For example, it is a requirement of MMG1 that information is provided on the proposed operating methods to be adopted by the dredger, in terms of overflow arrangements and screening requirements. Without these data, it will not be possible to produce numerical plume models that will predict the spatial extent of any plume produced or any depositional effects. Similarly, information is required, again under MMG1, on the estimated number of shipping movements on an annual and, where appropriate, seasonal basis and the number of vessels likely to be operating within the area at any one time. The routes likely to be taken by dredgers to and from the application area should also be specified. Without these data, potential impacts on other sea uses, such as commercial shipping and fishing vessels, will not be able to be assessed.

2.2.2 DATA REQUIREMENTS

Box 2.1 Information referred to in the definition of ES (2001 Regulations)

Part I

1. Description of the project, including in particular:

(a) a description of the physical characteristics of the whole project and the land-use requirements during the construction and operational phases; and
(b) a description of the main characteristics of the production processes, for instance, nature and quantity of the materials used.

Part II

1. A description of the project.

These requirements are described in more detail in MMG1 (ODPM, 2002) and, for ease of reference, are summarised below.

2.2.3 MARINE MINERALS GUIDANCE NOTE 1: SCHEME DETAILS REQUIRED

- **The location of the proposed dredging area should be specified by a list of chart co-ordinates together with a map showing its location in relation to the surrounding sea area, other dredging areas and adjacent coastlines;**

- **The size of the area specified in square kilometres;**

- **The total volume of material to be extracted together with an indication of the maximum depth to which material will be removed;**

- **A description of the material to be extracted, including the particle size distribution of the material found within the proposed dredged area. This should be presented as the percentage of gravel, sand and finer material, at representative locations within and adjacent to the application area;**

- **The type of dredgers to be used (e.g. trailing suction hopper dredger), together with details of the vessels' load capacity, overflow arrangements and operating methods. It should be made clear whether on-board screening (i.e. rejection of particular size fractions) is to be used, and the likely nature and quantity of material to be returned to the seabed as a result of screening;**

- **The proposed annual extraction rate and the predicted lifetime of deposits;**

- **Estimates of the likely number of shipping movements on an annual and, where appropriate, seasonal basis and the number of vessels likely to be operating within the area at any one time. The routes likely to be taken by dredgers to and from the application area should also be specified;**

- **Details of proposed operational control procedures to ensure that dredging only takes place in the permitted area and that interference with other uses of the sea is minimised both within and outside the proposed extraction area. Applicants should consider appropriate notification and liaison arrangements with other relevant users of the sea (e.g. fishermen) to ensure harmonious working relationships between the different parties; and**

- **The need to exploit the resources in question through careful, comparative consideration of local, regional and national need for the material in relation to the identified impacts of the proposal and the relative environmental and social costs of provision from other marine and terrestrial sources.**

2.2.4 ICES GUIDELINES FOR THE MANAGEMENT OF MARINE SEDIMENT EXTRACTION

As well as the data requirements set out in MMG1, there are some additional requirements relating to the proposed activity set out in the ICES Guidelines for the Management of Marine Sediment Extraction (ICES, 2002). It is recommended that these additional requirements are met within the ES.

- **Spatial design and configuration of aggregate dredging;**

- **Substrate composition on cessation of aggregate dredging;**

- **Proposals to phase (zone) operations;**

- **Number of days per year on which aggregate dredging will occur;**

- **Whether aggregate dredging will be restricted to particular times of year or parts of the tidal cycle;**

- **Direction of aggregate dredging (e.g. across or with tide);**

- **Energy consumption and gaseous emissions;**

- **Ports for landing materials/servicing ports;**

- **On-shore processing and onward movement; and**

- **Project-related employment.**

2.2.5 METHODS OF DATA COLLECTION

Information from applicant (dredging company)

The majority of the data requirements outlined above will be able to be provided by the dredging company making the application for an extraction licence. With respect to data relating to the physical environment at the site (e.g. sediment composition), data are usually obtained at both the prospecting survey stage (undertaken by the dredging company prior to applying for a full extraction licence) and during surveys undertaken specifically as part of the EIA process (e.g. benthic surveys and physical surveys).

More specifically, data on the physical nature of the site can be collected using the following methods (further details on the methods for collecting physical data are described in **Section 2.3**):

- Seismic acquisition (side scan sonar);
- Review of bathymetric data;
- Vibracore sampling; and
- Grab sampling for Particle Size Analysis (PSA).

2.2.6 DATA ANALYSIS AND PRESENTATION

The requirement for direct analysis of the data described above is limited, as they are only required so that detailed analysis and assessment of other potential impacts can be undertaken. In terms of data presentation, it is recommended that the following information is presented, either in the form of tables or figures:

- Co-ordinates of the proposed extraction site;
- Proposed zoning/dredging management plan;
- Predicted production levels and dredging activity at differing production levels;
- Estimated depth that dredging will occur to;
- Details on estimated screening;
- Predicted dredger occupancy within the site at differing production levels and during a typical (24hr) day; and
- Estimated total dredged area over the lifetime of the licence at differing production levels.

In order that these data are collated and presented in a single document, it is highly recommended that a Resource Management Plan is developed for all applications. This plan should include all the information set out above and should be used as the basis for the impact assessment. This plan should also be able to be updated, when and where required, and should provide a transparent overview of the nature and extent of any proposed dredging.

GOOD PRACTICE RECOMMENDATION 2.4: RESOURCE MANAGEMEN T
Details on proposed dredging activity, i.e. zoning, extraction rates, areas to be dredged and occupancy times, should be set out in a Resource Management Plan.

REFERENCES

ICES (2002). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM2002/E:06. Ref. D, ACME, ACE.

ODPM (2002). *Marine Minerals Planning Guidance Note 1 (MMG1): Guidance on the extraction by dredging of sand, gravel and other minerals from the English seabed*. Office of the Deputy Prime Minister. The Stationery Office, London.

SECTION 2.3 PHYSICAL PROCESSES

2.3.1 THE NEED TO COLLECT BASELINE DATA

Establishing a baseline understanding of the physical conditions and physical processes operating at, and in the vicinity of, a proposed dredging site is important for a number of reasons:

- An understanding of existing processes is essential to assess the likelihood of the activities proposed causing an impact;
- A knowledge of the baseline physical environment provides the benchmark for any future changes to be measured against;
- Data on the physical environment provides important input to the assessment of effects on a number of other environmental parameters;
- The data gathered and knowledge accumulated in developing the baseline add to the overall knowledge base and, therefore, assist in managing the seabed and adjacent coastline; and
- To provide input into any subsequent numerical modelling work that is required within the EIA process.

2.3.2 LITERATURE-BASED DESK STUDY (SCOPING)

At the start of any study into the potential impacts of a proposed marine aggregate extraction scheme, an important step is to collate and review existing information on the physical conditions of the site in question. Such a review should include consultation with the relevant licensing authority, statutory consultees, and other interested parties. By undertaking well-targeted consultation at the start of the data collection process, time and effort will be saved during the later data review process, as key organisations and individuals with site-specific knowledge should be able to detail relevant studies, data-sets and survey information that will assist in the description of the baseline environment.

GOOD PRACTICE RECOMMENDATION 2.5: SCOPING CONSULTATION
At the first stage of the EIA process, a scoping study should be undertaken (see Section 1.3 for details). During the production of the initial scoping report, consultation should be undertaken with a range of key organisations that may hold data on the physical environment.

2.3.3 BASELINE DATA REQUIREMENTS

This section provides details of the information that should be included in the description of the baseline physical environment. The data requirements set out below are in accordance with the guidance provided in key documents including MMG1, draft Marine Aggregates Dredging Policy (South Wales) and ICES Guidelines for the Management of Marine Sediment Extraction.

Based on the review of these existing guidelines and current practices, the baseline description of the physical environment can be broken down into three topics, which cover:

- A sub seabed description (Geology);
- A description of seabed form and composition (Geomorphology); and
- A description of the processes acting on the seabed (Physical Processes).

Box 2.2 Summary of baseline data requirements for physical processes

GEOLOGY
- **A description of the geology**

GEOMORPHOLOGY
- **A description of the bathymetry**
- **A description of bed forms**
- **A description of the characteristics of seabed sediments**
- **A description of seabed mobility**
- **A description of coastal morphology and change**

PHYSICAL REGIME
- **A description of the tidal regime**
- **A description of the wave conditions**
- **A description of sediment transport pathways and rates**
- **A description of suspended sediment concentrations**

Contact details for key organisations and data holders are provided in **Appendix B (iii) and (iv).**

2.3.3.1 GEOLOGY

A description of the geology

This description should include consideration of the lithology, geological structure and stratigraphy of the bedrock and any overlying quaternary deposits. Consideration should also be given to the geological evolution of the area in and around the proposed site. In addition, the geology of the adjacent coastline should be described when relevant.

2.3.3.2 GEOMORPHOLOGY

A description of the bathymetry

This is an important data set for understanding the processes operating on the seabed. The footprint of the proposed dredging will inform the scale of bathymetry should be considered (i.e. an area aligned with local tidal flows).

A description of bed forms

The identification and interpretation of bedforms is important in gaining an overall understanding of the dominant processes at the seabed. Bedforms are indicators of the speed and direction of sediment transport driven by tidal and/or wave driven currents.

Bedforms should be mapped, noting their location, size, orientation and geometry. This information will then allow an interpretation of the relationship of the features to present day processes (i.e. waves, tides, currents). At present no standard bedform classification exists in terms of scale, with different boundaries of scale being used by different authors. However, such differences do not affect the interpretation of the bedforms. The principal bedform types are reproduced in **Box 2.3**. Further details regarding the nature, classification and interpretation of bedforms are provided in Pantin (1991).

Box 2.3 Classification of bedforms

Large Scale Bedforms
Tidal sand ridges; banner banks; linear deeps; distinctive substrates; submarine cliffs and platforms; sand sheets

Meso Scale Bedforms

Bedforms dependent on present day processes

Transverse Bedforms
sand waves; megaripples; transverse sand patches

Longitudinal Bedforms
sand streaks; obstacle marks; sand ribbons; longitudinal sand patches; furrows; elongate kolk depressions

Irregular or Equant Bedforms
sand patches (some); kolk depressions (some)

Bedforms not dependent on present day processes

Iceberg plough marks; ice rafted sediment mounds; pingo; pockmarks; gas blisters; furrow (relict or only partially active)

Photo 2.1 Example of Sand Waves Plot

Small-Scale Bedforms (less than 0.6m in width
bedforms related to sediment transport; biological forms (e.g. submarine reefs)

Reproduced from Pantin (1991)

This description of seabed features should also incorporate the location and description of any man made features, such as dredging furrows and trawler scars.

A description of the characteristics of seabed sediments

In order to consider sediment transport processes, knowledge of the characteristics of the seabed sediments is required. The following typical information should be used in a description of the seabed:

- The spatial distribution of particle sizes;
- The thickness of sediments; and
- The size distribution of particles in each location.

In describing the baseline seabed sediments, it is important that information relating to particle sizes is described accurately. This is particularly important as particle size is key to some of the EU Habitats definitions. Further detail on the classification of gravel, is provided in **Appendix B (ii)**.

A description of seabed mobility

Assessing the mobility of the seabed sediment is an important step in the assessment of the potential impact of proposed dredging on the movement of material. Several forms of investigation can be employed to evaluate the mobility of sediments on the seabed:

- Investigation of the existence, nature and behaviour of bedforms across the site. The presence of certain features can be taken as an indication that the surface sediments are mobile;
- Comparison of particle sizes with flows across the site to evaluate if thresholds for sediment movement are exceeded;
- Investigation of the spatial variations in particle size;
- Investigation of historical bathymetric changes at the site; and
- Assessment of other features on the seabed, for example, the existence of sand shadows in the lee of wrecks or other obstructions.

A description of coastal/seabed morphology and change where relevant

The degree of emphasis that is placed on the coast will be determined by considering the potential impact on the coastline. This will be informed by water depths at the site and other site specific conditions.

Due to the potential physical implications of dredging for adjacent coastlines, it is important to develop a detailed understanding of the dynamics of the adjacent coastline, with consideration of the relationship between the dredge site and the coast. This should include the following:

- A description of the different morphological units that make up the coastline, e.g. mudflats, saltmarsh and cliffs; and
- A discussion of past, ongoing and future processes of change along the coastline. This should take into account sea level rise where relevant.

Photo 2.2 Coastline subject to geomorphological change

Consideration of morphological development should also focus on offshore banks and other offshore features. The precise focus that is placed on the coast, and/or other areas, should be determined on a site-specific basis. For example, for an application in the Severn Estuary, consideration of the morphological development of the coast and banks will form an important element of the baseline. Whereas, an application to dredge a relict feature further offshore may not require a detailed consideration of morphological change.

2.3.3.3 PHYSICAL PROCESSES

A description of the tidal regime

There is the potential for dredging operations to result in changes to tidal currents, but such changes would typically be small and localised for marine aggregate extraction (Brampton and Evans, 1998). However, establishing an understanding of tidal currents as part of baseline studies is important, as this information feeds into the assessment of other potential impacts, such as alterations to the sediment transport regime, suspended sediment concentrations and wave transformation processes.

The following information should be included in the baseline regarding the tidal regime:

- The mean spring and neap tidal ranges within the proposed dredging area and mean water depth;
- A qualitative description of the tidal regime, to include a description of regional tidal currents; and
- A quantitative description of the tidal regime, including a description of data sources, a description of flood and ebb tide directions and speed across the site, and the direction and nature of residual currents.

A description of the wave conditions

One of the consequences of dredging will be the alteration to water depths at the dredge site. Such changes have the potential to alter wave climate at the site and hence to have an impact on the coastline that subsequently receives this wave climate. It is, therefore, vital to build up an understanding of the wave climate at both the site and offshore of the site.

It is also valuable to obtain data on the average number of storm days per year.

The following information can be used to represent the wave climate:

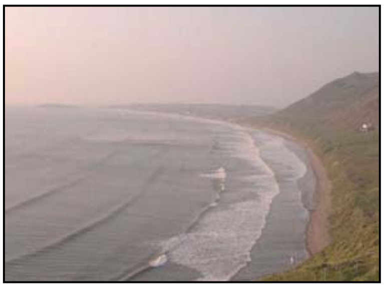


Photo 2.3 Breaking Waves
© Posford Haskoning, 2003

- A description of wind direction and frequency, directions of wave approach and fetch distances;
- Any sheltering effects. For example, where shallow sand banks that provide shelter to the coast are included within the application area, it is important to fully describe the effects these banks have on wave conditions on adjacent coasts. More specifically, the effects of the bank(s) on wave dissipation (wave energy) and transformation are all key data that should be provided within the baseline; and
- A description of data sources should be provided, along with data on extreme offshore wave conditions.

Wave modelling may be required at this stage of the ES in order to fully describe baseline wave conditions within the site. Details of wave modelling are provided in **Section 4.2.2**.

A description of sediment transport pathways and rates

An important aspect when assessing transport pathways is to consider the site within the wider context of sediment circulation and its affects the coastline. Consideration should also be given to the dominant mechanism driving sediment transport (e.g. tidal currents). Description of transport pathways and rates should include:

- A broad scale discussion of the key transport pathways in the region surrounding the proposed site (at least 50km across, for example, drawn from the relevant regional scale sediment transport study);
- An evaluation and discussion of any potential pathways between the site and the coast;
- An evaluation and discussion of sediment transport (littoral drift) along adjacent coast(s); and
- An evaluation and discussion of any potential sediment transport pathways between the site and any sensitive resources, e.g. shellfish beds, fish spawning areas, marine archaeological sites and nature conservation areas. These sensitive features may depend on the supply of sediments to maintain normal functioning, so any disruption could create adverse effects.

Tools for developing and understanding sediment transport pathways include:

- **Regional scale sediment transport studies**: Such studies provide broad scale details of sediment transport pathways. These are key documents in assessing dredging licence applications (i.e. HR Wallingford *et. al.*, 2002);

- **Sediment transport inferred from bedforms**. The asymmetry of sand waves can be used to indicate a direction of transport. When undertaking this assessment, greater confidence can be placed in transport direction indicated by the asymmetry of larger scale sand waves, relative to smaller scale features, which may form more rapidly and reverse under local tidal conditions;

- **Sediment transport inferred from numerical modelling**. Such models can provide predictions of sediment transport in an area where there is little information available with which to make an assessment. In deeper water, a tidally driven model will be sufficient, whereas in shallow water a model incorporating the effects of both waves and tides may be necessary; and

- **Sediment particle size trend analysis**. This technique is based on the principle that sediment transport involves the selective entrainment, transport and deposition of grains. As a result of selective deposition, the particle size distributions will vary along a sediment transport pathway. Such changes, generally recorded in terms of the mean, sorting and skewness, can be used to identify transport pathways.

A description of suspended sediment concentrations

A baseline assessment of suspended sediment load should be undertaken, along with an indication of seasonal variability, where applicable. Existing, albeit ephemeral, data will be important, as collecting data to represent all temporal scales over which variation occurs is difficult. To provide representative information, the description of the baseline environment should account for the above variations by providing data as a range. Background levels of suspended sediment concentrations should be defined as far as possible and the level of confidence and degree of representation provided by the data should be stated.

2.3.4 METHODS OF BASELINE DATA COLLECTION

Section 2.3.3 provides details on the baseline data that should be collected in order to describe the physical processes associated with the study area in question. This section provides details on the various methods that can be used to *collect* these data. A combination of these methods should be used to develop the comprehensive understanding of the physical environment at a proposed dredge site that is required to define the baseline. This section is divided into existing data sources (previous studies, research and raw data) and specific survey work.

Extent of the study area

One of the most important aspects of any data collection exercise is to accurately define the extent of the area over which data should be collected. The spatial scale over which the baseline physical environment should be considered, to a certain extent, needs to be determined on an individual project basis. The study area will be affected by factors such as the depth of water at the proposed site, proximity to the coast and other sensitive areas, nature and sensitivity of the adjacent coast and other sensitive areas, and proximity to features such as sand banks and other activities that could affect the physical environment. It is generally useful to distinguish between direct effects due to the impact of the draghead and indirect effects due to sediment fall out from plumes and subsequent bedload transport. However, as a general rule, a description of the baseline environment should cover the following:

Box 2.4 Extent of the study area for physical process studies

1. The area at, and directly surrounding, the dredge site, i.e. the likely footprint of the sediment plume associated with the dredging activity and from subsequent bedload transport (see **Section 4.2**) described as the **NEAR-FIELD**;

2. The area between the proposed dredge site and the coast, including offshore structures within this area, i.e. wind farms, described as the **FAR-FIELD**; and

3. The adjacent coast itself.

With respect to point 1, there is an increasing level of knowledge on the behaviour of sediment plumes and the re-deposition of sediments in aggregate extraction areas. Much of this knowledge has been obtained through a combination of specific field surveys and actual extraction activities. With this knowledge of the behaviour of sediments following extraction, it is possible to develop conceptual plans that illustrate the impact assumptions for the deposition and transport of sand around an operational dredge zone. Details on how to develop these plans are provided in **Section 4.2**.

GOOD PRACTICE RECOMMENDATION 2.6: DEFINITION OF THE STUDY AREA

Existing generic knowledge of the behaviour of sediment plumes and sediment deposition following marine aggregate extraction (from conceptual models) should be used to help define the study area at, and directly surrounding, the dredge site (see Sections 3.2 and 4.2).

It should be recognised that these models are currently based only on a sound understanding of the key processes and that further validation is required from field data.

It is also important to note that recent applications have been submitted for license areas in the East Channel Region (ECR), at water depths of over 30m. Dredging at this water depth will result in a reduced likelihood of such activities affecting the coast. If it is considered that the depth of water at the proposed dredge location would reduce the likelihood of an impact at the coast, then the focus of the physical environment baseline should be the footprint of the sediment plume (Point 1 above). Under this scenario the coastline, as described by points 2 and 3 above, should be included but with less focus. However, if the proposed dredging is in shallow enough water for potential impacts to occur at the coast (<30m), it would be necessary to focus the baseline on both the footprint of the dredge (Point 1) and the coastline (Points 2 and 3).

The following sources, listed under the three key topic areas (Geology, Geomorphology, Physical Processes), should be investigated to determine the availability and suitability of data required to describe baseline conditions. Data sets that are of use in defining baseline conditions for both the geological and geomorphological aspects of a site are listed in **Appendix B (iii)** and **(iv)**.

Site-specific surveys

Following a thorough review of existing data sources it will be possible to identify what aspects of the baseline physical environment require additional data collection. This section provides details of specific survey techniques that are appropriate for the different elements of the physical baseline. Reference is made, where appropriate, to literature sources containing more in-depth information on specific survey techniques and these documents should be consulted prior to undertaking any survey work.

In particular, the reader is referred to the following key reference.

KEY REFERENCE
DTLR (2002). Guidelines for the conduct of benthic studies at aggregate dredging sites. Report produced by CEFAS on behalf of the Department for Transport, Local Government and the Regions. May 2002. 117pp.

The decision as to which technique of the various techniques available to adopt should be made on a site specific basis and should also take into account comments from the initial consultation process.

GOOD PRACTICE RECOMMENDATIONS 2.7: BASELINE SURVEY PLAN
A plan for baseline surveys (including prospecting and seismic surveys) can be submitted to key organisations, such as CEFAS, the Joint Nature Conservation Committee (JNCC), English Nature (EN), Scottish Natural Heritage (SNH), Countryside Council for Wales (CCW) and English Heritage, prior to mobilisation. This should help to ensure that survey techniques are appropriate, particularly in areas of nature conservation and/or archaeological concern. **It is important that this plan provides enough detail for these organisations to comment on the proposed survey objectives, design and methodologies.**

2.3.4.1 GEOLOGY

Seismic (sub-bottom) profiling

Preliminary details on undertaking seismic (sub-bottom) profiling are provided in the CEFAS 2002 guidelines (see Key Reference above).

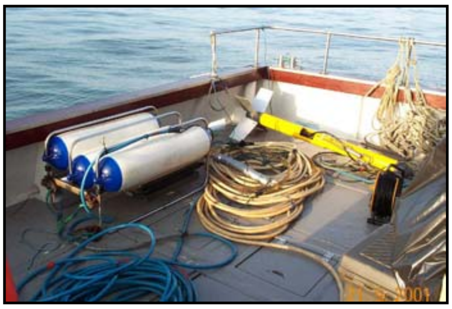


Photo 2.4 Typical boomer system
© Posford Haskoning, 2001

2.3.4.2 GEOMORPHOLOGY

Bathymetry and bedforms

GOOD PRACTICE RECOMMENDATION 2.8: BATHYMETRIC DATA
When collecting bathymetric data, a recognised set of guidelines for the conduct of surveys should be followed, e.g.: ***International Hydrographic Organisation (1998). IHO Standards for Hydrographic Surveys, IHO, Special Publication No 44, 4th Edition, 23pp.***

Single beam echo-sounding

Details on single beam echo-sounding are provided in the CEFAS guidelines (DTLR, 2002). The reader is referred to this document for further details.

GOOD PRACTICE RECOMMENDATION 2.9: SINGLE BEAM ECHO-SOUNDING
Where a single beam echo-sounder is selected, it is recommended that a sidescan sonar survey is also completed. The combination of these two systems should provide 100% coverage of the seabed, surface sediments and sediment transport features.

Multi-beam echo-sounding

Details on multi-beam echo-sounding are provided in the CEFAS guidelines (DTLR, 2002). The reader is again referred to this document for further details.

GOOD PRACTICE RECOMMENDATION 2.10: MULTI-BEAM ECHO-SOUNDING
The sounding density will relate to the type of equipment used for the survey. For multi-beam surveys, survey lines should be spaced at approximately 250m intervals, with cross lines at 100 m intervals.

Acoustic ground determination systems (agds)

AGDS are based on single beam echo-sounders and are designed to detect different substrata by their acoustic reflectance properties (Davies *et. al.*, 2001). A review of the use of AGDS in benthic physical surveys is provided by CEFAS (DTLR, 2002).

GOOD PRACTICE RECOMMENDATIONS 2.11: AGDS
AGDS should NOT be used in isolation as a tool for the prediction of physical seabed traits. **Ground-truthing methods (grab samples, video), should ALWAYS be used to confirm interpretations and should be undertaken in consultation with JNCC and/or the relevant Country Agency for nature conservation to avoid inappropriate techniques in sensitive areas.**

Sidescan sonar

Details on undertaking sidescan sonar surveys are provided in the CEFAS guidelines referenced above (DTLR, 2002).

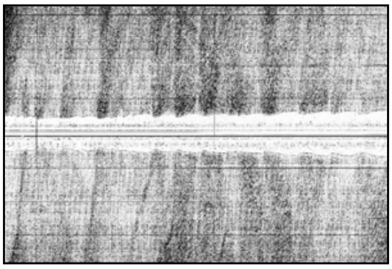


Photo 2.5 Typical sidescan sonar output © **Posford Haskoning, 2001**

GOOD PRACTICE RECOMMENDATIONS 2.12: ACOUSTIC TECHNOLOGY
Acoustic technology is constantly changing and improving. New acoustic systems and techniques regularly enter the market place. Therefore, it is important that new physical mapping methodologies are reviewed regularly, and augmented with the incorporation of improved acoustic techniques. **ICES have set-up the Study Group on Acoustic Seabed Classification (SGASC). This group aims to produce an ICES Co-operative Research Report on Acoustic Seabed Classification by 2005. Outputs from this study group should be used to keep up-to-date with developments in this area.** ***http://www.ices.dk/iceswork/workinggroups.asp***

Seabed sediments

In some cases, sampling undertaken as part of benthic assessments can be co-ordinated with sediment sampling undertaken as part of the physical assessment. Details on collecting and analysing seabed sediments are provided in the CEFAS guidelines (DTLR, 2002).

Any analysis should produce a standard set of grain size statistics/descriptors. When presenting the overall sediment size data for a site on a chart, it is useful to use the Folk Classification (see **Appendix B ii**).

2.3.4.2 PHYSICAL PROCESSES

Tidal regime

If there are very limited tidal level data for a particular site, then water levels should be recorded. There are a number of types of automatic tide gauges, suitable for seabed mounting, such as pressure gauges and acoustic gauges that can be used to collect such data.

Further details on collecting data on the tidal regime are provided in the CEFAS guidelines (DTLR, 2002).

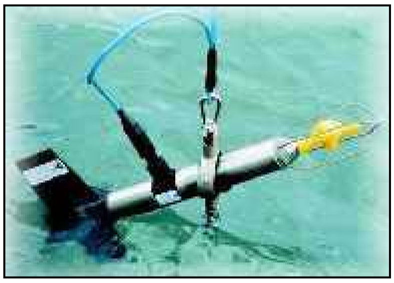


Photo 2.6 Typical Current Meter

Wave conditions

If, after the initial review of existing data, it is considered that suitable wave data are not available or cannot be extrapolated to cover the site, then site-specific measurements can be taken. Suitable methods of wave recording are summarised in **Appendix B (v)** and also in the CEFAS guidelines (DTLR, 2002).

A minimum of a full years recording is essential to enable a reliable extrapolation of the data and, due to the inherent risks associated with deployment of the required equipment at sea, a deployment of longer than one year may be required to obtain the necessary data record. However, these data would still need to be correlated with simultaneous, but longer-term records, such as the UKHO model (data from 1986 to date). In practice, data collection over this period may not be feasible within the scope of the EIA process and it is recommended that the maximum use is made of existing data sources, including the use of hind-casting models.

Sediment transport

For details on collecting baseline data with respect to sediment transport, the reader is again referred to the CEFAS guidelines (DTLR, 2002) for an overview of an appropriate approach.

Suspended sediment concentration

Following the data review exercise, if it is deemed that sufficient data is not available to provide an overview of background suspended sediment concentrations, then field data should be collected. There are a number of complicating factors involved in obtaining representative data for background suspended sediment levels at a particular location. Background levels will vary both temporally and spatially. Temporally, suspended sediment concentrations can differ on a seasonal scale, over tidal cycles and subject to weather events. Spatially, variations will occur vertically through the water column, with near-bed values generally greater than sea-surface values.

Tools for measuring background suspended sediment concentrations are summarised in **Appendix B (vi)** and in the CEFAS guidelines (DTLR, 2002).

2.3.5 BASELINE DATA ANALYSIS AND PRESENTATION

Data analysis

To a certain extent, the data analysis required in order to determine the nature of the geology, geomorphology and physical processes is implied in the description of the baseline data requirements. In-depth information is not provided here of specific analysis techniques as, in addition to varying between parameters, analysis will also vary according to the data available (e.g. the nature of the data, the spatial and temporal coverage of the data, etc.).

In terms of the parameters that determine the geology and geomorphology, analysis will involve processing the survey data (as appropriate) and combining this with collated existing data. Interpretation of which data will allow a conceptual understanding of the site to be developed. In terms of the physical process data, interpretation can range from a visual examination and qualitative description of the data to quantitative computations of large data sets (as in the case of wave data).

GOOD PRACTICE RECOMMENDATIONS 2.13: DATA PROCESSING

Where standard procedures and protocols for the processing of survey data exist they should be followed.

GIS provide a useful medium with which to store, manipulate and analyse data when developing the baseline. A GIS will:

- **Allow a comparison of data coverage;**
- **Aid data collection and collation decisions;**
- **Assist in the analysis of data;**
- **Provide a means of comparison of different data sets; and**
- **Assist in data presentation through data storage.**

Data presentation

Some general comments on data presentation can be made, as follows:

- The majority of data relating to geology and geomorphology (*geology, bathymetry, seabed characteristics and seabed mobility*) is ideally presented in chart form with an accompanying discussion and interpretation of the data;

- The remaining geomorphology parameter (*coastal morphology and change*) is most likely to be described through literature review and so is most suited to a textual discussion along with any appropriate illustrative material;

- Tidal levels should generally be presented in the form of tables;

- Tidal currents data can be plotted graphically using arrows to indicate the direction of the current, with the length of the arrow indicating the velocity of the current;

- Tidal currents can also be presented as time-series, histograms of speed and direction, residual drift, tidal ellipses, mean / maximum / minimum currents etc.; and

- Wave data can be represented in a wide variety of ways, as can information regarding sediment transport. For sediment transport data, plots illustrating potential transport pathways are most appropriate, along with accompanying text.

GOOD PRACTICE RECOMMENDATIONS 2.14: DATA PRESENTATION

Selection of an appropriate presentation method should be based on the required output for the baseline description and the data being utilised.

Consideration should be given to presenting data on charts together with bathymetry.

2.3.6 REPORTING OF BASELINE DATA

A specific stand-alone report should be produced that details the findings of the baseline data collection stage for physical processes.

Report format

GOOD PRACTICE RECOMMENDATIONS 2.15: REPORTING

Final reports should be produced both in a hard copy format and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. Reports should be converted to PDF format so that they can be easily e-mailed or made available on the Internet.

GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

REFERENCES

Brampton, A.H. and Evans, C.D.R. (1998). Regional seabed sediment studies and assessment of marine aggregate dredging. CIRIA C505. London.

DTLR (2002). Guidelines for the conduct of benthic studies at aggregate dredging sites. Report produced by CEFAS on behalf of the Department for Transport, Local Government and the Regions. May 2002.

HR Wallingford, CEFAS/UEA, Posford Haskoning, and D'Olier, B. (2002) Southern North Sea Sediment Transport Study. Phase 2. Report produced for Great Yarmouth Borough Council.

International Hydrographic Organisation, (1998). IHO Standards for Hydrographic Surveys, IHO, Special Publication No 44, 4th Edition, 23pp.

MMS (2001). Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment: Report to the US Minerals Management Service. Prepared by Research Planning Inc., W.F.Baird & Associates Ltd., and Applied Marine Sciences. October, 2001.

ODPM (2002). Marine *Minerals Planning Guidance Note 1 (MMG1): Guidance on the extraction by dredging of sand, gravel and other minerals from the English seabed*. Office of the Deputy Prime Minister. The Stationery Office, London.

Pantin, H.M. (1991) The seabed sediments around the United Kingdom: their bathymetry and physical environment, grain size, mineral composition and associated bedforms. British Geological Survey Research Report SB/90/1.

SECTION 2.4 MARINE ECOLOGY

2.4.1 THE NEED TO COLLECT BASELINE DATA

2.4.1.1 Benthic and Epibenthic Resources

The extraction of marine aggregate has its primary impact at the seabed, on bottom substrata and associated benthic communities. Such communities comprise 'epibenthic' organisms that live on the surface of the deposits, and 'infauna' that burrow below the surface of the deposits, sometimes to depths of more than 10cm. The 'epifauna' comprises organisms that may be attached to larger stable stones, shells and cobbles on the seabed, but also includes a major component of mobile organisms (such as shrimps and crabs) that often have a sporadic or seasonal occurrence in a particular area.

Benthic communities have the following features that are of importance both in terms of biodiversity and wider ecosystem function:

- They have strong links with other components of the marine ecosystem, providing a food resource for other species including those that are commercially harvested;
- They contain species that are commercially harvested themselves, such as crabs, shrimps and flatfish (see **Section 2.6**);
- They may have intrinsic value in terms of their rarity and hence conservation status (which may also apply to individual species); and
- Due to the open nature of the marine environment, evaluations of benthic biodiversity, productivity and trophic interactions may all bear upon wider ecosystem integrity (DTLR, 2002).

Certain species and habitats are also identified for protection under different Directives and initiatives. These include the European Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the Habitats Directive) and Biodiversity Action Plans (BAP). Where a species or habitat is identified that is specifically protected under relevant legislation or a national strategy, due consideration must be given to its status and the objectives for its management. The species and priority habitats listed in the Habitats Directive and the UK BAP include *Sabellaria* reefs and sands and gravels. Further details can be found on the relevant web sites (***http://www.ukbap.org.uk***) and in **Section 2.5** relating to Annex I habitats and Annex II species.

2.4.1.2 Marine Mammals and Elasmobranchs

UK waters support significant populations of marine mammals and elasmobranchs (sharks and rays). With regard to marine mammals, both pinipeds (seals) and cetaceans (whales, dolphins and porpoise) are found in internationally important numbers and, in some cases, have led to the designation of candidate Special Areas of Conservation (cSAC). In terms of elasmobranchs, many of these species are endangered within UK waters and 5 species are proposed for protection under the Wildlife & Countryside Act, 1981.

Marine mammals

With respect to seals, UK coastal waters support significant breeding populations of the grey seal *Halichoerus grypus* and the common seal *Phoca vitulina*. Both of these species are listed in Annex II of the Habitats Directive as "*animal species of community interest whose conservation requires the designation of Special Areas of Conservation (SACs)*". The UK also has its own specific legislation, The Conservation of Seals Act 1970, which makes it an offence to kill, maim or knowingly injure grey or common seals and establishes a general framework (including times of year and methods) in which seal killing is illegal.

The UK is also a signatory to the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS). ASCOBANS covers all toothed whales (Odontoceti) that occur in the North and Baltic Sea; the most important species being:

- Harbour porpoise (*Phocoena phocoena*);
- Bottlenosed dolphin (*Tursiops truncatus*);
- Common dolphin (*Delphinus delphis*);
- White-beaked dolphin (*Lagenorhynchus acutus*);
- Striped dolphin (*Stenella coeruleoalba*);
- Risso's dolphin (*Grampus griseus*);
- Killer whale (*Orcinus orca*);
- Long-finned pilot whale (*Globicephala melas*);
- Northern bottlenosed whale (*Hyperoodon ampullatus*); and
- Other beaked whales (*ziphiidae*).

Several cetacean species are also identified for protection under UK Biodiversity Action Plans (BAP). The plans identify the status of the species, factors affecting them and actions and objectives for this protection (see **Appendix B xi)**.

Elasmobranchs (Sharks and Rays)

Many species of sharks and rays found within UK waters are protected under nature conservation legislation. This is a reflection of the endangered status of many of these species due to a variety of factors, including over-fishing, habitat constraints and other environmental factors.

Both the basking shark (*Cetorhinus maximus*) and the common skate (*Diptura batis*) have Species Action Plans prepared for them, under the terms of the UK BAP (see **Appendix B xi).** The existence of these plans reflects the endangered status of these species and sets out key objectives and actions aimed at preventing further damage and promoting the recovery of existing populations.

Since 1998, the basking shark has also been listed in Schedule 5 of the Wildlife and Countryside Act, 1981. In addition, the Fourth Quinquennial Review of Schedules 5 and 8 of the Wildlife and Countryside Act, 1981, undertaken by the JNCC in 2001, proposed that the following five species of elasmobranch also be added to Schedule 5:

- Angel Shark (*Squatina squatina*);
- Common Skate (*Dipturus batis*);
- Black Skate (*Dipturus nidarosiensis*);
- Long-nose Skate (*Dipturus oxyrhincus*); and
- White Skate (*Rostroraja alba*).

Therefore, a legal requirement exists for an assessment of the importance of the general area around a dredge site for marine mammals to be undertaken; a requirement that is supported by the guidance on EIA for marine aggregate extraction laid out in MMG1 and the ICES Guidelines for the management of marine sediment extraction.

In practice, many of the sites selected for aggregate extraction are not significant for either marine mammals or elasmobranchs. However, detailed local assessment may find that specific parts of a study area are important to some of these species. For example, some parts of the seabed may be functionally important as nursery and/or pupping areas for certain elasmobranch species.

2.4.1.3 Sea Birds

Sea birds form an important component of the marine ecosystem, and also have the potential to be adversely affected by marine aggregate extraction (see below). Therefore, it is important that data are collected to determine the importance of the study area for these species, so that the potential for any impacts can be identified.

2.4.2 LITERATURE-BASED DESK STUDY (SCOPING)

As the first step in the EIA process, it is recommended that a Scoping Study is undertaken. With respect to marine ecology, this scoping study should involve the review, collation and assessment of any relevant data on marine ecology that exists for the study area, including published literature and previous Environmental Statements relevant to the study area. Contact should also be made with governmental and research agencies, e.g. CEFAS, to establish whether there are on going survey and monitoring initiatives in the study area.

In addition to the overall objectives of a Scoping Study, set out in **Section 1.3**, this review should also:

- Enable the study area to be accurately defined; and
- Enable a decision to be made as to whether or not a site-specific benthic survey is required, based on the level of data that currently exists for the study area.

If such a survey is required, the desk study will provide a rationale for an appropriate sampling design and sampling frequency, as well as an indication of the suitability of the various sampling devices to meet survey needs (DTLR, 2002).

Such a desk-based review will also reduce uncertainties at the planning stage by informing decisions about the type of sampling equipment required and the design of the survey. As a consequence, a desk study will increase the cost-effectiveness of baseline survey sampling programmes.

Box 2.5 Information sources for pre-survey desk study

- Published literature
- Geological maps and Admiralty charts
- Research and monitoring initiatives by government and research agencies
- Industry surveys at the prospecting stage (especially the output from acoustic surveys and the sampling of sediments using vibrocores or hydraulic grabs)
- The results of mathematical models utilised to predict changes in water movements or particulate transport
- Published Environmental Statements for previous developments in the study area
- Consultation with individuals with knowledge of the area (scientists, fishermen etc.)
- Technical Reports produced as part of SEA process being undertaken by the DTI for the oil and gas industry - see ***http://www.offshore-sea.org.uk/sea/dev/html_file/library.php***

The desk study should also give consideration to cumulative impacts on the seabed from a variety of human activities. Cumulative impacts have been defined as effects on the environment, either from the summation of individually minor but collectively significant impacts, or as a result of the interaction of impacts from one or more source (DETR, 2001). The influence of other existing activities in the area should be considered in the planning of the benthic survey (e.g. potential for the area to be used for fishing activities, presence of pipelines, etc.). The outcome of research by CEFAS, and others, into the cumulative impacts of marine aggregate extraction will, in due course, help in the planning of sampling programmes (DLTR, 2002). Cumulative impacts were also considered in the Eastern English Channel Regional Environmental Assessment (Posford Haskoning, 2003).

2.4.3 BASELINE DATA REQUIREMENTS

Based on a review of existing guidelines, and in particular MMG1, draft Marine Aggregates Dredging Policy (South Wales) and ICES Guidelines for the management of marine sediment extraction, the following data related to the biological status of the study area are required for any EIA carried out for marine aggregate extraction.

Benthic and Epibenthic Resources

- **A description of the benthic communities present within and adjacent to the application area. This should include evaluation of the typical assemblages of different species, covering diversity, abundance, extent, species richness, representativeness, naturalness, rarity and fragility in and around the proposed dredged area;**

- **A summary of the survey and analysis techniques used, records of all species identified and their abundance at each sampling station;**

- **An indication of the sensitivities, and vulnerability, of particular habitats and species, for example *Sabellaria* reefs or *Modiolus* beds;**

- **An assessment of known predator-prey relationships and measures of abundance of dominant or key species (e.g. those that support other species or provide an important niche for other species) likely to be influenced by dredging, including temporal and spatial population dynamics of the benthic assemblages; and**

- **A description of any ecologically sensitive species or habitats that may be particularly vulnerable to extraction operations.**

Marine Mammals and Elasmobranchs

- **An assessment of whether or not the study area provides a feeding ground for populations of marine mammals and elasmobranchs;**

- **An assessment of whether or not the study area provides a breeding ground for populations of marine mammals and elasmobranchs; and**

- **An assessment of whether or not the study area supports migratory routes of marine mammals and elasmobranchs.**

Sea Birds

- **An assessment of the importance of the wider study area for sea birds.**

GOOD PRACTICE RECOMMENDATION 2.16: DATA REQUIREMENTS

Not all these data requirements will need to be investigated at the same level. The decision as to which data requirements should be investigated in the greatest detail should be determined through scoping.

2.4.4 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods of data collection that can be adopted to gather the information described above. It is expected that a combination of these methods would be used in order to provide the most robust and comprehensive collection of baseline data possible.

2.4.4.1 Benthic and Epibenthic Resources

For the majority of EIAs related to marine aggregate extraction activities, site-specific benthic and epibenthic surveys are usually requested by regulatory bodies. Guidelines for the conduct of benthic studies at aggregate dredging sites were prepared by CEFAS in 2002, on behalf of the Department of Transport, Local Government and the Regions (DTLR, 2002). These guidelines were produced in response to the rapid increase in survey work required for Environmental Statements to accompany dredging applications, and in response to impending legislation which will bring extraction activity under statutory control (DTLR, 2002).

These guidelines provide information on the following:

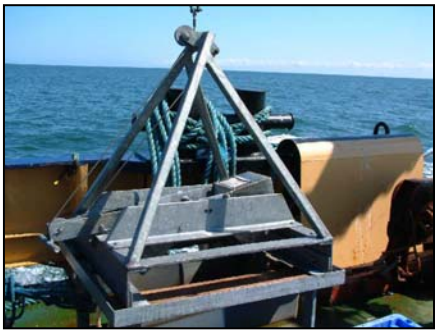


Photo 2.7 Hamon Grab ©MESL-Photo Library

- Planning and design of benthic surveys at aggregate extraction sites;
- Conduct of benthic surveys at aggregate extraction sites;
- Approaches to processing benthic samples;
- Remote acoustic methods for examining the seabed;
- Oceanographic surveys;
- The collection and analysis of sediment samples for particle size analysis;
- Methods for data analysis of benthic samples;
- Quality assurance;
- Format for reporting findings from environmental surveys; and
- Future developments.

In addition to guidelines set out in the document above (DTLR, 2002), the following Good Practice recommendations are also made.

GOOD PRACTICE RECOMMENDATIONS 2.17: GRAB SAMPLING

If scoping or pilot surveys indicate that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, *Modiolus* reefs or Serpulid reefs, then grab sampling should NOT be undertaken.

The assessment of grab success should intrinsically account for locations where the grab did not fire. This is important information as it could indicate the presence of a bedrock reef or stony reef and, as such, should always be recorded.

Epibenthic Survey Methods

In addition to collecting data on benthic in-fauna, data are also required on the epibenthic resources of a study area. Therefore, epibenthic surveys are also required. As for benthic sampling, the guidelines produced by CEFAS on behalf of DTLR (DTLR, 2002), provide details on the approach to undertaking epibenthic surveys. The reader is referred to these guidelines for further details.

Photo 2.8 Beam Trawl
© MESL-Photo Library

GOOD PRACTICE RECOMMENDATIONS 2.18: EPIBENTHIC SURVEYS

For details on the conduct of epibenthic studies at aggregate dredging sites, the reader is referred to "Guidelines for the conduct of benthic studies at aggregate dredging sites", prepared by CEFAS on behalf of the DTLR (DTLR, 2002).

If the study area supports a significant static-gear fishery (pots, nets, long-lines), then consideration should be given to adopting an alternative sampling method other than trawling or dredging, i.e. remote sensing (see below).

If scoping or pilot surveys indicate that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, *Modiolus* reefs or Serpulid reefs, then trawling and/or dredging should NOT be undertaken.

Underwater video and still photography

Alternative methods to epibenthic trawls and dredges include remotely deployed underwater video and still photography. Further details on these methods are again provided in the CEFAS guidelines (DTLR, 2002). Additional guidance is also provided in the Marine Monitoring Handbook, produced by the JNCC (Davies *et. al.*, 2001). For a more detailed review of these methods, the reader is referred to Procedural Guideline Numbers. 3-5 and 3-12 in this document.

KEY REFERENCE

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. and Vincent M. (Eds). (2001). Marine Monitoring Handbook. Joint Nature Conservation Committee, Peterborough. 405pp.

2.4.4.2 Marine Mammals and Elasmobranchs

Accurate data on the distribution of marine mammals and elasmobranchs are much harder to collect than baseline data on benthic invertebrates and fish. This is because these species are generally transient over large geographic ranges and they do not occur in great abundance. Therefore, any area would require long periods of monitoring (probably years), before any useful data could be obtained on the typical abundance of these animals and their use of an area for feeding, breeding or migration. In practice, a desk-based review of existing data is the typical format for collecting useful data.

Marine mammals

There are various sources of information on the population status and distribution of marine mammals in UK coastal waters. The Sea Mammal Research Unit (SMRU), based at the University of St Andrews, carries out research into seal and cetacean populations and can provide a reliable overview of the importance of a particular area for marine mammals, as well as providing advice on or carrying out monitoring programmes.

The Sea Watch Foundation also monitors cetaceans within British and Irish waters through its team of volunteers. These surveys occur from shore and at sea and provide a good source of information, where surveys have been carried out and where the coastline provides a high vantage point over the sea.

The RSPCA is another useful point of contact as they can provide details of strandings and dead marine mammals for a particular area. Dead and stranded individuals can provide an indication of mammal presence in a given area and also provides a mortality baseline against which future impact assessment and monitoring methods can be designed.

Other sources of data on marine mammals can be obtained from the national nature conservation agencies, the JNCC, local wildlife trusts and County Recorders responsible for collating data on mammal sightings.

Data held by these organisations should be obtained through consultation. Contact details for these organisations are provided in **Appendix B (vii).**

Atlas of cetacean distribution in north-west European waters

Of particular note, is a recent publication by the JNCC of the "Atlas of cetacean distribution in north-west European waters[1]". The atlas is based on sightings made by hundreds of observers over the past 25 years and is a first for UK waters. It is also the first atlas globally to take full account of the variation between areas in the amount of searching that observers have carried out to gather the information. Although published by JNCC, the Atlas is a co-operative venture between three main organisations: JNCC, the Sea Watch Foundation and SMRU.

Joint cetacean database

The Joint Cetacean Database (JCD) comprises the most complete and detailed information that exists on the distribution of porpoises in the waters around the UK and represents the amalgamation of three cetacean databases from the JNCC, the SMRU and the SeaWatch Foundation. It includes sightings of porpoises at sea and related search effort made by the European Seabirds at Sea Teams, including the JNCC's Seabirds at Sea Team, and by Sea Watch contributors around the UK. The 1994 EU funded Small Cetacean Abundance in the North Sea (SCANS) data are also included. Most of the data are sightings made by trained personnel on board platforms of opportunity (i.e. vessels that are likely to encounter marine mammals).

The database presently comprises 403,000 effort records consisting of survey legs totalling 941,000km, and a cumulative search time of 97,000 hours. The data mainly pertains to the years 1979 to1998 and records start and end locations and times, distance travelled (which may be zero for timed cliff or static platform-based observations), duration of observation, sea state and observer. Sighting data include number of individuals, location and behaviour.

SEA technical reports

As part of the SEA process being undertaken by the DTI in relation to the oil and gas industry, the distribution of marine mammals in the various SEA areas has been reviewed through a series of Technical Reports. It is recommended that if dredging activity is to occur within one of the SEA areas, then the relevant reports be obtained. These reports are available from ***http://www.offshore-sea.org.uk/sea/dev/html_file/library.php***

Basking shark watch

Data on the basking shark sightings can be obtained from the Marine Conservation Society (MCS) web-page (***http://www.mcsuk.org***). In 1987, the MCS initiated the Basking Shark Watch. The reports from the period 1987 to 2001 are summarised in a recent report, produced by the MCS, entitled "Basking Shark Watch, 1987-2001 Report". A summary of this report is available from the MCS web-site or the full copy can be ordered from MCS, 9 Gloucester Road, Ross-on-Wye, HR9 5BU.

Elasmobranchs

Data on elasmobranchs can be obtained from a number of specific sources. As a first source of information, it is recommended that the Shark Trust be contacted (***http://www.sharktrust.org***). The Trust promotes the study, conservation and management of sharks, skates and rays in the UK and internationally. It has, as one of its priorities, a remit to improve records of catches, landings and international trade in species of sharks and rays. Therefore, they may hold relevant data.

Another potential source of data on elasmobranchs is from commercial and recreational fishermen. Details on Good Practice with respect to collating baseline data from these organisations are provided in **Sections 2.6** and **2.7.**

[1] Price £17.00 from the Natural History Book Service (**http://www.nhbs.com**), or phone +44 (0)1803 865913

GOOD PRACTICE RECOMMENDATION 2.19: PRECAUTIONARY APPROACH

Even considering the data sources listed, distribution information on marine mammals and elasmobranchs is still relatively patchy and uncertain. Therefore, a precautionary approach should be adopted in order to reduce potential impacts of aggregate extraction to a minimum.

2.4.4.3 Sea Birds

Data on sea bird numbers in UK waters are routinely collated as part of the JNCC Seabird Monitoring Programme, which summarises the present state of sea bird populations within British and Irish waters. Annual reports are produced which are available from JNCC. Details of the most recent report, published in 2002, are provided below:

Box 2.6 Data on sea birds in UK and Irish waters

Sea birds numbers and breeding success in Britain and Ireland, 2001 (UK Nature Conservation, No 26): R.A. Mavor, G. Pickerell, M. Heubeck and P.I. Mitchell

60 pages A4 softback ISBN 1 86107 541 3 2002

Previous reports and other relevant data on sea birds are available from:
http://www.jncc.gov.uk/communications/pubcat/birds-sb.htm

2.4.5 BASELINE DATA ANALYSIS AND PRESENTATION

2.4.5.1 Benthic and Epibenthic Resources

Details with respect to the analysis and presentation of baseline data from benthic and epibenthic surveys are provided in the CEFAS guidelines (DTLR, 2002).

Fish gut analysis

In addition to the methods set out in this document, it is suggested that, where feasible, a selection of fish stomachs should be retained from epibenthic samples so that gut analysis can be undertaken. This will enable site-specific information on the feeding ecology of certain species to be obtained. This gut analysis should be targeted at the 5 most dominant species within the samples. However, it should be noted that there are complicating issues such as seasonality, sample size and survey equipment needs which could lead to erroneous conclusions about the 'importance' of an area. Full consideration should, therefore, be given to these issues before undertaking stomach analysis.

Photo 2.9 Fish gut removal at sea ©MESL-Photo Librarv

Stomach analysis should be carried out following standard procedures, such as those described by Windell and Bowen, 1978 (in Bagenal and Tesch, 1978). The stomach, oesophagus and digestive tract should be opened, all contents removed and then examined under a microscope in order to identify all prey items present. All prey items should also be enumerated and any unidentifiable contents assessed as a percentage of the total stomach contents.

GOOD PRACTICE RECOMMENDATIONS 2.2O: GUT ANALYSIS

Consideration should be given to undertaking fish stomach content analysis in order to gain additional information on the use of the area for feeding purposes. There are complicating issues which need to be fully considered before this decision is taken.

Gut analysis should be targeted at the 5 most dominant species within the samples.

Ideally, a range of sizes of the same species should be retained for gut analysis, as for any one species, the main prey items of juveniles and adult fish are likely to differ significantly.

The benefits of obtaining data from gut analysis outweigh the small extra costs associated with collecting it.

Statistical analysis

Methods for the data analysis of benthic samples are provided in the CEFAS guidelines (DTLR, 2002), including an overview of the PRIMER v5 software package, which is widely employed and gained general acceptance as a tool for analysing benthic datasets (DTLR, 2002).

However, although PRIMER v5 is now well-established and used extensively by consultants undertaking benthic studies for marine aggregate extraction sites, it is also important to note that other methods of data analysis also exist. A summary of some of these is presented in **Appendix B (viii)**.

Data presentation

The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, to allow for ease of explanation. In particular, the following figures should be produced:

- Location of benthic survey grab samples in relation to the aggregate licence application area and other features such as bathymetry;
- Location of sampling (trawl) stations in relation to the boundaries of the proposed production licence;
- Distribution of sediment types for the benthic survey grab samples;
- Outputs of acoustic surveys;
- Distribution of community descriptors such as diversity, species richness, evenness and biomass of benthic survey grab samples;
- Distribution of key biotopes/community types;
- Location and spatial extent of any sensitive features or features that require special protection (e.g. BAP priority habitats); and
- Figures illustrating any major trends in the data (histograms of species diversity at each station, overall species density per standard area at each station, overall biomass per standard area at each station etc.).

2.4.5.2 Marine Mammals and Elasmobranchs

- The location of any sightings of marine mammals or large sharks, along with any inferred routes of migration.

2.4.5.3 Sea Birds

- Location of feeding, roosting and moulting aggregations.

Box 2.7 Use of Geographical Information Systems (GIS)

GIS have become an established tool used to display spatially referenced information. The graphical representation of information effectively illustrates what are often important spatial patterns in data in a way that cannot easily be achieved by other means.

For example, plots of grab sample locations can be superimposed over marine aggregate licence areas allowing inferences to be drawn concerning the relationships between the two data-sets. Furthermore, spatially mapped information can be themed to show additional information such as the species richness of grab samples, the intensity of dredging or the results of mathematical models predicting suspended sediment dispersion. Data-sets which provide 100% coverage maps, such as those produced during sidescan sonar surveys, can also be draped over bathymetric plots, for example within a GIS.

Figure 2.1, below, is an example of a thematic map, produced using GIS, showing the species richness of Hamon grab samples taken from a number of surveys of the Eastern English Channel in relation to marine aggregate licence application areas.

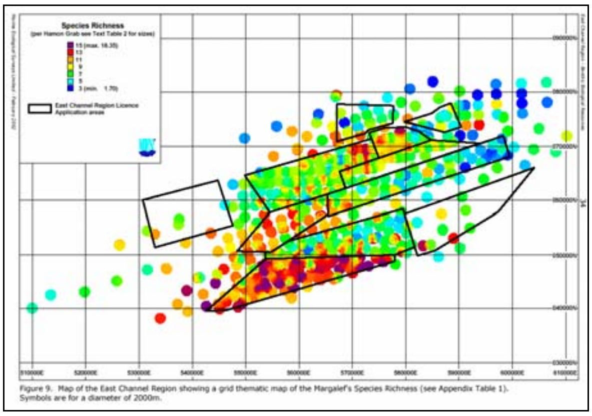


Figure 2.1 Map of the East Channel Region showing a grid thematic map of the Margalef's Species Richness (from MES Ltd, 2002, in Posford Haskoning, 2003)

2.4.6 REPORTING OF BASELINE DATA

Details on the reporting of baseline data with respect to benthic and epibenthic resources are provided in the CEFAS guidelines (DTLR, 2002).

The process of editing any stand-alone survey reports for inclusion into the published ES should involve the consultants responsible for producing the ES **and** the consultants responsible for producing the specialist survey. However, it is recommended that at least a summary of the materials and methods used, results and discussion are included within the overall ES.

GOOD PRACTICE RECOMMENDATIONS 2.21: REPORTING

If a large, technical benthic report is summarised within the final ES, then the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included.

Key organisations (CEFAS, JNCC, the relevant Country Agency and any local Sea Fisheries Committee/s) should be issued with a copy of the full technical report, complete with appendices containing the raw species data for each station sampled.

Final reports should be produced both in hard copy and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. All reports should also be converted into PDF format so that they can be easily e-mailed or made available on the Internet.

GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

REFERENCES

Brown, C.J., Hewer, A.J., Meadows, W.J., Limpenny, D.S., Cooper, K.M., Rees, H.L. and Vivian, C.M.G. (2001). Mapping of gravel biotopes and an examination of the factors controlling the distribution, type and diversity of their biological communities. Sci. Ser. Tech. Rep., CEFAS Lowestoft, 114: 43pp.

Clarke, K. R. and Warwick, R. M. (1994). Changes in marine communities: an approach to statistical analysis and interpretation. Plymouth Marine Laboratory. 1-144pp.

Clarke. K.R., and Gorley, R.N. (2001). PRIMER v5. User Manual. PRIMER-E, Plymouth, 91pp.

Davies, J., Baxter, J., Bradley, M., Connor, D., Khan, J., Murray, E., Sanderson, W., Turnbull, C. and Vincent M. (Eds). (2001). Marine Monitoring Handbook. Joint Nature Conservation Committee, Peterborough. 405pp.

DTLR (2002). Guidelines for the conduct of benthic studies at aggregate dredging sites. Report produced by CEFAS on behalf of the Department for Transport, Local Government and the Regions. May 2002.

Marine Ecological Surveys (MES) (2002). East Channel Region: Marine Benthic Resources. Technical Report prepared for Posford Haskoning. Regional Environmental Assessment for Aggregate Extraction in the Eastern English Channel. Report on behalf of ECA. January 2003.

Mavor, R.A, Pickerell, G, Heubeck, M and Mitchell, P.I. (2001). Sea birds numbers and breeding success in Britain and Ireland, 2001 (UK Nature Conservation, No 26): 60 pages ISBN 1 86107 541 3 2002.

MMS (2001). Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment: Report to the US Minerals Management Service. Prepared by Research Planning Inc., W.F.Baird & Associates Ltd., and Applied Marine Sciences. October, 2001.

ODPM (2002). Marine *Minerals Planning Guidance Note 1 (MMG1): Guidance on the extraction by dredging of sand, gravel and other minerals from the English seabed*. Office of the Deputy Prime Minister. The Stationery Office, London.

Posford Haskoning (2003). Regional Environmental Assessment. Report on behalf of East Channel Association. January 2003.

Windell, J.T. and S.H. Bowen (1978). Methods for study of fish diets based on analysis of stomach contents. Pages 219–226 *In* T.B. Bagneal and Tesch, ed,. Methods for Assessment of Fish Production in Fresh Waters, third edition. Blackwell Scientific Publishers, Oxford, England.

SECTION 2.5 NATURE CONSERVATION

This section of the report provides details on the baseline data that should be collected in order to define the baseline environment in terms of nature conservation aspects. More specifically, details are provided with respect to sites designated under nature conservation legislation and habitats and species of nature conservation interest. Detailed information in relation to marine mammals, elasmobranchs and sea birds, which are all either assigned protection under nature conservation legislation or are of significant conservation interest, has been provided in the preceding Section.

2.5.1 THE NEED TO COLLECT BASELINE DATA

There is a need to collect baseline data with respect to nature conservation for the following reasons:

- A significant proportion of the UK's total biodiversity is found in the 335,000 square miles of UK waters (Source: ***http://www.jncc.gov.uk/marine***);

- Many areas of the 335,000 square miles of UK waters are designated under local, national or international nature conservation legislation. For example, a network of SACs, designated under the EU Habitats Directive, exists around the UK, whilst Special Protection Areas (SPAs), designated under the EU Birds Directive, also exist in UK coastal waters. Together these sites form part of the *Natura* 2000 network;

- There are legal requirements to ensure that any form of development, including marine aggregate extraction, does not adversely affect the designated features of these areas;

- Crucially, the draft Offshore Marine Conservation (Natural Habitats &c) Regulations 2003, once implemented, will require any marine aggregate extraction application to have fully taken account of any nature conservation issues that may be encountered in the application area. The legal weight of the draft Regulations is considerable. For example, the draft Regulations provide for affirmation, amendment or revocation of an existing licence, if there is shown to be a significant effect (following appropriate assessment) on an area that becomes a European Marine Site. Further information on the draft Regulations is provided in **Box 2.8** and **Appendix A (viii);**

- There are also requirements to ensure that any form of development does not lead to an adverse effect on biodiversity targets (the UK Biodiversity Action Plan) and/or other areas, habitats and species of nature conservation importance.

Therefore, it is essential that an EIA for a marine aggregate extraction project fully describes all aspects of nature conservation within its initial baseline. The importance of considering nature conservation within the EIA process is especially relevant in light of recent legislative developments with respect to UK offshore waters (see **Box 2.8**).

Box 2.8 The "Greenpeace Ruling"

On the 5th November 1999 a UK High Court decision (following legal action by Greenpeace) ruled that the Habitats Directive "applies to the UK Continental Shelf and to the superjacent waters up to a limit of 200 nautical miles from the baseline from which the territorial sea is measured".

As a result of this judgement, it is predicted that certain *offshore* sand banks, reefs and other relevant features (including biogenic reefs such as those formed by *Sabellaria*, mussels and serpulid worms) will be nominated as candidate SACs in the near future. It is, therefore, important that developments in this process are followed by all bodies involved in the marine aggregate extraction industry. This is particularly relevant in the context of marine aggregate extraction moving further offshore to exploit new resources.

Although this judgement did not apply to the Birds Directive, the UK Government subsequently prepared Regulations to apply both the Habitats and Birds Directives to the offshore marine area. These regulations will be known as **The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2003** and seek to ensure that activities for which the UK has competence to manage

Box 2.8 The "Greenpeace Ruling"

or control are carried out in a manner that is consistent with the Habitats and Birds Directives.

A consultation document with respect to these Regulations was issued by Defra in 2003. This document seeks the views of a wide range of stakeholders on the Government's regulatory proposals for ensuring compliance with the Habitats and Birds Directives in the offshore marine area. Further details on these draft Regulations and the status of the consultation process are provided in **Appendix A (viii)**.

***Natura* 2000 in UK Offshore Waters (JNCC Report 325)**

Following the Greenpeace ruling, projects were initiated to investigate the designation of sites worthy of designation under these new Regulations. One of the key projects has been undertaken by the JNCC, who were commissioned by the Government to provide information to enable the identification of offshore SACs and SPAs. This exercise was conducted by the JNCC under a steering group consisting of representatives from sponsoring Government departments (Defra and DTI), other Government departments, devolved administrations and country conservation agencies.

The final report produced by the JNCC contains information necessary to identify those areas in UK offshore waters (12nm-200nm) that may contain species or habitats for which sites are required to be considered as potential cSACs or SPAs. The full report can be obtained from the following web-site:

http://www.jncc.gov.uk/Publications/JNCC325/intro325.htm

KEY REFERENCE

Natura 2000 in UK offshore waters: Advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters. JNCC report 325. C. N. Johnston, C. G. Turnbull and M. L. Tasker.

It should be noted that Report 325 was collated on the basis of information available at the time of publishing. Some of the information presented will have been superceded by further work and site-specific survey data.

The JNCC's most up-to-date thinking on offshore issues can be found in the JNCC Committee Papers (see *http://www.jncc.gov.uk/management/committee/index.htm*)

2.5.2 LITERATURE-BASED DESK STUDY (SCOPING)

As the first step in the EIA process, it is recommended that a Scoping Study be undertaken. With respect to nature conservation and protected species, this scoping study should identify all areas of nature conservation interest within the immediate and wider study area. The study should also identify the potential for protected species to be found within the study area and should determine whether the standard approaches apply to the site-specific conditions.

In order to address nature conservation issues, it is important to fully understand the remit of the relevant nature conservation agencies. Details of these, plus appropriate contact details are provided in **Appendix B (ix) and (x)**.

GOOD PRACTICE RECOMMENDATION 2.22: NATURE CONSERVATION DATA

As the first step in the data collection exercise, the JNCC and the relevant Country Agency (EN, SNH, CCW) should be contacted in order to obtain initial information on all nature conservation aspects of the study area.

2.5.3 BASELINE DATA REQUIREMENTS

Based on a review of existing guidelines, and in particular MMG1 (ODPM, 2002) and ICES Guidelines for the management of marine sediment extraction, the following data related to nature conservation are required for any EIA carried out for marine aggregate extraction.

Box 2.9 Summary of baseline data requirements for nature conservation

- **A description of the presence (and location) of any areas of special scientific or biological interest in or adjacent to the proposed extraction area, such as sites designated under local, national or international regulations (e.g. Ramsar sites, Marine Protection Areas (MPAs), Special Areas of Conservation (SACs), Special Protection Areas (SPAs), Sites of Special Scientific Interest (SSSI))[2];**

- **A description and subsequent assessment of any habitats or concentrations of species that *could* be included in future cSACs or SPAs (both within and outside 12nm) present in the area that is likely to be affected by the proposed activity;**

- **A description and subsequent assessment of whether any species protected under nature conservation legislation are present within the study area[3];**

- **If the licensed site is in water depths of <30m, then a description of the presence (and location) of any coastal designations (e.g. SSSIs);**

- **A description and assessment of the presence (and location) of any Biodiversity Action Plan (BAP), Species Action Plan (SAP) or Habitat Action Plan (HAP) features; and**

- **A description and assessment of any other features of nature conservation interest.**

GOOD PRACTICE RECOMMENDATIONS 2.23: DATA REQUIREMENTS

Not all of these data will need to be investigated at the same level. The decision as to which data requirements should be investigated in the greatest detail should be determined through scoping.

The JNCC and the Country Agencies are also currently working on guidance which will provide further details on what baseline data are required for the assessment of impacts on potential Annex I habitats and Annex II species. Once published, the reader should refer to this guidance.

Areas of special scientific or biological interest in or adjacent to proposed extraction areas

It is essential that the baseline section of the EIA provides details of any designated areas within the area of proposed activity in order that the potential for the dredging to create an adverse effect on the integrity of the designated feature can be fully assessed.

Where a proposed marine aggregate extraction area contains all, or part, of a site designated under the EU Habitats Directive, permission will only be granted if the competent authority (the Secretary of State in England, Environment Minister in Wales and Minister for Communities in Scotland) is satisfied that certain conditions are met (see **Box 2.10**). Therefore, there is a direct need to accurately describe and consider all aspects of nature conservation within a study area.

[2] A full list of statutory and non-statutory Marine Protected Areas is provided in Appendix B (xix)
[3] Baseline data requirements related to certain species protected under nature conservation legislation, e.g. certain marine mammals, elasmobranchs and sea birds, are detailed in Section 2.4

Box 2.10 Conditions required by the competent authority for dredging in a designated conservation area
• The proposal would not adversely affect the integrity of the site; • Appropriate conditions can be imposed that would mitigate any adverse impacts on the integrity of the site; • If it is determined that an adverse affect on the integrity of the site would resul,t that there are no practical alternatives to the proposal and that dredging must be carried out for imperative reasons of overriding public interest; • The proposed dredging is required for reasons of human health, public safety, beneficial consequences of primary importance to the environment, or any other reason of overriding public interest; and • Compensatory measures can be taken in order to preserve the integrity of the *Natura* 2000 network of sites.
Source: MMG 1, Draft Marine Aggregate Dredging Policy (South Wales)

With respect to **Box 2.10**, it is important to note that these same conditions will also apply for any operations *outside* designated conservation areas if the dredging is likely to affect site integrity. This is of particular relevance to marine aggregate extraction, as many of the potential effects can arise distant from the licensed extraction site itself.

Assessment of habitats or concentrations of species that could be considered in future cSACs or SPAs (both within and outside 12nm)

The above requirement arises due to the implications of the Greenpeace Ruling and the consequent development of the draft Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2003. JNCC Report 325 (and subsequent Committee papers) provides the information necessary to identify those areas in UK waters that may contain species or habitats required to be considered as potential cSACs or SPAs. In relation to the Habitats Directive, sites in the offshore zone are likely to be:

- Reefs;
- Sand banks that are slightly covered by sea water all of the time;
- Spectacular submarine structures; and
- Submerged or partially submerged sea caves.

However, for marine aggregate extraction, sand banks that are permanently covered by sea water and 'reefs' (including biogenic reefs such as those formed by *Sabellaria*, mussels and serpulid worms) are the most likely Annex I habitats to be encountered. It is also possible that some sites may be identified for the harbour porpoise and for sea birds (under the Birds Directive) (JNCC, 2004).

Criteria for designation as an SPA under the Birds Directive are:

- Extensions to existing breeding colonies;
- Inshore non-breeding concentrations; and
- Offshore feeding areas.

Additionally, areas that are not yet identified in JNCC Report 325 (and subsequent Committee papers) but support potential habitat suitable for designation may also be considered for selection (JNCC, 2004).

For both offshore cSACs and SPAs, site specific data will need to be assessed in respect of the above criteria in order to clarify the site's importance to nature conservation,

Presence of species protected under nature conservation legislation

In addition to the need to describe the distribution of existing and potential designated areas, it is also vital that the baseline environment describes whether or not any species protected under nature conservation legislation are present within the study area. Without such information, the impact assessment will not be able to fully comment on the scope for the dredging to have an impact on such species. If damage is caused to protected species as a result of the dredging, then the applicant could be subject to prosecution.

In water depths of <30m the presence (and location) of any coastal designations

It is important to recognise that marine aggregate extraction can create potential effects in areas outside the actual licensed area. In particular, in areas where the water depth is less than 30m, it is vital that the assessment fully explores the potential for impacts to arise on adjacent coastlines. If such coastal impacts are likely, then the baseline should also determine whether there are any designated sites on adjacent coastlines and describe the features that these are designated for, as they may also be affected.

Biodiversity Action Plan, Species Action Plan or Habitat Action Plan features

In addition to their remit to manage and assess potential impacts of development on designated sites (SAC, SPA, SSSI), the JNCC and the relevant Country Agencies also have responsibilities for assessing potential impacts and their significance on species or areas of nature conservation importance covered by BAPs, SAPs or HAPs.

In June 1992, the Convention of Biological Diversity was signed by 159 governments at the Earth Summit, which took place in Rio de Janeiro. It entered into force on 29 December 1993 and it was the first treaty to provide a legal framework for biodiversity conservation. It called for the creation and enforcement of national strategies and action plans to conserve, protect and enhance biological diversity.

In 1994, following an extensive consultation exercise, the UK government launched "Biodiversity: the UK Action Plan". The report established fundamental principles for future biodiversity conservation in the UK, including Partnership, Targets, Policy Integration, Information and Public Awareness (source: ***http//www.ukbap.org.uk***).

One of the key outputs of the UK Biodiversity Action Plan is the production of 3 main types of Action Plans:

1. Species Action Plans;

2. Habitat Action Plans; and

3. Local Biodiversity Action Plans.

Further details of these plans are provided in **Appendix B (xi)**. This Appendix also lists those habitats and species covered by HAPs and SAPs that may coincide with licensed sites.

Other features of nature conservation interest

As well as habitats and species protected under nature conservation legislation and/or SAPs/BAPs/HAPs, it is also important to provide a description and assessment of other features of nature conservation interest that may not be afforded official protection, but still have important conservation value. With regard to marine aggregate sites, a good example of such a feature is sub-tidal brittlestar beds. English Nature regard brittlestar beds as one of a number of important sub-features of Annex I habitats which aid in the definition of marine SAC quality and extent (Hughes *et. al.*, 1998 in EMU, 2002).

The report by Hughes *et. al.*, concluded that the conservation importance of subtidal brittlestar beds is because:

- The distribution of the biotope MCR.Oph.Oacu is restricted;
- The British Isles contain a large proportion of the known shallow-water epifaunal brittlestar beds, and these are the best-known examples of their type; and
- Large beds may be locally important elements in ecosystem functioning.

Therefore, although brittlestar beds do not receive any formal protection, they do form important components of some cSACs and are, therefore, of conservation importance. Consequently, the baseline of any ES should fully describe such features.

2.5.4 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods of data collection that can be adopted to gather the information described above. It is recommended that a combination of these methods is used in order to provide the most robust and comprehensive collection of baseline data possible.

Desk study

Much of the information required to describe baseline conditions with respect to nature conservation can be obtained from existing data sources. Therefore, a desk study is likely to be the most appropriate method of data collection. As part of this desk study, JNCC and the Country Agencies should be fully consulted in order to take advantage of their expert knowledge of this particular aspect. Full contact details for these organisations are presented in **Appendix B (ix).**

- Information with respect to *potential* SACs/SPAs can be obtained from JNCC Report 325 (and subsequent Committee papers);
- Sources of baseline information with respect to certain species protected under nature conservation legislation (marine mammals, elasmobranchs, sea birds) are listed in **Section 2.4**;
- Information on UK BAP species and habitats can be obtained from ***http://www.ukbap.org.uk*** and **Appendix B (ix)**; and
- Information on species and habitats that, although not afforded protection still have important conservation value as components of cSACs, can be found at ***http://www.ukmarinesac.org.uk.***

GOOD PRACTICE RECOMMENDATIONS 2.24: POTENTIAL SACs/SPAs
JNCC Report 325 (and subsequent Committee papers) should be fully reviewed in order to determine the *potential* for future SACs/SPAs to be designated within the proposed area of activity.

Site-specific surveys

In addition to information on designated sites obtained from the desk study, site-specific information on species and/or habitats of conservation importance may also be obtained through baseline surveys undertaken define the baseline marine ecological features of a site. Such surveys may include grab sampling, epibenthic trawling or dredging and/or video and stills photography. Details on such surveys are provided in **Section 2.4.4**.

2.5.5 BASELINE DATA ANALYSIS AND PRESENTATION

Data presentation

The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, to allow for ease of explanation. In particular, it is recommended that the following figures should be produced with respect to nature conservation:

- The location and spatial extent (boundaries) of any statutory designated sites of nature conservation interest within the wider study area;

- The location and spatial extent (boundaries) of any non-statutory sites of nature conservation interest within the wider study area;

- The location and spatial extent of any areas that contain habitats or concentrations of species that *could* be considered in future cSACs or SPAs (both within and outside 12nm) that are present in the area that is likely to be affected by the proposed activity; and

- The known extent and/or distribution of populations of protected habitats and species covered by HAPs and SAPs.

GOOD PRACTICE RECOMMENDATION 2.25: QUALIFYING FEATURES
Ensure that site-specific data is used in the assessment of presence or absence of qualifying features under the EU Habitats Directive or the EU Birds Directive

2.5.6 REPORTING OF BASELINE DATA

Due to the importance of nature conservation and the potential implications for all license holders of adverse effects arising within areas or on species of conservation importance, it is recommended that every ES prepared contains a separate section dealing with nature conservation issues. However, this section should be linked to other, relevant sections, where appropriate.

REFERENCES

EMU Environmental Ltd (2002). Areas 474 and 475 Eastern English Channel North & South. Environmental Statement. Prepared for Hanson Aggregates Marine Ltd. April, 2002.

Hughes, D.J. (1998). Subtidal brittlestar beds (Volume IV). An overview of dynamics and sensitivity characteristics for conservation management of marine SACs. Scottish Association of Marine Science (UK Marine SACs project), 78pp.

JNCC (2001). *Natura* 2000 in UK offshore waters: Advice to support the implementation of the EC Habitats and Birds Directives in UK offshore waters. JNCC report 325. Charlotte N Johnston, Caroline G Turnbull and Mark L Tasker.

JNCC (2004). Technical review comments on MIRO Best Practice Guide. Comments supplied by JNCC, EN, SNH and CCW with respect to the designation of offshore cSACs/SPAs.

SECTION 2.6 FISH AND SHELLFISH RESOURCES

2.6.1 THE NEED TO COLLECT BASELINE DATA

It is important to collect baseline data on fish and shellfish resources for the following reasons:

- They form part of the overall marine ecosystem and are often key species in local food webs, acting as both predator and prey to range of other associated species;
- Sedentary shellfish species (mussels, cockles, scallops) provide a direct route for carbon from the water-column to the sea-bed via filter-feeding; and
- Many species provide exploitable stocks for commercial fisheries, which in turn provide significant socio-economic benefits to many coastal areas.

2.6.2 LITERATURE-BASED DESK STUDY (SCOPING)

As the first step in the EIA process, it is recommended that a scoping study should be undertaken. With respect to fish and shellfish resources, it is recommended that the scoping study should involve the review, collation and assessment of any relevant data on fish and shellfish resources that exists for the study area, including published literature and previous Environmental Statements (ESs) relevant to the study area. Contact should also be made with governmental and research agencies, e.g. CEFAS, to establish whether there are on-going survey and monitoring initiatives in the study area (CEFAS young fish survey, CEFAS beam trawl surveys, IFREMER channel ground surveys etc.). It is recommended that the review should also present data on the ecological characteristics of key species within the study area, e.g. the resource status (at a regional level), spawning times, migration patterns, planktonic juvenile stages and feeding ecology (see Data Requirements, above).

In addition to the overall objectives of a scoping study, set out in **Section 1.3**, the study should also:

- Define the extent of the study area; and
- Enable a decision to be made as to whether or not a site-specific fish and shellfish resource survey is required, based on the level of data that currently exists for a study area.

If such a survey is required, the desk study should also provide a rationale for an appropriate sampling design and sampling frequency, as well as an indication of the suitability of various sampling devices to meet survey needs (DETR, 2001).

A considerable quantity of information for the UK coastal zone is available in published documents and reports, and it is recommended that this source of information is primarily used to determine the presence, distribution and seasonality of fish and shellfish resources (CEFAS, 2001).

Broad scale descriptions of the distribution of the most important commercial fish species are available for the North Sea and other shelf seas around the British Isles. These are based on annual research vessel surveys undertaken by both UK and other European Government Fisheries Laboratories and make use of data collected for the annual stock assessment process. These annual surveys are often co-ordinated by ICES with the results usually published in the scientific literature. These data are widely distributed spatially and, therefore, at best provide an overview of broad, spatial patterns in fish distributions (Posford Haskoning *et. al.*, 2004).

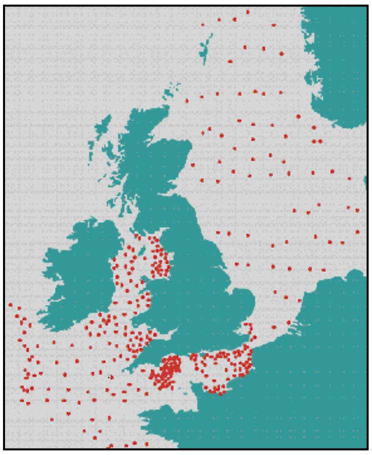


Figure 2.2 Areas covered by CEFAS groundfish surveys

There have also been a large number of more site-specific surveys carried out to describe the distribution and extent of specific areas, such as crab over-wintering grounds and fish spawning grounds (including the young fish survey). These data are of a higher resolution than that collected for stock assessment purposes. The quality of these data is uniformly high and much of these survey data have now been amalgamated into a comprehensive description of the distribution of key species in British Waters in the form of the UK Fisheries Sensitivity Maps (Coull *et. al.*, 1998).

The Department of Trade and Industry (DTI) also intends to complete a series of Sectoral Strategic Environmental Assessments (SEA) to assess the potential impacts of offshore oil and gas and renewable energy (e.g. offshore wind farms) developments (plans or projects), and to promote the environmentally sound development of Britain's hydrocarbon and renewable resources (CEFAS, 2001; DTI, 2002). Information provided as part of the SEA process will be used to inform the environmental sensitivity of the region and, as a result, blocks may be withdrawn or conditions imposed. A large amount of information on fish and shellfish resources is included within the current Technical Reports produced as part of the SEA process. These data include information on the distribution and seasonal abundance of eggs, larvae, juvenile and adult fish and represent some of the most accurate data currently available.

The reports can be obtained from:

- ***http://www.offshore-sea.org.uk/sea/dev/html_file/library.php; and***
- ***www.dti.gov.uk/energy/leg_and_reg/ consents/future_offshore/chp6.pdf***

Other useful information may be obtained from regional sea fisheries managers (i.e. Sea Fisheries Committee, Environment Agency etc), who may hold relevant commercial fisheries information.

2.6.3 BASELINE DATA REQUIREMENTS

Based on the review of existing guidelines, and discussions with relevant experts, the following key data requirements have been identified with respect to fish and shellfish resources. These data requirements represent a generic list of data that may need to be collected at any one site. It is very important to note that not all of these data will need to be collected at the same level of detail for every project. For this reason, scoping is a very important stage of the EIA process.

GOOD PRACTICE RECOMMENDATION 2.26: SCOPING

The decision as which data requirements should be investigated in the greatest detail should be determined through the scoping stage.

Box 2.11 Summary of baseline data requirements for fish and shellfish resources

- **The distribution and relative abundance of all fish and shellfish species of ecological, conservation or commercial significance should be described;**
- **The location and spatial extent of spawning grounds should be described;**
- **The seasonality of spawning activity should be described for key resource species;**
- **The location and spatial extent of nursery areas should be described;**
- **The seasonal use of nursery areas should be described;**
- **The location and spatial extent of over-wintering grounds for ovigerous (egg-bearing) crustaceans should be described;**
- **The location and spatial extent of shellfish beds should be described;**
- **The location, spatial extent and seasonal use of feeding grounds within the area by key species should be described;**
- **Migratory routes of finfish, crustaceans and cephalopods should be described; and**

Box 2.11 Summary of baseline data requirements for fish and shellfish resources

- **Any known predator-prey relationships between fish and shellfish species and benthic species likely to be adversely affected by dredging should be described.**

Distribution and relative abundance of all fish and shellfish species of ecological, conservation or commercial significance

This assessment should seek to describe the seasonality of these resources, as far as possible. Particular emphasis should also be placed on describing the distribution of fish species which have a vulnerable life-history stage that may be impacted by dredging activities. A selection of such species is provided in **Appendix B (xii)**.

GOOD PRACTICE RECOMMENDATION 2.27: DISTRIBUTION AND ABUNDANCE

When describing the distribution and relative abundance of fish and shellfish species within a study area, particular effort should be concentrated on those species which have a vulnerable life-history stage that may be impacted by dredging activities

Location and spatial extent of spawning grounds

The location and spatial extent of spawning grounds should be described initially for key resource species (those exploited by commercial fishermen), but should also consider those species that, although not commercially targeted, form an important part of the wider marine ecosystem. In particular, this applies to species that provide prey to larger species or have other important roles in ecosystem function. Particular regard should be given to benthic spawning species such as herring, black bream and sandeels, as these species rely on specific substrate types in order for successful spawning to occur (see **Appendix B xii**). Spawning grounds of key crustacean species, such as edible crab and lobster, should also be considered as part of this data collection exercise.

However, it should be noted that many species spawn over very wide areas, therefore, it may be difficult to assess the relative importance of the study site in the wider context (Seymour, *pers comm*). Large uncertainties also exist in the exact delineation of spawning areas (Courbet and Lemoine, 2003). These data are being obtained and updated by CEFAS, in parallel with further developments.

Seasonality of spawning activity for key resource species

By building up a picture of when key species (such as herring, black bream and sandeel) spawn, the most sensitive time of year, with respect to spawning activity, can be identified. Subsequently, operating procedures associated with any marine aggregate extraction could be modified to take account of these critical times. Therefore, it is critical that the seasonality of spawning is identified as part of any baseline study. However, as with the spatial extent of spawning grounds, uncertainties still exist with respect to the presence/absence ratio, i.e. when are the fish actually using these grounds (Courbet and Lemoine, 2003)?

Location and spatial extent of nursery areas

Nursery areas are defined as areas that are of particular importance, year-on-year, for juvenile fish (Anon, 2001). Emphasis should be placed on describing the nursery areas of key resource species, but there should also be an effort to identify the location and spatial extent of nursery area for non-target species that act as prey to key resource species or play a role in wider ecosystem function.

Photo 2.10 Poole Harbour: A Designated Bass Nursery Area

Certain nursery areas are defined within statutory regulations. For example, bass nursery areas are specified in the Bass (Specified Areas)(Prohibition of Fishing)(Veriation) Order 1999. Again, however, it should be noted that the nursery areas of many species extend over very large areas. It may, therefore, be very difficult to assess the exact spatial extent of nursery areas for certain species (Seymour, *pers comm*).

Seasonal use of nursery areas

As for spawning areas, the use and importance of nursery areas is seasonal, and varies at different times of the year. As part of the baseline data collection exercise, information should be gathered as to the seasonal use/importance of nursery areas within the study area.

Location and spatial extent of over-wintering grounds for ovigerous (egg-bearing) crustaceans

Mobile crustaceans, in particular the edible crab, undergo extensive migrations over a number of miles during the year, as an integral part of the breeding cycle. Following mating (in the period July to September) and subsequent spawning (during October and November) in inshore areas, ovigerous (egg bearing) female crabs move offshore to over-wintering grounds where they remain until the following spring/early summer period. During this over-wintering period, the crabs remain buried in coarse sediments and exhibit reduced mobility. As a result of this, they are particularly susceptible to dredging operations, both in terms of direct mortality and through loss of over-wintering sites (Rogers and Carlin, 2002). It is, therefore, essential that the location and spatial extent of these over-wintering areas are described as part of any baseline study.

Location and spatial extent of shellfish beds

Many species of shellfish, including mussels, cockles and scallops, are sedentary and do not have the ability to leave an area. Therefore, the effects of marine aggregate extraction activity on these species are potentially greater than for mobile finfish and other, mobile shellfish species. It is important that the location and spatial extent of any shellfish beds in a study area is determined as part of any baseline studies.

When considering existing data on the distribution of shellfish beds, it should be recognised that beds can be of an ephemeral nature. Therefore, it may be necessary to consult historical data which could demonstrate the likelihood of recolonisation in areas where no evidence of shellfish currently exists.

Location, spatial extent and seasonal use of feeding grounds within the area by key species

Some areas also provide specific feeding grounds for a range of different fish and shellfish species. As with other ecological functions, the use of feeding grounds is also seasonal in many cases, with certain species moving to and from discrete feeding grounds at different times of the year. The location, spatial extent and seasonal use of feeding grounds within an area should therefore be described in order to highlight sensitive times of year.

However, in reality, it may be very difficult to satisfy this particular data requirement, as adult fish that are not actually spawning, or about to spawn, usually feed opportunistically (i.e. wherever they are). Similarly, immediately after spawning, adult fish also feed expansively. Therefore, realistically, feeding takes place in all areas, so it may be difficult to clearly define exact feeding grounds.

Migratory routes of finfish and crustaceans

Due to the often seasonal use of spawning and nursery grounds, many fish and shellfish species undergo migrations to and from these key areas. The disruption of these migration pathways has the potential to create an adverse effect on the key activities of fish and shellfish species. For example, if the migration of adult fish onto spawning grounds is prevented or disrupted, then there may be serious consequences for spawning activity and subsequently the wider stock in future years. Other key migration pathways include the movement of edible crabs to and from offshore over-wintering grounds and inshore mating/spawning grounds and the passage of anadromous fish species (such as salmon and sea trout) along coastal areas on their way to freshwater rivers to spawn.

Any known predator-prey relationships between fish and shellfish species and benthic species likely to be adversely affected by dredging

In order to assess the wider potential effects of marine aggregate extraction on fish and shellfish resources, it is important to have an understanding of the predator-prey relationships that exist between key resource species and benthic species. An understanding of which benthic organisms key fish and shellfish species predominantly feed on, will enable an assessment to be made of the effects on these species that may arise if a reduction in benthic organisms occurs.

2.6.4 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods of data collection that can be adopted to gather the information described above. A combination of these methods should be adopted in order to provide the most robust and comprehensive collection of baseline data possible.

Extent of the study area

Generic approaches to good practice in defining the extent of the study area is provided in **Section 2.1**. With respect to assessing the baseline environment for fish and shellfish resources, the study area should extend beyond the 'zone of influence' described in **Section 4.2** and should include high-level data at a regional level at least. It is important to gather data at this wider level in order to place any site-specific data into context. A regional overview is also important given the mobile nature of many fish and shellfish resources.

Interpretation of official landings/stock assessment data

Defra fish statistics

One of the main sources of information on the status of fish and shellfish stocks within a study area are landings data, which are collated and reported by Government Fisheries Departments. The UK Fisheries Departments comprise the Department for Environment, Food, and Rural Affairs (Defra), the Scottish Executive Environment & Rural Affairs Department (SEERAD), the National Assembly for Wales Agriculture Department (NAWAD) and the Department of Agriculture and Rural Development for Northern Ireland (DARD). Departments in the Isle of Man, Jersey and Guernsey are responsible for administering fishing activity in their respective areas.

Since 1984, the regulations of the Common Fisheries Policy have required those UK vessels which account for most of the fish caught to provide the Sea Fisheries Inspectorates of the respective Fisheries Departments, located at the main ports, with information on each trip. This includes the main species caught, the area of capture and the quantities landed. Additional information is collected to complete, as far as possible, the coverage of fishery activity. The combined data provide the main source of catch and landings statistics for UK vessels and are recorded as tables in the United Kingdom Sea Fisheries Statistics.

Box 2.12 Fish landings data sets available from Defra

Port landings data
Monthly estimates of landings and landed values by port within England, Wales and Northern Ireland. These data include estimates for the under 10m fleet and, therefore, provide a comprehensive and very detailed record of fishery production.

Landings from ICES Statistical Rectangles
An ICES rectangle is a statistical area used by the International Council for the Exploration of the Seas (ICES) to spatially assess fisheries and marine community information. These rectangles form a grid covering the Northeast Atlantic, with each cell defined by half a degree of latitude and one degree of longitude.

Monthly estimates of landings and landed values (by gear/species/weight/value) are available for ICES sub-rectangles (quarter rectangles measuring approximately 30km x 30km) around the UK.

These data provide a high-level, regional overview of catches within a study area. They do not fully represent catches in these areas, as there is no statutory requirement under either EU or national legislation for vessels <10m in length to declare their catches. Information for this sector is collected informally with the co-operation of the industry.

Source: Fisheries Statistics Unit, Department for Environment, Food and Rural Affairs, Room 434 Nobel House, 17 Smith Square, London SW1P 3JR, Tel: 020 7238 5906, Fax: 020 7238 5889 fsu@defra.gsi.gov.uk

The Defra data provide a valuable record of the distribution of, and trends in, landings and form an important part of the analysis of any commercial fishery. However, any set of fisheries statistics has its limitations, and it is necessary at the outset to understand how they have been derived and how external factors might have influenced them. Further details of the Defra data and an overview of these issues is provided in **Appendix B (xiii)**.

Even taking the limitations into account, official landings data collated and published by Defra still represent one of the main sources of accessible information that enable high-level trends in the fish resources of an area to be described. For this reason, it is recommended that these data are collected and reviewed as part of any baseline study. In order to take account of medium to long-term trends in landings data, it is recommended that at least 5 years of data (preferably the 5 years of data prior to the date of current study) is collected and analysed. Where possible, longer time-series data sets should be obtained.

GOOD PRACTICE RECOMMENDATIONS 2.28: LANDINGS DATA
Obtain at least 5 years of landings data (preferably the 5 years of data prior to the date of the current study). **Defra Landings data should be treated with caution and all ESs should recognise that these data often represent an under-estimation of the true landings made within a fishery.**

ICES stock assessment reports

The Advisory Committee on Fishery Management (ACFM) is responsible, on behalf of ICES, for providing scientific information and advice on living resources and their harvesting to the European Commission and other member countries of ICES.

In formulating its advice on the management of approximately 135 stocks of fish and shellfish, ACFM utilises information prepared by numerous stock assessment Working Groups. These working groups produce annual stock assessment reports which provide information on the resource status/state of key stocks, as well as management advice. They also propose biological reference points for parameters such as fishing mortality and spawning stock biomass. These reports provide a high-level overview of the state of key fish stocks in UK waters for individual species and areas and can be of use in describing high level trends in certain key stocks. These annual stock assessment reports can be downloaded from the ICES web-site at; ***http://www.ices.dk/iceswork/acfm.asp***

Sea fisheries committee data

Regional Sea Fisheries Committees may have byelaw regulated permit schemes for the taking of shellfish which require returns to be supplied to the committee. Committees should be approached for this information, which is regionally specific and can provide detailed information within six nautical mile limits.

Consultation

As described above, although the Defra data represent one of the main sources of information accessible to enable high-level trends in the fish resources of an area to be described, these data still have limitations and, often, are not detailed enough to enable site-specific descriptions to be undertaken. For this reason, consultation with the local fishing industry is an essential part of any data collection exercise related to fish and shellfish resources.

Consultation with the fishing industry is important for any offshore or coastal development, in order that fishermen are made aware of any proposed works that may affect their routine activities or fishing gears. This need for consultation has been long recognised and, in 1981, MAFF published a “Code of Practice for the Extraction of Marine Aggregates” to avoid conflicts between fishing and the marine aggregate industry when new reserves are proposed for exploitation (MAFF, 1981). The publication of this Code of Practice was an important step in recognising and seeking to reconcile the operating difficulties that were being experienced on a routine basis. However, apart from consultation being required in order to make fishermen aware of any developments, it is also significant in helping to build up a picture of the baseline conditions of a study area with respect to fish and shellfish resources.

Fishermen spend more time at sea than most scientific survey vessels and catch fish and shellfish on a daily basis all year round. As a result of these activities, commercial skippers have an extensive knowledge of the distribution, location and spatial extent of spawning, nursery and feeding areas for key resource species and also often have knowledge of the seasonality of these resources and the location of migratory pathways for other key species. For this reason, it is essential that contact is made with representatives of the local fishing industry as early as is possible in a project life cycle so that this local knowledge can be obtained and used.

There are a range of key organisations that should be consulted.

Box 2.13 Key consultees for the collation of local fish and shellfish data

- Defra Sea Fisheries Inspectorate Fishery Officer;
- Local Sea Fisheries Committee Fishery Officer;
- National Federation of Fishermen's Organisations;
- Local Fish Producers Organisations; [4]
- Local Fishing Organisations (contact details usually obtained from Defra office or Local Sea Fisheries Committee office);
- Fish Merchants and Processors; and
- Individual Fishermen.

In terms of methods of consulting and obtaining these data, the best way of obtaining local data is to initially contact local fishing organisations and then contact individual fishermen themselves, as far as is possible, and ask them to provide information on the location and spatial extent of key areas, based on their day to day knowledge of a site. This can be done through the following methods:

- Individual questionnaires;
- Individual interviews (face-to-face); and
- Individual interviews (telephone).

The most important aspect of this form of consultation is ensuring that the right individuals are identified and approached. It is, therefore, advisable to spend some time at the start of any consultation process building up a contact list (database) of key fishermen, with the help of local Defra and SFC Fishery Officers and local fishing organisations. Once this list is complete, then a well-structured set of questions should be devised that will form the basis of any subsequent interview or questionnaire.

The major difficulty in this form of consultation and data gathering exercise is the occasional wariness of commercial fishermen to provide detailed information on their landings or fishing patterns. Often, this is for reasons of commercial confidentiality or an unwillingness to tell others of certain areas that they know are particularly productive or support notable fish and shellfish resources. Unfortunately, this wariness is just as often based on a degree of mis-trust towards any form of offshore development that may adversely affect fish and shellfish resources. In order to prevent this from creating a barrier that hinders the collection of useful site-specific data, it is highly recommended that local fishermen are provided with as many details as possible of any proposed development, at all stages of the project. By demonstrating a commitment to keep the local industry informed at all stages of a project, the chance of obtaining data back from fishermen will be greatly increased.

[4] Producer Organisations (POs) are established under the Common Fisheries Policy (CFP to enable groups of fishermen to market the fish they catch. Since 1995, POs wishing to manage quota allocations for whitefish stocks in Areas IV, VI and VII have been required to do so for all such stocks; a similar requirement for pelagic stocks was introduced in 1999. Allowing POs to take on this management responsibility enables them to plan their uptake of their particular allocations to optimise the benefit to their members. In 2001 there were 20 POs in the UK.

GOOD PRACTICE RECOMMENDATIONS 2.29: CONSULTATION

It is essential that consultation with the fishing industry is undertaken as EARLY as possible (i.e during the Scoping stage) and that key representatives are kept up-to-date of all proposals and changes throughout the project, in order to build up a strong working relationship, based on a degree of trust and co-operation.

Local fishermen potentially have the greatest knowledge of the status of fish and shellfish resources at a local level. Therefore, time should be spent at the start of the process compiling an accurate list of fishermen who should be contacted.

Information can be collected through questionnaires or interviews/meetings.

Data from epibenthic trawl surveys

In many areas, epibenthic trawl surveys are undertaken in conjunction with benthic grab sampling, in order that the epibenthic resources of a study area can be described. Specific details on the methods and rationale of these surveys are provided in **Section 2.4**. The data collected from these surveys often also provides useful data on fish resources within the study area and should be used to complement the desk-based data collated through the literature review.

Dedicated fish/shellfish resource surveys

A specific fish and/or shellfish survey should only be commissioned if, after the scoping stage, it is demonstrated that there are likely to be particular concerns about fish or shellfish resources. If it is judged that a survey is required, the literature review undertaken as part of the scoping exercise should also be able to provide a rationale for appropriate sampling design and sampling frequency, as well as an indication of the suitability of various sampling devices to meet survey needs (DTLR, 2002).

GOOD PRACTICE RECOMMENDATION 2.30: SITE SPECIFIC SURVEYS

The decision on whether or nor a site-specific fish/shellfish survey is required should be made following Scoping.

Design of the trawl survey

If a dedicated fish survey is required, it is recommended that any trawl stations should correlate, as far as possible, with those sites used to collect benthic data. Therefore, investigation of different trophic levels at a site (i.e. as part of an ecosystem approach) can be better carried out. However, the trawl should always take place after the benthic grab trawl in order to not bias the benthic data collected (MMS, 2001).

Once a plan of survey intentions and rationale is produced for the epibenthic survey, this should be issued to key consultees, such as CEFAS and English Nature, so that they can comment on the design and objectives of the survey. Comments from these organisations should be acknowledged and any necessary changes to the original survey design made. The agreed survey rationale should then also be issued to the local Sea Fisheries Committee and relevant Defra District Inspector approximately four weeks before the work is due to begin (DTLR, 2002).

Selection of the gear

The gear selected to undertake the fish resource survey should be appropriate to the target species being considered. For example, if flatfish are the key concern, then a beam trawl should be used, if data on demersal fish needs to be collected then an otter trawl should be used and if the target species are crustaceans (crab and lobster), then pots should be used.

If the survey is designed to gather as much relevant data as is possible, then it makes sense that the specific trawl type used is similar to that used by commercial fishermen in the area of survey. This ensures that the catch is representative of what commercial fishermen may themselves catch at the particular time of the year that the survey is carried out. In most cases, it is recommended that a small-mesh cod-end liner be used to retain juvenile fish. Where small mesh nets are required for any surveys, applicants must apply to the Defra Sea Fish Conservation Division for special dispensation. It may also be necessary to seek a byelaw dispensation from the relevant Sea Fisheries Committee.

GOOD PRACTICE RECOMMENDATIONS 2.31: RESOURCE SURVEYS

The objectives and proposed design of any dedicated fish resource survey should be issued to CEFAS an d the local Sea Fisheries Committee and Defra District Inspector approximately 4 weeks prior to beginning the survey so that they can (a) comment on it fully and (b) inform local fishing organisations. Their comments should determine the final survey design and objectives.

The actual gear type to be used should be similar to those used by local fishermen, as far as possible.

Where small mesh nets are required for any surveys, applicants must apply to the Defra Sea Fish Conservation Division for special dispensation.

The trawl survey stations should correlate with benthic stations as far as possible so that potential ecological interactions can be investigated.

Although striving for consistency in data collection, \`flexibility\` in survey design and gears used will still be required, in order to take account of site-specific conditions.

In the event that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, it may be necessary to define these in more detail, using non-intrusive methods such as underwater video.

As with benthic grab surveys, any fish surveys should be supervised by an experienced marine scientist to ensure that the catches and methods of survey are representative of the area.

It is recognised that there are many issues associated with site-specific fish and shellfish surveys (cost, time, usefulness of data). Therefore, alternative approaches to collating data to describe baseline conditions with respect to fish and shellfish resources should also be investigated. Some future developments in fish resource surveys are outlined in Appendix B (xiv).

Overall, a multi-strand approach, combining acoustic data collection, a literature review, analysis of Defra landings data and previous survey data, consultation and site-specific surveys (if required), is recommended.

2.6.5 BASELINE DATA ANALYSIS AND PRESENTATION

Data analysis

Data collected as part of baseline studies related to fish and shellfish resources can be analysed in a variety of ways. **Section 2.4.5** provides details on methods of statistical analysis that can be undertaken on epibenthic (and fish) data, collected during trawl surveys.

Much of the landings data provided by Defra are issued in the form of MS Excel worksheets, which enable the data to be easily converted into appropriate graphical figures. Defra statistics often show landings for demersal and pelagic finfish and shellfish. It is rarely helpful to aggregate fish and shellfish landings, as the distribution of shell-fisheries is very patchy and the species concerned can often introduce a very significant bias to landings data and, hence, any trends. It is also advisable to further separate the shellfish data into bivalves and crustaceans.

Alternatively, landings data on the top (5-10) species by weight can be presented individually and the remaining data should be grouped as “others”. The approach adopted should be guided by whether or not the landings are dominated by a few individual species – if not then broad categories are probably more useful.

It is recommended that these data are analysed to assess any significant long-term trends in the landings of key species, either by port or ICES rectangle. Although these data have limitations they still provide an indication of high-level trends in some major resource species.

GOOD PRACTICE RECOMMENDATION 2.32: LANDINGS DATA
At least 5 years of landings data should be assessed for high-level trends. Data on fish and shellfish landings should not be aggregated but should be either assessed under the broad headings that Defra data are usually organised into (demersal fish, pelagic fish and shellfish) or by separating the information out on the top 5-10 species and grouping all other data.

GIS can also be used to analyse baseline data. Using GIS to build up an impression of the level of spawning intensity of certain key fish species in certain areas has recently been undertaken by CEFAS.

Data presentation

Data is best presented through the use of graphical figures such as histograms, pie-charts or line graphs. Histograms and line graphs enable trends over time to be displayed, which can often demonstrate changes in a certain fishery. It can also be useful to rank species by the value of their overall landings. This enables those species that contribute the most to the overall value of the fishery to be identified. Any figures produced through this analysis can also be easily incorporated into a GIS. For example, figures based on the landings obtained from ICES rectangles can be displayed as an overlay to the ICES rectangles.

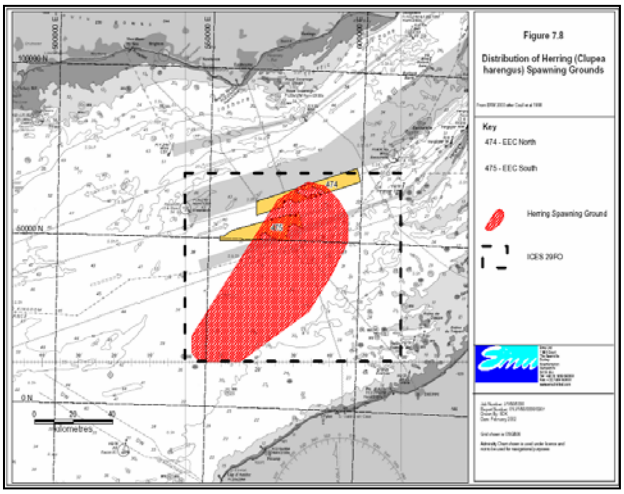


Figure 2.3 Distribution of herring (*Clupea harengus*) spawning grounds **Source: EMU Ltd, 2002**

As far as possible, figures should be used to display data, reducing the potential amount of supporting text required. In particular, the following figures should be produced in order to help define the baseline conditions if the fish and shellfish resources:

- Seasonality of spawning times for key resource species (see **Box 2.14**);
- The distribution and spatial extent of spawning, nursery, feeding and crab over-wintering grounds;
- Inferred migration routes of key species (crab, spawning fish, salmon); and
- Defra landings data presented as time-series. Figures should be plotted within ICES rectangles or by port, using a GIS.

GOOD PRACTICE RECOMMENDATION 2.33: DATA PRESENTATION
The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, therefore reducing the potential amount of supporting text required.

Box2.14 Spawning times of fish and shellfish within VIId and their main fishing periods

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Brill			+++	***	***	***						
Turbot				***	***	***	***					
Sole			+++	***	***							
Plaice	***	***	+++									+++
Lemon sole				***	***	***						
Black bream							+++					
Thornback ray		+++	+++	+++	+++	+++	+++					
Cod		***	+++	+++								
Whiting		***	***	***								
Pogge	***											
Dragonet		***	***							***	***	***
Herring	*a*			*s*						*a*	*a*	*a*
Scallops					+++	***	+++					

Key: *** Peak Spawning Activity; +++ Lower spawning intensity; [shaded] Main fishing period

Herring: a = Autumn spawning stock; b = Spring spawning stock

2.6.6 REPORTING OF BASELINE DATA

With respect to reporting the findings of any specific survey undertaken, guidelines on the format and structure of reports on the outcomes of ecological (benthic/epibenthic/fish and shellfish) surveys are provided within the recent "Guidelines for the conduct of benthic studies at aggregate dredging sites", prepared by CEFAS on behalf of the DTLR in May 2002 (DTLR, 2002). It is recommended that the format and contents of any reports produced should follow closely those suggested within these guidelines.

Report structure and format

This should mirror the structure set out in **Section 2.4**. The key findings, conclusions and recommendations of any dedicated fish and shellfish report should form an integral part of the final ES so that the basis of the impact assessment is transparent.

GOOD PRACTICE RECOMMENDATIONS 2.34: REPORTING

If a site-specific fish/shellfish survey report has been produced and summarised within the final ES, then the original author(s) should review the summarised version to ensure that key points and issues have been included.

Final reports should be produced both in hard copy format and digitally. Copies of all reports should be converted into PDF format and issued on CD to consultees and Regulators, where possible. Ideally reports should be made available on the Internet.

GIS files, with the licence area shown, should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

2.6.7 FUTURE DEVELOPMENTS

The methods described within this section outline current practices for collating data to describe baseline conditions with respect to fish and shellfish resources. For the majority of the methods described, e.g. consultation, literature review and analysis of landings data, it is recommended that these are undertaken as standard good practice. However, with respect to site specific surveys, although these are often used in order to increase the level of knowledge of the distribution of fish and shellfish resources in more poorly sampled regions, in practice, it is unlikely that further sampling is a practical or affordable option and, often, the natural inter-annual variability and mobility of these populations reduces the value of one-off surveys. As a result of these issues, research is currently being undertaken to explore new methods for describing the distribution of fish assemblages. An overview of current developments is provided in **Appendix B (xiv).**

REFERENCES

Anon (2001). A Glossary of Marine Nature Conservation and Fisheries. Countryside Council for Wales, Bangor. ISBN: 1 861 69 085 1.

CEFAS (2001). Strategic Environmental Assessment (SEA2) - North Sea Fish and Fisheries. Technical Report TR_003, August 2001.

Coull, K.A., Johnstone, R., and Rogers, S.I (1998). Fisheries Sensitivity Maps in British Waters. Published and distributed by UKOAA Ltd.

Courbet, F. and Lemoine, M. (2003). Apparent incompatibility between biological settings of WGEXT guidelines and current aggregate dredging applications in the Eastern English Channel. Annex 16 in ICES CM (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM 2003/E:07. Ref. ACME ACE, D.

DTI (2002) Future Offshore: A strategic framework for the offshore wind industry. Department of Trade and Industry consultation paper.

DTLR (2002). Guidelines for the conduct of benthic studies at aggregate dredging sites. Report produced by CEFAS on behalf of the Department for Transport, Local Government and the Regions. May 2002.

EMU Environmental Ltd (2002). Area 473, Greenwich Light East. Environmental Statement. Prepared for Hanson Aggregates Marine Ltd and South Coast Shipping Ltd. March, 2002.

Ministry of Agriculture Fisheries and Food (1981). A Code of Practice for the Extraction of Marine Aggregates. MAFF. London, II pp.

MMS (2001). Development and design of biological and physical monitoring protocols to evaluate the long-term impacts of offshore dredging operations on the marine environment: Report to the US Minerals Management Service. Prepared by Research Planning Inc., W.F.Baird & Associates Ltd., and Applied Marine Sciences. October, 2001.

ODPM (2002). Marine *Minerals Planning Guidance Note 1 (MMG1): Guidance on the extraction by dredging of sand, gravel and other minerals from the English seabed*. Office of the Deputy Prime Minister. The Stationery Office, London.

Posford Haskoning, CEFAS and David Tyldsley Associates (2003). A Development Plan for Marine Aggregate Extraction in England – Scoping Study.

Rogers, S.I. and Carlin, D. 2002. A Procedure to Assess the Effects of Dredging on commercial Fisheries. Draft Final report of CSG Contract A0253. Defra, Nobel House, London.

Seymour, A.G. (2003). *Personal Communication*. Independent Fisheries Consultant.

SECTION 2.7 COMMERCIAL FISHERIES

2.7.1 THE NEED TO COLLECT BASELINE DATA

Based on data provided by the Sea Fish Industry Authority (Seafish) and Defra, recent figures (2002) indicate that just over 15,000 fishermen are employed within the UK fishing industry. In addition to fishermen themselves, commercial fishing supports a large land-based industry, comprising fish processors and merchants, suppliers and boat manufacturers. In total, it is estimated that just under 78,000 people are employed full-time in the UK economy from the activities of fish catching and processing (Seafish, 2001). In addition to UK boats, the waters around the UK also provide fishing grounds to vessels from other countries, attracted by the productive nature of large parts of UK waters, in particular the English Channel, North Sea and Irish Sea.

When the activity of vessels from these other countries, in particular Spain, Ireland, Netherlands, France and Belgium is considered in conjunction with UK based activity, it becomes apparent that commercial fishing activity within UK waters occurs at a high level. For this reason, it is important that an attempt is made to describe the spatial extent, distribution and pattern of commercial fishing activity, so that potential impacts from marine aggregate extraction can be assessed. Commercial fishermen may be the only group of marine users to sustain a direct financial impact. They are, therefore, likely to be vociferous objectors to any such schemes. Consequently, the assessment of baseline conditions with respect to commercial fishing activity is of great importance to any EIA process associated with marine aggregates.

2.7.2 LITERATURE-BASED DESK STUDY (SCOPING)

As the first step in the EIA process, it is recommended that a scoping study is undertaken. With respect to commercial fisheries, a source of useful data is previously published ESs and, in particular, fisheries intensity studies commissioned as part of these. They often include a range of data on fishing activity patterns and the value of key fisheries. Therefore, any ESs produced for areas close to a new application should be obtained. Other useful sources of data include Seafish Industry Reports, Sea Fisheries Committee data and various CEFAS Technical Reports and published survey data.

With respect to foreign fisheries, information on these can be obtained from the following sources:

- The French Research Institute for Exploitation of the Sea (IFREMER) reports and publications (experimental trawl surveys, fishing fleet activities studies) see ***http://www.ifremer.fr***;
- ICES databases; and
- COFREPECHE reports, see ***http://www.ifremer.fr/cofrepeche***.

Further information should be obtained through direct consultation with the fishing industry. Details on consultation are provided in **Section 2.6.2**.

2.7.3 BASELINE DATA REQUIREMENTS

Based on a review of existing guidelines, the following key data requirements have been identified with respect to commercial fisheries. It is very important to note that not all of these data will need to be collected at the same level of detail for every project.

GOOD PRACTICE RECOMMENDATION 2.35: DATA COLLECTION
The decision as to which data requirements should be investigated in the greatest detail should be determined as part of the scoping stage.

ROYAL HASKONING

Box 2.15 Summary of baseline data requirements for commercial fisheries
• **An overall assessment of the level of commercial fishing activity in the vicinity of the application area should be undertaken;** • **An overall assessment of the nature of commercial fishing activity in the vicinity of the application area should be undertaken;** • **Recent and current numbers of vessels operating out of all ports in the vicinity of the application area, that are likely to be affected, should be determined;** • **The quantity and value of fish and shellfish landings by fishery, port of landing and season/year should be described;** • **The number of people involved in the commercial fishery (including the wider processing/support industry) should be described;** • **Charter boat fishing activity within a study area should be described; and** • **Local fishing industry trends should be described.**

Assessment of the level of commercial fishing activity

It is essential that, at the very minimum, an attempt is made to describe the level of commercial fishing activity/effort in the vicinity of an application area. Without such data, it will not be possible to assess the potential level of disruption that could arise if aggregate extraction takes place. This assessment should also consider the amount of fishing activity undertaken by foreign vessels.

Assessment of the nature of commercial fishing activity

In addition to describing the level of fishing activity within a study area, it is also important to describe the nature of this activity. More specifically, information should be provided that describes the following:

- Gear types/fishing methods used within the various fisheries;
- Seasonality of the various fisheries;
- Fishing patterns (spatial);
- Typical geographic range of fishing vessels; and
- Main species targeted throughout the year.

This information will enable a fuller understanding of commercial fishing activity within a study area to be provided.

Recent and current numbers of vessels operating out of all ports are likely to be affected

In conjunction with the above, an assessment should also be made of the number and type of vessels based at ports in the vicinity of the proposed study area that are likely to be affected. This can be done by using official data (UK Fishing Vessel List; see ***http://www.defra.gov.uk/fish/industry.htm***), through consultation with local fishermen and actual physical inspection of ports and harbours within the wider study area to determine the numbers of vessels operating. However, it should be noted that, at best, the UK Fishing Vessel List will only provide an indication of where boats are and the list also includes many inactive vessels. In practice, physical inspection will reveal that vessels based in one port are often recorded as fishing from another. Although actual physical inspection is the better of the approaches, this will also miss vessels that are temporarily out of the area or undergoing refit ashore. Therefore, the best way is to use all three methods. A printout from the fishing vessel list is a very useful tool for discussions with fishermen, as they can be asked about any vessels that are on the list but have not been discovered.

Quantity and value of fish and shellfish landings by fishery, port of landing and season/year

Data on fish landings, by weight and value, is available in a variety of formats for UK ports and waters. These data can either be obtained for a port or specific ICES rectangles. This latter form enables landings from the ICES rectangles in which aggregate license areas are located to be assessed. The use of and methods for the collection of data related to the quantity of landings are discussed in **Section 2.6**. Therefore, only data related to the value of landings is discussed below. Although it is discussed in detail here, it is important to note that official (Defra) figures dealing with the value of commercial landings often fall well below estimates made through detailed fishery studies. For example, Nicholson and Mounce (1989) reported the value of landings by the UK Southeast fleet to be approximately double the MAFF (now Defra) estimate, and Myers (1992) estimated the real value of landings by the south coast fleet to be between two and three times the MAFF estimate. Similarly, in a recent survey of the Thames estuary fisheries, undertaken by MacAlister Elliot & Partners, the value of all fisheries (excluding cockles, oysters and whiteweed) was estimated at 4.4 times the official Defra estimate (MacAlister Elliot & Partners, 2002).

Data should also be collected, as far as is possible, on the added value of fish landings within a study area. Estimates on the value of landings provided by Defra are based on first hand sales and do not take into account the added value that is often realised through specialist processing or preparation. Without, at least, an indication of the scope for added value from key species, estimates of the true value of a particular fishery are likely to be underestimated.

Photo 2.11 Landing Prawns at Mallaig
© Sea Fish Industry Authority

Unfortunately, data on the value added to fish landings within a study area is rarely available "off the shelf", and in interview surveys with fish merchants and processors probably less than half will be willing to give information on mark-up. Therefore, the main priority should be to provide an accurate description of the local fish trade and the amount of local processing. Published information can then be used to make a reasonable estimate of value added.

People involved in the commercial fishery

In addition to describing the number of boats based at ports in the vicinity of the proposed aggregate site, an attempt should be made to calculate the number of individuals that are involved in the local fishing industry, either directly as fishermen and but also indirectly as processors, merchants and suppliers. This will enable the importance of the local fishing industry as a source of employment to be placed into context with employment from other sources within the study area.

Charter boat fishing activity within a study area

In addition to commercial fishing activity, many coastal areas of the UK also support well-established charter boat industries, which provide both inshore and 'deep-sea' fishing trips to the public. These trips usually target established fishing marks such as wrecks, reefs and sand banks and a wide range of species, including cod, bass, pollack, conger eel, turbot, tope, smoothound and rays, amongst others. These boats contribute significantly to the economy of many coastal areas, and also provide a source of employment to a large number of individuals. As with commercial fishing activity, marine aggregate extraction activities have the potential to effect charter boat fishing. Therefore, it is essential that at least an overview is provided of the extent, nature and distribution of charter-boat activity within a study area.

Photo 2.12 Charter Boat Fishing

Local fishing industry trends

Current information relating to the size of the UK fishing fleet, the numbers of persons employed at sea and on-shore and overall landings, indicate that the UK fishing industry is changing fast. In fact, in some areas of the UK significant parts of the industry are quickly disappearing. Recognising this recent, rapid change in the UK fishing industry, it is not sufficient to just describe the current situation with respect to commercial fishing activity within a study area without giving some indication of the current rate of change. Clearly, a potential impact on a fishery that is dying out is less serious than a potential impact on a growing fishery.

Box 2.16 Common trends within the UK fishing industry

- A general reduction in the over 10m fleet as vessels are decommissioned;
- Linked to the above, an increase in under 10m vessels as owners downsize;
- Changes in fishing patterns as fleets respond to quota changes, or the availability of fish or markets. An example of this is the way that crab boats have gone in and out of the whelk fishery in response to high-amplitude price changes in the latter as the Korean market has switched on and off; and
- A robust inshore shellfishery (particularly for crabs and *Nephrops*), with the potential for expansion (see **Box 2.18** for links to Defra fisheries statistics).

2.7.4 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods of data collection that can be used to gather the information described above. It is recommended that a combination of these methods is adopted in order to provide a robust and comprehensive collection of baseline data.

Consultation

The most important information required for a marine aggregate extraction area, and the most difficult to accurately obtain, is the number of boats from nearby ports which visit it and the income they derive from it. Realistically, the only way that this information can be obtained is from the fishermen who actually work these areas. To obtain this information, targeted consultation is required.

Early consultation with representatives of the local fishing industry in a study area is essential in order that the level of, pattern of and nature of local fisheries can be accurately described. This need for consultation has been long recognised and in 1981 MAFF published a “Code of Practice for the Extraction of Marine Aggregates”, aimed at avoiding conflict between the fishing and marine aggregate industries when new reserves were proposed for exploitation (MAFF, 1981). The publication of this Code of Practice was an important step in recognising and seeking to reconcile the operating difficulties that were being experienced on a routine basis. However, apart from consultation being required in order to make fishermen aware of any developments, it also has a significant role to play in helping to collate information on commercial fisheries within a study area. In particular, information related to patterns of fishing activity, the seasonality of certain fisheries, the main species targeted, the gears and methods used and the value of landings from key areas, can all be obtained if consultation is carried out well.

Key consultees for the collection of commercial fisheries data are presented in **Box 2.17**.

Box 2.17 Key consultees for the collation of commercial fisheries data
• Defra Sea Fisheries Inspectorate Fishery Officer; • Local Sea Fisheries Committee Fishery Officer; • National Federation of Fishermen's Organisations; • Local Fish Producers Organisations; • Local Fishing Organisations (contact details usually obtained from Defra office or Local Sea Fisheries Committee office); • Fish Merchants and Processors; and • Individual Fishermen.

Effective consultation with the fishing industry depends on a degree of mutual trust between the applicant and local representatives. However, this does not always exist, and it is vital that the consultant spends time at the beginning of the process identifying the key people to target and ensuring that as much detail as possible about the proposed development is provided to these people. By demonstrating a commitment to keep the local industry informed at all stages of a project, the chance of obtaining data back from fishermen will be greatly increased.

Specific methods of collecting useful data include the following:

- Issuing questionnaires to fishermen/processors/merchants;
- Carrying out individual face-to-face interviews with fishermen/processors/merchants;
- Carrying out individual telephone interviews with fishermen/processors/merchants; and
- Carrying out beach surveys with the local fishing industry.

Interviews are a preferable approach to questionnaires, as they allow direct contact to be made, establish a relationship of information exchange and takes the responsibility of completing the questionnaire away from the recipient. The information that typically should be requested as part of an individual interview is summarised in **Appendix B (xv)**.

When gathering fisheries data, it is important to recognise that they are often commercially sensitive and, as such, should be treated accordingly. For example, data should be grouped where possible so that individual boats fishing activities and/or earnings are not displayed separately. Similarly, data on exact fishing patterns can be aggregated and presented in the form of presence/absence distribution maps.

The actual methods used to collect data from the fishing industry should be decided on by those undertaking the assessment. However, it is essential that at least some of the methods outlined above, if not all, are adopted so that the maximum amount of data can be obtained with respect to commercial fisheries.

GOOD PRACTICE RECOMMENDATIONS 2.36: CONSULTATION
EARLY consultation with the fishing industry is critical. Ideally, consultation should be undertaken by a dredging company at the exclusive prospecting stage. **Consultation should take place at the Regional (Defra), District (Sea Fisheries Committee) and local level (Fishing Organisations).** **Key consultees should be kept up-to-date with all changes throughout the project, in order to build up a strong working relationship, based on a degree of trust and co-operation.** **Local fishermen have the greatest knowledge of the status of commercial fishing activity at a local level, therefore, time should be spent at the start of the process compiling an accurate list of individual fishermen who should be contacted.** **Information can be collected through questionnaires or interviews/meetings.**

Interpretation of official landings/fishing effort data

One of the main sources of information on the status of fish and shellfish stocks within a study area are landings data, which are collated and reported by Government Fisheries Departments. These data provide information on landings, by weight and value, as well as on fishing effort and are, therefore, useful in assessing high-level trends in commercial fisheries activity. Details on the use of the 'landings by weight' data are provided within **Section 2.5**. This section concentrates more on the data associated with landings by value and fishing effort.

The following data sets are available from the Defra Fish Statistics Unit and are of use in assessing commercial fisheries resources:

Box 2.18 Fish landings data sets available from Defra

Port landings data
Monthly estimates of landed values by port within England, Wales and Northern Ireland. These data include estimates for the under 10m fleet and, therefore, provide a comprehensive and very detailed record of fishery production.

Landings from ICES Statistical Rectangles
Monthly estimates of landed values (by gear/species/value) for relevant ICES sub-rectangles (areas of 30x30 miles). These data can provide a high-level, regional overview of catches within study area. They do not fully represent catches in these areas, as there is no statutory requirement under either EU or national legislation for vessels <10m length to declare their catches. Information for this sector is collected with the co-operation of the industry. It comprises log sheets and landing declarations voluntarily supplied by fishermen and assessments of landings derived from market sources and by correspondents located in the ports.

Data Available From:
Fisheries Statistics Unit
Department for Environment, Food and Rural Affairs
Room 320, East Block
10 Whitehall Place
London SW1A 2HH (Please note that this address may change at the end of 2004)
Tel: 020 72708096
Fax: 020 72708072
fsu@defra.gsi.gov.uk

The limitations of these official landing data, namely the potential error that can arise through (a) estimation of catches for which logbook reporting is not required and (b) under-reporting of catches, are discussed in detail in **Appendix B (xiii)**. An example of the potential for error in these data, with particular respect to commercial fisheries, was demonstrated during a recent study by MacAlister Elliot & Partners of the Thames Estuary fishery.

In the wider Thames Estuary, the general trend towards under 10m vessels meant that there was, in consequence, a trend towards increasing under estimation of landings (and landed values). That is, the change in fleet structure imposed a progressive bias in landing trends, amplifying the decline in landings to an extent that was difficult, in practice, to quantify. Ground-truthing in this instance was provided through interviews with fishermen and the Sea Fisheries Committee. Therefore, it is recommended that when official landing data are used to provide a high-level overview of trends in a fishery, the analysis should take any shifts between the over 10m and under 10m fleet into account. This analysis should also always be backed up by interviews, at least with the SFC and preferably with local fishermen.

For these reasons, official landing data are often just used to provide a high-level overview of trends in a fishery and should not be used as the primary basis for assessing any economic impacts of marine aggregate extraction on commercial fisheries.

GOOD PRACTICE RECOMMENDATIONS 2.37: LANDINGS DATA
Official landing data should not be used as the primary basis for assessing any economic impacts of marine aggregate extraction on commercial fisheries, as they often only identify high-level trends. **When official landing data are used to provide an overview of trends in a fishery, the analysis should take any shifts between the over 10m and under 10m fleet into account. This analysis should also always be backed up by interviews, at least with the SFC and preferably with local fishermen.**

Defra sea fisheries surveillance data

Fisheries surveillance data is collected by the Sea Fisheries Inspectorate of Defra for England and Wales and is available for all waters within the United Kingdom's Exclusive Economic Zone (EEZ). Equivalent information for Scottish waters is held by the Scottish Fisheries Protection Agency. There is a small fee associated with these data, which is payable to Defra.

Defra employs the services of the Royal Navy's Fisheries Protection Squadron to carry out surveillance at sea, including inspections, as well as civilian aircraft that carry out aerial surveillance of fishing activity, co-ordinating with the Royal Navy. Spotter planes fly routes over each quarter of an ICES rectangle approximately once a week, during daylight hours throughout the year. Observation effort of fishing activity may be concentrated within certain areas from time to time. This observation effort is quantified as the number of visits made to each ICES sub-rectangle. Surveillance data includes information about the nationality of the vessel, the type of fishing gear employed, as well as the vessels activity at the time of sighting, including whether it was actively fishing. The exact time of the sighting as well as the vessels geographical location, in terms of ICES rectangles and longitude/latitude, is also recorded. Data from these aerial observations are most comprehensive for offshore regions, beyond 6nm from shore.

Although these data provide some useful information, they also have some significant limitations. In particular, these data do not provide a complete picture as flights are intermittent and the identification of vessels is not possible during hours of darkness (night flights are not carried out as Port Letters and Numbers cannot be identified, but contacts are recorded). These data are also likely to under-represent under 10m vessels, as many do not have the required Port Letters and Numbers on their wheelhouse roofs for aerial recognition (indeed, many do not even have wheelhouses).

Therefore, over-flight data can only provide a high level overview of commercial fishing activity within certain areas and does not fully represent the intensity and coverage of commercial fishing activity within an area. In particular, these data do not accurately reflect fishing activity in inshore waters, due to the large number of often part-time vessels which are active close to the shore. However, it might still be useful in showing the importance (or not) of an application area relative to the large areas of sea that surround it. It should also be noted that aircraft surveillance may be restricted in certain locations due to highly active military ranges, such as the Wash.

Box 2.19 Contact details for Defra surveillance data
Sea Fisheries Inspectorate Department for Environment, Food and Rural Affairs Room 1, East Block 10 Whitehall Place London SW1A 2HH (Please note that this address may change at the end of 2004) Tel: 020 72708334 Fax: 020 72706566 Email: sat.ops@defra.gsi.gov.uk

GOOD PRACTICE RECOMMENDATION 2.38: SURVEILLANCE DATA
Defra surveillance data should be treated with caution. All ESs should recognise the potential shortcomings of these data.

In summary, the broad-scale patterns that surveillance data describe are not sufficiently detailed for the study of site specific impacts, providing only a coarse description of broad spatial patterns. Therefore, other methods are also required to build up a more realistic picture of fishing activity within a study area. In the majority of cases, the most successful secondary method is direct consultation with individuals involved in the fishing industry.

Sea Fisheries Committee fishing activity data

Sea Fisheries Committees also collect data on the spatial and temporal distribution of fishing activity within their jurisdictions, albeit at varying levels of detail and coverage. One particular 'flagship' project is being undertaken by Sussex Sea Fisheries District, which is being funded by the Minerals Industry Sustainable Technology (MIST) Programme.

The aim of this project is to develop a tool for mapping the spatial and temporal distribution of fishing activity within the Sussex Sea Fisheries District, in a format that can be used by decision makers to avoid understanding of use of the coastal zone. Data relating to the position and fishing activity of commercial vessels is recorded by fisheries patrol vessels during routine surveys and this is then input into a dedicated GIS system. The final output of this project will the production of a fishing activity database for the Sussex Sea Fisheries District that will facilitate better understanding of the resource. The project will also produce a manual detailing the methodology for describing fisheries activity from fisheries enforcement, with a view to developing a standard format (see ***http://www.sussex-sfc.gov.uk*** for more details).

Structure of the fleet

Information on structural changes in the local fleet of a study area can be obtained from a number of sources. Firstly, the Defra Fishing Vessel Lists can be reviewed over a number of years (over 10m vessels lists are downloadable from the internet from 1996 onwards; under 10m lists from 2001 (***http://www.defra.gov.uk/fish/industry.htm***) and should be obtainable direct from Defra). Sea Fisheries Inspectorate District Offices also keep detailed lists of local fleets.

Secondly, most Sea Fisheries Committees keep their own records of fleet composition and these should be obtained and reviewed, where possible. Thirdly, the useful periodic series of industry studies carried out by MAFF (now Defra)/CEFAS and the Seafish Industry Authority (SFIA) – e.g. Nicholson and Mounce (1989); Pawson and Rogers (1989); Myers (1992); and Pawson, Pickett and Walker (2002) - all provide useful data. Again, these should be obtained and reviewed, where possible. Finally, local fishermen should be consulted and the information they provide should enable a judgement to be made as to whether the inferences drawn from the hard data make sense.

Site visits

An overview of the 'health' of a fleet in a study area can often be obtained through a simple site visit to local ports or harbours. Through undertaking such a visit, it is possible to record what state the boats and land-based infrastructure is in. Typically, well-maintained boats with good equipment usually reflect a healthy fishery in that fleet/port, whereas badly-maintained boats suggest that the fishery is in decline.

Photo 2.13 Fishing Boats in Brixham Harbour © **Sea Fish Industry Authority**

Vessel monitoring system data

Vessel Monitoring Systems (VMS) are devices that enable the location and activity of fishing vessels to be tracked and monitored by Fisheries Departments, using satellite technology. The system is primarily an aid for the enforcement and control of fishing activities. The basic function of VMS is to provide reports of the location of a vessel at regular intervals. VMS tracks a vessel's movements and may provide information on its speed and course. The system does not identify the activity of the vessel (i.e. whether it is fishing).

The system works by installing devices (transceivers) or 'blue boxes', on board fishing vessels. These devices automatically send data to a satellite system, which transmits them to a land based, station that, in turn, sends them to the appropriate monitoring centre. The information received is monitored by cross-checking it with other data. On specific request, the European Commission can have access to these data files to ensure that the Member States are fulfilling their monitoring obligations.

Since 1 July 1998, vessels over 24 metres overall length (20m between perpendiculars) operating in the high seas (other than the Mediterranean), in third country waters (on a reciprocal basis) or engaged in industrial fisheries have been equipped with blue boxes. On 1 January 2000 the measure became mandatory for all vessels over 24 metres overall length (except those fishing exclusively within territorial waters or for trips of less than 24 hours). From January 2005 it is expected that all vessels over 15 metres will be subject to mandatory satellite monitoring. Furthermore, exemption is likely to be limited to vessels engaged in inshore fishing or shellfish farming.

Satellite tracking data is usually transmitted at 2-hour intervals to UK Fisheries Monitoring Centres. These data can be made available to consultants (within the constraints of the Data Protection Act), albeit in a form that prevents individual vessels being identified.

Fisheries verification studies

Fisheries verification studies involve actually undertaking trips to sea in the area of the proposed extraction licence in order to visually verify fishing activity within this area. The distribution and types of gear used by fishermen can be noted and compared to the data collated through the other methods described within this section. In the majority of cases, such a verification survey can be undertaken as an indirect part of other surveys associated with baseline data collection (e.g. benthic surveys, epibenthic beam trawl surveys and geophysical surveys).

GOOD PRACTICE RECOMMENDATIONS 2.39: BASELINE DATA ASSESSMENTS

Baseline data assessments of commercial fisheries within any study area should be based on a 'multi-strand approach', i.e. a range of data sources should be used, such as Defra over-flight data and landings data, consultation responses and site visits, to build up a comprehensive overview of commercial fishing activity at a site.

All of the various data sources should be reviewed together in order to identify any significant contradictions.

2.7.5 BASELINE DATA ANALYSIS AND PRESENTATION

Details on the analysis and presentation of data related to official landings data (by weight) are provided in **Section 2.5** in relation to fish and shellfish resources. Due to the similarities in the data for landings by weight and by value/fishing effort (which are the relevant parameters for commercial fisheries), a summary only of the analysis and presentation methods is provided here.

Data analysis

Landings by Value Data

Data provided by Defra (usually in the form of an MS Excel worksheet) should be used to produce graphical figures that indicate the value of landings for individual ports, regions or ICES rectangles. Fishing effort data is also included within these raw data-sets. As for landings by weight data, the value of fish and shellfish landings should not be aggregated, as the distribution of shell-fisheries is very patchy and the species concerned can often introduce a very significant bias to landings data and, hence, any trends. Defra data is organised into demersal fish, pelagic fish and shellfish so data should be presented using these divisions. It is also advisable to further sub-divide the shellfish data into crustaceans and molluscs.

It is often useful to rank species by the value of their overall landings. This enables those species that contribute the most to the overall value of the fishery to be identified. The decision whether to describe landed values in terms of broad classes (demersal, pelagic, crustacean, mollusc) **or** by individual species should be guided by whether or not the landings are dominated by a few individual species. If they are not, then use of the broad classes is probably more useful.

It is recommended that at least 5 years of data (preferably the 5 years prior to the date of current study) is collected and analysed.

GOOD PRACTICE RECOMMENDATIONS 2.40: LANDINGS BY VALUE DATA
At least 5 years of data showing the value of landings should be assessed for high-level trends. Data on the value of fish and shellfish landings should not be aggregated but should be assessed either under the broad headings that Defra data are usually organised into (demersal fish, pelagic fish and shellfish) or by ranking species by the value of their overall landings. This enables those species that contribute the most to the overall value of the fishery to be identified.

Defra fisheries surveillance data

With respect to Defra surveillance data (over-flight data), because the observation effort is not homogenous, any assessment of relative fishing intensity over the region becomes difficult because all areas are not comparable. The number of fishing vessel sightings in an area will inevitably be a function of observation effort so, to get a balanced view, this variability in observation effort must be accounted for.

A variety of methods have been developed that attempt to take account of this variability in observation effort. Two methods developed by Oakwood Environmental Ltd and by CEFAS are detailed in a recent report by CEFAS (Rogers and Carlin, 2002). The reader is referred to this report for details on these methods.

Analysis of data to determine the value of commercial fisheries within a specific application area

The data described to date within this section enables, at best, the intensity and broad-scale distribution of regional fishing activity to be described. However, they do not have sufficient resolution to describe the time spent by all vessels within a small application area or the total landings of fish and shellfish taken from it.

A recent Defra research report produced by CEFAS (Rogers and Carlin, 2002) describes a procedure to assess the effects of dredging on commercial fisheries. Within this report, two techniques to more accurately assess the exact value of fisheries within a proposed extraction area are described (Proportional Time and Proportional Area). For details on these methods the reader is referred to this report.

KEY REFERENCE
Rogers, SI. and Carlin, D. 2002. A Procedure to Assess the Effects of Dredging on commercial Fisheries. Final report of CSG Contract A0253. Defra, Nobel House, London.

Data presentation

The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data reducing the potential amount of supporting text required. This is especially of relevance for data on fish landings, due to the large amount of raw data generated for this parameter. In particular, at least the following figures should be included within any report:

- Defra (and SFCs) landings data presented as a time-series. Figures should be plotted within ICES rectangle or by port, using GIS;
- Location and extent of key fishing areas displayed in the form of schematic diagrams. The fishing areas covered by different gear types and the seasonality of the fishery should also be displayed;
- Specific fishing positions of individual fishermen (if available) plotted in a GIS;

- Fisheries surveillance data (over flight data) plotted on GIS to show the distribution of fishing activity by nationality and gear type. (These data should be standardised to allow for variation in surveying effort in each ICES rectangle);

- Distribution of vessels around main ports shown graphically; and

- Position of key charter-boat 'marks' and fishing areas.

Figure 2.4 Total UK fishing activity, 1992-1997, Eastern Channel Region
(Source: EMU Ltd, 2002)

GOOD PRACTICE RECOMMENDATION 2.41: GIS
The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, reducing the potential amount of supporting text required.

2.7.6 REPORTING OF BASELINE DATA

Baseline data collated in relation to commercial fisheries should be incorporated into the final ES. These data should either form part of the main body of the ES or should be supplied as Appendices or Technical Reports. If larger reports require editing and summarising for inclusion within the final ES, then this editing should be undertaken by the person(s) responsible for producing the overall report dealing with commercial fisheries. If another person undertakes this editing process, then they should be qualified professional with experience of commercial fisheries. The final version of the ES should be reviewed by whoever produced the original commercial fisheries report.

GOOD PRACTICE RECOMMENDATIONS 2.42: REPORTING
If a separate commercial fisheries report has been produced and then summarised within the final ES, the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included. **Final reports should be produced both in hard copy format and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. All reports should be converted into PDF format so that they can be easily e-mailed or made available on the Internet.** **GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.**

REFERENCES

EMU Environmental Ltd (2002). Area 473, Greenwich Light East. Environmental Statement. Prepared for Hanson Aggregates Marine Ltd and South Coast Shipping Ltd. March, 2002.

MAFF (1981). A Code of Practice for the Extraction of Marine Aggregates. MAFF. London, 11pp.

MacAlister Elliot & Partners Ltd. (2002). An assessment of the Thames estuary fisheries. Report on behalf of P&O Ports. November, 2002.

Myers, M.A. (1992). A profile of the south coast fisheries - Lyme Regis to Selsey Bill. Seafish Report No. 411. Seafish Industry Authority, Hull. 4pp.

Nicholson, R.J.A. and Mounce, R. (1989). Study of the fishing industry in the S.E. of England. Internal report No 1394, Seafish Industry Authority, Hull. 20pp.

Oakwood Environmental Ltd (1999). *Strategic Cumulative Effects of Marine Aggregates Dredging*. Contract No: 1435-01-98-CT-30894. Research Project Prepared for US Department of the Interior, Minerals Management Service, February, 1999.

Pawson, M.G. and Rogers, S.I. (1989). The coastal fisheries of England and Wales, Part II, A review of their status in 1988. Int. Rep., MAFF Direct. Fish. Res., Lowestoft, **19**: 76pp.

Pawson, M.G., Pickett, G.D. and Walker, P. (2002). The coastal fisheries of England and Wales, Part IV: A review of their status 1999-2001. Sci. Ser. Tech Rep., CEFAS Lowesoft, **116**: 83pp.

Rogers, S.I. and Carlin, D. 2002. A Procedure to Assess the Effects of Dredging on commercial Fisheries. Final report of CSG Contract A0253. Defra, Nobel House, London.

Seafish (2001). Input-Output Multiplier Study of the UK and Scottish Fish Catching and Fish Processing Sectors. Seafish Industry Authority, Edinburgh 2001.

SECTION 2.8 ARCHAEOLOGY AND CULTURAL HERITAGE

2.8.1 THE NEED TO COLLECT BASELINE DATA

There are a number of reasons why baseline data on the existing and potential archaeological and historical resource should be collected. In terms of the EIA process, an accurate description of the archaeological and historical assets within a study area is essential in order that the full effect of a proposed development can be identified and an understandable evaluation of impact significance can be made. Furthermore, this enables more detailed and achievable measures to avoid, minimise or offset destruction (through recording) to be identified.

In wider terms, the archaeological and historical resource is important on a number of levels:

- They are a finite and non-renewable resource that cannot be replaced;
- Prehistoric landsurfaces and individual sites, wrecks or artefacts are unique assets; and
- The archaeological resource provides a source of information regarding past human activities, culture and technologies, as well as providing information regarding past climate and ecology.

2.8.2 BASELINE DATA REQUIREMENTS

There are a wide range of existing guidance notes and best practice guides that provide details as to the type of data that should be collected to describe baseline conditions with respect to the historical and archaeological resource. These have been reviewed and summarised as part of the preparation of this guide. Relevant key documents are listed in **Appendix B (xvi)**.

Guidance on archaeological research, studies, assessments, surveys and mitigation measures has predominantly developed over the last 5 to 10 years. Most of the guidance has been related generally to the extent, organisation and progression of work and has, on the whole, not been specific or detailed. Recent guidance, in particular that developed in relation to coastal and marine archaeological assessment has become more prescriptive. However, the actual methods for report writing and the definition of impacts are still generalised and, consequently, assessments vary in terms of the resulting analysis and description of impacts.

Based on the review of existing guidelines, the following key data requirements have been identified with respect to archaeological and historical resources:

Box 2.20 Summary of baseline data requirements for archaeological and cultural heritage

- **The ES should provide information on wrecks and wreckage (including Protected Wrecks under the Protection of Wrecks Act 1973).**
- **The ES should provide information on the presence of prehistoric landsurfaces and associated human artefacts (although no Scheduled Ancient Monuments have yet been designated in estuarine or territorial waters, the Ancient Monuments and Archaeological Areas Act 1979 does have the provision for this with respect to upstanding features and wrecks).**
- **The ES should provide information on military sites (protected under the Protection of Military Remains Act 1986).**

One of the most difficult requirements is determining the extent to which the resource is known or unknown, this extends to maritime remains as well as prehistoric remains. The extent of knowledge or assumption in the identification and description of the heritage resource should be clearly described. **Table 2.1**, below, presents a sliding scale of the extent of knowledge regarding maritime and prehistoric remains. An ES should identify where, on this scale, relevant information is situated.

Table 2.1 Extent of knowledge regarding maritime and prehistoric remains

Maritime Remains	Known	Prehistoric Remains
Surveyed wreck/debris – identified	↑	Surveyed site/artefact(s) – identified
Surveyed wreck/debris – unidentified		Surveyed site/artefact(s) – unidentified
Documented wreck/debris – identified		Documented site/artefact(s) – identified
Documented wreck/debris – unidentified		Documented site/artefact(s) – unidentified
Surveyed anomaly – direct trace (net fastening/obstruction)		Surveyed deposit/landsurface – direct trace (core/grab etc.)
Surveyed anomaly – indirect trace (geophysical/bathymetric)		Surveyed deposit/landsurface – indirect trace (geophysical/bathymetric)
Documented geophysical anomaly/net fastening/obstruction		Documented deposit/landsurface
Documented wreck debris in general vicinity		Documented artefacts in general vicinity/region/palaeo-catchment
Casualty		
Local maritime activity		Local prehistoric activity
General maritime activity		General prehistoric activity
	Potential	

Key:

Surveyed = position (and extent) known to reasonable degree of accuracy.
Documented = known to be present, but position (and extent) uncertain.
Identified = details available on attributes such as name, period, type, condition etc.
Casualty = recorded loss based on documentary sources, but actual presence and position uncertain.
Local activity = as indicated by sources specific to area.
General activity = as indicated by overall historical and archaeological knowledge.

2.8.3 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods of data collection that can be adopted to gather the information described above. The order in which these methods are presented, should be the order in which they are carried out. That is: (1) Consultation; (2) Desk-based assessment; and (3) Survey and evaluation.

The section is largely based on a recent guidance note produced by BMAPA and English Heritage (see below) and the reader is referred to this note for a fuller description of baseline data collection issues related to archaeology and marine aggregate extraction.

KEY REFERENCE

BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment: Guidance Note.* British Marine Aggregate Producers Association and English Heritage, London: see *http://www.bmapa.org/pdf/arch_guidance.pdf*

Consultation

The relevant authority with respect to archaeological and historical resources is English Heritage in England, CADW in Wales, Historic Scotland in Scotland and the Environment and Heritage Service (EHS) in Northern Ireland. As appropriate, the relevant national authority and the local authority (e.g. the County Council) archaeologists should also be contacted. They should be approached at the outset of a proposal and contact should be maintained throughout the undertaking of any work in relation to the historic environment. This is essential in order to obtain agreement to the scope of works proposed at all stages (desk-based and primary data collection). Furthermore, identification of appropriate mitigation measures can only realistically be designed and accepted in close consultation with English Heritage/CADW/Historic Scotland/EHS and the Local Authority Archaeologist.

Where other organisations have an extensive knowledge of aspects of a study area, it is appropriate to contact them, both for information and also to gain knowledge of the locality. In addition, their 'use' of the resource may also need to be taken into account in the assessment and identification of appropriate mitigation measures.

<table>
<tr><th colspan="2">GOOD PRACTICE RECOMMENDATIONS 2.43: CONSULTATION</th></tr>
<tr><td colspan="2">Consultation is a key part of any baseline data collection exercise related to the historic environment.

The key consultee (English Heritage/CADW/Historic Scotland/EHS) should always be consulted early in the project, as well as at the commencement of any investigations and at appropriate stages of the assessment process.</td></tr>
<tr><td>English Heritage
Maritime Archaeology Team
Fort Cumberland
Fort Cumberland Road
Portsmouth
PO4 9EF
http://www.english-heritage.org.uk</td><td>CADW
Welsh Historic Monuments
National Assembly for Wales
Cathays Park
Cardiff
CF10 3NQ
http://www.cadw.wales.gov.uk</td></tr>
<tr><td>Historic Scotland
Historic Scotland
Longmore House
Salisbury Place
Edinburgh
EH9 1SH
http://www.historic-scotland.gov.uk</td><td>Environment and Heritage Service
5-33 Hill St
Belfast
BT1 2LA
http://www.ehsni.gov.uk</td></tr>
</table>

Desk-based assessment

The archaeological component of an ES should, as a minimum, be undertaken to the same level of detail as an archaeological desk-based assessment, which is a widely recognised and used approach for development led archaeological assessments.

Guidance for undertaking an archaeological desk-based assessment has been published by the Institute of Field Archaeology (IFA, 1999a), and is the accepted standard for the non-intrusive elements of archaeological assessment. There are a variety of sources of data that should be examined for this level of assessment. These are detailed in **Box 2.21**.

Box 2.21 Data sources for archaeological desk-based assessment

- National Monuments Record (English Heritage);
- Historic Environment Record (Local Authorities);
- UK Hydrographic Office (***http://www.ukho.gov.uk***);
- The Receiver of Wreck at the Maritime and Coastguard Agency (***http://www.mcga.gov.uk***);
- Existing bathymetric, geotechnical and geophysical data;
- Secondary sources (e.g. BGS data and diving publications); and
- Local Records Offices, Museums and Libraries.

GOOD PRACTICE RECOMMENDATIONS 2.44: DESK-BASED ASSESSMENT
A desk-based assessment should be undertaken. English Heritage/CADW/Historic Scotland/EHS should be contacted with regard to the development and to enable agreement of the brief for the proposed assessment. **Baseline information should be obtained from all relevant sources and all the known and potential archaeological sites and features within the study area should be identified. This study should state all assumptions made in carrying out the assessment. It should identify**

GOOD PRACTICE RECOMMENDATIONS 2.44: DESK-BASED ASSESSMENT
the potential impacts, assess the effects and specify appropriate mitigation measures. **Finally, it should identify data gaps and examine the need for further work (survey and evaluation) to address them.**

Survey and evaluation

As with the archaeological desk-based assessment, if further primary data collection is required (surveys), these should conform to the guidance identified in the Standards and Guidance for Archaeological Field Evaluation (IFA, 1999b). These are the accepted standards for intrusive archaeological surveys and the subsequent evaluation of the results.

Depending on the study area, its potential resource and the project type, site-specific surveys and evaluation may be required for the ES. Early discussions with English Heritage/CADW/Historic Scotland/EHS and the Local Authority Archaeologist will identify the appropriateness of undertaking this work at an earlier or later date, as well as ensuring the adequacy of the work.

There are a wide range of methods available (**Box 2.22**) for undertaking primary data collection, some of which may not be appropriate, whilst others may be essential. Selection of the appropriate and/or required filed survey method should be established through the desk study and consultation with the relevant Country Agency i.e. English Heritage/CADW/Historic Scotland/EHS

Box 2.22 Various field survey methods that may provide baseline data on the historical archaeological resource	
• Bathymetric survey*	• Borehole*
• Sidescan survey*	• Grab survey*
• Sub-bottom profiling*	• Benthic survey*
• Magnetometer survey	• Diving*
• Remote Operated Vehicles* (ROVs)	
*** Surveys usually undertaken as part of other baseline studies**	

The evaluation stage should provide a detailed description of the condition, character, extent and significance of the archaeological resource. This similarly applies to archaeological deposits (prehistoric landsurfaces, etc.) where the presence, character and extent of deposits should be identified or absence confirmed.

GOOD PRACTICE RECOMMENDATIONS 2.45: SURVEYS
Determine, in discussion with English Heritage/CADW/Historic Scotland/EHS and the Local Authority Archaeologist, the necessity for and extent of primary data collection for the EIA. This could include identifying a staged approach and thereby targeting resources towards appropriate phases of the project. A staged approach can also allow the scope of any detailed investigations required to be defined and to concentrate on key issues/areas only. **Where possible, integrate preliminary archaeological surveys with surveys undertaken for other purposes, such as resource mapping or environmental sampling.** **The specifications for these surveys should be drawn up with archaeological advice and tailored to archaeological requirements (e.g. side scan sonar settings and line).** **Ensure that the surveys provide sufficient data to identify the presence or absence of potential archaeological features and deposits. The level of information provided for any identified features should be sufficient to assess their character, extent, condition and significance.** **Ensure that recommendations for monitoring and/or mitigation measures (i.e. changes in development design/outline, exclusion measures, or recording requirements) are provided.**

2.8.4 BASELINE DATA ANALYSIS AND PRESENTATION

Desk based assessment

The desk-based assessment should include the following:

- A description of the historic environment likely to be significantly affected by the proposal;
- A description of the likely significant effects of the proposal on the historic environment, which should cover the direct effects and any indirect, secondary, cumulative, short, medium and long-term, permanent and temporary, and positive and negative effects;
- A description of the forecasting methods used to assess the effects of the proposal on the historic environment;
- A description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects on the historic environment;
- An indication of any difficulties (technical deficiencies of knowledge) encountered in compiling the required information; and
- A non-technical summary.

The assessment should also list and include detailed information on any archaeological features and finds within an Appendix, and should clearly illustrate the area of the proposal in relation to the various archaeological features, including areas of potential. The assessment should ensure sufficient coverage beyond the immediate study area to enable the assessment of indirect effects outside the development area. Furthermore, in relation to prehistoric landsurfaces, the study area should extend a sufficient distance to enable it to be placed into a relevant context.

Survey and evaluation

The presentation of results and their assessment should follow the Standard and Guidance for Archaeological Field Evaluations (IFA, 1999b). The analysis of the survey data should be undertaken by a suitably experienced archaeologist and all data sources should be analysed together, due to the synergistic value of the information when collected and viewed as one.

Data presentation

GOOD PRACTICE RECOMMENDATION 2.46: GIS
The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible figures should be used to display data, reducing the potential amount of supporting text required.

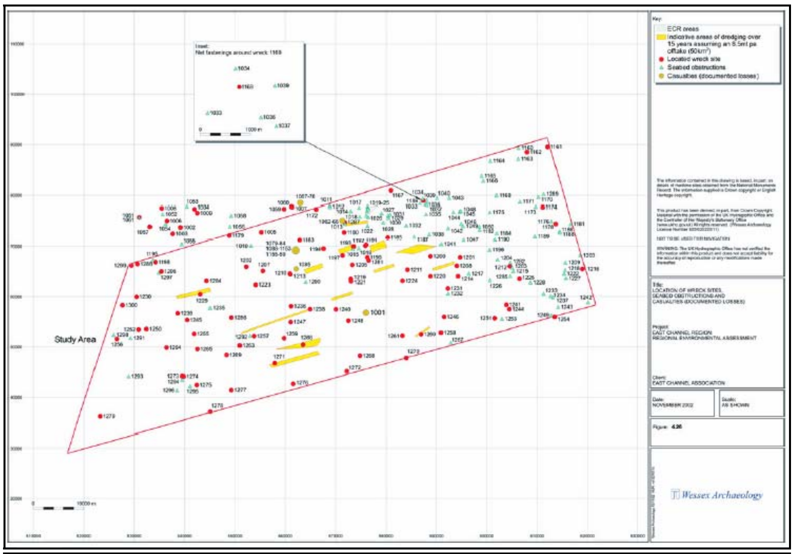


Figure 2.5 Location of wreck sites, seabed obstructions and documented losses
(Source: EMU Ltd, 2002)

2.8.5 REPORTING OF BASELINE DATA

The method and structure for reporting desk-based and survey work should conform to the Standard and Guidance for Archaeological Desk-based Assessments (IFA, 1999a) and the Standard and Guidance for Archaeological Field Evaluations (IFA, 1999b), respectively.

GOOD PRACTICE RECOMMENDATIONS 2.47: REPORTING
Final reports should be produced both in hard copy and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. Reports should also be converted into PDF format so that they can be easily e-mailed or made available on the Internet. **GIS files with the licence area shown should be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.**

2.8.6 FUTURE DEVELOPMENTS

There are a number of detailed guidance notes being produced under the Aggregate Levy Sustainability Fund, including one regarding wrecks and wreckage and one on prehistoric remains in the aquatic environment. The Department for Culture, Media and Sport (DCMS) will soon publish a review of marine heritage legislation (*Protecting Our Historic Marine Environment: Making the System Work Better*, available from ***http://www.culture.gov.uk)***. In addition, BMAPA and English Heritage are developing an industry wide protocol for reporting archaeological discoveries, particularly concerned with the marine environment. Finally, the MOD is engaged in a rolling programme of assessing wrecks to be designated under the Protection of Military Remains Act.

REFERENCES

DCMS (in press). *Protecting our Historic Marine Environment: Making the System Work Better*. DCMS: see ***http://www.culture.gov.uk***.

BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment: Guidance Note*. British Marine Aggregate Producers Association and English Heritage, London: see ***http://www.bmapa.org/pdf/arch_guidance.pdf***.

Institute of Field Archaeologists (1999a). Standard and Guidance for Archaeological Desk-Based Assessment. Published October 1994. Revised September 2001.

Institute of Field Archaeologists (1999b). Standard and Guidance for Archaeological Field Evaluations. Published October 1994. Revised September 2001.

SECTION 2.9 NAVIGATION, RECREATION AND OTHER USES

2.9.1 THE NEED TO COLLECT BASELINE DATA

Navigation

The assessment of navigational issues forms a key component of EIA in the marine environment. An accurate description of the existing use of a study area by dredgers, commercial and recreational vessels, along with information on any hazards to navigation and navigational management measures (such as traffic routing systems and the location of shipping lanes), are essential to ensure that a comprehensive overview of the importance of a study area, with respect to navigation and other uses, is provided.

The nature of marine aggregate dredging means that the number of large, slow moving vessels within an application area increases during the operational phase of the work. An increase in the number of slow moving large vessels in an area will often result in an inherent increase in the risk of collision between vessels and impacts upon other legitimate uses of the sea. Therefore, the baseline information relating to other legitimate uses of the sea is an essential component of any assessment of the potential impact of marine aggregate extraction.

Other uses

In addition to navigation, other legitimate uses of the sea include:

- Commercial fishing activity (discussed in **Section 2.7**);
- Other dredging activities;
- Waste disposal operations (by dumping or pipeline);
- Offshore energy production (e.g. oil, gas, wind) and associated activities;
- Military exercise areas;
- Recreational activities such as yachting, angling and scuba diving (with variable locations and magnitudes); and
- Pipelines, cables and other such features.

All of the above are activities that have the potential for interaction with dredging operations. Therefore, it is important that the level and spatial distribution of these activities in a study area is assessed as part of the EIA process.

Navigation and other uses is a parameter that has not, to date, been subject to the same level of research or published guidance as many of the other parameters considered in this document. However, it forms an important aspect of the dredging application process and, if the baseline conditions with respect to this parameter are not described fully, any subsequent impact assessment will be flawed.

2.9.2 LITERATURE-BASED DESK STUDY (SCOPING)

As the first step in the EIA process, it is recommended that a Scoping Study be undertaken. With respect to navigation and other uses, this scoping study should involve the review, collation and assessment of any relevant data that exists for the study area, including published literature and previous ESs. Contact should also be made with governmental and research agencies, to establish whether there are on-going survey and monitoring initiatives in the study area. Details of organisations that will hold relevant data are provided in **Table 2.2**.

The Department of Trade and Industry (DTI) also intends to complete a series of Sectoral Strategic Environmental Assessments (SEA) to assess the potential impacts of offshore oil and gas and renewable energy (offshore wind farms) developments (plans or projects) and to promote the environmentally sound development of Britain's hydrocarbon resources (e.g. CEFAS, 2001). The

SEA approach is now also being applied to the offshore renewables industry[5]. Information provided as part of the SEA process will be used to inform the environmental sensitivity of the region and, as a result, potential blocks of seabed proposed for exploitation may be withdrawn or conditions imposed on 'use' initiatives. A large amount of information on navigation, recreation and other uses is included within the Technical Reports produced as part of the SEA process and it is recommended that these be consulted when describing the baseline environment.

These reports can be obtained from:

http://www.offshore-sea.org.uk/sea/dev/html_file/library.php

2.9.3 BASELINE DATA REQUIREMENTS

Based on the guidelines set out in MMG1 the following key data requirements have been identified (**Box 2.23**). It is very important to note that not all of these data will need to be collected at the same level of detail for every project. For this reason, scoping is a very important stage of the EIA process. More details on scoping studies are provided in **Section 1.3**.

GOOD PRACTICE RECOMMENDATION 2.48: SCOPING
The decision as to which data requirements should be investigated in greatest detail should be determined through the scoping stage.

Box 2.23 Summary of baseline data requirements for navigation, recreation and other uses

- **The location of the proposed aggregate extraction area should be described;**
- **Shipping movements associated with the dredge operation should be estimated;**
- **Waste disposal operations (by dumping or pipeline) in the region should be identified;**
- **The location of offshore energy production activities should be identified;**
- **Patterns in the level and distribution of commercial shipping should be described;**
- **The location of navigational features should be described (surface and sub-surface);**
- **The position of any sub-sea pipelines and cables should be described;**
- **The location of any areas of military activity should be described; and**
- **Recreational uses of the study area should be described.**

Location of the proposed aggregate extraction area

The proposed extraction area should be specified through the provision of a list of chart co-ordinates together with a location figure showing the area of the proposed dredge in relation to the surrounding sea area, other dredging areas and adjacent coastlines. It is important that other dredging/extraction activities in the surrounding area are discussed in order to describe the current proposal in the context of the marine aggregate extraction industry regionally.

Shipping movements

Reliable estimates of the likely number of dredger movements on an annual and, where appropriate, seasonal basis, plus the number of vessels likely to be operating within the area at any one time, should be provided as a matter of course. This same information will be of considerable use in the preparation of a collision risk assessment and should be obtained from the dredging company.

[5] See: ***http://www.og.dti.gov.uk/offshore-wind-sea/***

Waste disposal operations (by dumping or pipeline)

Note
The dumping of wastes at sea is prohibited except under licences issued under Part II of the Food and Environment Protection Act 1985 (FEPA II). The categories of licensed waste have included sewage sludge, solid industrial waste and dredged materials. Under the OSPAR Convention, only dredged material, fish processing waste, inert materials of natural origin and vessels or aircraft may now be disposed of at sea under FEPA II in the UK. Dredged material now comprises virtually all of the material deposited at sea[6].

It is highly unlikely that a proposed aggregate extraction location will fall within the area of a licensed offshore disposal ground. Furthermore, the coarse nature of target aggregate would probably mean that it would not retain a high concentration of any pollutants present. However, the potential adverse consequences of dredging polluted sediments, both for the natural and human environment, are such that the possibility of contamination should be investigated as part of any EIA. Therefore, the presence of any (historical) waste disposal sites in both the immediate and wider study area should be identified.

Offshore energy production activities

The UK continental shelf supports major provinces of oil and gas exploration and exploitation. The infrastructure above, on and under the sea covers a very large area and in many cases may occur within the vicinity of a proposed aggregate extraction location.

The collation of baseline data describing the spatial distribution of oil and gas activities is essential in order to avoid potential negative interactions with its infrastructure (such as collisions or rupture of pipelines) and the subsequent, potentially disastrous environmental impacts (i.e. oil spills). The collection of these data allows for the formulation of mitigation and hazard avoidance measures at an early stage in the planning process.

Offshore renewable energy production is a major growth industry in UK coastal waters and the exact location (proposed or approved) of any wind farms or wave/tidal energy generators should be included within the baseline. These data should include accurate co-ordinates of the wind farm or wave/tidal energy generator.

Photo 2.14 Horns Rev Offshore Wind Farm, Denmark © Elsam A/S

GOOD PRACTICE RECOMMENDATION 2.49: CUMULATIVE EFFECTS
Information on the location and extent of offshore energy production installations is crucial in order to effectively assess any potential cumulative impacts upon navigation, when combined with the dredging operation.

Patterns in the level and distribution of commercial shipping

Commercial use of the sea for the transportation of cargo is a major international business. The UK alone has a commercial shipping fleet of over 1260 vessels representing over 13500 dead weight tonnes (DWT) of shipping. The high economic importance of commercial shipping, together with the potential risk of collisions, makes a description of shipping activity a key requirement for consideration within the EIA baseline.

The EIA should contain a description of the main ports and harbours in the vicinity of the dredging operation. This includes both UK and continental ports and harbours and should involve plotting these ports onto charts showing the location of the proposed extraction area.

6 See http://www.defra.gov.uk/environment/statistics/des/coastwaters/cw1719.htm#cmtb14

Any Traffic Separation Schemes (TSS) in the area should be described and mapped, along with a description (using text and tables) of the number and direction of travel of vessels using the shipping lanes and any vessels (such as ferries) that directly cross the separation scheme. Particular consideration should be given to any shipping lane that passes through the proposed extraction area.

Note
Rules for the use of TSS are contained in Rule 10 of the International Regulations for the Prevention of Collisions at Sea 1972 and Rule 10 of the Merchant Shipping (Distress Signals and Prevention of Collisions) Regulations 1996, with further explanation provided by Marine Guidance Note 200 (M+F) *Observations of Traffic Separation Schemes.* See the Maritime and Coastguard Agency website for further details: ***http://www.mcga.gov.uk***.

Navigational features

Baseline information relating to the location and nature of any navigational aids or potential obstructions should also be presented. This information should include both surface and sub-sea obstructions:

Surface

- Platforms;
- Floating Production, Storage and Offloading vessels (FPSOs);
- Loading Buoys; and
- Permanent marker buoys.

Sub-surface

- Suspended wellheads;
- Manifold wellheads;
- Pipelines (discussed below);
- Telecommunications cables (discussed below);
- Major debris (wrecks etc.); and
- 500m safety zones around oil and gas installations.

Photo 2.15
Permanent Marker Buoy

Sub-sea pipelines and cables

Under Section 3 of the Submarine Telegraph Act 1885, as applied by Section 8(i) of the Continental Shelf Act 1964, it is an offence to wilfully or by culpable negligence break or injure a submarine cable in such a manner as might interrupt or obstruct telegraphic or telephonic communication. Any damage to the cable must be put right, at cost, by the offender. For this reason, it is important that the EIA describes the position of any sub-sea pipelines or cables within both the immediate and wider study area.

Military activities

Baseline data on the location of military practice and exercise areas (PEXA) is required to ensure the safety of the dredging operation. PEXAs are those areas of coastal waters which are available for use or in active use by the military and in many cases involve the firing of live ammunition. The potential risk of the dredge arm running across any unexploded ordnance, along with the inherent risk to life of working in a live fire area, means that the location of all PEXAs in the vicinity of the proposed dredging area should be identified as part of the baseline studies.

Recreation

Recreational uses of the sea include hobby fishing, SCUBA diving, sailing and power-boating, amongst others. Information should be obtained (where possible) on the types, level and spatial/temporal distribution of all recreational activities that occur within the vicinity of the aggregate extraction area.

Photo 2.16 Recreational Sailing

2.9.4 METHODS OF BASELINE DATA COLLECTION

This section sets out the various methods available to collect the required data and the potential sources of these data. Where possible, contact addresses and web-page links have been provided for key data providers.

Table 2.2 Sources of baseline information for navigation, recreation and other uses

Information Requirement	Source
The location of the proposed dredging area should be described	This information is readily obtainable from the dredging company making the application, and from the Crown Estate[7], which holds information on and the locations of all UK dredging licence and application areas.
Shipping movements associated with the dredge operation should be estimated	The dredging company involved in the application should be able to provide reliable estimates of their proposed shipping movements and activities. This information should also have been collected as part of the baseline data collection undertaken to describe the proposed activity (see **Section 2.2**).
Waste disposal operations (by dumping or pipeline) in the region should be identified	Defra has statutory control over waste disposal at sea within UK waters and holds information on licensed disposal sites and the types and quantities of materials they receive. Baseline information relating to the exact location of offshore dumping sites in the vicinity of the proposed dredge and the types of material concerned should be obtained from Defra as part of the EIA process. Aggregate extraction areas usually occur far enough offshore to not effect Long Sea Outfalls (LSO). Information on LSO locations can be obtained through consultation with the local water authorities, local councils, the Environment Agency and Defra.
The location of offshore energy production activities should be identified	Oil and gas is regulated in the UK by the DTI, who can provide information and contact details relating to the oil and gas activities within a pre-defined area. Also, any SEAs that cover proposed or current extraction sites should be reviewed, along with studies of the relevant Admiralty Chart/s. There are currently 3 SEAs (SEA 4 was due to undergo final consultation in December 2003) prepared for UK waters, covering the north and west of Scotland, the 'mature' areas of the North Sea, and the north east and central North Sea. In total there are 8 planned SEAs for offshore oil and gas licensing in UK coastal waters. As landowner of the seabed out to the 12 nautical mile territorial limit, the Crown Estate can also provide information on the location of offshore energy production installations through their process of leasing the seabed. With respect to renewable energy activities, in England and Wales, energy policy is the responsibility of the DTI. DTI administers the provisions of the Electricity Act 1989, requiring developers to seek development consent from the Secretary of State for Trade and Industry for the construction, extension or operation of a generating station of 1 MW and over, offshore in England and Wales. In Scotland, similar development applications are dealt with by the Scottish Executive[8] and in Northern Ireland by the Department of Enterprise, Trade and Investment[9] (DETI(NI)). For offshore wind farms, information on the location of sites is also provided on the British Wind Energy Association (BWEA) web-site[10].

7 http://www.crownestate.co.uk/estates/marine/marine_agg.shtml
8 http://www.scotland.gov.uk
9 http://www.detini.gov.uk
10 http://www.offshorewindfarms.co.uk

Table 2.2 (cont.)

Information Requirement	Source
Patterns in the level and distribution of commercial shipping should be described	Various sources of information are available for the assessment of the level and distribution of commercial shipping. These include, but are not limited to: • Digital shipping databases, such as the COAST[11] database, ShipRoutes database[12] and Seasearcher.com, to name just a few, are an excellent source of reliable information on ship movements, size, class and departure/arrival points; • Lloyds Marine Intelligence Unit (LMIU)[13]; offer a range of information including vessel movement data dating back to 1976; • National Coastwatch Institute (NCI)[14] operate 25 NCI stations around the UK coast, the majority of which are found in the south-east and south-west. NCI stations are operated 365 days per year and each day a log is kept of the type, direction of travel and distance offshore of all vessels that can be visually detected. These visual detections are supported by radar coverage (on most occasions) in the event of adverse weather. Although perhaps not as easily accessible as the digital databases, the NCI data has the distinct advantage of including vessels that would be missed by the big databases, such as recreational vessels, small fishing vessels and other non-commercial shipping. However, issues exist in relation to the data quality and coverage of these data, which should be reviewed; and • Port Authorities can be contacted and may provide useful information on vessel arrivals and departures, as well as type, class and cargo.
The location of navigational features should be described	Data on the location and nature of major navigational issues within a study area can be obtained from the following sources: • Admiralty Charts; • Local Port Authorities; and • General Lighthouse Authorities – Trinity House Lighthouse Services, Northern Lighthouse Board, Commissioners of Irish Lights.
Military Activities	The UK Hydrographic office[15] produces PEXA charts on behalf of the MoD. The charts show the PEXA locations as polygons identified by numbers prefixed by either a 'D' or an 'X'. 'D' (for Danger) on the site serial number is used for areas which extend above ground/sea level. The prefix X is used for areas in which the activities are carried out at the surface or sub-surface level.

11 http://www.safetec.no/coast/
12 http://www.anatec.com/shiproutes.htm
13 http://www.lloydsmiu.com
14 http://www.nci.org.uk
15 http://www.ukho.gov.uk

Table 2.2 (cont.)

Information Requirement	Source
Sub-sea pipelines and cables	Data describing the position and type of sub-sea pipelines and cables are available from the following data sources: • Kingfisher Information Service (KIS)[16], aimed at the fishing industry, provides seabed charts that identify fishing grounds and navigational hazards based on information provided by fishermen, the oil and gas industry, telecommunications companies and other marine users; • Fishsafe[17], a relatively new database supported by the UK Offshore Operators Association (UKOOA) which uses data from the Kingfisher Information Service (UK continental Shelf) database. The information is converted into a common standard and added to other sources of data held by organisations such as the UKOOA and the Health and Safety Executive to provide a more holistic database. Like Kingfisher, the Fishsafe database is designed for use by the fishing industry to identify surface and sub-surface hazards and safety zones, while maximising fishing opportunity. However, it may also have invaluable potential for application in the aggregate extraction industry. • Kingfisher Cable Awareness (KIA-CA)[18] Charts are, again, produced for the safety of fishermen. However, as with the rest of the Kingfisher series, these charts have an equally important and useful application to the aggregate extraction industry. The charts can be used to form an accurate baseline of all telecommunications activities within the proposed dredging area and, consequently, steps can be taken at an early stage that will completely negate the risk of negative interaction.
Recreation	Reliable sources of information on recreational use of offshore areas can often prove difficult to obtain. The best source of information is held by operating organisations such as the Royal Yachting Association (RYA), British Sub Aqua Club (BSAC), Professional Association of Diving Instructors (PADI) etc, who will be able to provide details of local clubs and sites that are regularly used. Local fishing clubs should also be contacted as well as the National Federation of Sea Anglers[19] to gather data on the distribution and location of hobby boat-fishing areas. NCI also hold data on the number and movement of recreational vessels within their watch area.

GOOD PRACTICE RECOMMENDATION 2.50: RECREATIONAL VESSEL MOVEMENTS
Baseline information on recreational vessel movements can be obtained by looking at cruising routes and consulting with yacht clubs in the study area. Waypoints, which many recreational sailors then use to plot routes, are also often published in yachting magazines. Consultation with local boat clubs is also essential.

Consultation

Consultation is vital to the successful production of an EIA as it enables key organisations to be contacted and invaluable data to be collected. It also allows any potential conflicts of interest to be identified at an early stage of the process. Through well-targeted consultation, much of the information required to accurately describe the baseline conditions in relation to navigation and other uses, can be obtained. It is highly recommended that some form of consultation exercise is undertaken as part of the data review exercise. A summary of key consultees with respect to navigation, recreation and other uses data is provided in **Appendix B (xvii)**.

[16] *http://www.seafish.co.uk/kingfisher/dept_kingfisher.htm*
[17] *http://www.ukooa.co.uk/issues/fishsafe/*
[18] *http://www.kisca.org.uk*
[19] *http://www.nfsa.org.uk*

GOOD PRACTICE RECOMMENDATIONS 2.51: CONSULTATION

Baseline data relating to navigation and other uses should be collated through a combination of a data review exercise and consultation. Key consultees should always be consulted early on in the project.

Time should be spent at the start of the process compiling an accurate list of individual organisations that should be contacted.

2.9.5 BASELINE DATA ANALYSIS AND PRESENTATION

Data analysis

Detailed data analysis is only required for navigation-based data. For this reason, many EIAs contain specialist navigational risk assessments. This work would usually be undertaken by a company specialising in navigational risk assessment.

Data presentation

As a general rule, data pertaining to Navigation and Other Uses should be presented as clearly and simply as possible within the EIA. It is highly recommended that GIS is used to display the data graphically. Ideally, relevant data should be displayed using the same 'background layer', such as a digital Admiralty Chart, thereby making the spatial assessment of navigation and other uses easier.

In terms of graphical presentations and figures, it is recommended that the following figures should be produced:

- Location and boundaries of the proposed dredging area;
- Position and boundaries of adjacent dredging areas;
- Proposed route of any dredger or other vessels to and from the site;
- Location and boundary of any offshore disposal sites in the vicinity of the proposed dredging area;
- Location and boundaries of any offshore energy production activities;
- Patterns or routes of commercial shipping activity;
- Major navigational features and routeing measures, e.g. TSS;
- Position of sub-sea cables and/or pipelines;
- Location and boundaries of military exercise areas (PEXAs);
- Spatial distribution of recreational activities (dive sites, angling marks, routes of yacht races); and
- Location and spatial extent of any nature conservation sites within the study area.

In practice, much of these data will be able to be represented graphically on a small number of combined figures.

2.9.6 REPORTING OF BASELINE DATA

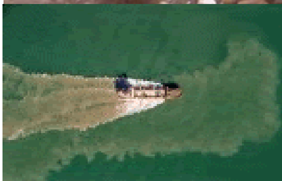
The majority of the baseline data collected in relation to navigation and other uses will be able to be reported directly within the final ES in the form of GIS figures. Any specialist navigation risk assessments should be issued as stand-alone technical reports, with key issues reported within the final ES. The process of incorporating certain parts of the navigational risk assessment into the final ES should preferably be done by the person(s) responsible for the risk assessment. If this is not the case, then this person(s) should at least review the final ES prior to publication to ensure that key issues are included.

Report format

GOOD PRACTICE RECOMMENDATIONS 2.52: REPORTING
If a site-specific navigation risk assessment has been produced and summarised within the final ES, the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included. **The navigational risk assessment should be produced both in hard copy format and digitally. Copies of this report should be issued on CD to consultees and Regulators, where possible. The report should be converted into PDF format so that it can be easily e-mailed or made available on the Internet.** **GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.**

REFERENCES

CEFAS (2001). Strategic Environmental Assessment (SEA2) - North Sea Fish and Fisheries. Technical Report TR_003, August 2001.



Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

3 GENERIC IMPACTS OF MARINE AGGREGATE EXTRACTION

Mineral Industry Research Organisation

ROYAL HASKONING

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Mineral Industry Research Organisation

ROYAL HASKONING

SECTION 3 GENERIC IMPACTS OF AGGREGATE EXTRACTION

SECTION 3.1 GENERIC GUIDANCE

Aggregate extraction activities have the potential to create a range of effects on the marine environment. These include physical, biological and chemical effects that can create a change in the baseline conditions beyond that which would be expected through natural variation. These effects can be direct or indirect, reversible or irreversible and/or cumulative (see definitions below and also **Section 4.1.4** Nature of the Effect).

This section of the document aims to provide a brief overview of the main effects of aggregate extraction on the various parameters being considered by this study. In addition to this guide, the reader is referred to the literature that already exists concerning the review of dredging impacts. A selected list of reviews and papers on this subject are provided in **Appendix C (i)**. In particular, reference should be made to Newell *et. al.,* (2004), another project funded through the ODPM aggregate fund, which provides the results of a comprehensive study on the impacts of aggregate dredging on sediment composition and benthic faunal communities within the boundary of dredged areas and along the axis of the settlement and transport of sand mobilised by dredging and screening at two sites in the North Sea. The report also includes an overview of current research on the impacts of dredging on sediment deposition, on benthic biological communities within dredge sites and in the surrounding deposits, and on the nature and likely rates of recovery processes in different deposit types.

It should be noted that in addition to the impacts listed and described in the following sections, other impacts may also arise that are not listed. This is particularly likely in instances where site-specific conditions may create unique circumstances.

An important consideration when assessing the implications of aggregate extraction are the natural perturbations that exist within any environment. It is important to determine what these may be for each individual site in order to distinguish natural changes from those caused by the extraction activity. It is for this reason that baseline data collection should cover a wide temporal scale and that reference (or control) sites should be monitored in order to record changes to an area outside the influence of the extraction activity (see **Section 2**). Natural changes could occur as a result of storm events, cyclical processes of erosion and accretion and natural successional changes in benthic community structure. For example, reefs built by *Sabellaria spinulosa* undergo natural cycles of erosion. It is, therefore, important to determine whether a reef is eroding naturally prior to undertaking extraction activities.

When considering impacts it is also important to determine what other proposed or actual activities are likely to occur within the study area. This is to ensure that the assessment of impacts that could occur within the receiving environment takes account (cumulatively) of all known activities. Guidance on cumulative assessment for aggregate extraction in relation to European marine sites is provided within PDE and Hill (2001). A further study undertaken by Oakwood Environmental Ltd (2002) developed a methodology for cumulative effects assessment (CEA) based on identified best practices. The study applied chosen tools and techniques to a CEA in the marine environment using the Liverpool Bay area as a case study. A number of limitations in the methodology were identified, including a lack of available digital data regarding information for both human activities and the natural environment, insufficient data on the sensitivity of many of the biotopes identified, limitations in fisheries data and a lack of information on relevant environmental thresholds.

There are a number of potential impacts that combine with aggregate extraction and these are tabulated in **Appendix C (ii)**.

GOOD PRACTICE RECOMMENDATIONS 3.1: IMPACT ASSESSMENT

An important consideration when assessing the potential effects of aggregate extraction are the natural perturbations that exist within any environment. It is important to determine what these may be for each individual site in order to distinguish natural changes from those caused by the extraction activity.

When considering impacts it is also important to determine what other proposed or actual activities are likely to occur within the study area. This is to ensure that the impacts that could occur from all known activities are assessed cumulatively.

3.1.1 KEY DEFINITIONS

Effect

An outcome, result or consequence to the environment brought about by some force, project or action.

Impact

Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services.

Direct impacts

Effects caused by a given action and occurring at the same time and place as the action. Direct removal of benthos is an example of a direct effect.

Indirect impacts

Effects caused by a given action, occurring later in time or farther removed in distance but which are reasonably foreseeable. Smothering of the benthos is an example of an indirect effect.

Reversible and irreversible impacts

The capability for an impact to be reversed. An irreversible impact might be a change to a natural process or operation (migration pattern of fish, wildlife habitat, etc.) such that it would never occur again due to the implementation of a project. For example, if the shingle substrate was to be totally removed due to dredging then it is unlikely that ecological activity would recommence (i.e. irreversible impact) conversely. The retention of some shingle substrate at a specific depth would help to maintain ecological activity following dredging (i.e. reversible impact).

Cumulative impacts

Cumulative impacts are effects on the environment, either from the summation of individually minor but collectively significant impacts, or as a result of the interaction of impacts from one or more sources. Thus, cumulative impacts might occur as a result of aggregate extraction at a single site, from multiple sites in close proximity, or *in-combination* with effects from other activities, such as fishing or installation of offshore structures (PDE and Hill, 2001).

Box 3.1 Relevant uses of cumulative and 'in-combination'	
Marine Minerals Guidance Note 1 (ODPM, 2002)	To examine *"cumulative physical and biological impacts through the combined effects of dredging and of other activities in other nearby areas as well as the proposed dredging area".*
English Nature Habitats Regulations Guidance Note 4 (June, 2001)	*In combination* applies to the effects of a plan or project "in combination with other plans or projects", which should include: • Approved but as yet uncompleted plans or projects; • Permitted ongoing activities such as discharge consents or abstraction licences; and • Plans or projects for which an application has been made and which are currently under consideration, but not yet approved by the competent authorities. In some cases it may also be appropriate to include plans and projects not yet submitted, but for which sufficient detail exists on which to make judgements on their impact. The term *cumulative effect* is used to include all plans listed under "in combination" together with: • Completed plans or projects; • Activities for which no consent was given or required; and • Natural processes (by natural mechanisms at a natural rate).
ICES Guidelines for the management of marine sediment extraction (2003)	"Cumulative impacts might occur as a result of aggregate dredging at a single site over time, from multiple sites in close proximity, or in-combination with effects from other human activities (e.g. fishing, offshore wind farms)".

The range of impacts considered in cumulative assessment will normally be wider than those for individual projects, since the area under consideration is generally larger and the variety of impacts greater. Due to the complexity of interactions inherent within cumulative impact assessment, it may not be possible to analyse impacts in detail. In many cases, a simple indication of the type and level of potential impacts may be sufficient. It is important to determine whether the cumulative impacts potentially arising for a feature are additive, interactive or synergistic.

Box 3.2 Types of cumulative impact
Additive Impacts: Impacts in which one unit of change to the environment may be added to (or subtracted from) another unit of chance. ***Interactive Impacts***: Impacts whereby the net accumulation of the units of change to the environment may be more or less than the sum of all the units of change. ***Synergistic Impacts***: Impacts whereby two impacts combine to create an additional impact that would not have occurred otherwise

3.1.3 THE ROLE OF MONITORING IN THE DEFINITION OF IMPACTS

The impacts detailed in the following sections summarise the key impacts that have been identified by numerous authors from a combination of previous EIA studies, field-based research, literature reviews and experimental studies. In this respect, they represent the current knowledge of potential impacts to date. However, it is important to recognise that the detailed knowledge base with respect to many of these impacts is still developing and, indeed, that many potential impacts currently identified within ESs are essentially predictions, based on current levels of knowledge.

Therefore, monitoring is a key aspect in the identification/definition of impacts, as the data collected from dedicated monitoring surveys will provide the evidence, and hence an audit trail, that these impact predictions are accurate. In a similar way, monitoring is essential in demonstrating the success of any mitigation measures proposed to offset the scale of any impacts. This is discussed in more detail in **Section 5.1.4**.

Consequently, it is recommended that in addition to providing details on the success of any mitigation measures, monitoring programmes developed for marine aggregate sites should also have, as one of their primary objectives, a remit to gather field data that proves/disproves the initial impact predictions made within the EIA studies. It is also important that this monitoring programme has some form of feedback and reporting mechanism that will enable dredging operations to be modified if the initial impact predictions are shown to be inaccurate. Further details on such feedback mechanisms are provided in **Section 6**.

GOOD PRACTICE RECOMMENDATIONS 3.2: MONITORING
Many of the impacts described within ESs are predictive. Therefore, it is recommended that one of the primary objectives of any associated monitoring programme is to validate these predictions through the collection of actual field data. **Any monitoring programme should also incorporate some form of feedback and reporting mechanism that will enable dredging operations to be modified if the initial impact predictions are shown to be inaccurate.**

REFERENCES

DETR (2001). Draft Marine Guidance Note 2: Guidance on the Extraction by Dredging of Sand, Gravel and Other Minerals from the English Sea Bed – Consultation Paper. Department of the Environment Transport and the Regions Crown Copyright, London.

English Nature (2001). Habitats Guidance Note 4, Alone or in combination. Issued by Wyn Jones, English Nature, Peterborough, UK.

Gubbay, S (2003). Marine aggregate extraction and biodiversity. Information, issues and gaps in understanding. Report to the Joint Marine Programme of the Wildlife Trusts and WWF-UK.

ICES (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM2003/E:07. Ref. ACME, ACE, D.

Newell, R.C., Seiderer, L.J., Robinson, J.E, Simpson, N.M., Pearce, B. and Reeds, K.A. (2004). Impacts of Overboard Screening on Seabed and Associated Benthic Biological Community Structure in Relation to Marine Aggregate Extraction. Technical Report to the Office of the Deputy Prime Minister (ODPM) and Minerals Industry Research Organisation (MIRO). Project No.SAMP.1.022. Marine Ecological Surveys Limited, St IVES, Cornwall.

Oakwood Environmental Ltd (2002). Development of a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study. CCW Contract Science Report Number 522.

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

SECTION 3.2 PHYSICAL PROCESSES

3.2.1 INTRODUCTION

Four main sources of physical disturbance arise from aggregate extraction. These are (ICES, 2001):

1. Substrate removal and alteration of seabed topography;
2. Creation of sediment plumes within the water column;
3. Sediment deposition on the seabed; and
4. Subsequent bedload transport of sediment.

1. Substrate removal and alteration of seabed topography

Changes in seabed topography will occur across the extraction site as a direct result of the extraction, with resulting changes to water depth. These changes exist as furrows or pits. The time period over which such features will persist will depend on factors such as:

- The rate, amount and depth of extraction;
- The degree of sediment transport around the extraction site;
- Water depth and local hydrodynamic conditions; and
- The nature of the sediments around the extraction site.

Various experimental studies have reported varying time periods over which dredge tracks remain visible as features on the seabed. Erosion of dredge tracks in areas of moderate wave exposure and tidal currents have been observed to take from 3 to more than 7 years (Kenny and Rees, 1996 *in* Boyd *et. al.*, 2003). Conversely, in an area exposed to long period waves, dredge tracks (of 0.3 to 0.5m deep) were found to completely disappear in a gravelly substrate at a depth of 38m within 8 months (van Moorsel, 1993 *in* Boyd *et. al.*, 2003).

2. Creation of sediment plumes within the water column

The introduction of sediment into the water column occurs as a direct result of the extraction process itself. Within the UK, aggregate extraction primarily uses trailing suction hopper dredgers, which in certain circumstances may also be used to static dredge. Extraction via these techniques usually involves sediment losses due to extensive overflowing and often also due to screening (if a particular sediment fraction is required) (John *et. al.*, 2000). These processes typically result in the creation of a sediment plume. Sediment can also be mobilised through the action of the drag-head itself, although the increase in suspended sediment levels produced in this manner is negligible compared to the increase caused by overflow and screening processes.

Further details of the nature of sediment plumes are provided below.

3. Sediment deposition on the seabed

Sediment mobilised through aggregate extraction will eventually get re-deposited on the seabed. The exact rate and spatial extent of sediment re-deposition will depend on a range of factors, including local hydrodynamic conditions, the amount and type of sediment that enters the water column and the type of extraction undertaken. Sediment re-deposition has the potential to create a range of impacts on biological resources within affected areas. Sediment deposition also has the potential to alter the physical characteristics of the seabed, in particular, sediment composition. Sediment is deposited from the plume in two phases. First, a near-field deposit of coarser sediment generally less than 100-200m from the dredger (the Dynamic Phase) and, second, a far-field deposit of finer sediment within a few kilometres (the Passive Phase).

4. Subsequent bedload sediment transport

Once the sediment from the Dynamic Phase (and possibly the nearer-field Passive Phase) has deposited on the seabed, there is potential for its movement as bedload, away from the dredging site. The direction and magnitude of movement will depend on the physical conditions that impinge on the newly deposited sediment, particularly tidal current velocity. The sediment may move into areas that would not necessarily have had transport across them prior to dredging.

Each of the direct *changes* arising from aggregate extraction described above has the potential to result in alterations to the processes of the baseline physical environment. Processes such as waves, tidal currents, sediment transport and suspended sediment concentrations. Changes to these processes can, in turn, potentially result in a number of *impacts*. It is these potential impacts that should be assessed for each licence application. The link between changes and impacts is illustrated in **Figure 3.1**.

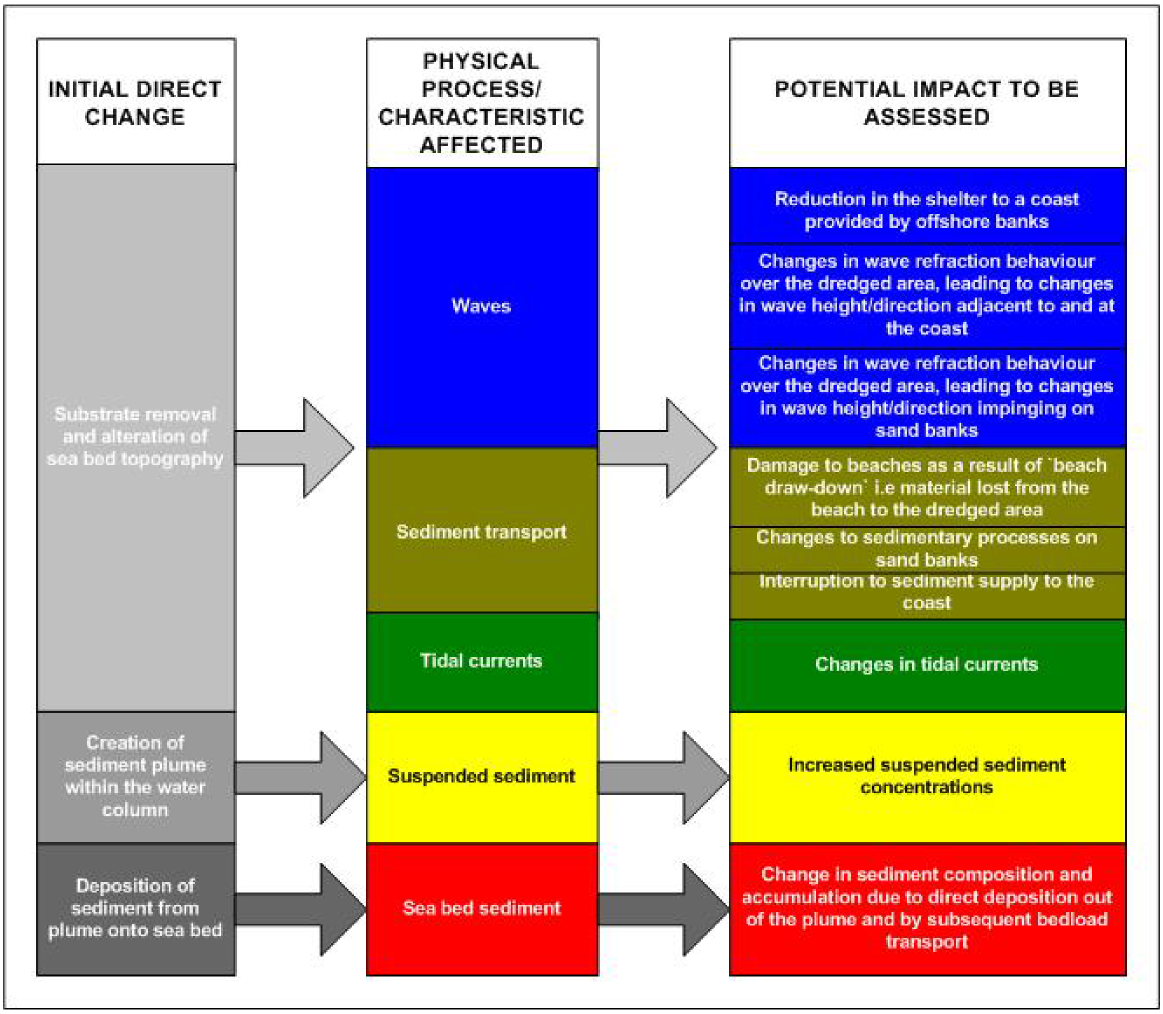

Figure 3.1 Link between physical changes, physical processes/characteristics and physical impacts

Each of the specific impacts to be assessed are discussed in more detail in the following subsections.

3.2.2 WAVES

Aggregate extraction may cause a change in wave refraction behaviour over the dredged area leading to changes in wave energy distribution adjacent to and at the coast

As waves enter shallow water approaching the coast, they become increasingly affected by the proximity of the seabed. This reduces the wave energy through frictional effects and the process of wave breaking. Similarly, if a wave passes over a near-shore sandbank on its path to the coast, wave dissipation processes will again act to reduce the total wave energy through frictional effects and breaking. Therefore, the resulting wave activity received by the coast can be greatly reduced by the presence of such banks, i.e. a degree of shelter is provided by the bank.

If aggregate extraction is undertaken on a near-shore bank, the crest level of the bank will be reduced, resulting in an increase in water depth in this area. This increased water depth will reduce the effect of wave dissipation processes as waves pass over the bank and, consequently, there will be the potential for a reduction in the resulting shelter afforded to the coastline by the bank. Any change to the wave energy received at the coast has the potential, therefore, to alter coastal morphology.

For aggregate extraction applications in near-shore waters, it is important to consider the effects of any lowering of the seabed on these processes.

Aggregate extraction may cause changes in wave refraction behaviour over the dredged area leading to changes in wave height/direction impinging on sandbanks

Changes in wave refraction behaviour at the dredge site may also cause changes to wave conditions at adjacent sites with different bathymetric heights (i.e. sandbanks), in a similar way to the impacts at the coast (see above).

Aggregate extraction may cause a change in wave refraction behaviour over the dredged area leading to changes in wave energy distribution at the coast

In addition to the potential effects on wave dissipation processes, the lowering of the seabed also has the potential to affect the process of wave refraction. As a wave enters shallow water its speed becomes a function of water depth. This results in the process of wave refraction, whereby wave crests are bent according to variations in seabed contours. Wave refraction alters the direction of wave propagation and, hence, the distribution of wave energy. Bathymetric highs and lows that a wave may pass over on its path to the coast can, therefore, result in wave 'focussing' at the coast, i.e. local concentrations of wave energy. This in turn can have implications for the behaviour and development of the adjacent coastline.

The lowering of the seabed at an extraction site, therefore, has the potential to alter existing refraction patterns at a particular location and change the wave energy subsequently received at the coast. Again, any changes to the wave conditions received at the coast have the potential to alter coastal morphology.

Any aggregate extraction licence application must consider alterations to wave refraction patterns. In doing so it is important to consider existing wave refraction patterns, incorporating natural irregularities at the seabed and if/how these have affected the development of the coast, in addition to considering a worst case post-dredge scenario (Brampton and Evans, 1998).

3.2.3 SEDIMENT TRANSPORT

Aggregate extraction may cause damage to beaches as a result of beach drawdown of material into the dredged area

One of the main concerns of stakeholders and regulating authorities in relation to the physical impacts of offshore extraction is possible damage to beaches. Beach drawdown is one of the potential mechanisms through which aggregate extraction can impact upon beaches.

The movement of sediment up and down a beach profile in a cross-shore direction is a naturally occurring process. Sediment is moved within the beach profile in an offshore direction by the action of waves during storm conditions and in an onshore direction during calmer conditions. This is a seasonal process due to variations in wave climate that results in fluctuating beach levels.

The cross-shore area over which this movement of sediment occurs is known as the 'active beach profile'. If aggregate extraction is undertaken within the active beach profile, there is potential for the drawdown of material from the beach profile to be artificially increased and for the drawdown sediment to be prevented from returning up the beach profile to restore beach levels. This prevention of material moving up the profile occurs if the material transported down the profile during a storm, settles within a dredged depression. The material can then become trapped within the depression, preventing it from moving back onshore during calmer conditions (Brampton and Evans, 1998). The result will be a net loss of material from a beach profile. This will facilitate further subsequent wave attack at the beach crest.

Aggregate extraction may lead to an alteration in the nature and rate of sediment transport to the coast

Another potential mechanism by which aggregate extraction may impact upon the coastline is an alteration in the nature and/or rate of a particular sediment supply pathway.

A dredging licence has the potential to affect the rate of supply of sediment to an adjacent coastline in both a direct and an indirect way. The alteration or interruption to a natural sediment transport pathway will directly affect supply, while dredging may have an indirect affect on sediment supply if it impacts upon another natural feature, e.g. a sandbank, which has a role to play within a pathway. Any disruption to the supply of material to the coast could result in the lowering of beach levels. As noted in **Section 2.3**, a number of regional scale sediment transport studies have been undertaken in the past. These studies identify sediment transport pathways, albeit at a regional scale, and are critical in the assessment of the impact of a dredging area on natural transport pathways.

Aggregate extraction may lead to an alteration in the nature and rate of sediment transport to sensitive features (e.g. fish spawning areas, areas of nature conservation interest)

In addition to potentially altering the rate and nature of existing sediment transport processes and pathways between the dredged site and nearby coasts, aggregate extraction may also lead to a similar interruption in existing pathways between the dredge site and other 'sensitive areas'. Many features in the immediate and wider study area are likely to rely on existing rates of sediment transport in order to be maintained or function. For example, *in situ* archaeological deposits may rely on a certain flux of sediment in order to maintain a protective layer over the resource. If this existing flux is altered in any way, either in terms of rate or general nature (different sized particles), then an adverse effect may arise. Similarly, the suitability and consequent success of certain fish spawning grounds may depend on existing rates of sediment transport. If these should be changed as a result of the aggregate extraction, then adverse effects may again arise.

The potential for an alteration in the nature and/or rate of sediment transport to affect other key environmental parameters is discussed in further detail in the following sections.

Aggregate extraction may cause changes to sedimentary processes on sandbanks

A change in wave conditions that may impact on a sandbank has the potential to alter sedimentary processes at the bank, causing changes to the morphology of its surface. At a broad scale, the change in wave conditions is unlikely to dramatically alter the sandbank structure, as this is controlled predominantly by tidal currents. However, at a local scale the surface composition could be changed, affecting the distribution of benthic species (see **Section 3.3**).

3.2.4 TIDAL CURRENTS

Aggregate extraction may create a change in tidal currents

Aggregate extraction can cause alteration to tidal currents. However, such changes are not considered to be a major alteration. Brampton and Evans (1998) cite such changes as being "typically small and localised" when dredging is undertaken in water depths of 20-30m. The spatial scale over which recordable changes occur is usually less than twice the dredge area in these water depths (Brampton and Evans, 1998).

As a result, when considering extraction in areas with water depths of 20-30m, changes to tidal currents will not constitute a significant impact. However, changes to tidal currents may constitute a significant impact where extraction is undertaken:

- in shallow water; and
- adjacent to a seabed feature, e.g. a sandbank (Brampton and Evans, 1998).

In the shallow water case, changes in tidal currents at an adjacent coast may affect beach behaviour and can, therefore, lead to an impact. In the case of an adjacent sandbank, a change to currents may either directly affect the behaviour of the bank or indirectly affect beach behaviour via coast-bank interactions.

In addition to the above, changes to tidal currents may also have implications for changes to other parameters, such as wave conditions and sediment transport.

3.2.5 SUSPENDED SEDIMENT

Aggregate extraction may lead to an increase in suspended sediment concentrations

The techniques utilised in aggregate extraction can involve three processes that contribute to sediment losses into the water column:

1. Action of the drag-head
The movement of a drag head and propeller disturbance may also contribute to sediment losses and plume duration in the case of suction dredgers (John *et. al.*, 2000). However, the increase in suspended sediment levels produced in this manner is negligible compared to the increase caused by overflow and screening processes.

2. Overflowing
Overflowing is a routine part of the dredging process, whereby unwanted fine sediment is displaced as pumping continues to increase the load after the dredger has been initially filled. The proportion of fine sediment in the load is typically small (1-5%) as sites selected for extraction generally have a low silt content (John *et. al.*, 2000).

3. Screening
Screening often takes place to divide the fine fraction from the coarse fraction, with the unwanted fraction discharged over the side of the vessel. The result of the sediment losses during the extraction process is the creation of a plume of turbid water. There are two types or phases of sediment plume;

- The dynamic plume phase; and
- The passive plume phase.

An overview of the dynamic and passive plume phases are provided in **Appendix C (iii) and (iv).**
For a comprehensive review of sediment plumes, see:

KEY REFERENCE
JOHN, S.A., CHALLINOR, S.L., SIMPSON, M., BURT, T.N. AND SPEARMAN, J. (2000). SCOPING THE ASSESSMENT OF SEDIMENT PLUMES FROM DREDGING. CIRIA REPORT C547.

The environmental impacts associated with this change in suspended sediment concentrations are influenced by factors such as:

- Sediment type;
- Dredger type;
- The phase of the plume; and
- Background levels of suspended sediment concentrations.

An increase in suspended sediment concentrations within the water column can cause impacts on ecological functions and specific species to arise. The potential impacts associated with increased suspended sediment concentrations on biological resources (benthos and fish and shellfish) are discussed in **Sections 3.3** and **3.4** respectively.

3.2.6 SEABED SEDIMENT

Aggregate extraction may result in a change in seabed surface sediment composition and accumulation

In addition to the effect of sediment within the water column, the deposition of sediment within the plume onto the seabed and its subsequent transport can also cause an impact to arise. The area that experiences this deposition of sediment from the plume is termed "the footprint". It is important to determine the spatial extent of the footprint associated with sediment plumes in order that potential impacts on the seabed, including physical and ecological impacts, can be assessed. As for increased suspended sediment concentrations, the potential impacts of sediment deposition and transport on biological resources are discussed further in **Sections 3.3** and **3.4**. However, in addition to ecological impacts created by these physical effects, increased deposition can also create direct physical effects, including a change in sediment composition and seabed topography.

Aggregate extraction may cause a change in sediment composition in two ways. Primarily, the removal of certain substrates from extraction sites, i.e. gravel, will lead to the residual sediment composition changing, in the case of gravel extraction, from one dominated by coarse sediments to one dominated by finer sediments.

Secondly, sediment composition can also change as a result of screening and overflow processes carried out by the dredger. These processes result in the proportion of fines at aggregate sites increasing. Therefore, a change in sediment composition can occur, usually from an admixture of sand and gravel to finer deposits (Dickson and Lee, 1972 cited in Boyd *et. al.,* 2003). In the UK, the most common scenario is that the sediment composition changes from a sandy gravel to a gravelly sand as a result of extraction activity. This may result from increasing fines which accumulate over time through screening activity or through the exposure of finer sediments (Boyd *et. al.*, 2003).

Thirdly, once the coarser fraction of the plume has been deposited it is then possible for the sediment to be transported further along the bed. Areas that previously had a static seabed may become affected by this sediment or accumulation rates may increase due to the added influx of new sediment.

REFERENCES

Boyd, S.E., Rees, H.L., Vivian, C.M.G., and Limpenny, D.S. (2003). Review of current state of knowledge on the impacts of marine aggregate extraction – a UK perspective. EMSAGG Conference. Delft University, The Netherlands, 20-21 February, 2003.

Brampton, A.H. and Evans, C.D.R. (1998). Regional Seabed sediment studies and assessment of marine aggregate dredging. CIRIA Report C505.

Dickson, R.R. and Lee, A. (1972). Study of effects of marine gravel extraction on the topography of the seabed. *ICES CM 1972/E:25*, 1-19.

ICES (2001). Effects of Extraction of Marine Sediments on the Marine Ecosystem. *ICES Co-operative Research Report No: 247*. ICES, Copenhagen.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). Scoping the assessment of sediment plumes form dredging. CIRIA Report C547.

Kenny, A.J. and Rees, H.L (1996). The effects of marine gravel extraction on the macrobenthos: early post-dredging recolonization. *Marine Pollution Bulletin,* **28:** 442-447.

Van Moorsel, G.W.N.M. (1993). Long term recovery of geomorphology and population development of large molluscs after gravel extraction at the Klaverbank (North Sea). Report No. 92. 16pp. 1-41.

SECTION 3.3 MARINE ECOLOGY (including marine mammals and sea birds)

3.3.1 BENTHIC AND EPIBENTHIC RESOURCES

This section outlines the potential impacts that could occur to benthic and epibenthic resources, marine mammals and sea birds as a result of marine aggregate extraction. For a detailed account of the potential impacts on benthic and epibenthic communities and subsequent rates of recovery, the reader is referred to Newell *et. al.*, 2004.

Direct removal of the seabed may lead to a reduction in habitat and species diversity, abundance and biomass

One of the most significant consequences of marine aggregate extraction is the removal of the substrate and the associated benthic species (ICES, 1992). This removal of benthic species can create a range of impacts, which are summarised below.

Removal of the seabed will lead to a reduction in the overall amount of habitat/species

The direct removal of substrate and associated habitats/species by aggregate dredging will obviously lead to a reduction in the overall amount of these habitats/species within the impacted area. The significance of the removal of these resources will depend on the type of habitats, and associated species/communities affected, and its distribution in the wider study area. A method to predict the scale of this impact is detailed in **Section 4.1**.

Removal of the seabed is likely to lead to a reduction in overall species abundance, diversity and biomass

Most studies have shown that dredging results in a significant fall in species numbers, population density and the biomass of benthic organisms (Newell *et. al.,* 1998). The magnitude of these changes has varied between studies. A study of the biological impacts of aggregate dredging off Dieppe, on the French coast of the eastern English Channel, showed an overall reduction in species richness of 63%, with reductions of 86% in abundance and 83% biomass (Desprez, 2000). A study of an experimentally-dredged site off the North Norfolk coast (Kenny and Rees, 1996) demonstrated a similar decrease in the number of species (66%) and even greater declines in species density (95%) and biomass (99%) as a result of dredging. Another study, undertaken in 2000 for Area 408 in the southern central North Sea, by contrast, was unable to detect any impact through dredging (or the deposition of material returned to the seabed during the screening process) on the mean species diversity or population density of benthic invertebrates in the survey area. In fact, both species diversity and population density were similar in dredged stations, stations at which dredging had been abandoned for up to 12 months, non-dredged stations situated outside the boundaries of the dredged area (where sediment released by the screening process potentially could be transported) and in 'control' areas well beyond the boundaries of potential impact of dredging at Production Licence Area 408 (Newell *et. al.*, 2002).

The conclusion drawn from these studies is that the effect of dredging on the resident benthic community is dependent on:

- The intensity of dredging at a particular site;
- The nature of the seabed community at the dredge site; and
- The status of the seabed following the cessation of extraction.

In areas that are lightly dredged by trailer-dredging techniques the impacts on marine benthos appear to be less than in sites of high-intensity dredging, such as the experimentally-dredged site off Lowestoft studied by Kenny and Rees (1996) and at sites dredged by static dredgers. Areas of sandy gravels that are naturally subject to disturbance by waves and seabed currents are colonised by small mobile species, such as polychaetes and crustaceans, which are able to rapidly recolonise recently-dredged deposits, to an extent that at some sites the rate of recolonisation appears to be in equilibrium with the rate of removal by dredging. At other sites, however, dredge trails are only slowly infilled by bottom currents and in these less-mobile deposits community composition may remain altered for several (or many) years after the cessation of dredging.

Further details on the re-colonisation, restoration and recovery of dredged sediments are provided below.

Re-colonisation, restoration and recovery

In describing the impacts of dredging on the benthic and epibenthic resources, it is important to recognise that the impact of dredging in terms of benthic and epibenthic species removal can be severe within dredged areas, but that it will not be permanent. Indeed, the process of re-colonisation starts almost immediately, with disturbed species returning to the seabed. It is important, however, to recognise that the substrate type is likely to be different to that present prior to dredging due to a number of factors, including the removal of substrate, settlement of disturbed material and increased mobility of the sediment.

Box 3.3 Key definitions

Recovery
The establishment of a successional community of species which progresses towards a community that is similar in species composition, population density and biomass to that present at non-impacted reference sites (from Newell *et. al.,* 1998).

Re-colonisation
The settlement of new recruits from the plankton or immigration of adults from outside the disturbed area (from Boyd *et. al.*, 2003).

Restoration
The return of community structure within the disturbed area (from Boyd *et. al.,* 2003).

The estimated time required for re-establishment of the benthic fauna following marine aggregate extraction may vary depending on the following factors:

- The scale and duration of disturbance;
- Hydrodynamic and associated bed-load transport processes;
- The topography of the area;
- The degree of similarity of the habitat with that which existed prior to dredging; and
- The availability of colonising species in adjacent, non-impacted areas (Desprez, 2000).

Available evidence suggests that substantial progress towards ‘recovery’ (see **Box 3.6**) could be expected within 2-3 years of the cessation of dredging in sandy gravel habitats exposed to moderate wave exposure and tidal currents (Boyd and Rees, 2001). This may take longer where rare, slow-growing components are present and preliminary observations from a recent study of a historic commercial extraction site off Harwich support this view, indicating that the recovery period may be more prolonged (i.e. > 4years), especially for sites dredged repeatedly (Boyd *et. al.*, 2003). Newell *et.* Al. (1998) carried out a review of the sensitivity to disturbance and In contrast, the study of Area 408 by MES Ltd. (Newell *et. al.*, 2002), indicated that restoration of overall community structure, including biomass, appeared to be substantially complete within just 12 months of the cessation of dredging. Newell *et. al*. (1998) carried out a review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed. This review suggests that the benthic community conforms to relatively well-established principals of succession, whereby those communities present in unstable, highly disturbed habitats (i.e. estuarine muds) are characterised by relatively short lived species that are adapted to rapid recolonisation of the seabed after disturbance. As environmental stability increases (i.e. coarser substrates such as gravels and reefs), a community develops that is long-lived and less adapted to rapid recolonisation. In this situation, estimates of recovery of 5-10 years are considered realistic.

Another recent study, undertaken by CEFAS, investigated the re-colonisation of a site used for the extraction of sand and gravel for approximately 25 years off the south-east coast of the UK, 4 years after the cessation of dredging (Area 222). Preliminary observations indicated that the fauna remained in a perturbed state some 4 years after cessation of dredging. Therefore, "*relatively 'rapid' recovery rates, such as those described above of 2-3 years for European coastal gravelly areas, should not be assumed to be universally applicable, especially in those areas subjected to repeated dredging*" (Boyd *et. al.*, 2003).

A four-year study is currently being carried out by CEFAS aimed at enhancing understanding of the processes leading to physical and biological recovery of the seabed. EMU Ltd. are also currently researching the potential for the remediation and enhancement of marine aggregate sites following the cessation of dredging. The key findings of this work to date, are summarised in **Section 5.3.2.**

Therefore, it is apparent that the recovery of sites following dredging will vary significantly, depending on a combination of the factors outlined above. The length of time required for recovery of a community will be site specific and it will be necessary to consider a combination of factors for each site in order to establish the potential rate of recovery. Another key aspect of recovery, is the nature of the existing biological communities within the dredged areas, in particular, whether they are short-lived, fast growing, opportunistic species (*r*-strategists) or long-lived, slow growing, equilibrium species (*k*-strategists).

Box 3.4 *r* and *K* strategists

***r*-strategist or opportunistic species**
Species that are capable of rapid invasion and colonisation of environments. These species normally have rapid growth, early reproduction, small body size and a short life span. They are typical of environments that are subject to high levels of disturbance.

***k*-strategist or equilibrium species**
Species that are selected for maximum competitive ability and live in environments where space for settlement and subsequent growth is limiting. Such organisms typically have delayed reproduction, slow growth and are late colonisers. They tend to be large mobile animals with long life spans.

In between the two extremes of *r*- and *K*-strategists, intermediate species occur which lie someway between the two strategies.

In areas that are subject to high levels of natural disturbance, the community structure will be characterised by communities of opportunistic (r-strategist) species likely to re-colonise rapidly (e.g. the polychaete worms *Capitella capitata* and *Streblospio benedictii*). Where levels of natural disturbance are low, slow-growing and long-lived (k-strategist) species (e.g. Horse mussel *Modiolus modiolus* and hornwrack *Flustra foliacea*) form the basis of diverse communities by creating food and habitat for a host of other species (Kenny and Rees, 1996).

With knowledge of these varying community types, the rapid recovery of community structure of Area 408 recorded by MES Ltd. can be better understood. This area is subject to the influences of tide and wave action and, therefore, is likely to support mobile opportunistic species. It would have been these species that were responsible for the rapid re-colonisation of the dredged area from the surrounding deposits. Coupled with the relatively low intensity of dredging in this area, this helps to explain why the site exhibited full 'recovery' within 12 months of the cessation of dredging.

However, as noted above, these results for Area 408 should not be applied uncritically to other areas. At higher levels of aggregate production, for example, it is probable that the rate of removal of macrofauna by dredging may exceed the rate of re-colonisation. Also, where the deposits are stable, as in deeper waters or where the deposits are coarse, the biological community would be represented by long-lived and slow-growing components which have a slow rate of reproduction (see Newell *et. al.*, 1998). These *k*-strategists or 'equilibrium' species may take longer to recover both species variety and population density and for the biomass to be restored through the growth of individuals. In such areas an impact on species variety, population density and biomass might be anticipated within both actively dredged sites and the zone of deposition/transport of sediment returned during the screening process even at relatively lower rates of dredging. The size of footprint of the impact on species variety and population density may thus reflect the equilibrium between re-colonisation rates for a particular habitat type and dredging intensity.

The role of natural variability in communities must also be considered. Biological monitoring of the dredging site off Dieppe, in the English Channel, indicated that natural fluctuations of densities at the control stations was caused by the intensity of local hydrodynamic processes, leading to surface sediment instability (Desprez, 2000). It has been argued that biological community composition is not determined by any one, or a combination of, simple granulometric properties of the sediments, such as particle size distribution. Instead, an array of environmental variables have a controlling influence, many of which reflect an interaction between particle mobility at the sediment-water interface and complex associations of chemical and biological factors operating over long time periods (Newell *et. al.,* 1998). Therefore, changes in seabed topography, hydrodynamics and biological factors are likely to play an equally important role in determining the biological community that develops following extraction. The indirect effects of aggregate extraction on hydrodynamic processes such as changes to sediment transport processes and mobility of sediment need to be determined in order to predict the type of habitat that could develop post-extraction and thereby the type of community that could be expected to colonise the area.

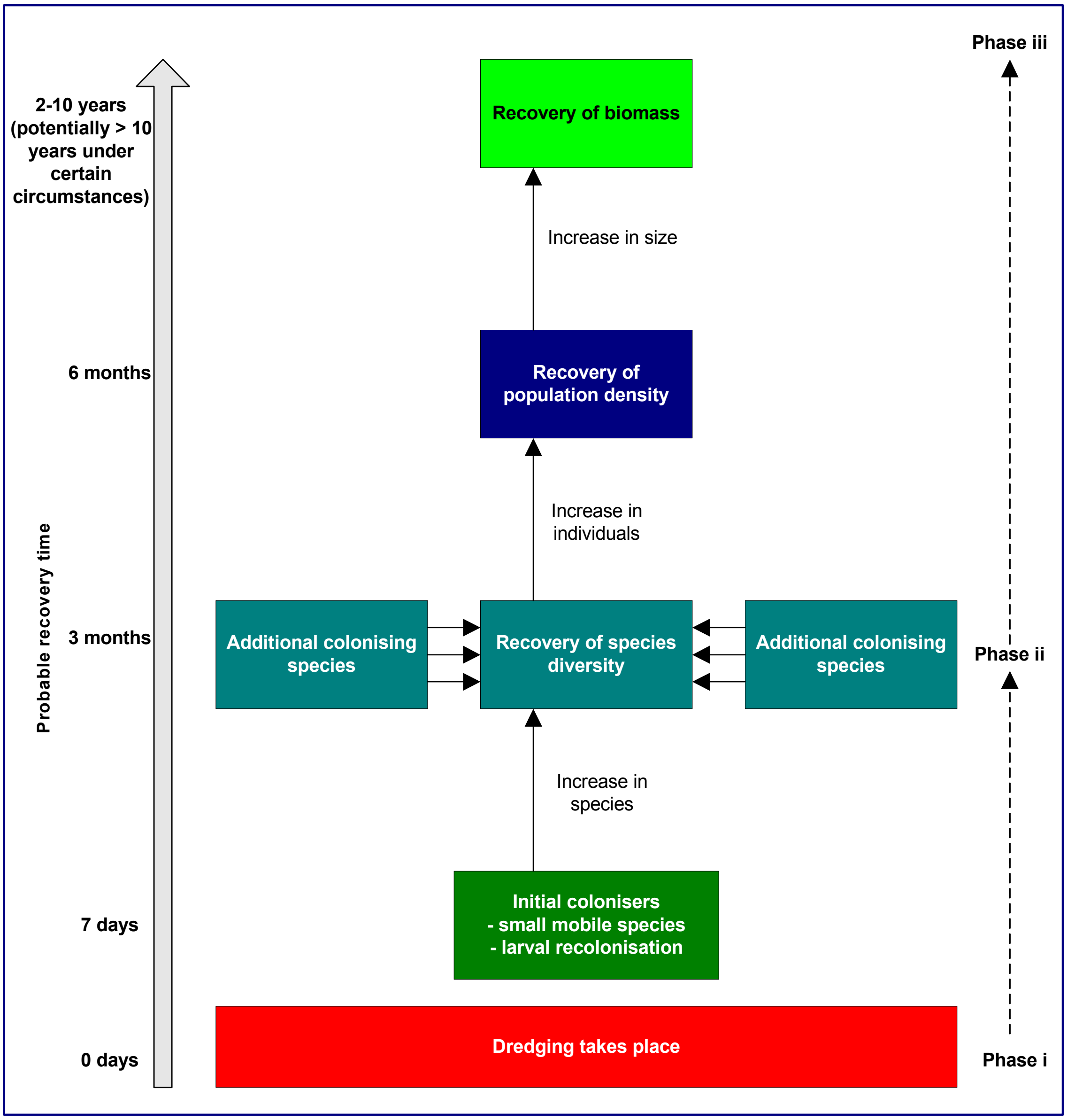

Figure 3.2 Generalised recovery sequence showing the nature and rate of recolonisation of benthic macrofauna in coastal deposits following dredging (after Newell *et. al.*, 2001). Phases i to iii correspond to a model of macrobenthic community response outlined in ICES (2001).

NOTE
The generalised recovery sequence outlined in Figure 3.2 is for a typical sandy gravel deposit in wave-disturbed deposits. As described above, such rapid recovery should not be assumed to be universally applicable, especially in those areas subjected to repeated dredging (Boyd *et. al.*, 2003).

Increased suspended sediment concentrations caused by sediment plumes may create adverse effects on benthic and epibenthic organisms

Suspended sediment plumes can affect species such as filter-feeding epifauna whose functioning is inhibited. Filter feeders are particularly sensitive to suspended sediment because their feeding apparatus can become clogged or overloaded. Respiratory and excretory functioning may also be impaired (Sherk, 1971).

Increased Suspended Sediment Concentrations (SSC) following dredging activity may depress phytoplankton productivity by reducing light penetration through the water column. In shallower coastal waters where sunlight reaches the seabed at sufficient intensity to facilitate photosynthesis, increased SSC may suppress macrophytic algae communities. Theoretically, this increased SSC could have an impact on primary production with subsequent implications through the food chain. In practice, however, this effect is likely to be localised around the dredger and insignificant in terms of total production (de Groot, 1986).

Initial deposition of suspended sediment may lead to smothering effects on benthic organisms

Aggregate dredging for sands and gravels mainly uses trailing suction hopper dredgers and suction dredgers for which overflow is acknowledged to be the dominant source of the release of fine sediment (Bray *et. al.*, 1997; John *et. al.*, 2000). Initial sedimentation is primarily confined to a zone of a few hundred metres from the discharge chute, where the coarse sediment in the dynamic phase settles out of suspension. Depending on the properties of the suspended sediment and local hydrodynamic conditions, sediment plumes, and less intensive deposition, can extend for several kilometers (John *et. al.,* 2000). Deprez's study of a site near Dieppe showed that an area of intensive deposition extended up to 500m along the tidal axis (Desprez, 2000).

The magnitude of the impact upon benthic communities depends largely on:

1. The nature of the indigenous fauna;
2. The rate of sediment deposition (compared to background rates); and
3. The relative increase in water turbidity (Desprez, 2000).

In addition, the distribution of the habitat type is important, in that, should significant deposition of sediment occur in areas of a homogenous substratum type, whereby the area surrounding the impacted area is the same as the area impacted, the impact on benthic communities is likely to be reduced when compared to deposition in a heterogenous substratum type. This is because the likelihood of eliminating a specific habitat type, or species specific to the habitat type, is reduced by the fact that the substrate is widely distributed.

The magnitude of the effect of smothering is reduced by the fact that several major taxonomic groups, such as polychaetes, molluscs and crustacean, are able to migrate vertically through the sediment (Maurer *et. al.,* 1986). Some species are able to migrate through 30cm of deposited sediment. Other studies have shown that approximately 50% of the macrofauna of the bathyal sea floor were able to burrow back to the surface through 4-10cm of rapidly deposited sediment (Kukert, 1991). In particular, species in areas of mobile sediment are likely to be morphologically and behaviourally adapted to a dynamic environment and, as such, are more likely to survive activities such as deposition (John *et. al.*, 2000).

Impacts are likely to be more significant in gravel seabed environments that have naturally low background levels of suspended sediment and deposition. These stable conditions promote the development of a community controlled by biological interactions rather than environmental variability (Newell *et. al.*, 1998). In gravel seabed environments, sedimentation is likely to affect sessile species that are unable to avoid smothering.

Bedload transport of deposited sediments may create adverse effects on the benthos and epibenthos

Following the initial deposition of sediment on the seabed during the dynamic phase (see **Appendix C iii**), sediment particles that remain suspended in the plume will eventually settle out of the water column, resulting in the re-deposition of sand and silt onto the seabed in and around the dredged area (Posford Haskoning, 2003). These re-deposited sediments may be subsequently mobilised and re-suspended via tidal induced near-bed currents, resulting in a change in bedload sediment transport processes.

With respect to potential impacts on benthic and epibenthic communities and species, this bedload transport of more mobile sediment following initial deposition, could affect certain benthic and epibenthic species by potentially causing scour and affecting the re-colonisation potential of the substrate (Posford Haskoning, 2003).

Scour effects could be a particular issue for soft-bodied organisms that are naturally sensitive to abrasion, although many species are actually tolerant of mobilised sands and intermittent burial, e.g. *Sabellaria spinulosa* and some hydroids and bryozoans (Holme and Wilson, 1985 *in* Posford Haskoning, 2003).

The mobilisation of fine sediment could also affect the rate of re-colonisation of the impacted substrates. If bedload transport is regular and frequent, re-colonising species could be constantly moved by the tidal induced bedload transport, therefore, reducing the rate of re-colonisation.

Further to these impacts, a change in the rate or amount of bedload transport along existing pathways, may result in wider impacts on features such as sandbanks and/or other bedforms, upon which benthic and epibenthic organisms rely.

Modification of seabed topography, substratum type and mobility as a result of aggregate extraction may lead to a change in benthic community structure

Post dredged habitats and, therefore, communities in the dredged areas, are likely to differ from those present prior to dredging. This is because, in practice, it is almost impossible to produce a habitat that is identical to the pre-dredging situation. For example, a reversion to communities characteristic of 'gravelly sand' rather than 'sandy gravel' is likely in the immediate vicinity of dredge sites. Over time sand deposited from the screening process may be winnowed away from the dredged zone (Posford Haskoning, 2003) but changes to the seabed may continue to have an effect on benthic communities for some time.

In their study off the North Norfolk coast, Kenny and Rees (1996) concluded that dredging had destabilised the seabed sediment such that, two years after dredging, winter tide and wave conditions were capable of transporting sediment which otherwise would have remained stationary. This mobile unconsolidated surface layer (or benthic boundary) layer had the effect of creating a more highly disturbed environment, which inhibited recolonisation by previously dominant species.

Aggregate extraction may result in the re-introduction of organic material from the seabed

The amount of organic material released by dredging will depend upon the nature of the seabed and the biomass of associated benthic fauna. As previously stated, settlement of inorganic particulate load discharged from marine aggregate dredging is mainly confined to a distance of a few hundred metres from the source. Plume effects, however, can extend for several kilometres beyond the point where the concentration of inorganic particles in the water column has fallen to background levels. It has been suggested that this 'far field' visibility of the dispersal plume is associated with organic enrichment derived from fragmented marine benthos discharged with outwash water (Newell *et. al.,* 1998).

During experimental dredging of previously unexploited deposits off Southwold, Suffolk, organic concentrations recorded in outwash water were high enough to produce such an effect (Newell *et. al.,* 1999). Significant quantities of lipids were associated with this material, and their buoyancy may act to reduce the rate of sedimentation in the plume. More recently, Newell *et. al.*, (2002) observed enhanced densities and biomass on the periphery of dredging operations at a gravel extraction site in the central

North Sea. This 'halo' effect was attributed to the settlement of particulate organic matter discharged in the dredger outwash. Enhanced species diversity and biomass of benthic invertebrates has also been reported beyond the boundaries of a dredged area by Poiner and Kennedy (1984).

Aggregate extraction may cause a reduction in oxygen levels

During dredging, 'reducing substances' bound in sediments (ammonium, sulphides, organic matter) may be released into the water column. In sheltered areas where the content of these compounds is high, a lowering of the oxygen level of sea water to concentrations that are critical to fish and benthos may occur (ICES, 2001). However, it should be emphasised that the chemical effects of aggregate dredging are likely to be minor on account of the very low organic and clay mineral content of commercial aggregate deposits. Furthermore, aggregate dredging rarely takes place in 'sheltered' areas and is generally of limited spatial extent and only of short duration which further limits the potential for any chemical impact (ICES, 2001).

3.3.2 MARINE MAMMALS AND ELASMOBRANCHS

Noise impacts from aggregate extraction may have adverse effects on marine mammals and elasmobranchs

Large vessels associated with dredging activity generate noise. Both marine mammals and elasmobranchs, such as basking sharks, are susceptible to disturbance through noise impacts and, as such, there is the potential for dredging activity to impact on these resources. The sound frequencies produced by larger vessels (<1kHz) can overlap with the frequencies used by cetaceans, particularly baleen whales, and also dolphins and porpoises when cavitation of the propeller occurs. The cetacean response is vessel avoidance or increased diving times (Evans *et. al.*, 1992; 1994 *in* EMU, 1999). Marine mammals will generally take avoidance action well before a noise level is a threat to survival.

However, where exposure to a particular type of noise is not associated with any serious concomitant problems, animals which may initially have avoided an area or exhibited another disturbance reaction may show weaker or no reactions during subsequent exposures. Seals are unlikely to be affected by noise produced by the dredging activities, unless they are in the immediate vicinity of the dredger whilst it is operating (EMU, 1999).

Aggregate extraction may result in physical collisions between dredgers and marine mammals and/or elasmobranchs

Larger vessels, i.e. aggregate dredgers, may also cause impacts to marine mammals present in a study area by direct physical damage as a result of collisions. However, this risk of collision is present for any moving vessel, often because dolphins (in particular) will move towards a vessel to play in the wake and bow wave. In reality, the likelihood of physical collision occurring is small, as the individual species in question will move from an area in which a dredger is working due to noise effects.

The removal of benthos may result in a reduction in potential food items

Aggregate dredging has the potential to reduce the amount of prey items available to fish, shellfish and other key species through the removal of benthos from dredged areas. Many marine mammals rely on these fish and shellfish as prey themselves. Therefore, any change in the distribution of fish assemblages as they move to areas where prey items have not been reduced may lead to a reduction in prey items for mammals.

In reality, the loss of benthic resources in areas subject to marine aggregate extraction affects only a relatively small area of seabed. Nevertheless, this does represent a potential loss of food resources for fish and for higher trophic levels in the food web, including mammals.

There is very little documented evidence linking a loss of benthic invertebrate species within dredged areas to a reduction of fish or animals at higher trophic levels. This is probably because marine food webs are immensely complex and fish stocks are primarily limited by other factors, including intensive commercial exploitation, rather than by food availability. However, this lack of direct evidence does not necessarily mean that there is no impact. Indeed, the fact that there is little evidence to support any link is due to the lack of studies specifically addressing this issue.

Therefore, until actual field data is produced that proves or disproves the importance of such trophic links, this potential impact cannot be dismissed.

Increased turbidity caused by sediment plumes may have adverse effects on marine mammals and elasmobranchs

Aggregate dredging creates sediment plumes that have the potential to cause a range of effects within the water column, including potential disruption to migration pathways. However, due to the relatively small area of the water column that these plumes affect, plus the highly mobile nature of marine mammals and other large mobile species, it is unlikely any adverse impacts will arise. Most marine mammals also use sophisticated echo-location systems for hunting and migration, therefore, reduced visibility is unlikely to be of concern. Similarly, most elasmobranchs utilise electro-magnetic systems for navigation and prey detection, therefore, suspended sediment plumes are unlikely to cause disruption to these functions.

Aggregate extraction may result in a loss of habitat for nursery/pupping elasmobranchs

Many species of elasmobranchs require specific habitat types as pupping, nursery and feeding areas. These habitat types often correspond to the material extracted by aggregate dredgers. Therefore, the potential exists for these important aspects of species life-history to be adversely affected. A fuller review of the potential effects of aggregate extraction on fish spawning is provided in **Section 3.5**.

3.3.3 SEABIRDS

Direct removal of benthos and fish through aggregate extraction may reduce the abundance of potential prey items for sea birds and adversely affect sea bird feeding

There is the potential that the removal of benthic resources and fish from a dredged area may reduce the abundance of potential prey items for sea birds. However, in practice, a very small percentage of the areas under Licence for marine aggregate extraction within UK waters are actually dredged at any one time. Even so, the potential still exists that key features, such as sandbanks, may constitute an important feeding ground for sea birds and, as such, any disturbance to such features may create adverse effects for sea bird feeding. In particular many sea birds rely almost exclusively on sandeel fisheries during the breeding season, so any large-scale damaging effects on this species will have a heavy impact further up the food chain.

Currently the distribution of marine aggregate dredging areas does not tend to coincide with important sea bird populations but, unfortunately, there is often limited field data to demonstrate that licensed areas do not support important trophic levels. Again, until such data exists, then this potential impact cannot be dismissed.

Noise impacts from aggregate extraction may have adverse effects on sea birds

As for marine mammals and other large mobile species, the noise (and vibration) associated with aggregate dredging has the potential to create adverse effects on sea bird behaviour and feeding. However, there is currently very little information available on the effects of noise disturbance on the foraging behaviour of birds at sea. In practice, it is often observed that many sea birds actively seek-out vessels underway as a source of food. Given that birds can avoid unsuitable conditions it is unlikely that noise impacts from aggregate extraction will create adverse effects on them.

Aggregate extraction may result in loss of intertidal habitat through beach drawdown

Dredging activities could lead to the removal of some important sea bird habitats. Aggregate extraction may cause damage to beaches as a result of draw-down, reducing areas for ground-nesting sea birds such as terns, gulls and waders. Changes in tidal currents and wave dynamics may further contribute to beach erosion. In addition, feeding and roosting habitats such as periodically submerged sandbanks and mudflats may be reduced or lost. However, the potential for such drawdown to occur is relatively limited (see **Section 3.2.3**)

Aggregate extraction may result in a loss of visibility through sediment plumes

Increased turbidity through the presence of sediment plumes may reduce visibility for plunge and pursuit-diving species (such as terns and auks) over a limited time period. However, plunge-diving birds (e.g. terns) will often seek out turbid waters as the decrease in light levels cause fish to move upwards in the water column (*pers comm*., Norman Ratcliffe, RSPB).

3.3.4 CUMULATIVE AND IN-COMBINATION IMPACTS

One of the main considerations for the sustainable use of resources is to ensure that allocation is based on future needs and the availability of resources. In this respect it is recommended that, as well assessing cumulative and in-combination effects during extraction, consideration is given to the potential alternative uses of the area following extraction. For example, the use of an area for aggregate extraction does not preclude the potential future use of a site for a wind farm but may affect the future potential of the area for fisheries, albeit temporarily, until recovery occurs.

It is also important to be aware of the limitations of the assessment process when considering cumulative effects. In particular, within the marine ecological environment this relates to the lack of information on the sensitivity of many species/communities to particular scales of impact. Although the general level of information on sensitivities is growing, a wide degree of uncertainty is still associated with each site specific project, where there are a number of variables that could influence the sensitivity and vulnerability of the species/communities present. This is particularly important when considering that a number of different thresholds may have been applied to a particular species for a number of plans or proposals. The derivation of thresholds should be determined based on and the implications for the accumulation of effects will need to be thoroughly assessed.

There are a number of activities that could combine to produce a cumulative impact on the marine environment. These are detailed in PDE and Hill (2001). The following section summarises the potential cumulative and in-combination impacts that may arise on marine ecology.

Fishing activity

Commercial fishing activity can result in significant alteration and physical damage to the substrate. Consequently, an obvious impact of fishing activity is that benthic and epibenthic species may be removed. In addition, trawling activity could also release sediment into suspension, causing sediment plumes. When assessed in conjunction with aggregate extraction activities, cumulative impacts can be expected to occur. However, fishing activity is a difficult aspect to assess in terms of impacts on the marine environment as the fishing industry are not required to undertake specific Environmental Impact Assessment for their activities. A review of the potential effects of fishing on European marine sites has been undertaken as part of the UK Marine SACs Project (Gubbay and Knapman, 1999).

Capital and maintenance dredging

Although potential in-combination effects could arise due to capital and maintenance dredging, in practice, the opportunity for such impacts to occur is extremely low. This is due to the very limited potential for spatial overlap between the activities, as the vast majority of capital and maintenance dredging takes place within existing navigational channels and/or within immediate near-shore areas, where aggregate extraction activity is at a very low level (PDE and Hill, 2001).

Activities that cause organic pollution and eutrophication

Aggregate extraction may increase the overall level of organic matter in the water column. In combination with other activities that input organic material this could have an effect on the potential for algal growth or may alter the benthic species diversity and abundance in the area affected. However, there is very limited chance of spatial overlap occurring between these activities due to the nature of aggregate extraction (i.e. occurring offshore in relatively deep water). Nevertheless, the potential for effect should be considered, particularly if aggregate extraction is to be carried out close to a disposal area or area affected by organic pollution (PDE and Hill, 2001).

Activities that cause other forms of pollution

In this context other pollutants include synthetic organic compounds which can cause long term effects on biological communities. Levels of stress arising from pollution can reduce the thresholds of sensitivity of certain species and this should be considered where aggregate extraction occurs in an area known to be subject to pollution (PDE and Hill, 2001).

Disposal of dredged material

A number of potential impacts arise from disposal activities that could cause cumulative effects in conjunction with aggregate extraction, including increased turbidity, smothering of benthic communities, changes in water quality and modification of the substratum composition. This activity is strictly regulated and, consequently, the potential for cumulative impact is relatively low compared to other activities (PDE and Hill, 2001).

Coastal alteration

The construction of coastal defences and other alterations to the coastline can affect the physical processes acting within a coastal cell. The Coastal Impact Study should determine whether the proposed aggregate extraction is likely to have an effect on the coastline and, if so, the potential for interaction with any other proposed activities on the coast will need to be considered (PDE and Hill, 2001).

Offshore structures

Offshore structures include oil and gas platforms, drilling rigs and offshore wind turbines. These structures have the potential for combined effects in relation to:

- Impacts on benthos during construction;
- Changes in local hydrodynamic system;
- Risk of pollution events;
- Modification of the wave climate; and
- Accumulated drilling discharges (PDE and Hill, 2001).

Other aggregate extraction activities

Other aggregate extraction activities obviously have the potential to cause very similar impacts to those created by the scheme being assessed. This means that where extraction sites are in close proximity the potential exists for cumulative impacts to occur. In terms of the various predicted impacts, changes in wave climate and sediment transport characteristics, the removal of benthic and epibenthic resources and the production of sediment plumes from a series of aggregate extraction sites are the most likely to have cumulative consequences (e.g. by increasing the area of the resource impacted within one region).

With regard to the cumulative effects of sediment plumes from several licensed sites, it is considered unlikely that, even where licence areas exist in close proximity, dredging will occur at the same time. It is expected that in areas where multiple extraction is taking place at the same time, management practices would be in place to avoid the potential for cumulative effects to arise (see **Section 5**, Mitigation). It is also unlikely, given that the plume will follow the tidal flow that sediment plumes would extend over the same geographical areas, thereby reducing the potential for a cumulative impact to arise.

Cumulative and in-combination effects potentially arising from adjacent aggregate extraction activities are considered in detail, along with management measures to minimise such effects, in the East Channel Association (ECA) Regional Environmental Assessment (REA) for the Eastern English Channel (Posford Haskoning, January 2003).

REFERENCES

Boyd, S.E., and Rees, H.L. (2001) Towards an understanding of the impacts of marine aggregate extraction on the seabed as a basis for developing an EcoQO approach for management. In: A Workshop to Discuss the Feasibility and Practicality of Developing Ecological Quality Objectives for Aggregate Extraction Areas. Held at CEFAS Lowestoft Laboratory on 11 and 12 October 2001. Final Report.

Boyd, S.E., Limpenny, D.D, Rees, H.L, Cooper, K.M. and Campbell, S. (2003). Preliminary observations on the effects of dredging intensity on the re-colonisation of dredged sediments off the south-east coast of England (Area 222). Estuarine, Coastal and Shelf Science **57** (2003): 209-223.

Bray, R.N., Bates, A.D. and Land, J.M. (1997) Dredging. A handbook for engineers. Second Edition. Arnold, London.

De Groot, S.J. (1986) Marine sand and gravel extraction in the North Atlantic and its potential environmental impact, with emphasys on the North Sea. Ocean Management, Vol 10 (1988) pp 21-36.

Desprez, M. (2000). Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel: short- and long-term post dredging restoration. *ICES Journal of Marine Science*, **57:** 1428-1438.

EMU (1999). Environmental Statement: North Nab (Area 372/1). Report produced on behalf of Hanson Aggregates Marine Ltd. 1999.

Evans, P. G. H., Canwell, P. J., and Lewis, E. J. (1992). An experimental study of the effects of pleasure craft noise upon bottle-nosed dolphins in Cardigan Bay, West Wales. European Research on Cetaceans. 6. Ed. P. G. H. Evans, 43-46. Cambridge, European Cetacean Society.

Evans, P. G. H., Carson, Q., Fisher, P., Jordan, W., Limer, R. and Rees, I. 1994. A study of the reactions of harbour porpoises to various boats in the coastal waters of south-east Shetland: European Research on Cetaceans, **8**. Ed., P.G.H. Evans, 60-64. Cambridge, European Cetacean Society. *In* EMU (1999). Environmental Statement: North Nab (Area 372/1). Report produced on behalf of Hanson Aggregates Marine Ltd. 1999.

Evans, P. G. H. (1995). Human disturbance of Cetaceans. In: Exploitation of Mammals, Ed: N. Dunstone and V. Taylor. London, Chapman and Hall.

Gubbay, S and Knapman, P.A. (1999). A review of the potential effects of fishing within European marine sites. English Nature (UK Marine SACs Project).

Holme, N.A. and Wilson, J.B. (1985). Faunas associated with longitudinal furrows and sand ribbons in a tide swept area in the English Channel. *J. Mar. Biol. Ass. UK* **65**:1051-1072.

ICES (1992). Effects of Extraction of Marine Sediments on Fisheries. *ICES Co-operative Research Report No: 182.* ICES, Copenhagen.

ICES (2001). Effects of Extraction of Marine Sediments on the Marine Ecosystem. *ICES Co-operative Research Report No: 247*. ICES, Copenhagen.

ICES (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM2003/E:07. Ref. ACME, ACE, D.

John, S.A., Challinor, S.L.,Simpson,M., Burt, T.N., and Spearman, J. (2000). Scoping the assessment of sediment plumes from dredging. Construction Industry Research and Information Association (CIRIA) Publication C547.

Kenny, A.J. and Rees, H.L. (1996). The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. Marine Pollution Bulletin, **32** (8/9): 615-622.

Kukert, H. (1991). *In situ* experiments on the response of deep sea macrofauna to burial disturbance. *Pacific Science 45, 95* only.

Maurer, D.L., Keck, R., Tinsman, J., Leathem, W., Wethe, C., Lord, C. and Church, T. (1986) Vertical migration and mortality of marine benthos in dredged material: a synthesis. *Internationale revue ges. Hydrobiologie* **71**: 49-63.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed *Oceanography and Marine Biology*: *An Annual Review*, **36**: 127-178.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1999). Organic enrichment associated with outwash from marine aggregate gredging: A probable explanation for surface sheens and enhanced benthic production in the vicinity of dredging operations. *Marine Pollution Bulletin*, **38** (9): 809-818.

Newell, R.C., Seiderer, L.J., Simpson, N.M. and Robinson, J.E. (2002). Impact of Marine Aggregate Dredging and Overboard Screening on Benthic Biological Resources in the Central North Sea:Production Licence Area 408, Coal Pit. Marine Ecological Surveys Limited *Technical Report No ER1/4/02* to the British Marine Aggregate Producers Association. 72 pp.

Newell, R.C., Seiderer, L.J., Robinson, J.E, Simpson, N.M., Pearce, B. and Reeds, K.A. (2004). Impacts of Overboard Screening on Seabed and Associated Benthic Biological Community Structure in Relation to Marine Aggregate Extraction. Technical Report to the Office of the Deputy Prime Minister (ODPM) and Minerals Industry Research Organisation (MIRO). Project No.SAMP.1.022. Marine Ecological Surveys Limited, St IVES, Cornwall.

Poiner, I.R. and Kennedy, R. (1984) Complex patterns of change in the macrobenthos of a large sandbank following dredging. Marine Biology **78**: 335-352.

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Posford Haskoning (2003). Eastern English Channel Regional Environmental Assessment Report on behalf of East Channel Association. January 2003.

Ratcliffe, p*ersonal communication* (2004). The RSPB, UK Headquarters, The Lodge, Sandy, Bedfordshire, SG19 2DL, United Kingdom

Sherk, J.A. (1971). *Effects of suspended and deposited sediments on estuarine organisms*. Chesapeake Biological Laboratory, University of Maryland. Contribution No 443.

SECTION 3.4 NATURE CONSERVATION

3.4.1 INTRODUCTION

This section sets out the potential impacts of aggregate extraction on nature conservation interests. Potential impacts on designated sites of nature conservation importance as well as habitats and species that are not designated but are of conservation importance, are discussed. Impacts on specific species of nature conservation importance, including marine mammals, elasmobranchs and sea birds, are covered in detail in the preceding section on Marine Ecology (**Section 3.3**).

This section differs slightly from other impact sections, in that the potential *sources* of impacts, e.g. removal of seabed, smothering by sediment deposition and scour effects, are not discussed in detail, as in other sections. Rather, the *types* of impacts on nature conservation features are outlined. For details on specific *sources* of impacts and good practice recommendations, the reader is referred to other, parameter-specific sections. Detailed guidance on the impact of aggregate extraction on European marine sites is provided in PDE and Hill (2001). Potential impacts on Annex I habitats and Annex II species are presented in **Table 3.1**.

Table 3.1 Potential impacts on Annex I habitats and Annex II species (after PDE and Hill, 2001)

	Potential Impact					
	Removal of sediment/benthos	Increased turbidity	Changes in sediment composition	Changes in hydrodynmanics/sediment transport	Water chemistry effects	Behavioural changes due to disturbance
Annex I Habitat						
Sublittoral sandbanks	●	●	●	●	●	
Estuaries	●	●	●	●	●	
Mudflats and sandflats	●	●	●	●	●	
Lagoons				●		
Large shallow inlest and bays	●	●	●	●	●	
Reefs		●	●		●	
Sea cliffs and shingle/ stony banks				●		
Saltmarshes and salt meadows				●		
Coastal sand dunes				●		
Rocky habitats and caves		●		●	●	
Annex II Species						
Marine mammals	●	●			●	●
Fish	●	●	●		●	●

Aggregate extraction may have adverse effects on areas designated under nature conservation legislation

If sites designated under nature conservation legislation exist within either the immediate or wider study area, then there is the potential that aggregate extraction activity may have adverse effects, either through direct impacts (loss or damage to designated species/habitats), indirect impacts (change in seabed topography and substrate type, alteration of sediment transport processes and pathways on which the site's integrity relies) or cumulative impacts (the in-combination effects of aggregate extraction with, for example, fishing). Aggregate extraction has the potential to damage or change the ecological character of a designated feature (i.e. SPA/cSAC) such that the integrity of the feature/site is compromised (see PPG9 box 10 and Habitats Regulations Guidance Note 1), if it is not undertaken with appropriate care.

Based on the existing distribution of designated areas, the potential for such direct impacts is limited due to the fact that aggregate extraction typically takes place away from areas that are currently designated for their nature conservation importance. However, potential effects can arise distant from the licensed extraction site itself and, for example, may lead to impacts within coastal areas. This is of particular relevance to areas currently designated under nature conservation legislation, in that a large number of identified cSACs and SPAs that form part of the *Natura* 2000 network are on or adjacent to the coast, as are many SSSIs.

The potential for impacts on designated sites from marine extraction operations could increase in the future due to the implications of the Greenpeace Ruling. This is discussed below.

Aggregate extraction may have adverse effects on habitats or concentrations of species that *could* be considered in future cSACs or SPAs (both within and outside 12nm) that are present in the study area

Section 2.5 outlines the issues related to the on-going process to designate areas of UK offshore waters (12-200nm) as a result of the Greenpeace Ruling. Taking this process into consideration, it is important to recognise that aggregate extraction may have the potential to create adverse effects on habitats and/or concentrations of species that *could* be considered as part of future cSACs/SPAs. For this reason, it is essential that the baseline environment section of future ESs fully consider the implications of this process and make reference to relevant existing guidance.

Aggregate extraction may have adverse effects on habitats or species that are protected by nature conservation legislation

Within those areas that may be subject to aggregate extraction, a variety of species and habitats protected by nature conservation legislation exist (e.g. Marine mammals, offshore sandbanks, brittlestar beds etc.). These include benthic species that may be subject to the direct removal of the seabed or the indirect effects of sediment deposition or bedload transport, as well as mammal, fish and bird species that may also be subject to direct and indirect effects.

A specific example of a potential effect of aggregate extraction on a protected habitat is loss of *Sabellaria spinulosa* reef through dredging. *Sabellaria spinulosa* reef is protected under Annex I of the Habitats Directive and also has a Habitat Action Plan under the UK BAP for its reef-building form. Loss of this species/habitat directly contravenes the conservation measures under which it is protected. Therefore, direct removal of reefs would represent a significant adverse impact and a breach of national responsibilities under the Habitats Directive.

Aggregate extraction may have adverse effects on BAP, Species Action Plan (SAP) or Habitat Action Plan (HAP) features

As detailed in **Section 2.5**, many habitats and species are also covered by BAPs, SAPs or HAPs, which set out objectives and targets for their conservation. As for designated areas, potential impacts may arise on habitats and species designated under statutory nature conservation legislation, such as the EU Habitats and Birds Directives. The sources of potential impacts will also be similar and will include direct and indirect effects.

Aggregate extraction may have adverse effects on other features of nature conservation interest, i.e. those not protected by nature conservation legislation

In addition to areas, habitats and species protected under statutory and/or non-statutory legislation, it is important to recognise that aggregate extraction has the potential to create adverse effects on other features of nature conservation interest that are not subject to specific protection and/or conservation measures, but nonetheless also require special protection (i.e. habitats that support important trophic relationships) (ICES, 2003).

The source of such impacts will be similar to those described previously and will include potential adverse effects from the direct removal of these features by dredging or indirect effects through increased sedimentation, bedload transport and scour, amongst others.

3.4.2 CUMULATIVE AND IN-COMBINATION IMPACTS

The Habitats Directive Article 6(3) states that any plan or project not directly connected with or necessary to the management of an SAC/SPA, but likely to have a significant effect on it, either individually or in combination with other plans or projects, shall be subject to an appropriate assessment of its implications for the site in view of the site's conservation objectives.

PDE and Hill (2001) provides a list of the potential impacts on designated features and the possible cumulative effects that could occur in-combination with other activities. That is:

Direct and Indirect Impacts

- Removal of substratum/benthos;
- Increased turbidity;
- Changes in sediment composition;
- Changes in hydrodynamic regime/sediment transport;
- Water chemistry effects; and
- Behavioural changes due to disturbance.

The potential also exists for cumulative impacts (of activities) on a designated or potential site where the impacts on each of the component conservation features may detrimentally affect the conservation status of the site. In this respect it is important to consider all potential effects in-combination and then determine the overall effect on the site.

REFERENCES

English Nature (2001). Habitats Regulations Guidance Note 1. *The Appropriate Assessment (Regulation 48). The Conservation (Natural Habitats &c) Regulations, 1994*. Issued by Greg Smith, English Nature, Peterborough.

ICES (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM2003/E:07. Ref. ACME, ACE, D.

Johnston, C.M, Turnbull, C.G. and Tasker, M.L (2001). Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Bird Directives in UK offshore waters. JNCC Report 325 (and subsequent Committee papers)

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Policy Planning Guidance 9 (PPG9): Nature Conservation. Office of the Deputy Prime Minister.

SECTION 3.5 FISH AND SHELLFISH RESOURCES

3.5.1 MAIN IMPACTS

Dredging works may lead to a loss of benthic species resulting in reduced food availability for fish and shellfish (and decreased productivity)

As much as 30% of total fish production is dependent on conversion through the communities which live on the seabed (Newell *et. al.*, 1998). The benthos is, therefore, very important in the flow of energy in coastal systems and becomes increasingly important in shallow water where production by benthic algae (macroalgae) and sea-grasses largely replaces that from the phytoplankton.

The removal of benthic biota has the potential to create an adverse impact through a reduction in the abundance and availability of food items. If a large amount of benthic biota is removed from a particular area, this may lead to pressures on fish and shellfish populations that rely on this biota as a principal food source. If food items are reduced beyond certain levels, fish and shellfish may need to move into new areas to exploit unaffected food resources. If these areas already support existing fish and shellfish populations, then the carrying capacity of the benthic food webs may be compromised. However, levels of many fish species are currently depleted, due to fishing activity and other environmental factors, therefore, it is unlikely that the carrying capacity of many areas of sea will be compromised by fish and shellfish moving into them from dredged areas. However, this impact may also disrupt complex predator-prey relationships that may exist between certain key species.

Such an impact will not be permanent, as all extraction sites will eventually recover to a level where they support fish species again. The rate and extent of recovery will depend on a range of factors. This process may take anywhere between a month to fifteen years, depending on the site in question (Rogers and Carlin, 2002). Further detail on the re-establishment and/or recovery of aggregate sites in terms of its biota is provided in **Section 3.3**.

Fish and shellfish may be entrained through direct uptake

Entrainment through direct uptake occurs where organisms are taken, with the aggregates, into the ship. Dredging removes the top layer of sediments and, thus, any sedentary epifaunal and infaunal species present within this layer. This is more likely to affect slow moving or sessile benthic organisms, such as certain crustaceans and molluscs which are unable to avoid or escape the draghead of the dredger (Rogers and Carlin, 2002). It is also worth noting that demersal eggs can be taken up by dredging activity.

Little work has been carried out regarding entrainment rates of fish in marine dredging (Henderson, 2003). A review of entrainment rates for certain species is provided in Nightingale and Simenstad, 2001. This review includes a summary table that indicates the rate of mean fish entrainment for hydraulic dredges ranges from 0 (fish/cubic yard) to 0.594 (fish/cubic yard). The highest rate of entrainment was recorded for Pacific Sand Lance, a demersal species. Within UK waters, it is also demersal species, such as flatfish and sand eels that are most likely to be entrained by aggregate dredgers. Similarly, over-wintering crabs are likely to be susceptible to direct uptake effects, as they typically exhibit low levels of activity during these over-wintering periods and, as such, would be unlikely to be able to avoid a dredger drag-head.

In terms of mortality, it is likely that any fish entrained will experience close to 100% mortality. However, for some shellfish, such as bivalve molluscs (mussels, cockles), although they may get entrained, their tough shells may enable them to survive and be returned to the seabed via the overflow or outwash of the dredger (Rogers and Carlin, 2002).

Noise generated by dredging may impact on fish and shellfish

It has been well documented that noise can influence fish behaviour. Fish detect and respond to sound utilising its cues to hunt for prey, avoid predators and for social interaction (Nightingale and

Simenstad, 2001). Dredging activities create noise effects which may affect these important behavioural traits of fish and shellfish populations.

With respect to noise generated by marine aggregate extraction, CEFAS have undertaken field studies of noise produced by active aggregate dredgers and compared these to the hearing sensitivities of certain fish species.

KEY REFERENCE
CEFAS (2003). Preliminary investigation of the sensitivity of fish to sound generated by aggregate dredging and marine construction. Final Project Report. Report for Defra project AE0914. March 2003.

The key findings of this report are summarised below:

1. Marine aggregate dredgers have the potential to impact acoustically on the environment through, (i) the operation of machinery onboard thee dredger, (ii) the noise which may be generated by the suction drag head moving over the seabed, and (iii) as a result of sound and vibration which is transmitted directly into the seabed;

2. Actual field measurements of radiated noise taken 50m from an aggregate dredger whilst it was conducting full dredging activities suggest that the noise generated whilst dredging was below the levels that will cause permanent or temporary loss of hearing to all the species studied;

3. Of all the species studied, members of the Clupeid taxonomic group, e.g. herring, appear to be one of the most sensitive to acoustic stimuli;

4. The field studies and associated desk-review indicated that, although noise levels would be lower than those that would create either permanent or temporary hearing damage to any species studied, both the salmonid and clupeid group of fish would be aware of the dredging activities and this may impact on their behaviour; and

5. Flatfish such as plaice and dab are less sensitive than Clupeids to far field sound. However, they may be sensitive to low levels of vibration when on the seabed.

It is also useful to place dredger noise into context. The noise produced by ships represents one of the most pervasive forms of man-made noise in the ocean, and in areas of high shipping density (such as the central and southern North Sea) produces a non-descript low frequency noise (< 500 Hz). This low frequency noise propagates extremely well in deep water (see below), with higher frequencies more limited in propagation range. Propagation will also be reduced in shallow water. Broadband source levels of ships between 55 and 85m in length are around 170-180 dB/1 μPa, with most energy below 1 kHz. Scrimger and Heitmeyer (1991) give source levels for 50 different merchant ships which range over 140-170 dB/1 μPa for frequencies between 100-700 Hz. Therefore, it is important to recognise that fish and shellfish in areas already subject to high levels of shipping activity (eastern English Channel, southern North Sea) are already subject to noise levels in excess of those caused by dredging, on a regular basis (Henderson, 2003).

Effects of sediment plumes

Aggregate extraction activities result in the production of sediment plumes. Details on the creation and nature of these are provided in **Section 3.2**. The effects on fish and shellfish will be a function of the actual increase in the suspended sediment concentration compared to background levels and the length of exposure to any increased concentration. Therefore, actual effects created by increased SSC will be related to the tendency for, and the ability of, affected species to take avoiding action.

Sediment plumes may cause a reduction in light levels (and visibility)

A reduction in light levels within the water column can create a number of adverse effects on fish and shellfish resources. For predatory fish species such as mackerel and turbot that rely on vision to detect and locate prey, decreased visibility can lead to a reduction in feeding efficiency. Many fish species, such as herring, also rely on light levels to aid migrations and shoaling behaviour. Low light levels caused by high levels of suspended sediment may, therefore, impair the ability of species to shoal as part of migrations to spawning or feeding grounds.

In practice, it is likely that mobile species will exhibit avoidance reactions and move away from areas where light levels are reduced due to increased turbidity.

Sediment plumes may cause gill damage and increase metabolic costs

Sediment plumes can result in the gills of fish being damaged. As gills are the physiological unit that enables fish to extract oxygen from water, any severe damage to them can create significant adverse effects, including death. In order to clear their gills of any clogging sediment, fish can produce excess amounts of mucus and also show a cough reaction. Both of these activities require energy and have a high metabolic cost associated with them. Therefore, if the sediment plume exists for a long enough period, the overall energy budget of the fish may be affected.

However, as with other impacts, in practice, it is likely that mobile species will exhibit avoidance reactions and move away from areas where SSC levels may cause gill damage.

Sediment plumes may have adverse effects on spawning

Spawning success of fish and shellfish can be adversely affected by sediment plumes, with both pelagic eggs (that exist within the water column) and demersal eggs (laid on the seabed) sensitive to plume effects. The introduction of material into the water column (from overflowing and screening processes) results in a water/sediment mixture of higher density than the surrounding water, which therefore, descends towards to the seabed (John *et. al.*, 2000). As the plume descends, a proportion of the sediment is stripped from the plume into the surrounding water column and advected away from the dredging area by currents as a passive plume. The remainder of the released sediment impacts upon the bed (John *et. al.*, 2000).

A series of discrete impacts on spawning can arise:

(a) *The sediment plume may cause fish/shellfish to avoid a former spawning area*: Many fish and shellfish species may avoid previous spawning areas if a sediment plume exists at the time of spawning. However, such a plume will be generated by dredging activity which will also create noise impacts. It is difficult to determine exactly whether it will be plume effects or noise effects that result in fish species avoiding spawning areas and, in practice, it is likely that it will be a combination of both.

(b) *The sediment plume may lead to an increased mortality of pelagic eggs*: Experiments by Westerberg *et. al.,* (1996, I John *et. al.*, 2000) concluded that the increased suspended sediment concentrations present within sediment plumes resulted in sediment adhering to eggs, which in turn gave a loss of buoyancy that was proportional to the sediment concentration and exposure time. In the majority of cases, if these eggs sink onto the seabed, it will result in a loss to benthic predation which will have a direct effect on reproductive success (Westerberg, *et. al.*, 1996).

Sediment plumes may have adverse effects on filter-feeding organisms (bivalve molluscs) through reducing feeding efficiency

The feeding efficiency of filter-feeding shellfish (bivalve molluscs) can be damaged through the clogging of their feeding apparatus by suspended sediments present within sediment plumes (Rogers and Carlin, 2002). Furthermore, suspended sediment can also be detrimental to filter-feeding organisms due to impairment of proper respiratory and excretory functioning (Sherk, 1971).

Increased SSC and deposition may have adverse effects on juveniles in nursery areas and planktonic larvae

Increased levels of suspended sediment and sediment deposition can result in adverse effects on fish larvae in nursery and spawning areas. Potential direct effects include blocked food intakes and clogged gills (Matsumo, 1984). Indirect effects include reduced feeding efficiency, as all larval fish are visual feeders and the lower visibility associated with sediment plumes can often lead to diminished feeding ability.

Fish and shellfish may be attracted to sediment plumes

Apart from the adverse effects noted above, sediment plumes can also attract many species of fish and shellfish due to the odour stream produced by the crushing of benthic organisms as they pass through the dredge plant.

Effect of initial sediment deposition

Deposition of sediment out of the sediment plume and onto the seabed may result in the alteration of a specific substrate required for spawning (demersal spawners)

Some species of fish that are demersal spawners (lay their eggs on the seabed), require a particular substrate type to spawn. For example, herring are known to spawn on raised banks comprised of uniform coarse gravel (Dragesund, 1970; Iles and Caddy, 1972), whilst black sea bream lay their eggs in depressions made in gravel substrates. In dredged areas, there is often a change in the sediment composition, with an increase in the proportion of fines recorded. This is due to the removal of coarse material and the deposition of fine sediment due to screening and overflow processes. If this deposition of fine sediments occurs in previously gravelly areas that provided spawning habitat for species such as herring and black sea bream, then these fish may avoid the area due to the habitat being unsuitable for spawning. This may result in an adverse impact on spawning, if alternative areas are not located.

Deposition of sediment out of the sediment plume and onto the seabed may result in the smothering of eggs after they have been spawned (demersal spawners)

Even if changes in the spawning habitats of demersal spawners are not large enough to prevent spawning, there is still the possibility that newly spawned eggs will experience smothering effects due to deposition of sediment from the plume, onto the seabed. Although demersal eggs will be resistant to a certain level of deposition through natural events (storms), the increased duration, extent and frequency of deposition associated with a sediment plume created by dredging activity, may create additional adverse effects. Adverse effects will occur if sediment settles out onto areas where these eggs are located and the eggs become totally buried. If smothering does occur, development of the embryo may be arrested.

Deposition of sediment out of the sediment plume and onto the seabed may adversely affect crustacean spawning

With respect to shellfish, crabs (and in particular the brown crab (*Cancer pagarus*)) are potentially sensitive to dredging effects that may reduce spawning success. Following mating in July-September and subsequent spawning in October-November in inshore areas, egg bearing (‘berried’) females move offshore to over-wintering grounds where they remain until the following spring/early summer period. In the period May to October, the eggs hatch, releasing planktonic larvae into the water column. Following hatching in offshore areas, females move back to inshore grounds to pair-up and begun mating again.

It is during the over-wintering phase, that female crabs are especially sensitive to dredging effects, as they become dormant and bury themselves in sand and gravel sediments. They are, therefore, at risk from direct uptake and smothering. If the crabs are adversely affected during this over-wintering phase, then there is the potential for subsequent hatching to be affected, leading to a reduction in the number of larvae released. This can have subsequent effects on recruitment and the overall stock of the resource.

Deposition of sediment may have adverse effects on shellfish habitat through the 'in-filling' of crustacean 'niche' habitats, resulting in a localised re-distribution of crustaceans

Both crab and lobster prefer areas that contain rocky outcrops or areas of exposed rock on the sea floor that provide crevices and niches in which they can defend themselves. Settlement of sediment from a sediment plume onto these areas can in-fill many of these niches and crevices, leading to a reduction in the extent of available habitat for crab and lobster. A localised redistribution of crustaceans can occur as a reaction to habitat loss (John *et. al.*, 2000).

Bedload transport of deposited sediments may have adverse effects on fish and shellfish spawning areas

As detailed in **Section 3.3**, following the initial deposition of sediment from dredging activity, there is a subsequent process of bedload sediment transport, driven by tidal-influenced currents. Such bedload transport has the potential to create similar effects to those produced through the initial deposition. One of the key differences between this effect and those created by the initial deposition is that the spatial extent of this effect is potentially much greater. This is because the sediments subject to bedload transport may be transported as much as 10km from the dredge site, in the direction of the dominant tidal residuals. Therefore, the scope for impacts is increased as a result of this bedload transport of re-deposited sediment. However, the degree of deposition (and, therefore, the extent to which an impact may arise) will be/may be significantly reduced with time and distance.

3.5.2 CUMULATIVE AND IN-COMBINATION IMPACTS

The following section lists the potential of marine aggregate extraction with other activities to cause cumulative and in-combination impacts to arise on fish and shellfish resources.

Fishing activity

Fishing activity, in particular that using towed gears such as beam trawls and scallop dredges that disrupt the sediment, has the potential to interact with aggregate extraction activities and produce in-combination effects on the fish and shellfish resource.

With respect to creating increased levels of SSC, and turbidity, evidence is available from monitoring work undertaken by CEFAS in relation to an aggregate extraction scheme in Area 107, in the North Sea. Minipods with the ability to record SSC were deployed at varying distances away from the extraction site in areas where any potential plumes were expected to disperse. One of these minipods recorded abnormally large spikes in SSC which were uncorrelated with dredging activity. These peaks also corresponded with neap tide conditions during calm weather, when SSC are normally at their lowest due to low levels of re-suspension. It was concluded that beam trawlers working in the area where the minipod was deployed were the most likely cause of the elevated SSC.

Fishing activity can also result in significant alteration and physical damage to the substrate. An obvious impact of fishing activity is that benthic, epibenthic and fish and shellfish species will be removed. When assessed along with aggregate extraction activities, cumulative impacts can clearly arise.

Capital and maintenance dredging

In practice, the opportunity for in-combination effects between marine aggregate extraction and capital and maintenance dredging to occur is extremely low. This is due to the very limited spatial overlap between the activities, as the vast majority of capital and maintenance dredging takes place from within existing navigational channels and/or within immediate near-shore areas, where aggregate extraction activity is at a very low level (PDE and Hill, 2001).

Offshore wind farms

The number of offshore wind farms in UK coastal waters is set to increase in future years as central Government policy to increase the contribution of renewable energy to the nation's energy supplies becomes reality. Offshore wind farms have the potential to create in-combination impacts with aggregate extraction on fish and shellfish resources, both during the construction and operational phases of these developments.

In particular, cumulative effects may arise through sediment plume effects, loss of benthic resources from the seabed, loss of actual fish and shellfish resources (in particular shellfish) and noise impacts.

Other aggregate extraction activities

Other aggregate extraction activities have the potential to cause very similar impacts to those created by the scheme being assessed. This means that the potential for cumulative impacts to occur is high when sites are adjacent to one another. In terms of the various effects, the direct loss of resources (i.e. scallops) from a series of licensed sites or the combined loss of valuable spawning habitat (herring spawning gravels) will potentially represent the most significant adverse in-combination effects on fish and shellfish resources. However, it is important to consider the full extent of the resource, as well as the potential for recovery, in any such assessment. It is essential that these effects be assessed fully during the EIA studies.

This issue is considered in detail in the ECA REA (Posford Haskoning, 2003).

REFERENCES

CEFAS (1998). *Impact of dredger plumes on Race Bank and surrounding areas* (*Short Version*). Internal CEFAS Report. Research carried out under Contract AO902.

CEFAS (2003). *Preliminary investigation of the sensitivity of fish to sound generated by aggregate dredging and marine construction*. Final Project Report. Report for Defra project AE0914. March 2003.

Dragesund, O. (1970). Recruitment studies of Norwegian spring spawning herring *Clupea harengus* (Linn). Fisk. Dir. Skr. Ser. Havunders. **15**. 381-450.

Henderson, P.A. (2003). A Review of Marine Dredging Effects on Fish. Technical Report for London Gateway Harbour Empowerment Order. February 2003.

Iles, T.D. and Caddy, J.F. (1972). Herring spawn in close-up. World Fishing, June, 14-16.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.T., and Spearman, J. (2000). Scoping the assessment of sediment plumes from dredging. *Construction Industry Research and Information Organisation*. CIRIA Publication C547. ISBN 0 86017 547 2

Matsumo, W.M (1984). Potential impact of deep seabed mining on the larvae of tunas and billfishes. *U.S Dept. Commerce. NOAA Technical Mem*. NMFS, NOAA-TM-NMFS-SWFC-44, 53pp.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed *Oceanography and Marine Biology*: *An Annual Review*, **36**: 127-178.

Nightingale, B. and C. A. Simenstad, (2001). Dredging Activities: Marine Issues. White Paper. Research project T1803, Task 35. Washington State Transportation Centre (TRAC).

Poseidon Aquatic Resource Management (2002). Technical Report on Fisheries. February 2002. *In*, Posford Haskoning (2003). Regional Environmental Assessment for Aggregate Extraction in the Eastern English Channel. Report on behalf of East Channel Association. January 2003.

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Posford Haskoning (2003) Eastern English Channel Regional Environmental Assessment. Report for the East Channel Association. January 2003.

Rogers, S.I. and Carlin, D. (2002). A Procedure to Assess the Effects of Dredging on commercial Fisheries. Draft Final report of CSG Contract A0253. Defra, Nobel House, London.

Scrimger P. and Heitmeyer R.M. (1991). *Acoustic source-level measurements for a variety of merchant ships ;* J. Acoust. Soc. Am. 89 (2), February 1991

Sherk, J.A. (1971). *Effects of suspended and deposited sediments on estuarine organisms*. Chesapeake Biological Laboratory, University of Maryland. Contribution No 443.

Westerberg H., Ronnback, P. and Frimansson, H. (1996). Effects of suspended sediments on cod egg and larvae and on the behaviour of adult herring and cod. ICES, CM 1996/E26.

SECTION 3.6 COMMERCIAL FISHERIES

3.6.1 MAIN IMPACTS

Aggregate extraction may cause a change in the distribution of fish and shellfish which may subsequently impact on commercial fisheries

There are two mechanisms by which fish and shellfish may be displaced from an aggregate production area. One is the direct avoidance of dredging works in response to noise, the turbidity plume or both. This will tend to be a local effect of short duration that will cease soon after the end of dredging works in any one area. The other is a more passive response to the inevitable downgrading of the dredged area as a feeding ground. This is likely to be a more widespread effect and also one of much longer duration.

The distribution of fish and shellfish may change due to fish and shellfish directly avoiding aggregate extraction

As outlined above, fish and shellfish may avoid areas of aggregate extraction in response to noise, turbidity or both. In practice, it may be difficult to distinguish between these two effects but this does not matter, the net result is that many fish and shellfish species may respond to aggregate dredging by moving out of the dredged area.

The distribution of fish and shellfish may change due to the loss of feeding grounds as a result of aggregate extraction

As stated within **Section 3.4**, the removal of benthic biota has the potential to create an adverse effect on fish and shellfish resources through the reduction in the abundance and availability of food items. If a significant amount of benthic biota is removed from a particular area, this may result in a decrease in the density of fish and shellfish in the affected area, as it may no longer represent an attractive feeding ground. Once extraction activity has ceased, or moved on, fish may return to the dredged area only to find that the ground no longer holds a suitable supply of prey items.

However, it is important to note that any effects related to a reduction in benthic and/or epibenthic biota will not be permanent, as all extraction sites will eventually recover in terms of their biological diversity and abundance of biota. This process may take anywhere between a month to fifteen years, depending on the specifics of the site in question (Rogers and Carlin, 2002). For the North Sea, a relatively complete recovery is estimated to take 3-4 years (ICES, 1992). Therefore, following the cessation of dredging activity, it is expected that ecological conditions will return to a level similar to those that existed before dredging began.

It should be noted, however, that prey availability for fish is not dependant upon the complete recovery of the benthic community. Many prey species are likely to partially recover within the first six months following cessation of dredging, although biomass may not be at pre-dredge levels (Posford Haskoning, 2003). Therefore fish may return to feed opportunistically on the benthic community long before the community fully recovers.

With respect to the effect on overall productivity of the fish and shellfish resources, this will only be adversely affected if the extraction area represented a feeding ground of special importance, or if food supplies were a dominant, limiting factor for productivity. In reality, the populations of most commercial fish species are now at such a low level that the availability of food is rarely a limiting factor.

Overall effects on commercial fisheries in-combination

Avoidance of dredging and loss of feeding grounds, as described above, will both have the same type of influence on fish distribution (albeit with different spatial and temporal characteristics), that is, fish will leave the extraction area and go somewhere else. Since the overall population size will be unaltered, it does not necessarily follow that there may be a reduction in commercial catch as, although there may be less fish inside the extraction area, there may, by default, be more outside. However, there are many circumstances in which the changes describe above will lead to a reduction in catch.

Firstly, fishermen have to find where the fish are. It is unrealistic to expect that they will simply be waiting patiently outside the extraction area boundary, and finding them may bear a cost in unproductive time. Secondly, if the extraction area constitutes or contains an important feeding ground, it may well be that the new distribution of fish will be less aggregated than before. In this scenario, even when the redistributed fish are located, both catch rates and fishing profitability may be lower. Finally, the redistribution of fish may intensify competition between fishers in adjacent areas (see below).

Impacts on stocks of fish and shellfish

Fish and shellfish may be entrained through direct uptake, which may, consequently, result in adverse effects on commercial fisheries (dependant on species)

Entrainment impacts do not involve the redistribution of fish or shellfish to new areas, simply their removal. This will apply mainly to shellfish. Provided the seabed substrate and topography remains suitable for re-colonisation by those species removed, then such areas will be re-populated by new settlement or by in-migration (depending on the species present) once extraction activity has ceased. Entrainment impacts will remove target species (shellfish) from the production area but will not have any effect on the populations in surrounding areas. Irrespective of whether or not fishing vessels are permitted to work within the extraction area, there will be less fish to catch and one would expect an absolute loss of catch until natural local recovery has taken place.

Aggregate extraction may create adverse impacts on spawning, which may, consequently, result in adverse effects on commercial fisheries (dependant on spawning aggregations)

If spawning activity is significantly affected, through removal or alteration of spawning habitat, disruption of migratory pathways to spawning grounds or damage to spawning adults, fish eggs and/or larvae, then this has the potential to have significant adverse effects on wider fish stocks within a particular area. If stocks are significantly affected significantly, then commercial catches can also be adversely affected. However, it is unlikely, given the broad distribution of spawning stocks of the majority of key resource species, that relatively localised aggregate extraction activities will cause a significant adverse effect on the overall level of spawning over a wider, regional area. It is more likely that any adverse effects on spawning, recruitment and the subsequent overall productivity of a fishery will be localised. Even so, it should be acknowledged that even localised changes in fish productivity can create adverse effects for commercial fisheries, through reduced catches and income.

An exception to the comments above is herring. Herring have very localised spawning grounds and these may be associated with discrete sub-stocks, e.g. the Thames herring. In such cases, localised disruption of spawning could have a serious impact on commercial fisheries dependant on spawning aggregations or, even worse, an impact on the stock or sub-stock itself (see **Section 3.4**).

Aggregate extraction may result in the physical exclusion of fishing vessels from licensed extraction areas, resulting in reduced catches

During aggregate extraction activities, areas of the seabed licensed for extraction become restricted to commercial fishing activity, including charter boat trips. If the dredging activity is long-term, then this restriction of fishing from within licensed areas can lead to adverse effects on commercial fishermen through reduced catches, landings and trips. The exact scope of this effect may depend on the level of fishing activity that normally exists within the licensed area, and the scale and extent of any restrictions associated with the extraction activities. For this reason, it is essential that accurate information relating to the extent, level, nature and seasonality of all fisheries in an area be collated during the baseline data collection phase.

However, it should be noted that extraction activities often result in the temporary exclusion of fish from dredged areas, therefore, even if commercial fishing vessels are excluded from extraction sites, this may not create as significant an impact on catches as would arise of fish stocks existed at normal levels.

Exclusion from fishing grounds may result in 'squeeze effects' on adjacent fishing areas (increased fishing pressures)

Associated with the effect described above, if commercial vessels are restricted from accessing a certain area due to dredging activity, they may be forced to fish in other areas in order to continue fishing at a level that produces commercially viable landings. In many areas around the UK, fishing activity exists at a relatively high level, therefore, it is often not possible for displaced vessels to simply move a few miles either side of their normal fishing areas without creating increased fishing pressure within areas that may already be fished by established vessels.

In this situation, not only does this displacement increase pressure on commercial fishing activity, with increased numbers of boats potentially fishing in the same area, but it also potentially increases the pressures on the fish and shellfish resources within this area.

In addition to the direct pressure created by increased numbers of boats fishing areas adjacent to extraction areas, such a squeeze effect may also intensify interactions between incompatible fishing methods. For example, if displaced boats predominantly fish static gears, such as crab pots, and they have to move into an area that supports a high level of mobile gears, such as demersal trawling or scallop dredges, then there adverse interactions between these gear types may arise.

Aggregate extraction may interfere with established trawl tows

In addition to total exclusion from a licensed aggregate site, extraction activities also have the potential to cause disruption to well-established demersal trawl tows. Demersal trawl tows incorporate the twin requirements to (a) work productive ground and (b) avoid seabed obstructions. Pelagic trawlers also require (a), but not (b), as their gears are not in contact with the seabed.

Demersal trawl tows are often not on a constant course and can require frequent changes in course to avoid fasteners. Most commercial skippers have in-depth knowledge of the location of such fasteners and, if dredging requirements result in them having to alter well-established tows and fish new grounds, then this could result in a loss of operational efficiency. The fishing methods that would suffer this kind of impact would be demersal otter trawlers, beam trawlers and scallop dredgers.

Aggregate extraction may lead to changes to seabed topography leading to the potential exposure of bedrock features, or other 'fasteners', that may cause trawl gear to come fast

Aggregate extraction activities result in the physical alteration of the seabed, including the lowering of the level of the seabed and the creation of trailer marks and depressions. The removal of sediment can also lead to the exposure of boulders previously covered by a layer of sediment. The creation or exposure of these features can lead to difficulties in certain fishing activities, in particular trawling, as the trawl gear is liable to come fast on these features. This can result in a reduction in the efficiency of trawling operations in areas recently subject to extraction activities.

The period of time following the cessation of dredging activity that these physical features will remain exposed is a function of a range of parameters including water depth, substrate type and near-bed water velocity. Except in areas of mobile sands, the process tends to be very slow (Newell *et. al.*, 1998 *in* Desprez, 2000). Furrows that are only 30cm deep when formed can be clearly visible on side-scan sonar records several years later, with even the strongest currents are unable to transport gravel from adjacent areas (Desprez, 2000).

Aggregate extraction may cause direct damage to fishing gears

There is the potential for aggregate extraction dredging to cause physical damage to fishing gears, both within areas licensed for dredging but, more likely, in areas through which the dredge vessel(s) must pass in order to reach the licensed area. In particular, static gears such as pots and nets are most at risk. In practice, the potential for damage to static gear arises through the loss of dhan buoys when the buoy-line is cut. Most static gear is buoyed at both ends using dhan buoys, so if both buoy-lines are cut, then the gear will be lost.

If a dredger causes damage to these gears, it can often have a significant financial and logistical effect on commercial fishermen that requires both time and money to remedy (i.e. to replace the damaged gears). However, it must be recognised that, in many cases, the movement of dredge vessels to and from a licensed area represents only a very small proportion of the total vessel movements (commercial shipping, recreational vessels, other fishing vessels) that typically occur in UK waters. Therefore, when assessing this impact, the amount of dredger vessel movements should be placed into context with the number of overall vessel movements within the wider study area.

Aggregate extraction may lead to a reduction in income for commercial fishermen who usually obtain a proportion of their income from the extraction area

All the impacts described above have the potential to cause a reduction in income for commercial fishermen.

3.6.2 CUMULATIVE AND IN-COMBINATION IMPACTS

The following section lists the potential of marine aggregate extraction, with other activities, to cause cumulative and in-combination impacts to arise on commercial fisheries.

The significance of the impact of physical exclusion from fishing grounds due to aggregate extraction may be elevated if other commercial fishing exists within the wider study area. The existence of other fishing activity may limit the area to which displaced fishing vessels can move, creating 'squeeze' effects

Fishing activity, in particular that using towed gears such as beam trawls and scallop dredges that disrupt the sediment, has the potential to interact with aggregate extraction activities and produce cumulative effects.

In terms of physical exclusion and subsequent potential 'squeeze' effects on fishing grounds adjacent to licensed areas, cumulative impacts may arise if other activities, including commercial fishing activity, aggregate extraction and/or offshore wind farms exist within the wider study area.

Fishing activity can also result in significant alteration and physical damage to the substrate. When assessed along with aggregate extraction activities, cumulative impacts can be expected.

Impacts of capital and maintenance dredging on commercial fisheries (increased turbidity, generation of sediment plumes, physical disturbance to the substrate and physical exclusion from fishing grounds) may interact with the effects of aggregate extraction

In reality, the opportunity for such cumulative impacts to occur is extremely low. This is due to the very limited spatial overlap between the activities, as the vast majority of capital and maintenance dredging takes place from within existing navigational channels and/or within immediate near-shore areas, where aggregate extraction activity is at a very low level (PDE and Hill, 2001).

The physical exclusion of fishing vessels from a number of aggregate extraction sites within a wider (regional) area may create cumulative impacts through increased fishing pressures and competition

Other aggregate extraction activities have the potential to cause very similar impacts to those created by the scheme being assessed. This means that the potential for cumulative impacts to occur with respect to the commercial fishery is high where sites are adjacent to one another. The potential effect of increased turbidity (due to the generation of sediment plumes) is of particular concern.

Of particular concern to the commercial fishing industry, is the reduction in available fishing grounds if multiple extraction licences are granted in a relatively small area. In this situation, the effects of physical exclusion created by one solitary licensed site may be exacerbated due to interaction with similar physical exclusion effects from other sites within the area.

The physical exclusion of certain types of fishing gears from offshore wind farms, coupled with the physical exclusion of fishing vessels from aggregate extraction sites, may create a cumulative impact

The development of offshore wind farms is a significant aspect of change in the UK marine environment. The recent (2003) '2nd round' of site applications is designed to increase the number of these facilities in UK waters over the next 10-15 years. Once operational, offshore wind farms may have the potential to create cumulative impacts with aggregate extraction, which could adversely affect commercial fishing activity.

The most likely impact of significance will be the physical exclusion of fishing activity from certain areas of the seabed. In particular, the use of towed gears (dredges, trawls) will not be permitted, therefore, the amount of seabed available to commercial fishers will be reduced. The additive effects of loss of fishing grounds due to wind farms and aggregate extraction sites (albeit that recovery will occur in the longer term) will have a cumulative impact on commercial fisheries. However, the significance of this effect will be highly variable from site to site dependant on quality of the fishery.

REFERENCES

Desprez, M. (2000). Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel: short- and long-term post dredging restoration. *ICES Journal of Marine Science*, **57:** 1428-1438.

ICES (1992). Effects of Extraction of Marine Sediments on Fisheries. ICES Co-operative Research Report No: 182. ICES, Copenhagen.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed Oceanography and Marine Biology: An Annual Review, 36: 127-178.

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Posford Haskoning (2003). Eastern English Channel Regional Environmental Assessment. Report on behalf of the East Channel Association. January 2003.

Rogers, S.I. and Carlin, D. (2002). A Procedure to Assess the Effects of Dredging on commercial Fisheries. Draft Final report of CSG Contract A0253. Defra, Nobel House, London.

SECTION 3.7 ARCHAEOLOGICY AND CULTURAL HERITAGE

3.7.1 MAIN IMPACTS

Aggregate extraction activities have the potential to create a range of generic effects on the marine environment. These include physical, biological and chemical effects that themselves have the potential to create changes in the baseline conditions, beyond these that would be expected through natural variation. Any change in the wider marine environment also has the potential to effect archaeological and historical resources. A summary of the main potential effects is provided below. For more detail on this subject, the reader is referred to the 2003 guidance note prepared by BMAPA and English Heritage.

KEY REFERENCE
BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment: Guidance Note*. British Marine Aggregate Producers Association and English Heritage, London.

Aggregate extraction may result in the direct loss of both known and potential archaeological and historical resources (including wrecks, artefacts and flooded landscapes) situated within the sand and gravel of the extraction site

This impact would arise due to the physical operation of dredging, whereby the sediment and any archaeological remains are removed from their position and sent into the hopper/barge. This not only damages and destroys remains, but also removes them from their context, which provides the link between the material and the wider associations that give it meaning and importance.

Aggregate extraction may result in the drawdown of surrounding sediments, exposing remains to increased biological and chemical degradation, as well as potential disturbance to their context, which can result in the loss of known and potential archaeological and historical resources

Dredging may cause sediments to be drawndown on the periphery of the dredge area due to instability. This could result in remains being exposed or covered by a reduced overburden. In addition, this could also result in some disturbance to the context of the remains, due to shifting of sediment.

Dredging works may result in the erosion of sediment in the area, exposing remains to increased biological and chemical degradation, as well as physical degradation from currents, which can result in the loss of the known and potential archaeological and historical resources

Changes in bathymetry from dredging can also result in an alteration to the patterns of erosion and deposition. This could cause exposure and primary (disturbance of materials due to currents) and secondary (biological and/or chemical breakdown of materials due to exposure) degradation of archaeological remains.

3.7.2 IN-COMBINATION IMPACTS

Dredging and indirect reduction of sediment may result in the removal of the protective overburden, leaving remains with insufficient cover to protect them from activities such as trawling

The direct or indirect removal or movement of sediment can reduce the overburden of material that effectively seals and protects archaeological remains. The magnitude of this impact will be dependent on the depth of overburden remaining, the vertical extent of the remains and the frequency of trawling activities. However, physical disruption to the context of the remains could occur and, if material is brought to the surface, biological and chemical processes may cause increased degradation.

REFERENCE

BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment Guidance Note*. British Marine Aggregate Producers Association and English Heritage, London.

SECTION 3.8 NAVIGATION, RECREATION AND OTHER USES

3.8.1 NAVIGATION, OFFSHORE DISPOSAL, CABLES AND PIPELINES, ENERGY PRODUCTION AND MILITARY ACTIVITY

Aggregate extraction may increase the risk of collision between dredging vessels and commercial shipping and/or grounding incidents

The presence of any major shipping lanes in close proximity to an area to be dredged has the potential to put vessels at risk of collision, cause delays to both shipping and dredging activities and cause unnecessary interference with routine shipping operations. The risk of grounding may also increase as vessels take avoidance measures away from dredging areas.

Aggregate extraction may create a sediment plume that crosses licensed disposal sites, potentially resulting in a breach of licence conditions

Although extraction activity should take place away from licensed disposal sites, the production and subsequent dispersion of a sediment plume could pass across a licensed disposal site, potentially causing a breach of the license conditions for the disposal site.

Aggregate extraction may cause damage to sub-sea cables and pipelines

If live underwater cables or pipelines exist within the dredge area, there is the potential for these to be damaged or broken as a result of extraction operations. This could have serious environmental and financial effects through the release of toxic/polluting substances (including oil), the disruption of communications technology or electricity supply and the costs associated with the clean-up and repair of any damaged structures or pollution events, which must be borne by the individuals/company responsible for the damage. Prior to the commencement of dredging, the location of all sub-sea installations in the vicinity of the dredge area should be determined, through consultation with the cable operating companies.

Aggregate extraction may have adverse effects on offshore energy production activities

Offshore oil, gas and wind energy production installations and their associated sub-sea infrastructure can occupy relatively large areas of the sea and seabed in the vicinity of a proposed extraction area. As for the risk of collision with other ships, the potential risk of collision with a rig, wind farm or other installation exists. The result of which could be similar, in terms of environmental and financial effects, to those effects described for cables and pipelines.

The presence of military exclusion zones may increase the collision risk between dredgers and commercial shipping due to the increased frequency of course changes by the dredger to avoid these areas

A military exclusion zone through a proposed aggregate extraction area may prohibit dredgers from entering that area. This means that the dredger would have to increase the frequency of its course changes and follow a more complicated navigation plan. These course changes have the potential to increase the risk of collision with other shipping. However, it is important to note that aggregate dredgers are not always prevented from accessing PEXA areas and consultation with the MoD may be required to determine whether or not access is permitted.

Aggregate extraction may cause alterations to sediment transport pathways potentially affecting navigation channels as anchorages

Dredging may cause alterations to sediment transport processes and pathways (see **Section 4.2.3**). Offshore banks may move position, causing a shift in any adjacent navigable channels or the loss of protection for a previously sheltered anchorage or mooring area.

Aggregate dredgers may come into contact with unexploded ordnance

During extraction operations, aggregate dredgers may come into contact with ordnance lost or expended during the various conflicts around the UK coast or disposed of at sea.

3.8.2 RECREATION

Aggregate extraction may have adverse effects on recreational/hobby boat fishermen

Recreational/hobby fishermen routinely use established locations (such as rough ground, wrecks or favoured sea areas) for fishing activities. Aggregate extraction has the potential to modify the seabed and create sediment plumes that may discourage fish from entering impacted areas. Under a worst case scenario, aggregate extraction has the potential to result in traditional fishing locations becoming unviable (until recovery occurs), resulting in a potential loss of income (i.e. for charter vessels) through reduced custom. Extraction works may also prevent some boat anglers from fishing favoured grounds due to access restrictions.

Aggregate extraction may increase the risk of collision between dredging vessels and recreational vessels

As for commercial shipping, there is a potential risk of collision between dredgers and recreational vessels. The level of useage and patterns of movement of recreational vessels are not generally considered within navigational risk assessments. Consequently, these parameters are usually only referred to qualitatively within an ES. The potential for a collision to occur would be far greater in an area that is heavily used by recreational craft, i.e. yacht racing lanes, but due to the large size and slow speed of the dredger, it is relatively unlikely that a collision would occur.

Aggregate extraction may create adverse effects on SCUBA diving activity through the creation of sediment plumes

Although marine aggregate extraction generally takes place far enough offshore to not directly interfere with dive sites, the possibility exists that indirect effects could occur. The increased suspended sediments associated with aggregate extraction can affect the turbidity of coastal waters in the short-term. This decrease in visibility and water quality could reduce the amenity value of the dive site and cause temporary loss of diving activity.

3.8.3 CUMULATIVE AND IN-COMBINATION EFFECTS

The following section lists the potential of marine aggregate extraction with other activities to cause cumulative and in-combination impacts to arise on navigation and other uses.

Fishing activity

Both commercial and recreational navigation has the potential to experience in-combination effects through the interaction of aggregate extraction and commercial fishing activity. Commercial fishing vessels are often required to move from licensed areas during extraction, resulting in fishing (i.e. the number of boats) increasing in adjacent areas. This increased number of fishing boats in these areas has the potential to increase navigation risk.

Offshore wind farms

The number of offshore wind farms in UK coastal waters is set to increase in future years. Offshore wind farms have the potential to cause in-combination impacts with aggregate extraction on navigation and other uses, both during the construction and operational phases of these developments.

In particular, cumulative effects may arise through increased navigation risk caused by shipping having to avoid both aggregate and wind farm sites.

Other aggregate extraction activities

Other aggregate extraction activities have the potential to cause very similar impacts to those created by the scheme being assessed. This means that the potential for cumulative impacts to occur is high where sites are adjacent to one another. With respect to navigation and other uses, if there are a number of aggregate sites within an area, then navigation risk may be increased due to commercial and recreational craft having reduced areas of sea to move through.

Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

4 METHODS OF IMPACT ASSESSMENT AND DERIVATION OF SIGNIFICANCE

Mineral Industry Research Organisation

ROYAL HASKONING

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SECTION 4 METHODS OF IMPACT ASSESSMENT AND DERIVATION OF SIGNIFICANCE CRITERIA

4.1 GENERIC INFORMATION

The aim of this section of the guide is to provide good practice recommendations relating to the impact assessment stage of EIA. The assessment of impacts within EIA involves four distinct phases:

1. Impact identification;
2. Description of impact;
3. Impact assessment; and
4. Derivation of significance.

Generic good practice with respect to these four phases is provided below. Parameter-specific issues are then detailed in subsequent sections. Details on methods of impact assessment for cumulative impacts are also provided.

It is important to note that the following section refers to potential impacts ***before*** mitigation is put in place. With successful mitigation, many of the impacts described may be eliminated or their significance reduced to minor or negligible levels. Specific details on mitigation are provided in **Section 5**.

4.1.1 IMPACT IDENTIFICATION

The identification of project-related impacts is a key stage within any EIA. **Section 3** of this report provides an overview of the generic impacts of aggregate extraction on the discussed parameters and it is recommended that this section acts as the preliminary checklist for the initial prediction and identification of impacts. However, in order to take site-specific characteristics into account, more detailed impact identification will be required. The identification of site-specific impacts should be based on:

- Inputs from consultation with the public, key marine users and regulatory authorities;
- A review of existing survey data;
- A review of impacts associated with similar schemes;
- The findings of specialist studies undertaken in relation to the EIA (e.g. modelling); and
- The expertise and judgement of the assessors.

Predominantly, site-specific impacts should have already been identified at the scoping stage (see **Section 1.3**). Therefore, this stage of the EIA should aim to further define the impacts identified during scoping, using the information from the sources listed above, and to ensure that no significant impacts are omitted from the assessment.

Use of up-to-date research findings

The impacts described for each parameter in **Section 3** are based on a review of previous studies and reviews into the impacts of aggregate extraction on the marine environment. Therefore, it represents, at the time of publication, an up-to-date list of the key impacts that could potentially arise through aggregate extraction. However, it is important to recognise that the knowledge base concerning the impacts of aggregate extraction on the marine environment is improving at a rapid pace, and that papers continue to be published that provide information on key impacts, based on real field data. Therefore, when preparing an EIA related to aggregate extraction, a proportion of the budget should be allocated to a review of new papers and/or recently published data. Doing this will ensure that, in terms of the type and nature of impacts identified, the resultant ES will be technically up-to-date.

GOOD PRACTICE RECOMMENDATIONS 4.1: REVIEW OF RECENT LITERATURE
A proportion of the overall budget for an EIA should be allocated to the review of recent published papers and data relating to the impacts of aggregate extraction on the marine environment. This will ensure that the resultant ES is technically up-to-date. **This should also include a review of any monitoring reports produced for other licensed sites, so that actual field data can be assessed.**

4.1.2 DESCRIPTION OF IMPACT

Following the identification of site-specific impacts, each impact should be described fully. Both MMG1 and the ICES Guidelines include a requirement that all potential impacts should be identified, quantified and expressed as testable hypotheses, ideally based on the results of earlier studies. Therefore, the environmental consequences should be summarised as an impact hypothesis or hypotheses. These hypotheses should then be tested through the use of well-designed monitoring programs (see **Section 6**). Good practice should, therefore, include the formulation of impact hypotheses, as far as possible.

GOOD PRACTICE RECOMMENDATION 4.2: IMPACT IDENTIFICATION
All potential impacts should be identified, quantified and all potentially significant impacts expressed as testable hypotheses.

4.1.3 IMPACT ASSESSMENT

The impact assessment phase should follow the identification and subsequent description of impacts. An *impact* arises when a particular *effect* interacts with a *receptor* to cause a *change* to the environment (adverse or beneficial). Therefore, during the the impact assessment stage of an EIA, any site-specific impacts identified should be assessed fully, taking account of both:

(a) The nature of the effect; and
(b) The nature of the receptor.

Without information relating to these two aspects, it will not be possible to confidently assess potential impacts. It will also not be possible to derive the significance of any impact on the receptor in question, as the derivation of significance is a function of the nature of the effect and the nature of the receptor (see below).

4.1.4 NATURE OF THE EFFECT

The following aspects of the effect should be defined, as far as possible:

Spatial extent	The spatial extent over which the predicted effect will arise
Magnitude	The scale of change that the effect may cause compared to the baseline
Duration	The length of time over which the effect occurs
Frequency	The number of times that the effect occurs within the duration of the activity

Box 4.1 Spatial extent of effect
This is the spatial extent over which the predicted effect will arise. That is: • *Regional to National/International* (e.g. entire English Channel, southern North Sea); • *Local to Regional* (between 5km away from dredge zone up to the whole regional); • *Local* (within 5km of dredge zone); and • *Site-specific* (i.e. at source of impact only).

Box 4.2 Magnitude of effect
This is the degree of change which the effect may cause compared to the baseline. That is: • *Very High* – a very large change compared to variations in the baseline; • *High* – a large change compared to variations in the baseline; • *Medium* – *c*hange which may be noticeable; and • *Low* – when compared with the baseline, change which may only just be noticeable.

In order to determine the degree of change created by a certain effect, compared to baseline conditions, an indication of the existing baseline level is required. Therefore, it is vital that accurate, high quality data is collected during the data collection phase of the EIA (see **Section 2**). It is also important to have at least an understanding, if not an accurate prediction, of the natural variation (temporal and spatial) present for each of these resources, e.g., the baseline study indicates that there is a discrete sole spawning ground within the study area. Has this increased or decreased in size over recent years? In addition, information relating to any other anthropogenic effects that could occur to the resource in question is necessary in order to define whether actual effects are due to the activity in question or an alternative activity.

In practice, it is often difficult to gather such data, but an attempt should be made so that, at least, any change predicted within the impact assessment stage can be placed into context with natural or other anthropogenic changes.

Box 4.3 Duration of effect
This is the length of time over which the effect occurs. That is: • *Long-term* – the effect will occur for >10 years; • *Medium-term* – the effect will occur for between 5 and 10 years; • *Short-term* – the effect will occur for between 6 months and 5 years; and • *Very short-term* – the effect will occur for up to 6 months.

The categories for duration of effect are based on a review of existing guidelines, e.g. PDE and Hill, (2001), and have been amended, where appropriate, based on expert judgement from the project team and members of the expert panel.

The predicted duration of any effect will have to be determined through the judgement of the assessors undertaking the EIA and consultation with relevant experts. The actual duration will only be determined following commencement of operations and through the use of monitoring programmes. Such monitoring will provide the project team and regulators with an indication as to when certain impacts are no longer occurring.

Box 4.4 Frequency of effect
This is the number of times that the effect occurs throughout the duration of the activity. Assessment of the scale of effect is dependent on the site conditions and the species present.

The frequency of dredging is important in terms of the recovery of the dredged area. If dredging occurs once, in isolation the area can then be colonised by opportunistic species followed by succession to a more diverse and stable community. However, if dredging occurs repeatedly, the successional stages may not occur, dependent on the frequency of dredging, past the opportunistic stage. The recovery of the seabed will also take time and is dependent on the mobility of the sediment. If dredging occurs frequently, the seabed is likely to take longer to recover and reach a degree of stability (dependent on the nature of the substrate). The predicted effect, with specific reference to the frequency of dredging, will be dependent on the site conditions and the species within the area that are able to recolonise the dredged area.

GOOD PRACTICE RECOMMENDATIONS 4.3: DEFINITIION OF EFFECTS
Every effect created by aggregate extraction should be defined in terms of its spatial extent, magnitude, duration and frequency. **The key physical effects related to aggregate extraction are (1) substrate removal and alteration of seabed topography, (2) creation of sediment plumes within the water column and (3) sediment deposition on the seabed.** **The nature of these effects can be relatively well-defined using a combination of numerical modelling techniques and conceptual models (see Section 4.2). However, it is important to recognise that such models require validation through quantified field data to increase their level of accuracy.** **The spatial extent of a predicted effect (a 'vulnerability map') should be displayed graphically where possible. The use of a GIS package or other similar mapping and interface tools is highly recommended.**

4.1.5 NATURE OF THE RECEPTOR

In addition to defining the nature of the effect, it is important to identify and describe the receptors that might be affected by the proposed activity or development. The key aspects of receptors that would require such description are as follows.

Vulnerability	The likelihood (or risk) of an effect interacting with (or affecting) the receptor
Sensitivity/intolerance	The sensitivity (level of intolerance) of the receptor to the effect being considered
Recoverability	How long/quickly does it takes for the receptor to recover to its pre-impact state following exposure to an effect
Importance	Is the receptor 'Important' based on a number of criteria, including its occurrence and value on a local, regional, national and international basis

Box 4.5 Vulnerability of receptor (likelihood of effect affecting receptor)
The vulnerability of the receptor is a measure of the probability of an effect interacting with the receptor in question. This is an important stage in the impact assessment process because if it is judged that the receptor is not at risk from a specified effect then, straight away, it is possible to state that there will be NO IMPACT on the receptor, irrespective of the sensitivity, recoverability and/or importance of the receptor. To facilitate easier assessment of an impact, the primary question that should be resolved is the following "Is the resource vulnerable to the effect (i.e. will the effect interact with the receptor)?": • **YES** – the receptor **IS** vulnerable to the effect; • **NO** - the receptor **IS NOT** vulnerable to the effect.

GOOD PRACTICE RECOMMENDATION 4.4: VULNERABILITY TO IMPACT
Whether or not the effect being assessed is likely to interact with the receptor in question (i.e. is the receptor 'vulnerable'), should be the first question answered as part of the impact assessment process.

Box 4.6 Sensitivity/intolerance of receptor

This factor relates to the sensitivity (level of intolerance) of the receptor to the effect being considered. It is important to have an understanding of this factor as it has the potential to greatly affect the actual significance of the impact.

- *High* – in ecological terms, the species/population is likely to be killed/destroyed by the effect under consideration;
- *Medium* – some individuals of a species/population may be killed/destroyed by the effect under consideration and the viability of a species/population will be affected;
- *Low* – some individuals of a species/population may be killed/destroyed by the effect under consideration, but the viability of a species/population will not be affected;
- *Not sensitive* – the effect does not have a detectable effect on the receptor.

GOOD PRACTICE RECOMMENDATIONS 4.5: SENSITIVITY TO IMPACT

Information on the sensitivity (intolerance) of key resources should be obtained from published literature and consultation with experts from relevant organisations. *MarLIN* (*http://www.marlin.ac.uk*) should be used, where appropriate, as this tool provides detailed information on the sensitivity/intolerance of many key features of the marine environment. However, it should be noted that the knowledge base for determining the sensitivity of species is inadequate and research is needed to further define these aspects.

The EIA should include a critical appraisal of the *MarLIN* data on sensitivity and recoverability, as these data are often extrapolated from other similar species.

Judgement of the sensitivity of the receptor should consider the spatial extent, magnitude, duration and frequency of the effect being assessed.

In order to define a level of sensitivity it is necessary to determine the threshold above or below which the receptor is affected. It is recognised that this is an area where there is some degree of uncertainty, particularly in the marine environment.

Box 4.7 Recoverability of receptor

This factor relates to the overall recoverability of the receptor (i.e. how long it takes for the receptor to recover to its pre-impact state following exposure to a particular effect). Conversely, this is also sometimes described as the reversibility or irreversibility of an impact (see **Section 3.1**).

- *Low recovery rate* – partial recovery could occur within 10 years and full recovery is likely to take up to 25 years, although it may not occur at all;
- *Medium recovery rate* – full recovery will occur but will take many months (or more likely years) but should be complete within about five years;
- *High recovery rate* - full recovery is likely within a few weeks or at most 6 months.

GOOD PRACTICE RECOMMENDATIONS 4.6: RECOVERABILITY

Information on the recoverability of key resources can be obtained from published literature and through consultation and discussion with experts from relevant organisations, such as CEFAS. *MarLIN* should also be used, where appropriate, as this tool provides detailed information on the recoverability of many key features of the marine environment.

Judgement of the recoverability of the receptor should consider the spatial extent, magnitude, duration and frequency of the effect being assessed. Recoverability will also be largely controlled by the residual environmental conditions that remain post-extraction (i.e. a receptor may show a high degree of recoverability from smothering effects but, if the physical conditions of the site have changed to ones that no longer suit the receptor, then recovery may not occur).

Box 4.8 Importance of receptor
It is recommended that the 'importance' of a receptor be based on the answers to the following questions: • *Rarity* - what is the existing level of distribution of the receptor on a local/regional/national/international scale[1]? • *Conservation value* - is the receptor recognised under nature conservation legislation or does it have some form of protection (Annex I of the Habitats Directive, Biodiversity Action Plan species or habitat)? • *Uniqueness* - *w*hat is the relative abundance of the receptor within the immediate study area, i.e. how much more of this resource/feature exists in relation to the extent of the impact? • *Commercial value* - *d*oes the receptor represent a resource of high economic value, i.e. a commercial fish species? • *Biodiversity/Ecosystem function* - does the receptor represent an important component of the wider ecosystem (in terms of food webs/predator prey relationships, habitat functions, i.e. *Sabellaria*)? The relevance and applicability of the above factors to defining importance will vary from receptor to receptor. For example, rarity and conservation value may be the dominant factors in determining the importance of a benthic resource. Alternatively, commercial value may be the dominant factor in determining the importance of a commercial fish or shellfish species. Once the above factors have been assessed, the overall importance of the receptor can be determined, as follows: • *High* – the receptor is of high importance due to it representing **either** a very rare/unique/valuable/ecologically important feature; • *Low* – the receptor is of low importance as it is **neither** rare, unique or of high economic value nor does it play an important role in the ecosystem.

GOOD PRACTICE RECOMMENDATION 4.7: IMPORTANCE
Judgement as to the 'importance' of various resource features should include some form of consultation or discussion with various key organisations. **The rationale for describing the importance of the receptor should be stated clearly within the ES, i.e. conservation value; rarity; uniqueness; ecosystem function etc.**

Once the effect and receptor being assessed have been fully defined, it is recommended that some form of summary table, similar to the one shown below (**Table 4.1**), be used to describe both the nature of the effect in question and the receptor being assessed.

[1] The spatial resolution of marine data can often be limited. Consequently, it is sometimes difficult to assess the existing level of distribution of a receptor on a regional and/or national scale and to make a meaningful assessment of 'importance' in terms of the wider distribution of a receptor. However, UK nature conservation agencies are able to determine the national and global importance of many species and habitats, hence the rationale for the EU Habitats Directive. Even so, a UK seabed habitat map would greatly benefit any judgement of importance and, as such, the development of one should be encouraged.

Table 4.1 Summary table of key aspects of the impact and receptor

Nature of Effect	
Description	**Intensive deposition of sediment from overflowing and screening**
Spatial Extent	This is judged to be **LOCAL** (within 5km of the dredge zone).
Magnitude	**HIGH** - based on the large amount of deposition compared to baseline deposition levels.
Duration	**SHORT-TERM** (6 months to 5 years), i.e. the effect will persist for the duration of the initial 5-year dredging licence.
Frequency	**VERY FREQUENT** – deposition is predicted to occur for a period of more than 50% of the life of the activity or will be intermittent.
Nature of Receptor	
Description (example)	**Herring spawning ground (identified through baseline studies)**
Is the receptor vulnerable to the impact being assessed?	**YES** – spatial analysis using GIS indicates that the deposition footprint and the herring spawning ground overlap.
Sensitivity (intolerance) of receptor to impact being assessed[2]	**HIGH** – the predicted depth of deposition is higher than values of smothering that would create adverse effects on herring spawning. Therefore, it is predicted that the deposition of sediment will change the substrate composition to a degree that makes the ground unsuitable for herring spawning.
Recoverability of receptor to the impact being assessed	**HIGH** – the receptor has a rapid recovery rate. The impact is judged to be temporary, as following the cessation of dredging (and deposition), excess sediment would be removed by natural processes and depths of sediment would return to baseline levels within 5 years. Therefore, the ground would once again be suitable for herring spawning.
Importance of the receptor	**HIGH** – it is the only known spawning ground for this species within the wider study area for this project. In addition, the pre-spawning aggregation of herring in this area also represents an important component of the local commercial fishery (i.e. it has economic value).

The output from such a table provides sufficient detail for the final stage in the impact assessment process, namely, derivation of impact significance.

4.1.6 DERIVATION OF SIGNIFICANCE

In terms of assessing environmental risk, guidelines have been produced that provide a framework for the development of functional risk assessment (DETR, 2000). This document emphasises the establishment of risk assessment, risk management and risk communication as essential elements of a structured decision-making processes across Government.

Traditionally, within EIA, the derivation of significance for individual impacts has been based on the following system:

Significance of Impact = Magnitude of Effect X Value and Sensitivity of the Receptor

With respect to the magnitude of the effect, this has traditionally been ascribed a value of high, medium or low, based on the scope and nature of the effect, whilst the value and sensitivity of the receptor has been based on, amongst other things, the relative geographic importance of the receptor, e.g. is it important on a national, regional, local or site-specific level?

Following assessment of these two factors, it is then possible to assign a level of significance to the impact, perhaps using a simple matrix as set out below.

[2] The judgement as to both the sensitivity and recoverability of the receptor should be based on the specific aspects of the impact being assessed, i.e. sensitivity and recoverability will vary based on impacts with differing spatial extents, magnitude, duration and frequency.

Box 4.9 Example of a traditional matrix for calculating significance criteria					
	Value and Sensitivity of Feature				
Magnitude of Effect	**Very High/**	**High**	**Medium**	**Low**	**Very Low**
High	Severe	Major	Major	Moderate	Minor
Medium	Major	Major or Moderate	Moderate	Minor	Minor
Low	Moderate	Moderate or Minor	Minor	Minor or None	None

However, although the method described above does enable the significance of an impact to be described, it *does not* take into account a range of other important factors related to both the effect and the receptor which will influence the overall significance of the effect. Therefore, in order to ensure that the impact is fully described, it is recommended that all of the information related to the nature of the effect and the receptor, as described in the preceding sections, is utilised.

In order that this additional information is fully considered, a *potential* framework for integrating information on sensitivity (intolerance), recoverability and importance of receptors into environmental assessment and management is described below.

4.1.7 POTENTIAL FRAMEWORK FOR DERIVING SIGNIFICANCE

The following section provides an overview of a framework that *could* be used to derive the significance of an impact, using information provided in the impact assessment phase relating to both the impact and receptor. This framework is illustrated in **Figure 4.1**.

It is important to note that this framework is simply a guide, which could be used to help those undertaking an EIA to ascertain the significance of an impact. Given that competent practitioners of EIA already undertake many of these steps, it is recognised that this framework simply represents a more transparent method of demonstrating (to Regulatory Authorities), how the decision to assign a certain level of significance to an impact has been reached. It is also important to recognise that alternative methods of deriving significance are available. However, whichever method is used, the key aspects of both the *Effect* and the *Receptor*, as detailed in preceding sections, should be fully described.

It is also important to note that this framework is only of practical use for the following environmental parameters:

- Marine ecology;
- Nature conservation;
- Fish and shellfish resources;
- Commercial fisheries; and
- Archaeology.

This framework should not be used in the assessment of 'impacts' related to physical processes, as impacts related to this parameter are assessed differently. Further details of impact assessment and the derivation of significance related to physical processes are provided in **Section 4.2**. Similarly, for navigation, specific methods of impact assessment exist, in the form of navigational risk assessments. A summary of these methods is provided in **Section 4.7**.

4.1.8 HOW TO USE THIS FRAMEWORK

Step 1: Description of the Receptor
A description of the resource (receptor) should be obtained. Such information would have been provided as part of baseline data collection studies and impact assessment.

Step 2:Description of the Nature of the Effect
A description of the nature of the effect should be compiled. This should include information on the predicted *spatial extent*, *magnitude*, *duration* and *frequency* of the effect. This will be available following the impact prediction and assessment phase.

Step 3: Vulnerability (Impact Interaction)
A decision should be made as to the vulnerability of the receptor being assessed, i.e. will the receptor in question 'interact' with the effect being assessed to generate an impact? This can be undertaken at a general level using GIS to display the location of the receptor in question, overlapped with the spatial extent of the impact being assessed. If this step indicates that there will be NO interaction between the receptor and the effect, then **NO IMPACT** will occur.

If it is shown that the effect and receptor will interact (YES), then proceed to Step 4.

Step 4: Sensitivity
The assessment of the sensitivity of the receptor to the effect in question should be used. This assessment should have been made during the impact prediction and assessment phase and should be based on the spatial extent, magnitude, duration and frequency of the effect.

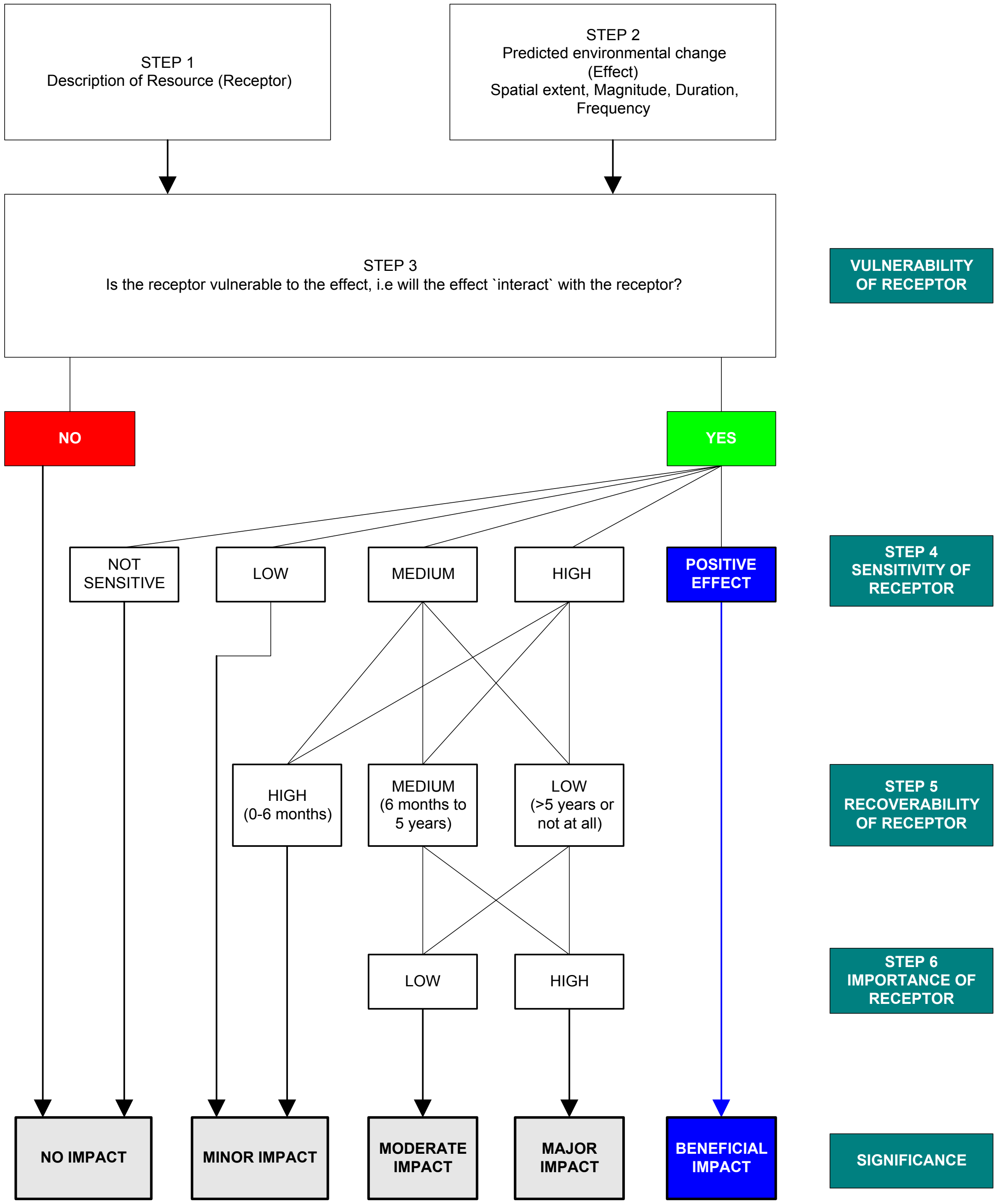
If the receptor is judged to be *Not Sensitive* to the effect, then **NO IMPACT** will occur. If the receptor is judged to have *Low Sensitivity* to the effect, then a **MINOR IMPACT** is derived. If the receptor is judged to have a *Medium* or *High Sensitivity*, then proceed to Step 5. In some cases, the effect may actually produce a *Beneficial Impact* on the receptor.

Step 5: Recoverability
If Step 5 is reached, information is required as to the recoverability of the receptor in question. As for sensitivity, the assessment of the vulnerability of the receptor should have been made during the impact prediction and assessment phase and should have been based on the spatial extent, magnitude, duration and frequency of the effect.

The receptor should be defined as having *High, Medium* or *Low Recoverability*. If the receptor is assessed as having *High Recoverability*, then the framework indicates that a **MINOR IMPACT** will arise. If the receptor is assessed as having *Low, Medium or Recoverability*, then proceed to Step 6.

Step 6: Importance
The information required at Step 6 relates to the importance of the receptor. This attribute is unrelated to any aspect of the effect (spatial extent, magnitude etc.) and is defined above.

If the receptor is judged to be of *Low Importance*, then a **MODERATE IMPACT** is derived. If the receptor is judged be of *High Importance*, then a **MAJOR IMPACT** is derived.



NOTE: The judgement as to both the sensitivity and recoverability of the receptor should be based on the specific aspects of the effect being assessed.

Figure 4.1 *Potential* decision framework demonstrating how vulnerability, sensitivity (intolerance), recoverability and importance information can be used to assign significance criteria (for certain environmental parameters)

GOOD PRACTICE RECOMMENDATIONS 4.8: ASSESSMENT OF SIGNIFICANCE
The assessment framework set out in Figure 4.1 provides a logical and transparent process whereby the steps taken in assigning significance criteria to a certain impact, are made more transparent. **It is recommended that similar frameworks are used within all marine aggregate EIAs and that up-to-date information on key factors (sensitivity/intolerance, recoverability and importance) is obtained from relevant sources, e.g. *MarLIN.*** **As far as is possible, the reason for assigning this level of significance should be fully explained within the supporting text of the ES.** **The final decision on significance will always require professional opinion and judgement and cannot be based on this framework alone.**

Data gaps, assumptions and the 'precautionary principle'

The assessment of potential impacts and derivation of significance is heavily reliant on the quantity and quality of the background data collated and also the amount of data on the sensitivity and recoverability of certain species/habitats to aggregate extraction effects, i.e. smothering and habitat removal. However, the collection of data in the marine environment, particularly in the offshore environment, is difficult due to the inherent physical conditions and, as a result, data gaps can occur. Given that data gaps are common, there is often incomplete knowledge about baseline conditions and certain effects or impacts. In a situation where such incomplete knowledge exists, the precautionary principle should be applied (see **Box 4.10**).

Box 4.10 The Precautionary Principle
The Precautionary Principle, as used to describe Principle 15 of the *Rio Declaration on Environment and Development*, states that: *"Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation"*. Where action is deemed necessary, measures based on the precautionary principle should be, *inter alia*: • *Proportional* to the chosen level of protection; • *Non-discriminatory* in their application; • *Consistent* with similar measures already taken; • *Based on an examination of the potential benefits and costs* of action or lack of action (including, where appropriate and feasible, an economic cost/benefit analysis); • *Subject to review*, in the light of new, scientific data; and • *Capable of assigning responsibility for producing the scientific evidence* necessary for a more comprehensive risk assessment. With respect to applying the Precautionary Principle, the Scottish National Planning & Policy Guidelines 14: *Natural Heritage* (1998), which is essentially the Scottish version of PPG9: *Nature Conservation*, states the following: "*..In exercising their development control function, planning authorities should apply the precautionary principle in circumstances where the impacts of a proposed development are uncertain, but there are good scientific grounds for believing that significant irreversible damage could occur to natural heritage interests of international or national significance. Where it appears that a precautionary approach is justified, careful consideration should be given to whether the proposal might be modified to eliminate risk of irreversible damage before a decision is reached to refuse permission (consent)."*

In addition to applying the precautionary principle on a project-specific basis, where data gaps and incomplete knowledge of key impacts may exist, it is also important to understand the context in which the UK Government applies this principle in relation to applications for marine aggregate extraction. **Box 4.11** includes text from MMG1 (DTLR, 2002), which describes the UK Government's procedures, policies and advice on the extraction of minerals from the seabed in English territorial waters.

Box 4.11 Text from Marine Minerals Guide Note 1
"*The Government will pursue a precautionary approach in the consideration of applications for marine minerals dredging. …There will be a presumption against permitting new areas of extraction unless the issues relating to environmental and coastal impacts are satisfactorily resolved*."

GOOD PRACTICE RECOMMENDATION 4.9: PRECAUTIONARY PRINCIPLE
Where uncertainties exist, either due to a current low level of knowledge about a specific impact/receptor or a data gap, then the Precautionary Principle should be applied and the data gaps identified.

It is also important to recognise that even with good quality baseline data and input from qualified professionals, an element of uncertainty will always be associated with the assessment of potential impacts and the derivation of significance. This is due to the fact that the marine environment is highly dynamic and subject to a range of stresses and drivers separate to anthropogenic influences. As a result of such uncertainties, the assessment of some impacts is often based on assumptions.

Where the assessment of impacts has been made on the basis of incomplete information or using assumptions, then this should be recognised and reported within the final ES. Without listing the assumption used in reaching a decision on the impact in question, it is difficult for regulatory bodies assessing the ES to fully follow the thought process and rationale of the consultants undertaking the assessment.

GOOD PRACTICE RECOMMENDATION 4.10: ASSUMPTIONS
Any assumptions used in predicting and describing a particular impact should be listed within the ES, thus making it more transparent and robust.

4.1.9 CUMULATIVE IMPACTS

Generic details on cumulative impacts are provided in **Section 3.1**. A review of the various methods available to assess cumulative impacts is presented in PDE and Hill, 2001 (see **Box 4.12**). This report summarises the findings of a more detailed review of cumulative impacts, produced by Oakwood Environmental Ltd(Oakwood Environmental Ltd, 1999). A further study by Oakwood developed a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study (Oakwood Environmental Ltd., 2002). These reports should be consulted for further details on the assessment of cumulative impacts.

Box 4.12 below provides an assessment framework for undertaking cumulative EIA. For more detail on how to undertake each step of the framework, reference should be made to the key references.

Box 4.12 Cumulative Assessment Framework	
Basic EIA steps	**Tasks to complete for a cumulative EIA**
Scoping	• Identify regional issues of concern; • Select appropriate regional Valued Ecosystem Components (VEC); • Identify spatial and temporal boundaries; • Identify other actions that may affect the same VECs; and • Identify potential impacts due to actions and possible effects
Analysis of Effects	• Complete the collection of regional baseline data; • Assess effects of proposed action on selected VECs; and • Assess effects of all selected actions on selected VECs
Identification of Mitigation	• Recommend mitigation measures

Box 4.12 Cumulative Assessment Framework	
Evaluation of Significance	• Evaluate the significance of residual effects; and • Compare results against thresholds/conservation objectives and trends
Follow-up	• Recommend regional monitoring and effect management
Source: Canadian Environmental Assessment Agency (1999)	

KEY REFERENCES

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Oakwood Environmental Ltd (1999). Strategic Cumulative Effects of Marine Aggregate Dredging (SCEMAD). Report on behalf of US Department of the Interior Minerals Management Service. Contract No. 1435-01-98-CT-30894. February 1999.

Oakwood Environmental Ltd (2002). Development of a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study. CCW Contract Science Report Number 522

It should also be noted that Defra have commissioned CEFAS to undertake a research project entitled *An investigation of the Potential for Cumulative Environmental Effects arising from Marine Aggregate Extraction*. This report should be available in 2004.

REFERENCES

Canadian Environmental Assessment Agency (1999). Addressing cumulative environmental effects.

DETR (2000). Guidelines for Environmental Risk Assessment and Management. The Stationery Office, London, 88pp.

DTLR (2001). Marine Minerals Guidance Note 1. Consultation Draft.

Oakwood Environmental Ltd (1999). Strategic Cumulative Effects of Marine Aggregate Dredging (SCEMAD). Report on behalf of US Department of the Interior Minerals Management Service. Contract No. 1435-01-98-CT-30894. February 1999.

Oakwood Environmental Ltd (2002). Development of a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study. CCW Contract Science Report Number 522

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

SECTION 4.2 PHYSICAL PROCESSES

4.2.1 INTRODUCTION

This section provides details on methods of impact assessment related to physical processes. When considering aggregate extraction in the context of physical processes, there are essentially two environments that are subject to potential effects: (1) the area at, and directly surrounding, the dredge site (i.e. the likely footprint of the sediment plume associated with the dredging activity) (**NEAR-FIELD**) and (2) the area between the proposed dredge site and the coast, including areas that support offshore structures within this area (wind farms) and the adjacent coast itself (**FAR-FIELD**) (see **Box 2.4** for further details). **Section 3.2** also highlights the possibility of changes to sediment transport on the surface of sandbanks adjacent to the dredge site. The implications of this relate to the potential change in benthic species distribution due to a change in sea bed sediment distribution. Although the effects are physical, the impacts are ecological and are, therefore, covered in **Section 4.3**.

With respect to near-field and far-field effects, the level of impact assessment undertaken for each area will vary from site to site. In some areas, key issues will relate to potential far-field effects, i.e. effects on local coastlines. However, for other sites, the proximity of local features such as pipelines, wrecks or distinct seabed forms mean that near-field effects need to be considered in the greatest detail.

The effects of aggregate extraction at the coastline and in areas subject to plume and deposition processes potentially have important consequences for the physical, biological and human environment. It is, therefore, essential that a cautious approach be adopted to predicting the nature and magnitude of any changes to the physical environment and assessing the significance of these predicted changes. In addition, the potential for aggregate extraction to lead to impacts on adjacent coastlines causes concern amongst coastal managers, coastal groups and the general public alike. Therefore, the assessment process must demonstrate a rigorous approach to ensure confidence from all parties in the outcomes.

However, when considering the effects on physical processes caused by aggregate extraction, it is important to recognise current and future trends in the marine aggregate extraction industry. Over the last 25 years, land-based sand and gravel production in South East England has declined by approximately 60%, leading to an increase in the marine aggregate contribution over this same period. Existing marine licensed sites have subsequently now been dredged for over 30 years, resulting in a reduction in the available resources in these areas. Therefore, surveying for alternative resources has been undertaken by several companies and has identified significant marine aggregate reserves, particularly in the eastern English Channel (the Eastern Channel Region (ECR)). Applications have subsequently been made to undertake aggregate extraction in this area, which is around 30km offshore, with typical water depths of between 30 and 60m.

Due to the distance offshore and water depth of these new sites, the potential for effects on adjacent coastlines will be greatly reduced. Therefore, the emphasis on assessing physical process effects will switch from potential effects on the coastline, to effects on the seabed due to habitat removal and sediment deposition. This change in emphasis is reflected in the following section, which concentrates more on the assessment of deposition effects than on effects on the coastline.

The good practice recommended in this paper has been drawn from a number of key documents, listed below, that provide appropriate guidance on the subject.

KEY REFERENCES

Brampton, A.H. and Evans, C.D.R. (1998). Regional Seabed sediment studies and assessment of marine aggregate dredging. CIRIA Report C505.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2002) Scoping the assessment of sediment plumes from dredging. CIRIA Report C547.

Simmons, R. and Hollingham, S. (2001). Marine Aggregate Dredging: A review of current procedures for assessing coastal processes and impact at the coastline. Technical Report HYD10401. UCL. London.

4.2.2 WAVES

As discussed in **Section 3.2**, there are three ways in which the lowering of the seabed due to aggregate extraction can alter waves passing over a dredge site and potentially lead to changes in the wave conditions arriving at sandbanks and the adjacent coastline(s). These are:

- **Aggregate extraction may cause a change in wave refraction behaviour over the dredged area leading to changes in wave energy distribution at the coast**;
- **Aggregate extraction may cause a reduction in the shelter to a coast provided by offshore sandbanks; and**
- **Aggregate extraction may cause a change in wave refraction behaviour over the dredged area leading to changes in wave height/direction impinging on sandbanks.**

All these effects can potentially have important implications for sandbank and beach behaviour and development and also for coastal defence structures. As a result, wave effects are of concern to coastal managers and should be considered (as standard practice) when assessing an extraction application. All of these effects result from alteration to processes associated with wave transformation and, therefore, essentially the same assessment methods can be adopted for both.

GOOD PRACTICE RECOMMENDATIONS 4.11: IMPACTS ON WAVE BEHAVIOUR

An initial assessment of the impacts of aggregate extraction on wave behaviour should always be undertaken.

The simplest way to assess if proposed extraction would affect a coastline by altering waves is to develop guidelines based on water depths where, implicitly, the nearshore waves depend upon the water depth. If an application is in water deeper than this guideline depth, then effects on the wave climate can be safely dismissed as insignificant. However, if the application is within the guideline water depth, then further investigation of the changes to the wave climate would be required. This is the approach adopted in The Netherlands where no studies of the effects on waves are undertaken for proposed extraction areas in water depths greater than 20m (relative to mean sea level).

In considering such an approach within UK waters, a number of factors must be considered:

1. Simply applying the figure from the Netherlands to the UK would be inappropriate, as different wave climates are involved in the two cases. Additionally, wave climates will vary around the UK coast. For example, the depth at which waves would begin to be affected is greater off the coastlines of the outer Bristol Channel than off the south east English coast, due to the fact that the outer Bristol Channel receives longer period oceanic swell waves. As a result of the need to introduce caution into the assessment, it is necessary to assume a worst case wave climate scenario when developing a UK guideline depth.

2. In the UK, there has been considerable pressure on those assessing extraction licence applications to consider ‘cumulative’ and ‘in combination’ effects. It is feared that alterations to the wave climate may arise as a result of multiple extraction areas in the same general region of the seabed. Hence, it is necessary to consider effects on waves for all applications in a site-specific

manner, unless all of the extraction areas in the vicinity are in water so deep that waves are not affected by the changes in depth that the dredging causes.

GOOD PRACTICE RECOMMENDATIONS 4.12: ASSESSMENT OF EFFECTS ON WAVE CLIMATE
If an initial assessment shows that the proposed extraction site is an isolated licence area and at water depths greater than 30m, then further investigation into changes in the wave climate WILL NOT be required. **If an initial assessment shows that the proposed extraction site is an isolated licence area and at water depths less than 30m, then further investigation into changes in the wave climate WILL be required.**

If it is concluded that further investigation is required, then this should include prediction of the effects of dredging on wave transformations using numerical models. This modelling should seek to establish whether the wave conditions arriving at any coastline (or sometimes at a feature of importance just offshore of a coast, e.g. a sandbank or wind farm), will be affected by the dredging. This essentially involves predicting nearshore wave conditions at an adjacent coast under two scenarios:

- based on the existing bathymetry (*Before*) and
- based on the post dredging bathymetry (*After).*

When undertaking this modelling exercise, it is crucial that a cautious approach is adopted, in order to add a factor of safety to the assessment and to ensure a 'worst case scenario' has been considered. A number of steps are required to be taken to ensure that appropriate caution is introduced into the assessment (see **Box 4.13**). It is also important to recognise that all models, by their nature, are predominantly theoretical unless validated by quantified field data. If any model has particular limitations, then there is a real risk that significant impacts may not be predicted. Therefore, a cautious approach is essential.

Box 4.13 Measures used to ensure a cautious approach to wave modelling assessment
Assume that the total amount of sediment specified in any application will be removed instantly. This removes any uncertainty about the possible effects of a different rate of extraction to that originally foreseen by the applicants. The amount actually extracted may never reach the amount permitted by the application and an area may partially infill over the course of a licence. Hence, this assumption will exaggerate the changes in the seabed levels that will be caused by the proposed dredging and ensure caution is introduced to the exercise. *Assume an additional amount is to be removed, of at least 50%, to provide a safety margin* Where the application is not certain about the precise pattern and depths of future extraction operations, it is often wise to increase this 'over dredging' percentage. In some cases, a maximum depth of extraction has to be assumed in the modelling, and this could then lead to a corresponding restriction to the actual future extraction patterns. This allows for a further margin of safety in the assessment process. *Assume a low tide level in the modelling, thus maximising the relative change in water depth* This maximises the amount of change that would be predicted to occur in nearshore wave conditions. However, modelling is often repeated for higher tidal levels, since this is the time when coastal defences, for example, would be most affected by any changes in the wave conditions. *Assume very severe wave conditions in the modelling, with correspondingly long periods, approaching from a wide range of directions* This measure reflects the fact that the largest waves are of the greatest concern to those living or working along a coastline, and that these waves can approach from various directions. Also, the largest waves are usually associated with the longest wave periods, and hence are most affected by changes in water depths caused by dredging.

Box 4.13 Measures used to ensure a cautious approach to wave modelling assessment
Consider a wide coastal area, with particular attention being paid to vulnerable locations Ensure that a long stretch of coastline either side of that point is considered in the modelling. A common approach is to select a variety of locations where changes in wave conditions might be a particular concern, and study these. *Do not incorporate the processes of diffraction or the effects of wind in the modelling process* Both these two processes will "smooth over" any local changes to waves that have crossed a dredged depression. By deliberately choosing a wave transformation model that does not include diffraction or the effects of wind, a further degree of caution is introduced into the assessment of the effects of extraction, satisfying the requirement of this assumption.

Summary procedure for undertaking wave modelling studies

A wave modelling exercise can essentially be considered as a two-stage process. The first involves specifying the 'offshore' waves entering the study area and the second involves wave transformation modelling to propagate these offshore waves across the study area, over the proposed dredge site, to the adjacent coast.

It is unlikely that offshore wave measurements would be available at a location suitable to provide the information required to input into a wave transformation model and, if measurements are available, they are unlikely to be of sufficient length. If this is the case, it is necessary to predict wave conditions using a wave forecasting or hind-casting model that generates wave conditions from records of wind speed and direction (recorded or predicted). Generally, such models can be used to obtain a realistic time-series of information on waves and essential wave parameters, such as significant wave height, mean direction and average period (Brampton and Evans, 1998).

GOOD PRACTICE RECOMMENDATION 4.13: WAVE GENERATION HIND-CASTING MODELS
In the majority of situations, it is acceptable to use wave generation or hind-casting models to obtain a realistic time-series of information on waves and wave parameters. The UK Met Office hosts the most commonly used model.

The second stage of the process involves modelling wave transformations as waves pass across the study area, over the proposed dredge site, to the coast. A number of different wave transformation models are available to perform this task. However, it is important to check that any model(s) used, both for the hind-casting of offshore waves and wave transformation, have previously been verified against wave measurements. For further details on modelling waves, the reader is referred to Appendix 4 of Brampton and Evans, 1998.

Significance assessment

Alteration to the wave climate caused by aggregate extraction has the potential to affect the behaviour, development and function of an adjacent coastline. Given the importance of these potential effects and the level of concern over the impacts of aggregate extraction on the coastline, the assessment processes must be rigorous and must introduce an element of caution (see **Box 4.13**). This rigorous approach to the assessment of the 'significance' of any predicted changes ensures confidence in the assessment process. Therefore, the judgement of significance should be based on "detectability".

As with all numerical simulations of physical processes, the results usually show some small differences between the pre- and post-dredging cases and analysis of these differences will allow a judgement to be made on whether a detectable change is predicted. These differences may be the result of imperfections in the transformation modelling, or a genuine reflection of the changes to the seabed caused by the proposed extraction, or a combination of the two.

Often the modelling shows that these changes, combined with those caused by the imperfections in the model, are small, e.g. only 2-3% in wave height. Hence, any genuine changes due to the extraction that might arise are smaller than the errors that can be expected from the imperfections in the model alone. In this sense, they can be regarded as not detectable and therefore not significant in the context of the specific modelling methods used.

If the modelling has also been carried out in a precautionary way, i.e. using a 'worst-case scenario' to deliberately over-emphasise the effect of the proposed extraction, then it is reasonable to further conclude that any changes in nearshore wave conditions will be insignificant in reality.

GOOD PRACTICE RECOMMENDATIONS 4.14: CHANGE IN NEARSHORE WAVE CONDITIONS
If the modelling shows a DETECTABLE (i.e. outside model scatter) effect on nearshore wave conditions between the pre- and post-dredge conditions, then this should be considered to be a significant change and therefore unacceptable. **If the modelling shows NO DETECTABLE (i.e. within model scatter) effect on nearshore wave conditions between the pre- and post-dredge conditions, then this should be considered acceptable.**

4.2.3 SEDIMENT TRANSPORT

Aggregate extraction has the potential to cause alterations to sediment transport processes and pathways. This is of particular concern with respect to (a) the coastline(s) adjacent to licences and (b) sensitive resources within the study area that are dependant on the pre-existing sediment transport processes and pathways, e.g. shellfish beds, spawning areas, archaeological features. **Section 3.2** outlined two principal mechanisms by which aggregate extraction can impact on beaches via alterations to sediment transport. These mechanisms are discussed below.

Aggregate extraction may cause damage to beaches as a result of beach draw-down of material into dredged area

It is important that an assessment is made to ensure that this potential impact does not occur. A cautious approach should be adopted, providing confidence to coastal managers and members of the public who have concerns about damage to beaches.

Assessing this issue requires analysis of the seaward limit of the active beach profile, i.e. the cross-shore location below which sediment is not actively moved up and down the beach profile. As long as extraction is not undertaken within the active beach profile, the natural processes of sediment being moved up and down the profile due to wave conditions will not be affected. The main method used to make this assessment involves developing an understanding of the beaches at the coastline adjacent to the site.

A number of studies have been undertaken to determine the seaward limit of the active beach profile at different locations. These studies provide quantitative estimates of the lower limit of the active beach profile that can then be used in a site specific assessment process. On the Californian coast, Inman and Rusnak (1956) carried out a comprehensive survey and showed that seasonal changes in the beach profile were not detectable in water depths greater than 10m. Brampton and Evans (1998) suggest that given the long period waves in California, the lower limit of the active beach profile on most UK coasts is likely to occur at shallower depths than this. This is supported by a study undertaken by Halcrow (1991) for the East Anglian coast, that suggested a limit for the active beach profile of 7m.

Applying a guideline water depth for the seaward limit of the active beach profile, below which draw-down could be safely dismissed, would provide a convenient method for assessment. However, the precise width of the active beach profile will be site specific and will vary from location to location. Therefore, it is important that a comparison of water depths with the guideline depths discussed above is supported by the development of an understanding of the beaches concerned. This ensures a rigorous assessment and adds confidence to the decision making process.

A number of factors affect the behaviour of the beach profile at a particular location and, hence, could be considered when developing an understanding, depending on the nature of the site, that is:

- The wave climate (a more severe climate will result in a deeper active beach profile);

- The nature of the sediments within the beach profile (coarser sediment will not be transported as far and result in a narrower active beach profile, whereas sand can be transported a considerable distance offshore below the low water line); and

- The beach profile itself, i.e. the seabed topography (the presence of a rocky shore platform, a sandbank or near-shore channel may limit the cross-shore distance of the active profile).

Much of the information required to develop this understanding will have been collated with the baseline data collection exercise (e.g. details of the wave climate, sediments and topography, see **Section 2.3**).

The approach outlined above allows guideline depths to be used in conjunction with site specific knowledge. This approach allows flexibility, so that the level of detail used in the assessment can be tailored to the likelihood of the impact occurring at a particular site. The assessment must culminate in a decision as to whether this impact will, or will not be significant for a particular application.

Significance assessment

The preceding section has emphasised the caution that should be adopted in assessing the potential for this impact. Due to the potential implications (i.e. damage to beaches), this cautious approach should also apply in assessing the significance of the impact. Accordingly, if the assessment process demonstrates the proposed extraction lies within the active beach profile, then the impact should be considered to be significant and the application should not proceed.

GOOD PRACTICE RECOMMENDATIONS 4.15 (based on Brampton and Evans, 1998): BEACH DRAW-DOWN
If dredging is to be undertaken in water depths greater than 10m and the understanding developed of the beach profile provides no evidence to suggest that the active beach profile extends beyond this depth, then NO IMPACT with respect to beach draw-down is expected. **If extraction is to be undertaken in water depths of less than 10m or knowledge of the beach profile suggests a possibility of beach draw-down, then it will be necessary to undertake further detailed investigations.** **If further investigations are to be carried out, the methods of Hallermeier (1981) are recommended for deriving the lower beach profile limit. If these investigations demonstrate that the extraction is within the active beach profile then the application should not proceed.**

Given the trend in the aggregate extraction industry to extract from sites in deeper water, it is considered unlikely that applications to dredge landward of the 10m contour will be common place in the future. If this is the case and beach draw-down is shown not to be an issue, then the main concern regarding sediment transport at the coastline will be the potential for interruption to sediment supply.

Aggregate extraction may lead to an interruption in sediment supply to the coast

This is one of the principal concerns of coastal managers and it is important that an assessment is made to ensure that the extraction process does not hinder sediment being transported to the coast.

GOOD PRACTICE RECOMMENDATION 4.16: SEDIMENT TRANSPORT
An assessment of the impacts of aggregate extraction on sediment transport should always be undertaken.

The information collected during the baseline data collection exercise (see **Section 2.3**) is vital in making an assessment of this impact. An appropriate regional scale sediment study, if available (see **Box 2.5**), should be used to provide an understanding of the sediment transport processes operating in and around a proposed extraction site and in the area between the site and the adjacent coast(s) and between the site and sensitive sites, human uses and natural resources.

In addition, other evidence of transport pathways in the area should be incorporated into this understanding, for example, using data collected as part of the evaluation of the aggregate resource. Data regarding sediment transport at/along adjacent coast(s) should also be incorporated, as appropriate, from other previous studies.

If no regional scale sediment study is available, a specific investigation into regional seabed sediment transport pathways may be the only means of providing the knowledge required to undertake this assessment (Brampton and Evans, 1998). Such an investigation would be required to the same degree of detail as the existing regional sediment studies, at least in areas where dredging in shallow water (<20m) was proposed.

Details of the approach that should be taken in undertaking such a study can be found in Section 2 of Brampton and Evans (1998).

GOOD PRACTICE RECOMMENDATION 4.17: UNDERSTANDING TRANSPORT PATHWAYS
The understanding of sediment transport pathways in the study area developed during the baseline data collection and analysis stage should be used as the basis of this assessment.

Once a regional understanding of sediment transport patterns in and around a proposed site has been developed, this should be used to make an assessment of whether the proposed extraction activity will disrupt a sediment pathway. In certain situations, there may be a need to combine this understanding with new site-specific predictive sediment transport modelling in order to make the assessment. This may be the case if, for example:

- Site specific conditions indicate that higher resolution modelling is required;
- Predicted or anticipated changes in tidal currents are considered significant; or
- Expert interpretation of collated available information indicates that further investigation is required.

Regardless of whether new modelling is required or if existing information is sufficient, a judgement must be made as to whether there is likely to be any significant change to sediment transport and supply to an adjacent coastline.

Significance assessment

The implications of a disruption of sediment supply to the coastline are the alteration to the behaviour, development and function of beaches. Therefore, it is vital that the assessment of the significance of any changes due to extraction is cautious, in order to guard against this impact and provide confidence to those with concerns over extraction applications. Due to the implications of this impact, any detectable change to sediment supply between the pre- and post-dredge conditions should be considered significant. Therefore, if any detectable change is noted by the assessment, then the application should not proceed.

GOOD PRACTICE RECOMMENDATIONS 4.18: CHANGE IN SEDIMENT SUPPLY
If the assessment indicates a DETECTABLE change in sediment supply between the pre- and post-dredge conditions, this should be considered to be a significant change and therefore unacceptable. **If the assessment indicates NO DETECTABLE change in sediment supply between the pre- and post-dredge conditions, then this should be considered an insignificant change and therefore acceptable.**

4.2.4 TIDAL CURRENTS

Aggregate extraction may create a change in tidal currents

The lowering of the seabed associated with aggregate extraction will result in alterations to tidal currents. These alterations are generally considered to be of small magnitude, of minor importance and confined to an area local to the extraction site.

However, there may still be circumstances under which caution is required regarding changes in tidal currents, as follows:

- In the unlikely event of extraction being proposed in shallow water, close to a coastline;
- Where other features of interest, such as wrecks or pipelines, lie close to the extraction area; and
- In areas where tidal currents have been a dominant factor in the formation and development of sandbanks or other large scale bedforms close to the extraction area.

Due to the limited extent of changes in tidal currents in deeper water, previous Coastal Impact Studies have not undertaken detailed investigations of this impact, following a consideration of site specific conditions. However, despite the limited extent of changes, it is recommended as good practice that a preliminary assessment of the potential impacts on tidal currents is made for each extraction application. This will allow knowledge of the specific conditions at the site and surrounding area to be taken into account and should result in a decision as to whether further in-depth investigation through modelling is required to investigate this potential impact.

GOOD PRACTICE RECOMMENDATIONS 4.19: TIDAL CURRENTS
A preliminary assessment of the potential impacts of aggregate extraction on tidal currents should be undertaken for each dredging application. If either of the following two criteria are met, further investigations in the form of tidal modelling should be undertaken: **(1) The application is for dredging in water depths of less than 10m below lowest tide; and** **(2) Surface seabed sediments are regularly mobilised by tides and waves.** **The area over which changes in tidal currents can be detected is usually thought to only extend over an area roughly twice the dimensions of the extraction site itself (Brampton and Evans, 1998).**

If this assessment indicates that modelling is required, measures should be taken to ensure that the modelling introduces a margin of safety into the assessment. To achieve this, similar methods can be employed as outlined in the **Box 4.14** for wave modelling studies. The first two items listed in **Box 4.14** are equally applicable to the modelling of tidal currents, namely assuming the 'instant' removal of the sediments within the application area and then assuming additional removal.

The modelling should provide predictions of the effects of dredging on tidal currents to establish any changes that will result. This will involve predicting tidal currents under the same pre- and post-dredge scenarios used for wave modelling. The prediction of tidal currents under the pre-dredge situation can then be compared to post-dredge model predictions. A variety of tidal current models are suitable and available for this purpose. For further details on tidal current models, the reader is referred to Appendix 3 in Brampton and Evans, 1998.

Even if the preliminary assessment indicates that modelling is not required to assess changes to tidal currents as a specific impact, this does not mean that tidal modelling should not be undertaken within the dredging assessment. It is possible that there will be a requirement to study changes to tidal currents due to the influence of such changes on other processes. For example, tidal modelling may be required as an initial stage in the investigation of other impacts. These are:

- *The effects of dredging on sediment transport*: A knowledge of predicted tidal current patterns both pre- and post-dredge can be valuable if detailed assessment of the effects of dredging on sediment transport (both bedload and suspended load) is required;

- *Changes in wave transformation processes:* If there are strong variations in tidal currents between two nearby locations, this can affect the propagation of waves and, hence, wave transformation processes. If this is the case, knowledge of the potential changes to tidal currents caused by the proposed dredging would be required for incorporation into the assessment of waves. However, this is a very complex undertaking and is rarely applied; and

- *Changes in suspended sediment concentrations*: This constitutes one of the main concerns regarding physical impacts associated with aggregate dredging and as such is discussed in the following section. The assessment of the re-suspension, transport and subsequent deposition of sediment associated with the dredging process may require knowledge of tidal currents both pre- and post-dredge.

Significance assessment

Although, changes in tidal currents would be expected to be limited in their extent (usually to twice the area of the dredging site (Brampton and Evans, 1998)), they may be greater when dredging is proposed close to the coastline in shallow water. If such changes do occur, there is potential for the behaviour, development and function of the adjacent coastline/nearshore bedforms to be affected. Any potential impact on the coast from dredging is important, and it is essential that a rigorous assessment process be adopted, as outlined in the preceding section.

The assessment of the significance of any modelled changes in tidal currents must also ensure a cautious approach. In accordance with the assessment of wave conditions, the judgement of significance should be based on detectability.

Numerical models of tidal currents will generate a certain degree of inaccuracy, due, for example, to imperfect representation of bathymetry and rounding over a large number of computations (Brampton and Evans, 1998). If the predicted change in tidal currents is within the levels of model imperfections, then the changes can be considered not detectable, and hence insignificant, in the context of the modelling undertaken. If no detectable change is predicted, and as long as a cautious approach to the modelling has been adopted, then the conclusion can be reached that changes in tidal currents at or near the coastline will not in reality be significant.

GOOD PRACTICE RECOMMENDATIONS 4.20: CHANGE TO TIDAL CURRENTS

If the modelling shows a DETECTABLE (i.e. outside model scatter) change to tidal currents at or near the coastline adjacent to the application between the pre- and post-dredge conditions, then this should be considered to be a significant change and therefore unacceptable.

If the modelling shows NO DETECTABLE (i.e. within model scatter) change to tidal currents at or near the coastline adjacent to the application between the pre- and post-dredge conditions then this should be considered acceptable.

4.2.5 SUSPENDED SEDIMENT

The process of dredging for aggregates results in the introduction of sediment into the water column. This causes the creation of a turbidity or sediment plume comprising a zone of elevated suspended sediment concentrations. Eventually, all of this sediment will be deposited on the seabed.

The creation and behaviour of sediment plumes represents two direct physical changes to the environment and, in turn, these physical changes have the potential to cause two distinct and separate impacts on this environment:

- **Aggregate extraction may lead to an increase in suspended sediment concentrations; and**

- **Aggregate extraction may result in a change in seabed surface sediment composition and accumulation (through deposition of sediment generated by the dredging process and its subsequent transport).**

These two effects and their associated potential impacts are distinct from each other. Further details of these impacts are provided in **Section 3.2**. Different processes are involved in each and, hence, different techniques are appropriate for their assessment. As a result, the two changes should be assessed separately. However, an approach is outlined below whereby an initial assessment is carried out prior to further detailed investigations.

GOOD PRACTICE RECOMMENDATION 4.21: ASSESSMENT OF SUSPENDED SEDIMENT EFFECTS
Once an initial assessment has been carried out, the two potential impacts (plumes and deposition) associated with suspended sediment should be investigated as separate issues.

Assessment framework

Much of the assessment procedure outlined below is drawn from the work of John *et. al.,* (2000). It is recommended that a two-tiered approach be adopted to assess the behaviour of sediment plumes. This staged approach ensures the investigation is focussed and prevents work being undertaken that is not necessary if it becomes apparent early in the process that the environmental impacts will be unacceptable.

1. Desk-based analysis

The first stage of the assessment process should involve an initial scoping exercise. This will provide a baseline understanding of the plume that can be used to determine, firstly, if further modelling investigation is required and, secondly, what the precise nature of further investigations should be. This initial assessment should be a desk-based analysis to appraise plume dispersal. Details on what this analysis should consider are provided in John *et. al.,* (2000).

2. Detailed studies

The following section of the guide provides information on the detailed studies that should be undertaken to assess the potential impacts of the sediment plume and the subsequent deposition of sediment onto the seabed.

Aggregate extraction may lead to an increase in suspended sediment concentrations

Prediction of the behaviour of the sediment plume may be required in order to provide a more detailed analysis of the increases in suspended sediment within the water column. To achieve this requires the application of numerical models. A number of models concerned with the formation and development of plumes are available and use of these models can provide a more accurate numerical estimate of the increase in suspended sediment concentrations than is possible using the initial desk study approach.

Passive plume models (see **Appendix C (iii) and (iv)** for definitions of dynamic and passive plumes) are probably the most established of the models that relate to plumes. They generally rely on representation of local hydrodynamic conditions using a flow model. The choices made for the flow modelling, such as finite element or finite difference and a regular or variable grid, are generally not important, though the ability and diligence of the user can significantly affect the quality of the flow model input. Details of passive plume models are provided in **Appendix D (i).**

In terms of the plume model itself, in order to provide relevant data, the model must be site specific. The initial desk assessment will provide important information regarding the nature of the plume and conditions in the surrounding environment that will feed into both the model selection process and the modelling process itself.

One of the main factors affecting the quality of the predictions produced by plume models is the accuracy with which the initial conditions are specified. In particular, the source term in the model that represents the release of fine sediment into the water column as a direct result of the dredging activity is crucial. The greater the degree of accuracy in specifying this as an input into a model, the greater the reliability of the model results and the confidence that can be placed on these results.

GOOD PRACTICE RECOMMENDATION 4.22: PASSIVE PLUME MODELLING

If passive plume modelling is required as part of the impact assessment, then this should be undertaken by established professionals with experience and expertise in this subject area.

The selected numerical model should be applied to provide predictions of the spatial and temporal behaviour of the plume. In assessing the model results, consideration should be given to:

- The area affected by the plume over different time periods;
- The duration that the plume exists for; and
- The nature of near bed concentrations (e.g. duration and magnitude).

Consideration of the above should input into the assessment of the impact of the increased suspended sediment concentrations on the environment. This assessment of impact should be based on the above predictions of the plume, coupled with a consideration of the nature, and therefore sensitivity, of the environment. This consideration of the environment will allow thresholds of acceptable change to be established, against which the predicted changes can be compared to draw conclusions.

GOOD PRACTICE RECOMMENDATION 4.23: ASSESSMENT OF INCREASED SUSPENDED SEDIMENT

The outputs of plume modelling studies should be used as the basis for assessing the impact of increased suspended sediment concentrations on the marine environment.

Aggregate extraction may result in a change in seabed surface sediment composition and accumulation (through deposition of sediment generated by the dredging process and its subsequent transport)

With aggregate extraction operations moving further offshore into deep (>30m) water, the focus of physical impact assessments is changing from assessing the effects on the coastline to looking at the effects on the seabed due to deposition of sediment generated by the dredging process. As a result of this shift in focus, this section of the guide provides details on how 'conceptual models' can be used to predict the footprint or 'zone of influence' related to the deposition of sediment. The nature of this effect on various ecological parameters (marine ecology, fish and shellfish resources) is discussed in **Sections 4.3** and **4.4**.

4.2.6 A FRAMEWORK FOR DEVELOPING A CONCEPTUAL MODEL FOR DERIVATION OF THE 'ZONE OF INFLUENCE' ARISING FROM THE DEPOSITION OF SEDIMENT

The development of a robust conceptual model of the zone of influence is crucial as it provides the basis for the subsequent assessment of deposition impacts on other parameters, i.e. such models enable the 'nature of the effect' to be defined (see **Section 4.1**).

The main aim of conceptual models related to the effects of sediment deposition is to provide a description of the zone of influence that is both qualitative (i.e. defines the main features) and quantitative (i.e. the limits of the zone of influence are estimated). Both of these facets are important for a robust impact assessment of the effects of extraction. The elements of the framework for developing such a conceptual model are discussed in detail below and summarised in a flow diagram in **Figure 4.2** and **Table 4.2**.

A conceptual model was produced as part of ECR REA (Posford Haskoning, 2003). This model was developed through discussions between dredging contractors and scientists at the forefront of research in this area. The model is not based on the results of process modelling but on their current knowledge of seabed processes and empirical evidence from detailed field studies of other offshore areas around the UK coast. Therefore, a degree of caution should be exercised in applying the model in its current state. In terms of the conditions in which the model applies (i.e. does the diagram show the situation after a single visit by the dredger, at some time during the lifetime of the licence or after the cessation of dredging). This will be dependent on the rates of deposition and dispersion and will be site specific. It is, therefore, important to understand the potential application of the model prior to its use.

It is important to note that the ECR conceptual model will inevitably develop as monitoring of licence applications in the ECR (if successful) or other licence applications and numerical modelling (see below) produces data to refine and improve the initial assumptions. This on-going validation of the model is essential. The main features of the ECR REA conceptual model are summarised in **Appendix D (ii)**.

GOOD PRACTICE RECOMMENDATION 4.24: USE OF MONITORING RESULTS
Licence applicants, or consultants working on the applicant's behalf, should make themselves aware of the published results of monitoring from the ECR, and/or other sites, before undertaking future predictive assessments.

The ECR REA conceptual model, as a general and qualitative model, can be extended to most proposed extraction areas. However, this model was developed for a location with deep water (~40m, i.e. where there is little or no contribution to sediment movement from waves) and rectilinear tides with peak current speeds of the order of 1m/s. Moreover, the model was developed as a response to envisaged screening of up to 33% of the dredger load. In this situation, as explained in the REA (Posford Haskoning , 2003), it was possible to quantify the main features of the zone of influence and this quantification has formed the basis of the impact assessment undertaken.

In order to demonstrate what this model may look like in an area similar to the ECR but with rotational tides, HR Wallingford were commissioned to produce an alternative version of this 'model'. Both the original conceptual model presented in the REA and the revised conceptual model for an area with rotational tides, are shown in **Appendix D (iii) and (iv)**.

Use of the REA conceptual model in future EIA studies

In order to demonstrate how the present (REA) conceptual model may be usefully applied to aid future EIA studies, good practice in relation to three varying situations are outlined for aggregate licence EIA studies (**Box 4.14**).

Box 4.14 Various scenarios and use of the REA conceptual model
Scenario 1*: Licence application is in an environment similar to the ECR but with reduced dispersion of screened deposit*   In this situation, it will be possible to use the REA model to define the 'zone of influence'. However, it is important to note that the outputs of this model will define the upper limit of this zone. Hence, the prediction of impact will be an over-estimate and slightly precautionary in nature.
Scenario 2: *Licence application is in an environment where there will be very limited dispersion of the screened deposit*   In environments where sediment transport is very limited, the simplifying aspects of such systems enable the short and long-term behaviour of the screened deposit to be characterised without recourse to detailed process studies. Therefore, the *type* of reasoning used in the REA model could usefully be applied to develop a new model of the zone of influence. The application of standard sand transport formulae to produce estimates for the time-scale of dispersion could be very useful in this respect.
Scenario 3: *Licence application is in an environment very different to the ECR or where dispersion is expected to be greater than in the ECR*   Where the dispersal of material is potentially more rapid or the environment very different from that existing in the ECR, it is likely that confidence in the overall environmental impact assessment (i.e. the identification of the zone of influence) will only be achieved through the development of a new zone of influence model for the environment concerned. This may require the application of specialist numerical models.   The zone of influence of screening will be a function of the balance between the rate of sediment production against the rate of sediment transport away from the dredge site. The rate of dispersion is, therefore, crucial to the impact assessment. Specialist dispersion models may be the only method of determining the nature of this balance.

Box 4.14 Various scenarios and use of the REA conceptual model

Such numerical modelling of the evaluation of the zone of influence will require:
 	
(a) An assessment of the initial footprint resulting from the initial descent of sand particles through the water column (the near field); and
(b) An assessment of the longer-term dispersion of sand particles under the action of currents and waves (the far field).
 	
For (a), the discharge of screened material into the water column results in a particulate dynamic plume. The speed of descent of the dynamic plume is usually significantly faster than the settling velocities of all but the coarsest (i.e. gravel) particles and the distribution of the initial footprint will depend on the initial dilution of the plume during descent and the nature of the collapse of the dynamic plume after impact on the bed. Thus, these complex processes essentially require the application of a dynamic plume model.
 	
For (b), the longer-term dispersion from the initial screening footprint can be modelled using a particle-tracking model, which has been specifically designed for the dispersion of mixed sand[3]. Such models have been developed in the scientific/consultant community.

Source: HR Wallingford, 2003

The application of specialist models in combination with a general conceptual model, such as that developed for the ECR, can significantly improve confidence in the description of the zone of influence and, thereby, provide a much better framework for assessing the implications for biological resources. However, although such models will give a good assessment of where impacts may be significant or insignificant, there may be grey areas where there are potentially ‘slight’ adverse impacts.

Sediment transport models are not yet reliable assessors of the detail of near bed processes where mixed sediments are concerned. This area of research is a focus of attention at the moment and will require dedicated field and laboratory measurement programmes. Moreover the limits at which the infiltration of fine sediment into coarser bed becomes adverse for different sensitive habitats is usually not clearly defined. In these *borderline* situations it may not be clear what all of the likely impacts of a proposed dredging licence is.

GOOD PRACTICE RECOMMENDATIONS 4.25 (based on Box 4.14): DEFINING THE ‘ZONE OF INFLUENCE’
Under Scenario 1, the licence application is in a similar environment to the ECR but with reduced dispersion, the existing REA conceptual model can be used to define the ‘zone of influence’. **Under Scenario 2, licence application is in an environment where there will be limited dispersion, the type of reasoning used in the REA model can be used to develop new, site-specific conceptual models.** **Under Scenario 3, licence application is in an environment very different to the ECR as where dispersion is expected to be greater than in the ECR, new zone of influence models will be required which may also require the application of specialist numerical models, e.g. dynamic plume models, particle-tracking models.**

Table 4.2 Details required when developing a new conceptual model for the zone of influence

[3] **NB** the application of a standard finite difference/element coastal/estuary sand transport model will result in significant numerical diffusion owing to the inability to resolve the dispersing sand adequately. The application of a particle tracking model, such as those used for examining the dispersion of fine sediment from a passive plume, will result in an over-estimate of the rate of dispersion because such models are designed for silt/clay particles, that travel at the speed of the ambient currents, as opposed to sand particles, which travel significantly more slowly than silt/clay particles.

Information Required	Source of Information
What is the rate of input of screened material onto the bed and for how long will this input occur?	- Operational dredging information from Applicant
What will be the initial distribution of this material (a) for a single dredging cycle and (b) over time as more and more dredging cycles are completed?	- Data on size of screened material from Applicant and baseline surveys - Simple analysis of theoretical settling rates and tidal transport distances for selected sediment grain sizes - Outputs from plume modelling.
How much of this material will be mobile and how will this mobility change with different tidal, wave and seasonal conditions?	- Simple analysis of theoretical settling rates and tidal transport distances for selected sediment grain sizes
What is the nature of the local seabed material and how much of this material is mobile?	- Data from baseline studies
Will the different sized particles in the screened deposit interact in a significant manner (armouring) or interact with the different sized particles of the surrounding seabed?	- Expert judgement from qualified geologists
What will be the rate of dispersion from the site?	- Simple analysis of theoretical settling rates and tidal transport distances for selected sediment grain sizes - Outputs from particle-tracking models
What will be the nature of any resulting bedforms?	- Outputs from plume modelling - Expert judgement from qualified geologists/geomorphologists
As material disperses from the site, what will be the thickness of screened material covering the surrounding seabed and how will this change over time?	- Simple analysis of theoretical settling rates and tidal transport distances for selected sediment grain sizes - Outputs from particle-tracking models
As the material disperses, where will its final destination be?	- Outputs from the findings of regional sediment transport pathways - Outputs from particle-tracking models - Data from field studies

Taking all of the above recommendations into account, it is possible to devise a framework that enables the user to determine what approach should be taken, based on the three scenarios outlined in **Box 4.14**. This framework is detailed below in **Figure 4.2**.

GOOD PRACTICE RECOMMENDATIONS 4.26 (based on Figure 4.2):
The process of progressing through the framework for developing a conceptual model concerned with the zone of influence should be undertaken on the basis of consultation with the regulator. Many of the issues involved are not black and white and agreeing an approach before undertaking the EIA studies in detail will improve the chances of a successful licence application. **Any assessment should also consider the potential for cumulative and in-combination effects to arise on physical process from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.**

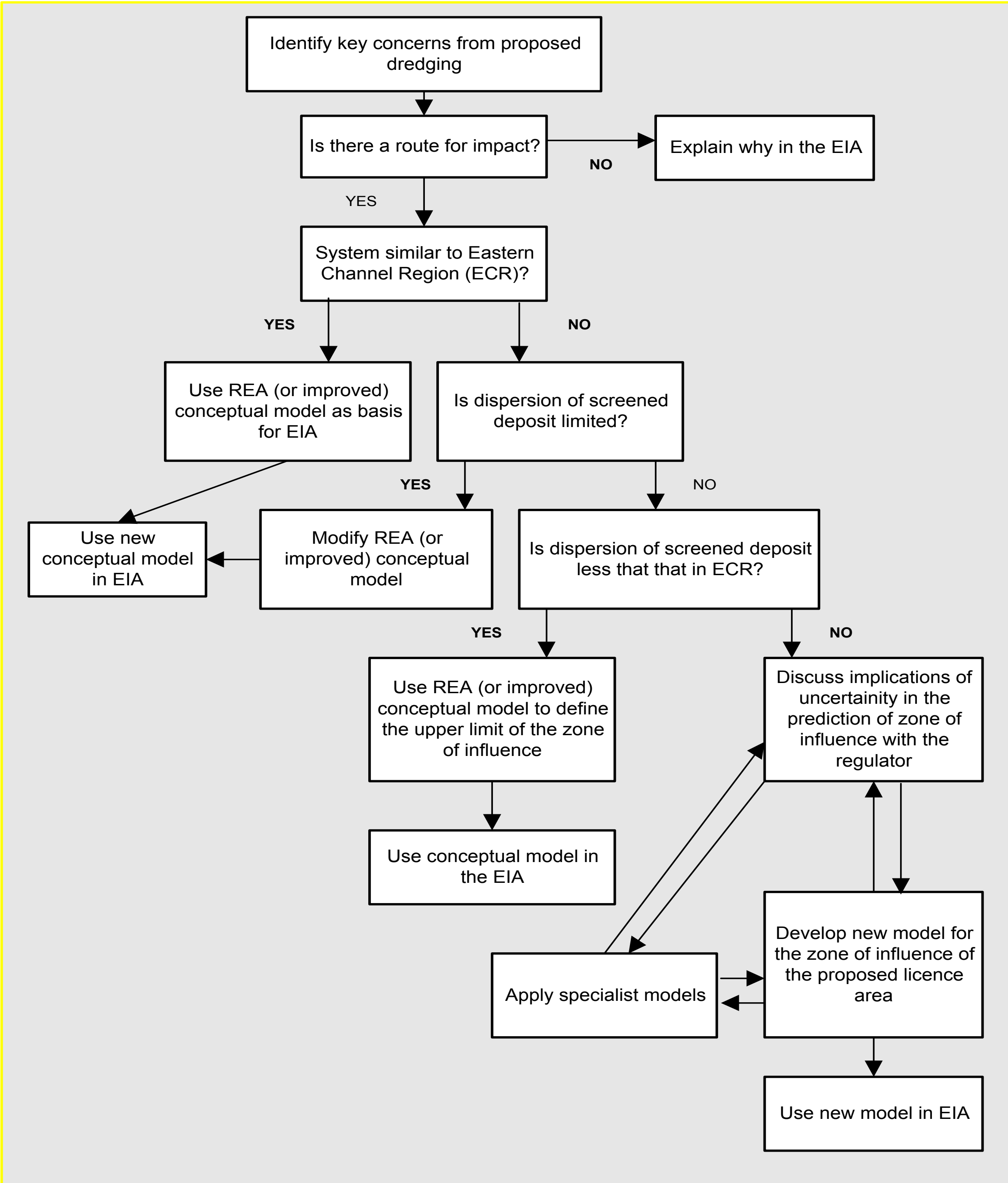


Figure 4.2 A framework for developing a model for the derivation of the 'zone of influence' arising from aggregate extraction activities (including screening)
(Source: HR Wallingford, 2003)

REFERENCES

Brampton, A.H. and Evans, C.D.R. (1998). Regional Seabed sediment studies and assessment of marine aggregate dredging. CIRIA Report C505.

Hallermeier, R.J. (1981). A profile zonation of seasonal sand beaches from wave climate. Coastal Engineering, 4, pp 253 – 277.

Hydraulics Research (HR) Wallingford (2003). Technical Support to Posford Haskoning Ltd for MIRO Best Practice Guide. HR Wallingford.

Inman, D.L. and Rusnak, G.S. (1956). Changes in sand levels on the beach and shelf at La Jolla, California. US Army Corps of Engineers, Beach Erosion Board, Technical Memorandum No. 82.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). Scoping the assessment of sediment plumes form dredging. CIRIA Report C547.

Simmons, R. and Hollingham, S. (2001). Marine Aggregate Dredging: A review of current procedures for assessing coastal processes and impact at the coastline. Technical Report HYD10401. UCL. London.

Halcrow (1991). The Anglian sea defence management study, Phase II, NRA Anglian Region, Study Report (unpublished report). Sir William Halcrow and Partners. 1991.

Posford Haskoning (2003). Regional Environmental Assessment Report on behalf of East Channel Association. January 2003.

SECTION 4.3 MARINE ECOLOGY

4.3.1 INTRODUCTION

In order to identify and assess impacts on the benthic environment, it is necessary to consider the following information:

- The spatial extent, magnitude, duration and frequency of the impact;
- The effect on specific species, communities and habitats;
- The effect on specific ecological processes; and
- The reversibility of the effects.

The extent, magnitude, duration and frequency of the impact

The spatial extent of an impact is referred to as the ‘impact footprint’, or the zone of influence. With respect to aggregate dredging, the zone of influence comprises the area to be dredged directly and the area that could be affected indirectly by the sediment plume (through sediment deposition and settlement) and changes in hydrodynamic processes, bedload transport, etc. This zone can be defined through the use of conceptual models and numerical models (see **Section 4.2**). The zone of influence and information on the dredging regime will be available from the physical processes impact assessment and the industry, respectively. This information can then be utilised to determine the area that is likely to be vulnerable to different effects. Using this information, the effects on various parameters can be assessed. The intensity, duration and frequency of the activity can be determined through knowledge of the type of dredger, the depth of dredging, rate of dredging activity and the periods of activity.

The effect on specific species, communities and habitats

Once the extent, intensity, duration and frequency are established, the areas vulnerable to any effects can be investigated in terms of the species, communities and habitats present. This should be applied at a number of levels to ensure that the assessment includes effects on species and communities. It will be necessary to determine the spatial distribution of communities and species (e.g. patchy distribution or gradual changes from one type to another). The scale of investigation will be determined by the extent of the predicted impact and the variability within the system under investigation.

Seasonal changes in the distribution of habitats and species are important considerations, particularly in respect of the significance of the impact and the necessary mitigation measures. Consideration should be given to the sensitivity of each parameter to each particular effect and its level of importance (discussed in **Section 4.1**). A process of risk assessment should be used in order to categorise the risk and to standardise the approach taken to impact assessment. The risk assessment process developed by CEFAS for fish and fisheries should be referred to for information and, although such an exercise has not yet been undertaken for benthos, the principles applied should be considered during the EIA process.

The effect on specific ecological processes

Certain parameters or particular species are considered to be important in structuring or maintaining ecological units (population, habitat, community, ecosystem and marine landscape) and/or in structuring or maintaining processes between units. Key species include those such as the ross worm (*Sabellaria spinulosa),* beds of the mussel (*Modiolus spp)* and other organisms that can increase habitat complexity and thus allow a higher diversity of species than would otherwise occur. Key habitats that could be affected by aggregate extraction include overwintering grounds for crabs and demersal spawning grounds for fish such as the herring (*Clupea harengus*).

The reversibility of the effects

Some of the effects caused by aggregate extraction are irreversible, such as the direct loss of habitat and individuals from the extraction area. Although the loss of the individuals is irreversible there still will be scope for a degree of recoverability of species based on the extent of extraction in relation to the distribution of the overall habitat/community. The degree of recoverability will be dependent on the dredging regime, the nature of the sediment, the rate of restoration of the physical nature of the substratum and the nature of the community impacted. In areas where high sediment mobility is associated with rapid restoration of sediment composition in sites where dredging has ceased, then recovery of species diversity and community composition is reported to be rapid. However, in other sites, dredge tracks and pits may take several (or many) years to infill and the sediment composition of the infilled areas may differ from the original substratum type. In these cases restoration of biological community composition is likely to take many years or, perhaps lead to a permanent alteration of community composition in the area of seabed at which dredging has taken place.

4.3.2 IMPACT ASSESSMENT FOR BENTHOS/EPIBENTHOS

The following section provides a summary of the main information that is required in order to assess the potential impacts identified in **Section 3.3**. For certain impacts, hypothetical examples of how differing levels of significance can be derived using the framework described in **Section 4.1** are provided (in **Appendix D**).

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Direct removal of the seabed will lead to a reduction in habitat and species diversity, abundance and biomass**
Impact assessment	***Nature of Effect*** The effect is direct removal of the seabed and associated species/habitats. The Dredging Plan should provide the following information: • The exact area over which seabed removal will take place (spatial extent); • How often this will take place(frequency of dredging); and • The depth of dredging and size of dredge tracks (magnitude). Based on existing knowledge of the physical processes within the study area, an estimate should also be made as to how long any dredge tracks will persist (duration of effect).
	Nature of Receptor In this case, the receptor is the type of habitat and the species within the dredged area. The exact nature of and area covered by the receptor will be described through baseline studies. *Sensitivity*: Assume to be HIGH as all of the habitat/species within the dredged area will be removed. *Recoverability:* Needs to take account of the dredging regime (nature of the impact), the physical environment and the distribution and characteristics of the habitat(s) and species. *Importance*: The importance of the habitat/species removed will only be able to be determined if baseline data has been collected on the distribution of similar habitats/species in the wider area. If the habitat that will be removed is widespread throughout the study area, then it will be less important than if it is the only example of this habitat in the wider study area.

Stage of Impact Assessment	Description
Impact assessment (cont.)	The importance of a certain receptor can be measured in many different ways. In this example, importance is judged in terms of the amount of habitat type to be removed by dredging, as a proportion of the overall resource within the wider study area. An example of this process, undertaken for the eastern English Channel REA is shown below (**Box 4.15**). Any reduction in benthic/epibenthic biomass has the greatest implications for wider ecosystem function, as these resources represent a key source of food for many other species, in particular fish. Therefore, in order to determine the importance of benthic species, in terms of biomass (and productivity), the following information should be obtained: • Average wet biomass of benthic resources in the study area (data from baseline studies); • Equivalent value expressed as kg/km^2; and • Estimated annual benthic production expressed as kg/km^2/year (this can be calculated using an appropriate Production/Biomass (P/B) ratio; a P/B ratio of 1.4 has been used in previous studies in UK coastal waters). Once the annual benthic production has been calculated (kg/km^2/year), it should be possible to express the removal of substrate and associated benthic/epibenthic communities in terms of the overall reduction in biomass (and annual benthic production) within the study area. This loss of biomass, can then be placed into context with the wider study area in order to determine the importance of its removal. The key assumption with this form of impact assessment is that removal of the substrate results in complete removal of all benthic species, i.e. 100% reduction in biomass. In reality, the immediate reduction in biomass may range from 83% (Desprez, 2000) to 99% (Kenny and Rees, 1996) and, within weeks, biomass may have increased above immediate post-dredge levels, following cessation of dredging. This method of impact prediction enables a very broad scale assessment of the effect on substrate type and broad associations of species/communities. However, it is aimed at putting the removal of habitat into context and is based on a very generalised picture of habitat type derived through the use of BGS data. The inadequacies of this broad scale data are that they could miss important localised changes in habitat and associated species.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Two examples of how slight changes in the nature of the receptor can produce impacts of varying significance are provided in **Appendix D (v) and (vi)**. Once the significance of the initial impact is determined the mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.

Box 4.15 Substrate/habitat types within the ECR and extent of potential impact

Substrate/ Habitat Type	Amount (Area, km^2) within East Channel Region (ECR)	Amount (Area, km^2) within area potentially impacted by dredging	Proportion of substrate/habitat type potentially impacted (%)
Muddy Sandy Gravel	202	12	6%
Sandy Gravel	589	29	5%
Gravelly Sand	401	9	2%

Based on this example, it is apparent that the habitats that will be removed by the dredging are typical of the wider region (ECR) and, as such, can be classed as being of LOW importance.

<table>
<tr><th>Stage of Impact Assessment</th><th>Description</th></tr>
<tr><td>Description of impact</td><td>Dredging may cause an increase in suspended sediment concentrations (SSC) that could affect certain species</td></tr>
<tr><td rowspan="2">Impact assessment</td><td>Nature of Effect
The effect is increased SSCs generated by the sediment plume. The following information related to the plume should be obtained. These data should be provided through baseline studies and the outputs of numerical models:

• Spatial extent of the plume;
• Predicted increase in SSC (above background levels);
• Peak concentration predicted;
• Temporal characteristics of any increase in SSC within the study area, i.e. how long do elevated levels persist for;
• Differences between near-bed, depth-averaged and surface SSC; and
• Background levels of SSC within the study area (expressed as a range). This is one of the key issues with respect to predicting impacts of increased SSC on benthic and epibenthic communities. Without information on background SSC, it is not possible to put any increases in SSC predicted by numerical models into context. For example, a predicted increase in SSC of 5mg/l is unlikely to be significant if the background SSC is in the range 50-300mg/l. However, the same increase (of 5mg/l) will be much more significant if the background SSC is in the range 1-10mg/l.</td></tr>
<tr><td>Nature of Receptor
In this case, the receptors are benthic and epibenthic species. The exact nature of the receptors will be described through baseline studies.

Sensitivity: In order to determine the sensitivity of the various receptors to sediment plumes, the following information is required:

• Characteristics of the plume (see Nature of Effect); and
• Threshold levels of these receptors with respect to SSC (from literature reviews and/or www.marlin.ac.uk).

Recoverability: In order to determine the recoverability of any receptors to plume effects, the following information is required:

• Temporal characteristics of the plume (see Nature of Effect);
• Threshold levels of these receptors with respect to SSC; and
• Distribution and characteristics of the species affected.

Importance: To define importance the following should be assessed:
(a) the area potentially affected by the plume should be defined as a proportion of similar species/habitats within the wider study area, i.e. is it unique?;
(b) the conservation status of the species/habitat should be determined; and
(c) the role of the species/habitat in ecosystem function.</td></tr>
<tr><td>Derivation of significance</td><td>Should be assessed using the framework set out in Figure 4.1. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.</td></tr>
</table>

Stage of Impact Assessment	Description
Description of impact	**Initial deposition of sediment may cause the smothering of certain benthic or epibenthic species**
Impact assessment	***Nature of Effect*** The effect is the deposition of sediment onto the seabed. The following information related to deposition should be obtained. These data should be provided through baseline studies and the outputs of numerical models: • Spatial extent of deposition; • Predicted frequency and rate of deposition due to dredging; • Depth of deposition; • Type of sediment that will be deposited; and • Background levels of deposition within the study area (expressed as a range). As with SSC, a basic level of knowledge on the background level of deposition within the study area is important. In areas where deposition of sediment already occurs at high levels, further deposition of sediment is likely to cause less of an impact than in areas that are not subject to high levels of existing deposition.
	Nature of Receptor In this case, the receptors are benthic and epibenthic species. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: In order to determine the sensitivity of the various receptors to deposition, the following information is required: • Characteristics of deposition (see *Nature of Effect*) and • Threshold levels of these receptors with respect to deposition (from literature reviews and/or ***www.marlin.ac.uk***). *Recoverability:* In order to determine the recoverability of any receptors to deposition, the following information is required: • Temporal characteristics of deposition (see *Nature of Effect*); • Threshold levels of these receptors with respect to deposition; and • Distribution and characteristics of the species affected. *Importance*: To define importance the following should be assessed: (a) the area potentially affected by deposition should be defined as a proportion of similar species/habitats within the wider study area, i.e. is it unique? (b) the conservation status of the species/habitat should be determined; and (c) the role of the species/habitat in ecosystem function.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	***Bedload transport of deposited sediments may create adverse effects on benthos***
Impact assessment	***Nature of Effect*** The effect is the re-mobilisation and transport of deposited sediment along the seabed following initial deposition and the subsequent effects on the benthos. The following should be considered: • The spatial extent, duration, frequency and magnitude of the effect will need to be determined though use of numerical models and/or theoretical knowledge of the processes operating at the site in question; • Existing conceptual models developed for the ECR, (see **Appendix D(ii), (iii) and (iv)**)should be reviewed and used as the basis for more detailed assessment; and • A site-specific model may be required which, in turn, may require validation through field data.
	Nature of Receptor As for initial deposition, the receptors are benthic species. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: In order to determine the sensitivity of the various receptors to deposition, the following information is required: • Characteristics of deposition; and • Threshold levels of these receptors with respect to deposition (from literature reviews and/or ***www.marlin.ac.uk***). *Recoverability:* In order to determine the recoverability of any receptors to deposition, the following information is required: • Temporal and spatial characteristics of the bedload transport; • Threshold levels of these receptors with respect to bedload transport; and • Distribution and characteristics of the species affected. *Importance*: To define importance the following should be assessed: (a) the area potentially affected by deposition should be defined as a proportion of similar species/habitats within the wider study area, i.e. is it unique? (b) the conservation status of the species/habitat should be determined; and (c) the role of the species/habitat in ecosystem function.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Changes resulting from modification of seabed topography, substratum type and mobility may result in a change in species/community type**
Impact assessment	***Nature of Effect*** The effect is a combination of direct seabed removal, sediment deposition and changes to the physical environment. Information related to these impacts can be obtained from the Dredging Plan and numerical models, as described for earlier impacts.
	Nature of Receptor In this case, the receptors are specific community types. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: In order to determine the sensitivity of the various receptors to this impact, the following information is required: • Characteristics of the impact; and • The response of these communities to the predicted change. This prediction should be based on a combination of expert judgement, information from previous studies in similar environments and definition of the *Nature of Effect*. *Recoverability:* In order to determine the recoverability of any receptors to this effect, the following information is required: • Temporal characteristics of the effect, i.e how long will any changes last for?; and • The response of these communities to the predicted change (from literature reviews and/or ***www.marlin.ac.uk***). *Importance*: To define importance the following should be assessed: (a) the area potentially affected by deposition should be defined as a proportion of similar communities within the wider study area, i.e. is it unique? (b) the conservation status of the community should be determined; (c) the role of the community in ecosystem function.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Although unlikely, dredging activity might release toxic chemical substances from contaminated sediments which can affect certain species**
Impact assessment	***Nature of Effect*** The sediments may provide a source of various chemical contaminants. The impact pathway comprises dredging induced sediment disturbance and mobilisation, which changes the physical, chemical and biological conditions of the seabed and overlying water column, and indirectly changes the habitats of receptors. Information related to these impacts can be obtained from the Dredging Plan and numerical models, as described for earlier impacts. **It is worth reiterating that this type of impact is unlikely to occur in aggregate dredging projects**. Therefore, a simplified approach to impact assessment is suggested here. It is based on a tiered assessment approach, and is similar to that established under the OSPAR Guidelines for the Management of Dredged Material (OSPARCOM, 1998), which consider dredged material for disposal at sea. Initially, it uses a desk study and physical sediment data to identify whether the sediment has impact potential. If this procedure shows that the sediment may contain significant concentrations of chemicals, then the assessment progresses to chemical and possibly biological sediment data which can be compared to criteria indicative of significant impacts to the biological receptors.
	Nature of Receptor In this case, the receptors are specific community types. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: In order to determine the sensitivity of the various receptors to this effect, the following information is required: • Characteristics of the effect; and • The response of these communities to the predicted change. This prediction should be based on a combination of expert judgement, information from previous studies in similar environments and definition of the *Nature of Effect*. *Recoverability:* In order to determine the recoverability of any receptors to this effect, the following information is required: • Temporal characteristics of the effect, i.e how long will any changes last for?; and • The response of these communities to the predicted change (from literature reviews and/or ***www.marlin.ac.uk***). *Importance*: To define importance the following should be assessed (a) the area potentially affected by deposition should be defined as a proportion of similar communities within the wider study area, i.e. is it unique?; (b) the conservation status of the community should be determined; (c) the role of the community in ecosystem function.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment of the significance undertaken to determine the significance of the residual impact.

One approach to predicting and assessing the potential chemical effects of aggregate dredging on benthic/epibenthic resources is provided in **Appendix D (vii).** Although this is an unlikely impact, due to the nature of contaminant pathways and the general requirement for coarse sediment for extraction, it does require consideration. Such effects could arise, for example, where an extraction site occurs close to a disposal site or close to an area that has been dredged and used as a navigation channel.

The potential approach set out is, therefore, included for completeness and to ensure that where such effects could occur, good practice recommendations are available.

GOOD PRACTICE RECOMMENDATIONS 4.27: PREDICTION OF IMPACTS OF THE PLUME
The output of numerical and/or conceptual models should be used as the basis for predicting the impact of the sediment plume and deposition on benthic/epibenthic communities. It is vital that these models consider key operational details of dredging activity, such as the amount of material to be screened and the nature of this material, the amount of over-flowing required and the rate of extraction. **These outputs should be analysed in detail to further define the relevant proportion of the dredging footprint (i.e. the zone of influence) in which adverse effects on the receptor in question are likely to arise (that is, species will be affected by the different impacts within the zone of influence as a whole in different ways, where some effects may be important (i.e. dredging) while others may not (i.e. shallow smothering). The assumption that the entire footprint will create adverse effects is too precautionary and needs to be considered on a case-by-case basis.**

GOOD PRACTICE RECOMMENDATIONS 4.28: DEFINITION OF BACKGROUND LEVELS AND UNCERTAINTY
It is also important that an effort is made to describe background levels of SSC and sediment deposition within the study area, so that plume and deposition effects created by dredging activity can be placed into context. **Even though models should be used as the basis for impact prediction, the potential for error in the model outputs should be recognised and reported within the ES.** **Any assumptions and uncertainties in the assessment of a parameter should be detailed within the ES.**

4.3.3 IMPACT ASSESSMENT FOR MARINE MAMMALS AND ELASMOBRANCHS

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Aggregate extraction may result in physical collisions between dredgers marine mammals and/or elasmobranchs**
Impact assessment	***Nature of Effect*** The effect is physical collision between the dredger and any marine mammals and/or elasmobranchs.
	Nature of Receptor The receptors are marine mammals and elasmobranches. The exact nature of these receptors will be described through baseline studies. As an important step prior to assessing sensitivity, recoverability and importance, the likelihood of this impact arising (effect/receptor interaction) (i.e. *vulnerability*) should be assessed. In practice, the potential for such collisions is highly unlikely due to the fact that the individual species in question will generally move from an area in which a dredger is working, due to noise effects.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Noise impacts from aggregate extraction may create adverse effects on marine mammals and elasmobranchs**
Impact assessment	***Nature of Effect*** The effect is noise emissions from the dredger. Information on noise levels produced by dredgers should be able to be obtained from the Applicant and/or research literature. The duration and frequency of dredging should be determined from the Dredging Plan and this will provide some guide as to how long potential noise impacts may occur for.
	Nature of Receptor The receptors are marine mammals and elasmobranches. The exact nature of these receptors will be described through baseline studies. *Sensitivity*: Should be determined through a review of existing literature on the effects of noise on marine mammals and elasmobranchs. *Recoverability:* In practice, many marine mammals and elasmobranches will exhibit avoidance reaction if noise emissions reach levels that species find adverse. This is facilitated by the fact that most aggregate extraction occurs in open water, which enables these species to move away easily. *Importance*: The importance of these receptors is HIGH, as many of them are afforded protection under conservation legislation.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Relevant literature for noise effects on marine mammals and elasmobranchs

CEFAS (2003). Preliminary investigation of the effects of sound generated by aggregate dredging and marine construction. Research PROJECT AE0194. FINAL PROJECT REPORT CSG 15.

Evans, P.G.H., Carson, Q., Fisher, P., Jordan, W., Limer, R. and Rees, I. (1994). A study of the reactions of harbour porpoises to various boats in the coastal waters of south-east Shetland. In: European Research on Cetaceans, 8, ed., P.G.H. Evans, 60-64. Cambridge, European Cetacean Society.

Gordon J. and Moscrop A. (1996). Underwater noise pollution and its significance for whales and dolphins. In: M.P. Simmonds and J.D. Hutchinson (eds.). The Conservation of Whales and Dolphins 281- 319. New York: Wiley and Sons.

Hawkins, A.D. (1986). Underwater sound and fish behaviour. In: Pitcher, T.J (ed.). The Behaviour of Teleost Fish. Groom Helm Ltd, Kent 114-149

Simmonds M., Dolman S. and Weilgart L. (2003). Oceans of Noise. A WDCS Report. Whale and Dolphin Conservation Society. http://www.wdcs.org.

Stage of Impact Assessment	Description
Description of impact	**The removal of benthos may result in a reduction in potential food items for marine mammals and/or elasmobranchs**
Impact assessment	***Nature of Effect*** The effect is the removal of benthic and epibenthic species from the seabed, or fish from the pelagic/demersal zone, which may provide a food source for marine mammals and/or elasmobranchs.
	Nature of Receptor The receptors are marine mammals and elasmobranches. The exact nature of these receptors will be described through baseline studies. *Sensitivity*: Will need to be determined through a review of the typical feeding ecology of these species and how this relates to the species that may be lost as a result of the aggregate extraction. In practice, this is likely to be LOW as the amount of any potential prey resources lost will likely be a small proportion of the overall prey resource available in the wider area. *Recoverability:* This is likely to be HIGH, as these species are likely to be able to easily seek and obtain alternative food resources. *Importance*: Not applicable
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Increased turbidity caused by sediment plumes may create adverse effects on marine mammals and elasmobranchs**
Impact assessment	Details on the method of impact assessment for sediment plumes and benthic/epibenthic resources are provided in **Section 4.3.2**. The same approach should be adopted for potential plume effects on marine mammals and elasmobranchs. Therefore, the reader is referred to this earlier section.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may result in a loss of habitat for nursery/pupping elasmobranchs**
Impact assessment	***Nature of Effect*** The effect is the removal of potential nursery/pupping habitat by aggregate extraction. The Dredging Plan should provide the following information: • The exact area over which seabed removal will take place (spatial extent); • How often this will take place(frequency of dredging); and • The depth of dredging and size of dredge tracks (magnitude).
	Nature of Receptor The receptor is potential nursery/pupping habitat. The exact nature of this receptor will be described through baseline studies. *Sensitivity*: This is likely to be HIGH due to the direct removal of potential nursery/pupping habitat. *Recoverability:* In order to determine the recoverability of this receptor to this effect, information is required on the temporal characteristics of the effect, i.e. how long will the habitat remain unsuitable as nursery/pupping habitat? *Importance*: To define importance the following should be assessed: (a) the area potentially affected by deposition should be defined as a proportion of similar habitat within the wider study area, i.e. is it unique?; (b) does this nursery/pupping habitat form an important part of a wider fish resource?; and (c) is this habitat important in terms of supporting a fish population that supports a related commercial/recreational fishery?
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

4.3.4 IMPACT ASSESSMENT FOR SEABIRDS

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Direct removal of benthos and fish through aggregate extraction may reduce the abundance of potential prey items for sea birds and adversely affect sea bird feeding**
Impact assessment	This potential impact should be assessed in the same way as that set out above for a potential reduction in prey items for marine mammals and elasmobranchs.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Noise impacts from aggregate extraction may create adverse effects on sea birds**
Impact assessment	This potential impact should be assessed in the same way as that set out above for potential noise impacts on marine mammals and elasmobranchs.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may result in loss of intertidal habitat through beach draw down**
Impact assessment	***Nature of Effect*** The effect is the potential loss of intertidal habitat as a result of beach draw-down. This potential effect is covered in detail in Section 4.2. The reader is, therefore, referred to this section.
	Nature of Receptor The receptor is intertidal habitat that provides feeding/roosting habitat for birds. *Sensitivity*: The sensitivity of this habitat to this potential effect should be based on the physical process assessment (see **Section 4.2**). *Recoverability:* The recoverability of this habitat to this potential effect should be based on the physical process assessment (see **Section 4.2**). *Importance*: Baseline studies should describe the importance of any intertidal habitat within the study area for birds.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and the residual significance determined.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may result in a loss of visibility through sediment plumes**
Impact assessment	***Nature of Effect*** The effect is increased turbidity generated by the sediment plume. Data related to the spatial extent, duration, magnitude and frequency of any plume should be provided by the physical process assessment (see **Section 4.2**).
	Nature of Receptor In this case, the receptor is the visual capacity of feeding sea birds. *Sensitivity*: This should be determined through a review of existing literature that details the sensitivity of sea bird feeding to reduced visibility. *Recoverability:* If an impact does arise through reduced visibility, recoverability will be based on the temporal characteristics of the plume. *Importance*: This will be determined through an expert assessment of the importance of the area affected in terms of sea bird feeding (in particular divers and visual feeders).
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and the residual significance determined.

GOOD PRACTICE RECOMMENDATION 4.29: CUMULATIVE/IN-COMBINATION EFFECTS

Any assessment should also consider the potential for cumulative and in-combination effects to arise on marine ecology from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.

REFERENCES

CEFAS (1997). Final Report of the Sediment Bioassay Task Team. Marine Pollution Monitoring Management Group. The Group Co-ordinating Marine Disposal Monitoring. Science Series. Aquatic Environment Monitoring Report No. 48. Centre for Environment, Fisheries and Aquaculture Science, Lowestoft, 1997.

Desprez, M. (2000). Physical and biological impact of marine aggregate extraction along the French coast of the eastern English Channel: short- and long-term post dredging restoration. ICES Journal of Marine Science, **57:** 1428-1438.

Kenny, A.J. and Rees, H.L. (1996) The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. Marine Pollution Bulletin, **32**: 615-622.

MarLIN (2003). Assessing the sensitivity of sea bed biotopes to human activities and natural events.

OSPARCOM (1998). OSPAR Guidelines for the Management of Dredged Material. OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Ministerial Meeting of the OSPAR Commission, Sintra 22-23 July 1998.

SECTION 4.4 NATURE CONSERVATION

4.4.1 INTRODUCTION

The following section provides a summary of the main information that is required to assess the potential impacts on nature conservation identified in Section 3.4. The specific impacts relating to species and habitats covered by nature conservation legislation are dealt with in Section 4.3 and 4.5 and, therefore, this section is set out differently to other parameters and covers the procedural processes only.

Aggregate extraction may create adverse effects on features designated under nature conservation legislation

The assessment of potential impacts on biological interest features designated under national and international nature conservation legislation (e.g. Wildlife and Countryside Act, Habitats Directive, Birds Directive) should be undertaken with respect to the specific feature that may be affected by the proposed aggregate dredging operation. This applies to features that may be directly affected by aggregate dredging (although this is unlikely) or indirectly affected through operations or activities outside of a designated site (potentially more likely). Assessment, therefore, relates to the identification and determination of impacts on ecological and biological criteria and the further assessment of the result of this analysis in the context of procedural (legislative or management) processes.

For sites designated under European and international legislation, guidance on the assessment process is set out for England in Planning and Policy Guidance 9 (Nature Conservation) (ODPM), for Scotland in National Planning Policy Guideline 14 (Natural Heritage) (Scottish Office, 1999) and for Wales in Technical Advice Note (TAN) 5 – Nature Conservation and Planning (1996) (Welsh Office, 1996). These guidance documents also deal with assessment issues related to sites of nature conservation importance designated under national legislation.

Detailed advice has been set out in a number of supplementary guidance documents and reference should be made to these to ensure that assessment requirements are compliant with international and national legislation. In England this guidance comprises a number of notes produced by English Nature which detail requirements at certain points in the procedural process. The most pertinent of these notes are Habitats Regulations Guidance Note 1 (HRGN 1) which provides information on the appropriate assessment process, as required under Regulation 48 of the Conservation (Natural Habitats &c.) Regulations 1994 and HRGN 3, which deals with the determination of likely significant effect. In Scotland, guidance on the assessment of proposals affecting Natura 2000 areas is set out in Appendix A of Annex D to Scottish Office Environment Department Circular 6/1995 (Scottish Office, 1995). If the situation is one where assessment is required under relevant Environmental Impact Assessment legislation (as for aggregate extraction), and it has been determined that the works are 'likely' to have a 'significant effect' on a European designated site, then the Environmental Statement produced should also contain the information needed to meet the requirements of the Habitats Regulations (that is, the information for 'appropriate assessment').

Aggregate extraction may have adverse effects on habitats or concentrations of species that *could* be considered in future cSACs or SPAs (both within and outside 12nm)

With regard to assessing the impacts on habitats or concentrations of species that *could* be considered in future cSACs or SPAs (both within and outside 12nm) and that are present in the area that is likely to be affected by the proposed activity, the JNCC are preparing guidance (in conjunction with the country agencies) as to the approach that should be adopted in the EIA process. It is anticipated that this guidance will outline the approach that applicants should take in providing and assessing information on nature conservation issues, particularly those aspects regarding potential Annex I habitat. It is imperative that site-specific information is incorporated into this process.

The draft guidance outlines the situation with respect to the designation of SACs/SPAs in UK offshore waters and states that, in the period prior to identification of the proposed *Natura* 2000 sites, a precautionary approach should be adopted. As part of the impact assessment process, all *potentially* suitable habitats should be considered with care. JNCC Report 325 (and subsequent Committee papers) provides the information necessary to identify those areas in UK offshore waters that may contain species or habitats which are required to be considered as potential cSACs or SPAs. Therefore, this report should be consulted and reviewed as part of the impact assessment process.

Within any ES, it is important that both a description of any habitats or concentration of species that *could* be included in future as cSACs or SPAs (both within and outside 12nm) and the assessment of likely impacts on these features due to the proposed activity are provided. This assessment should follow the principles referenced above for existing designated areas of nature conservation.

Aggregate extraction may have adverse effects on habitats or species that are protected by nature conservation legislation

The methods for assessing impacts on individual species or habitats that are protected through national or international legislation (i.e. those that are not covered by designated sites under the Habitats Directive and Birds Directive) will largely be the same as those set out for assessing impacts on benthic and epibenthic resources, pelagic fauna and birds, discussed in **Section 4.3**. In addition, some of the species that fall within this category will also be covered by specific SAPs and assessment will need to relate to identified objectives and targets (see below).

Aggregate extraction may create adverse effects on any Biodiversity Action Plan (BAP), Species Action Plan (SAP) or Habitat Action Plan (HAP) features

The methods for assessing impacts on individual habitats or species that are subject to BAPs, SAPs and/or HAPs will largely be the same as those set out for assessing impacts on pelagic (e.g. marine mammals), benthic and epibenthic resources within **Section 4.3**. In addition, the assessment of potential impacts should include a critical review of the relevant action plan, its objectives and targets, and assess whether or not the proposed activity will compromise these criteria. Details on these objectives and targets can be obtained from ***http:www/ukbap.org.uk***.

Aggregate extraction may create adverse effects on other features of nature conservation interest

The methods for assessing impacts on individual habitats or species that are not protected by nature conservation legislation, again, will be the same as those set out for assessing impacts on benthic and epibenthic resources in **Section 4.3**.

GOOD PRACTICE RECOMMENDATION 4.30: IN-COMBINATION EFFECTS
Any assessment should consider the potential for in-combination effects to arise on nature conservation interests from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms and oil and gas operations (including seabed infrastructure) or their construction.

REFERENCES

English Nature (2001). Habitats Regulations Guidance Note 1. The Appropriate Assessment (Regulation 48). The Conservation (Natural Habitats &c) Regulations, 1994. Issued by Greg Smith, English Nature, Peterborough, UK.

English Nature (2001) . Habitats Regulations Guidance Note 3. The Determination of Likely Significant Effect under The Conservation (Natural Habitats &c) Regulations, 1994. English Nature, Peterborough, UK.

Johnston, C.M, Turnbull, C.G. and Tasker, M.L. (2001). Natura 2000 in UK Offshore Waters: Advice to support the implementation of the EC Habitats and Bird Directives in UK offshore waters. JNCC Report 325.

Office of the Deputy Prime Minister (OPDM). Policy Planning Guidance 9 (PPG9): Nature Conservation. Office of the Deputy Prime Minister.

Scottish Office (1995). Environment Department Circular No. 6/1995 Nature Conservation. Implementing in Scotland E C Directives on the conservation of Natural Habitats and of Wild Flora and

Fauna and the conservation of Wild Birds (the Habitats and Birds Directives). (Scottish Executive June 2000).

Scottish Office (1999). National Policy Planning Guidance 14 (NPPG14). Natural Heritage. Produced by the Scottish Office Development Department. ISBN 0-7480-7997-1.

Welsh Office (1996). Technical Advice Note (TAN) 5. Nature Conservation and Planning. ISBN 0 7504 2173 8.

SECTION 4.5 FISH AND SHELLFISH RESOURCES

4.5.1 INTRODUCTION

The following section provides a summary of the key information required to assess the specific impacts identified in **Section 3.5**. For certain effects, hypothetical examples of how differing levels of significance can be derived (using the framework described in **Section 4.1)** are provided.

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Dredging works will lead to a loss of benthic species which may result in reduced food availability for fish and shellfish (and decreased productivity)**
Impact assessment	***Nature of Effect*** The effect is direct removal of the seabed and associated species/habitats. The Dredging Plan should provide the following information: • The exact area over which seabed removal will take place (spatial extent); • How often this will take place (frequency of dredging); and • The depth of dredging and size of dredge tracks (magnitude). Based on existing knowledge of the physical processes within the study area, an estimate should also be made as to how long any dredge tracks will persist (duration of impact).
	Nature of Receptor In this case, the receptor is benthic species. The exact nature of the receptor will be described through baseline studies. *Sensitivity*: Assume to be HIGH, as all benthic macro-fauna (biomass) will be removed by dredging. *Recoverability:* Needs to take account of the dredging regime (nature of the impact), the physical environment and characteristics of the benthic community. *Importance*: The benthic species removed are important as they: (a) provide biomass; and (b) make up a constitute part of the fish and shellfish resources within the affected area. In order to determine the importance of benthic species, in terms of biomass (and productivity), the following information should be obtained. • Average wet biomass of benthic resources in the study area (data from baseline studies); • Equivalent value expressed as kg/km^2; • Estimated annual benthic production expressed as kg/km^2/year (this can be calculated using an appropriate Production/Biomass (P/B) ratio; a P/B ratio of 1.4 has been used in previous studies in UK coastal waters); and • Once the annual benthic production has been calculated (kg/km^2/year), it should be possible to determine the 'Supported Annual Fish Production'. Both a 5% and 10% value of incorporation from benthos to fish production is used within UK studies.

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Stage of Impact Assessment	Description
Impact Assessment (cont.)	Using these figures, it is possible, albeit crudely, to predict what effect a reduction in biomass through aggregate dredging will have on fish and shellfish productivity. An example of how this has been done within an actual ES is shown below, in **Box 4.17**.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Box 4.16 Example of calculating fish production from average wet biomass

Wet Biomass (kg/km^2)	Estimated Annual Production[1] (kg/km^2/Year)	Supported Annual Fish Production[2] (kg/km^2/Year)	Supported Annual Fish Production[3] (kg/km^2/Year)
72,000	100,800	5040	10,080

[1] utilising a Production/Biomass (P/B) ratio of 1.4
[2] utilising a 5% value of incorporation from benthos to fish production
[3] utilising a 10% value of incorporation from benthos to fish production

Source: Ecological Survey of the West Bassurelle area undertaken by Marine Ecological Surveys Ltd (MES, 1999). These data were collected as part of a dedicated marine ecology survey to support the EIA for Areas 458 & 464, produced by Oakwood Environmental Ltd (Oakwood, 2000).

NOTE

With respect to **Box 4.16**, this approach represents a relatively simple method of calculating fish production from biomass values, which can then provide an indication of the potential impact of biomass removal on fish production. However, such analysis, if used in isolation, without any further professional judgement, can often lead to inaccurate conclusions. Therefore, an expert review should always be undertaken as part of any such analysis.

Stage of Impact Assessment	Description
Description of impact	**Fish and shellfish may be entrained through direct uptake**
Impact assessment	***Nature of Effect*** The effect is direct removal of the seabed and the subsequent uptake of fish and shellfish species. The Dredging Plan should provide the following information: • The exact area over which dredging will take place (spatial extent); • How often this will take place(frequency of dredging); and • The depth of dredging and size of dredge tracks (magnitude). The duration of the effect will be the time it takes any species removed by dredging to return to the area post-dredging. Therefore, this will be closely linked to 'Recovery' see below).
	Nature of Receptor In this case, the receptor is fish and shellfish species that may get entrained. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: Assume to be HIGH as any species entrained by the dredger will experience close to 100% mortality. (In practice, only sedentary shellfish such as scallops will likely be entrained in any significant numbers). *Recoverability:* Needs to take account of the dredging regime (see *Nature of Impact*), the physical environment and characteristics of the benthic community. *Importance*: In order to determine the importance of any fish and shellfish species entrained, the following information should be obtained (using scallops as an example): • Density of scallops from the proposed dredged areas (data from baseline studies); • Density of scallops from the wider study area, i.e. relevant ICES Area; and • Spatial extent of the dredged area (see *Nature of Effect*). The density of scallops in both the dredged area and wider study area will likely be expressed as a range. Therefore, in taking a precautionary approach, the higher figure of this range should always be used. The density of scallops within the dredged area should be used to calculate the potential loss of this species in terms of weight per annum. This figure should then be compared to the overall weight of scallop landings within the region, so that the proportion removed by aggregate dredging could be estimated. Based on the proportion of landings made in the wider region, the Importance of this receptor will be able to be determined.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Noise generated by dredging may impact on fish and shellfish**
Impact assessment	***Nature of Effect*** The effect is noise emissions from the dredger. Information on noise levels produced by dredgers may be able to be obtained from the Applicant and should be able to be obtained from relevant literature. However, in practice, it is difficult to quantify the potential impact of noise produced by aggregate dredging on fish and shellfish species. The duration and frequency of dredging should be determined from the Dredging Plan and this will provide some guide as to how long potential noise impacts may occur for.
	Nature of Receptor In this case, the receptor is fish and shellfish species. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: Any assessment of this impact will need to be based largely on the findings of a literature review into the effects of noise on certain fish and shellfish species. There is a relatively large amount of literature that addresses this particular issue (see **Box 4.18**). Once the species composition of the study area is known, specific data for key species can be obtained from the literature review. These data can then be compared to the actual noise levels expected to be produced by the dredging activity in order to assess sensitivity. *Recoverability:* In practice, mobile fish and shellfish species will exhibit avoidance reactions if noise emissions reach levels that species find adverse. This is facilitated by the fact that most aggregate extraction occurs in open water, which enables fish to move away easily. *Importance*: Not applicable.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Box 4.17 Relevant literature for noise effects on fish

Hawkins, A.D. (1986). Underwater sound and fish behaviour. In: Pitcher, T.J (ed.). The Behaviour of Teleost Fish. Groom Helm Ltd, Kent 114-149.

Kalmijn, A.J. (1994). Near-field acoustic detection. Physical principles and biological relevance. Sensory Systems 8 (3-4). pp 202-209.

CEFAS (2003). Preliminary investigation of the effects of sound generated by aggregate dredging and marine construction. Research PROJECT AE0194. FINAL PROJECT REPORT CSG 15.

Stage of Impact Assessment	Description
Description of impact	**Adverse effects of sediment plumes** **(See Section 3.4 for a full review the of effects of sediment plumes on fish and shellfish)**
Impact assessment	***Nature of Effect*** The effect is increased SSC generated by the sediment plume. The following information related to the plume should be obtained. These data should be provided through baseline studies and the outputs of numerical models: • Spatial extent of the plume; • Background levels of SSC within the study area (expressed as a range); • Predicted increase in SSC (above background levels); • Peak concentration predicted; • Temporal characteristics of any increase in SSC within the study area, i.e. how long do elevated levels persist for?; and • Differences between near-bed, depth-averaged and surface SSC.
	Nature of Receptor In this case, the receptors are either fish and shellfish undertaking spawning migrations or reaching spawning grounds where sediment plumes have been generated **and/or** species feeding **and/or** pelagic eggs and larvae. The exact nature of the receptors will be described through baseline studies. *Sensitivity*: In order to determine the sensitivity of the various receptors to sediment plumes, the following information is required: • Characteristics of the plume (see *Nature of Impact*); and • Threshold levels of these receptors with respect to SSC (from literature reviews and/or ***www.marlin.ac.uk***). *Recoverability:* In order to determine the recoverability of any receptors to plume effects, the following information is required: • Temporal characteristics of the plume (see *Nature of Impact*); and • Threshold levels of these receptors with respect to SSC. *Importance*: To fully asses this potential impact, the particular receptor being assessed should be placed in context with the wider study area.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Intensive deposition of sediment from overflowing and screening**
Impact assessment	***Nature of Effect*** The effect is the deposition of sediment onto the seabed. The following information related to deposition should be obtained. These data should be provided through baseline studies and the outputs of numerical models: • Spatial extent of deposition; • Background levels of deposition within the study area (expressed as a range); • Predicted frequency and rate of deposition due to dredging; • Depth of deposition; • Type of sediment that will be deposited; and • Subsequent 'behaviour' of any deposited sediment, i.e. will it be re-mobilised?
	Nature of Receptor In this case, the receptors are either sedentary shellfish species **and/or** spawning grounds comprised of characteristic sediment composition (herring spawning gravels) **and/or** niche habitats used by crustaceans. The exact nature of the receptors will be described through baseline studies. *Sensitivity:* In order to determine the sensitivity of the various receptors species to deposition, the following information is required: • Characteristics of deposition (see *Nature of Impact*); and • Threshold levels of these receptors with respect to deposition (from literature reviews and/or ***www.marlin.ac.uk***). *Recoverability:* In order to determine the recoverability of any receptors to deposition, the following information is required: • Characteristics of deposition (see *Nature of Impact*); and • Knowledge of the physical processes within the study area. These will largely determine the rate at which physical recovery of the site will occur (if it does at all). *Importance*: To fully assess this potential impact, the particular receptor being assessed should be placed into context with the wider study area. For example, if assessing the potential effect of deposition on a herring spawning ground (causing a change from a gravel-dominated substrate to one dominated by sand), then the area potentially affected by deposition should be expressed as a proportion of the overall amount of similar spawning grounds within the wider study area.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Two examples of how slight changes in the nature of the receptor can produce impacts of varying significance are provided in **Appendix D (viii) and (ix)**. Once the significance of the initial impact is determined, the mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

GOOD PRACTICE RECOMMENDATIONS 4.31: DEFINITION OF IMPACT

Outputs of numerical models should be used to define the 'footprint' of the effect. These outputs should be analysed in detail to further define the relevant proportion of the dredging footprint (i.e. the zone of influence) in which adverse effects on the receptor in question are likely to arise (that is, species will be affected by the different impacts within the zone of influence as a whole in different ways, where some effects may be important (i.e. dredging) while others may not (i.e. shallow smothering). The assumption that the entire footprint will create adverse effects is too precautionary and needs to be considered on a case-by-case basis.

Up-to-date data relating to the sensitivity of key receptors to depositional effects should be obtained through literature review. Local commercial fishermen should be consulted at an early stage in the EIA process.

GOOD PRACTICE RECOMMENDATION 4.32: CUMULATIVE/IN-COMBINATION EFFECTS

Any assessment should also consider the potential for cumulative and in-combination effects to arise on fish and shellfish resources from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.

REFERENCES

CEFAS (2003). Preliminary investigation of the effects of sound generated by aggregate dredging and marine construction. Research Project AE0194. FINAL PROJECT REPORT CSG 15.

Courbet, F. and Lemoine, M. (2003). Apparent incompatibility between biological settings of WGEXT guidelines and current aggregate dredging applications in the Eastern English Channel. Annex 16 in ICES CM (2003). Report of the Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem. ICES CM 2003/E:07. Ref. ACME ACE, D.

Hawkins, A.D. (1986). Underwater sound and fish behaviour. *In: Pitcher, T.J (ed.)*. The Behaviour of Teleost Fish. *Groom Helm Ltd*, *Kent 114-149.*

Kalmijn, A.J. (1994). Near-field acoustic detection. Physical principles and biological relevance. *Sensory Systems* 8 (3-4). pp 202-209.

Rogers, S.I. and Carlin, D. (2002). A Procedure to Assess the Effects of Dredging on Commercial Fisheries. Draft Final report of CSG Contract A0253. Defra, Nobel House, London.

SECTION 4.6 COMMERCIAL FISHERIES

4.6.1 INTRODUCTION

The aim of this section is to define what information is required to enable the assessment of impacts specific to commercial fisheries. The framework for deriving significance, set out in Figure **4.1**, can also be used for assessing impacts on commercial fisheries.

The following tables summarise three generic categories of impact on commercial fisheries, namely:

(i) Impacts on the distribution of fish and fisheries through direct or indirect effects;
(ii) Direct impacts on fish and shellfish; and
(iii) Impacts on commercial fishing activities.

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Aggregate extraction may cause a change in the distribution of fish and shellfish which will subsequently impact on commercial fisheries**
Impact assessment	***Nature of Effect*** The effect is a combination of the effects of noise, sediment plumes, deposition and direct removal of the seabed on fish and shellfish resources. The approaches required for the assessment of these impacts is detailed in Section 4.4.
	Nature of Receptor In this case, the receptor is fish and shellfish resources within the study area. Details on defining this receptor are provided in **Section 4.4**.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Direct impacts on stocks of fish and shellfish**
Impact assessment	***Nature of Effect*** The effect is a combination of the effects of noise, sediment plumes, deposition and direct removal of the seabed on fish and shellfish resources.
	Nature of Receptor In this case, the receptor is fish and shellfish resources within the study area.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate dredging may result in the physical exclusion of fishing vessels from licensed extraction areas, resulting in reduced catches**
Impact assessment	***Nature of Effect*** The effect is direct exclusion of fishing vessels from licensed areas. The Dredging Plan will provide details as to when and where fishing will be excluded from the study area. Therefore, this document should be used as the basis for defining this impact.
	Nature of Receptor In this case, the receptor is commercial fishing activity. The exact nature of the receptor will be described through baseline studies. *Sensitivity*: This will be determined by the exact nature of restrictions to fishing activity (see *Nature of Effect*) and also the ability for displaced vessels to fish elsewhere. *Recoverability:* This will also be determined by the exact nature of restrictions to fishing activity, i.e. how soon following the cessation of dredging will commercial fishing activity be permitted. *Importance*: The importance of the area from which commercial fishing activity is excluded will be defined by the number of boats that fish in this area and the economic value of fish caught here. These data will be obtained through baseline studies. It is worth noting that CEFAS are developing a GIS that will enable potential conflicts between fishing fleets and aggregate extraction sites to be explored. This system will be entirely dependant on good quality data describing the seasonal distribution of fisheries. These data are being obtained and updated by CEFAS, in parallel with further developments.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. An example of how the significance of an impact can be derived using this framework is provided in **Appendix D (xi)**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Exclusion from fishing grounds may result in 'squeeze effects' on adjacent fishing areas (increased fishing pressures)**
Impact assessment	***Nature of Effect*** The direct effect to be considered is the exclusion of fishing vessels from licensed areas, leading to an in-direct effect on adjacent areas and the displacement of vessels responding to an alteration in the distribution of fish. The Dredging Plan will provide details as to when and where fishing will be excluded from the study area. ***Nature of Receptor*** In this case, the receptor is commercial fishing activity, both within the extraction area **and** in adjacent areas. The exact nature of this receptor will be described through baseline studies. *Sensitivity*: This will be determined by the exact nature of restrictions to fishing activity (see *Nature of Effect*). *Recoverability:* This will also be determined by the exact nature of restrictions to fishing activity, i.e. how soon following the cessation of dredging will commercial fishing activity be permitted. *Importance*: Defining the importance of the receptor will involve an assessment of the level of fishing activity within both the extraction area and adjacent areas. These data will be obtained through baseline studies and the use of GIS.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate dredging may interfere with established trawl tows**
Impact assessment	***Nature of Effect*** The direct effect is the prevention of routine fishing activities due to aggregate dredging. The Dredging Plan will provide details as to the position and timing of dredging activities. Therefore, this document should be used as the basis for defining this impact. ***Nature of Receptor*** In this case, the receptor is commercial fishing activity, more specifically, the ability to use established trawl tows. The exact nature of the receptor will be described through baseline studies. *Sensitivity*: This will be determined by the exact nature of restrictions to fishing activity (see *Nature of Effect*). *Recoverability:* This will also be determined by the exact nature of restrictions to fishing activity, i.e. how soon following the cessation of dredging will commercial fishing activity be permitted. *Importance*: Defining the 'importance' of the receptor will involve an assessment of the nature of fishing activity within the extraction area, i.e. do a greater number of well-established tows occur within the extraction area, compared to surrounding areas? These data will be obtained through baseline studies and could be input into a GIS to establish where tows and dredging areas overlap.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate dredging may lead to changes to sea-bed topography leading to the potential exposure of bedrock features, or other 'fasteners', that may cause trawl gear to come fast**
Impact assessment	***Nature of Effect*** The direct effect is the change in seabed topography caused by dredging. The approach to defining such an impact is described in **Section 4.2**. ***Nature of Receptor*** In this case, the receptor is commercial fishing activity, more specifically, the potential for certain gear types (trawls, dredges) to come fast on obstructions exposed by extraction activities. *Sensitivity*: This will be determined by the exact nature of restrictions to fishing activity. *Recoverability:* For *temporary* fasteners, this will be the rate at which the seabed topography recovers following dredging, which will be defined by assessing physical processes. For *permanent* fasteners, recoverability will be depend on the time taken for fishermen to learn the new seabed topography. *Importance*: Defining the importance of the receptor will involve an assessment of the nature of fishing activity within the extraction area, i.e. what level of towed gears are used within the area that may be impacted? This assessment will be largely qualitative and will require knowledge of the type of gears used within the study area, and how these may be adversely affected by changes in seabed topography.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate dredging may cause damage to fishing gears**
Impact assessment	***Nature of Effect*** The direct effect is the actual passage and routine activity of the dredger vessel. The Dredging Plan will provide relevant information.
	Nature of Receptor In this case, the receptor is: (a) the value of the commercial fishing gear lost or damaged; and (b) the loss in income caused by the loss of the gear. *Sensitivity*: This is likely to be HIGH because, if a dredger collides with these gears, they will experience damage or be totally lost. *Recoverability:* This is likely to be LOW, as once damaged or lost the gears will remain so. *Importance*: The importance of this receptor will be based on the amount of gears within the study area and their relevant financial values. It is worth noting that, in practice, most fishermen will avoid the areas closest to dredging activity, in order to avoid the possibility of damage to gear, and ensure safe navigation, and this means that fishing gears and dredging vessels are likely to be separated during dredging activities.
Derivation of significance	Should be assessed using the framework set out in **Figure 4.1**. Once the significance of the initial impact is determined, mitigation measures should be applied and a re-assessment undertaken to determine the significance of the residual impact.

4.6.2 OVERALL ASSESSMENT OF IMPACTS ON COMMERCIAL FISHERIES

Risk assessment

The primary reference for the assessment of risks to commercial fisheries should be Annex A of MMG1. Further, more detailed information is, however, available in a number of other specific reports. In the recent CEFAS report A0253, A *Procedure to Assess the Effects of Dredging on Commercial Fisheries* (Rogers and Carlin, 2003), an approach to risk assessment in relation to fish and shellfish resources and commercial fisheries is described, based on progress already made with respect to risk assessment in relation to coastal and environmental protection (DoE, 1995; ABP, 1997). The risk assessment process outlined within this report can be used both by the consultant, to assist with impact assessment of a human activity, and also by the Regulator to evaluate the quality of such an assessment and to provide expert opinion as to the relative importance of the impacts and mitigation measures proposed (Rogers and Carlin, 2002). This method, specifically with regard to its use in predicting impacts on fish and shellfish resources, is described in **Section 4.5**.

NOTE
The 2002 Report of the ICES Working Group on the Effects of Extraction of Marine Sediments on the Marine Ecosystem, discussed methods to assess localised impacts of aggregate extraction on fisheries. The report recommended that the approach risk assessment detailed above should be employed, based on approximately 20 species and, for each, separating life histories into adults (feeding grounds), migrations, spawning grounds, juvenile drift and nursery grounds. For each of the 20 species, the risk matrix would assess *potential* sensitivity of the species at each life-history stage and *actual* vulnerability to dredging operations. The list of 20 species should be based on the detailed study undertaken by MAFF/IFREMER in 1993 to identify the biogeographic distribution of 25 stocks within the English Channel. The findings from this work should form a major theme in the planned *ICES Co-operative Research Report*.

REFERENCES

ABP (1997). A guide to the Environmental Risk Assessment (ERA) Package. ABP Research & Consultancy Ltd. Report No. R.717. November 1997. ABP Research & Consultancy, Pathfinder House, Maritime Way, Southampton, SO14 3AE.

DoE (1995). A guide to risk assessment and risk management for environmental protection. HMSO Publications, ISBN 011753091 3, 92pp.

Rogers, SI. and Carlin, D. (2003) A Procedure to Assess the Effects of Dredging on commercial Fisheries. Final report of CSG Contract A0253. Defra, Nobel House, London.

SECTION 4. 7 ARCHAEOLOGY AND CULTURAL HERITAGE

4.7.1 INTRODUCTION

Aggregate extraction activities have the potential to cause a range of potential effects on the preserved remains of the historic environment. The methods used to assess the scope, nature and significance of these impacts vary between individual consultants and have also changed over time. Within this section, the various methodologies used to assess impacts are described, along with methods for deriving the significance of impacts.

4.7.2 METHOD OF IMPACT ASSESSMENT

Section 4.1 outlines a generic approach to impact assessment and the derivation of significance, based on the need to define the nature of both the impact *and* the receptor. Within this section, the definitions related to the nature of the receptor, i.e. sensitivity/intolerance, recoverability and importance are described in largely ecological terms and consequently do not apply to the historic environment, e.g. *High Sensitivity* is defined as "the species/population is likely to be killed/destroyed by the impact under consideration".

Therefore, to allow the application of this generic guidance to archaeological and cultural heritage impacts, parameter-specific definitions of the nature of the impact and receptor are provided below, where appropriate.

Nature of the impact

The definition of spatial extent, duration and frequency of impact, set out in **Boxes 4.1**, **4.3** and **4.4** respectively, can be used with regard to archaeology and cultural heritage. However, a parameter-specific definition of the magnitude of impact is provided below in **Box 4.18**.

Box 4.18 Magnitude of impact

This is the scale of change which the impact may cause compared to the baseline and how this change relates to accepted thresholds and standards:

- *High* – All deposits are removed within the horizontal and vertical footprint of the impact;
- *Medium* – Some deposits are removed or all deposits are disturbed within the horizontal and vertical footprint of the impact; and
- *Low* – No deposits are removed but some are disturbed within the horizontal and vertical footprint of the impact.

Nature of the receptor

Parameter-specific definitions of the various aspects of archaeological receptors are provided below.

Box 4.19 Vulnerability

For archaeological and cultural resources, the vulnerability of the receptor (i.e. will the impact *interact* with the receptor?) can be assessed easily through the use of GIS. GIS can be used to provide an accurate indication of where resources exist and the basis for the impact assessment. This process and tool is extremely useful in relation to changes in erosion and depositional patterns, as the digital results of hydrodynamic modelling can also be overlaid onto the historic resource (GIS) layers to facilitate identification of areas and assets that would be affected. Digital mapping techniques can also present clearly the location of known wrecks and features, show various geological and sub-surface layers, and other related information, that would be considered potentially sensitive to marine aggregate extraction.

GOOD PRACTICE RECOMMENDATION 4.33: GIS

GIS should be used to assess the vulnerability of archaeological and cultural resources to impacts from aggregate extraction.

Box 4.20 Sensitivity/Intolerance

- ***High*** – The receptor is intolerant of change, that is, both physical disturbance as well as biological and chemical degradation. In archaeological terms, the remains would be removed from their context and physical damaged.
- ***Medium*** – The receptor is intolerant of physical disturbance. In archaeological terms, the context of the remains would be removed, thereby losing the valuable information associated with it.
- ***Low*** – The receptor is tolerant of change. Damage/disturbance will be insufficient to detract from the receptor's character and importance.
- ***Not Sensitive*** – The impact does not have a detectable effect on the receptor.

GOOD PRACTICE RECOMMENDATIONS 4.34: DEFINITION OF SENSITIVITY

Information on the sensitivity (intolerance) of key resources should be informed by information from published literature, consultation and discussion with experts from relevant organisations, such as English Heritage and CADW. Any new guidance should also be used.

Judgement as to the sensitivity of the receptor should consider the spatial extent, magnitude, duration and frequency of the impact being assessed.

Box 4.22 Recoverability

Archaeological remains are a finite and non-renewable resource and, as such, cannot be replaced or recover from damage caused to physical properties or archaeological context. Arguably the recording of remains before their removal could be considered as recoverability, as some of the information held within the remains (and their context) would be preserved. Furthermore, preservation of remains could be undertaken which would maintain some of the remains and their context (e.g. preserving a wreck and exhibiting it at a museum). However, in the context of assessment, these are mitigation measures. They should not, therefore, be taken into account in the initial assessment of the potential impact of a proposal for aggregate dredging. However, their role in reducing the magnitude of the loss of the resource or its information should be considered within the impact assessment framework (**Section 5.7**).

Box 4.22 Importance

Without an understanding of the 'importance' of the receptor, the significance of any impact will not be able to be fully assessed. Therefore, it is essential that an attempt is made to define importance. It is recommended that definition of the importance of a receptor be based on the criteria described in PPG 16: Archaeology and Planning, for judging the national importance of remains.

In order to determine the value and importance of any remains, the amount of information available about them is paramount. The more information regarding possible remains, the more informed the evaluation of its importance.

GOOD PRACTICE RECOMMENDATIONS 4.35: DETERMINATION OF IMPORTANCE

It is essential that advice is sought from specialists in relevant fields as well as statutory organisations in the determination of the importance of identified remains.

Reference should be made throughout the assessment of impacts on archaeology and cultural heritage to the BMAPA/English Heritage publication: *Aggregate Dredging and the Historic Environment: Guidance Note*.

4.7.3 SUMMARY OF IMPACT/RECEPTOR INFORMATION

Once the impact and receptor being assessed have been fully defined, it is recommended that some form of summary table, similar to **Table 4.1**, should be used to describe both the nature of the impact in question and the receptor being assessed.

Following this, the significance of the impact should be derived using the framework set out in **Figure 4.1**.

4.7.4 RESIDUAL IMPACTS

When assessing the significance of the residual impact, taking account of the proposed mitigation measures, the recoverability of the remains is an important feature, in addition to more direct measures, such as avoidance. This should always be considered and the degree to which the remains and their contextual information can be 'recovered' should be described and any assumptions highlighted.

4.7.5 DATA GAPS

It is important to recognise that even with good quality baseline data and input from qualified professionals, an element of uncertainty will always be associated with the prediction of impacts. This is due to the fact that the survival and nature of archaeological remains are difficult to determine without destructive investigations. This is discussed in **Section 2.7** with regard to the varying levels of confidence that can be assigned to whether the presence of sites is known or potential.

Therefore, where impact predictions have been made on the basis of incomplete information or using assumptions, this should be recognised and reported on within the final ES. Without listing the assumptions used in reaching a decision on an impact, it is difficult for regulatory bodies assessing the ES to fully follow the thought process and rationale of the consultants undertaking the assessment.

GOOD PRACTICE RECOMMENDATION 4.36: ASSUMPTIONS
Any assumptions used in predicting and describing a particular impact should be listed within the ES, thus making it more transparent and robust.

4.7.6 CUMULATIVE IMPACTS

Limited potential exists for cumulative or in-combination impacts to arise with respect to archaeology and cultural heritage. Such effects could occur, however, in areas that are experiencing erosion as a result of natural processes or where other activities that result in disturbance below the seabed are occurring such as cable laying, pipelines, wind turbine construction.

In addition, the 'value' of a specific heritage resource may change due to impacts occurring upon similar remains elsewhere (in the locality, the region or even globally). For example, if a wreck is a certain type or class of vessel that has systematically been removed through various physical, biological and anthropogenic processes (i.e. has suffered cumulative losses), the importance of the existing remains will increase.

Future trends in erosional processes can be ascertained from the hydrodynamic modelling. The likelihood of other disturbance activities being undertaken should be determined through consultation and other data gathering activities undertaken for the ES. The potential for a cumulative effect to arise should then be assessed based on the methodology outlined in **Section 4.7.2** above.

GOOD PRACTICE RECOMMENDATION 4.37: CUMULTIVE/IN-COMBINATION EFFECTS
Any assessment should also consider the potential for cumulative and in-combination effects to arise on archaeological resources from other activities.

SECTION 4.8 NAVIGATION, RECREATION AND OTHER USES

4.8.1 NAVIGATION

Aggregate extraction may increase the risk of collision between dredging vessels and commercial shipping

Prediction of the impacts of dredging on navigational activities is generally assessed through the preparation and analysis of a navigation risk assessment. Navigational risk assessments initially involve the collation of baseline information on commercial shipping activity within and around a proposed dredging area, including the types and classes of vessel in the region, location of any associated routing measures, numbers of vessels using the shipping lanes, direction of travel and local tidal information. In addition, historic collision records, including information on the visibility at the time of collision, vessel type and vessel flag, are also collated.

The majority of these data are collected through the use of databases such as those described in **Section 2.9** (i.e. COAST, ShipRoutes). These databases generally do not include information on fishing vessels or recreational craft. Data on these vessels/craft either have to be obtained from other sources (i.e. NCI, fishing industry, RYA) or are not included in the model analysis.

These baseline data are subsequently used to develop a quantitative ship/ship collision risk model. The actual model used will depend upon the company/organisation that carries out the assessment but will essentially utilise the same, or a similar methodology. The collision risk model predicts the frequency of a ship/ship collision taking account of the following influencing factors:

- Exposure times;
- Encounter situation (head-on, crossing or overtaking);
- Relative velocity;
- Vessel type;
- Vessel size; and
- Visibility.

For reliability, the model is calibrated against historical UK data such as the Lloyd's UK serious ship collision casualty data[4], covering a ten-year period.

GOOD PRACTICE RECOMMENDATIONS 4.38: NAVIGATION RISK ASSESSMENT

A dedicated navigation risk assessment should be undertaken as part of the EIA process.

This should be undertaken by a professional company with expertise and experience in undertaking such assessments.

As far as is practical, data on recreational and fishing vessels should be incorporated into the collision risk model. Recreational craft will generally avoid major shipping channels and often follow entirely different routes to commercial shipping. This should be considered in combination with the fact that the radar, VHF and other observational and communication technologies (e.g. AIS) carried by recreational craft, are likely to be much less sophisticated than those onboard commercial vessels.

In a navigation risk assessment, the area around the study site, in this case a proposed dredging area, is split into a grid which is then used to plot shipping densities, distances travelled by ships through the area (nautical miles per cell per day) and the duration spent by ships in the area (hours per cell per day). Examples of the type of grids used are presented in **Figures 4.3** and **4.4,** prepared for the Regional Environmental Assessment of the proposed dredging areas within the East Channel Region (Anatec 2002).

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[4] *see: http://www.lloydsmiu.com/LCRS*

ROYAL HASKONING

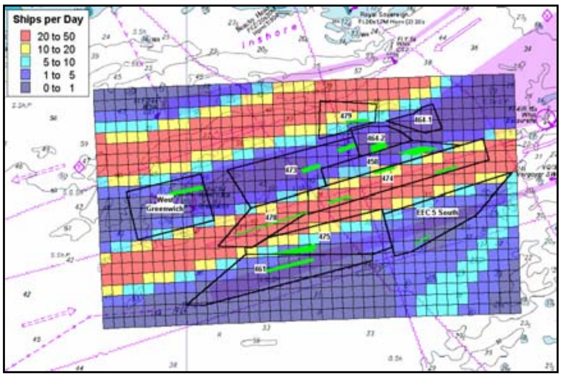

Figure 4.3 Average shipping Densities within grid per day

(from Anatec Navigational Risk Assessment for the Eastern English Channel Regional Environmental Assessment (Posford Haskoning, 2003); on behalf of East Channel Association)

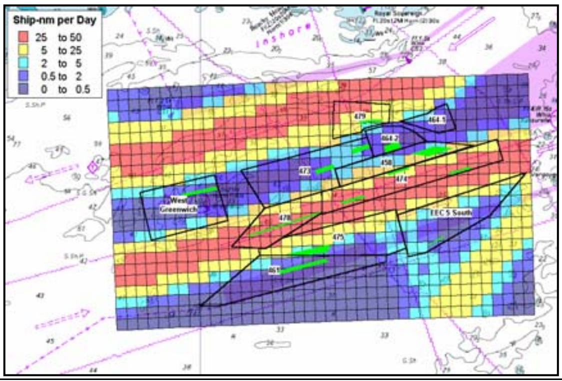

Figure 4.4 Nautical miles travelled by ships within grid per day

(from Anatec Navigational Risk Assessment for the Eastern English Channel Regional Environmental Assessment (Posford Haskoning, 2003); on behalf of East Channel Association)

Once the model parameters have been established in this way, it is possible for the model to predict the potential number of collisions that would involve a dredger. The models generally use the assumptions that the dredger will be travelling at around 1.5 knots, will dredge a set quantity of material annually, will cover a set area in one dredging run and will follow all necessary safe operating procedures (see **Section 5.8**).

The output of the model is generally a table or set of tables that show the estimated collision frequencies (assuming a given production rate) per kilometre dredged and per hour of dredging. Such tables are often supplemented by additional columns that show the number of tonnes dredged per collision, the time (in years) per collision and the number of cargoes per collision (the model does not, however, consider the potential severity of collisions, i.e. loss of life, damage to vessels, etc.).

In many areas, however, there is not just one isolated extraction area, rather, a series of sites. Therefore, a requirement exists to assess the cumulative effect of ship collision risk. A good example of such an area is the ECR, where there are currently 10 licence applications. The cumulative annual risk of dredging in this area can be derived from the activity levels estimated by each of the applicants for each application area and the collision frequencies. These figures can then be compared to the existing ship-to-ship collision risk levels in the same area, identified from national statistics. An example of a table indicating the estimated annual collision frequencies within the ECR, is shown below:

Table 4.3 Estimated annual collision frequencies for ECR licence areas

Company	License / Application Area	Dredging Hours/Year	Collision Frequency/Hour	Annual Collision Frequency
Britannia	477	1556	3.1×10^{-7}	6.1×10^{-3}
UMD/RMC Marine	458	1556	3.1×10^{-7}	6.1×10^{-3}
	464-1	-	N/A	N/A
	464-2	1556	1.7×10^{-7}	6.1×10^{-3}
Hanson	473	895	1.7×10^{-7}	6.1×10^{-3}
	474	895	2.3×10^{-6}	6.1×10^{-3}
	475	1791	7.4×10^{-7}	6.1×10^{-3}
	EEC5 South	-	N/A	N/A
Dredging International	478	196	2.4×10^{-6}	6.1×10^{-3}
	479	196	2.0×10^{-6}	6.1×10^{-3}
Volker	461	1556	2.9×10^{-7}	4.5×10^{-4}
Annual Total	**N/A**	**10,197**		**6.1×10^{-3}**

This particular output of a navigational risk assessment collision model indicates that the total annual collision frequency associated with dredging in the ECR, based on a production of 8.5Mtpa, is 6.1 x 10^{-3}; an average of one collision in 164 years dredging. Compared to the existing frequency of collision risk, dredging activity in this area is expected to increase the frequency of collisions by 0.006 per year; an increase of 0.15%.

GOOD PRACTICE RECOMMENDATIONS 4.39: CUMULATIVE FREQUENCY ASSESSMENT
In areas with more than one license application, the cumulative annual risk of dredging should be assessed to provide the total annual collision frequency. **Any increase in the frequency of collision risk due to dredging activity should be expressed as a % of the existing frequency.**

4.8.2 OTHER USES

Stage of Impact Assessment	Description
Impact identification	Undertaken during scoping (see **Section 1.3**)
Description of impact	**Aggregate extraction may create a sediment plume that crosses licensed disposal sites, resulting in a breach of the conditions of licence of this site**
	Nature of Impact The impact is the sediment plume that will be generated by dredging activity. The following information related to the plume should be obtained. These data should be provided through baseline studies and the outputs of models developed as part of the physical processes assessment (see **Section 4.2**). • Spatial extent of the plume; • Background levels of SSC within the study area (expressed as a range); • Predicted increase in SSC (above background levels); and • Peak concentration predicted.
Impact assessment	***Nature of Receptor*** The receptor is any licensed disposal site within the study area.
Derivation of significance	In order to derive the significance of this impact, the first question that should be answered is whether or not the impact is likely to occur, i.e. will the sediment plume generated overlap with any disposal sites. This can be assessed using a GIS to plot the movement of the sediment plume. If there is no spatial overlap between the plume and any licensed sites, then No Impact will arise. If there is spatial overlap, then the assessment has to consider whether or not the suspended sediment concentrations (SSC) present within the plume will exceed any limits set with respect to SSC for the disposal site. The SSC of the plume will be able to be predicted using numerical models. If the predicted SSC within the sediment plume does exceed the licence conditions, then a Major Adverse impact will arise. If such an impact is predicted, then mitigation measures (see **Section 5.8**) should be applied and a re-assessment of the significance undertaken. With successful implementation of standard mitigation measures, the significance of this impact should be reduced to No Impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may cause damage to sub-sea cables and pipelines**
Impact assessment	***Nature of Impact*** There are two source of impact: (1) Direct damage to existing in-service or out-of-service sub-sea cables or pipelines as a result of dredging activity; and (2) Indirect damage or exposure due to increased scour effects. With respect to (1), there is no need to assess the nature of the impact, i.e. spatial extent, magnitude, in any great detail, as the impact is simply contact with a cable or pipeline. For (2), outputs of the physical process assessment should enable the nature of this impact (scour) to be defined.
	Nature of Receptor The receptors are any sub-sea cables or pipelines in the dredged area. The location and status of these will be determined through baseline studies.
Derivation of significance	It can be concluded that any damage to sub-sea cables or pipeline will have a Major Adverse impact, due to the implications for the operational functioning of the cable and health and safety, amongst others. Therefore, the only question that needs answering is whether or not the receptor is vulnerable to the impact, i.e. will dredging cause damage to a cable? If the answer to this question is yes, then mitigation measures (see **Section 5.8**) should be applied and a re-assessment of the significance undertaken. With successful implementation of standard mitigation measures, the significance of this impact should be reduced to No Impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may create adverse effects on offshore energy production activities**
Impact assessment	***Nature of Impact*** There are two sources of impact: (1) Direct damage to offshore installations as a result of dredging activity; and (2) Indirect damage or exposure due to increased scour effects. With respect to (1), there is no need to assess the nature of the impact, i.e. spatial extent magnitude, in any great detail, as the impact is simply contact with an installation. For (2), outputs of the physical process assessment should enable the nature of this impact (scour) to be defined.
	Nature of Receptor The receptors are any offshore energy production facilities in the dredged area. The location and status of these will be determined through baseline studies.

Stage of Impact Assessment	Description (cont.)
Derivation of significance	It can be concluded that any collision between a dredger and an offshore energy production facility will create a Major Adverse impact, due to the implications the operational functioning of the energy facility and health and safety issues. Therefore, the only question that needs answering is whether or not the receptor is vulnerable to the impact, i.e. will the dredger collide with these facilities? In order to assess this impact, a collision risk assessment can be undertaken, as described above with respect to shipping collision risk. If the answer to this question is yes, then mitigation measures (see **Section 5.8**) should be applied and a re-assessment of the significance undertaken. With successful implementation of standard mitigation measures, the significance of this impact should be reduced to No Impact.

GOOD PRACTICE RECOMMENDATION 4.40: COLLISION RISK-STATIONARY OBJECTS
Risk assessment models should also be used to analyse the risk of collision between dredgers and other ships with stationary objects, i.e. offshore wind farms.

Stage of Impact Assessment	Description
Description of impact	**The presence of military exclusion zones within the extraction area may increase the collision risk between dredgers and commercial shipping due to the increased frequency of course changes by the dredger, to avoid these areas**
Impact assessment	***Nature of Impact*** The impact is collision between commercial shipping and aggregate dredgers. There is no need to assess the nature of the impact, i.e. spatial extent magnitude, in any great detail, as the impact is simply contact or collision between vessels.
	Nature of Receptor The receptors are the vessels potentially involved.
Derivation of significance	The derivation of significance should be based on the findings of a dedicated navigation risk assessment. Details of these are provided above. This navigation risk assessment should ensure that the position of any PEXAs or ordnance areas are noted and incorporated into the collision risk model. If the initial risk assessment indicates that collision risk will increase due to the presence of military exclusion zones within the study area, then mitigation measures to reduce collision risk should be implemented and a re-assessment of the significance undertaken. With successful implementation of standard mitigation measures (see **Section 5.8**), the significance of this impact should be reduced to No Impact.

4.8.3 RECREATION

Stage of Impact Assessment	Description	
Impact identification	Undertaken during scoping (see **Section 1.3**)	
Description of impact	**Aggregate extraction may create adverse effects on recreational/hobby boat fishermen**	
Impact assessment	***Nature of Impact*** The impact is a combination of general disturbance and reduced access, generation of sediment plumes and loss of favoured 'marks' due to changes in seabed topography.	
	Nature of Receptor The receptors are the vessels potentially involved.	
Derivation of significance	To derive the significance of this particular impact, a relatively qualitative assessment is required. A judgement needs to be made, based on consultation and discussion with local fishermen, as to what degree they will be affected by the dredging activity. Based on these discussions, the significance of impact will be derived. If the significance turns out be high (Major Adverse), then suitable mitigation measures should be implemented (see **Section 5.8**) in order that the residual impact is acceptable, i.e. Minor or No Impact.	

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may increase the risk of collision between dredging vessels and recreational vessels**
Impact assessment	***Nature of Impact*** The impact is collision between recreational vessels and aggregate dredgers. There is no need to assess the nature of the impact, i.e. spatial extent magnitude, in any great detail, as the impact is simply contact or collision between vessels.
	Nature of Receptor In this case, the receptor is recreational vessels potentially involved.
Derivation of significance	The derivation of significance related to navigation risk is usually based on the findings of a dedicated navigation risk assessment. However, at the present time, navigational risk assessment models do not take recreational vessels into account. This means that the prediction of any potential impact upon these vessels, either adverse or beneficial, must be carried out in a qualitative manner. Most frequently, the impact prediction can be based upon information obtained through consultation with local recreational boat users. If the initial risk assessment indicates that collision risk will increase, then mitigation measures to reduce collision risk should be implemented and a re-assessment of the significance undertaken. With successful implementation of standard mitigation measures (see **Section 5.8**), the significance of this impact should be reduced to No Impact.

Stage of Impact Assessment	Description
Description of impact	**Aggregate extraction may create adverse effects on SCUBA diving activity through the creation of sediment plumes**
Impact assessment	***Nature of Impact*** The impact is reduced visibility for SCUBA diving due to the generation of a sediment plume.
	Nature of Receptor In this case, the receptor is SCUBA divers that use the study area.
Derivation of significance	The impact assessment and derivation of significance for this impact will need to be undertaken qualitatively using information obtained from relevant local diving clubs and the BSAC. It is unlikely that any Major Adverse impacts will arise with respect to this parameter due to the location and type of areas where aggregate dredging typically occur and the fact that only a small proportion of potential diving areas will be lost temporarily. However, if the qualitative assessment indicates that an adverse impact will occur, then the mitigation measures set out in **Section 5.8** should be implemented to reduce the impact to acceptable levels (No Impact).

It is considered that, with the exception of navigational risk assessment, it is not possible to quantitatively assess the potential impact of dredging operations upon other uses of the sea. Assessment, in almost all cases, will be qualitative and entirely dependent of the presence of the receptor within a proposed dredge area.

The established criteria for impact assessment cannot be satisfactorily applied to this parameter in the same way that they can to others, e.g. marine ecology. That is, it is not possible to say whether one particular subsea cable is more sensitive, or vulnerable, than another and, perhaps more importantly, the potential loss of one life at sea is just as significant as the loss of ten.

Therefore, the framework for impact assessment, shown in **Figure 4.1**, is not wholly applicable to the assessment of impacts on navigation and other uses of the sea. Where collision impacts occur they would usually be of major significance, due to the associated risk to human life. By contrast, in the case of visual amenity and restriction to certain recreational activities, effects are likely to be considered to be of minor significance. Therefore, the framework shown in **Figure 4.5** is more likely to be applicable to the assessment of impacts for this parameter.

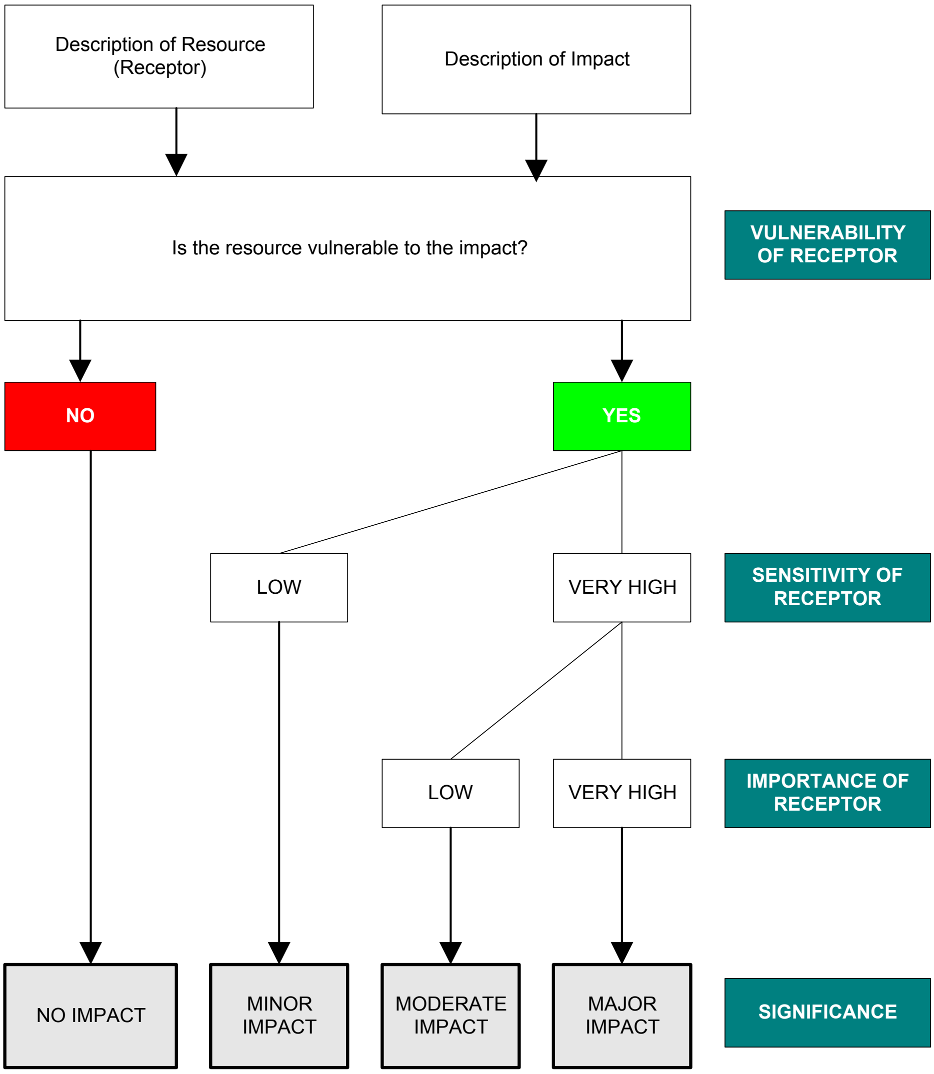

Figure 4.5 Potential decision framework demonstrating how vulnerability, sensitivity (intolerance) and importance information can be used to assign significance criteria for impacts on navigation, recreation and other uses of the sea

REFERENCES

Anatec UK Ltd (2002) East Channel Region – Navigational Risk Assessment. Report prepared for Posford Haskoning.

Posford Haskoning (2003). Regional Environmental Assessment for Aggregate Extraction in the Eastern English Channel. Report prepared for the East Channel Association.

Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

5 MITIGATION

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SECTION 5 MITIGATION

SECTION 5.1 GENERIC GUIDANCE

In the context of this document, mitigation measures are **“*Those steps taken to reduce, remove or avoid the predicted effects of aggregate dredging activity”*.**

The key objective of this document, with respect to mitigation, is not to simply provide a list of the standard measures that might be used to reduce the impacts of aggregate extraction, but also to investigate more fully how *appropriate* these measures are and how *practical* they are in terms of their implementation.

Thus, the following sections of this chapter present those mitigation measures relevant to each key environmental parameter typically proposed within aggregate extraction ESs, along with a discussion of their appropriateness and practicality.

NOTE
Many of the mitigation measures outlined in this section are already routinely implemented by the aggregates industry, either in a voluntary capacity or as part of the licence conditions attached to new permissions. **The mitigation measures outlined do not represent an exhaustive list, rather a summary of the most typical measures proposed. In practice, more ‘novel’ solutions may be required for certain projects, based on site-specific conditions.**

5.1.1 GENERIC MITIGATION MEASURES IDENTIFIED IN GUIDANCE NOTES

Existing guidance related to marine aggregate extraction and EIA (MMG1) highlights the need to minimise the potential impacts of marine aggregate extraction by identifying appropriate mitigation measures where potential concerns have been identified. Generic mitigation measures are actually listed within relevant guidance documents, such as MMG1, which are often simply replicated within site-specific ESs. For example, MMG1 suggests that the following measures (see **Box 5.1**) be adopted in order to minimise the impacts of dredging activities:

Box 5.1 Measures to avoid, reduce or remedy significant adverse effects (mitigation) as set out in MMG 1

- Modification of the dredging depth to limit changes to hydrodynamics and sediment transport patterns to acceptable levels;
- Agreed dredger navigation routes to minimise interference with shipping, fishing and other uses of the sea;
- Zoning of the permitted area to protect sensitive fisheries, optimise access to traditional fisheries and to reduce the impact on sensitive benthic assemblages;
- Exclusion zones to protect rare or stable communities identified in small areas within a much larger application area. Such exclusion zones also provide a refuge for species that may assist in the eventual recolonisation of the worked-out area. Where such an approach is considered appropriate, it is important that the exclusion zones are large enough to protect the area of critical importance;
- The choice of dredging technique and the timing and phasing of working may also assist in preventing disturbance. For example, it may be appropriate to allow dredging only at particular stages of the tide, to ensure that disturbed sediments are transported away from exclusion zones by the tide, or to prohibit screening;
- Seasonal restrictions, where appropriate, to minimise impacts on migratory fish stocks or on vulnerable life history stages of fish or the benthos; and
- Safety buffer zones around war graves, important wrecks or other marine archaeological sites, pipelines and cables.

The recently published ICES Guidelines for the management of marine sediment extraction also set out high-level mitigation measures (see **Box 5.2**).

Box 5.2 ICES guidelines for the management of marine sediment extraction: mitigation measures
• The selection of aggregate dredging equipment and timing of aggregate dredging operations to limit impact upon the biota (such as birds, benthic communities, any particularly sensitive species and habitats, and fish resources); • Modification of the depth and design of aggregate dredging operations to limit changes to hydrodynamics and sediment transport and to minimise the effects on fishing; • Spatial and temporal zoning of the area to be authorised for extraction or scheduling extraction to protect sensitive fisheries or to respect access to traditional fisheries; • Preventing on-board screening or minimising material passing through spillways when outside the dredging area to reduce the spread of the sediment plume; and • Agreeing exclusion areas to provide refuges for important habitats or species, or other sensitive areas.

In addition to these generic mitigation measures, a series of parameter-specific measures are commonly reported within aggregate extraction ESs. Details of these measures, and how they relate to parameter-specific impacts, are provided in the following sections.

Before examining the range of potential mitigation measures available to reduce the impacts of aggregate extraction on certain parameters, it is also important to note that the ***avoidance*** of damage is often the best form of mitigation.

5.1.2 THE ROLE OF CONSULTATION IN DEVELOPING MITIGATION

The importance of consultation within the overall EIA process is described in detail in **Section 1.3**. In order for mitigation to be appropriate, practical and ultimately successful, it is vital that key stakeholders are involved at some stage in the formulation of any measures proposed within the ES. Without using the site-specific knowledge often held by individuals and groups (such as local nature conservation officers and fishing industry representatives), as well as the knowledge of the industry as to what is achievable, many mitigation measures proposed may be unrealistic, impractical to implement and, consequently, unsuccessful. Therefore, it is recommended that consultation with key stakeholders is undertaken in the development of mitigation measures for aggregate extraction schemes in order to maximise the potential success of these measures. This should include the captains of the dredging vessels to ensure that proposed measures are practical at an operational level.

GOOD PRACTICE RECOMMENDATION 5.1: CONSULTATION
To increase the chances of success, the development of mitigation measures should involve some form of stakeholder consultation/engagement with key individuals/organisations within the study area.

5.1.3 RESIDUAL IMPACT ASSESSMENT

Following the determination of appropriate mitigation measures it is necessary to investigate the significance of the impact that remains (i.e. the residual impact), based on the assumption that, the mitigation proposed will be effective. The process identified for impact assessment in **Section 4.1** should also be used to assess the residual impact.

5.1.4 LINKING MITIGATION TO MONITORING

One of the key issues related to mitigation, is the need to recognise the role that monitoring plays in assessing the effectiveness of any mitigation measures imposed (as well as providing information on the actual environmental effects of the dredging activity taking place and feedback on the predictions made in the EIA).

As good practice (and as appropriate), it is recommended that the preparation of dedicated Dredge Management Plans, incorporating mitigation and monitoring requirements are developed by the applicant and/or their impact assessors as standard practice. Such plans are currently being developed by the industry. They should detail all of the key mitigation measures set out within the ES and link these to a discrete monitoring programme. A full review of the key issues related to the development of a monitoring programme is provided in **Section 6**.

GOOD PRACTICE RECOMMENDATIONS 5.2: MITIGATION AND MONITORING PLANNING
The mitigation measures set out within a Dredging Plan should be linked to a discrete monitoring programme. One of the key objectives of this monitoring should be to test the effectiveness of any mitigation measures implemented. **Key mitigation measures should be summarised within a dedicated Mitigation and Monitoring Management Plan.**

5.1.5 IMPLICATIONS OF THE NEW STATUTORY CONTROLS FOR MITIGATION

As detailed in **Section 1.4**, a new statutory system for the control of aggregate extraction license applications is being developed by the UK government. Once implemented, these statutory regulations will transpose into UK legislation, in so far as marine dredging is concerned, the provisions of EC Directive 85/337/EEC, as amended by EC Directive 97/11/EC, on the assessment of the effects of certain public and private projects on the environment.

With respect to mitigation, the new statutory regulations will signal a shift in the level of detail that needs to be provided on mitigation within the ES to be submitted in support of the license application. Under the current system, it is possible to just provide an outline plan of proposed mitigation measures within the ES. The exact details of these measures and an agreed mitigation plan, or plans, drawn up by the applicant and regulatory authorities, are then produced following discussions between these parties on the submitted ES.

Under the new system, a detailed plan of agreed mitigation measures will be required within the ES submitted to the regulatory authorities. Therefore, there will be a much greater emphasis on the applicant and their assessors to ensure that a suitable level of detail is provided, in the first instance, within the ES.

5.1.6 ON-GOING RESEARCH RELATED TO MITIGATION

There are a number of on-going research projects that are investigating measures to mitigate the effects of marine aggregate extraction. Four of the main projects are summarised below:

(a) Assessment of the rehabilitation of the seabed following marine aggregate dredging

This is a 4-year research project (2000-2004) being undertaken by CEFAS, HR Wallingford and BGS. The principal aim of the project is to provide a better understanding of the processes leading to the physical and biological recovery of the seabed following marine aggregate extraction. However, in addition, it aims to identify dredging practices that minimise environmental harm at licensed sites and promote rehabilitation on cessation.

(b) Marine aggregate site restoration and enhancement: a strategic feasibility and policy review

This study, undertaken by EMU for BMAPA and the Crown Estate, was published in March 2004. It explores the feasibility of undertaking the remediation of marine aggregate extraction sites and the supporting policy framework.

(c) A review of existing and emerging environmentally-friendly offshore dredging technologies

This project, currently in progress, is being undertaken by a group led by Baird & Associates (US), including Dredging Research Ltd (UK) and Marine Ecological Surveys Ltd (UK), on behalf of the United States Minerals Management Service (MMS). The project aims to review new and emerging technology and techniques designed to reduce the adverse environmental impacts of dredging sand and gravels in offshore borrow areas. The project is due for completion in around September 2004, with a workshop to be held in April 2004.

(d) A strategic evaluation of the impacts of aggregate extraction on marine fauna

This is a five-year project due to be completed in 2008 and, being undertaken by CEFAS (AE0916). The aim of the study is to assist government departments and the industry to more clearly determine the environmental consequences of marine aggregate extraction and, using a UK regional seas approach, provide scientifically robust advice on the sensitivity of habitats and their restoration.

GOOD PRACTICE RECOMMENDATION 5.3: LITERATURE REVIEW
The findings of on-going research projects should be reviewed and used to formulate mitigation measures within future ESs for marine aggregate extraction.

REFERENCES

EMU (2004). Marine aggregate site restoration and enhancement: a strategic feasibility and policy review. Report by EMU Ltd on behalf of BMAPA and Crown Estate. Emu Limited 04/J/1/06/0598/0414. March 2004.

SECTION 5.2 PHYSICAL PROCESSES

5.2.1 INTRODUCTION

This section provides a brief overview of the main mitigation measures that can be adopted to help minimise the impacts of aggregate extraction on physical processes (described in **Section 3.2)**. In order to link the various sections of this document together, the mitigation measures described below are grouped under the impact headings used in **Section 3.2**.

Table 5.1 Measures to reduce impacts on physical processes

<table>
<tr><th colspan="2">IMPACT</th><th>MITIGATION</th></tr>
<tr><td rowspan="5">IMPACTS ON THE COASTLINE</td><td>Aggregate extraction may cause a reduction in the shelter to a coast provided by offshore banks</td><td rowspan="5">The assessment of the significance of the impacts listed in the left-hand column is discussed in Section 4.2.

The significance of all these impacts focuses on the ‘detectability’ of the changes predicted. Due to the wider implications of any impacts on physical processes (effects on ecological function, sediment transport, coastal flood defences) any detectable change is considered to be significant. Therefore, if detectable change is predicted during the assessment process, the application should not proceed.

As a result, no (active) mitigation measures are proposed, given that steps will be taken to ‘avoid’ the impact. Alternatives should be sought.</td></tr>
<tr><td>Aggregate extraction may cause changes in wave refraction behaviour over the dredged area leading to changes in wave energy distribution adjacent to and at the coast</td></tr>
<tr><td>Aggregate extraction may cause damage to beaches as a result of beach draw-down of material into dredged area</td></tr>
<tr><td>Aggregate extraction may lead to an interruption in sediment supply to the coast</td></tr>
<tr><td>Aggregate extraction may create a change in tidal currents</td></tr>
</table>

IMPACT		MITIGATION
IMPACTS ASSOCIATED WITH THE SEDIMENT PLUME	**Aggregate extraction may lead to an increase in suspended sediment concentrations**	The creation of increased suspended sediment concentrations within the water column is an inevitable consequence of the aggregate dredging process. However, a number of mitigation measures can be put in place to minimise or reduce this change to the physical environment. These mitigation measures focus on either (**A**) seeking to reduce the increase in suspended sediment or (**B**) minimising the area affected by the increase. The appropriateness of each of these measures to a particular application will depend on the nature of the environment at the site and the resources to be extracted. The potential mitigation measures are as follows: • A.1. *Appropriate choice and operation of dredging equipment:* this is fundamental in reducing the sediment plumes arising from aggregate dredging. • A.2. *Minimising Screening:* where possible, minimising screening will reduce the magnitude of the plume. • A.3. *Dredge appropriate locations within licensed sites:* this measure involves targeting the resources to be extracted to avoid areas with finer grain sizes. It is envisaged that this would be undertaken in most circumstances as a matter of course by the dredging companies. Collation of data regarding sediment types within a licence site will enable these areas to be avoided. • B.1. *Dredge parallel to peak tidal currents:* the tidal ellipse will be an important control on the area covered by the sediment plume. Dredging along a track parallel to the orientation of peak tidal currents will reduce the area covered by the sediment plume arising from the dredging. This measure is adopted in many cases as a matter of course by the dredging companies (i.e. as an operational requirement). However, the ability of the dredging company to achieve this is driven by the geometry and orientation of the resource itself. • B.2. *Dredged area to be minimised and worked to exhaustion:* minimising the area to be dredged will act to reduce the area over which dredging will create a plume.

IMPACT		MITIGATION
IMPACTS ASSOCIATED WITH THE SEDIMENT PLUME (cont'd)	**Aggregate extraction may result in a change in seabed surface sediment composition (through deposition of sediment generated by the dredging process)**	The deposition of sediment from within a sediment plume onto the seabed is an inevitable consequence, and direct result, of the creation of sediment plumes. Therefore, any mitigation measures aimed at reducing or minimising the sediment plume, will equally apply as measures aimed at reducing the deposition of material from the plume onto the bed. Therefore, all of the suggested mitigation measures outlined above (A1 to A3 and B1 and B2) are applicable to this impact.

5.2.2 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

The following section reviews the standard mitigation measures related to reducing impacts on physical processes in terms of how appropriate they are, how practical they are to implement and how successful they are. This section has been developed through consultation with industry representatives and dredger masters who are responsible for implementing many of these mitigation measures.

Appropriateness

Mitigation measures to reduce the scale of any impacts on physical processes are highly appropriate. Physical processes are one of the dominant factors that control marine ecological processes. Therefore, any changes in physical processes can lead to knock-on effects for marine ecological resources. For this reason, it is important that suitable mitigation measures are implemented in relation to physical impacts.

Practicality

As detailed in the tables above, the most practical mitigation measure that can be adopted with respect to physical impacts, is where 'detectable' change is predicted during the EIA process, i.e. the application will not proceed. This clear, transparent framework is practical to implement as it effectively represents a simple Yes/No question, the answer to which is provided by the outputs of the EIA. It can be concluded that A1-A3 and B1-B2 are both practical and achievable as they are widely undertaken by the dredging industry as standard practice.

Success

A1-A3 and B1-B2 can be considered as being successfully implemented to date by the industry. In general, however, the success of mitigation measures should be well established; otherwise the likelihood of a significant impact remaining may be substantial. The success/failure of mitigation measures can only be demonstrated through the analysis of data from well-designed, targeted monitoring programmes. Therefore, it is important that stronger links are established between mitigation measures and monitoring programmes (see **Section 6** for more details).

SECTION 5.3 MARINE ECOLOGY (including marine mammals and sea birds)

5.3.1 INTRODUCTION

As described in **Section 3.3**, many of the impacts on marine ecological parameters are related to the physical effects of aggregate extraction activities. Therefore, many of the mitigation measures outlined in this section relate to minimising any physical effects of dredging. More details on mitigation measures to reduce physical effects are provided in **Section 5.2**.

A lot of work has been undertaken recently and is currently being undertaken in order to understand more about the effects of dredging on vulnerable resources and how to reduce the scale of these effects. There is still a requirement for more work to be undertaken to allow these aspects to be understood sufficiently to provide confidence in recommending mitigation measures for different areas. A number of site-specific conditions need to be taken into account in each case in order to identify relevant measures. The examples that follow are provided to give an insight into mitigation measures that have been utilised in the past and what needs to be considered in each case. As new information becomes available this must also be considered.

Table 5.2 Measures to reduce impacts on benthic and epibenthic resources

IMPACT	MITIGATION
Removal of the seabed will lead to a reduction in the overall amount of habitat	To reduce the impact of loss of habitats and species, the area of dredging should be minimised, as far as possible. This can be facilitated by ensuring that the resources in any one location are dredged to 'economic exhaustion' before new areas are exploited. However, such an approach would need to be within the constraints of the recommendations to leave a similar (physical) habitat following the cessation of dredging (see below). Zoning areas for dredging within the permitted area will enable activities to be concentrated in one area at a time and will enable a dredged area to recover once the 'zone' is exhausted. This should be weighed against the results of recent research which indicate that a lower intensity of dredging could reduce the significance of the effect on the benthic invertebrates (Boyd *et. al.,* 2003). In order to aid recolonisation, and where adequate vibrocore data exists, it should be possible to ensure that a similar sediment environment is left behind following dredging. This measure is aimed at the avoidance of gross change as there inevitably will be small-scale effects on the substrate due to the removal of a specific substrate type and the settlement of suspended material. In order to aid the recovery of benthic resources following the cessation of dredging, it is sometimes recommended that, dependent on the area of dredging and the homogeneity of the substrate, 'buffer zones' be left between production lanes. These un-dredged areas can aid re-colonisation by providing a source of larval recruits to the dredged areas. Seasonal restrictions on dredging could be applied, as appropriate, in order to protect particular species during their most sensitive periods. In areas where only thin layers of sand or gravel overlay bedrock, dredging should not take place. This will prevent bedrock being exposed which is unsuitable for benthic communities.
Removal of the seabed may lead to a reduction in overall species abundance, diversity and biomass	

IMPACT	MITIGATION
Increased suspended sediment concentrations caused by sediment plumes may create adverse effects on benthic organisms	General mitigation measures to reduce the effects of suspended sediment plumes are outlined in **Table 5.1**. In sites where an area to one side of the extraction site is considered sensitive to smothering, another potential mitigation measure to reduce the impacts of sediment plumes and deposition is to ensure that extraction only takes place during states of the tide when suspended sediments will be carried away from the sensitive area (where prevailing conditions and the location of the resource allows).
Deposition of suspended sediment may lead to smothering effects on benthic organisms	
Modification of seabed topography, substratum type and mobility as a result of aggregate extraction may lead to a change in benthic community structure	In certain areas, it may be possible to undertake bed levelling/seabed re-profiling where this impact is identified as a particular issue. However, re-profiling is often not possible in larger licensed areas. Using vibrocore data and knowledge of seabed characteristics it should be possible, to a certain extent, to leave behind a habitat that is similar to that which occurred prior to dredging. Inevitably there will be changes to the substrate type due to removal of material and settlement of suspended material where there is a gross change in substrate. However, at a depth indicated by the vibrocore data, dredging should be stopped before significant change occurs.
Aggregate dredging may result in the re-introduction of toxins/organic material from contaminated sediments	Baseline data should be assessed to identify any areas where sediment contaminant levels are judged to be beyond acceptable limits and where dredging may cause their release into the water column. If such areas are identified, then the dredger should avoid these.

Table 5.3 Measures to reduce impacts on marine mammals and elasmobranchs

IMPACT	MITIGATION
Noise impacts from aggregate dredging may have adverse effects on marine mammals and/or elasmobranchs	Potential noise effects on marine mammals and/or elasmobranchs are an unavoidable consequence of dredging activity and there are limited mitigation measures that can reduce this effect. However, the choice of dredging plant may influence noise emissions to a degree, as will minimising loading time and, therefore, times on site. It is also important to note that the majority of mobile species will exhibit avoidance reactions once noise levels reach limits that they find unacceptable.
Aggregate dredging may result in physical collisions between dredgers and marine mammals and/or elasmobranchs	The likelihood of marine mammals and/or elasmobranchs to physically colliding with dredgers is very low. This is due to the fact that these species will avoid the area to be dredged due to noise and disturbance impacts. Therefore, no mitigation is usually proposed. However, the strategic measure of limiting the area to be dredged will further reduce the potential risk of collision.
The removal of benthos may result in a reduction in potential food items	See mitigation above for (a) removal of the seabed will lead to a reduction in the overall amount of habitat and (b) removal of the seabed will lead to a reduction in overall species abundance, diversity and biomass.

IMPACT	MITIGATION
Increased turbidity caused by sediment plumes may have adverse effects on marine mammals and/or elasmobranchs	Mitigation measures to reduce the effects of suspended sediment concentrations are outlined in **Table 5.1**.

Table 5.4 Measures to reduce impacts on sea birds

IMPACT	MITIGATION
Direct removal of benthos and fish through aggregate dredging would reduce the abundance of potential prey items for sea birds and adversely affect sea bird feeding	See mitigation above for (a) removal of the seabed will lead to a reduction in the overall amount of habitat and (b) removal of the seabed will lead to a reduction in overall species abundance, diversity and biomass.
Noise impacts from aggregate dredging may create adverse effects on sea birds	Potential noise effects on sea birds are an unavoidable consequence of dredging activity and there are limited mitigation measures that can reduce this effect. However, the choice of dredge plant may influence noise emissions to a degree, as will minimising loading times and, therefore, time on site. It is also important to note that bird species are mobile and will exhibit avoidance reactions once noise levels reach limits that they find unacceptable.

5.3.2 REMEDIATION AND ENHANCEMENT

As discussed in **Section 5.1.6**, there is on-going research being carried out to explore the potential for the remediation and enhancement of marine aggregate sites following the cessation of dredging.

5.3.3 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

The following section reviews the standard mitigation measures related to marine ecological parameters in terms of how appropriate they are, how practical they are to implement and how successful they are (based on results from actual extraction sites). This section has been developed through consultation with industry representatives and dredger masters who are responsible for implementing many of these mitigation measures. However, for the most comprehensive development of mitigation measures, iteration between key stakeholders should be undertaken. It is also worth considering that, in some instances, the only suitable mitigation measures may be ones not used by the aggregates industry before.

Appropriateness

With respect to benthic and epibenthic communities, aggregate extraction has the potential to have impacts on these resources through their direct removal from dredged areas and smothering effects in areas subject to increased sediment deposition. The importance of these resources has been well documented throughout this guidance, with one paper suggesting that as much as 30% of total fish production is dependent on conversion through the communities which live on the seabed (Newell *et. al.,* 1998). These resources form an essential component of the wider marine ecosystem and it is for these reasons that dedicated mitigation measures are required in order to reduce any impacts. Therefore, all of the measures outlined above are judged to be appropriate, in the relevant circumstances.

In terms of defining appropriate mitigation measures, it is important to identify the sensitivity of the receptor to the particular impact and to determine the overall effect of the action on it. For example, there have been situations recently where a particular species (*Sabellaria spinulosa)* has been found at a site and immediately there has been an alert triggered to avoid the area. This species is defined as a UK BAP species and as such is subject to certain management measures. The primary importance associated with this species is the reefs that they build and the associated species that rely on the reef for shelter and as a food resource. However, this species does not always exist in the reef building form and protection could, in certain situations, be given unnecessarily.

It is important to note that the mitigation measures outlined above are not an exhaustive list and that novel technologies or practices may also be available. For this reason, the user is again encouraged to ensure that all relevant research publications are reviewed as part of the identification of mitigation measures (see **Section 5.1.6**).

Practicality

The key measures adopted to reduce impacts on marine ecological resources are outlined in **Table 5.2**. In many cases, it is in the interest of an operational dredger to adopt these measures anyway, for economic and practical reasons. That is, in economic terms, most dredgers would seek to limit screening in order to reduce loading times which, in turn, represents important time and cost savings. In practical terms, dredging parallel to the tide is also undertaken, as most dredgers are not able to dredge across the tide due to mechanical constraints. With regard to leaving behind a suitable substrate following the cessation of dredging, this should be possible where the change is considered to be significant and can be identified through vibrocore data analysis.

It is also practical to avoid sensitive areas, such as *Sabellaria* reefs, as these areas are usually identified during marine ecological baseline surveys and clearly marked upon charts. In practice, dredging is undertaken in 'lanes', typically 100-250m wide. If a sensitive feature is located in one 'lane', then the dredger master will usually only dredge in adjacent lanes. However, one measure that is sometimes judged impractical is the creation of dredging zones. In principle, the establishment of zones within overall licence areas is simple and practical to implement. However, in many cases, these zones are fixed, usually for 6-month periods. It would be more practical for the dredging industry if the time-period over which the zones were fixed was more flexible.

Many of the mitigation measures suggested will be practical in certain situations but not in others. Each situation should be assessed on a case-by-case basis in order to determine practicality. Research is being undertaken on some of these measures which should provide knowledge to help determine their practicality and effectiveness.

Success

There are two issues to consider in this regard. Firstly, how successful is the actual implementation of these measures and, secondly, how successful are these measures in reducing the impacts of aggregate dredging on marine ecological resources?

With respect to the first point, it is generally felt, by both the aggregates industry and regulatory bodies, that the mitigation measures described above can be and are successfully implemented during the operational phase of a dredging scheme. Using zoning as an example, BMAPA and The Crown Estate routinely produce active zoning charts which provide detailed information on the zoning of marine aggregate licence areas located around the coastline of England and Wales. This bi-annual series of charts define the current active dredge area for eight separate regions and also contain the associated co-ordinates for each licence area together with contact details for the operating companies. The active dredge area charts are available to be downloaded from the websites of both BMAPA (***www.bmapa.org***) and The Crown Estate (***www.crownestate.co.uk***), and copies are also distributed via the established dredging liaison committees on the South and East coasts. The charts will be updated biannually, with the next issue due at the beginning of July 2004.

It is much more difficult to comment on the second point, that is, whether or not these measures are successful in actually reducing any impacts. The reason for this is that the success of mitigation in reducing the scale of any impact can only be truly assessed through the analysis of monitoring data collected specifically to indicate the success/failure of a particular measure. Unfortunately, there is a lack of suitable data from well-designed, targeted monitoring programmes, to be able to make any judgement as to which 'standard' mitigation measures are successful and which are less so. This issue of designing targeted monitoring programmes that are strongly linked to demonstrating the success/failure of mitigation measures is a key one with respect to aggregate extraction and EIA and, as such, is discussed further in **Section 6**.

GOOD PRACTICE RECOMMENDATIONS 5.4: MITIGATION MEASURES FOR MARINE ECOLOGY
The area of dredging (the spatial footprint) should be minimised, as far as possible. This can be facilitated by ensuring that the resources in any one location are dredged to 'economic exhaustion' before new areas are exploited. **Zoning dredging within the permitted area will enable activities to be concentrated in one area at a time and will enable a dredged area to recover once the 'zone' is exhausted.** **In order to aid recolonisation, it should be possible to ensure that a similar habitat is left behind following dredging.** **In order to aid the recovery of benthic resources following the cessation of dredging, undredged 'buffer zones' should be left between production lanes.** **In areas where only thin layers of sand or gravel overlay bedrock, dredging should not take place. This will prevent bedrock being exposed which is unsuitable for benthic communities.** **When proposing mitigation measures to reduce impacts on key species, e.g. *Sabellaria spinulosa*, always consider the appropriateness of the mitigation, i.e. is the *Sabellaria* being protected in its reef building form? If not, is mitigation to avoid damage appropriate?** **When developing mitigation measures ensure that all relevant research projects are reviewed and any novel technologies available considered.**

REFERENCES

Boyd, S.E., Limpenny, D.D, Rees, H.L, Cooper, K.M. and Campbell, S. (2003). Preliminary observations on the effects of dredging intensity on the re-colonisation of dredged sediments off the south-east coast of England (Area 222). Estuarine, Coastal & Shelf Science **57** (2003): 209-223.

EMU (2004). Marine aggregate site restoration and enhancement: a strategic feasibility and policy review. Report by EMU Ltd on behalf of BMAPA and Crown Estate. Emu Limited 04/J/1/06/0598/0414. March 2004.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed *Oceanography and Marine Biology*: *An Annual Review*, **36**: 127-178.

SECTION 5. 4 NATURE CONSERVATION

5.4.1 INTRODUCTION

This section provides guidance on mitigation measures that can be adopted to reduce impact on key aspects of nature conservation interest, e.g. designated areas and protected species.

Measures to avoid adverse impact on habitats or species that are protected by nature conservation legislation (or likely to be proposed for protection)

Suitable mitigation measures to offset identified adverse impacts on ecological and biological interests are covered in **Section 5.3**.

With respect to sites and features designated under the Habitats Directive and Birds Directive (European Sites) and, thus, covered by the Conservation (Natural Habitats &c.) Regulations 1994, the procedural aspects of how measures to avoid adverse impacts should be dealt with is covered through the Appropriate Assessment (Regulation 48) process.

Measures to avoid adverse impact should be built into and contained within any proposal for aggregate extraction. As part of the 'appropriate assessment' process, as outlined in English Nature's Habitats Regulations Guidance Note (HRGN) 1, the determination of adverse effect on the integrity of the site (i.e. the European Site) is made with respect to any residual effects (i.e. the effects remaining after mitigation). The procedures following this stage in the assessment process are explained in HRGN1 and the reader is referred to this document for more detail. However, in summary, if a proposal is determined to adversely affect the integrity of a European Site, then the competent authority should determine whether the proposal could be modified, or conditions or restrictions imposed so as to avoid the adverse effects. Such measures could include, for example, changes to the location or extent of the proposed works and/or the timing or specific activities and the use of obligations or legal agreements. In effect, this stage of the assessment procedure provides further opportunity for suitable measures to be sought to offset the impact and included in the overall project. Compensatory measures seeking to redress but not remove residual adverse effects on designated international interests cannot be considered in the appropriate assessment, but may be considered later in the decision making process (Reg. 53 of the Habitats Regulations).

There are no specific measures or procedures for dealing with the amelioration of effects likely to impact upon areas and species designated and protected under the Wildlife and Countryside Act 1981. Both generic and specific methods for avoiding adverse impacts are detailed in **Section 5.3** and these are likely to appropriate for use in the vast majority of situations where impacts on SSSIs and protected species need to be ameliorated. However, it is important throughout the assessment process to ensure that, where impacts of a very specific nature are identified, tailored measures to offset harm are employed. This is particularly likely to be the case with respect to protected species populations that may be affected through specific pathways (e.g. auditory impacts on cetaceans).

Measures to offset adverse impacts on Biodiversity Action Plan (BAP), Species Action Plan (SAPs) or Habitat Action Plan (HAP) features

There are no specific ways or procedures for dealing with the mitigation of impacts on BAP species , SAP species or HAP features. Suitable measures to offset such potential impacts are effectively covered through the guidance presented in **Section 5.3**. However, specific reference should be made to BAP objectives and targets for potentially affected species and habitats contained in BAP plans. Measures to offset or avoid impacts should be geared to ensure compliance with adopted objectives and targets.

Measures to offset adverse effects on other features of nature conservation interest, i.e. those not protected by nature conservation legislation

There are no specific ways or procedures for dealing with the mitigation of impacts on features of nature conservation interest not covered by legislation. Suitable mitigation measures for such impacts are effectively covered through the guidance presented in **Section 5.3**.

REFERENCE

English Nature (2001) The Appropriate Assessment (Regulation 48): The Conservation (Natural Habitats &c.) Regulations, 1994. Habitats Regulations Guidance Note 1. Issued by Greg Smith, Environmental Impacts Team, English Nature, Peterborough.

SECTION 5.5 FISH AND SHELLFISH RESOURCES

5.5.1 INTRODUCTION

In order to link the various sections of this document together, the mitigation measures described below are grouped under the impact headings used in **Section 3.5**.

Many of the mitigation measures designed to reduce impacts on the physical environment also act as mitigation for potential impacts on the marine ecological environment. This is due to the close links between physical changes and ecological changes. In addition to the measures proposed to reduce impacts on the physical environment, the following mitigation measures have also been identified.

Table 5.5 Measures to reduce impacts on fish and shellfish resources

IMPACT	MITIGATION
Dredging works will lead to a loss of benthic species resulting in reduced food availability for fish and shellfish (and decreased productivity)	Measures to reduce the impacts of aggregate extraction on benthic species are provided in **Table 5.2**.
Fish and shellfish will be entrained through direct uptake	The uptake of fish and shellfish species is an unavoidable effect associated with aggregate extraction dredging. Therefore, there are limited mitigation measures available to minimise this effect. However, one potential mitigation measure is the use of temporal/spatial restrictions on dredging activity, to protect sensitive stages of a species life-cycle (e.g. migration, over-wintering); see **Box 5.3**.
Noise generated by extraction may impact on fish and shellfish	Potential noise effects on fish and shellfish are an unavoidable consequence of dredging activity and there are limited mitigation measures that can reduce this effect. However, the choice of dredge plant may influence noise emissions to a degree, as will minimising loading times and, therefore, time on site. It is also important to note that the majority of mobile species will exhibit avoidance reactions, once noise levels reach limits that they find unacceptable.
Effects of sediment plumes (and deposition)	Mitigation measures to reduce the effects of suspended sediment concentrations are outlined in **Section 5.2**. Dredging activity should also be moved from any areas where aggregations of particularly sensitive species are identified (e.g. spawning herring and sand-eel, over-wintering crabs), or screening strategies should be modified to reduce the level of suspended sediment concentration.

Box 5.3 "Environmental windows"

*Environmental windows associated with dredging operations are **temporal/spatial constraints** placed on dredging or dredged material disposal operations such that sensitive biological resources or their habitats may be protected from potentially detrimental effects. Environmental windows are based on the assumption that potential conflicts or detrimental effects may be avoided if dredging or placement of dredged material is prevented during times when biological resources are most sensitive to disturbance* (in, NY and NJ Harbour Navigation Study, Mitigation of Navigation Improvement Impact, September 1999).

Section 5.5.2 provides further information on the perceived effectiveness of environmental windows.

5.5.2 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

The following section reviews the standard mitigation measures related to fish and shellfish resources in terms of how appropriate they are, how practical they are to implement and how successful they are (based on results from actual extraction sites). This section has been developed through co-ordination with representatives of the aggregates industry and regulatory bodies.

Appropriateness

The majority of the standard mitigation measures outlined above are required to reduce the significance of key impacts on both ecologically and commercially valuable fish and shellfish resources. Without suitable mitigation to reduce these impacts, significant effects could arise that would have knock-on effects in terms of wider ecosystem function and could create economic impacts through reduced catches for commercial fishermen (see **Section 3.5**).

With respect to temporal/spatial restrictions on dredging activity, a technical note produced by the Dredging Operations and Environmental Research (DOER) Program (Technical Note DOER-E2, 1998) summarised the key issues related to the application of such constraints for Federal navigation projects in both marine and freshwater systems. From this review, it was clear that although applied to up to 80% of Federal projects within the USA, temporal/spatial restrictions are viewed as being overly conservative and based largely on poorly quantified data or merely on subjective opinion.

Unfortunately, the type of well-quantified data that may enable these constraints to be less restrictive does not, in most instances, currently exist. Therefore, they are usually applied as part of a 'precautionary approach' and still represent the most appropriate method of minimising the risk of impacts on key species or habitats. Until quantified data exists on key impacts, e.g. herring spawning beds can cope with **X**mm of sediment deposition, deposited at a rate of **X**mm/hr, then such measures will continue to provide effective mitigation.

Once quantified data on key impacts is obtained, it is believed that the use of temporal/spatial constraints, where dredging activity is required to cease *entirely* for a certain period, will become very limited. Instead, during sensitive periods, i.e. herring spawning, threshold limits for key effects, such as suspended sediment concentrations or rate of deposition, will be able to be set and the dredger made to carry out its activity in a way that ensures that these threshold limits are not compromised.

If these threshold levels are reached or exceeded, then a feedback monitoring system should be used to inform the dredger so they can either modify the dredging or cease works entirely until levels fall back below threshold value (see **Section 6** for a full review of monitoring feedback processes).

Practicality

The 'practicalities' of applying the mitigation measures outlined above, have been discussed with representatives of both the aggregates industry and regulatory bodies, through a series of meeting dedicated to mitigation (and monitoring). From these meetings, it is possible to note that, with respect to routine operational dredging procedures, the majority of mitigation measures described are practical and relatively easy to implement. Temporal/spatial restrictions can usually be accommodated as, during these periods, dredging activity simply shifts to other locations within the overall licensed area.

Any mitigation that aims to reduce screening and loading times is also practical, as the commercial drivers of aggregate dredging result in dredgers aiming to minimise these activities, as far as possible, in order to reduce time and costs.

Success

The perceived success of general mitigation measures has been discussed with representatives of both the industry and regulatory bodies. From these discussions it is clear that, at the most basic level, temporal/spatial constraints are deemed to be successful as they demonstrate a clear, transparent action by the dredging applicant to reduce or cease activity at critical times of year with respect to fish and shellfish resources. However, at the more scientific level, there is still a degree of uncertainty related to the apparent 'success' of environmental windows. The reason for this uncertainty is that many monitoring programmes developed for aggregate extraction schemes are not linked closely enough to mitigation measures, i.e. many monitoring programmes are simply designed to show trends in time and space and not to prove/disprove the success of a specific mitigation measure.

Therefore, it is essential that mitigation measures are linked to well-designed monitoring programmes in order that the success (or failure) of these measures can be scientifically proven.

REFERENCES

DOER (1998). Environmental Windows Associated with Dredging Operations. Technical Note DOER-2. December 1998. Dredging Operations and Environmental Research Program.

LTMS Management Plan (Draft) (2000) (Derived from the Hartman Consulting Group presentation "How to Develop and Manage Successful Dredging Projects", June 2000.

National Research Council (2001). Environmental Windows for Dredging Workshop. Workshop materials and notes (by C. Simenstad) derived from March 19-20, 2001 workshop, Washington D.C.

New York and New Jersey Harbour Navigation Study (1999). Mitigation of Navigation Improvement Impact, September 1999.

SECTION 5.6 COMMERCIAL FISHERIES

5.6.1 INTRODUCTION

This section of the guidelines provides a brief overview of the main mitigation measures that can be adopted to help minimise the effects of aggregate extraction on commercial fisheries. Obvious parallels exist with **Section 5.5** (fish and shellfish resources). The mitigation measures described below are grouped under the various effect headings used in **Section 3.6**.

Table 5.6 Measures to reduce impacts on commercial fisheries

IMPACT	MITIGATION
The distribution of fish and shellfish may change due to fish and shellfish directly avoiding aggregate dredging works	Direct avoidance of dredging works by fish and shellfish is likely to occur due to a combination of the noise produced by the dredger and turbidity plumes created by the dredging activity. Mitigation measures for both of these impacts are outlined in **Section 5.4**. Therefore, reference should be made to this section for mitigation measures relevant to these effects.
The distribution of fish and shellfish may change due to the loss of feeding grounds as a result of aggregate dredging works	Mitigation measures to reduce the effect of the removal of benthos from an aggregate site are discussed in detail in **Section 5.3**.
Fish and shellfish will be entrained through direct uptake, which will, consequently, result in adverse effects on commercial fisheries dependant on these species	Mitigation measures to reduce the effect of direct entrainment of fish and shellfish from an aggregate site are discussed in detail in **Section 5.4**.
Aggregate extraction may create adverse impacts on spawning which will, consequently, result in adverse effects on commercial fisheries dependant on spawning aggregations	Similarly, mitigation measures designed to minimise any adverse effects on spawning of key resource species are discussed in **Section 5.4**.
Exclusion from fishing grounds may result in 'squeeze effects' on adjacent fishing areas (increased fishing pressures)	Mitigation measures to minimise squeeze effects include minimising the areas licensed and the area worked (through zoning). These measures are discussed in **Table 5.2**.

IMPACT	MITIGATION
Aggregate extraction may interfere with established trawl tows	This effect is closely related to reduced access to existing fishing grounds (see above). For this reason, the mitigation measures are very similar. Again, it is important that an accurate description of fishing activity within the study area is obtained. More specifically, for this potential effect, the location of established trawl lines should be described. This will only be able to be done through effective consultation and liaison with local fishermen. However, in practice, fishermen would be unlikely to trawl in areas actively used for aggregate extraction, given the significant risk of damage to their gear.
Aggregate extraction may result in the physical exclusion of fishing vessels from licensed extraction areas, resulting in reduced catches	One of the main effects of aggregate extraction on commercial fisheries is the physical exclusion of fishing vessels, including charter boats, from licensed areas. To minimise this effect, a number of mitigation measures that are recommended. Restricted access to the licence area by fishing vessels should be limited to the exact zone being dredged for the periods of dredging activity, i.e. not the entire license area. The maximum active dredging area should also be restricted at any one time and consideration given to timing any dredging operations to avoid sensitive times of year with respect to fishing activities. A Code of Practice also already exists that sets out the need for and method of liaison between the fishing and aggregate industries. This Code includes a standard requirement for dredging vessels to broadcast their intention to dredge on Channel 16 one hour prior to commencing operations. Under certain site-specific conditions, there may be a requirement to formalise navigation arrangements to and from the site and agree potential scheduling and zoning of dredging works with the local fishing industry. In such a situation, a standard Fisheries Liaison post should be set-up. It is essential that representatives of the fishing industry are involved in the appointment of an individual to this important post. In some areas of the UK, where aggregate extraction activities are more intensive than others (e.g. the south and east coasts of England), dedicated fisheries liaison groups have been created. The South Coast Aggregates Fisheries Liaison Group was set up in order to provide better liaison between the dredging and fishing industries along the South coast (West of the Isle of Wight to Kent), to minimise interference and to provide a forum for discussion of matters of mutual interest. This group meets twice a year and provides an opportunity for the fishing industry to raise concerns and for these to be discussed in a constructive way. It is recommended that similar groups are set up in areas where aggregate dredging activities have the potential to conflict with commercial fishing activity. The original liaison group was the East Coast Dredging Fishing Liaison Committee.
Aggregate extraction may lead to changes to sea-bed topography leading to the potential exposure of bedrock features, or other 'fasteners', that may cause trawl gear to come fast	Successful beam and otter trawling is mainly undertaken in areas of relatively flat seabed, free of obstructions known as 'fasteners'. Aggregate extraction activities can result in the physical alteration of the seabed, including the lowering of the level of the seabed, the creation of trailer marks and depressions on the seabed and the exposure of boulders previously covered by a layer of sediment. The creation or exposure of these features can lead to difficulties in certain fishing activities in particular trawling, as the trawl gear is liable to come fast on these features, once dredging ceases.

IMPACT	MITIGATION
	To minimise these impacts, in particular the potential exposure of 'fasteners', it is recommended that a layer of substrate (gravel/sand) should be left above the bedrock. Under existing licence conditions within the UK, there is already a requirement to leave 0.45m of sand/gravel over bedrock.
Aggregate extraction may cause damage to fishing gears	In addition to excluding fishing vessels from license areas, aggregate extraction activities also have the potential to cause damage to fishing gears. This can arise directly through actual physical damage to gears such as strings of crab-pots and nets (static gear) by the dredger vessel or drag-head. Indirectly, aggregate extraction can potentially expose sub-sea cables or pipelines. The exposure of these features also has the potential to damage fishing gears, through snagging and fastening. However, mitigation measures are available: Under existing practices, no Dredging Zones of 250m and Dredging Notification Zones up to 500m are established around sub-sea cables and pipelines during extraction in order to reduce the risk for damage (see **Table 5.10**). There is an operational code of practice in place to facilitate aggregate industry and fisheries liaison. In areas where there is the potential for conflict to arise between dredgers wishing to access licensed sites and commercial fishing activity, a measure that can be adopted is the creation of defined access routes to and from the licence area, the positions of which are then communicated to local fishermen. By doing this, and ensuring that all dredgers follow these defined routes, fishermen will know which areas of seabed they should avoid setting gears in. However, this is not a generic requirement and is only relevant under certain scenarios.
Aggregate extraction may lead to a reduction in income for commercial fishermen who usually obtain a proportion of their income from the extraction area	Dredging activity has the potential result in a reduction in income due to reduced catches and landings. The potential for reduced income for commercial fishermen will be related to the physical, biological and chemical effects caused by dredging activity, described in previous sections. Therefore, the majority of mitigation measures proposed to minimise these effects will, either directly or indirectly, mitigate the potential adverse economic effects that may be experienced by commercial fishermen. In addition to these measures, the consultation process is used to resolve concerns through appropriate mitigation and monitoring (BMAPA*, pers.comm. 2004*).

5.6.2 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

Appropriateness

The key impacts related to commercial fisheries can be roughly divided into (a), effects on fish and shellfish resources, leading to reduced catches for commercial fishermen, and (b), physical effects of dredging activity, i.e. increased collision risk, reduced access to fishing grounds and the potential loss or damage to gear.

The appropriateness of mitigation measures to reduce impacts on (a), fish and shellfish resources are discussed in **Sections 5.4**. With respect to (b), mitigation measures currently proposed are judged to be appropriate to the level of impact that may arise on commercial fisheries.

Practicality

The majority of mitigation measures designed to reduce the threat of collision risk and disturbance to commercial fishing vessels from dredging activity are highly practical, as they are based on basic seamanship and existing best practice. All of the measures proposed, such as informing vessels on a common VHF channel (16) of the ETA for a dredger at a particular location within 10 miles of the site, are simple to implement and are already carried out by aggregate dredgers.

Success

The success of the majority of mitigation measures related to the commercial fishing industry relies heavily on communication between the two industries. For this reason, it is important that well-established lines of communication be established early in the process. Such links should be put in place at the early consultation/scoping stage and maintained throughout a projects life-cycle. In areas where commercial fishing activity is high, the creation of a fisheries liaison post should be considered. However, such a position will not be required in all circumstances.

With respect to using defined access routes to and from licence sites to reduce the damage to fishing gears, this has also been proven to be successful in certain license areas on the South coast (Angus Radford, Defra SFI, *pers. Comm..*). However, the demarcation of the boundaries of the licence area with marker buoys has not been as successful as other measures and, therefore, should not be used in isolation to inform fishing vessels of the boundaries of licence areas. In practice, all fishing vessels have navigation plotters or GPS, so licence and zone boundaries can be accurately plotted without the need for such buoys.

The operational Code of Practice includes a requirement for liaison between the industry and fishermen. An example of a successful measure that has been put into practice on the South coast, is that aggregate companies operating in this area regularly fax their predicted vessel movements through to a central point; the office of a local fishing company (Angus Radford, Defra SFI, *pers. Comm.*). By doing this, the information can then be accessed easily by local fishermen through a visit to the office or, alternatively, the information can be re-issued from this central point to other fishermen in the region via phone, fax or post. Finally, with respect to zoning, Active Dredge Area Charts are now produced by BMAPA and The Crown Estate, following discussions with the fishing industry, that identify the need for clear and up-to-date regional overviews. Further details of these are provided in **Section 5.3.3**.

GOOD PRACTICE RECOMMENDATIONS 5.5: MITIGATION MEASURES FOR COMMERCIAL FISHERIES
The success of mitigation measures aimed at reducing the impacts of dredging on commercial fishing activity rely heavily on clear communication between the two industries. Therefore, the lines of communication between these industries established at the start of the process (initial consultation and data collection) should be maintained throughout the project life-cycle, so that mitigation measures can be easily and successfully implemented. **The existing zoning of dredging activity is generally perceived to be an effective way of reducing the physical exclusion of fishing vessels from licensed sites and should be continued. Active Dredge Area Charts produced by BMAPA and Crown Estate should be obtained and used.** **If site-specific conditions require them, well-defined access routes to and from the site should be established and these communicated to local fishermen prior to dredging beginning.** **If site-specific conditions require them, predicted dredger movements could be issued (by fax/post) to a central contact point, where they can be easily disseminated to local fishermen. However, this measure need not be applied generically to every site.**

REFERENCES

Angus Radford, Southern Region District Inspector, Defra Sea Fisheries Inspectorate. *Personal Communication*, 2003.

SECTION 5.7 ARCHAEOLOGY AND CULTURAL HERITAGE

5.7.1 INTRODUCTION

This section provides a brief overview of the main mitigation measures that can be adopted to help minimise the impacts of aggregate extraction on archaeological and cultural heritage, described in **Section 3.7**. Mitigation for all dredging activities should conform with the advice set out in *Marine Aggregate Dredging and the Historic Environment: assessing, evaluating, mitigating and monitoring the archaeological effects of marine aggregate dredging* (BMAPA and English Heritage, 2003), as well as that obtained through discussion with the relevant statutory consultees.

The mitigation measures described below are grouped under the various impact headings used in **Section 3.7**.

Table 5.7 Measures to reduce impacts on archaeology and cultural heritage

IMPACT	MITIGATION
Aggregate extraction may result in the direct loss of archaeological and historical resources situated within the sand and gravel of the extraction site	*Known wrecks and prehistoric sites:* • Dredging exclusion zones; and • Recording and conserving prior to dredging. *Unknown wrecks and prehistoric sites:* • Reporting of fortuitous discoveries (although the difficulty of intercepting prehistoric material in the course of dredging and screening is acknowledged); • Implementing dredging exclusion zones if wrecks or material is found in a coherent area; and • Recording and conserving finds.
Aggregate extraction may result in the drawdown of surrounding sediments, exposing remains to increased biological and chemical degradation, as well as potential disturbance to the context of the remains, which results in the loss of the archaeological and historical resource	*Known wrecks and prehistoric sites:* • Dredging exclusion zones; • Monitoring to ascertain whether slumping and drawdown is occurring and instigate re-stabilisation techniques (e.g. placement of material over the site, considering the discussion given in "**Appropriateness**", overleaf); and • Recording and conserving finds. *Unknown wrecks and prehistoric sites:* • Reporting of fortuitous discoveries (although the difficulty of intercepting prehistoric material in the course of dredging and screening is acknowledged); • Implementing dredging exclusion zones if wrecks or material is found in a coherent area; • Monitoring to ascertain whether slumping and drawdown is occurring and instigate re-stabilisation techniques (e.g. placement of material over the site); and • Recording and conserving finds.

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IMPACT	MITIGATION
Aggregate extraction may result in the erosion of sediment in the area, exposing remains to increased biological and chemical degradation, as well as physical degradation from currents, which results in the loss of the archaeological and historical resource	*Known wrecks and prehistoric sites:* • Monitoring to ascertain whether erosion is exposing material in areas of erosion, and instigate re-stabilisation (e.g. placement of material over the site); and • Recording and conserving finds. *Unknown wrecks and prehistoric sites:* • Reporting of fortuitous discoveries; • Instigate re-stabilisation techniques if coherent sites and wrecks become exposed; and • Recording and conserving finds.
Dredging and indirect reduction of sediment may result in the removal of the protective overburden, leaving remains with insufficient cover to protect from activities such as trawling	*Known wrecks and prehistoric sites:* • Monitoring to ascertain whether sites or wrecks are becoming exposed if there is a risk of other disturbing activities following the dredge, and instigate re-stabilisation if sites are exposed; and • Recording and conserving finds.

5.7.2 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

The following section reviews the standard mitigation measures related to archaeology and cultural heritage in terms of how appropriate they are, how practical they are to implement, and how successful they are (based on results from actual extraction sites). This section has been developed through consultation with industry representatives who are responsible for undertaking many of these mitigation measures.

Appropriateness

For coherent sites and wrecks, the use of exclusion zones is an effective and easily implemented method of mitigating any potential adverse effects due to the direct disturbance of dredging and the indirect effect of drawdown. In terms of the overall dredge area, exclusion zones do not generally result in a significant loss of the potential resource to be dredged. However, in some cases, the exclusion zone could inhibit access to a resource. Consequently, there may be a need to determine the extent and importance of a site to a greater degree. For unknown wrecks and sites, the use of exclusion zones is only appropriate once some indication of the location and extent of the site or wreck has been established. Even if the actual type and importance of a site is unknown exclusion zones could be used in principal.

The use of re-stabilisation techniques on known sites is not considered to be the most appropriate approach, mainly due to expense, but also due to the lack of current knowledge regarding re-stabilisation and its effectiveness within UK waters. Wherever possible, exclusion is preferable. The use of any re-stabilisation technique should be discussed and agreed with the statutory consultees. For unknown sites and wrecks, the use of re-stabilisation techniques is again considered inappropriate for the reasons mentioned above, with exclusion being the most effective and least costly method. The nature of any site being considered for re-stabilisation would need to be determined prior to the identification of the appropriate technique and, as above, the agreement of statutory consultees sought.

Recording and conserving finds from known sites or wrecks is appropriate if the sites are small in scale. However, costs mount significantly the greater the size and complexity of a site or wreck. On the whole the preference would be for the declaration of exclusion zones, where practicable. In terms of unknown sites or wrecks being exposed as a result of dredging, drawdown, erosion or secondary indirect effects (e.g. trawling), the recording and preserving of finds is an appropriate technique to use for disturbed finds, although (again) the use of exclusion zones are more appropriate for the preservation of the remaining site or wreck. However, judgement as to the approach to be adopted needs to be based on information regarding the extent and preservation of the remainder of the site or wreck.

Practicality

The use of exclusion zones is a practical measure given the continual location monitoring that is undertaken as part of the operation of a dredge area and due to the use of modern technology to locate and position the vessel. Exclusion areas can therefore be readily avoided.

On the whole, the lack of current knowledge over the effectiveness of stabilisation techniques inhibits its inclusion as a practical method of mitigation. Further research in the future may alter this position.

Recording and conserving of finds is not entirely practical for unknown sites. Not only are the finds likely to be damaged during the dredging process, as a result of exposure to biological and chemical degradation, or erosion processes or other activities (e.g. trawling), but the difficulty in locating the finds within the dredged material makes this extremely impractical.

Success

Exclusion zones have a high probability of success in f preventing any change to the existing nature of a site or wreck.

Due to the lack of current knowledge regarding re-stabilisation methods or their effectiveness, these techniques are currently perceived to have a low probability of preventing any further deterioration of a site or wreck. This is also dependent on the time lag between disturbance, identification of the fact that a site or wreck has been disturbed and the re-stabilisation action.

Recording of finds from known wrecks and sites is successful in terms of preserving information regarding a specific site and providing finds for various types of further analyses. Conserving finds from known sites or wrecks, obtained through excavation or other form of organised collection, can prevent deterioration of the materials. However, due to the nature of finds and material, rapid deterioration often occurs on their removal from the preserving layer, so some degree of deterioration is expected. The recording and conserving of finds from unknown (discovered) sites or wrecks is not considered to be hugely successful, due to the fact that the context of the finds and the inter-relationships that can be determined from their original positioning are usually lost as they are found. However, this should not prevent an emergency action plan being produced in the event that unknown wrecks or sites are disturbed, as some degree of information can be obtained by analysing and conserving the remaining finds, even though potentially extensive deterioration may have occurred, depending on the time lag between disturbance, discovery and the implementation of conservation techniques.

REFERENCE

BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment Guidance Note*. British Marine Aggregate Producers Association and English Heritage, London.

SECTION 5.8 NAVIGATION, RECREATION AND OTHER USES

5.8.1 INTRODUCTION

The potential impacts of marine aggregate extraction on navigation and other uses are described in **Section 3.8**. This section of the guidelines provides a brief overview of the main mitigation measures that can be adopted to help minimise these impacts. It should be noted that many of the measures outlined below are ones that have been developed for site-specific extraction licenses. Other, alternative measures may be required for sites where site-specific navigation issues exist. It is also important to recognise that the majority of these measures are standard operating requirements for all shipping and are, therefore, routinely applied.

Table 5.8 Measures to reduce impacts on navigation

IMPACT	MITIGATION
Aggregate extraction may increase the risk of collision between dredging vessels and commercial shipping	There are a wide range of standard mitigation measures that are routinely adopted to reduce the risk of collision between commercial shipping, which includes aggregate dredgers. These include compliance and observance with the measures set out in the following key documents: 1. International Regulations for Preventing Collision at Sea 1972 (COLLREGS); 2. International Safety Management (ISM) Code; and 3. International Convention for the Safety of Life at Sea (SOLAS). As standard operating practice, aggregate dredgers in UK waters must comply with all the measures set out in these regulations and codes. In addition to these generic 'laws of the sea', aggregate dredgers also routinely liaise with the UK Hydrographic Office to ensure that details of dredging activity are included in Navtex broadcasts, Notices to Mariners and Admiralty Charts of the area.

Box 5.4 Automatic Identification Systems (AIS)

AIS is a new system with the potential to make a significant contribution to the safety of navigation at sea. In 2000, the IMO adopted a new requirement (as part of a revised chapter V of the SOLAS Regulations) for ships to carry AIS capable of providing information automatically about the ship to other ships and to coastal authorities. The regulation requires that AIS shall:

- provide information - including the ship's identity, type, position, course, speed, navigational status and other safety-related information - automatically to appropriately equipped shore stations, other ships and aircraft;
- receive automatically such information from similarly fitted ships;
- monitor and track ships; and
- exchange data with shore-based facilities.

AIS will be required to be fitted on all of the following:
- All ships 300 gross tonnes (gt) and upwards on international voyages or calling at a port of a Member state of the EU;
- Cargo ships of 500 gt and upwards not engaged on international voyages; and
- All passengers ships irrespective of size or of 300 gt and upwards if engaged in domestic trade.

KEY REFERENCE

IMO Guidelines for the installation of a ship-borne Automatic Identification System (AIS), IMO 2000

Table 5.9 Mitigation measures to reduce impacts on other uses

IMPACT	MITIGATION
Aggregate extraction may create a sediment plume that crosses licensed disposal sites, resulting in a breach of the licence conditions of this site	The licensed extraction area should take account of the proximity of licensed disposal sites. If the outputs of numerical modelling work indicate that a sediment plume will cross over a licensed disposal site and increase SSC beyond licence conditions for the site, then dredging activity should be managed to prevent this occurring.
Aggregate extraction may cause damage to sub-sea cables and pipelines	An agreement exists between the UK Cable Protection Committee (UKCPC) and The Crown Estate that allows for a No Dredging Zone of 250m to be implemented either side of a cable and a Dredging Notification Zone, 250 to 500m either side of an in-service cable. These zones should prevent any disturbance to submarine cables from either the direct or indirect effects of aggregate extraction.
Aggregate extraction may have adverse effects on offshore energy production activities	Offshore oil and gas production facilities have a manned 'Safety Zone'. A safety zone is an area of 500m radius established automatically around all offshore installations that project above the sea at any state of the tide. Vessels of all nations are required to respect them. It is an offence to illegally enter a safety zone, carrying a fine of up to £5000. The risk of collision can be greatly reduced by ensuring that all dredging operations occur with full knowledge of safety zones in the area and that alarms are set to sound as a safety zone is approached. Information on the position and location of safety zones can be obtained from: • Admiralty Charts; • Notices to Mariners; • Radio navigation bulletins; and • Fortnightly bulletins produced by Kingfisher Charts (aimed at the fishing industry but applicable to all marine navigation). Similar, though potentially less strict, safety zones are proposed for offshore wind farms and other marine renewables installations.
The presence of military exclusion zones may increase the collision risk between dredgers and commercial shipping due to the increased frequency of course changes by the dredger to avoid these areas	See mitigation for increased collision risk (above).
Aggregate dredgers may come into contact with unexploded ordnance	The risk of coming into contact with unexploded ordnance arises from historical material expended in previous conflicts or disposed of at sea; not modern material. Therefore, the risk of contact with such material is not necessarily related to the extent of PEXA areas and, as such, dredging may still be permitted in such areas, subject to consultation with the MoD. As a precautionary measure, consultation with the MoD should be undertaken.

Table 5.10 Mitigation measures to reduce impacts on recreation

IMPACT	MITIGATION
Aggregate extraction may have adverse effects on recreational/ hobby boat fishermen	Every care should be taken to avoid potential conflict with any other users of the sea. Under existing standard operating procedures, the applicant, as part of the dredging process, advises the UK Hydrographic Office at least 4 weeks in advance of dredging commencing in any area, ensuring that details of any dredging activity are included in NAVTEX broadcasts, Notices to Mariners and Admiralty Charts of the area. The area is then charted on the largest scale of Admiralty Chart. These measures, although aimed at general navigation issues, should be highly effective in giving recreational fishermen prior warning of dredging activities in, or near to, their local fishing grounds. NOTE: Where navigation safety information is promulgated through Coastguard, NAVTEX or VHF radio facilities, a charge may be levied by the Maritime and Coastguard Agency on the dredging company concerned.
Aggregate extraction may increase the risk of collision between dredging vessels and recreational vessels	Care should be taken by the Master of any dredger to avoid conflict with recreational users. Relevant user groups (yacht clubs, angling clubs, diving clubs etc.) should also be notified of all works. Spatial zoning (see **Box 5.1**) will significantly reduce potential interference with recreational activities. As detailed for previous parameters, such zoning is already implemented as standard practice, with active zoning charts produced by BMAPA (***www.bmapa.org***) and The Crown Estate (***www.crownestate.co.uk***). A convenient contact route, such as VHF 16, should be used to inform recreational vessels of the intention to dredge in the area. Under certain site-specific conditions, aggregate companies (or their consultants) should prepare information sheets describing any proposed dredging activity and issue these to local sailing clubs and also publish them in relevant magazines (Yachting Monthly, Yachting World). However, such a measure will not be required for every licence site and should only be applied following consideration of its need on a site-specific basis, taking into account the level of recreational vessel activity.
Aggregate extraction may create adverse effects for SCUBA diving activity through the creation of sediment plumes	Relevant diving clubs should be notified of all works and access arrangements organised to minimise any impacts on diving activities.

5.8.2 ASSESSMENT OF THE APPROPRIATENESS, PRACTICALITY AND SUCCESS OF THESE MEASURES

The following section reviews the standard mitigation measures related to navigation, recreation and other uses of the sea in terms of how appropriate they are, how practical they are to implement and how successful they are. This section has been developed through consultation with industry representatives and dredger masters who are ultimately responsible for undertaking many of these mitigation measures.

Appropriateness

Mitigation measures to prevent collisions between dredgers and commercial shipping, fishing vessels, recreational vessels, offshore installations and sub-sea infrastructure are considered to be wholly appropriate. Almost all of the mitigation measures described are based upon the statutory requirements of the various international legislation covering safety of lives at sea. Without these measures in place, the potential risk of loss of life at sea would be significantly higher.

In terms of reducing and/or avoiding impacts upon other users of the sea, the mitigation measures presented are considered appropriate.

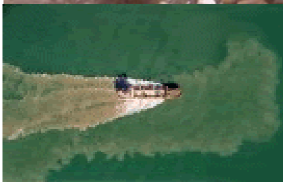
Practicality

The mitigation measures that are now considered to be generic to all dredging licences are practical. The mitigation is founded upon the principles of basic seamanship, international legislation and simple communication, all of which have been practised by sea going vessels for many years.

Success

Mitigation measures for the reduction of collision risk can be considered successful, as there has not been a single, reported collision between a dredger and a commercial vessel. The success of these mitigation measures relies heavily upon ongoing communication between the different user groups of the sea and upon the seamanship of the master of the dredger.

GOOD PRACTICE RECOMMENDATIONS 5.6: MITIGATION FOR COLLISION RISK
The success of mitigation measures aimed at reducing the impacts of dredging on collision, rely heavily on clear communication between all users of the sea. Therefore, the lines of communication between these industries/user groups, established at the start of the process (initial consultation and data collection) should be maintained throughout the project life-cycle, so that mitigation measures can be easily and successfully implemented. **Well-defined access routes to and from the site should be established and these communicated to relevant regulatory bodies, industry representatives and user groups prior to dredging beginning.** **Under certain site-specific conditions, predicted dredger movements should be issued (by fax/post) to a central contact point, i.e. the local offices of a fish merchant, trawler company, the RYA or local coastguard, where they can be easily disseminated to local mariners.** **Under certain site-specific conditions, the dredging industry, with input from the fishing industry, RYA and the Maritime Coastguard Agency, should publish a leaflet describing the operating procedures, manoeuvrability and methods of identification of dredger vessels. These can be distributed directly by the regulatory and governing bodies of each industry and through publication in the relevant media, i.e. Yachting Monthly, Fishing News etc.**



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6 MONITORING

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SECTION 6 MONITORING

SECTION 6.1 GENERIC INFORMATION

Monitoring of marine minerals dredging licences and permissions is discussed within MMG1, where the key points are outlined and the importance of defining clear objectives is stressed. MMG1 also recommends that monitoring should start before dredging commences in order to provide a baseline, and that periodic reviews of monitoring are undertaken as specified in the licence conditions (usually at 5-year intervals).

Purposes of monitoring

Monitoring has a number of purposes, including:

- To test impact hypothesis and thus further understand and improve predictive capability for future extraction activities;
- To modify mitigation measures if there are unpredicted harmful effects on the environment;
- To verify the effectiveness of mitigation measures;
- To assess performance and monitor compliance with agreed conditions specified in operating licences;
- To provide early warning of undesirable change so that corrective measures can be implemented;
- To provide evidence to refute or support claims for damage compensation; and
- To further the knowledge base relating to the actual effects of a particular activity.

Monitoring review process

One of the critical elements of monitoring is the review of results. Results should be reviewed against agreed thresholds, above or below which pre-determined action should be taken. The monitoring process must, therefore, be flexible enough to allow reaction to the results of monitoring.

Management responses

These are responses taken as a result of the outcome of the review process. The process should allow changes to be made, as necessary, in order to ensure that the dredging is undertaken in the most environmentally sound manner.

Without the results of monitoring, the success of the licence conditions and subsequent mitigation measures would not be known. There would be no knowledge progression and, as a result, a greater reliance upon the Precautionary Principle, which would, in turn, be likely to result in more onerous monitoring requirements.

6.1.1 IMPLICATIONS OF THE NEW STATUTORY CONTROLS FOR MONITORING

As detailed in **Section 1.4.4**, a new statutory system for the control of aggregate extraction license applications is being developed by the UK government. Once implemented, these statutory regulations will transpose into UK legislation, in so far as marine dredging is concerned, the provisions of EC Directive 85/337/EEC, as amended by EC Directive 97/11/EC, on the assessment of the effects of certain public and private projects on the environment (the EIA Directive) and the provisions of EC Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (the Habitats Directive).

As for mitigation, with respect to monitoring, the new statutory regulations will signal a shift in the level of detail required to be provided on monitoring within the ES to be submitted in support of the license application. Under the current system, it is possible to just provide an outline plan of proposed monitoring measures. The exact details of these measures and an agreed monitoring plan or plans, drawn up by the applicant and regulatory authorities, are then produced following discussions between these parties on the submitted ES.

Under the new system, a detailed plan of agreed monitoring measures will be required within the ES submitted to the regulatory authorities. Therefore, there will be a much greater emphasis on the applicant and their consultants to ensure that a suitable level of detail is provided, with respect to monitoring, in the first instance. Coupled with this, this requirement will also place a far greater responsibility upon regulators and their scientific advisors to commit to the specific scope and details of any monitoring up front.

6.1.2 THE MONITORING PROCESS

An example of a potential monitoring plan for an aggregate extraction site is presented in **Appendix E(ii).**

The general steps taken to devise a monitoring strategy are as follows.

- **Define objectives;**
- **Agree baseline conditions;**
- **Define criteria to monitor (based on the adverse impacts and mitigation measures);**
- **Determine methodology for measuring change against control sites;**
- **Agree thresholds above or below which action should be taken;**
- **Define review procedures; and**
- **Agree action required should thresholds be exceeded.**

6.1.3 DEFINE OBJECTIVES

The first step in devising a monitoring plan is to define the relevant objectives. The objectives of monitoring must be realistic and measurable. It is important to ensure that the scale of monitoring relates to the scheme and that the results will be meaningful and provide effective guidance for management of the activity. An overview of an approach to designing a sampling strategy for a hypothetical scenario is given in **Appendix E (i)**.

GOOD PRACTICE RECOMMENDATION 6.1: MONITORING TARGETS
SMART monitoring targets (Specific, Measurable, Achievable, Realistic and Time-bound) represent a transparent and robust approach to resolving key issues, through monitoring in an acceptable timeframe. They should be used within all ESs submitted for aggregate extraction applications.

6.1.4 AGREE BASELINE CONDITIONS

The baseline survey and interpretation of results (**Section 2**) should have provided an effective baseline against which future monitoring can occur. It is important, however, to recognise that other factors could influence the parameters that are being measured. In this respect, the baseline conditions used for monitoring should take account of other activities that occur or could occur within the study area (e.g. fishing activity, pipelines, etc.) as well as natural variation. The natural variability within a system will need to be determined, as far as possible, in order to predict the possible changes in the seabed morphology and the benthic environment which result from natural occurrences, such as seabed mobility and increases in suspended sediment concentrations due to storm activity. The control stations that are selected for monitoring (see **Section 6.1.6**) will also need to take account of these factors to ensure that results are not biased by activities occurring outside the control of the aggregate industry.

GOOD PRACTICE RECOMMENDATIONS 6.2: BASELINES CONDITIONS
Survey work should commence before the dredging activity in order to establish a baseline. **The assessment of baseline conditions should always take account of influencing factors that are outside the control of the aggregate industry (fishing, shipping, seasonal occurrences, natural variability).** **The baseline conditions against which to monitor should be agreed with the Regulators.**

6.1.5 DEFINE CRITERIA TO MONITOR

The monitoring criteria will be defined by the predicted impacts and the resultant mitigation measures that are recommended within the ES. Requirements for monitoring will be site-specific and based on the findings of the baseline surveys and subsequent interpretation. For example, surveys could be necessary in order to record the following:

- Abundance and distribution of species in order to determine the rate of recovery of species/communities within the study area;
- Effect of dredging on seabed morphology;
- Type of substrate remaining following extraction;
- Use of the area by fish; and/or
- Actual effect on any sensitive species/communities within the study area.

The identified monitoring criteria will then help to determine the methodology to be adopted.

6.1.6 DETERMINE METHODOLOGY

The methodology used for monitoring environmental effects should be the same as that used for determining the characteristics of the relevant parameter during the baseline survey. The sampling stations need to be the same, although there are likely to be fewer stations, depending on the objective of the monitoring (e.g. the feature of interest may require a more targeted approach than that adopted for the baseline survey). The timing of repeat surveys is critical for certain surveys (e.g. benthic and fish sampling), in that they should be undertaken at the same time of year as the baseline. This is to ensure that seasonal changes in abundance and distribution do not affect the results and that "like is compared with like". The frequency of sampling will be determined based on the objectives and the criteria for the monitoring. Changes in certain parameters will occur over a much longer time scale than others and, therefore, require less frequent monitoring (e.g. impacts on geology). There are standard procedures for surveying many of the relevant parameters and these are outlined within **Section 2**.

When undertaking a monitoring survey it is important to establish control sites that are outside of the area of influence of the extraction activity. This is to ensure that changes due to natural occurrences or other activities within the area are recorded and the resultant effect on the parameter being monitored can be taken into consideration.

An overview of an approach to sampling design for a hypothetical scenario is given in **Appendix E (i).** It should be noted, however, that this overview is not specific to aggregate extraction and that certain assumptions are made that would need qualifying for a real situation.

GOOD PRACTICE RECOMMENDATION 6.3: CONTROL SITES
The locations for control sites should be carefully selected to ensure that the physical biological conditions are the same (or as similar as possible) to the area to be affected.

6.1.7 AGREE THRESHOLDS

Dependent on the objective of and criteria for monitoring, it is important to define a level above or below which an effect is considered to be unacceptable, i.e. an 'environmental threshold'. An environmental threshold has been defined as "*a trigger point above which additional monitoring or remedial/corrective action takes place to ensure that appropriate environmental conditions are maintained*" (ABP, 2000). That is, the point beyond which changes in environmental conditions become unacceptable for the maintenance of the habitat or species.

Without this knowledge, monitoring for many parameters is only justified on the basis of improving the knowledge base of the particular effect. Certain parameters, however, do not require this level of information as they are measured just to record changes or reactions to a certain effect (e.g. recovery of benthos). Defining this level of information requires a high level of knowledge about the parameter being measured. The type of information that is required relates to the sensitivity and vulnerability of the receptor.

Ideally, the thresholds defined would be used within a feedback monitoring and management programme that would be developed to react to spatial and temporal trends in data. A number of responses could be adopted to cover different levels of impact. An example of such a feedback system is shown in **Figure 6.1** (below).

In general, the difficulty in setting thresholds is due to the determination of the level above or below which an effect becomes sufficiently adverse to warrant action being taken. In order to determine this level there is a need for detailed knowledge on the sensitivity of various receptors to environmental change. The level of knowledge relating to this subject is increasing all the time but in many areas the knowledge base is still patchy and there is still a need for the precautionary principle to be applied. However, this should be applied bearing in mind the specific situation under investigation and should be based on a realistic scenario and the latest information. As more information becomes available on the limits of tolerance of receptors, thresholds will become more realistic.

GOOD PRACTICE RECOMMENDATION 6.4: THRESHOLDS
Appropriate thresholds should be set, against which environmental change can be monitored. Such thresholds should be agreed through consultation with Regulatory Authorities. They should, ideally, form part of a feedback monitoring and management programme.

6.1.8 DEFINE REVIEW PROCEDURES

The results of the monitoring surveys will need to be interpreted in the same way as for the baseline surveys in order to provide a comparison over time. The results should be written up within a compliance report to show what actions have been taken to comply with the conditions of the licence and what monitoring has been undertaken. It is recommended that the results should also be circulated to a review panel.

GOOD PRACTICE RECOMMENDATION 6.5: MONITORING REVIEW PANEL
A monitoring review panel should be established consisting of members of the industry, a survey representative, expert scientific advisors and the Regulators.

The discussions of the review panel should include the following aspects:

- The results of the survey and whether the survey has met the agreed objectives;
- Whether the survey work has been effective in recording actual effects;
- The interpretation of the results and the degree to which the predicted impacts have occurred;
- Any deviation from the predicted impacts and the expected consequences;
- Any unexpected impacts that have been observed;
- Whether the mitigation has been effective in reducing/eliminating the effect;
- Any necessary changes to the actions taken to mitigate impacts; and
- Any necessary changes that have been agreed to the monitoring programme.

The review period for monitoring will be dependent on the objective(s) and methodology of monitoring. As the monitoring conditions are generally set by the licence agreement, it is recommended that the review periods ensure that enough information is available to inform the licence renewal. This will ensure that, if necessary, the dredging operation can be modified in light of the results. Dredging licences are generally consented for five-year periods.

The results of the review will determine whether the dredging activity should continue based on the same dredging regime or whether there is a requirement for the dredging programme or conditions attached to dredging to be modified in some way. In certain cases, the results of monitoring will be such that it may be deemed necessary to terminate dredging activities to ensure protection of the marine environment. Consideration will need to be given as to the necessity to undertake restoration work.

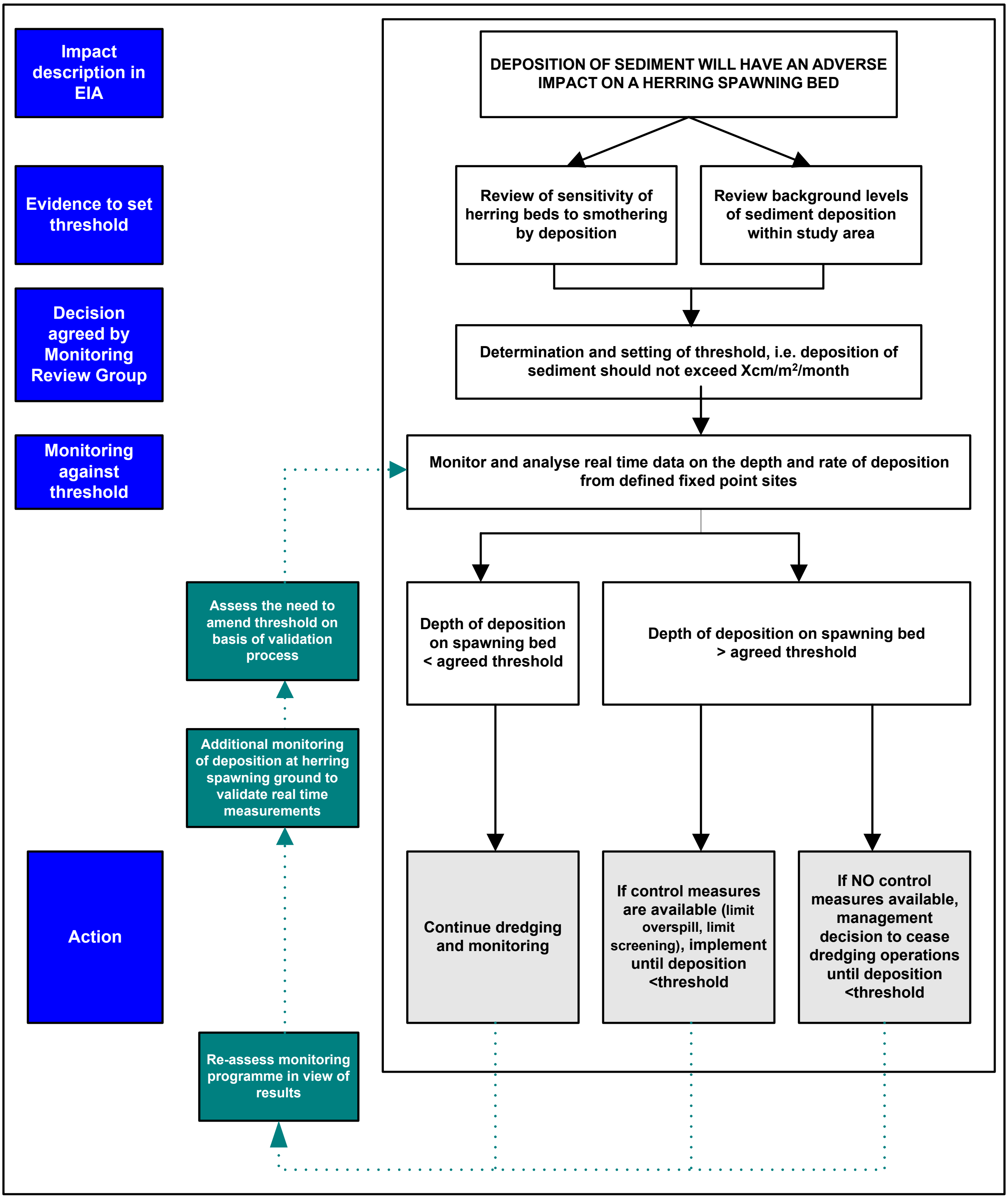

Figure 6.1 Example of a feedback monitoring process for the protection of herring spawning beds from increased deposition

6.1.9 AGREE ACTION

An agreed response to the results of monitoring is necessary in order to react quickly and effectively to an adverse activity. The level of response can be targeted to the receptor and should be dependent on its sensitivity. Responses could be:

(a) Continue with dredging under the existing regime;
(b) Modify the dredging regime to reduce the actual effect on a sensitive parameter;
(c) Cease dredging within the area until further information gained;
(d) Cease dredging altogether within an area; or
(e) Cease dredging and implement recovery measures.

In terms of monitoring, there are a number of scenarios that could occur once results have been reviewed, as follows:

- Reduce level of monitoring as no effect observed;
- Continue with existing monitoring programme to gain further clarification of response; or
- Increase the monitoring programme to include additional surveys or additional sites within an existing survey.

One of the key issues related to any environmental monitoring programme, is that there is scope for combining broad monitoring objectives for separate parameters into single surveys. For example, any bathymetric or side-scan sonar surveys undertaken in relation to physical process impacts may also be used to collect monitoring data related to archaeological resources (e.g. effect on site stability), commercial fisheries (e.g. exposure of fasteners) and navigation, recreation and other uses (e.g. exposure of cables etc.).

Subsequently, many of the results from key monitoring surveys will be directly relevant to a range of parameters. For example, although monitoring of any sediment plumes and changes in seabed morphology will be directly linked to assessing potential impacts on physical processes, the results will also be of relevance to impacts on all the other parameters, including marine ecology, fish and shellfish resources and commercial fisheries.

GOOD PRACTICE RECOMMENDATION 6.6: MONITORING PROGRAMMES

Monitoring programmes should be developed taking account of all the key parameter-specific issues. By doing this, several monitoring objectives will be able to be met by single monitoring surveys, e.g. data from bathymetric surveys (physical processes) can be used to assess impacts on seabed topography (commercial fisheries). Data from side scan sonar surveys (physical processes) can also be used to assess impacts on seabed composition (marine ecology) and spatial extent of spawning grounds (fish and shellfish resources).

REFERENCE

ABP (2000). Dibden Terminal: Marine Environmental Thresholds. Technical Statement TS/ME6. August 2000.

Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

7 SUMMARY OF GOOD PRACTICE RECOMMENDATIONS

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SECTION 7 SUMMARY OF GOOD PRACTICE RECOMMENDATIONS

This section of the document, presents all the Good Practice Recommendations listed within each chapter. In considering these recommendations, it is important to note that many of these are already undertaken by the industry and as such, represent existing Good Practice.

SECTION 1 INTRODUCTION

GENERIC INFORMATION - EIA	
Number	**Recommendations**
1.1	EIA should commence as early in a projects design or planning as possible, and then should continue well into a projects lifetime (i.e. monitoring of operations, if applicable) and up to the cessation of activities or decommissioning of the development.
1.2	A scoping study should be undertaken as the first stage of a 2-stage approach to EIA (the second being the production of the ES). This represents the most cost-effective approach to EIA. Consultation with organisations likely to be affected by the proposals AND organisations that may hold relevant baseline data is critical to this stage. The scoping study should review existing data and enable a decision to be made as to the need for more detailed baseline studies. The scoping study should also highlight key issues, enabling time and resources to be targeted towards these issues within the ES. If producing a scoping study as part of a wider EIA study, consultants should allocate a reasonable proportion of the overall project budget to preparing and producing the scoping report. By spending time and effort at the start of the EIA process, many of the key issues will be identified at an early stage and resources can be re-directed appropriately.
1.3	Consultation is an essential part of EIA and should be undertaken in all projects and during all stages of the process. All views and concerns expressed to the assessment team should be adequately dealt with, either through discussion or within the ES itself. For transparency and clarity, it is good practice to include the key comments made by consultees within the ES. Specific specialist consultation should be undertaken with key industries, i.e. commercial fishing. Consultation should not end with the ES and should continue throughout the project’s life and until abandonment. Good consultation will save time and money, build relations and improve the image of the developer and the project. Bad consultation will extend the planning process whilst grievances are resolved, will reduce the level of assistance received (particularly in terms of available data) and could tarnish a developer’s image in future applications.
1.4	Given the importance of the ES to decision-making and the general raising of awareness amongst all readers, the presentation and appearance of the ES should be of high quality. The use of maps, drawings and photographs is encouraged in order to reduce the amount of text required and to allow greater understanding of the development, the environment of the study area and the identified impacts. As far as possible, the ES should be concise and concentrate its discussions and assessment on those key impacts identified during the scoping stage. The NTS will be the preferred document for non-specialists or for readers requiring an overview before concentrating on their own specialisation. As such, ensure that it is not too complex, avoids technical jargon and, above all, is clear and easy to read. The final ES should be issued to consultees either in hard format, digital format (CD, PDF) or made available on the internet.

Number	Recommendations
1.5	Prior to undertaking a prospecting survey, the licence holder should consult statutory nature conservation agencies over information held on the area in question. This will remove the risk of grab sampling being undertaken in sensitive habitats. This consultation will have been undertaken as part of the Coast Protection Act consenting process, required for minerals prospecting.

SECTION 2 DATA COLLECTION, ANALYSIS AND PRESENTATION

DATA COLLECTION - GENERIC GUIDANCE	
Number	**Recommendations**
2.1	The collection and subsequent analysis of baseline data for all parameters should be undertaken by suitably qualified staff. Discussion should be ongoing between investigators preparing the baseline environment descriptions for related parameters (e.g. physical processes and benthic ecology; fish and shellfish resources and commercial fisheries) to avoid unnecessary replication and to ensure that the ecosystem approach is developed. The ecosystem approach relies on the integrated management of human activities based on knowledge of ecosystem dynamics to achieve sustainable use of resources and maintenance of ecosystem integrity. If specialist surveys are required, then these should be undertaken by well-qualified companies with experience of carrying out similar surveys.
2.2	The study area should be defined as early as possible within the EIA process. The overall spatial extent of the study area should include the zone of influence and also a wider area where no impacts are predicted. By extending the study area, it will be possible to (a) select potential control sites and (b) determine the `uniqueness` of resources within the zone of influence compared to the wider study area. Information on the potential zone of influence can be obtained through the use of conceptual models. A framework for developing such conceptual models is provided in Section 4.2. Whilst promoting the use of such models in the definition of study area, it should be recognised that these models are currently based only on a sound understanding of the key processes. There are clear data gaps in the quantification of the processes and fluxes, which demands a cautious approach.
2.3	The quality of data and any confidence limits associated with these data should be fully described within the ES. The question of natural variability should also be addressed, as far as is possible, within any baseline studies.

DATA COLLECTION - DESCRIPTION OF THE PROPOSED ACTIVITY	
Number	**Recommendations**
2.4	Details on proposed dredging activity, i.e. zoning, extraction rates, areas to be dredged and occupancy times, should be set out in a Resource Management Plan.

DATA COLLECTION - PHYSICAL PROCESSES	
Number	**Recommendations**
2.5	At the first stage of the EIA process, a scoping study should be undertaken (see Section 1.3 for details). During the production of the initial scoping report, consultation should be undertaken with a range of key organisations that may hold data on the physical environment.
2.6	Existing generic knowledge of the behaviour of sediment plumes and sediment deposition following marine aggregate extraction (from conceptual models) should be used to help define the study area at, and directly surrounding, the dredge site (see Sections 3.2 and 4.2). It should be recognised that these models are currently based only on a sound understanding of the key processes and that further validation is required from field data.
2.7	A plan for baseline surveys (including prospecting and seismic surveys) can be submitted to key organisations, such as CEFAS, the Joint Nature Conservation Committee (JNCC), English Nature (EN), Scottish Natural Heritage (SNH), Countryside Council for Wales (CCW) and English Heritage, prior to mobilisation. This should help to ensure that survey techniques are appropriate, particularly in areas of nature conservation and/or archaeological concern. It is important that this plan provides enough detail for these organisations to comment on the proposed survey objectives, design and methodologies.

Number	Recommendations
2.8	When collecting bathymetric data, a recognised set of guidelines for the conduct of surveys should be followed, e.g.: *International Hydrographic Organisation (1998). IHO Standards for Hydrographic Surveys, IHO, Special Publication No 44, 4th Edition, 23pp.*
2.9	Where a single beam echo-sounder is selected, it is recommended that a sidescan sonar survey is also completed. The combination of these two systems should provide 100% coverage of the seabed, surface sediments and sediment transport features.
2.10	The sounding density will relate to the type of equipment used for the survey. For multi-beam surveys, survey lines should be spaced at approximately 250m intervals, with cross lines at 100 m intervals.
2.11	AGDS should NOT be used in isolation as a tool for the prediction of physical seabed traits. Ground-truthing methods (grab samples, video), should ALWAYS be used to confirm interpretations and should be undertaken in consultation with JNCC and/or the relevant Country Agency for nature conservation to avoid inappropriate techniques in sensitive areas.
2.12	Acoustic technology is constantly changing and improving. New acoustic systems and techniques regularly enter the market place. Therefore, it is important that new physical mapping methodologies are reviewed regularly, and augmented with the incorporation of improved acoustic techniques. ICES have set-up the Study Group on Acoustic Seabed Classification (SGASC). This group aims to produce an ICES Co-operative Research Report on Acoustic Seabed Classification by 2005. Outputs from this study group should be used to keep up-to-date with developments in this area. *http://www.ices.dk/iceswork/workinggroups.asp*
2.13	Where standard procedures and protocols for the processing of survey data exist they should be followed. GIS provide a useful medium with which to store, manipulate and analyse data when developing the baseline. A GIS will: • Allow a comparison of data coverage; • Aid data collection and collation decisions; • Assist in the analysis of data; • Provide a means of comparison of different data sets; and • Assist in data presentation through data storage.
2.14	Selection of an appropriate presentation method should be based on the required output for the baseline description and the data being utilised. Consideration should be given to presenting data on charts together with bathymetry.
2.15	Final reports should be produced both in a hard copy format and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. Reports should be converted to PDF format so that they can be easily e-mailed or made available on the Internet. GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

DATA COLLECTION - MARINE ECOLOGY	
Number	**Recommendations**
2.16	Not all these data requirements will need to be investigated at the same level. The decision as to which data requirements should be investigated in the greatest detail should be determined through scoping.
2.17	If scoping or pilot surveys indicate that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, *Modiolus* reefs or Serpulid reefs, then grab sampling should NOT be undertaken. The assessment of grab success should intrinsically account for locations where the grab did not fire. This is important information as it could indicate the presence of a bedrock reef or stony reef and, as such, should always be recorded.

Number	Recommendations
2.18	For details on the conduct of epibenthic studies at aggregate dredging sites, the reader is referred to "Guidelines for the conduct of benthic studies at aggregate dredging sites", prepared by CEFAS on behalf of the DTLR (DTLR, 2002). If the study area supports a significant static-gear fishery (pots, nets, long-lines), then consideration should be given to adopting an alternative sampling method other than trawling or dredging, i.e. remote sensing (see below). If scoping or pilot surveys indicate that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, *Modiolus* reefs or Serpulid reefs, then trawling and/or dredging should NOT be undertaken.
2.19	Even considering the data sources listed, distribution information on marine mammals and elasmobranchs is still relatively patchy and uncertain. Therefore, a precautionary approach should be adopted in order to reduce potential impacts of aggregate extraction to a minimum.
2.20	Consideration should be given to undertaking fish stomach content analysis in order to gain additional information on the use of the area for feeding purposes. There are complicating issues which need to be fully considered before this decision is taken. Gut analysis should be targeted at the 5 most dominant species within the samples. Ideally, a range of sizes of the same species should be retained for gut analysis, as for any one species, the main prey items of juveniles and adult fish are likely to differ significantly. The benefits of obtaining data from gut analysis outweigh the small extra costs associated with collecting it.
2.21	If a large, technical benthic report is summarised within the final ES, then the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included. Key organisations (CEFAS, JNCC, the relevant Country Agency and any local Sea Fisheries Committee/s) should be issued with a copy of the full technical report, complete with appendices containing the raw species data for each station sampled. Final reports should be produced both in hard copy and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. All reports should also be converted into PDF format so that they can be easily e-mailed or made available on the Internet. GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

DATA COLLECTION - NATURE CONSERVATION	
Number	**Recommendations**
2.22	As the first step in the data collection exercise, the JNCC and the relevant Country Agency (EN, SNH, CCW) should be contacted in order to obtain initial information on all nature conservation aspects of the study area.
2.23	Not all of these data will need to be investigated at the same level. The decision as to which data requirements should be investigated in the greatest detail should be determined through scoping. The JNCC and the Country Agencies are also currently working on guidance which will provide further details on what baseline data are required for the assessment of impacts on potential Annex I habitats and Annex II species. Once published, the reader should refer to this guidance.
2.24	JNCC Report 325 (and subsequent Committee papers) should be fully reviewed in order to determine the *potential* for future SACs/SPAs to be designated within the proposed area of activity.
2.25	Ensure that site-specific data is used in the assessment of presence or absence of qualifying features under the EU Habitats Directive or the EU Birds Directive

DATA COLLECTION - FISH AND SHELLFISH RESOURCES	
Number	**Recommendations**
2.26	The decision as which data requirements should be investigated in the greatest detail should be determined through the scoping stage.
2.27	When describing the distribution and relative abundance of fish and shellfish species within a study area, particular effort should be concentrated on those species which have a vulnerable life-history stage that may be impacted by dredging activities
2.28	Obtain at least 5 years of landings data (preferably the 5 years of data prior to the date of the current study). Defra Landings data should be treated with caution and all ESs should recognise that these data often represent an under-estimation of the true landings made within a fishery.
2.29	It is essential that consultation with the fishing industry is undertaken as EARLY as possible (i.e during the Scoping stage) and that key representatives are kept up-to-date of all proposals and changes throughout the project, in order to build up a strong working relationship, based on a degree of trust and co-operation. Local fishermen potentially have the greatest knowledge of the status of fish and shellfish resources at a local level. Therefore, time should be spent at the start of the process compiling an accurate list of fishermen who should be contacted. Information can be collected through questionnaires or interviews/meetings.
2.30	The decision on whether or nor a site-specific fish/shellfish survey is required should be made following Scoping.
2.31	The objectives and proposed design of any dedicated fish resource survey should be issued to CEFAS an d the local Sea Fisheries Committee and Defra District Inspector approximately 4 weeks prior to beginning the survey so that they can (a) comment on it fully and (b) inform local fishing organisations. Their comments should determine the final survey design and objectives. The actual gear type to be used should be similar to those used by local fishermen, as far as possible. Where small mesh nets are required for any surveys, applicants must apply to the Defra Sea Fish Conservation Division for special dispensation. The trawl survey stations should correlate with benthic stations as far as possible so that potential ecological interactions can be investigated. Although striving for consistency in data collection, \`flexibility\` in survey design and gears used will still be required, in order to take account of site-specific conditions. In the event that resources of special conservation significance are detected in the survey area, e.g. *Sabellaria* reefs, it may be necessary to define these in more detail, using non-intrusive methods such as underwater video. As with benthic grab surveys, any fish surveys should be supervised by an experienced marine scientist to ensure that the catches and methods of survey are representative of the area. It is recognised that there are many issues associated with site-specific fish and shellfish surveys (cost, time, usefulness of data). Therefore, alternative approaches to collating data to describe baseline conditions with respect to fish and shellfish resources should also be investigated. Some future developments in fish resource surveys are outlined in Appendix B (xiv). Overall, a multi-strand approach, combining acoustic data collection, a literature review, analysis of Defra landings data and previous survey data, consultation and site-specific surveys (if required), is recommended.
2.32	At least 5 years of landings data should be assessed for high-level trends. Data on fish and shellfish landings should not be aggregated but should be either assessed under the broad headings that Defra data are usually organised into (demersal fish, pelagic fish and shellfish) or by separating the information out on the top 5-10 species and grouping all other data.
2.33	The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, therefore reducing the potential amount of supporting text required.

Number	Recommendations
2.34	If a site-specific fish/shellfish survey report has been produced and summarised within the final ES, then the original author(s) should review the summarised version to ensure that key points and issues have been included. Final reports should be produced both in hard copy format and digitally. Copies of all reports should be converted into PDF format and issued on CD to consultees and Regulators, where possible. Ideally reports should be made available on the Internet. GIS files, with the licence area shown, should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

DATA COLLECTION - COMMERCIAL FISHERIES	
Number	**Recommendations**
2.35	The decision as to which data requirements should be investigated in the greatest detail should be determined as part of the scoping stage.
2.36	EARLY consultation with the fishing industry is critical. Ideally, consultation should be undertaken by a dredging company at the exclusive prospecting stage. Consultation should take place at the Regional (Defra), District (Sea Fisheries Committee) and local level (Fishing Organisations). Key consultees should be kept up-to-date with all changes throughout the project, in order to build up a strong working relationship, based on a degree of trust and co-operation. Local fishermen have the greatest knowledge of the status of commercial fishing activity at a local level, therefore, time should be spent at the start of the process compiling an accurate list of individual fishermen who should be contacted. Information can be collected through questionnaires or interviews/meetings.
2.37	Official landing data should not be used as the primary basis for assessing any economic impacts of marine aggregate extraction on commercial fisheries, as they often only identify high-level trends. When official landing data are used to provide an overview of trends in a fishery, the analysis should take any shifts between the over 10m and under 10m fleet into account. This analysis should also always be backed up by interviews, at least with the SFC and preferably with local fishermen.
2.38	Defra surveillance data should be treated with caution. All ESs should recognise the potential shortcomings of these data.
2.39	Baseline data assessments of commercial fisheries within any study area should be based on a 'multi-strand approach', i.e. a range of data sources should be used, such as Defra over-flight data and landings data, consultation responses and site visits, to build up a comprehensive overview of commercial fishing activity at a site. All of the various data sources should be reviewed together in order to identify any significant contradictions.
2.40	At least 5 years of data showing the value of landings should be assessed for high-level trends. Data on the value of fish and shellfish landings should not be aggregated but should be assessed either under the broad headings that Defra data are usually organised into (demersal fish, pelagic fish and shellfish) or by ranking species by the value of their overall landings. This enables those species that contribute the most to the overall value of the fishery to be identified.
2.41	The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible, figures should be used to display data, reducing the potential amount of supporting text required.
2.42	If a separate commercial fisheries report has been produced and then summarised within the final ES, the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included. Final reports should be produced both in hard copy format and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. All reports should be converted into PDF format so that they can be easily e-mailed or made available on the Internet. GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

DATA COLLECTION – ARCHAEOLOGY AND CULTURAL HERITAGE	
Number	**Recommendations**
2.43	Consultation is a key part of any baseline data collection exercise related to the historic environment. The key consultee (English Heritage/CADW/Historic Scotland/EHS) should always be consulted early in the project, as well as at the commencement of any investigations and at appropriate stages of the assessment process.
2.44	A desk-based assessment should be undertaken. English Heritage/CADW/Historic Scotland/EHS should be contacted with regard to the development and to enable agreement of the brief for the proposed assessment. Baseline information should be obtained from all relevant sources and all the known and potential archaeological sites and features within the study area should be identified. This study should state all assumptions made in carrying out the assessment. It should identify the potential impacts, assess the effects and specify appropriate mitigation measures. Finally, it should identify data gaps and examine the need for further work (survey and evaluation) to address them.
2.45	Determine, in discussion with English Heritage/CADW/Historic Scotland/EHS and the Local Authority Archaeologist, the necessity for and extent of primary data collection for the EIA. This could include identifying a staged approach and thereby targeting resources towards appropriate phases of the project. A staged approach can also allow the scope of any detailed investigations required to be defined and to concentrate on key issues/areas only. Where possible, integrate preliminary archaeological surveys with surveys undertaken for other purposes, such as resource mapping or environmental sampling. The specifications for these surveys should be drawn up with archaeological advice and tailored to archaeological requirements (e.g. side scan sonar settings and line). Ensure that the surveys provide sufficient data to identify the presence or absence of potential archaeological features and deposits. The level of information provided for any identified features should be sufficient to assess their character, extent, condition and significance. Provide further recommendations for monitoring or mitigation measures (changes in development design/outline, exclusion measures, or recording requirements).
2.46	The use of GIS is strongly advocated as a tool for presenting data-sets in a format that is easy to view and interpret. As far as possible figures should be used to display data, reducing the potential amount of supporting text required.
2.47	Final reports should be produced both in hard copy and digitally. Copies of all reports should be issued on CD to consultees and Regulators, where possible. Reports should also be converted into PDF format so that they can be easily e-mailed or made available on the Internet. GIS files with the licence area shown should be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

DATA COLLECTION - NAVIGATION, RECREATION AND OTHER USES	
Number	**Recommendations**
2.48	The decision as to which data requirements should be investigated in greatest detail should be determined through the scoping stage.
2.49	Information on the location and extent of offshore energy production installations is crucial in order to effectively assess any potential cumulative impacts upon navigation, when combined with the dredging operation.
2.50	Baseline information on recreational vessel movements can be obtained by looking at cruising routes and consulting with yacht clubs in the study area. Waypoints, which many recreational sailors then use to plot routes, are also often published in yachting magazines. Consultation with local boat clubs is also essential.
2.51	Baseline data relating to navigation and other uses should be collated through a combination of a data review exercise and consultation. Key consultees should always be consulted early on in the project. Time should be spent at the start of the process compiling an accurate list of individual organisations that should be contacted.

DATA COLLECTION - NAVIGATION, RECREATION AND OTHER USES	
2.52	If a site-specific navigation risk assessment has been produced and summarised within the final ES, the original author(s) should review the summarised version within the ES to ensure that key points and issues have been included. The navigational risk assessment should be produced both in hard copy format and digitally. Copies of this report should be issued on CD to consultees and Regulators, where possible. The report should be converted into PDF format so that it can be easily e-mailed or made available on the Internet. GIS files with the licence area shown should also be supplied with the final reports. The best format would be .MIF files, as these can be used by a variety of GIS packages.

SECTION 3 GENERIC IMPACTS OF MARINE AGGREGATE EXTRACTION

IMPACTS OF AGGREGATE EXTRACTION - GENERIC GUIDANCE	
Number	**Recommendations**
3.1	An important consideration when assessing the potential effects of aggregate extraction are the natural perturbations that exist within any environment. It is important to determine what these may be for each individual site in order to distinguish natural changes from those caused by the extraction activity. When considering impacts it is also important to determine what other proposed or actual activities are likely to occur within the study area. This is to ensure that the impacts that could occur are assessed cumulatively from all known activities.
3.2	Many of the impacts described within ES's are predictive. Therefore, it is recommended that one of the primary objectives of any associated monitoring programme is to `validate` these predictions through the collection of actual field data. Any monitoring programme should also incorporate some form of feedback and reporting mechanism that will enable dredging operations to be modified if the initial impact predictions are shown to be inaccurate.

SECTION 4 METHODS OF IMPACT ASSESSMENT AND DERIVATION OF SIGNIFICANCE CRITERIA

METHODS OF IMPACT ASSESSMENT - GENERIC GUIDANCE	
Number	**Recommendations**
4.1	A proportion of the overall budget for an EIA should be allocated to the review of recent published papers and data relating to the impacts of aggregate extraction on the marine environment. This will ensure that the resultant ES is technically up-to-date. This should also include a review of any monitoring reports produced for other licensed sites, so that actual field data can be assessed.
4.2	All potential impacts should be identified, quantified and all potentially significant impacts expressed as testable hypotheses.
4.3	Every effect created by aggregate extraction should be defined in terms of its spatial extent, magnitude, duration and frequency. The key physical effects related to aggregate extraction are (1) substrate removal and alteration of seabed topography, (2) creation of sediment plumes within the water column and (3) sediment deposition on the seabed. The nature of these effects can be relatively well-defined using a combination of numerical modelling techniques and conceptual models (see Section 4.2). However, it is important to recognise that such models require validation through quantified field data to increase their level of accuracy. The spatial extent of a predicted effect (a 'vulnerability map') should be displayed graphically where possible. The use of a GIS package or other similar mapping and interface tools is highly recommended.
4.4	Whether or not the effect being assessed is likely to interact with the receptor in question (i.e. is the receptor 'vulnerable'), should be the first question answered as part of the impact assessment process.
4.5	Information on the sensitivity (intolerance) of key resources should be obtained from published literature and consultation with experts from relevant organisations. *MarLIN* (http://www.marlin.ac.uk) should be used, where appropriate, as this tool provides detailed information on the sensitivity/intolerance of many key features of the marine environment. However, it should be noted that the knowledge base for determining the sensitivity of species is inadequate and research is needed to further define these aspects. The EIA should include a critical appraisal of the *MarLIN* data on sensitivity and recoverability, as these data are often extrapolated from other similar species. Judgement of the sensitivity of the receptor should consider the spatial extent, magnitude, duration and frequency of the effect being assessed.
4.6	Information on the recoverability of key resources can be obtained from published literature and through consultation and discussion with experts from relevant organisations, such as CEFAS. *MarLIN* should also be used, where appropriate, as this tool provides detailed information on the recoverability of many key features of the marine environment. Judgement of the recoverability of the receptor should consider the spatial extent, magnitude, duration and frequency of the effect being assessed. Recoverability will also be largely controlled by the residual environmental conditions that remain post-extraction (i.e. a receptor may show a high degree of recoverability from smothering effects but, if the physical conditions of the site have changed to ones that no longer suit the receptor, then recovery may not occur).
4.7	Judgement as to the 'importance' of various resource features should include some form of consultation or discussion with various key organisations. The rationale for describing the importance of the receptor should be stated clearly within the ES, i.e. conservation value; rarity; uniqueness; ecosystem function etc.

Number	Recommendations
4.8	The assessment framework set out in Figure 4.1 provides a logical and transparent process whereby the steps taken in assigning significance criteria to a certain impact, are made more transparent. It is recommended that similar frameworks are used within all marine aggregate EIAs and that up-to-date information on key factors (sensitivity/intolerance, recoverability and importance) is obtained from relevant sources, e.g. *MarLIN.* As far as is possible, the reason for assigning this level of significance should be fully explained within the supporting text of the ES. The final decision on significance will always require professional opinion and judgement and cannot be based on this framework alone.
4.9	Where uncertainties exist, either due to a current low level of knowledge about a specific impact/receptor or a data gap, then the precautionary principle should be applied and the data gaps identified.
4.10	Any assumptions used in predicting and describing a particular impact should be listed within the ES, thus making it more transparent and robust.

METHODS OF IMPACT ASSESSMENT - PHYSICAL PROCESSES	
Number	**Recommendations**
4.11	An initial assessment of the impacts of aggregate extraction on wave behaviour should always be undertaken.
4.12	If an initial assessment shows that the proposed extraction site is an isolated licence area and at water depths greater than 30m, then further investigation into changes in the wave climate WILL NOT be required. If an initial assessment shows that the proposed extraction site is an isolated licence area and at water depths less than 30m, then further investigation into changes in the wave climate WILL be required.
4.13	In the majority of situations, it is acceptable to use wave generation or hind-casting models to obtain a realistic time-series of information on waves and wave parameters. The UK Met Office hosts the most commonly used model.
4.14	If the modelling shows a DETECTABLE (i.e. outside model scatter) effect on nearshore wave conditions between the pre- and post-dredge conditions, then this should be considered to be a significant change and therefore unacceptable. If the modelling shows NO DETECTABLE (i.e. within model scatter) effect on nearshore wave conditions between the pre- and post-dredge conditions, then this should be considered acceptable.
4.15	If dredging is to be undertaken in water depths greater than 10m and the understanding developed of the beach profile provides no evidence to suggest that the active beach profile extends beyond this depth, then NO IMPACT with respect to beach drawdown is expected. If extraction is to be undertaken in water depths of less than 10m or knowledge of the beach profile suggests a possibility of beach drawdown, then it will be necessary to undertake further detailed investigations. If further investigations are to be carried out, the methods of Hallermeier (1981) are recommended for deriving the lower beach profile limit. If these investigations demonstrate that the extraction is within the active beach profile then the application should not proceed.
4.16	An assessment of the impacts of aggregate extraction on sediment transport should always be undertaken.
4.17	The understanding of sediment transport pathways in the study area developed during the baseline data collection and analysis stage should be used as the basis of this assessment.

Number	Recommendations
4.18	If the assessment indicates a DETECTABLE change in sediment supply between the pre- and post-dredge conditions, this should be considered to be a significant change and therefore unacceptable. If the assessment indicates NO DETECTABLE change in sediment supply between the pre- and post-dredge conditions, then this should be considered an insignificant change and therefore acceptable.
4.19	A preliminary assessment of the potential impacts of aggregate extraction on tidal currents should be undertaken for each dredging application. If either of the following two criteria are met, further investigations in the form of tidal modelling should be undertaken: (1) The application is for dredging in water depths of less than 10m below lowest tide; and (2) Surface seabed sediments are regularly mobilised by tides and waves. The area over which changes in tidal currents can be detected is usually thought to only extend over an area roughly twice the dimensions of the extraction site itself (Brampton and Evans, 1998).
4.20	If the modelling shows a DETECTABLE (i.e. outside model scatter) change to tidal currents at or near the coastline adjacent to the application between the pre- and post-dredge conditions, then this should be considered to be a significant change and therefore unacceptable. If the modelling shows NO DETECTABLE (i.e. within model scatter) change to tidal currents at or near the coastline adjacent to the application between the pre- and post-dredge conditions then this should be considered acceptable.
4.21	Once an initial assessment has been carried out, the two potential impacts (plumes and deposition) associated with suspended sediment should be investigated as separate issues.
4.22	If passive plume modelling is required as part of the impact assessment, then this should be undertaken by established professionals with experience and expertise in this subject area.
4.23	The outputs of plume modelling studies should be used as the basis for assessing the impact of increased suspended sediment concentrations on the marine environment.
4.24	Licence applicants, or consultants working on the applicant's behalf, should make themselves aware of the published results of monitoring from the ECR, and/or other sites, before undertaking future predictive assessments.
4.25	Under Scenario 1, the existing REA conceptual model can be used to define the "zone of influence". Under Scenario 2, the type of reasoning used in the REA model can be used to develop new, site-specific conceptual models. Under Scenario 3, new "zone of influence" models will be required which may also require the application of specialist numerical models, e.g. dynamic plume models, particle-tracking models.
4.26	The process of progressing through the framework for developing a conceptual model concerned with the zone of influence should be undertaken on the basis of consultation with the regulator. Many of the issues involved are not black and white and agreeing an approach before undertaking the EIA studies in detail will improve the chances of a successful licence application. Any assessment should also consider the potential for cumulative and in-combination effects to arise on physical process from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.

METHODS OF IMPACT ASSESSMENT - MARINE ECOLOGY	
Number	**Recommendations**
4.27	The output of numerical and/or conceptual models should be used as the basis for predicting the impact of the sediment plume and deposition on benthic/epibenthic communities. It is vital that these models consider key operational details of dredging activity, such as the amount of material to be screened and the nature of this material, the amount of over-flowing required and the rate of extraction. These outputs should be analysed in detail to further define the relevant proportion of the dredging footprint (i.e. the zone of influence) in which adverse effects on the receptor in question are likely to arise (that is, species will be affected by the different impacts within the zone of influence as a whole in different ways, where some effects may be important (i.e. dredging) while others may not (i.e. shallow smothering). The assumption that the entire footprint will create adverse effects is too precautionary and needs to be considered on a case-by-case basis.

Number	Recommendations
4.28	It is also important that an effort is made to describe background levels of SSC and sediment deposition within the study area, so that plume and deposition effects created by dredging activity can be placed into context. Even though models should be used as the basis for impact prediction, the potential for error in the model outputs should be recognised and reported within the ES. Any assumptions and uncertainties in the assessment of a parameter should be detailed within the ES.
4.29	Any assessment should also consider the potential for cumulative and in-combination effects to arise on marine ecology from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.

METHODS OF IMPACT ASSESSMENT – NATURE CONSERVATION (also refer to Benthic Ecology and Fish and Shellfish Resources Sections)	
Number	Recommendations
4.30	Any assessment should consider the potential for in-combination effects to arise on nature conservation interests from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms and oil and gas operations (including seabed infrastructure) or their construction.

METHODS OF IMPACT ASSESSMENT – FISH AND SHELLFISH RESOURCES	
Number	Recommendations
4.31	Outputs of numerical models should be used to define the 'footprint' of the effect. These outputs should be analysed in detail to further define the relevant proportion of the dredging footprint (i.e. the zone of influence) in which adverse effects on the receptor in question are likely to arise (that is, species will be affected by the different impacts within the zone of influence as a whole in different ways, where some effects may be important (i.e. dredging) while others may not (i.e. shallow smothering). The assumption that the entire footprint will create adverse effects is too precautionary and needs to be considered on a case-by-case basis. Up-to-date data relating to the sensitivity of key receptors to depositional effects should be obtained through literature review. Local commercial fishermen should be consulted at an early stage in the EIA process.
4.32	Any assessment should also consider the potential for cumulative and in-combination effects to arise on fish and shellfish resources from other activities, e.g. fishing, other aggregate extraction activities, offshore wind farms or their construction.

METHODS OF IMPACT ASSESSMENT - ARCHAEOLOGY AND CULTURAL HERITAGE	
Number	Recommendations
4.33	GIS should be used to assess the vulnerability of archaeological and cultural resources to impacts from aggregate extraction.
4.34	Information on the sensitivity (intolerance) of key resources should be informed by information from published literature, consultation and discussion with experts from relevant organisations, such as English Heritage and CADW. Any new guidance should also be used. Judgement as to the sensitivity of the receptor should consider the spatial extent, magnitude, duration and frequency of the impact being assessed.
4.35	It is essential that advice is sought from specialists in relevant fields as well as statutory organisations in the determination of the importance of identified remains. Reference should be made throughout the assessment of impacts on archaeology and cultural heritage to the BMAPA/English Heritage publication: Aggregate Dredging and the Historic Environment: Guidance Note.
4.36	Any assumptions used in predicting and describing a particular impact should be listed within the ES, thus making it more transparent and robust.
4.37	Any assessment should also consider the potential for cumulative and in-combination effects to arise on archaeological resources from other activities.

METHODS OF IMPACT ASSESSMENT - NAVIGATION, RECREATION AND OTHER USERS	
Number	**Recommendations**
4.38	A dedicated navigation risk assessment should be undertaken as part of the EIA process. This should be undertaken by a professional company with expertise and experience in undertaking such assessments. As far as is practical, data on recreational and fishing vessels should be incorporated into the collision risk model. Recreational craft will generally avoid major shipping channels and often follow entirely different routes to commercial shipping. This should be considered in combination with the fact that the radar, VHF and other observational and communication technologies (e.g. AIS) carried by recreational craft, are likely to be much less sophisticated than those onboard commercial vessels.
4.39	In areas with more than one license application, the cumulative annual risk of dredging should be assessed to provide the total annual collision frequency. Any increase in the frequency of collision risk due to dredging activity should be expressed as a % of the existing frequency.
4.40	Risk assessment models should also be used to analyse the risk of collision between dredgers and other ships with stationary objects, i.e. offshore wind farms.

SECTION 5 MITIGATION

NOTE
Many of the mitigation measures outlined in this section are already routinely implemented by the aggregates industry, either in a voluntary capacity or as part of the licence conditions attached to new permissions. The mitigation measures outlined do not represent an exhaustive list, rather a summary of the most typical measures proposed. In practice, more 'novel' solutions may be required for certain projects, based on site-specific conditions.

MITIGATION - GENERIC INFORMATION	
Number	**Recommendations**
5.1	To increase the chances of success, the development of mitigation measures should involve some form of stakeholder consultation/engagement with key individuals/organisations within the study area.
5.2	The mitigation measures set out within a Dredging Plan should be linked to a discrete monitoring programme. One of the key objectives of this monitoring should be to test the effectiveness of any mitigation measures implemented. Key mitigation measures should be summarised within a dedicated Mitigation and Monitoring Management Plan.
5.3	The findings of on-going research projects should be reviewed and used to formulate mitigation measures within future ES's for marine aggregate extraction.

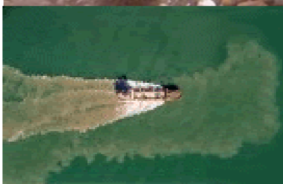
MITIGATION - MARINE ECOLOGY	
Number	**Recommendations**
5.4	The area of dredging (the spatial footprint) should be minimised, as far as possible. This can be facilitated by ensuring that the resources in any one location are dredged to 'economic exhaustion' before new areas are exploited. Zoning dredging within the permitted area will enable activities to be concentrated in one area at a time and will enable a dredged area to recover once the 'zone' is exhausted. In order to aid recolonisation, it should be possible to ensure that a similar habitat is left behind following dredging. In order to aid the recovery of benthic resources following the cessation of dredging, undredged 'buffer zones' should be left between production lanes. In areas where only thin layers of sand or gravel overlay bedrock, dredging should not take place. This will prevent bedrock being exposed which is unsuitable for benthic communities. When proposing mitigation measures to reduce impacts on key species, e.g. *Sabellaria spinulosa*, always consider the appropriateness of the mitigation, i.e. is the *Sabellaria* being protected in its reef building form? If not, is mitigation to avoid damage appropriate? When developing mitigation measures ensure that all relevant research projects are reviewed and any novel technologies available considered.

MITIGATION - COMMERCIAL FISHERIES	
Number	**Recommendations**
5.5	The success of mitigation measures aimed at reducing the impacts of dredging on commercial fishing activity rely heavily on clear communication between the two industries. Therefore, the lines of communication between these industries established at the start of the process (initial consultation and data collection) should be maintained throughout the project life-cycle, so that mitigation measures can be easily and successfully implemented. The existing zoning of dredging activity is generally perceived to be an effective way of reducing the physical exclusion of fishing vessels from licensed sites and should be continued. Active Dredge Area Charts produced by BMAPA and Crown Estate should be obtained and used. If site-specific conditions require them, well-defined access routes to and from the site should be established and these communicated to local fishermen prior to dredging beginning. If site-specific conditions require them, predicted dredger movements could be issued (by fax/post) to a central contact point, where they can be easily disseminated to local fishermen. However, this measure need not be applied generically to every site.

MITIGATION - NAVIGATION, RECREATION AND OTHER USES	
Number	**Recommendations**
5.6	The success of mitigation measures aimed at reducing the impacts of dredging on collision, rely heavily on clear communication between all users of the sea. Therefore, the lines of communication between these industries/user groups, established at the start of the process (initial consultation and data collection) should be maintained throughout the project life-cycle, so that mitigation measures can be easily and successfully implemented. Well-defined access routes to and from the site should be established and these communicated to relevant regulatory bodies, industry representatives and user groups prior to dredging beginning. Under certain site-specific conditions, predicted dredger movements should be issued (by fax/post) to a central contact point, i.e. the local offices of a fish merchant, trawler company, the RYA or local coastguard, where they can be easily disseminated to local mariners. Under certain site-specific conditions, the dredging industry, with input from the fishing industry, RYA and the Maritime and Coastguard Agency, should publish a leaflet describing the operating procedures, manoeuvrability and methods of identification of dredger vessels. These can be distributed directly by the regulatory and governing bodies of each industry and through publication in the relevant media, i.e. Yachting Monthly, Fishing News etc.

SECTION 6 MONITORING

MONITORING - GENERIC INFORMATION	
Number	**Recommendations**
6.1	SMART monitoring targets (Specific, Measurable, Achievable, Realistic and Time-bound) represent a transparent and robust approach to resolving key issues, through monitoring in an acceptable timeframe. They should be used within all ESs submitted for aggregate extraction applications.
6.2	Survey work should commence before the dredging activity in order to establish a baseline. The assessment of baseline conditions should always take account of influencing factors that are outside the control of the aggregate industry (fishing, shipping, seasonal occurrences, natural variability). The baseline conditions against which to monitor should be agreed with the Regulators.
6.3	The locations for reference sites should be carefully selected to ensure that the physical and biological conditions are the same (or as similar as possible) to the area to be affected.
6.4	Appropriate thresholds should be set, against which environmental change can be monitored. Such thresholds should be agreed through consultation with Regulatory Authorities. They should, ideally, form part of a feedback monitoring and management programme.
6.5	A monitoring review panel should be established consisting of members of the industry, a survey representative, expert scientific advisors and the Regulators.
6.6	Monitoring programmes should be developed taking account of all the key parameter-specific issues. By doing this, several monitoring objectives will be able to be met by single monitoring surveys, e.g. data from bathymetric surveys (physical processes) can be used to assess impacts on seabed topography (commercial fisheries). Data from side scan sonar surveys (physical processes) can also be used to assess impacts on seabed composition (marine ecology) and spatial extent of spawning grounds (fish & shellfish resources).



Marine Aggregate Extraction: Approaching Good Practice in Environmental Impact Assessment

TECHNICAL APPENDICES

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ROYAL HASKONING

APPENDIX A INTRODUCTION

A (i) Existing Guidance Documents

<u>EIA Guidance</u>

EC Directive 'The Assessment of the Effects of Certain Public and Private Projects on the Environment' (85/337/EEC) (Adopted June 1985, came into force July 1988)

This EC Directive identified the exploitation of mineral resources as an activity that might, under certain circumstances, require an Environmental Assessment in support of an application. The Directive stated a number of information requirements that were required in order for an assessment to be undertaken.

Amendment of EC Directive 85/337/EEC by EC Directive 97/11/EEC (1997-2003)

In 1997, the existing EC Directive related to EIA was amended by EC Directive 97/11/EEC. The amended directive came into force in the UK in 2000 and made explicit mention of `marine and fluvial dredging` in Schedule 2, i.e., projects that might, under certain circumstances, require an EIA. The directive has been translated into UK legislation through The Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2000 (Draft).

The introduction of this legislation means that there will be statutory control of marine aggregate dredging activity in England and Wales. The regulation will formalise the GV procedure, so that applications are made to, and licences are issued by, the Secretary of State (ODPM). The Crown Estate will remain the "land owner", a key consultee, and will enter into private legal contracts with applicants/operators for the exploitation of the resource in their charge if a licence is issued. But legal powers for determining applications and their subsequent enforcement will become the responsibility of the Government, acting through their statutory agencies.

Department of the Environment (1995) Preparation of environmental statements for planning projects that require environmental assessment: A good practice guide

A guide to best practice in preparing Environmental Statements for projects falling within the scope of Town and Country Planning Regulations. Aimed at consultants and developers.

Department of Environment Transport and the Regions (DETR) (1999) Environmental impact assessment – DETR Circular 02/99

This Circular gives guidance on the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 - SI 1999 No 293

DETR: Environmental Impact Assessment: A Guide to Procedures (2000)

This generic guidance document, produced by the DETR and intended primarily for developers and their advisers, explains how European Community (EC) requirements for the environmental impact assessment (EIA) of major projects have been incorporated into consent procedures in the U.K. It revises the booklet `Environmental Assessment: A Guide to the Procedures', first published in 1989, to take account of the requirements of Directive 97/11/EC (the `Directive), which was adopted on 3 March 1997 and came into effect on 14 March 1999.

Parts 1 and 2 of this booklet explain the procedures which apply to projects falling within the scope of the Directive and requiring planning permission in England and Wales. For such projects the Directive was given legal effect through the Town and Country Planning (Environmental Impact Assessment) (England and Wales) Regulations 1999 (SI No. 293), which came into force on 14 March 1999 and apply to relevant planning applications lodged on or after that date.

Formal guidance on procedures under the Regulations, directed principally at local planning authorities, was issued in DETR Circular 2/99 (Welsh Office Circular 11/99). Although the present booklet, like its predecessor, is meant to be reasonably self-contained, developers may need to refer to that Circular, particularly for fuller information on how planning authorities are expected to judge the significance of a project's likely effects for the purpose of deciding whether environmental impact assessment is required.

Although useful, the generic nature of this document means that it should be supplemented by more specific guidance addressing the particular issues raised by applications for sand and gravel extraction (Vivian, 2003).

Environment Agency (2002) A Handbook for Scoping Projects

This handbook outlines good practice in approaches to carrying out scoping as part of the EIA process. Targeted at developers, consultants and planning authorities, the handbook provides specific examples of the information that needs to be presented in a scoping study for numerous types of project.

Further generic and specific guidance and information on the EIA process can be found on the European Union's EIA web pages. Go to ***http://www.europa.eu.int/comm./environmental/eia***

Marine Aggregate Extraction Guidance

Government View (GV) Procedure (1968)

This is a non-statutory system, which dates back to 1968, under which the Crown Estate, as owners of the majority of seabed around the UK, would only issue a dredging licence if the Government were satisfied that predicted impacts on the environment were viewed to be acceptable. This process involves detailed consultation with key consultees.

Revision of the GV Procedure (1989)

In 1989, the existing GV Procedure was revised in order that the requirements of EC Directive 85/337/EEC could be incorporated. This revision meant that an EIA was required to be undertaken by all dredging applicants as part of the application process for a dredging licence/permit.

A Code of Practice for the Extraction of Marine Aggregates. Ministry of Agriculture Fisheries and Food (MAFF, 1981)

In 1981, MAFF published a Code of Practice for the Extraction of Marine Aggregates to avoid conflicts between fishing and marine aggregate industry when new reserves were proposed for exploitation. The publication of this Code of Practice was an important step in recognising and seeking to reconcile the operating difficulties that were being experienced on a routine basis.

International Council for the Exploration of the Seas (ICES) Co-operative Research Report No. 182 – Effects of Extraction of Marine Sediments on Fisheries (1992)

This report was produced by the ICES Working Group on the Effects of Extraction on Marine Sediments in 1992. It represented, at that time, a state of the art assessment of the impacts of sand and gravel extraction. It also provided a `***Code of Practice for the Commercial Extraction of Marine Sediments*** (including minerals and aggregates). This Code of Practice was evolved from the Code of Practice developed by MAFF in 1981 and was intended to promote sound management to ensure that the dredging industry operates in harmony with fisheries and other ocean space users. It was initially produced in 1989 but was published within this 1992 document.

The guidelines were intended to provide a flexible framework that any country could adopt within its own regulatory system. They were also intended to ensure that sufficient information is produced to enable an environmental impact assessment, covering the effects of the proposals on other interests, including fisheries, to be carried out and an environmental impact statement be produced as necessary.

Guidelines for Assessing Marine Aggregate Extraction (MAFF, 1993, Laboratory Leaflet No. 73)

These short guidance notes, produced by J.A. Campbell (MAFF) in 1993 were drawn up with regard to the work done on marine aggregate extraction by the ICES Working Group on the Effects of Extraction on Marine Sediments in 1992 (see above). They also took account of technical guidelines for the management of dredged material disposal. The guidelines are set out in two parts, the first dealing with pre-licensing assessment and the second with monitoring the impact of the extraction operation.

ICES Working Group on the Effects of Extraction on Marine Sediments – Guidelines for Environmental Impact Assessment of Marine Aggregate Dredging (1993)

Guidelines produced in 1994 by IECS that formed the basis of the officially published ICES guidelines set out in Co-operative Research Report No. 247 (see below). These were initially published in the 1993 Report of the Working Group on the Effects of Extraction of Marine Sediments on Fisheries.

Mineral Planning Guidance Note 6 (MPG 6) - Guidelines for Aggregates Provision in England (1994)

This Guidance Note provided advice to mineral planning authorities and the minerals industry on how to ensure that the construction industry received an adequate and steady supply of material at the best balance, of social, environmental and economic cost, whilst ensuring that extraction and development are consistent with the principles of sustainable development.

Scientific Aspects of Marine Pollution Arising from the Exploration and Exploitation of the Sea-bed – Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP, 1977)

This report included specific consideration of sand and gravel dredging and was one of the earliest high-level guidance documents that addressed this particular issue.

Helsinki Commission (HELCOM) Recommendation 19/1 (1998)

This was adopted in March 1998, having regard to Article 13, Paragraph b) of the Helsinki Convention. The Recommendation took into consideration the work done by ICES on the issue of managing the effects of marine sediment extraction, *inter alia* the “Code of Practice for the Commercial Extraction of Marine Sediments (including minerals and aggregates).

It recommended to the Governments of Contracting Parties to the Helsinki Convention that all sediment extractions should be carried out according to the Guidelines for Marine Sediment Extraction provided with Recommendation 19/1.

ICES Co-operative Research Report No. 247 –Effects of Extraction of Marine Sediments on the Marine Ecosystem (2001)

This co-operative research report was produced by the ICES Working Group on the Effects of Extraction on Marine Sediments in 2001. It built upon Report No. 182 that was published in 1992. Within this earlier report, 14 future research themes were identified and recommendations were made as to how these themes should be investigated. The 2001 report provided a synthesis of the most recent advances in the knowledge and understanding of ecosystem effects resulting from the extraction of marine sediments.

This report includes a section on patterns and trends in the extraction of marine sediments in various countries as well as a review of the environmental effects of marine sediment extraction on living resources and fisheries. Of particular note is that within this report, “Guidelines for the Preparation of an Environmental Impact Assessment Evaluating the Effects of Seabed Aggregate Extraction on the Marine Environment” are included. These guidelines are an updated version of guidelines produced by ICES in 1994 (see above).

In January 2003, the OSPAR[1] Biodiversity Committee (BDC) agreed to accept this report as an overall assessment of the impacts of sand and gravel extraction.

Guidelines on the Impact of Aggregate Extraction on European Marine Sites (2001)

These guidelines were produced by Posford Duvivier (now Posford Haskoning) and Hill, M.I in May 2001 as part of the UK Marine SACs project. The overall aim of the guidelines were to provide information on the potential impacts of aggregate extraction on marine and coastal habitats and species listed in Annexes I and II of the Habitats Directive and provide guidance on the assessment of potential impacts.

The guidance provides details on

- Dredging techniques and equipment;
- Legislative framework for marine aggregate extraction;
- Potential effects on physical, water quality and biological parameters;
- Potential effects on specific Annex I habitats and Annex II species;
- Methods of cumulative impact assessment; and
- Monitoring (aims and methods);

DRAFT Marine Aggregates Dredging Policy (South Wales) (2004)

In May 2001, the Welsh Assembly Government issued Draft Marine Aggregates Dredging Policy (South Wales) for consultation. This document set out the Assembly's strategic policy to enable objective and transparent decisions to be taken about the most appropriate locations for dredging marine aggregates in Welsh waters of the Bristol Channel, Severn Estuary and the River Severn. Following an extensive consultation process, a final version is to be published early in Summer 2004.

ICES Guidelines for the Management of Marine Sediment Extraction (2002)

These guidelines were published as an Annex in the 2002 Report of the Working Group on the Effects of Extraction on Marine Sediments (WGEXT). The guidelines had been circulated widely and comments received from a number of authorities including OPSAR. Following discussions on these comments, relevant changes were incorporated with the revised version representing the final guidelines.

Previously published work by ICES (ICES, 1992, 1993) and the more recent guidance by HELCOM (HELCOM recommendation 19/1), were taken into account in preparing these guidelines. The final guidelines, that form Annex 10 of the 2003 ICES WGEXT report, are designed to be an update to *both* the previous Code of Practice (ICES, 1992) and guidelines on EIA (see above).

Marine Minerals Guidance Note 1 (MMG1) – Guidance on the Extraction by Dredging of Sand, Gravel and Other Minerals from the English Seabed (2002)

MMG1 sets out the Government's policies and procedures on the extraction of minerals by dredging from the seabed in English marine waters. The note applies to both the applications for dredging licences made under the GV procedure and for Dredging Permissions made under a new statutory system when it is introduced. CEFAS advised the ODPM and its predecessors on the content of this note.

Annex A of MMG1 provides Guidance on Environmental Impact Assessment in Relation to Marine Minerals Dredging Application. This detailed guidance has been derived from the ICES guidance (see above) and the experience of Defra/CEFAS staff in applying it.

[1] The Convention for the Protection of the Marine Environment of the North-East Atlantic

Guidelines for the Conduct of Benthic Studies at Aggregate Dredging Sites (2002)

This document, produced by CEFAS in 2002, on behalf of the Department for Transport, Local Government and the Regions (DTLR, 2002), aims to provide detailed guidance on the conduct and reporting of benthic surveys. This guidance aims to facilitate consistency of approaches among consultants employed by the dredging industry to conduct ES's and when carrying out monitoring surveys.

The guidance is already widely accepted amongst both consultants and regulators as `Best Practice` and is currently considered the core guidance when designing and undertaking benthic studies at marine aggregate extraction sites. The guidance covers;

- Benthic grab sampling, design and methods;
- Processing of benthic samples;
- Methods of data analysis;
- Use of remote acoustic methods;
- Oceanographic surveys;
- Physical process surveys (wave, tide);
- Sediment sampling (Particle Size Analysis, PSA);
- Use of Geographical Information Systems, GIS);
- Habitat mapping tools; and
- Cumulative impact studies.

GOOD PRACTICE RECOMMENDATION A1
Guidelines for the Conduct of Benthic Studies of Aggregate Dredging Sites (2002) aims to combine the key recommendations of many existing guidelines into one overall document. However, practitioners should still obtain and review existing guidelines, as far as possible, when undertaking an EIA related to marine aggregate extraction.

A (ii) Key National (UK) Organisations that should be Consulted	
British Marine Aggregates Producers Association (BMAPA) **http://www.bmapa.org**	Joint Nature Conservation Committee (JNCC) **http://www.jncc.gov.uk**
British Wind Energy Association (BWEA) **http://www.bwea.com**	Lloyds Marine Intelligence Unit (LMIU) **http://www.lloydsmiu.com**
British Sub-Aqua Club **http://www.bsac.com**	Marine Conservation Society (MCS) **http://www.mcsuk.org**
CADW **http://www.cadw.wales.gov.uk**	Maritime & Coastguard Agency (MCA) **http://www.mcga.gov.uk**
Crown Estate **http://www.crownestate.org.uk**	Ministry of Defence (Directorate of Safety, Environment and Fire Policy) **http://www.mod.uk**
CEFAS **http://www.cefas.co.uk**	National Assembly for Wales **http://www.wales.gov.uk**
Countryside Agency **http://www.countryside.gov.uk**	National Coastwatch Institute (NCI) **http://www.nci.org.uk**
Countryside Council for Wales **http://www.ccw.gov.uk**	National Federation of Fisherman's Organisations **http://www.nffo.org.uk**
Chamber of Shipping **http://www.british-shipping.org**	Northern Lighthouse Board **http://www.nlb.org.uk**
Defra Sea Fisheries Inspectorate **http://www.defra.gov.uk/fish**	Office of the Deputy Prime Minister (ODPM) (Minerals and Waste Planning Division) **http://www.odpm.gov.uk**
Defra European Conservation **http://www.defra.gov.uk/wildlife-countryside/ewd/index.htm**	Quarry Products Association (QPA) **http://www.qpa.org**
Defra Environmental Protection **http://www.defra.gov.uk/environment**	Royal Commission on Historic Monuments in England: Maritime Division (RCHME) **http://www.rchme.gov.uk**
Department of Trade and Industry (DTI) **http://www.dti.gov.uk**	Royal Society for the Protection of Birds (RSPB) **http://www.rspb.org.uk**
Department of Transport (DfT) **http://www.dft.gov.uk**	Royal Yachting Association (RYA) **http://www.rya.org.uk**
English Nature **http://www.english-nature.org.uk**	Scottish Executive **http://www.scotland.gov.uk**
Environment Agency **http://www.environment-agency.gov.uk**	Scottish Natural Heritage **http://www.snh.org.uk**
English Heritage **http://www.english-heritage.org.uk**	Sea Fish Industry Authority **http://www.seafish.co.uk**
Environment and Heritage Service (Northern Ireland **http://www.ehsni.gov.uk**	The Corporation of Trinity House **http://www.trinityhouse.co.uk**
Fisheries Research Services (FRS) **http://www.marlab.ac.uk**	The Wildlife Trusts **http://www.wildlifetrusts.org**
Historic Scotland **http://www.historic-scotland.gov.uk**	United Kingdom Offshore Operators Association (UKOAA) **http://www.ukooa.co.uk**
International Maritime Organisation (IMO) **http://www.imo.org**	World Wide Fund for Nature (WWF-UK) **http://www.wwf-uk.org**

A (iii) Key Local Organisations that should be Consulted	
Coastal/Estuary Management Initiatives (e.g. *Thames Estuary Partnership, Severn Estuary Partnership)*	Local dive clubs
Local Sea Fisheries Committee **http://www.nfsa.org.uk/general/sfc.htm**	Local Maritime Council
Local Fish Producers Organisation	Local Wildlife Trusts
Local Fishing Organisations	Local yacht and boat clubs

A (iv) Key International Organisations that should be Consulted	
IFREMER (France) ***http://www.ifremer.fr/anglais***	RIVO (Netherlands) ***http://www.rivo.dlo.nl***
COFREPECHE (France) ***http://www.ifremer.fr/cofrepeche/accueilanglais.htm***	Rederscentrale (Belgium) ***http://www.rederscentrale.be***
Danish Directorate of Fisheries (Denmark) ***http://www.fd.dk***	

A (v)
Key Stages And Components Of Each Stage Of The Production Licence Application

STAGE		COMPONENTS
(1) APPLICATION	A	Application for a GV made to ODPM (copy of application also sent to Defra and Crown Estate.
	B	ODPM writes to applicant acknowledging receipt of application and enclosing a list of consultees.
	C	Applicant arranges informal discussions with key consultees and fishing industry representatives to identify possible areas of concern, and scope of EIA.
	D	Once step (C) is complete applicant advises ODPM and Defra of outcome of informal discussions, and confirms whether they wish to proceed with the application.
	E	ODPM arranges a meeting with Defra, the applicant and Crown Estate, if required.
	F	If applicant wishes to proceed they commission a CIS and ES.
(2) CONSULTATION	A	Once CIS and ES produced, applicant advertises the proposal in Fishing News and at least two local papers, and is also advised to issue a press release. Comments on the proposal are to be sent to the applicant.
	B	Applicant arranges for consultation papers to be lodged for a 10 week period with at least 2 local authorities.
	C	Applicant writes to those on consultee list enclosing relevant reports, copying all correspondence to the ODPM.
	D	Applicant acknowledges response and corresponds directly with relevant consultee to resolve any concerns.
	E	Applicant chases outstanding consultee responses at week 9 of consultation process.
	F	Applicant prepares consultation report incorporating summary of consultations and subsequent discussions/correspondence, and how any concerns have been resolved.
	G	Applicant arranges for preparation of a supplement to the ES which details how concerns expressed during consultations have been addressed, and includes a draft schedule of conditions.
	H	Applicant submits summary report including the ES supplement as an appendix, to ODPM and CEFAS and sends a copy to Crown Estate.
(3) CONFIRMATION	A	ODPM sends a copy of summary report to all consultees seeking confirmation that concerns expressed during consultation stage have been resolved.
	B	If no response is received within six weeks it is assumed that the consultees concerned are content.
	C	ODPM to copy any response to CEFAS and the applicant.
(4) ASSESSMENT AND DETERMINATION	A	Towards the end of the confirmation stage ODPM and Defra will discuss likely outcome of application i.e.: favourable GV, unfavourable GV, informal hearing/discussions or public enquiry.
	B	If application is to be considered by public enquiry this process will be co-ordinated by the ODPM.
(5) DECISION	A	After consideration of Inspectors recommendation (where inquiry/hearing held) and after necessary consultation with other departments, ODPM issues GV letter to the applicant (copied to Crown Estate and all consultees).

Source: Oakwood Environmental Ltd, 1999

A (vi) International Legislation – Nature Conservation

Convention on Biological Diversity (CBD)

The CBD was negotiated under the auspices of the United Nations Environment Programme (UNEP) and entered into force on 29 December 1993. The three goals of the CBD are;

1) To promote the conservation of biodiversity;
2) The sustainable use of its components; and
3) The fair and equitable sharing of benefits arising out of the utilisation of genetic resources.

EC Directive 85/337/EEC on the Assessment of the Effects of Certain Private and Public Projects on the Environment (as amended by EC Directive 97/11 and Regulated according to Statutory Instruments 1999, No. 293); The EIA Directive

The EIA Directive was implemented in the UK through the *Town and Country Planning Regulations 1998* (SI 1998 No. 1199) with subsequent amendments. Projects are grouped into two main Annexes, dependent upon their potential impact on the environment. Annex I projects are those which are predicted to have a significant impact on the environment. It is obligatory to carry out an EIA for all Annex I projects. Projects that fall into Annex II are determined individually and on a case by case basis depending on the scale, nature and location of the project. Mineral extraction falls under Annex II, and due to the conditions of the GV and the nature and scale of most aggregate dredging proposals, a full EIA is generally required.

The 97/11 EC amendment implemented new requirements on Trans-boundary Consultation (UK SI 193). Any potential trans-boundary issues must now be considered throughout all aspects of the EIA.

EC Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Flora and Fauna; The Habitats Directive

Under this Directive, Member States agree to establish a series of protected sites that are selected because of their importance as either a natural habitat or as a habitat of one of the species listed in Annex I or II of the Directive. These Special Areas of Conservation (SACs), together with the Special Protected Areas (SPAs), designated under 79/409/EC (the "Birds Directive"), will form a single pan-European network of nature conservation sites called 'Natura 2000'. The administration of the Habitats Directive in the U.K is the responsibility of JNCC and its sister agencies in individual countries (English Nature, Countryside Council for Wales, Scottish Natural Heritage and Northern Ireland Environment and Heritage Service).

Full transposition of this Directive into UK law will hopefully be achieved by the Offshore Marine Conservation (Natural Habitats &c.) Regulations 2003 (*see below*). Until these regulations are placed on the statute books,the Conservation (Natural Habitats &c) Regulations 1994 only transpose the Directive out to the 12nm limit (JNCC, 2004). However, even after these regulations have been transposed into U.K law, their implementation is likely to take a period of time.

Although no offshore cSACs have yet been designated up to the publication of this report, it is important to note that the Darwin Mounds have been notified to Defra with JNCC's recommendation to designate. Defra have also stated their intention to designate, once appropriate legislation to do so is made available (JNCC, 2004).

This process of implementation of the Habitats Directive between 0-12nm and beyond 12nm (to 200nm) will be the responsibility of the relevant country agencies. At the time of publication, this process is at different stages for each of these agencies. Therefore, it is recommended that the user contacts the relevant country agency to determine the status of this process as part of the EIA process.

EC Directive 79/04/EEC on the Conservation of Wild Birds; The Birds Directive

In the UK, the provisions of the Birds Directive are implemented through the Wildlife & Countryside Act 1981, the Wildlife (Northern Ireland) Order 1985, and the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985.

The Directive provides a framework for the conservation and management of, and human interactions with, wild birds in Europe. It sets broad objectives for a wide range of activities, although the precise legal mechanisms for their achievement are at the discretion of each Member State (in the UK delivery is via several different statutes). The Directive identifies key species of concern and designates areas for their conservation and management as SPAs. As with cSACs, no offshore SPAs have been designated. However, as a result of the “Greenpeace Ruling” and the subsequent production of the draft Offshore Marine Conservation (Natural Habitats &c.) Regulations 2003 (*see below*), work is now underway to identify important conservation areas for birds between 0-200nm.

EC Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment; the Strategic Environmental Assessment (SEA) Directive

This Directive is expected to effect many changes in the way that the environment and wider sustainability issues are considered. The main objective of the Directive is, “*to contribute to the integration of environmental considerations into the preparation and adoption of plans and programmes with a view to promoting sustainable development*”. An important point to note is that the responsibility for undertaking SEA lies with the Government regulator and not a developer.

A (vii) International Legislation – Other

EC Directive 2000/60/EC for establishing a framework for community action in the field of water policy; The Water Framework Directive

The Water Framework Directive (WFD) is the most substantial piece of European Commission (EC) water legislation produced to date. The WFD imposes a requirement for Member States to work towards and achieve at least "Good Ecological Status" (in all bodies of surface water and groundwater. The WFD also aims to prevent deterioration in the status of those water bodies (some water bodies will be only be required to achieve "Good Ecological Potential").

The potential for the WFD to influence aggregate extraction activities may be limited due to the fact that the requirements of the WFD will only extend to between 1 and 3nm offshore, whilst aggregate extraction schemes are moving much further offshore. However, this important piece of legislation should still be considered when undertaking the EIA.

International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol 1978 relating thereto (MARPOL 73/78)

The MARPOL Convention is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. It is a combination of two treaties adopted in 1973 and 1978 respectively.

EU Directive 76/60/EEC Concerning the Quality of Bathing Waters

In England and Wales, the Environment Agency monitors the quality of designated bathing waters against mandatory and guideline standards set out in the bathing water regulations (SI 1991/1597), which are derived from the EC Bathing Water Directive (76/160/EEC). A proposal for the revision of 76/160/EE was produced in October 2002 and aims to introduce tighter standards.

The implication on this Directive from marine aggregate extraction should be considered during the preparation of an EIA to show the location of testing sites in the vicinity and any potential impacts on bathing beaches.

EC Directive 79/923/EEC The Shellfish Waters Directive

The Shellfish Waters Directive (79/923/EEC) is implemented in the UK under the Shellfish Waters (Shellfish) (Classifications) Regulations 1997. The legislation requires the designation of shellfish waters and requirements for water quality such that the waters contribute to the quality of shellfish for human consumption. Compliance is monitored against quality standards for shellfish waters. The standards form the assessment guidelines for water quality concerning shellfish waters.

Draft EC Environmental Liability Directive

The draft EC Environmental Liability Directive could have implications for activities in the marine environment. This Directive currently refers to species and habitats listed in the EU Habitats Directive, which do not have to form part of any designated areas. The scope of the Directive also appears to be that an "operator" could be responsible for remedial measures where damage has occurred.

A (viii) National (UK) Legislation – Nature Conservation

Draft Environmental Impact Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations 2001

These new regulations will replace the Interim GV procedure when they come into force (Vivian, 2003) and will transpose into UK legislation, in so far as marine dredging is concerned, the provisions of EC Directive 85/337/EEC, as amended by EC Directive 97/11/EC, on the assessment of the effects of certain public and private projects on the environment.

The new regulations will separate the Crown Estate from the environmental consideration of dredging proposals; In England, the Crown Estate will still issue commercial licenses but these will become distinct from the dredging permission issued by the ODPM (Marker, 2003). Similarly, in Wales, the new regulations being developed by the Welsh Assembly Government will separate the Crown Estate licenses from dredging permissions that will be granted by the Welsh Environment Minister. Further details on the implications of these new Regulations are provided in **Section 1.4.4**.

Draft Offshore Marine Conservation (Natural Habitats, &c) Regulations 2003

The Conservation (Natural Habitats, &c.) Regulations 1994 transpose the Habitats Directive into domestic legislation. They apply to England, Wales and Scotland and their territorial seas up to 12 nautical miles (nm) from the baselines. Northern Ireland has its own Regulations with the same coverage of territorial sea.

In 1999 Greenpeace sought judicial review of the conduct of the UK's Department of Trade and Industry (DTI). They sought confirmation that DTI could not legally decide whether to grant applications for oil exploration in the Northeast Atlantic beyond 12nm without first considering and applying the Habitats Directive. The court made a declaration that the Directive "applies to the UK Continental Shelf and to the superjacent waters up to a limit of 200 nautical miles...". On 23 November 1999, the Government announced that it would not appeal against the decision.

The declaration in the Greenpeace case did not mention the Birds Directive. However, the Habitats and Birds Directives share some common features so there is justification for treating them both in the same way as regards their geographical scope. Therefore, the UK Government has prepared the Regulations to apply both the Habitats and Birds Directives in relation to the offshore marine area.

These draft Regulations implement the Habitats and Birds Directives for all activities for which the UK Government has competence to legislate on the UK Continental Shelf or in waters beyond 12nm but within British fishery limits. The proposed Regulations do not cover the Isle of Man, the Channel Islands or Gibraltar. They seek to ensure that activities for which the United Kingdom has competence to manage or control are carried out in a manner that is consistent with the Habitats and Birds Directives. They do not currently cover activities such as oil and gas exploration and exploitation that are covered by separate Regulations[2].

[2] The Offshore Petroleum Activities (Conservation of Habitats) Regulations 2001

These regulations represent a critical indication of how nature conservation issues are likely to be dealt with in the near future for all offshore operators. Therefore, a summary of the key aspects of the Draft Regulations is provided. However, the user is recommended to obtain a full copy of the Regulations for a more comprehensive review, available from:
http://www.defra.gov.uk/corporate/consult/offshore-marine/index.htm

Regulation	Description
5	Places an obligation on all competent authorities who have functions relevant to marine conservation to carry out those responsibilities in a way that will ensure compliance with the requirements of the Habitats and Birds Directives.
6 – 8	Places a statutory requirement on the Secretary of State to identify and notify to the European Commission a list of European offshore marine sites hosting: i. Marine natural habitats listed in Annex I of the Habitats Directive; ii. Habitats of marine species listed in Annex II of the Habitats Directive.
9	Places a statutory duty on the Secretary of State to classify Special Protection Areas for birds.
11-13	Outlines the procedures for notifying site boundaries to those competent authorities who exercise functions in or around the site, and those persons/operators who may be affected by the site notification. There will also be a duty on the Secretary of State to compile and maintain a register containing information about European offshore marine sites.
14 – 16	Outline the procedures for adopting management schemes for offshore marine sites. They enable competent authorities to set up management schemes for a single European offshore marine site or group of sites, to secure compliance with the requirements of the Directives. Schemes will list conservation objectives and any operations which may cause deterioration of the site. Where management schemes have been established, competent authorities must take reasonable steps to exercise their functions in accordance with that scheme.
16	Requires the Secretary of State to consult other Member States to co-ordinate the management of sites which adjoin SACs or SPAs in other Member States.
17 – 22	A competent authority will be required to undertake an appropriate assessment before agreeing to any plan or project which, either alone or in combination with other plans or projects, would be likely to have a significant effect on a European offshore marine site and is not directly connected with or necessary to the management of the site. Competent authorities will only be able to agree to a plan or project after ascertaining that it will not affect the integrity of the site unless there are imperative reasons of overriding public interest for carrying it out. There will also be a duty to review existing consents along similar lines. Where, despite a negative assessment it is decided that a plan or project should proceed, the Secretary of State will be placed under a duty to provide compensatory measures, thus ensuring the coherence of the Natura 2000 network
23	Will introduce a new criminal offence of deliberate or reckless destruction, damage or disturbance of the species or habitat features for which a European offshore marine site has been designated.
25 – 34	Cover the protection of species of fauna and flora. They will seek to prevent the deliberate disturbance of protected animal species, prohibit the deliberate capture or killing of birds and protected animal species (those listed on Annex IVa to the Habitats Directive) and prohibit damage or destruction of, or acts which result in the deterioration of the breeding sites or resting places of protected animal species. They will also make it an offence to intentionally pick, collect, cut, uproot or destroy a wild plant of a European protected species
25 (3)	Transposes Article 5(d) of the Wild Birds Directive. This requires Member states to prohibit deliberate disturbance of birds, particularly during the period of breeding and rearing, in so far as disturbance would be significant having regard to the objectives of the Directive. On present evidence Defra has not identified any species of wild bird which is liable to a level of disturbance that would be significant in terms of the objectives of the Directive.
29	The Regulations will, however, give the Secretary of State the power to grant exceptions from the protection afforded to species by licence. Licences may be issued for purposes permitted by Article 16 of the Habitats Directive, and Article 9 of the Birds Directive.

Regulation	Description
24 & 39	Are designed to fulfill the obligations under Articles 11 and 12(4) of the Habitats Directive respectively. They introduce a duty for the Secretary of State to make arrangements for the surveillance of the conservation status of natural habitats and species listed by the Habitats Directive and for monitoring the incidental capture and killing of a European protected species.
35	Prohibits the deliberate release of non-native fauna and flora into the offshore area. This Regulation is in line with the obligations placed on Member States by Article 22(b) of the Habitats Directive.
40 – 43	Deal with the proceedings for offences under the Regulations. Most of the offences carry a maximum penalty on summary conviction of a level 5 fine or three months imprisonment.

As of March 2004, the Government has not yet compiled a response to the consultation process, which closed in October 2003.

Wildlife and Countryside Act (1981) as amended by Countryside and Rights of Way Act 2000

The Wildlife and Countryside Act 1981 (WCA 1981) consolidates and amends existing national legislation to implement the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and Council Directive 79/409/EEC on the Conservation of Wild Birds (Birds Directive) in Great Britain[3]. It is complimented by the Wildlife and Countryside (Service of Notices) Act 1985, which relates to notices served under the 1981 Act, and the Conservation (Natural Habitats, &c.) Regulations 1994[4], which implement Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (EC Habitats Directive).

In Scotland, the Act was amended in 2001 in the form of the The Wildlife and Countryside Act 1981 (Amendment) (Scotland) Regulations 2001. These Regulations came into force on 4th November 2001.

Amendments to the Act have occurred, the most recent being the Countryside and Rights of Way (CRoW) Act 2000 (in England and Wales only). There is also a statutory five-yearly review of Schedules 5 and 8 (protected wild animals and plant respectively), undertaken by the country agencies and co-ordinated by the Joint Nature Conservation Committee.

A (ix) National (UK) Legislation – Other

Coast Protection Act 1949 (as amended by the Merchant Shipping Act 1988)

Section 34 of the Coast Protection Act is concerned with the safety of navigation in tidal waters. This consent is only awarded if a GV permission is forthcoming. The award of a GV permission will only take place if there are no objections on the grounds of the Coast Protection Act.

Protection of Wrecks Act, 1973

This Act protects historic wrecks from unauthorised interference. The Act provides for the designation of sites in all UK territorial waters which of historical or archaeological importance.

It is advisable to contact the English Heritage National Monuments Record (NMR) in Swindon to find out information about any designated wrecks in a proposed dredging area. Usually an EIA of this nature, where maritime archaeology is thought to be an issue, would benefit from the commissioning of a specialist archaeological review.

[3] Equivalent provisions for Northern Ireland are contained within the Wildlife (Northern Ireland) Order 1985 and the Nature Conservation and Amenity Lands (Northern Ireland) Order 1985.

[4] Equivalent provisions for Northern Ireland are contained within the Conservation (Natural Habitats, etc.) Regulations 1995.

Ancient Monuments and Archaeological Areas Act, 1979, Chapter 46

UK Planning Policy Guidance (PPG) Note 16 is the main means by which the Regulations presented in the 1979 Act have been implemented into the UK planning system. Both the act and the PPG Note make provisions for the protection, investigation, and recording of all matters of historical or archaeological interest.

Protection of Military Remains Act, 1986

This Act applies to vessels that have been sunk or stranded whilst on military service or any aircraft which has, at any time, crashed while on military service. It establishes protected places to encompass the remains of all military craft. Again, investigations should be carried out to find out the location of any designated site within the vicinity of the proposed dredging area.

REFERENCES

JNCC (2004). Technical Comments on MIRO Best Practice Guide. Received from Joint Nature Conservation Committee (JNCC) on behalf of JNCC, English Nature, Scottish Natural Heritage and Countryside Council for Wales. February 2004.

B – DATA COLLECTION, ANALYSIS AND PRESENTATION

GENERIC INFORMATION

B (i) – Geographical Information Systems

Role of GIS in EA

The vast majority of data collected for EIA's have a spatial location; for example the data collected from a benthic grab survey is related to the specific location where the sample was collected. GIS are important due to their ability to store, integrate, manipulate, analyse and present the large quantities of geographically referenced data (spatial data) referred to during the course of EA. Cartographic output is traditionally the result of analysis in GIS; however the flexibility of modern GIS applications allows cartographic output in a variety of different formats and projections, as required by the project. Additionally raw data can be provided, in an agreed data format, if required for use in the clients GIS application.

Overview of GIS Capabilities

GIS allows complicated spatial and temporal analysis to be performed across multiple datasets in two and three dimensions. Inbuilt functionality allows the visualisation and calculation of relationships between different variables, ultimately providing an invaluable aid in decision making and evaluation. Sophisticated functionality exists to integrate many external data sources, ranging from aerial photography and film clips to data derived from modelling packages, creating an integrated and potentially comprehensive data set of the study area.

Software Market

Central to GIS applications is a database used for efficient storage and retrieval of spatial datasets. Traditionally GIS databases store information in a proprietary format - one that is specific to the GIS software being used. Interoperability between different GIS vendors is, at time of print, an area of rapid growth, driven predominantly by the work of the Open GIS Consortium (OGC, www.opengis.org). Whilst there is no common standard data format for the storage of spatial data, improvements in software functionality and interoperability mean this is not a significant issue for modern GIS applications.

Data Integration

GIS are now a relatively mature technology, having existed in the commercial market place since the 1970's, and as such most GIS software can import a wide range of, often proprietary, spatial data formats. Currently no single standard transfer format exists for the exchange of spatial data in the UK; however certain formats, such as eXtensible Mark-up Language (XML) and Geographic Mark-up Language (GML), are emerging as de facto standards. Indeed the EU MarineXML project (www.marinexml.net) is currently working to develop a framework to improve the interoperability of data for the marine community using XML technology.

GIS can integrate data stored in a wide range of national co-ordinate systems and different scales. However care must be taken when calculating distances, areas and lengths from data stored in different co-ordinate systems due to the intrinsic errors associated with calculating such information in different co-ordinate projections.

Metadata

Whilst GIS can prove very useful in assisting EA it is vital that the user is aware of any issues relating to each dataset intended for analytical use. It is imperative that these issues are fully understood to ensure that analysis is appropriate, sensible and accurate in relation to the individual datasets.

Information concerning any aspect of a dataset, such as its creation date or originator, is referred to as metadata, or data about data. Metadata is crucial to assessing the suitability of using a dataset in any given EA and when used properly can provide a comprehensive resource of information about a dataset. It is vitally important that all metadata is consulted prior to using a dataset in order to ensure that the user is completely satisfied of the applicability of each dataset in a particular EA. Metadata is the primary location where specific details concerning a dataset should be stored; such details include copyright restrictions, usage rights, scale of data capture, co-ordinate system, positional accuracy, and so on.

At time of print there is no international published standard regarding the creation of metadata, however a draft international standard (Draft ISO Standard 19115 Geographic Information) is due for publication in the near future and should be consulted to ensure complete metadata information is provided for each dataset. In the UK the information service GIGateway has been set up to promote the use of metadata and provide access to geospatial metadata through the internet (www.gigateway.org.uk). GIGateway provide a tool for the creation of metadata compliant to the current specification (formally the UK's National Geospatial Data Framework Standard). This tool will be re-designed to be compliant with the emerging international standard when published.

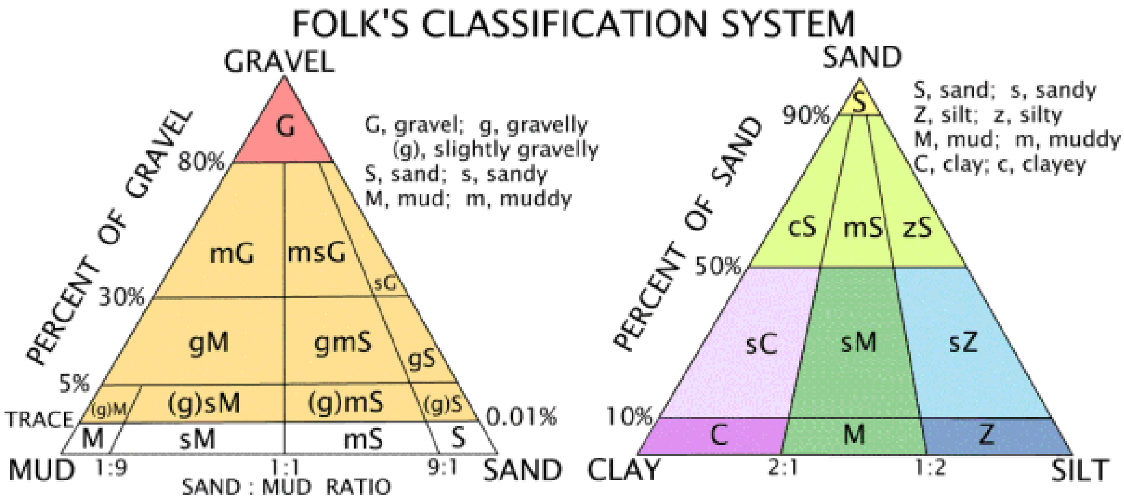
All users of spatial data should consult the metadata supplied with a dataset to ascertain if it is appropriate for a specific EA. If information is missing from the metadata of a dataset the user should approach the data originator and clarify any omission in order to confirm the applicability of the dataset.

PHYSICAL PROCESSES

B (ii) Classification Of Gravel

It is convenient to classify sediments on the basis of their particle size. Wentworth (1922) broke down the gravel fraction into four categories; granules (2-4 mm), pebbles (4-64 mm), cobbles (64-256 mm) and boulders (>256 mm). However, in a later system, developed by Folk (1954), gravel is classified as any sediment with a particle size greater than 2 mm (Finer sediment in the 0.063 mm to 2 mm range is classified as sand by both schemes). Therefore, it is critical within any baseline studies that an accurate description of what is meant by `gravel` is provided.

Although several classification schemes have been adopted to describe the approximate relationship between the size fractions, many sedimentologists use the system described by Folk (1954). This system is based on two triangular diagrams, with 21 major categories (see figures below). In Folk's system, slightly gravelly sediments can have as little as 0.01% gravel.



B (iii) Sources Of Baseline Data For Geology And Geomorphology

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Crown Estate (CE)
http://www.crownestate.co.uk/estates/marine

Large GIS (run and managed by Posford Haskoning) including data collected by the dredging industry and other organisations. The data primarily relates to that collected in both extraction and prospecting areas. Access to these data requires permission from CE and the dredging industry.

Dredging Companies

Data held includes:

- Sediment samples;
- Sidescan sonar
- Seismic records, collected during prospecting, extraction and monitoring of dredging activities

Access to these data requires permission from CE and the dredging industry.

Academic Data

Universities may hold data from specific research projects and contracts for certain data. No overall data catalogue is available and tracking down site specific data can be difficult.

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British Geological Survey (BGS)
http://www.bgs.ac.uk

The National Geoscience Data Centre (part of BGS) holds data including:

- Boreholes and cores;
- Seismic profiles (mainly boomer, sparker, pinger and airgun);
- Seabed sediment data (grab samples, particle size data);
- 1:250,000 maps: Solid Geology, Quaternary Geology, Seabed Sediments;
- Offshore regional reports;
- Data from commercial organisations (access to which may be restricted).
- Academic and Hydrographic Office seabed sample data
- **DigBath250** (A vector attributed digital bathymetry of UK and adjacent European waters, with a proposed coverage of the UK continental shelf; and
- **DigSBS250** (Digital maps of offshore seabed sediments based on seabed grab samples of the top 0.1m, combined with cores and dredge samples as available.

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The Hydrographic Office (UKHO)
http://www.ukho.gov.uk

Main repository of both contemporary and historical UK continental shelf bathymetry data. Also hold some sidescan sonar data and seabed texture maps as well as commercial data (available subject to permission of owner).

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EU-Seased
http://www.eu-seased.net

A searchable internet metadata database of seabed samples and seismic lines from European seas. The database covers data held at European institutions, universities, marine stations and industrial companies.

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Consultants Reports
Data from other studies undertaken within the immediate or wider study area. These data will generally remain, either with the consultant or the client or in some cases the data is stored by organisations such as BGS and HR Wallingford. There is no catalogue detailing the data that exists and site specific investigations would be required to determine availability.

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B (iii) cont.	
Regional Scale Sediment Studies Series of research projects undertaken over recent years, which have investigated the mobility and transport of sediment around the UK coast. The studies provide information to aid management decisions regarding the seabed and coastline. Relevant projects include: • South Coast Seabed Mobility Study: Isle of Wight to Brighton. Coast to 50m depth contour (HR Wallingford, 1993) • Seabed Sediment Mobility Study: Durlston Head (Isle of Purbeck) to St Catherine's Point (Isle of Wight). Coast to 50m contour (Brampton *et al*, 1998) • Southern North Sea Sediment Transport Study, Flamborough Head, Yorkshire to North Foreland, Kent (HR Wallingford, 2002) • Bristol Channel Marine Aggregates: Resources and Constraints Research Project: Line drawn across Severn Estuary at Collow Pill, Newham to line between St Ann's Head to Hartland Point (Posford Duvivier, 2000)	**Inshore Seabed Characterisation Project** Project undertaken by BGS which aimed to enhance knowledge and understanding of the geology of the inshore seabed off selected parts of eastern and southern England. The work particularly focussed on the sediment transport regime and the potential sand and gravel resource. The project covered the following areas up to 20km offshore: • Gibraltar Point to Flamborough Head; • Winterton-on-Sea to Hunstanton; • Deben Estuary to Winterton-on-Sea; • Shoreham to Dungeness; • St Catherine's Point to Shoreham; and • Portand Bill to St Catherine's Point. The project incorporated data sets from BGS, UKHO, commercial and academic sources. Data (which is held digitally) is presented under the following headings: • Sub-surface geology; • Bathymetry and oceanography; • Littoral zone sediment information; • Seabed sediments; • Sediment transport indicators; • Man-made features and boundaries; and • Sand and gravel resource information.

B (iv) Sources Of Baseline Data For Physical Processes	
UK Met Office ***http://www.met-office.gov.uk/marine*** Main supplier of both hindcast and forecast wind and wave data. There is a cost associated with the purchase of wave data from the Met Office. Wave data can be obtained, either via modelled outputs at specified offshore points or data collected from a network of offshore buoys. Marine Data Analysts at the Met Office should be contacted to determine the availability and costs of data.	**British Oceanographic Data Centre (BODC)** ***http://www.bodc.ac.uk*** BODC is the Natural Environment Research Council's designated data centre for marine sciences. A variety of oceanographic information is held including wave data and current meter records. The web-site should be contacted for data queries.
WaveNet ***http://www.cefas.co.uk/wavenet*** WaveNet is Defra's strategic wave monitoring network for England and Wales and consists of a network of wave buoys located in areas at risk from flooding. Further details regarding the availability of data from this source can be found on the CEFAS website.	**Admiralty Charts** ***http://www.ukho.gov.uk*** Tidal current measurements have been made at a number of locations around the coast of the UK and many of these are presented on Admiralty charts in the form of Tidal Diamonds. This information is supplemented by Tidal Atlases. Admiralty Charts and Tidal Atlases can be obtained from UK Hydrographic Office.

B (iv) (cont.)	
Voluntary Observing Ships (VOS) ***http://www.met-office.gov.uk/marine*** The VOS, run by the World Meteorological Office, provides observational wave data from voluntary observing vessels along the major shipping routes. These data are available from the Met Office.	**Futurecoast** ***http://www.environment-agency.gov.uk*** ***http://www.defra.gov.uk*** This project was completed in 2002 and provides predictions of coastal evolutionary tendencies over the next century, to input into the next phase of shoreline management plans (SMP's). Details are provided of behavioural characteristics and likely future shoreline evolution for individual sections of coast.
Shoreline Management Plans (SMPs) ***http://www.environment-agency.gov.uk*** SMP's provide details regarding all aspects of the physical processes operating along a specific stretch of coast. SMPs for specific areas can be obtained from the relevant Environment Agency Regional Office and/or maritime authority.	**Strategy Studies** ***http://www.environment-agency.gov.uk*** Strategy studies normally stem from SMP's and cover a smaller area with more site specific information and detail. Details regarding strategies and how to obtain copies of strategies can be obtained from Environment Agency regional offices and relevant maritime authorities.
Data from Dredging Companies Currently, there are plans to install water quality monitoring equipment aboard dredgers and for these to be operating whilst dredgers steam to and from port. This will enable background data with respect to water quality, in particular, suspended sediment loads, to be collated. As these data are collected and analysed over time, a better indication of background water quality in areas away from specific dredge areas will be possible. This will, in turn, benefit any future impact assessments related to increased suspended sediment loads as a result of aggregate dredging.	

B (v) Suitable Methods Of Wave Recording

Surface systems: Surface buoys use accelerometers to record wave dynamics and do not require a fixed structure for support, simply a mooring system. Have the disadvantage of not being capable of recording long period waves.

Sub-surface systems: These devices utilise pressure sensors to record pressure variations. They can record accurately in 5m of water, although the optimum deployment depth will depend on the instrument used. The local tidal range is also important as the changes in depth experienced between high and low water could be greater than 5m.

Above surface systems: Such systems measure waves using radar or laser beams from aircraft, satellites or ground stations. The advantage of such an approach is the wide spatial coverage obtained and the fact that there is no need to deploy equipment at sea. However, a disadvantage is that no data can be provided for wave direction or period and the spatial variations in waves in coastal waters cannot be well represented.

Directional systems: Pitch, roll and heave buoys can be used to provide directional wave data and an estimate of directional wave spectrum.

B (vi) Tools For Measuring Suspended Sediment Concentrations

Bed mounted sensors
An optical backscatter sensor can be used to record fine particles in suspension while an acoustic backscatter sensor can be used to measure coarse particles in suspension. The sensors should be deployed as close to the bed as possible and aligned to minimise disturbance from flow around the frame upon which they are mounted.

Water Sampling
(a) Depth integrated samplers collect a sample as they are lowered from the surface to the seabed and brought back to the surface. This type of equipment is restricted to shallow depths due to its capacity to store samples.
(b) Point Integrated samplers operate in a similar manner to above, but have a remote operated inlet valve. This allows samples to be taken at selected depth intervals in deep water.

Silt Meters

Use an infrared light source and photo detector to record the amount of light received. The amount of light fluctuates as the suspended sediment load varies.

Acoustic Recorders:
Acoustic Doppler devices are available that are capable of recording depth profiles of sediment concentrations

Remote Sensing:
Remote sensing can only provide information regarding surface concentrations. However, this may still be of benefit in certain situations, for example, in comparing percentage changes.

REFERENCES

Brampton, A.H., Evans, C.D.R. and Velegrakis, A.F. (1998) Seabed sediment mobility study – west of the Isle of Wight. CIRIA Project Report 65. London.

HR Wallingford (1993). South coast sea bed mobility study. HR Wallingford Report. Report No. EX 2795. Wallinford, Oxon.

HR Wallingford (2002) Southern North Sea sediment transport study Phase 2. Sediment transport report. Report produced by HR Wallingford, Posford Haskoning, CEFAS / UEA and Dr B. D'Olier. Report EX 4526. Wallingford. Oxon.

Posford Duvivier and ABP Research and Consultancy (2000). Bristol Channel Marine Aggregates: Resources and Constraints Research Project. Final Report to the Welsh Office, Department of Environment, Transport and regions and The Crown Estate. August 2000.

MARINE ECOLOGY

B (vii) Contact Details For Organisations Holding Data On Marine Mammals

Sea Mammal Research Unit Sea Mammal Research Unit Gatty Marine Laboratory University of St Andrews St Andrews Fife KY16 8LB ***http://www.smub.st-and.ac.uk***	JNCC Monkstone House, City Road, Peterborough PE1 1JY ***http://www.jncc.gov.uk/***
Sea Watch Foundation 36 Windmill Road Headington Oxford 0X3 7BX ***http://www.seawatchfoundation.org.uk***	RSPCA Wilberforce Way Southwater Horsham West Sussex RH13 9RS ***http://www.rspca.org.uk***

B (viii) Other Methods/Tools For Analysing Benthic/Epibenthic Data

Multivariate analysis is used to search for relationships between or classify objects (usually samples or sites) that are defined by a number of attributes (usually the abundance of species or higher taxa). If the objective is to assign objects to a number of discrete groups then cluster analysis should be considered. If there is no *a priori* reason to believe the objects will or could naturally fall into groups then an ordination technique may be more suitable. Ordination assumes the objects form a continuum of variation and the objective is often to generate hypotheses about the environmental factors that mould community structure. There is a considerable literature on multivariate techniques. Useful introductory texts are Digby and Kempton (1987) and Kent and Coker (1992).

When sites are compared using similarity measures a cluster analysis can be undertaken. This seeks to identify groups of sites, or stations that are similar in their species composition. For computational and presentational reasons hierarchical-agglomerative methods are the most popular as these will result in the production of a dendrogram - a branched diagram depicting the relationship, often the degree of closeness or similarity – between sites or species. Two-Way Indicator Species Analysis, TWINSPAN, (Hill *et al.* 1975) also produces dendrograms of the relationship between both species and samples but uses the reciprocal averaging ordination method to order the species and samples. Thus, the method is a hybrid between classificatory and ordination methods. TWINSPAN can be used with presence-absence, % cover and quantitative data. It is particularly attractive in studies where the objective is to classify communities using their characteristic species (termed indicator species).

A number of ordination techniques are commonly used and it is not possible to give clear guidance as to the best method. Principal Component Analysis (PCA) is the oldest and still one of the most frequently used ordination techniques in community ecology. It is most appropriate for full quantitative data, but can be used if abundance is classified into a number of abundance classes. Non-metric multidimensional scaling (NMDS) is a generalisation of PCA and may not always produce a better ordination than PCA. Reciprocal Averaging (also termed Correspondence Analysis) and an adjusted version called Detrended Correspondence Analysis (DECORANA) are best used on quantitative data although they can give good results with classed abundance data. Both of these methods are particularly effective when it is suspected that the sites can be arranged along an environmental gradient such as depth, salinity or sediment type. Further, these methods plot the site and species ordinations on the same figure, which allows the influence of the species in determining the ordination of the sites to be uncovered.

If information on the environment at each sampling site is also available then the relationship between the species, samples and environmental variables can be investigated simultaneously using Canonical Correlation Analysis (CCA).

The following general computer packages are available which offer most of the above techniques.

CAP (Community Analysis Package)/ECOM – PISCES Conservation Ltd.
(***http://www.pisces-conservation.com***)
CANOCO – Microcomputer Power (***http://www.microcomputerpower.com***)
PcORD – MJM Software Design (***http://www.pcord.com***)
BRODGAR - by Highland Statistics (***http://www.brodgar.com***)
MSVP - Kovach Computing Services ***(http://www.kovcomp.com/mvsp)***

SOURCE: Peter Henderson (PISCES Conservation Ltd), 2003

REFERENCES

Digby, P. G. N. and Kempton, R. A. (1987). *Multivariate analysis of ecological communities*. Chapman & Hall, London.

Hill, M. O., Bunce, R. G. H. and Shaw, M. W. (1975). Indicator species analysis, a divisive polthetic method of classification and its application to a survey of native pinewoods in Scotland. *J. Ecol.* 63, 597-613.

Kent, M. and Coker, P. (1992). *Vegetation description and analysis*. John Wiley & Sons, Chichester, New York.

NATURE CONSERVATION

B (ix) Contact Details Of Organisations That Hold Data On Designated Sites		
Organisation	**Address**	**Contact Details**
Joint Nature Conservation Committee (JNCC)[5]	Monkstone House City Road Peterborough PE1 1JY United Kingdom	Tel: 01733 562626 Fax: 01733 555948 ***http://www.jncc.gov.uk***
Scottish Natural Heritage (SNH)	12 Hope Terrace Edinburgh EH9 2AS	Tel: 0131 447 4784 Fax: 0131 446 2277 ***http://www.snh.org.uk***
Countryside Council for Wales (CCW)	Maes-y-Ffynnon Penrhosgarnedd Bangor Gwynedd LL57 2DW	Tel: 01248 385500 Fax: 01248 355782 ***http://www.ccw.gov.uk***
English Nature (EN)	Northminster House Peterborough PE1 1UA	Tel: 01733 455000 Fax: 01733 568834 ***http://www.english-nature.org.uk***
Environment and Heritage Service Northern Ireland		
UK Marine SAC Project	c/o JNCC	***http://www.ukmarinesac.org.uk***

[5] JNCC also hold data on areas where there is the *potential* for Annex I habitats to be present. This information is critical in considering what area may be considered in the future as possible cSACs.

B (x) Remit Of UK Nature Conservation Agencies	
Organisation	**Remit**
Joint Nature Conservation Committee (JNCC)	The JNCC is the UK Government's wildlife adviser and also represents the forum through which the three country nature conservation agencies deliver their statutory responsibilities for Great Britain as a whole and internationally. These responsibilities, known as special functions include: - Advising ministers on the development of policies for, or affecting, nature conservation in Great Britain and internationally; - Providing advice and knowledge to anyone on nature conservation issues affecting Great Britain and internationally; and - Establishing common standards throughout Great Britain for the monitoring of nature conservation and for research. JNCC has a remit out to 200nm.
English Nature (EN)	EN is a Government funded body whose purpose is to promote the conservation of England's wildlife and natural features. With respect to marine aggregate extraction, EN works to ensure that marine aggregate resources are won in a way that does not diminish the quality and diversity of England's natural environment. EN also seek to ensure that industry and planners take full account of important areas for nature conservation and seek measures to minimise the adverse environmental impacts of extraction. EN has a specific remit to ensure that any aggregate developments that could result in significant impacts on sites of nature conservation interest such NATURA 2000 (SAC/SPA) and Sites of Special Scientific Interest (SSSI's) are avoided. They also seek full mitigation measures, revocation or alternative outcomes for permissions where aggregate working is likely to harm or destroy irreplaceable sites.
Countryside Council for Wales (CCW)	CCW is the Government's statutory adviser on sustaining natural beauty, wildlife and the opportunity for outdoor enjoyment in Wales and its inshore waters. Similar to EN, CCW has a remit to ensure that marine aggregate extraction does not cause impacts on resources of nature conservation interest within Wales or Welsh waters. These include, amongst others, NATURA 2000 sites (SAC/SPA), SSSI's and National Nature Reserves (NNR's). CCW also have to ensure that overall biodiversity within their boundaries are not adversely affected by marine aggregate extraction in any way.
Scottish Natural Heritage (SNH)	SNH is the Government's statutory adviser on nature conservation in Scotland and Scottish waters. One of SNH's major responsibilities is to ensure the conservation and enhancement of habitats, species and landscapes. One mechanism to enable this is the system of 'protected' areas which operates both on a UK and an international basis. With respect to marine aggregate extraction, this is carried out at a much lower level in Scottish water compared to English and Welsh waters. However, SNH still has a remit to ensure that such activities do not create adverse effects on designated nature conservation sites and/or overall biodiversity.
Environment and Heritage Service (EHS)	EHS is an Agency of the Northern Ireland Department of the Environment and takes the lead in advising on, and in implementing, the U.K Government's environmental policy and strategy in Northern Ireland. The Agency carries out a range of activities, which promote the Government's key themes of sustainable development, biodiversity and climate change. EHS has a specific remit to conserve the natural heritage of Northern Ireland and, therefore, is responsible for the development of biodiversity action plans, a programme for protecting habitats and species and providing advice on designated areas of nature conservation.

B (xi) Marine Protected Areas and UK BAP

STATUTORY PROTECTED AREAS

Special Areas of Conservation (SACs)

SAC's are sites designated under the Habitats Directive, the purpose of which is to contribute to the maintenance or restoration of the favourable conservation status of selected habitats or species. The UK is required to apply the Directive to the 200 nautical mile limit, though at present it is only applied to habitats and species within the 12 nautical mile limit of territorial waters.

Special Protection Areas (SPAs)

SPA's are sites designated under the Birds Directive to conserve bird habitats. Terrestrial and littoral parts of a SAC or SPA are protected under SSSI legislation, but this only applies as far down the shore as the low water mark. Thus, for those sites that also include sublittoral areas, an alternative approach has been taken. These zones (which extend from Highest Astronomical Tide level to the specified seaward extent of the site) are referred to as European marine sites (62). A single scheme of management is prepared for each site which takes into account all activities that may cause damage to the habitats or disturbance of the species for which the site was designated.

Ramsar Sites

Ramsar Sites, or Wetlands of International Importance, are defined under the Wetlands Convention, signed in Ramsar, Iran, in 1971. In order to qualify as a Ramsar site, an area must have "international significance in terms of ecology, botany, zoology, limnology or hydrology. Coastal waters of particular importance can be designated as Ramsar sites but they do not normally exceed 6m in depth (Anon, 2001).

Sites of Special Scientific Interest (SSSIs)

An area of land notified under the Wildlife & Countryside Act 1981 (as amended), which is 'of special interest by reason of any of its flora, fauna, or geological or physiographical features'. The notification is made to owners and occupiers, local planning authority and the Secretary of State, who may make representations or objections to the nature conservation agencies regarding the notification. Any representation or objection made must be considered by the nature conservation agencies before a decision is made by them to confirm the notification.

In Northern Ireland the designation Areas of Special Scientific Interest (ASSIs) is the equivalent of the SSSIs. The responsibility for the identification and designation of these sites rest with the Environment and Heritage Service, Northern Ireland.

National Nature Reserves (NNRs)

The relevant country nature conservation agencies have powers stemming from the National Parks and Access to the Countryside Act 1949 to designate land as a National Nature Reserve (NNR). The aim of these designations is both to secure protection and appropriate management of the most important areas of wildlife habitat, and to provide a resource for scientific research.

NNRs are usually designated for their broader ecological value rather than for the presence of any rare species. There are however a number of sites which hold important numbers of scarce or rare species. A number of factors may contribute to the designation of a NNR. These may include; how fragile a site is, the size of the site, how 'natural' the site is and the presence of species rich communities. The NNR network represents almost every kind of vegetation type found in England.

Within a European context, NNRs are also very important. A number of sites are designated as Special Protection Areas (SPA) under the EC Birds Directive and Special Areas of Conservation (SAC) under the EC Habitats and Species Directive or as Ramsar sites under the Ramsar Convention. (source: ***http://www.defra.gov.uk/wildlife-countryside***).

Marine Nature Reserves (MNRs)

Marine Nature Reserves (MNRs) are the coastal and tidal equivalent to the land-based National Nature Reserves (NNRs), designated for their flora and fauna. Once established they are actively managed by either English Nature, Countryside Council for Wales or Scottish Natural Heritage (SNH). Three MNRs have been designated to date; Lundy MNR off the coast of Devon, Skomer MNR in South West Wales and Strangford Lough in Northern Ireland. The EIA would have to consider any potential impact on these sites if dredging is to take place within or with the potential to affect them.

The MNR arrangements are, in common with the other site safeguard provisions of the 1981 Act, based on the "voluntary approach" and are thus dependent on securing the co-operation of all the local interests concerned - e.g. fishermen, divers, local authorities, - to agree the detailed provisions for protecting each site.

NON-STATUTORY PROTECTED AREAS

Marine Sites of Nature Conservation Interest (mSNCI)

These are non-statutory sites identified on account of their special interest with regard to habitat, wildlife, geology or geomorphology. The designation of mSNCIs was pioneered by the local authorities in Sussex, setting a model which could usefully be applied elsewhere to raise the profile of marine sites and emphasize the risks facing them.

Voluntary Marine Conservation Areas (VMCAs)

These are non-statutory sites designated primarily for the purpose of raising awareness of the marine environment and encouraging local stakeholder support.

Sensitive Marine Areas (SMAs)

These are non-statutory sites identified by English Nature as being nationally important. 27 areas have been identified.

Natural Areas

Natural Areas are English Nature’s non-statutory subdivisions of England, each with a characteristic association of wildlife and natural features. The coastal Natural Areas cover inshore waters as far as the 6 nautical mile limit.

Marine Natural Areas

These are English Nature’s non-statutory divisions of the offshore environment (6 nautical miles to the Median Line).

UK BIODIVERSITY ACTION PLAN

Species Action Plans

- Priority Species Action Plans: provide detailed information on the threats facing 391 species and the opportunities for maintaining and enhancing their populations;
- 'Grouped' Species Action Plans: produced where a range of common policies and actions are required for a number of similar species, for example marine turtles or commercial fish; and
- Species Statements: provide an overview of the status of the species and set out the broad policies that can be developed to conserve them.

Source: ***http//www.ukbap.org.uk***

Broad Habitat Statements and Priority Habitats Action Plans

- Priority Habitat Action Plans: Provide detailed descriptions for 45 specific types of habitats and set out detailed actions that can be taken to safeguard and enhance these habitats.
- Broad Habitat Statements: provide summary descriptions of all habitats found within the UK and identify the current issues affecting the habitat and the broad policies which can be put in place to address these.

Source: ***http//www.ukbap.org.uk***

Local Action Plans

Around 160 Local Action Plans are in preparation or being implemented across Great Britain. Each Action Plan works on the basis of partnership to identify local priorities and to determine the contribution they can make to the delivery of the national Species and Habitat Action Plan targets.

Northern Ireland has its own biodiversity strategy that reflects their priorities for the wildlife and habitats considered rare and vulnerable in Ireland.

Source: ***http//www.ukbap.org.uk***

Habitat Action Plans and Species Action Plans relevant to marine aggregate sites	
HABITAT ACTION PLANS	
Priority Habitats	- *Modiolus modiolus* beds - *Sabellaria alveolata* reefs - *Sabellaria spinulosa* reefs - *Serpulid* reefs - Sublittoral sands and gravels - *Lophelia pertusa* reefs
Broad Habitats	- Inshore sublittoral sediment - Offshore shelf sediment - Oceanic seas

Habitat Action Plans and Species Action Plans relevant to marine aggregate sites (cont'd)		
SPECIES ACTION PLANS		
Grouped Species Plans	Grouped plan for toothed whales	- *Globicephala melas*, Long-finned pilot whale - *Hyperoodon ampullatus*, Northern bottlenose whale - *Mesoplodon bidens*, Sowerby`s beaked whale - *Mesoplodon mirus*, True`s Beaked Whale - *Orcinus orca*, Killer Whale - *Physeter macrocephalus*, Sperm Whale - *Ziphius cavirostris* Cuvier`s, beaked whale
	Grouped plan for baleen whales	- *Balaenoptera acutorostrata*, Minke Whale - *Balaenoptera borealis*, Sei Whale - *Balaenoptera musculus*, Blue Whale - *Balaenoptera physalus*, Fin Whale - *Eubalaena glacialis*, Northern right whale - *Megaptera novaeangliea*, Humpback Whale
	Grouped plan for small dolphins	- *Delphinus delphis*, Common Dolphin - *Grampus griseus*, Risso`s dolphin - *Lagenorhynchus acutus*, Atlantic white-sided dolphin - *Lagenorhynchus albirostris*, White-Beaked Dolphin - *Stenella coeruleoalba*, Striped dolphin - *Tursiops truncatus*, Bottlenosed dolphin
	Grouped plan for commercial marine fish[6]	- *Clupea harengus*, Herring - *Gadus morhua*, Cod - *Merlangius merlangus*, Whiting - *Merluccius bilinearis*, a Hake - *Pleuronectes platessa*, Plaice - *Pollachius virens*, Saithe - *Scomber scrombrus*, Mackerel - *Solea vulgaris*, Sole - *Trachurus trachurus*, Horse Mackerel
Individual Species Plans	- *Amphianthus dohrnii*, An anemone - *Eunicella verrucosa*, The pink sea fan - *Leptopsammia pruvoti*, Sunset Cup Coral - *Phocoena phocoena*, Harbour Porpoise - *Alosa alosa*, Allis Shad - *Alosa fallax*, Twaite Shad - *Cetorhinus maximus*, Basking Shark - *Diptura batis*, Common Skate	

[6] There is also a Grouped Species Plan for deepwater (>400m depth) fish. However, these species are not considered relevant to current marine aggregate extraction sites.

FISH AND SHELLFISH RESOURCES

B (xii) Selection Of Fish And Shellfish Species Which Have A Vulnerable Life-History Stage That May Be Impacted By Dredging Activities (Adapted From ICES, 1999)		
Species Name	Common Name	Vulnerable habitat or life-history stage
Clupea harengus	Herring	Spawns on raised gravel banks in coastal waters
Ammodytidae	Sandeel	Occupies clean sandy seabed during daytime and deposits eggs on sand
Aspitrigla cuculus	Red Gurnard	Feeds on sand and gravel seabed
Galeorhinus galeus	Tope	Feeds on coarse seabeds and undergoes coastal migrations
Melanogramus aeglefinus	Haddock	Bottom feeding and important commercial fish species
Mullus surmeltus	Red Mullet	Feeds on sand and gravel seabed
Mustelus mustelus	Smooth hound	Feeds on coarse seabeds and undergoes coastal migrations
Pollachius pollachius	Pollack	Bottom feeding on and near rocky and sandy ground
Rajidae (including *Raja batis*, UK BAP species)	Skates and Rays	Bottom living on sand and gravel, and lays eggs in discrete coastal nurseries
Scopthalmus maximus	Turbot	Adults and juveniles feed on coarse sediments
Scopthalmus rhombus	Brill	Adults and juveniles feed on coarse sediments
Spondyliosoma cantharus	Black Sea Bream	Lays eggs in seafloor hollows inshore and males brood eggs
Squalus acanthias	Spurdog	Migratory small shark most abundant in coastal waters
Cancer pagurus	Edible Crab	Females migrate long distances and bury over-winter in coarse sediments
Maja squinada	Spider Crab	Inshore migrations in spring support important local fisheries
Homarus gammarus	Lobster	Adults and juveniles occupy coarse sediments
Buccinum undatum	Whelk	Adults live and spawn on coarse sediments
Sepiidae	Cuttlefish	Inshore migrations in spring, deposit eggs on coarse sediments

B (xiii) Overview Of Defra Landings Data

Information on the landings of over-10m vessels is compiled from obligatory logbook returns submitted by each skipper at the end of a trip. More precise weights and landed values are provided in some cases by means of sales returns completed by the fish merchant or vessel agent handling the catch. Prior to January 2000, skippers were obliged to complete a logbook return only in respect of trips exceeding 24 hours duration and logbooks were required only to show details of pressure stock species[7] retained. The reporting of non- pressure stock species was voluntary. However, the current reporting regime now requires skippers to submit returns in respect of all trips from which 50 kgs or more of fish was landed, and the logbook must now report details of all species retained, regardless of whether or not they are pressure stocks.

Under-10m vessels are not required to complete logbooks, and their catches are estimated from a variety of information sources:

- Some skippers submit voluntary catch returns direct to Defra District Inspectors of Fisheries;

- Defra Fisheries Inspectors make estimates of landings as a result of visual inspections at landing sites, and in some cases they may also collect information on a systematic basis from fish merchants; and

- Fisheries Officers of the Sea Fisheries Committees (SFCs) also make their own estimates of landings from visual inspections, and many SFCs have catch reporting schemes, especially for shellfish. This information is normally made available to Defra and many of the SFC's also produce their own Annual Reports that present landing data that is often of use.

There are potentially two principal sources of error in the Defra estimates of catches and values.

Principal sources of error in Defra landings data

1. Error may arise from the estimation of catches for which logbook reporting is not required. However, under most circumstances, there is no reason to expect estimation errors to alter systematically over time, and Defra estimates are therefore expected to be useful in illustrating seasonal and longer term trends in fishery production (MEP, 2002).

2. Error may also arise through the under-reporting of catches of pressure stock species by vessels that have exceeded their quotas or run the risk of doing so. Wherever the availability of fish on the grounds exceeds the quota allocation, catches are likely to be under-reported or mis-reported (e.g. reported as another species, or having been taken from a different management area). Similarly, it is in the interests of under-10m vessels (that do not fish against individual quota limits) to hide their landings of pressure stock species in order to reduce the probability of fishery closure. The net result is that the data set might represent landings of some species better than others, with high-value, low-quota species being underestimated (MEP, 2002).

REFERENCE

MacAlister Elliot & Partners Ltd. (2002). An assessment of the Thames estuary fisheries. Report on behalf of P&O Ports. November, 2002.

[7] Species managed by means of quotas

B (xiv) Future Developments In Fisheries Data Collection

Modelling to determine habitat preferences (from Posford Haskoning *et al*, 2003)

A potentially cost-effective way to predict the distribution of species which have particular requirements in the marine environment would be to use information on their habitat requirements obtained from other parts of the region. Recent developments using habitat modelling and generalised additive models (GAM) have provided accurate predictions of habitat preferences for individual species based on their association with physical factors characterising their habitat (Freeman and Rogers, 2003)

This process quantifies the strength of the association between the distribution of benthic fauna and the physical factors of their habitat such as substrate, bathymetry, and near bed hydro-dynamics. Attributes such as these are important in structuring the habitat of organisms, and can provide useful parameters for predicting patterns in their spatial distribution. These preferences also describe the probability of a species occurring across a range of different habitats, otherwise known as the habitat-envelope.

Some organisms, particularly echinoderms, show distinct patterns in their habitat preferences, and allow reliable predictions to be made of their likely distribution.

Environmental data can also be used to predict the distribution of fish species which are closely associated with the seabed. These approaches use a number of different physical variables to define the association between the seafloor environment and the fish species that occur at a location. The advantage of using this multivariate approach is that it avoids the logistical complexities of sampling fish populations over 100% of an area.

A number of methods are available. The simplest use least squares regression to describe the association between species abundance and each of a range of important physical factors such as salinity, depth, tidal flow rate (stress) and temperature. More complex methods use a Generalised Additive Model (GAM), which in an extension of the Generalised Linear Model (GLM), a non-parametric technique that has an advantage over conventional regressive methods because it is not dependent on linearity in data. It is, therefore, less restrictive in its assumptions about the underlying statistical distribution of the data and allows for a greater degree of flexibility for modelling spatial trends.

REFERENCE

Freeman, S.M. and Rogers, S.I. (2003). A new analytical approach to the characterisation of macro-epibenthic habitats: linking species to the environment. Estuarine, Coastal and Shelf Science **56** (2003) pp 749-764.

Linking acoustic seabed classification to fish and macro-epifaunal habitats in the Irish Sea (Freeman *et al*, 2002)

Increasing use of seabed biological resources and the effects of fishing on the seabed requires an urgent need to assess the extent and diversity of those habitats affected. Traditional techniques of site-specific sampling do not adequately map the extent of seabed habitats and are prone to overlooking uncommon habitats. Assessing the utility of remote assessment techniques such as multi-beam bathymetry, sidescan sonar and acoustic ground-discrimination systems is important because they provide a predictive basis for better-targeted benthic sampling. Acoustic surveys were conducted in the Irish Sea conjunction with traditional biological sampling methods at eight study sites selected for differences in demersal fish abundance. Using a 2-m and 3-m beam trawl, distinct fish and macro-epifaunal assemblages were identified. These were strongly associated with acoustically distinct habitats identified using QTC VIEW™. Sidescan sonar images provided detailed information on surface texture and seabed sediment types, whilst sediment samples were used effectively to ground-truth acoustically distinct habitats. An index of habitat complexity was correlated with the acoustic data, which provided an effective assessment method for mapping the spatial extent of fish and macro-epibenthic habitats.

REFERENCE

Freeman, S.M., Bergmann, M., Hinz, H., Kaiser, M.J., and Rogers, S. (2002). Use of acoustic seabed classification to identify fish habitats. Session: Ocean Observation, Theme Session K8: The Integration of Acoustic and Optical Survey Techniques and Marine Biological Data for the Purpose of Seabed Classification. ICES 2002.

Combining acoustic and trawl data for estimating fish abundance – CATEFA

The primary aim of CATEFA is to develop and apply appropriate methodologies for the use of both acoustic and trawl data from bottom trawl surveys. The project involves a number of participants from the UK, France, and Norway.

Specifically, the project has four main objectives; to determine the relationships between acoustic and trawl data, to develop mathematical models to calculate combined stock abundance indices, to test the performance of these indices within the stock assessment process, and to provide advice on improved survey designs which allow optimum collection of both types of data.

The integration of acoustic methods with trawl surveys will allow more accurate distribution maps to be developed than is possible with the trawl data alone. This will greatly improve assessments of the distribution and geographical limits of the fish stocks. The results will provide invaluable information to fisheries managers, at little extra cost.

COMMERCIAL FISHERIES

B (xv) Typical Information Requested Through Interviews/Questionnaires

Commercial Fishermen

- Name, address and contact details and name and port registration of vessel;
- Description of vessel and gear, as seen (if seen);
- Principal areas fished, fisheries and seasons;
- Level of catches by season, any obvious long-term trends, and, if possible, an indication of annual grossing;
- Means of marketing the catch;
- Awareness of the proposed project (aggregate extraction), and views on whether and how his operation might be affected;
- Maintenance of records – what records are kept, if any, including participation in any log book schemes; and
- Membership of a representative association.

Fish Processors & Merchants

- Name, address and contact details;
- Description of operation – trading / processing, nature and capacity of processing operations, equipment owned etc;
- Principal sources of supply, species and seasons;
- Volumes of fish purchased from within the study area – if possible with an indication of which ports are the main suppliers, and any obvious long-term trends;
- Destination markets for fish bought and/or processed, and an indication of total value added; and information on other trading or processing operations in the area.

ARCHAEOLOGY AND CULTURAL HERITAGE

B (xvi) Existing Key Guidance Documents Relating To Archaeology and Cultural Heritage

- BMAPA and English Heritage (2003). *Marine Aggregate Dredging and the Historic Environment Guidance Note*. British Marine Aggregate Producers Association and English Heritage, London.
- Institute of Field Archaeologists (1999). Standard and Guidance for Archaeological Desk-Based Assessment. Published October 1994. Revised September 2001.
- Institute of Field Archaeologists (1999). Standard and Guidance for Archaeological Field Evaluations. Published October 1994. Revised September 2001
- JNAPC. Code of Practice for Seabed Developers. (now superseded by the above). Joint Nautical Archaeological Policy Committee.
- Planning Policy Guidance 16: Archaeology and Planning. ODPM, London, 2002.
- Royal Commission on Historical Monuments, England and English Heritage (1996). England's Coastal Heritage: a Statement on the Management of Coastal Archaeology.
- Taking to the Water – English Heritage's Initial Policy for The Management of Maritime Archaeology in England. Paul Roberts and Stephen Trow. English Heritage 2002. English Heritage, 23 Savile Row, London, W1S 2ET

NAVIGATION, RECREATION AND OTHER USES

B (xvii) Key Consultees For The Collation Of Navigation And Other Uses Data	
BMAPA 156 Buckingham Palace Road London SW1W 9TR ***http://www.bmapa.org***	**Lloyds Marine Intelligence Unit (LMIU)** Telephone House 69-77 Paul Street London EC2A 4LQ ***http://www.lloydsmiu.com***
British Wind Energy Association (BWEA) ***http://www.bwea.com***	**MoD** ***http://www.mod.uk***
BSAC Telford's Quay, South Pier Road, Ellesmere Port, Cheshire CH65 4FL ***http://www.bsac.com***	**National Coastwatch Institute** NCI can be contacted through each of their coastal stations. The addresses of each station is given on the NCI website ***http://www.nci.org.uk***
Crown Estate 16 Carlton House Terrace London SW1Y 5AH ***http://www.crownestate.org.uk***	**Port and Harbour Authorities**
Defra Nobel House 17 Smith Square London SW1P 3JR ***http://www.defra.gov.uk***	**RYA** RYA House Ensign Way Hamble Hampshire SO31 4YA ***http://www.rya.org.uk***
DTI The best source of contact for the DTI is through their website, which provides contact details for each division and area of enquiry. See: ***http://www.dti.gov.uk***	**SeaFish** Sea Fish Industry Authority 18 Logie Mill Logie Green Road Edinburgh EH7 4HG ***http://www.seafish.co.uk***
Environment Agency Rio House Waterside Drive Aztec Way Almondsbury Bristol BS32 4UD ***http://www.environment-agency.gov.uk***	**Telecommunications Companies** **Trinity House** Trinity House Tower Hill London EC3N 4DH ***http://www.trinityhouse.co.uk***
IMO 4 Albert Embankment London SE1 7SR ***http://www.imo.org***	**UKOOA** 2nd Floor, 232-242 Vauxhall Bridge Road, London, SW1V 1AU ***http://www.ukooa.co.uk***

C – GENERIC IMPACTS OF AGGREGATE EXTRACTION

GENERIC GUIDANCE

C (i) Selected Reviews Of The Effects Of Aggregate Extraction On The Marine Environment

Arntz, W.E and Rumohr, H. (1982). An experimental study of macrobenthic colonisation and succession, and the importance of seasonal variation in temperate latitudes. *Journal of Experimental Marine Biology and Ecology*, **64:** 17-45.

Bonsdorff, E. (1983). Recovery potential of macro-zoobenthos from dredging in shallow brackish waters. *In* Proceedings 17th European Marine Biology Symposium, Brest, France, 27 September to 1st October, 1982, pp. 27-32. *Oceanologica Acta*, No. SP.

Boyd, S.E., Limpenny, D.D, Rees, H.L, Cooper, K.M. and Campbell, S. (2003). Preliminary observations on the effects of dredging intensity on the re-colonisation of dredged sediments off the south-east coast of England (Area 222). Estuarine, Coastal and Shelf Science **57** (2003): 209-223.

De Groot, S.J. (1986) Marine sand and gravel extraction in the North Atlantic and its potential environmental impact, with emphasis on the North Sea. Ocean Management, Vol 10 (1988) pp 21-36.

ICES (1992). Effects of Extraction of Marine Sediments on Fisheries. *ICES Co-operative Research Report No: 182.* ICES, Copenhagen.

ICES (2001). Effects of Extraction of Marine Sediments on the Marine Ecosystem. *ICES Co-operative Research Report No: 247*. ICES, Copenhagen.

Kenny, A.J. and Rees, H.L. (1994). The effects of marine gravel extraction on the macrobenthos: early post-dredging recolonization. *Marine Pollution Bulletin,* **28:** 442-447

Kenny, A.J. and Rees, H.L. (1996) The effects of marine gravel extraction on the macrobenthos: Results 2 years post-dredging. Marine Pollution Bulletin, **32**: 615-622.

Marine Life Information Network (MarLIN). ***http://www.marlin.ac.uk***

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed *Oceanography and Marine Biology*: *An Annual Review*, **36**: 127-178.

Newell, R.C., Seiderer, L.J., Robinson, J.E, Simpson, N.M., Pearce, B. and Reeds, K.A. 2004. Impacts of Overboard Screening on Seabed and Associated Benthic Biological Community Structure in Relation to Marine Aggregate Extraction. Technical Report to the Office of the Deputy Prime Minister (ODPM) and Minerals Industry Research Organisation (MIRO). Project No.SAMP.1.022. Marine Ecological Surveys Limited, St IVES, Cornwall.

Nunny, R.S. and Chillingworth, P.C.H. (1986). *Marine Dredging for Sand and Gravel,* HMSO, London. 192.

Oakwood Environmental Ltd (2002). Development of a methodology for the assessment of cumulative effects of marine activities using Liverpool Bay as a case study. CCW Contract Science Report Number 522

Posford Duvivier Environment and Hill, M.I. (2001). Guidelines on the impact of aggregate extraction on European Marine Sites. Countryside Council for Wales (UK Marine SACs Project).

Van Dalfsen, J.A. and Essink, K. (1998). The effects on macro-zoobenthos of sub-aqueous sand extraction North of the Island of Terschelling, The Netherlands. ICES **CM 1998**/E: 5, 7pp.

NOTE: This list is not exhaustive and a full review of existing literature on the impacts of aggregate extraction should be undertaken as part of the EIA process.

GENERIC GUIDANCE

C (ii) Possible Impacts Of Various Activities When Combined With Aggregate extraction

	Activity								
	Fishing	Organic Pollution / Eutrophication	Other Pollution	Coastal Alteration	Spoil and Waste Disposal	Capital and Maintenance Dredging	Anchoring of Large Vessels	Other Aggregate Extraction Areas	Offshore Structures
Increased Turbidity	√	√			√	√		√	
Removal of Substrate / Effects on Benthos	√	√	√	√	√	√	√	√	
Modification of Sediment Composition	√	√			√	√	√	√	√
Excessive Sedimentation	√	√			√	√		√	
Water Chemistry Effects		√	√		√	√		√	√
Increased Primary Production	√	√				√		√	
Increased Food Supply	√	√				√		√	
Changes in Hydrodynamics	√			√	√	√		√	√
Changes in Sediment Transport				√	√	√		√	

C (iii) The Dynamic Plume Phase

The introduction of material into the water column results in a water/sediment mixture of higher density than the surrounding water. Therefore, during the initial dynamic phase of plume development the water/coarser sediment mixture descends rapidly through the water column eventually being deposited on the seabed. The downward movement of the plume during the dynamic phase is given additional momentum due to the original mode of release of the material from the dredger, i.e. directed downwards.

As the plume descends, ambient water is entrained into the plume, diluting the plume and slowing its downward movement. A proportion of the sediment (usually a small proportion of finer material), is stripped from the plume into the surrounding water column and advected away from the dredged area by currents as a passive plume (see below). The remainder of the released sediment impacts upon the seabed as a density current. Some sediment is re-suspended as a result of the impact, while the remainder moves radially outwards across the seabed as a dense pancake-like plume.

During this radial expansion, settling of sediment occurs from the density current onto the bed. Initially, the mixing that occurs between the density current and the ambient waters is limited. However, when the concentration and thickness of the density current are sufficiently low, and if the ambient currents are sufficiently high, then significant mixing occurs and sediment is released into the water column to form a passive plume (HR Wallingford, 2003).

The zone of impact of this dynamic plume is relatively small, usually affecting an area less than 100-200m from the dredger. The suspended sediment concentration within this initial dynamic plume can be several thousands of milligrams of sediment per litre of water (John *et al*, 2000).

C (iv) The Passive Plume Phase

Passive plumes may be generated by the dynamic plume phase and by different types of dredging operation. In the case of generation due to the dynamic phase, a passive plume forms when sediment is stripped from the plume into the water column during the rapid descent of sediment, or subsequently during the flow of sediment along the bed.

During the passive phase, the plume broadly moves due to other influences acting upon it. This phase of the plume is controlled to a greater extent than the dynamic phase, by the hydrodynamic environment, in particular the strength and direction of tidal currents.

Suspended sediment concentrations within the passive plume phase are lower than during the dynamic phase, as are the settling velocities of the sediments within the plume (John *et al*, 2000). The duration of the plume and its dispersion will depend to a large extent on local currents, but also on the nature of the sediment. The areas affected by this passive plume can extend several kilometres. Hitchcock and Drucker (1996), noted that very fine sand dispersed by dredging may be carried up to 11km from the dredging site, fine sand up to 5km, medium sand up to 1km and coarse sand less than 50m. These estimates were based on Gaussian diffusion principles.

However, recent studies made on the dispersion of sediment plumes generated from dredging operations, suggest that the area of impact of over-spill and screening is smaller than estimates based on Gaussian diffusion models, especially where the proportion of silt and clay in the deposits is low (Newell *et al*, 1998). Therefore, in general, the vast bulk of material drops out within a few hundred metres of the dredger (Dynamic Phase) and most of the rest within a couple of kilometres (Passive Phase) (Gubbay, 2003).

REFERENCES

Gubbay, S. (2003). Marine aggregate extraction and biodiversity. Information, issues and gaps in understanding. Report to the Joint Marine Programme of the Wildlife Trusts and WWF-UK.

Hitchcock, D.R. and Drucker, B.R. (1996). Investigation of benthic and surface plumes associated with marine aggregates mining in the United Kingdom. *In: "The Global Ocean - Towards Operational Oceanography."* Oceanology International.

HR Wallingford (2003). Technical Input to MIRO Best Practice Guide to Assessing the Impacts of Marine Aggregate Extraction. November 2003.

John, S.A., Challinor, S.L., Simpson, M., Burt, T.N. and Spearman, J. (2000). Scoping the assessment of sediment plumes form dredging. CIRIA Report C547.

Newell, R.C., Seiderer, L.J. and Hitchcock, D.R. (1998). The impacts of dredging works in coastal waters. A review of the sensitivity to disturbance and subsequent recovery of biological resources on the seabed *Oceanography and Marine Biology*: *An Annual Review*, 36: 127-178.

D – METHODS OF IMPACT ASSESSMENT

PHYSICAL PROCESSES

D (i) Passive Plume Models

The term “plume models” generally refers to models, which reproduce the behaviour of the (far-field) passive plume (given the necessary source term input). These models are used to predict the likely increases in suspended sediment concentrations (above the background levels previously defined in the baseline environment) and to predict the extent of deposition arising from the release of sediment. These models generally fall into three categories:

1. Analytical advection-diffusion models;
2. Numerical advection-diffusion models; and
3. Lagrangian (or random walk) models

Analytical Advection-Diffusion Models are based on the analytical solutions for an instantaneous discharge of material dispersing in two dimensions. **This type of model is simple and quick to use but for a number of reasons the information resulting from the use of this method is today considered insufficiently robust for the EIA procedure.**

Numerical Advection-Diffusion Models are basically (2D or 3D) suspended sediment (mud) transport models. **The use of these models for plume modelling is usually less reliable than the use of Lagrangian models (see below)** because the method of solving the equations of diffusion of a concentrated source on a numerical mesh introduces numerical diffusion that will compromise the accuracy of the prediction.

Lagrangian Models do not attempt to solve the advection-diffusion equations. Instead the plume is represented by a large number of individual particles which are individually advected over the model domain according to the flow model current predictions. The models can be either 3D (for 3D-flow input) or quasi-3D (for 2D-flow input, assuming a logarithmic velocity profile).

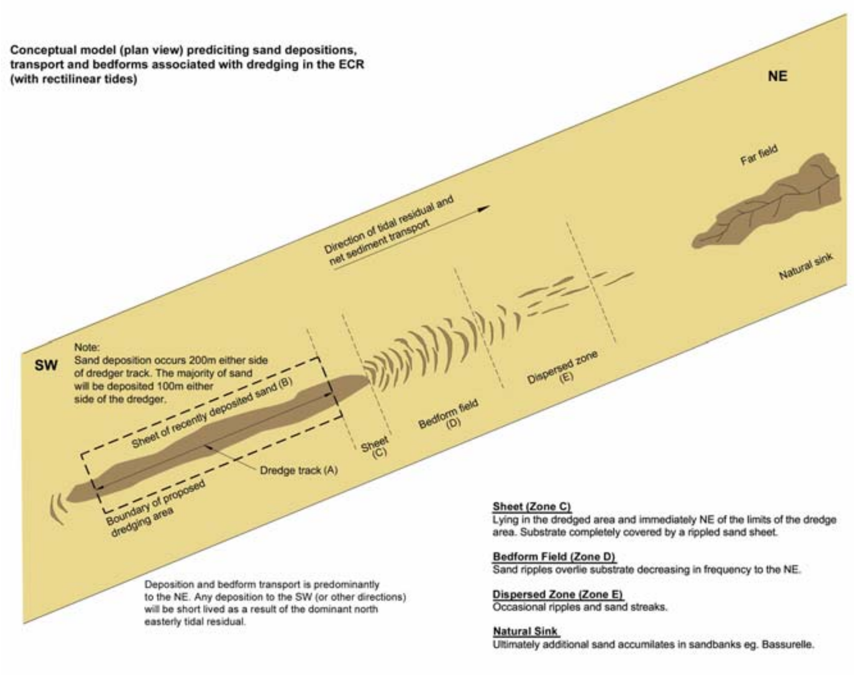
The Importance of the Source Term in Plume Models

Although there are distinctions between even the better models used for plume dispersion, the differences between these (better) models will not be as critical as the source terms (ie the rates of release from the dredger) used to drive the models. Since the dredger (and the dredger operation), the sediment and the ambient flow conditions vary, the source terms for plumes also vary from operation to operation. A means of calculating these source terms is therefore an important part of plume modelling capability. Some plume models exist which calculate the release from the dredger and reproduce the subsequent (near field) dynamic plume phase to provide the source terms for the passive plume far-field dispersion.

D (ii) Main Features Of The ECR REA Conceptual Model

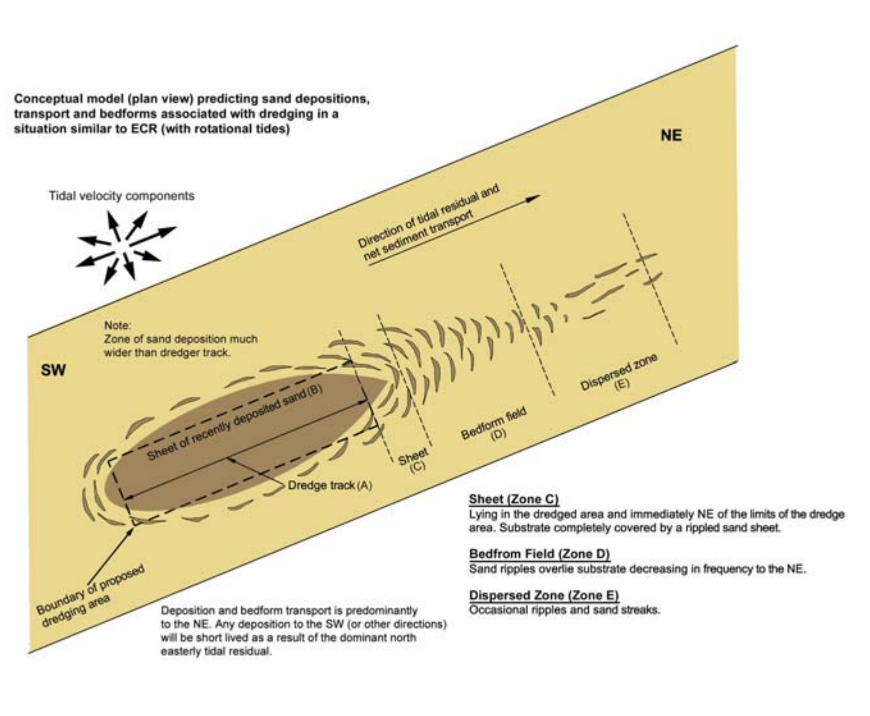
- The model relates to the effects of screening while dredging a narrow zone (3km x 250m) of the proposed dredging area (**A**). For an EIA this model needs to be applied (i.e. superimposed) for the whole of the proposed dredging area;
- The time-scale relating to the zone of influence outlined by the conceptual model is not explicitly stated in the REA but can be taken to be typical of the situation towards the end of operations when dispersion (of the mobile fractions) is more or less at its maximum;
- Most of the screened sediment will deposit in the area close to dredging, defined as an area 100-200m either side of the dredge path (**B**) and up to 200m along the tidal axis in the direction of the residual current (**C**). In this area the substrate will be completely covered by a rippled sand sheet;
- A small amount of fine sediment may be stripped from the plume as it descends potentially extending the initial footprint up to 1km downstream, although the amount of sediment dispersed in this way is expected to be small (**D**);
- A bedform field (sand ripples) will extend over the 0.2-1.2km zone in the direction of the residual current, i.e. a 1km zone extending from the core of the initial footprint (**C&D**);
- A dispersed zone (sand streaks) will extend over the 1.2-2.2km zone in the direction of the residual current, i.e. a 1km zone extending from the outer edge of the bedform field (**E**);
- The zone of influence thus extends either side of the dredging area and up to 2.2km from it in the direction of the residual current;
- A natural sand sink at some distance (tens of kilometres or more) from the dredging area. (This feature is specific to the REA as there is a convergence of sand transport between Hastings on the north of the English Channel and the Somme Estuary on the south of the English Channel).

D (iii) Conceptual Model (Plan View) Predicting Sand Deposition, Transport And Bedforms Associated With Extraction In The ECR (With Rectilinear Tides)



Source: HR Wallingford, 2003

D (iv) Conceptual Model (Plan View) Predicting Sand Deposition, Transport And Bedforms Associated With Extraction In The ECR (With Rotational Tides)



Source: HR Wallingford, 2003

MARINE ECOLOGY

D (v) Hypothetical Example Of Derivation Of Significance Using Assessment Framework	
Nature of Effect	
Description	**Reduction in overall species diversity, abundance and biomass**
Spatial Extent	**Site-Specific-** removal of the seabed will only occur where the dredger is operating (point source)
Magnitude	**VERY HIGH** – dredging will cause complete removal of approximately the top 0.3m of seabed.
Duration	**MEDIUM TERM** (5-10 years) – due to the local physical conditions, sediment movement across the seabed and weathering effects, by wave action, are thought to be comparatively reduced. Therefore, any in filling and erosion of dredge furrows will take longer than that for shallower mobile sands.
Frequency	Seabed removal will occur every time dredging is undertaken. The exact frequency of this impact will be determined by the final dredging plan.
Nature of Receptor	
Description	**Benthic macrofauna**
Is the receptor vulnerable to the effect being assessed?	**YES** – baseline studies indicate that a well-developed benthic macro-fauna exists within the proposed dredging area.
Sensitivity (Intolerance) of receptor to effect being assessed	**HIGH** – all the macro-fauna in the dredged area will be removed. It is estimated that 90% of all marine infaunal macro-invertebrate species inhabit the top 20cm of the seabed). The species/population is likely to be killed/destroyed by the impact under consideration.
Recoverability of receptor to the effect being assessed	**LOW** – the benthic community in the study area is characterised by slow growing, long-lived organisms, not well suited to disturbance (an 'equilibrium community'). Following the cessation of dredging, it is unlikely that similar gravel sediments to those found pre-dredge, will fill in the dredge tracks. Instead, sand material will likely fill these tracks, therefore changing the dominant substrate from gravel dominated to sand dominated. As a result of the change in substrate type, the ecological characteristics of the species lost (slow growing, long-lived) and also the reduction in abundance of "keystone" species, which increase seabed complexity, it is predicted that recovery of the benthic macro-fauna may take >5 years and even may not occur at all.
Importance of the receptor	**LOW** – Baseline studies indicate that although the dredged area supports a rich and stable macro-fauna, it is not particularly productive, compared to other areas in the wider study area. The site also contains biotopes that are common throughout the wider region.
SIGNIFICANCE	**MODERATE IMPACT**

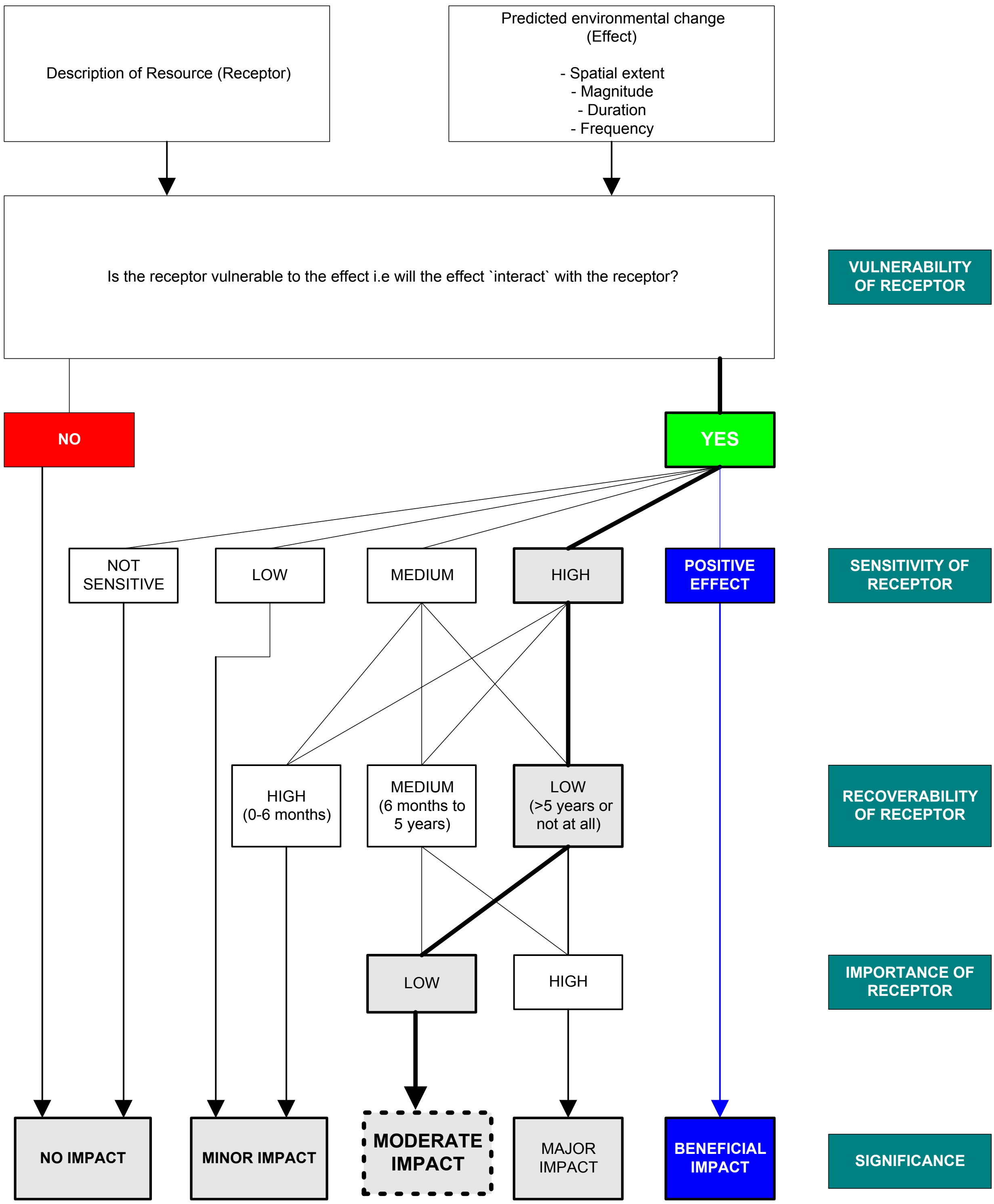


Figure D (i) Use of framework to determine MODERATE adverse impact on marine ecology

D (vi) Potential Framework For Assessing The Potential Chemical Effects Of Aggregate Dredging On Benthic/Epibenthic Resources

Characterisation and Assessment

The potential for sediment plumes to cause toxic effects on benthic and epibenthic resources can be approached as a tiered assessment and can make use of samples and/or data collected routinely as part of site investigations. A tiered assessment should include an initial desk assessment followed by a physical, chemical and biological assessment, in the order listed.

1. Desk Assessment

A desk assessment should identify whether the material to be dredged could be affected by significant sources (both point and diffuse sources) of contaminants, including historic inputs, relating to anthropogenic activity. Since contaminants preferentially attach themselves to particulate matter in the water column, this assessment would also need to consider the hydrodynamic sediment transport and deposition pathways between sources and the material to be dredged. The desk assessment should be supported by evidence from (at least one of) the following characterisations of the sediment at the proposed aggregate extraction site.

2. Physical Assessment

The physical assessment should detail whether the material to be dredged is predominantly coarse-grained (contains sand, gravel and/or rock), comprises previously undisturbed geological materials, and/or contains low amounts of organic matter. Key measurements of sediment's physical properties include particle size distribution and total organic matter content.

If the physical assessment determines that the sediment comprises predominantly coarse-grained undisturbed material with little organic matter, then it is likely that chemical substances do not significantly contaminate the sediment. This is reflected in analytical methods for chemical characterisation, which are typically carried out on the whole sediment (defined as fraction <2mm) or the fine-grained portion (<0.064mm). If the sediment could be affected by contaminant sources and meets one or more of the physical assessment criteria, then chemical characterisation could be necessary to support an impact assessment.

3. Chemical Assessment

It may be necessary to undertake a chemical characterisation of some or all of the material to be dredged at an extraction site. The need for (and extent of) chemical characterisation should be agreed with the statutory authority responsible for issuing the extraction licence. This need is likely to increase if the desk assessment identifies local or historic contaminant sources, a hydrodynamic pathway between a source and the extraction site, and the presence of fine-grained sediments and high organic matter contents.

A primary list of contaminants that could be used to assess impacts on fish and shellfish may include metals (particularly arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc), polychlorinated biphenyls (PCBs), tributyl tin compounds and their degradation products (TBT and DBT), and polycyclic aromatic hydrocarbons (PAHs). Other contaminants (e.g. pesticide compounds) may be relevant, depending on the specific conditions (e.g. local or historic inputs) identified by the desk assessment). There are no UK sediment quality standards with which the results of chemical analyses can be compared. There are standards used in other countries (e.g. Canadian sediment quality standards for threshold and probable biological effects), but these should be used with caution since they are not established for UK conditions.

At best, perhaps comparison to other nation's standards should only be used for screening individual chemicals. If chemicals are present at concentrations likely to cause probable biological effects, then biological assessment should be considered.

4. Biological Assessment

In some cases where elevated concentrations of chemicals are identified, it may be necessary to examine sediment's biological properties. The need for biological characterisation occurs because the preceding physical and chemical assessments cannot provide a direct measure of the potential biological impact (i.e. toxic effect), since they do not reflect contaminants' bioavailability.

There are a number of biological tests that can be carried out on sediment. Toxicity bioassays are probably the most common test. These tests expose an organism to the sediment sample, and compare effects to exposure to a clean (control) sample. The tests measure the toxic effect of all the sediment sample's constituents, including additive effects, synergistic effects and bioavailability. In this respect, bioassay tests may offer some advantage over chemical tests because they can be used for samples of unknown or incompletely known composition and provide an integrated assessment of the sample rather than an assessment of individual chemicals (CEFAS, 1997).

Most bioassay tests for sediments measure toxicity at acute lethality levels, and hence, mortality is the primary end-points for these tests. Acute toxicity tests include the 24-hour oyster embryo larval assay (OEL) test and 10-day amphipod tests on *Corophium* species. Examples of two acute toxicity test methods that have been developed and published by international organisations are given below.

The 24-hour OEL test was developed by the International Council for the Exploration of the Seas (ICES) and uses embryos of the Pacific oyster (*Crassostrea gigas*). The test measures the extent of embryo development when exposed to the (contaminated) sediment sample compared to embryo development when exposed to a clean (control) sample, such that inhibition is expressed as a percentage of that seen in the control sample (i.e. percent net response). It is regularly used for seawater monitoring surveys and for toxicity testing of discharges to marine environments, and is recommended under the UK Direct Toxicity Assessment (DTA) programme.

The amphipod test was developed by the Paris Commission (PARCOM) and uses specimens of *Corophium volutator*. The test measures the extent of specimen mortality when exposed to the (contaminated) sediment sample compared to mortality when exposed to a clean (control) sample. It is used for the biological assessment of dredged material (from capital and maintenance dredging) proposed to be disposed of at sea.

Bioassay tests for sub-lethal effects are less well-developed. The use of these tests is potentially important, particularly if a sediment sample contains contaminants that tend to have chronic effects (e.g. PCBs) that may be overlooked by acute toxicity tests. Another test involving Arenicola species is known to show a sub-lethal secondary endpoint based on the production rate of faecal casts (CEFAS, 1997), but a definitive chronic toxicity test for sediments is still under development.

There are no UK sediment quality standards with which the results of bioassays can be compared. The Sediment Bioassay Task Team (see CEFAS, 1997) recommended that an "initial criterion of 40-50% mortality is adopted" for solid-phase tests of dredged material (to be disposed of at sea), and that this criterion be used for a pass/fail assessment.

FISH AND SHELLFISH RESOURCES

D (vii) Hypothetical Example Of Derivation Of Significance Using Assessment Framework	
Nature of Effect	
Description	**Intensive deposition of sediment from overflowing and screening**
Spatial Extent	This is judged to be **LOCAL** (within 5km of the dredge zone).
Magnitude	**HIGH** - based on the large amount of deposition compared to baseline deposition levels.
Duration	**SHORT TERM** (6 months-5 years) – dredging (plus overflowing and screening) and will take place over a 5 year period.
Frequency	Deposition is expected to occur following every dredging run. Therefore, the impact of deposition is will occur at a high frequency.
Nature of Receptor	
Description	**Herring spawning ground**
Is the receptor vulnerable to the effect being assessed?	**YES** – spatial analysis using GIS indicates that the deposition footprint and the herring spawning ground overlap
Sensitivity (Intolerance) of receptor to effect being assessed	**HIGH** – the predicted depth of deposition is greater than values of smothering reported in the literature as creating adverse effects on herring spawning. Therefore, it is predicted that the deposition of sediment will change the substrate composition to a degree that makes the ground unsuitable for herring spawning.
Recoverability of receptor to the effect being assessed	**LOW** – the herring spawning ground occurs at a water depth where physical drivers (tidal and wave currents) are minimal. Therefore, any sand deposited on the spawning bed will likely remain there indefinitely, preventing \`recovery\` to a gravel-dominated substrate suitable for herring
Importance of the receptor	**LOW** – Based on the output of numerical models, the area of the total footprint over which deposition will occur at a level that creates adverse effects on the receptor in question (e.g. herring spawning ground), is calculated at 2.5km$^{2.}$ Previous survey work indicates that the wider study area supports a total of 50km^2 of herring spawning grounds. Therefore, the area, which will be adversely affected, represents **5%** of this total resource within the wider study area. The pre-spawning aggregation of herring in this area does not support a significant commercial fishery. **NOTE:** The actual calculation of the proportion of dredge footprint that overlaps a key resource area (over-wintering ground, spawning ground) can be calculated using GIS, as described in Box **4.23**.
SIGNIFICANCE	**MODERATE IMPACT**

NOTE
Although the approach outlined above, with respect to assessing the impact of deposition on key resources features, such as herring spawning beds, appears relatively simplistic, in reality, it often needs further refinement to enable a realistic assessment of impacts to be undertaken. This is due to the following reasons; The exact location and spatial extent of key resource features such as spawning grounds are difficult to define and there is still a lack of low-level information on these areas in UK waters. Therefore, even if it is possible to assess whether the dredge footprint overlaps with a key resource feature, if the overall spatial extent of this feature is not known, then an assessment of the potential impact is not possible; This approach assumes that the thresholds of impact are known to the extent that the area of impact can be measured. Therefore, a more detailed understanding of the sensitivity of the receptor to actual effects and the spatial extent of various components of the total footprint is required to make this assessment more realistic and pragmatic.

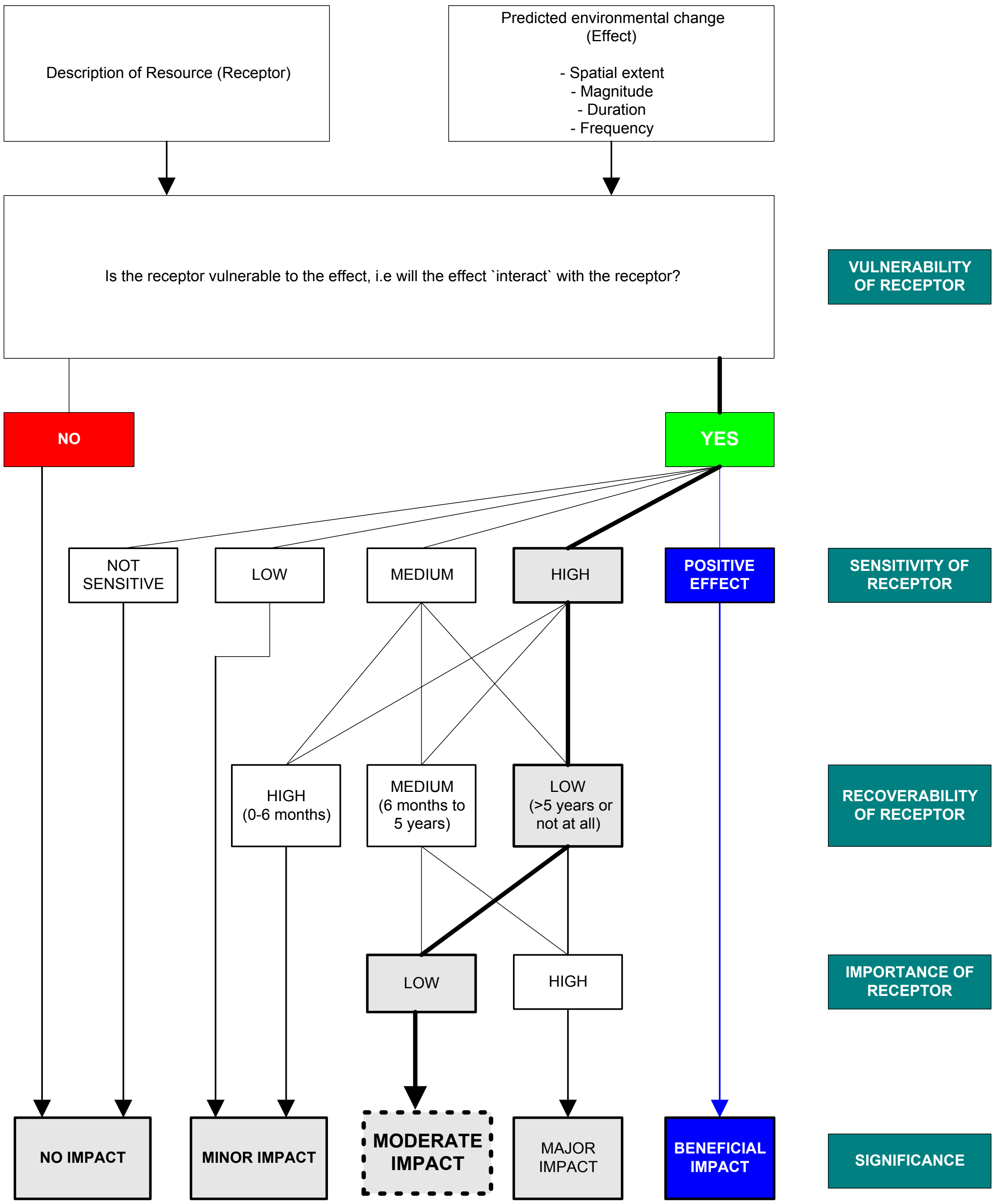


Figure D (iii) Use of framework to determine MODERATE impact on fish & shellfish resources

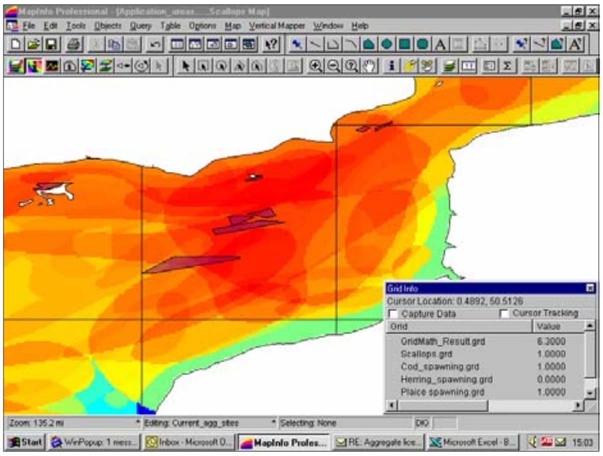
D (viii) Using Digital Mapping Techniques To Predict The Impact Of Dredging On Fish Resources

Digital mapping techniques, using GIS can be used to identify and quantify the spatial extent of areas that are intensively used by fish for spawning, and which may, therefore, be considered potentially sensitive to marine aggregate extraction. An example of a method, developed by CEFAS, is described. This is taken from the recent CEFAS report, “A Procedure to Assess the Effects of Dredging on Commercial Fisheries” (Rogers and Carlin, 2002).

Maps of spawning areas for 16 different species were digitised in a vector format. The digitising process creates electronic maps of geographically referenced polygons from paper map references. Data related to each polygon (in this case data such as species, timing of spawning season) is stored in an attribute table. The attribute table also contains a value of 0 (no spawning) or 1 (spawning) in order to describe spawning intensity over a wide area

The vector plots are converted into raster of grid-file format, with each cell of the grid having a numeric value for each species (0 or 1) based on whether spawning is recorded in that area. A derivative map is then produced that describes the combined total of species which spawn in each cell. Each cell can be queried to determine which species contribute to the total spawning intensity at that position.

The output is a map with different shaded areas, the colours of which relate to different levels of spawning intensity. On a regional scale, the total vulnerability of these sensitive spawning areas can be assessed, since the GIS process allows the user to calculate their total area and the proportion of each aggregate extraction license area that encroaches sensitive regions.



The areas of greatest intensity of shading represent those locations that support the most fish and shellfish species. The GIS user can also select information relating to the vulnerability of species to certain activities, the timing and duration of sensitive periods (spawning, over-wintering) and the relative importance of species in terms of their economic and conservation value. The degree of overlap between these intensively used zones and individual licensed areas, can be used to assess the potential impact of individual site-specific activities on sensitive areas.

On a regional scale, the total vulnerability of these intensively used zones can be also be assessed, since the GIS process allows the user to calculate their total area and the proportion of each aggregate extraction licence or application area which encroaches sensitive regions. Knowing how much of a particular resource coincides with aggregate licences is the first step towards evaluating whether dredging will adversely affect the resource.

Even though this method appears well developed and of great use in impact assessment, it is, as with many other similar tools, entirely dependant on good quality data describing the distribution of fish spawning grounds or the seasonal distribution of fisheries. A considerable constraint with this method is that large uncertainties still exist in the exact delineation of spawning areas and it is still not possible to determine exactly the presence/absence ratio, i.e when are the fish actually using these grounds (Courbet and Lemoine, 2003). These data are being obtained and updated by CEFAS, in parallel with further developments.

COMMERCIAL FISHERIES

D (ix) Hypothetical Example Of Derivation Of Significance Using Assessment Framework	
Nature of Effect	
Description	**Aggregate dredging may result in the physical exclusion of fishing vessels from licensed extraction areas, resulting in reduced catches and income**
Spatial Extent	This is judged to be **LOCAL** (within 5km of the dredge zone).
Magnitude	**HIGH** – fishing activity will be prevented in certain areas where previously it had been permitted.
Duration	**SHORT-TERM** (6 months-5 years) – the typical duration of activity within each dredged zone is expected to last between 1 and 3 years. It is noted that exclusion will not occur for this entire period, rather, for short periods (e.g. 18 hr occupancy period) over this longer time-scale.
Frequency	The frequency of exclusion from certain areas will vary according to the dredging plan.
Nature of Receptor	
Description	**Commercial fishing activity (e.g. beam trawling for flatfish)**
Is the receptor vulnerable to the impact being assessed?	**YES** – spatial analysis using GIS indicates that an established commercial fishery exists within the proposed dredging area.
Sensitivity (Intolerance) of receptor to impact being assessed	**HIGH** – The receptor has a high intolerance to the effect, as displaced fishing vessels cannot fish in adjacent areas due to a high intensity of existing fishing activity in these areas. The proposed dredging regime within the extraction area is also intensive enough to prevent fishing taking place at levels that will provide the same level of income.
Recoverability of receptor to the impact being assessed	**HIGH** – the recovery of this `receptor` is judged to be HIGH. Following the cessation of dredging, commercial fishing activity will be permitted almost straight away.
Importance of the receptor	**NA**
SIGNIFICANCE	**MINOR IMPACT**

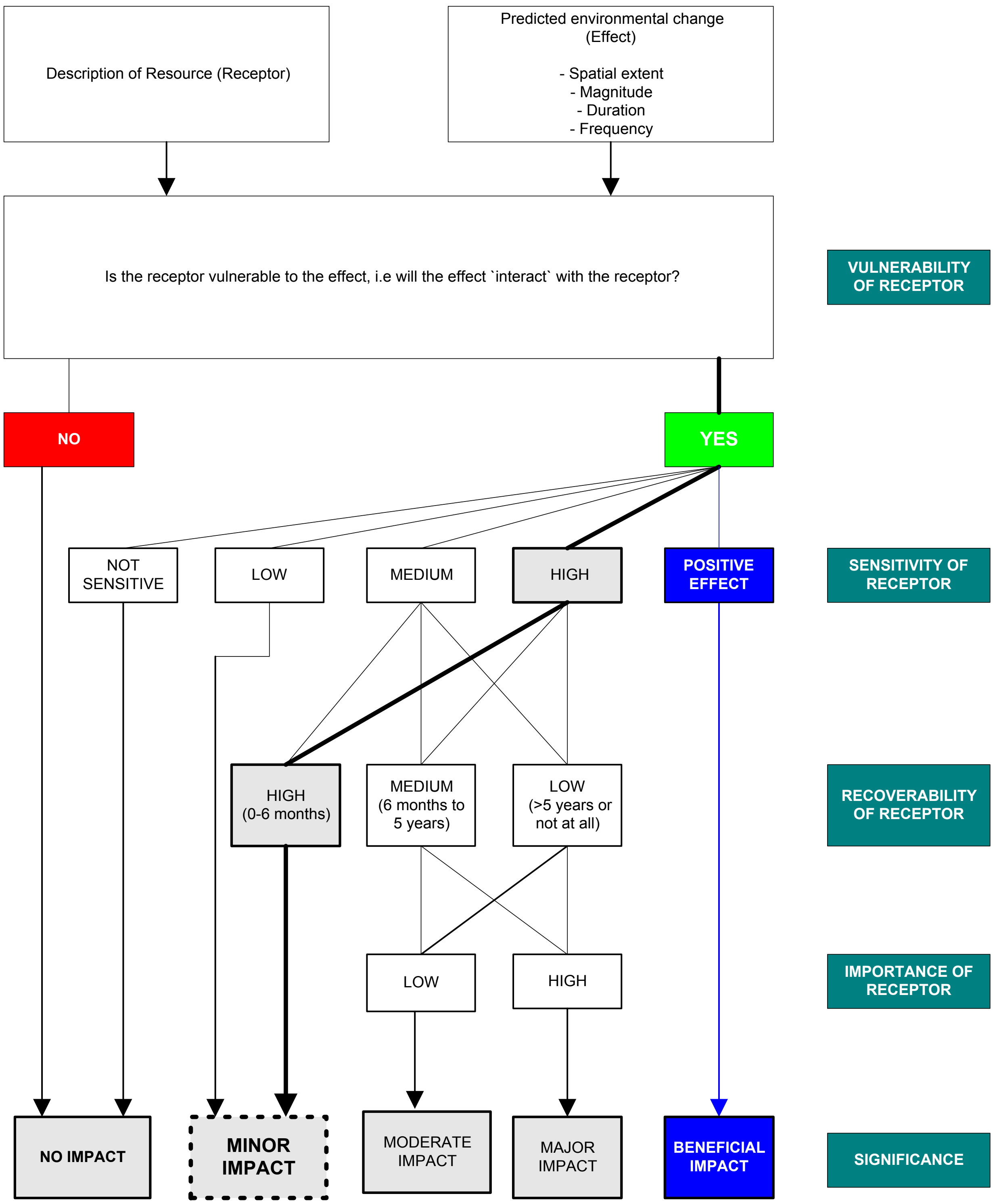


Figure D (iv) Use of framework to determine MINOR impact on commercial fisheries

E – MONITORING

E (i) Overview Of Sampling Strategy And Design

INTRODUCTION

This paper presents specific issues related to sampling strategy and design. It has been prepared by Paul Somerfield of Plymouth Marine Laboratory.

The key issues in designing a monitoring study are:

- Defining the hypotheses to be tested - what differences are to be detected and where;
- Determining the number of replicates needed to detect differences with adequate statistical power; and
- Deciding how to distribute replicates.

Monitoring should be prospective, not retrospective (Posford Duvivier Environment and Hill, 2001). In retrospective monitoring programmes the types, magnitudes, and extent of adverse impacts are not defined beforehand. Sampling is just 'done' according to some general design and results are interpreted. Far too many 'monitoring' programmes are of this type. The US EPA (1997) states that the most fundamental step in the development of a monitoring programme is to define the goals and objectives. The changes to be detected should be stated unambiguously and quantitatively, or if not quantitatively at least falsifiably. In other words, the null hypothesis should have a clear, testable alternative, e.g.

H_0: There is no difference in community structure

This is a weak null hypothesis. The logical alternative is that there is a difference in community structure, but it does not state what is to be measured. There is an infinity of possible measures of community structure ranging from abundances of individual species to indices to multivariate similarities. It does not state how much change is to be detected. With enough sampling it will always be falsified, as a difference in some measure of community structure, even a tiny difference in average abundance, is inevitable. We cannot calculate how much power a design will have, or consequently how many replicates are required. If we fail to detect a difference with no knowledge of power we cannot conclude that there is no difference.

H_1: Average abundance decreases by 10 %

This is a testable alternative. We can calculate average abundance (the variable of interest). With knowledge of variability in abundance (residual standard error from the pilot or baseline surveys for example) we can calculate the number of replicates required to detect a 10 % difference (the effect size) with predefined errors (Type I, the chance of concluding there is an effect when there is none; Type II, the chance of concluding there is no effect when there is one). Although there is no framework for determining power in similarity-based multivariate analyses we can be reasonably confident that a survey designed to have adequate power in a univariate context will also have adequate power for the detection of differences in multivariate analyses (see Somerfield et al. 2002). In what follows we will use the term 'community structure' to imply any measure of community structure, with the explicit assumption that alternative hypotheses are stated in testable ways. We must define where changes are to be detected.

H_0: There is no difference in community structure between a 'representative station' in the dredged area and one in a reference area.

H_1: There is a difference in community structure between a 'representative station' in the dredged area and one in a reference area.

Explicit in these hypotheses is the fact that 'representative stations' are to be compared. If we have followed the guidelines above we should know how many replicates are required to detect an effect. However, a problem still exists. The hypotheses refer to 'a reference area'. As such they are poorly defined and we do not know where to place the sampling station. It could be anywhere other than in dredged area. This may be a trivial point but it is included to demonstrate how exact one has to be in formulating hypotheses and their alternatives. More importantly, the exact formulation of the hypotheses determines the appropriate distribution of the replicates and the inference that may be drawn from consequent statistical analyses. In this case we must take replicate samples to determine the variables of interest and their variability at 'representative stations'. We may do so, and determine whether differences are significant. This is in essence what the ODPM 2002 guidelines tell us to do.

Unfortunately the only conclusions we can draw from the analysis are about the two stations. If we draw any conclusions about the areas in which the stations are located we are committing pseudo-replication (Hurlbert 1984), that is the testing for treatment effects (the effects of dredging) with an error term inappropriate to the hypothesis being considered. We have not estimated the variability in the dredged area or in the reference area, only in small parts ('representative stations') of each area. While the regulatory authorities may decide that an approach to monitoring the effects of dredging based on 'representative stations' is sufficient, it makes little sense from a statistical point of view and will almost certainly lead to pseudo-replication, which requires a combination of sampling design and statistical analysis which is inappropriate for the hypothesis of interest.

Concentrating on 'reference stations' also misses one of the most likely effects of dredging disturbance, namely a change in variability within the dredged area, and also within areas subject to dredging-related disturbance. The area directly impacted by the dredge head is small compared to the dredged area as a whole. If a dredger happens to pass across a 'representative station' prior to sampling a large effect may be observed. If it passes nearby a smaller effect may be observed. If it passes 50 m away no effect at all may be apparent, but the dredged area is still being impacted. Hypotheses should be formulated in such a way that replicates are distributed in space (and/or time) to detect potential changes that may be attributable to dredging impacts.

Finally, the detection of differences which may be related to dredging disturbance should not be goal in itself. Monitoring should function as a key component in management. The questions of interest are, therefore, complicated. We do not simply wish to know whether some areas are different to others. We also wish to know whether observed differences are confined to those areas, or are spreading. This requires that hypotheses be constructed which allow us to determine these things.

Let us consider the hypothetical model of sediment deposition and transport (**Figure E1**). Assuming that the seabed is homogeneous prior to the commencement of dredging, what samples should be taken and how should they be distributed? What do we want to know? Assume for the present that we have determined that 5 replicates are sufficient to allow us to detect a difference in a variable of interest, where should we take them? We need to take 5 replicates from each condition, or set of conditions, to determine whether differences between them are significant. Thus, if we wish to know about differences between Zones A to E, we must distribute 5 single samples within each zone. Benthic communities tend to be spatially auto-correlated (samples from close together tend to be more similar than samples taken further apart), so the physical dispersion of samples is an important consideration. In fact systematic sampling may induce the necessary randomness owing to the random nature of the environment being sampled (the process may be 'stationary'), but it is important that the average spatial dispersion is similar in the different zones. This may be problematic (Zone C, for example, is rather small) so sensible compromises may be required. The crucial consideration is that the samples are representative of the conditions that one wishes to infer something about. So we distribute 5 samples in each of the zones expected to be influenced by dredging disturbance. This will tell us about differences between them, but not about the affects of the disturbance relative to an undisturbed condition. We need 'reference' zones (not stations) with which to compare our findings. Comparing one place with another allows no generality in inference. Ideally there should be several 'reference' zones. These should be outside the predicted zone of influence of the dredging activity. In fact our requirements are more subtle than this. We predict that effects will be confined to within 100 m either side of the dredged zone but we do not know this. Further 'reference' zones should be located immediately outside the predicted influence of activity, so that the regulator can be assured that, in the absence of changes in these zones compared to 'reference' zones further away, the dredging influence is confined as predicted. The diagram below shows a possible survey design which would provide information suitable for baseline survey and ongoing monitoring at a hypothetical site.

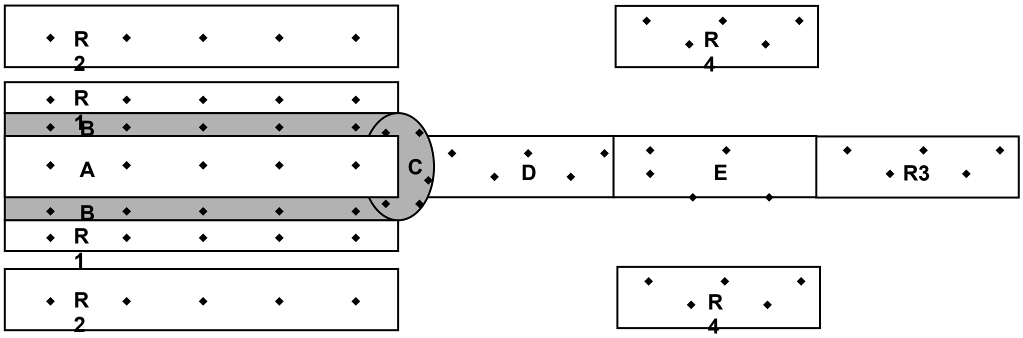


Figure E1 An example of a possible sampling design for survey and monitoring at a hypothetical dredging zone

R1 to **R4** are reference zones.
Sampling locations (•) indicate positions from which single samples are to be collected on each sampling occasion for use as replicates.

Note that as far as possible the spatial dispersion of replicates is similar in different zones, and representative of each zone as a whole. Different reference zones serve different purposes.

R2: These are the standard reference zones predicted to be well outside the zone of influence of dredging activity. These should not change as a result of dredging, but allow us to track changes that may occur naturally against which to compare changes in the predicted zone of dredging influence and within the closer reference zones.

R1 and R3: If dredging activity remains inside predicted boundaries these zones will be unaffected. If dredging influence impacts beyond the predicted boundaries changes will be detected here.

R4: These are possible further reference zones which allow us to assess changes along the deposition field more accurately, and also to assess the effect of a slightly different dispersion of samples in zones **D** and **E**. Dispersing the replicates in this way allows us to examine a whole range of hypotheses. If the dredging influence is within predicted bounds R2=R1=R3=R4. If downstream dispersion has more of an effect than expected R2=R1=R4≠R3, or possibly (if dispersion is more diffuse than expected) R2=R1≠R3=R4. If lateral dispersion exceeds predicted bounds R2≠R1. And so on. Dispersing replicates in this way also allows us to examine spatial structure. For example, if we want to be sure that the area as a whole is homogeneous the vertical transects across zones R2 to R2 can be compared. If changes in community structure away from the centre of dredging activity are to be examined, we have replicate transects with which to do so.

CONCLUSIONS

It is easy to pose unanswerable questions. The real world is a variable place, and undertaking some of the procedures outlined here may result in considerable surprises. It is quite likely that power analyses will determine that for some variables the required degree of replication will be in the order of hundreds or thousands of samples. This is obviously impractical, so it is unjustifiable for a regulator to require that these variables are monitored. There is no point, and failing to detect a difference in them with a reduced amount of replication tells us nothing. Which variables can not be effectively monitoring should become apparent during pilot and baseline surveys. An infinite number of hypotheses and potential impacts are imaginable. Monitoring should be limited to a subset that have potential biological significance.

REFERENCES

Hurlbert, S. H. (1984) Pseudoreplication and the design of ecological field experiments. Ecological Monographs 54, 187-211.

Posford Duvivier Environment and M. I. Hill, (2001). Guidelines on the impact of aggregate extraction on European marine sites. Countryside Council for Wales (UK Marine SACs Project).

Somerfield, P. J., Clarke, K. R. and Olsgard, F. (2002). A comparison of the power of categorical and correlational tests applied to community ecology data from gradient studies. Journal of Animal Ecology 72, 581-593.

US EPA (1997). Monitoring guidance for determining the effectiveness of nonpoint source controls. US Environmental Protection Agency, September 1997. EPA/841-B-96-004.

E (ii) Example Of A Potential Monitoring Plan For An Aggregate Extraction Site

The following section sets out a *potential* monitoring programme that may be developed for an aggregate extraction site. It is expected that all of the principles set out in the monitoring section of this document would be applied in the design and implementation of this monitoring programme. The programme covers a five-year period, following which a review of the licence and associated monitoring data would be undertaken. This example is largely based on monitoring programmes designed for actual extraction sites and represents a realistic and pragmatic approach to monitoring potential environmental effects related to aggregate extraction.

Parameter	Potential Effect	Pre-Dredge	Year 1	Year 2	Year 3	Year 4	Year 5
Physical Processes	Substrate removal and alteration of sea be topography	Swath survey	Swath survey	Swath survey	Swath survey	Swath survey	Swath survey
	Interruption in sediment supply to the coast	Side scan sonar	Side scan sonar	Side scan sonar	Side scan sonar	Side scan sonar	Side scan sonar
		Sediment tracer, seabed video/camera, sediment sampling (PSA)	Sediment tracer, seabed video/camera, sediment sampling (PSA)	Sediment tracer, seabed video/camera, sediment sampling (PSA)	Sediment tracer, seabed video/camera, sediment sampling (PSA)	Sediment tracer, seabed video/camera, sediment sampling (PSA)	Sediment tracer, seabed video/camera, sediment sampling (PSA)
	Increased suspended sediment concentrations (sediment plume)	NONE	ADCP, water column sampling, aerial photography, plume model testing and calibration, Monitoring of overspill and screened material during initial dredging periods	NONE	NONE	NONE	Plume model testing and calibration

Parameter	Potential Effect	Pre-Dredge[8]	Year 1	Year 2	Year 3	Year 4	Year 5
Marine Ecology (Benthos)	Direct removal of the seabed will lead to a reduction in habitat and species diversity, abundance and biomass	Targeted baseline benthic survey using grabs and trawls	NONE	Targeted benthic survey using grabs and trawls	NONE	Targeted benthic survey using grabs and trawls	NONE
	Deposition of suspended sediment will lead to smothering effects on benthic organisms	Sediment sampling and PSA as part of benthic survey	NONE	Sediment sampling and PSA as part of benthic survey	NONE	Sediment sampling and PSA as part of benthic survey	NONE
Fish and Shellfish Resources	Fish and shellfish, e.g. scallops, will be entrained through direct uptake	Define the spatial extent of scallop beds using appropriate surveys (dredges, video)	NONE	Monitor spatial extent and abundance of scallops using appropriate surveys (dredges, video)	NONE	Monitor spatial extent and abundance of scallops using appropriate surveys (dredges, video)	NONE
	Deposition of sediment will alter specific substrate required for spawning, e.g. demersal spawners (herring)	Define spatial extent of herring spawning grounds using appropriate surveys (video, plankton trawls, otter trawls, remote acoustic methods)	NONE	Targeted survey to monitor spatial extent (and condition) of herring spawning ground, i.e. video and PSA and/or remote acoustic methods	NONE	Targeted survey to monitor spatial extent (and condition) of herring spawning ground, i.e. video and PSA and/or remote acoustic methods	NONE

[8] **Many of the 'Pre-Dredge' surveys will form part of the baseline studies undertaken at the beginning of the EIA process**

Parameter	Potential Effect	Pre-Dredge	Year 1	Year 2	Year 3	Year 4	Year 5
Fish and Shellfish Resources (cont'd)	Deposition of sediment will adversely affect crustacean spawning, e.g. over-wintering crabs	Define spatial extent of crab over-wintering grounds using appropriate surveys	NONE	Monitor spatial extent (and condition) of crab over-wintering grounds using appropriate surveys	NONE	Monitor spatial extent (and condition) of crab over-wintering grounds using appropriate surveys	NONE
Commercial Fisheries	Physical exclusion of fishing vessels from licensed extraction areas, resulting in reduced catches	Assess level of commercial fishing activity within study area	Collate and assess landings data for key species landed within study area	Collate and assess landings data for key species landed within study area	Collate and assess landings data for key species landed within study area	Collate and assess landings data for key species landed within study area	Collate and assess landings data for key species landed within study area
			Operate and assess findings of a log-book scheme	Operate and assess findings of a log-book scheme	Operate and assess findings of a log-book scheme	Operate and assess findings of a log-book scheme	Operate and assess findings of a log-book scheme
Archaeology and Cultural Heritage	Damage, loss or disruption to known wrecks/sites	Design exclusion zone(s) based on seabed survey and sediment mobility studies	Monitor exclusion zone(s) by geophysical (sidescan/swath) survey and reference to recorded dredger tracks	Monitor exclusion zone(s) by geophysical (sidescan/swath) survey and reference to recorded dredger tracks	Monitor exclusion zone(s) by geophysical (sidescan/swath) survey and reference to recorded dredger tracks	Monitor exclusion zone(s) by geophysical (sidescan/swath) survey and reference to recorded dredger tracks	Monitor exclusion zone(s) by geophysical (sidescan/swath) survey and reference to recorded dredger tracks

Parameter	Potential Effect	Pre-Dredge	Year 1	Year 2	Year 3	Year 4	Year 5
Archaeology and Cultural Heritage (cont'd)	Damage or disruption to hitherto unknown wrecks/sites	Institute reporting protocol	Report on implementation of reporting protocol	Report on implementation of reporting protocol	Report on implementation of reporting protocol	Report on implementation of reporting protocol	Report on implementation of reporting protocol
	Exposure of hitherto unknown wrecks	Potential for wrecks assessed in desk-based assessment	Review data from side scan sonar survey (see Physical Processes, above)	Review data from side scan sonar survey (see Physical Processes, above)	Review data from side scan sonar survey (see Physical Processes, above)	Review data from side scan sonar survey (see Physical Processes, above)	Review data from side scan sonar survey (see Physical Processes, above)
	Exposure of hitherto unknown (prehistoric) sites	Apply reporting protocol to benthic monitoring procedures	NONE	Report on any artefacts identified from processing of benthic samples (see Marine Ecology (Benthos) above)	NONE	Report on any artefacts identified from processing of benthic samples (see Marine Ecology (Benthos) above)	NONE
Navigation, Recreation and Other Uses	Damage to sub-sea cables and pipelines		Review data from side scan sonar for evidence of scour or slumping	Review data from side scan sonar for evidence of scour or slumping	Review data from side scan sonar for evidence of scour or slumping	Review data from side scan sonar for evidence of scour or slumping	Review data from side scan sonar for evidence of scour or slumping