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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Final Report

February 1999

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PREFACE

The following document was commissioned by the Minerals Management Service, United States Department of the Interior and outlines a framework for the assessment of strategic cumulative effects of marine aggregates dredging (SCEMAD) in coastal waters, within the environmental assessment (EA) process. It has been prepared in the first instance as a consultation document to address the issues raised by the increasing numbers of aggregates licence areas which are concentrated in restricted areas of suitable gravel deposits in UK waters.

We have used an intensively worked area to the south east of the Isle of Wight as a case study to illustrate the complexity of the issues raised in the management of coastal zone resources. We nonetheless regard the protocol as one which can be usefully applied to other coastal areas where potentially conflicting resource use occurs. With this in mind, it is our intention for this framework to be used as a Consultation Document, both within the marine aggregates mining industry and a wide range of consultees, with a view to establishing an agreed methodology which can be used for future environmental impact assessment studies elsewhere.

MMS Minerals Management Service U.S. Department of the Interior Year of the Ocean

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OBJECTIVES OF STRATEGIC CUMULATIVE EFFECTS STUDY

Marine aggregates are an important national resource. An essential component in the exploitation of this resource is the dredging necessary to raise the aggregates from the seabed and transport them to the shore. These activities, and other nearshore human interventions, inevitably give rise to effects that impact on the physical and biological marine environment, which is itself subject to natural change.

The **Principal Objective** of this study is to produce a guidance document that sets out an appropriate and effective framework for the environmental assessment of the potential cumulative effects of aggregates dredging in the context of the general exploitation of nearshore seas.

An area to the east of the Isle of Wight has been chosen as a pilot study area in order to facilitate development of the assessment framework. This area has been chosen because a variety of human interventions, including aggregate dredging, have and are taking place within its boundary. Additionally, the area has already been studied in some detail and a significant amount of relevant data are available. The study will not result in a cumulative environmental assessment being completed for this area. However, the experience gained by using the area as an example will help identify a suggested approach. In order to do this, the project has the following subsidiary objectives:

- the execution of a world-wide literature review, investigating the past and present implementation of cumulative effects assessment techniques, in order to determine good practice requirements for cumulative effects assessment (see Section 1);
- the identification of types of data and methods of measurement, prediction and assessment that have been adequately researched and developed, and which can be used with confidence when undertaking comprehensive cumulative effects assessment (see Section 2);
- the development of a good practice methodology for assessing the cumulative effects of aggregates dredging, using the pilot study area as an example (see section 3);
- the development of appropriate environmental monitoring and audit procedures and the identification of potential mitigation measures (see Section 4);
- the identification of those data types and methodologies that have yet to be developed to the extent that they can be used with a high degree of confidence but which might be further improved with future research (see Section 5).

PROJECT TERMS OF REFERENCE

The Terms of Reference for the Cumulative Effects Study have been split into two parts: **Core Terms of Reference** which give the scope of the study within current funding commitments, and **Additional Terms of Reference** which outline more detailed studies which could be undertaken under additional funding arrangements.

A. Core Terms of Reference

- The collection of published and unpublished data on offshore aggregate dredging, demands, resources, and factors affecting the exploitation of nearshore waters;

- Development of a broad overview of the marine aggregates industry, highlighting its importance, and the extent to which it conflicts with other coastal activities;

- A review of environmental resources in a coastal and nearshore cell, and their stability in space and time. A specific agreed location will be used to do this on a pilot scale;

- A review of man's impact on identified environmental resources in the coastal region, using the pilot study area as an example;

- Development, from the above, of a good practice methodology for environmental assessment of marine aggregates dredging in the coastal zone, taking account of the cumulative effects of various interventions by man in the study area;

- Development of a good practice methodology for monitoring the environmental parameters of a coastal cell and the natural and man-induced changes occurring, with particular reference to marine aggregates mining;

- Development of a good practice methodology for mitigating the unacceptable environmental effects of marine aggregates mining;

- Identification of areas of uncertainty in the above items, where more research and development is needed.

B. Additional Terms of Reference

- Development of descriptive models for sedimentation and dispersion profiles close to sites of marine aggregates dredging using recent data for sedimentation, with a view to refining predictive models currently used in environmental assessment;

- Specific research proposals which are needed to identify the likely zone of impact of individual dredged areas, and the interaction between adjacent areas where multiple worked licences are close to one another.

METHODOLOGY

A. Introduction

This SCEMAD study has been developed to investigate the pertinent issues relevant to the creation of procedural guidelines for the assessment of cumulative effects. The study has been split into five main task areas, each focusing on a set of clear objectives. These task areas were formulated in the opening months of the study, and comprise the following:

B. *Task 1*- Introduction & Overview

Develop an overview and perspectives on the marine aggregates industry.

C. *Task 2* - Literature Review

Undertake a world-wide literature review to identify good practice that can be applied to the scientific objectives described previously.

D. *Task 3* - Good Practice Methodology for Cumulative Effects Assessment

Identify and develop a good practice methodology for cumulative assessment in the chosen pilot study area.

As all coastal areas have their own characteristics, and will thus all be special cases as far as environmental assessment is concerned, it is the intention of the authors to select one pilot study area to develop the framework formulated during the initial phase of Task 3. The tools and techniques identified as being likely to be suitable for CEA will go some way toward developing a combined project oriented EA/CEA approach. Task 3 will comprise technical details on approaches to the assessment of baseline conditions in the coastal zone which are an essential prerequisite to understanding the impact of natural variations in environmental conditions and that of aggregates dredging on coastal resources. The review will comprise sections on:

- Methodology for assessment of sea bed topography and structure;
- Methodology for assessment of coastal morphology and coastal processes;
- Predictive methods and their limitations for assessing the likely impact of marine aggregates dredging on coastal zone processes;
- Methodology to assess benthic biological community composition, including sampling strategy and methods and analysis of community structure;
- Strategies for the assessment of the economic impact of disturbance by man;
- Proposals on the assessment of conservation issues including historic sites, wildlife resources and amenity use of the coastal environment.

Task 3 will, through the pilot study area, develop more extensively the good practice methodology, subdividing major resources into sections covering: Physical, Biological and Socio-Economic resources (i.e. Human exploitation and Amenity Use & Conservation Issues of the coastal environment):

(i) Physical Resources & Impacts

- A review of what is known of the physical environment in the nearshore and offshore zones, i.e. sediment transport and coastal geomorphology and their interaction with coastal processes with special reference to the pilot study area to the south-east of the Isle of Wight;

- The impact of perturbation by man, including spoils disposal and marine aggregates dredging on coastal resources will be included into the descriptive framework for the study area;

- The interaction between natural environmental variables and the impact of man will be reviewed to give some understanding of the complexity of coastal zone processes and the issues raised in management and conservation in relation to marine aggregates dredging.

It is anticipated that the review of the Physical impact of marine aggregates dredging will identify the need for descriptive and predictive models which incorporate recent information on plume dispersion, and for some detailed information on the behaviour of recently deposited material at the sediment-water interface.

(ii) Benthic Biological Resources & Impacts

- A review of what is known of the biological resources which occur in coastal deposits, especially those suitable for marine mining, their sensitivity to disturbance and their role in supporting marine food webs leading to commercially significant fish stocks, with special reference to the pilot study area to the south-east of the Isle of Wight;

- The impact of perturbation by man, including fishing, spoils disposal and marine aggregates dredging on biological resources will then be included into the descriptive framework for the pilot study area.

It is anticipated that the review of biological resources will identify the need for improving methods of collection, analysis and recording of biological data before there is sufficient information to assess both the variation in biological resources occurring under natural conditions (in terms of species variety and population density) and the impact of man against the background of natural variations in benthic community composition.

Some information will be made available on the impact of marine aggregates dredging and on the likely rate of recovery following cessation of dredging. The review is likely to highlight the need for a comprehensive database for biological resources as a prerequisite for any assessment of impact or appropriate management and mitigation measures.

(iii) Human Exploitation

- A review of the economic significance of the coastal zone for fisheries exploitation, with special reference to the pilot study area to the south-east of the Isle of Wight;

- The impact of perturbation by man, including the process of fishing itself, spoils disposal and marine aggregates dredging on fisheries resources.

It is anticipated that this review will highlight the difficulties of assessing the economic value of exploited yields. It will also investigate whether the impact of man, including fishing, can be distinguished in a cause-and-effect fashion from long-term variations in population density and community structure imposed by factors at some distance from the site of exploitation.

(iv) Amenity Use & Conservation Issues

- An assessment of the extent to which coastal zone resources are of importance for amenities such as recreational angling, boating, diving, significant wildlife stocks including those of estuarine mudflats and wetlands, and historic and archaeological resources;

- The impact of perturbation by man, especially spoils disposal and marine aggregates dredging on recreational and amenity uses of coastal resources, and on conservation of wildlife and historic resources.

It is unlikely that any quantitative models could be developed for the interaction between marine aggregates exploitation and resources for which there are few quantifiable measures of economic importance. Nevertheless the review is expected to illustrate the significance of coastal zone resources which may not have an immediate economic value, and the importance of integrating these into a framework of coastal zone management in relation to exploitation of marine gravels and sands.

Task 3 will eventually conclude by addressing the question of the extent to which the impact of man on coastal zone resources can be adequately understood and predicted, the interaction between natural physical and biological factors, and the influence of man on such interactions. The need for standardisation of research methods, interpretation and recording procedures is likely to emerge from this review.

E. *Task 4* - Good Practice Monitoring & Mitigation Methods

Identify and develop a good practice methodology for monitoring and possible mitigation of cumulative effects.

The Study Team will then develop specific recommendations for an environmental monitoring methodology, interpretation and recording which recent experience has shown to be suitable for the marine aggregates dredging industry. These recommendations are intended as a basis for consultation and discussion both within

the marine aggregates dredging industry and with those concerned with wider issues of coastal zone management.
This task will outline proposals for monitoring and subsequent management and mitigation of the impact of marine aggregates dredging on coastal zone resources. It will comprise a cost-effective approach to:

- Monitoring the physical impact of marine aggregates dredging on the sea bed and water column;

- Monitoring the impact of marine aggregates dredging on biological resources, and their rate of recovery following cessation of dredging;

- Monitoring the economic impact of marine aggregates dredging on other uses of the marine environment including fisheries exploitation.

This section of the project will essentially propose a monitoring strategy necessary to determine the scale and impact of dredging within individual licence areas, and of any potential cumulative impact of multiple licence areas in close proximity.

It will investigate whether, until such measurements have been made, it is possible to predict whether the impact of dredging in adjacent licence areas is greater, or less than that of the sum of the individual areas. That is, whether a "cumulative impact" of the complex patchwork of proposed licence areas in some parts of UK waters occurs.

F. *Task 5* - Future Research Needs

Identification of areas of uncertainty and future research needs.

G. Output

Once finalised with the Minerals Management Service (MMS), it is intended to make this research project available to a wider audience via publication in international scientific journal(s). Eventually it is aimed to produce a Good Practice Handbook, from which, following consultation with all relevant bodies, it is hoped guidelines can be developed for use within a legislative EA framework, for use in all coastal zone management development requiring an assessment of cumulative effects.

INTRODUCTION

I. Geographic & Economic Background to the Marine Aggregates Industry

Marine aggregates comprise sands and gravels that are found in the coastal waters of the continental shelf. They are used principally in the construction industry, in infrastructure developments such as roads, railways and airports, and for land reclamation and coastal protection works. Significant quantities of such material are required for such schemes. A typical house construction, for example, requires approximately 60 tonnes of aggregate, whilst each mile of motorway can require as much as 200,000 tonnes of aggregate.

Recent estimates that as many as 4 million new homes may be needed to meet demographic requirements by the year 2016 implies that a further 240 million tonnes of aggregates will be needed for the new housing sector alone.

This figure is quite apart from all other end uses, including requirements for refurbishment and repair. The breakdown of end-use for the 240-300 million tonnes of aggregates required annually to meet UK new project and repair and maintenance requirements are as follows (DoE, 1994):

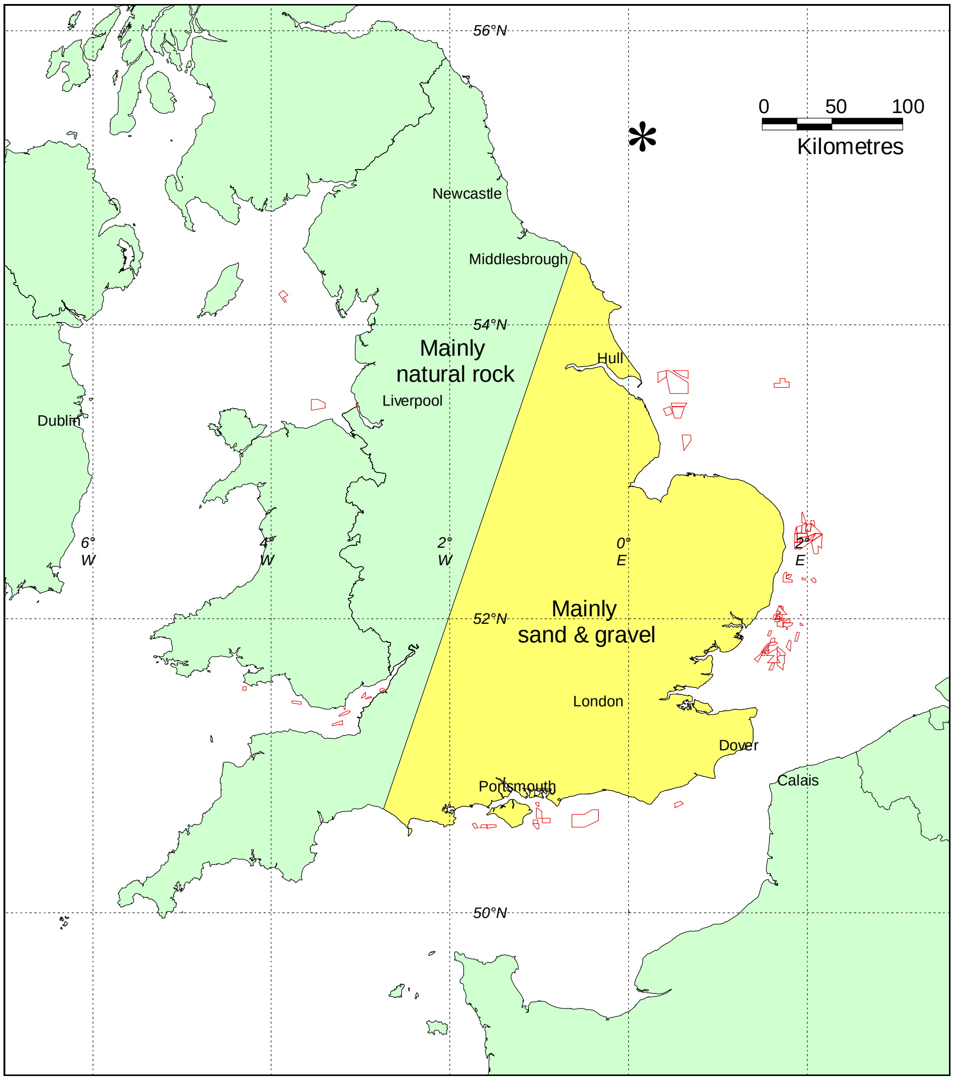
- roads 32%;
- housing 28%;
- private projects 23%;
- public projects other than roads and housing 13%; and
- other projects 4%

Currently approximately 18% of the national supply of aggregates for the construction industry in the United Kingdom is derived from marine sources. There are, however, significant regional differences in the availability of sands and gravels (*see* Figure A over), the south and east of England comprising the main sources of sands and gravels where up to 30% of the market is supplied from marine aggregates deposits (British Marine Aggregate Producers Association, 1995).

Some forecasts of the likely demand for aggregates for use in the construction industry have been summarised in MPG6, April 1994. It is estimated that demand for aggregates in the United Kingdom will rise to between 330 and 365 million tonnes by the year 2006. At present the traditional sources of supply in England and Wales comprise sand and gravel pits, and quarries which produce crushed rock. These have consented reserves of 6,400 million tonnes, of which it is estimated that over 4,000 million tonnes could be worked in the next 15-20 years. However these sources are finite, and there are increasing environmental obstacles to continued exploitation of land-based resources on the scale which is required to meet demand.

A number of options are therefore considered in the MPG6 Document. These include improved efficiency of use of aggregates and recycling of materials for secondary use in reclamation works. Recycled secondary aggregates have found some use as concreting aggregate in the south east of England, particularly west of London. It is, however, reasonable to assume that at present secondary aggregates are unlikely to displace traditional sources given the volatility of the market relating to both availability of materials and price instability.

Figure A: Location of marine aggregates dredging areas around the UK, showing the lack of natural rock and the importance of marine aggregates in the south-east of England



Key:
Marine aggregates licence area

Oakwood Environmental Ltd
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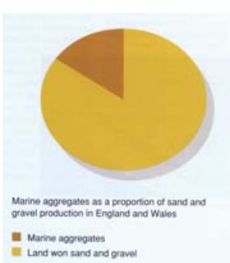
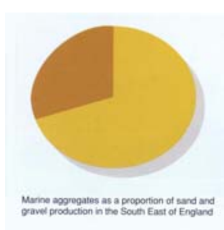
Datum: OSGB36





Source: Crown Estate (1998), BMAPA (1995)

The current targets set out in the Guidance Note for use of secondary/recycled material in England is 40 million tonnes by 2001 and 55 million tonnes by 2006. If these figures are achieved, they imply that secondary aggregates are likely to supply only some 10% of the projected demand of 330-365 million tonnes required by the year 2006.

Coastal super-quarries have also been considered as a possible option to meet the projected demands for aggregates. These comprise quarries with reserves of at least 150 million tonnes and capable of supplying 5 million tonnes of aggregates per year. Several localities occur in north-western Europe where these could be developed, but they involve transport of relatively low value bulk materials for considerable distances to the point at which they can be used by the construction industry. Major port facilities are also required both at the quarry site and ports of destination which are capable of accommodating ships of up to 70,000 dead-weight tonnage.

There seems little doubt that coastal super-quarries will have a role to play in the supply of aggregates in the future, particularly if the price of aggregates increases significantly above current levels. However their contribution is uncertain for the immediate future (Mellis: **In:** *Planning*, No. 1252: 23rd January 1998), and environmental downsides of super-quarries have already been recognised in deterioration of areas of often important scenic quality at the quarry site. There is also some difficulty in identifying a sufficient number of suitable shore-based facilities of at least 8 hectares which would be required to handle an annual throughput of 3-5 million tonnes of material alongside major docking facilities.

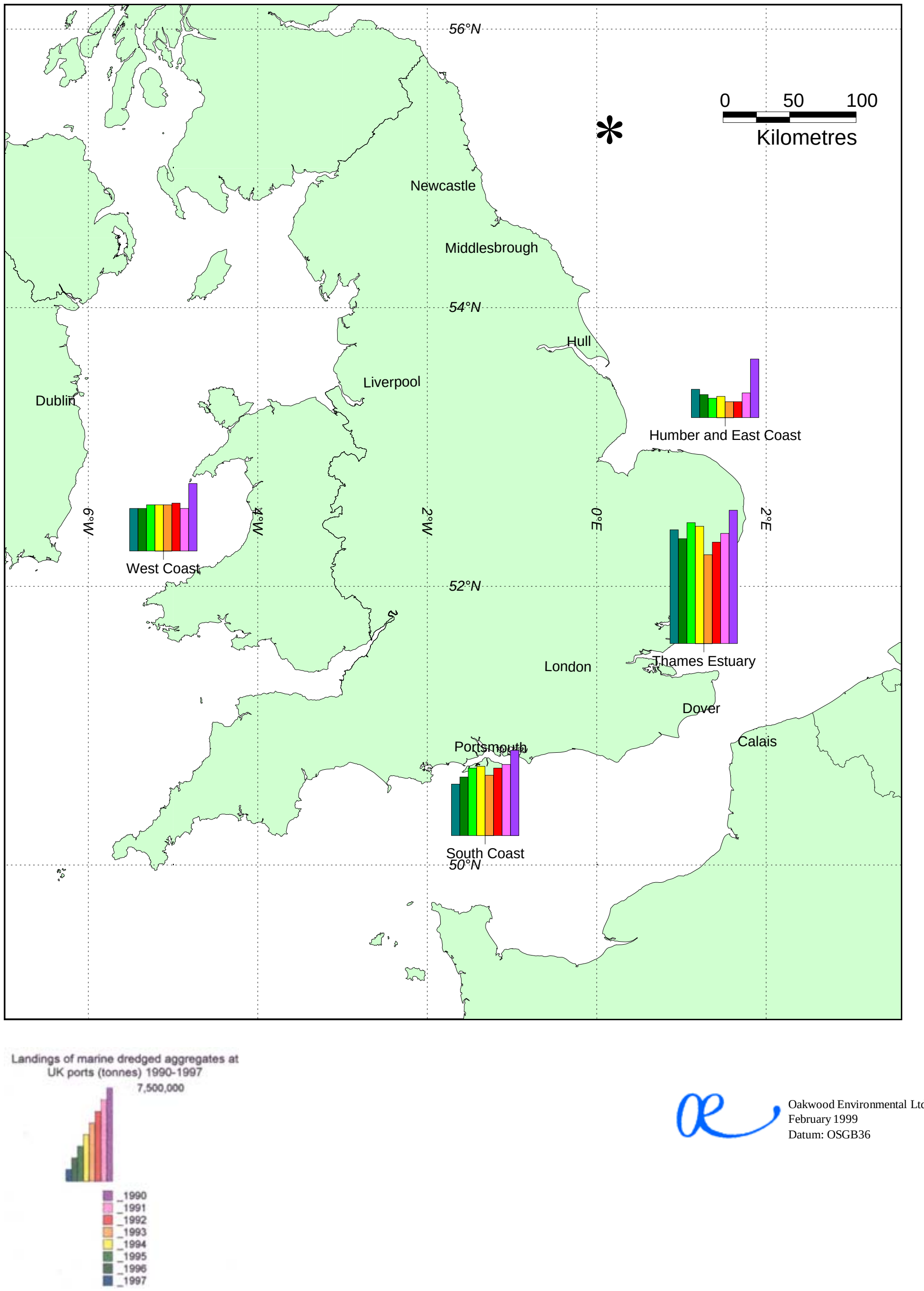
From this brief overview, it is clear that marine dredged sand and gravel is likely to continue to provide a significant contribution to the overall demand for aggregates in UK and mainland Europe into the foreseeable future. These sources reduce pressure to exploit resources on land of agricultural or environmental value, but can at the same time conflict with other activities including amenity and recreation, shipping and fisheries exploitation of coastal zone resources.

II. The Marine Aggregates Industry: Scale & Growth Forecasts

Marine sand and gravel mining in European coastal waters has shown significant growth in recent years, the principal operating states being the United Kingdom, Belgium and the Netherlands. Annual extraction rates from the United Kingdom amounted to 21-28 million tonnes per year in the period 1988-97 (Crown Estate, 1988-97) (for landings *see* Figure B over), from a permitted and licensed amount of 38-43.6 million tonnes per year over the same period (*see* Figure C).

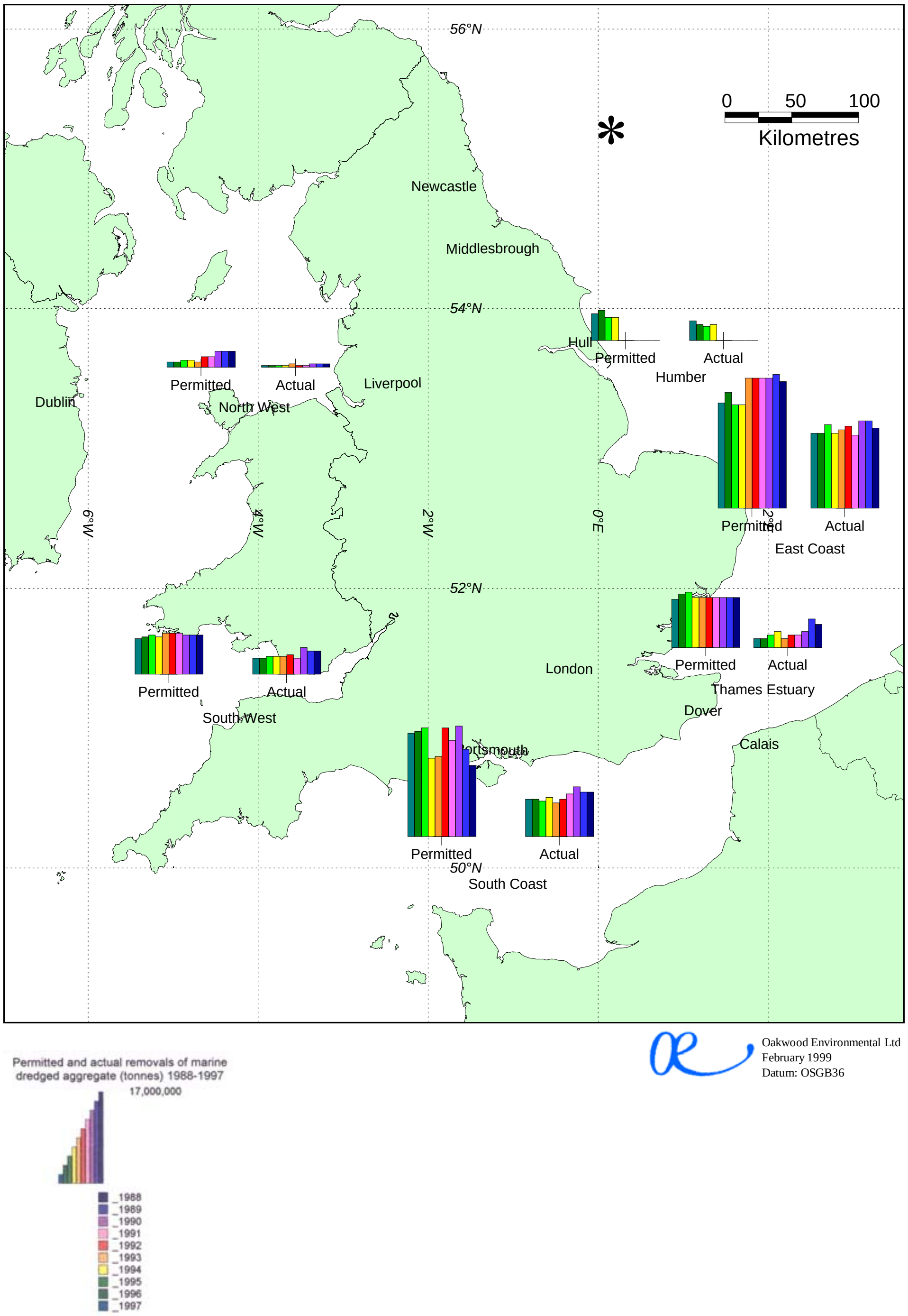
By comparison, extraction rates for Belgium decreased from approximately 50 million tonnes per year in 1984 to approximately 32 million tonnes per year in 1994. In the Netherlands, annual production increased from only 5 million tonnes in the period 1974-84 to more than 32 million tonnes by 1994, the last date for which figures are available (ICES 1992b, 1993; de Groot, 1996). Annual extraction of sands and gravels used principally for the construction industry, beach feed and other sea defence works thus amounts to as much as 100 million tonnes per year from these three countries which border the North Sea, additional quantities being exploited along the coastline of France.

Figure B: Landings of marine dredged aggregates at UK ports between 1990 and 1997



Source: Crown Estate, 1988-1997

Figure C: Permitted and actual removals of marine dredged aggregates between 1988 and 1997



Source: Crown Estate (1988-1997)

The scale of the marine aggregates mining industry is therefore significant and provides construction materials that would otherwise have to be supplied from land-won sources. Based on a projected annual requirement of 250 million tonnes, aggregates production from coastal sources supply 35 million tonnes or approximately 14% of the total demand for the construction industry in UK.

The estimated value of the industry, based on an average of £5.00 per tonne at the point of discharge, (an average of 1997 prices ranging from £3.00 to £7.00 per tonne depending on the type of cargo), is in excess of £500 million per year for the three principal operating states bordering the North Sea. Of this figure, the UK industry comprises approximately £175 million per year, or approximately 35%. The industry itself is a significant source of employment, approximately 2,500 employees operating almost entirely on British registered ships. The latter comprise a significant proportion of the British merchant fleet, amounting to at least 45 vessels, some of which have a cargo capacity of as much as 5,000 tonnes.

It is probably realistic to assume that the extraction rates summarised above will increase to supply major European land reclamation and construction projects scheduled for the future. The following sections assess the factors controlling the scale and distribution of marine aggregates mining activities in coastal waters, and the potentially conflicting interests which occur in exploitation and management of coastal zone resources.

III. Palaeohistoric Locations of Marine Aggregates Deposits

The coarse sands and gravels which are required by the construction industry do not occur uniformly on the sea bed, but are confined to relatively restricted geological features which have a well-defined distribution in the waters surrounding the British Isles. This occurs because marine gravels are found mainly in deposits which were laid down in shallow waters during the glaciations of the Pleistocene period. During that time, much of the British Isles was covered in glaciers extending from central Britain southwards into southern England. The periods of glaciation were interrupted by a number of interglacial periods when global temperatures rose and the ice retreated. This led to a rise in sea level and the formation of raised beaches, many of which form the principal sources of land-based gravel deposits exploited today.

Approximately 10,000 years ago global temperatures rose during the last interglacial period and the glaciers began to melt. Vast deltas of mixed alluvial deposits formed by the rivers which carried melt waters westwards down the Mersey Estuary into Liverpool Bay, westwards down the Severn estuary into the Bristol Channel, southwards through the Solent, and eastward through the Thames Estuary and Humber. Well-defined beaches were formed during this interglacial period, and these, together with the alluvial terraces and other material deposited by the glacial rivers became submerged as the sea levels rose to present day levels. The gravels which are now exploited as marine resources are therefore primarily transitory features of freshwater origin or were deposited along ancient shorelines long since submerged by a rise in sea level.

The present major estuaries in the British Isles and Europe are, in fact, flooded valleys of these ancient post-glacial river systems. It is therefore to be expected that marine gravel deposits will occur principally at, or adjacent to the major estuaries and along isolated coastal terraces which are all that remain of former beaches. Part of the skill of the sedimentary geologist is to locate potential sites of riverine terraces and relics of submerged beach structures, and to assess whether these occur in exploitable depths and without contamination by muds and silts laid down in subsequent periods. This is often achieved by surveys at sea using onboard monitoring of seabed topography and interpretation of the subsurface geology by sonar and seismic techniques.

Inspection of alluvial structures bordering modern river systems and beaches shows that exploitable deposits are very restricted in area, often being eroded and re-eroded many times as rivers change their course. This is also true of ancient river systems and can lead to gravels becoming inaccessible through deep deposits of overlaying material, or loss of beach material by subsequent erosion. It is therefore by no means certain how much of these residual and transitory gravel bearing structures remain in an exploitable form in sufficiently shallow waters on the sea bed. The second task of the field geologist is therefore to assess the quality of the deposits by grab sampling and the depth of the deposits by core sampling. This then allows an assessment of the type of resource, and estimates of whether it is present in commercially viable quantities.

This review of the sites and geological history of gravels deposits serves to emphasise that the areas of exploitable marine gravels in particular are very restricted geographically, and often comprise a small area of exploitable resource remaining from what might have been an extensive alluvial terrace or beach structure. There seems little realistic likelihood that entirely new alluvial and ancient beach terrace structures will be located since these are already well-documented. It is therefore not surprising to find that the marine aggregates industry is primarily sourced from well-identified geographical areas which have a long history of sands and gravels dredging. It is also clear that where suitable deposits occur, there may be a complex patchwork of aggregates Licence Areas close to one another and following the course of ancient river systems or beach structures.

In view of the requirement for at least 30-40 million tonnes per year of marine aggregates to be supplied from marine sources to meet projected targets for the construction industry, there is likely to be increasing pressure for marine aggregates mining licences. These will be concentrated in areas already identified and exploited for sands and gravels.

IV. Sources & Sites of Exploitation

It has been shown above that geological factors from glaciation in the Pleistocene and the subsequent re-erosion and depositional history of the area control whether exploitable deposits occur in a particular locality. However commercial factors are also important in controlling whether potential deposits are commercially exploitable. These include the type of material which comprises the deposit and the commercial demand from customers during the period the dredging licence is held, the distance from the port of landing and commercial endpoint, the depth of water and difficulties of dredging.

The depth from which material can be exploited is also strictly limited, even with modern trailer suction dredgers. Most operate in the depth range 20-30 metres, but some recent vessels have a capacity to operate to 50 metres depth. In general, it can be assumed that for the foreseeable future, only those deposits occurring in depths of less than 50 metres will be commercially exploitable. Both the location of gravel deposits, and the possibility of commercial exploitation, therefore tend to concentrate licensed gravels dredging to strictly coastal waters and often to areas of importance for commercial inshore fishing vessels and amenity use within the coastal zone.

It should be emphasised that although the marine aggregates industry accounts for fairly large bulk cargoes, the value is relatively low as compared with exploration and dredging costs. The current profit margins are therefore controlled by the costs of running the dredger, the amount of onboard or land-based processing of the material required to meet customer specifications and the distance which the cargo has to be transported to the customer, as well as the costs and difficulties of dredging in deeper waters. This means that there is a good deal of commercial pressure for operating companies to select deposits which are as close to the sale endpoint as possible, or close to the home port where land-based processing is carried out. This operates against exploiting potential deposits elsewhere in the British Isles because the end markets are in the south-east UK and on continental Europe.

There are thus powerful resource-based and commercial reasons why the majority of present and future marine aggregates dredging licence applications are likely to be concentrated in the south and east of the British Isles. This situation is likely to continue in an increasingly competitive commercial environment until alternative sources including coastal super-quarries replace existing commercially viable gravel resources on the seabed.

V. Conflicting Uses & Interests

The resource-based and commercial reasons for the concentration of large numbers of licensed dredging areas within relatively restricted areas near the site of ancient river systems in the south of the British Isles has been reviewed above. It has also been pointed out that this brings the industry into potential conflict with other legitimate uses of the coastal zone, principally nearshore fishing interests.

In recent years, the UK fishing industry has seen a considerable contraction from a fleet which traditionally exploited far-northern waters for cod and haddock. With the exclusion of UK vessels from these waters in the 1960's, increased fishing effort in the North Sea led to the collapse of successive fish stocks through over-exploitation. Herring stocks have recovered somewhat following a moratorium on all herring fishing for a number of years, but the catches are now much reduced per unit effort for all wild fish stocks and are subject to increasingly rigorous control of landings.

This has led to two main developments in the UK fishing industry. First there has been a great reduction in the number of larger vessels operating in the North Sea. Some activity has developed for the offshore fleet operating out of Newlyn in Cornwall, but the fleet as a whole is merely a remnant of the vast trawler fleets which operated out of Hull, Grimsby and Lowestoft in past decades.

Secondly, that there has been a considerable increase in small nearshore fishing vessels, generally of less than 12 metres length and often operating on a part-time basis. These vessels account for significant landings of up to 5 tonnes of fish per square mile, but are necessarily restricted to exploitation of areas which are within convenient day sailing from the home port. Some migration occurs from port to port, according to the seasonal occurrence of fish stocks, but essentially such vessels need to deploy their gear in areas not more than 20 miles from the home port. This gives them a 2-3 hour steaming time in each direction and sufficient time to return their catch in good condition to the port.

Hence the requirements of nearshore fishing vessels are not unlike those of the dredging industry. Namely, the sites where resource exploitation is commercially viable are geographically limited and it is not possible to simply direct the fishing effort elsewhere if the chosen fishing area coincides with one where marine aggregates resources occur. The situation is complicated by the fact that it is difficult to assess the true value of the nearshore fisheries catch from recorded landing statistics which, for various reasons, are customarily under quoted by factors which are thought to range from two-fold to four-fold.

Indirect methods are therefore needed to value the fisheries resource and to carry out a cost-benefit analysis on the relative merits of proposals to exploit the deposits for marine aggregates. It is also clear that fishing activity itself, and especially by vessels using heavy bottom gear, has a profound impact on seabed resources and that these cannot be excluded from any assessment of man's activity in the coastal environment (Holmes, 1997 *in* New Scientist 14.06.97).

It has been estimated that the area of the North Sea impacted by fishing amounts to 309,204 km^2 compared with only 180 km^2 by aggregates dredging. Although the area impacted by marine aggregates dredging amounts to only 0.03% of the North Sea compared with as much as 54% of the sea bed which is affected by fishing, any comparisons on a basis of area alone are over-simplistic. Coastal deposits of the sort which are often favoured for gravels extraction are those which are breeding areas for commercially important fish stocks elsewhere. Herring, for example, are thought to return to particular sand and gravel banks not unlike the salmon that return to particular tributaries in the rivers from which they were spawned. It is probable that many other demersal fish species have highly specific breeding sites and that alteration of conditions in these areas will have an impact on fish stocks which goes far beyond that implied from the small area concerned.

The exploitation of sands and gravels along the course of ancient river and beach terraces also has implications for other resources of importance for coastal zone management. Many of the remains of Palaeolithic man are to be found in hunter-gatherer remains on the terraces of the interglacial river systems. It is no coincidence that many of the earliest hominoid remains have been found in land quarries coinciding with ancient river terraces, and there is little doubt that these extend to submerged terraces below sea level. Such flooded valleys have also an historical association with shipping and coastal settlements.

There is no doubt that areas to the south and east of the Isle of Wight, the Thames Estuary and many other locations of potential importance for aggregates exploitation are also the site of historic wrecks and unrecorded artifacts of archaeological and historic significance. Early vessels are occasionally recorded in many of the estuaries of the British Isles, as well as in coastal waters near the approaches of historic harbours in the vicinity of The Solent.

Finally, the near coastal environment is also increasingly recognised as of importance for conservation use, including the establishment of Special Areas of Conservation (SACs) under the European Union Habitats Directive. Estuaries are themselves recognised as highly productive and support well-recognised wildlife resources which play an important role in food webs leading to internationally significant bird populations in many coastal areas.

Yachting, angling and diving are all also concentrated close to the coast and often near to sites of potential aggregates resources.

It is part of the purpose of this document to identify the potential sources of impact of marine aggregates dredging, especially where multiple licensed areas are operational or planned in close proximity to one another. It is the intention to prepare a framework for the assessment of the cumulative effects of sand and gravel dredging in coastal waters based upon these sources of impact.

VI. Potential Impact of Marine Aggregates Exploitation

(i) Sources of Environmental Impact

The impact of marine aggregates dredging on environmental resources has already been widely reviewed (Hess, 1971; ICES 1975, 1977, 1992a,b, 1993; Millner *et al*, 1977; de Groot, 1979, 1986; Jones & Candy, 1981; Hurme & Pullen, 1988; Sips & Waardenburg, 1989; Charlier & Charlier, 1992; Kenny & Rees, 1994, 1996; Hodgson, 1994; Hitchcock & Drucker, 1996; Hitchcock *et al* 1998; Newell *et al* 1998).

Most of the sea-going aggregates dredgers are self-contained and use a centrifugal suction pump to lift the aggregates from the sea bed into a hopper where the material is screened before being transferred to the hold. Unless the material is otherwise suitable for direct use as a beach-feed or landfill, the gravel:sand ratio in the final cargo is adjusted to between 50:50 and 65:35 depending on customer requirements. The principal impacts on environmental resources are therefore related to:

(a) the removal of material from the dredged area itself; and
(b) the deposition of material from the outwash and reject chutes during the screening process.

(ii) Impact Within the Boundaries of the Dredged Area

Essentially the physical impact of dredging works is dependent partly on the method of dredging. Two main methods are used for gravels extraction in European coastal waters. These are (a) **anchor hopper dredging** and (b) **trailer suction dredging**:

(a) In **anchor hopper dredging** the vessel is stationary and dredges the deposits from a sequence of specific points on the sea floor. The vessel can therefore leave pits or depressions on the seabed which have been reported to reach as much as 20 metres in depth and 75 metres in diameter (Dickson & Lee, 1972; Cruikshank & Hess, 1975). Such depressions have been found to be persistent features of seabed topography for several years except in areas of high sediment mobility. Dickson & Lee (1972) found that test pits dug by anchor dredge in gravel deposits in the Hastings Shingle Bank off the south-east coast of England were still detectable after two years. In another study, van der Veer *et al* (1985) showed that pits in channels of the Dutch Waddensea filled within one year in areas of high current velocity, but took 5-10 years to fill in tidal watersheds and even longer in tidal flat areas.

The effects of these changes to seabed topography are predictable, given a knowledge of the grain size of the aggregate being extracted and the tidal velocities in the area. However, the effects of the changes to sediment structure are less predictable, being dependent upon the amount and nature of extraction (ICES, 1979; Seafish, 1991), with either infilling or scouring of pits or depressions occurring.

Infilling can occur mainly through slumping of the sides and subsequent infilling by fine particles transported by tidal currents into the pits, which thus act as sediment traps. This can lead to anoxic sediments and to colonisation by biological communities which differ considerably from those in the original deposits (Shelton & Rolfe, 1972; Dickson & Lee, 1972; Kaplan *et al*, 1975; Bonsdorff, 1983; Hily, 1983; van der Veer *et al* 1985). However, disturbance of the bottom topography may also result in an increase in tidal scour, with fine particles lifted in suspension more readily by tidal streams (Seafish, 1991). Thus rather than acting as a sediment trap, fine particles maybe removed from the pits and deposited on adjacent banks.

(b) In **trailer suction dredging** deposits are removed by suction through one or a pair of pipes deployed whilst the vessel is slowly under way. In this case, side-scan sonar records show that the sea bed within the boundaries of dredged areas is crossed by a series of dredge tracks which are 2-3 metres wide and up to 50 cm deep (van Moorsel & Waardenberg, 1990; Kenny & Rees, 1994). Davies & Hitchcock (1992) reported dredge cuts of between 20-55 cm depth and 3.0-3.8 m width in commercially exploited deposits of the Bristol Channel. Somewhat deeper troughs of up to 70 cm were reported for the Baltic (Gajewski & Uscinowicz, 1993). It is even possible to detect with side-scan sonar the type of dredge head which has been used from the form and depth of the dredge track (Hitchcock *et al*, 1998).

Despite the shallower depth of removal compared with anchor dredging, the evidence suggests that infilling of troughs from trailer suction dredging often takes at least 12 months. Infilling may take substantially longer in some areas (Millner *et al*, 1977, Hily, 1983; van der Veer *et al* 1985; Gajewski & Uscinowicz, 1993), or may be more rapid in areas of high sediment mobility.

The impact of these activities on biological resources on the sea bed is dependent on the intensity of dredging in a particular area, the degree of sediment disturbance, and the intrinsic rate of reproduction, recolonisation and growth of the community which normally inhabits the particular deposits. In general, the evidence suggests that dredging results in:

- 30-70% reduction of the species diversity;
- 40-90% reduction in the number of individuals; and
- a similar reduction of the biomass of benthic communities within the boundaries of the dredged area, depending on the intensity of dredging. (Newell *et al*, 1998).

The potential impact upon fin fish and shellfish resources arises from the direct disturbance to the seabed caused by the draghead, and the temporary suspension of sediment particles in the water column which results in, at first, elevated turbidity and subsequently sediment deposition in and around the area dredged. These physical effects can have a direct adverse impact in that they cause the death of the food source, the benthic organisms, through damage or smothering by sediment. There are also more subtle effects through alterations to the organisms food supply or habitat. These too can lead to death, but are more likely to cause a reduction in growth rate or movement out of the area affected, although for the most part, the key demersal species have sufficient mobility to avoid direct destruction by the draghead.

As a result, seabird populations, and indeed sea mammals may be impacted if fisheries resources and food sources are severely affected, with commercial fisheries activities affected as a consequence.

(iii) Physical Impact Outside the Boundaries of the Dredged Area

Although a good deal of concern has been expressed about the possible impact of marine aggregates extraction on coastal resources (ICES 1992a,b; Pearce, 1996), the possible scale of impact outside the immediate dredged area is poorly understood. Effects are of particular concern in areas where multiple licences for aggregates extraction occur. Such effects are likely to relate to:

- deposition of material rejected by outwash from the hoppers and through the reject spillways of the screening chutes; and
- potential impacts of the removal of relatively large quantities of material from the sea bed on coastal erosion, beach draw down and replenishment processes, and on wave refraction and height.

Hitchcock & Drucker (1996), and more recently Hitchcock *et al* (1998), have summarised values for material lost through hopper overflow spillways and from the reject chutes during the screening process on a typical modern trailer suction dredger (4,500 tonnes hopper capacity) operating in UK waters off the coast of East Anglia. During a recorded average loading time of 290 minutes, as much as 12,158 tonnes of dry solids and 33,356 tonnes of water were pumped by the dredge pump. Of this, 4,185 tonnes of dry solids were retained as cargo, whilst 7,235 tonnes of dry solids were returned overboard during the screening process and a further 750 tonnes of dry solids from overspill.

Much of this material falls on to the seabed directly under the dredge vessel (Davies & Hitchcock, 1992), although the sand and finer fractions can potentially be carried some distance on tidal currents. In its simplest form, the settlement velocity and residence time of such particles in the water column can be estimated from Stoke's law. If the residence time of the particles in the water column is known, the duration and speed of currents will then determine the excursion pattern before settlement. Clearly, this is highly site-specific.

Estimates of dispersion of the fine material based on these Gaussian diffusion principles suggested that very fine sand particles may travel up to 11 km from the dredge site. Fine sand may travel up to 5 km, medium sand up to 1 km and coarse sand less than 50 metres in typical current velocities recorded in UK coastal waters (H.R.Wallingford, 1994; cited in Hitchcock & Drucker, 1996). Similar estimates based on the settlement velocity of fine silt-sized particles (<0.063 mm diameter) suggest that this material could remain in suspension for up to 4-5 tidal cycles and be carried for as much as 20 km on each side of a point source of discharge depending on the speed of local current flow.

However, most recent studies made on the dispersion of sediment plumes generated from marine aggregates dredging suggest that the area of impact of outwash from dredging is smaller than estimates based on Gaussian diffusion models, especially where the proportion of silt and clay in the deposits is low. This appears to be due to complex cohesion properties of the discharged sediment particles, which flow towards the sea bed as a density current and do not conform to settlement rates based on the specific gravity and size of the component particles themselves (Land *et al* 1994; Whiteside *et al*, 1995; Hitchcock & Drucker, 1996; Hitchcock *et al*, 1998).

As a result, the principal area likely to be affected by sediment deposition is much less than the "worst case" scenarios predicted from conventional Gaussian diffusion simulation models, and is mainly confined to a zone of a few hundred metres from the discharge chutes.

There remain, however, many areas of uncertainty, including the extent to which removal of large quantities of marine aggregates from multiple licence areas might have on wave height, wave refraction, beach drawdown into the excavated area and other coastal processes which are of importance in beach replenishment and coastal erosion.

(iv) Biological Impact Outside the Boundaries of the Dredged Area

Little is known either of the extent of the "footprint" of impact on biological resources for either individual worked licence areas, or the overlap between adjacent areas where multiple dredging licences occur. However it is likely that the impact of dredging activities mainly relate to the physical removal of substrate and associated organisms from the seabed along the path of the draghead, and to the impact of subsequent deposition of sediment from outwash during the dredging process.

The evidence from direct studies on the sedimentation of particulate matter suggests that the impact of sedimentation on biological resources on the seabed is likely to be confined to distances within a few hundred metres of the dredger where the deposits are sands and gravels. These dispersion studies are of great relevance, although the extent of the ‘footprint’ of impact of worked dredged areas on biological resources outside the boundary of the dredged area is one which has been directly studied in only a few instances (see Poiner & Kennedy, 1984).

Research has shown that rates of recovery for biological communities within sands and gravels may be in the order of 2-3 years, depending on the proportion of sand and level of environmental disturbance by waves and currents, and may take even longer where rare, slow-growing components were present in the community prior to dredging. This estimate is based on recovery rates recorded for a wide range of deposits world-wide (de Groot, 1979, 1986; van der Veer *et al*, 1985; Desprez, 1992; van Moorsel, 1994; Kenny & Rees, 1994, 1996) and as summarised by Newell *et al* (1998). Most recent studies suggest that the time course of recovery of an equilibrium community characteristic of undisturbed deposits is also controlled partly by the processes of compaction and stabilisation which occurs following deposition. These processes themselves involve a complex interaction between particle size, disturbance by currents and episodic wave action and cementation processes associated with biological activities of the benthos.

The potential impact upon fin fish and shellfish resources arises from the effect of a zone of elevated turbidity extending for a few hundred metres around a working dredger. This elevation in turbidity will usually however be transitory, lasting for approximately 6 hours after each dredging operation. However, as stated previously, the key demersal species have sufficient mobility to avoid these zones. There is nonetheless the possibility that damaged benthic animals discharged by the dredger will attract scavenging fish to the dredging site. This benthic invertebrate material may play a significant part in the enhancement of benthic production in areas close to dredged deposits (Newell *et al*, in press). Thus, on balance, it is considered that the effect of any sediment plume, in terms of elevated turbidity, is likely to be minor.

Furthermore, beyond the immediate proximity of a working dredger, rates of deposition attributable to dredging will be low, of the order of a few millimetres per year at most. These rates are considered to be sufficiently low such that the effects upon the benthic community and the fish it supports will be relatively modest outside the area actually dredged.

Finally, the effects of dredging activity both within and beyond the dredged area, on spawning and nursery areas, and migratory routes should also be considered. The level of impact will be a function of the size of the dredged, and licenced, area, as compared to the spawning and nursery areas and the ability of the species to avoid the area dredged and that affected by the sediment plume. Fish and shellfish that release their eggs at the seabed (demersally) such as herring, dogfish, skates/rays, lobster and edible crab are, for example, more vulnerable to aggregate extraction because of the potential for egg damage.

More often than not, it is difficult to determine the potential for impact to migratory routes, and in particular the migratory patterns of juveniles leaving spawning and nursery areas for deeper offshore waters. Nonetheless, if migratory activity is along broad and ill-defined routes with little direct dependence on the dredged area, impacts are likely to be minor.

Again, any severe impact to benthic or fish populations will in turn potentially affect seabird populations, and indeed sea mammals, with commercial fisheries activities impacted as a consequence.

VII. Existing Policy Framework

(i) Licence Application & the "Government View" Procedure

The process of consent for minerals prospecting and subsequent exploitation of marine aggregates resources is different from that for land-based projects. For planning purposes, local planning authorities have powers to control development of land, including the coastal zone down to mean low water mark under the Town and Country Planning Act 1990.

Activities including aggregates dredging in nearshore waters are controlled by a number of agencies. Works which interfere with rights of navigation, for example, require a consent from the Department of Transport or other procedures set out in the Transport and Works Act 1992, whilst licences for oil and gas are issued by the Department of Trade and Industry.

Decisions on development proposals below mean low water mark are generally outside the scope of this planning system. This arises because all minerals rights, with the exception of coal, oil and gas are vested in the Crown who own most of the sea bed around the coasts of the British Isles from mean low water out to the limits of territorial waters. The management of these resources is the responsibility of the Crown Estate who issue two types of licence: a **Prospecting Licence** and a **Production Licence**.

(a) **Prospecting Licences: -** awarded by the Crown Estate through a tender process. This awards a successful tenderer a fixed time in which to carry out the necessary geological prospecting to assess the geomorphology of the sea bed, the occurrence of potential aggregate deposits, the nature and quality of the deposits and their extent and depth. Prospecting commonly involves use of sidescan sonar and seismic techniques and bathymetric surveys to determine sea bed topography and structure, grab sampling in areas of potentially exploitable deposits and vibrocore sampling to determine the depth and granulometry of the deposits through a core sample of up to 4 metres.

(b) **Production Licences: -** controlled at present in England and Wales by an interim non-statutory "Government View" procedure, as issued in May 1998 by the Department of the Environment, Transport and the Regions (DETR). On receipt by the Crown Estate of a formal application (usually accompanied by an Environmental Statement (ES)) for an aggregate production licence, DETR initiates the “Government View” procedure. Should these extensive formal consultations proceed without overriding objections from consultees, then a favourable “Government View”, and an aggregate extraction licence is issued by the Crown Estate. The licence frequently incorporates conditions, including for example measures to mitigate the environmental impact of the dredging.

These interim non-statutory procedures are presently being observed in England and Wales prior to the implementation in the UK of statutory procedures on 14th March 1999. The implementation of these statutory procedures is to meet the requirements of the EC Environmental Impact Assessment Directive

(85/337/EEC) supplement and amendment (EC Directive 97/11/EC) of March 1997 (for further details see section (*ii*) over).

Previously, licensing was controlled by the (then) Department of the Environment (DoE) under a non-statutory procedure issued in May 1992 (see Department of the Environment, Welsh Office *Planning Policy Guidance: Coastal Planning* September 1992. PPG20 HMSO), which modified the original procedures issued in May 1989. In July 1992, the Crown Estate issued a "Project Management" procedure for production applications seeking a "Government View" (Crown Estate, July 1992). Until the introduction of the recent interim procedures, this remained the basis for applications for production licences for the marine aggregates sector.

(The 1989 procedures are still presently adopted in Scotland, where neither the 1992 nor 1998 modifications were implemented, although they will be amended in March 1999 in line with the introduction of statutory procedures).

Under the present interim procedures, only one Environmental Statement (ES) is produced rather than a draft and a final version, as was the case with the previous non-statutory procedures. Instead of informal and formal rounds of consultation under the previous procedures, the ES is now subjected to a single Consultation Stage. Any relevant comments on the ES, or further work or analysis identified as necessary during the consultation stage is included in an accompanying Consultation Report, rather than in a 'final' ES.

It is helpful to summarise the procedures here, although reference should be made to the original document 'Government View: New Arrangements for the Licensing of Minerals Dredging' (DETR, May 1998), since this gives a detailed outline of procedures, timing and content of each stage of the Production Licence Application:

1 APPLICATION STAGE

a) Application for a Government View (GV) made to DETR (copy of application also sent to MAFF and Crown Estate (CE).

b) DETR 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 Environmental Impact Assessment (EIA).

d) Once step c) is complete applicant advises DETR and MAFF of outcome of informal discussions, and confirms whether they wish to proceed with the application.

e) DETR arranges a meeting with MAFF, the applicant and CE, if required.

f) If applicant wishes to proceed they commission a Coastal Impact Study (CIS) and Environmental Statement (ES).

2 CONSULTATION STAGE

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 DETR.

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 DETR and MAFF and sends a copy to CE.

3 CONFIRMATION STAGE

a) DETR 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) DETR to copy any response to MAFF and the applicant.

4 ASSESSMENT AND DETERMINATION STAGE

a) Towards the end of the confirmation stage DETR and MAFF 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 DETR.

5 DECISION STAGE

After consideration of Inspectors recommendation (where inquiry/hearing held) and after necessary consultation with other departments, DETR issues GV letter to the applicant (copied to CE and all consultees).

(ii) Existing and Future Requirements for Environmental Impact Assessment

In the UK, European Community (EC) Directives on the environment are incorporated into United Kingdom law and therefore affect the consent procedure outlined above. The key legislation comprises EC Environmental Impact Assessment Directive 85/337/EEC "*The assessment of the effects of certain public and private projects on the environment*", which came into effect in July 1988.

The EC Environmental Impact Assessment Directive requires an ***Environmental Assessment (EA)*** to be carried out before consent is granted for certain types of major projects, (listed in Annexes), likely to have significant environmental effects. Exploitation of mineral resources is identified in the Directive as an activity that might, under certain circumstances, require a supporting EA.

The original EC Directive (85/337/EEC) was supplemented and amended by a new Directive (97/11/EC) in March 1997 (EC, 1997) whose changes are to be transposed into the domestic legislative regime of Member States by 14th March 1999. The main purpose of the amendments is to clarify and supplement the original Directive to achieve a more uniform application in all Member States, and to improve the quality and scope of the information provided. The increased scope of the amendments added 12 new classes of projects to Annex I (for which an EA is always required) and 8 new classes of project to Annex II (where an EA is required where the project is likely to have significant environmental effects). It also clarified that modifications to both Annex I and Annex II projects are considered to be Annex II projects in their own right.

As a response to the new EC Directive (97/11/EC), DETR issued an initial Consultation Paper in July 1997 (DETR, 1997a) setting out the general principles for implementing in the UK the amendments of the new Directive. Essentially the main effects of the amendments identified in the DETR Consultation Paper are as follows:

Increased Coverage

- more projects require an Environmental Assessment.

Changes to Procedures

- clarification of the way in which Member States can decide whether Annex II projects (those which are likely to have significant environmental effects but which do not always require an EA) require an EA;

- competent authority must publicise its decision on whether or not an EA is required;

- competent authority must, if requested by a developer, give advice on the content ("scoping") of any proposed EA;

- competent authority is required to give reasons for consent decisions;
- improved arrangements for consultation with other Member States for projects likely to have significant transboundary environmental effects.

For the purposes of the "Government View" Procedure outlined previously, most recent marine aggregates licence applications have already required a supporting Environmental Assessment (EA). With the introduction of the new EC Directive (97/11/EC), which classifies the extraction of minerals by marine dredging under Annex II, all new operations to extract minerals by dredging, or any increase in extraction from existing dredging operations, must be considered for EA.

In a subsequent DETR Consultation Paper of 19th December 1997 (DETR, 1997b), comments were invited on proposals by the Government to determine the need for an EA in the UK. It was proposed that, with regard to the 'extraction of minerals by marine or fluvial dredging' an:

> "EA may be required: where it is expected that more than 100,000 tonnes will be extracted per year. EA will generally be required for any major extraction activities which are proposed in or close to sensitive locations such as spawning grounds, Marine Nature Reserves, Sites of Special Scientific Interest etc."

As extraction rates for marine aggregates licences generally exceed 100,000 tonnes per year, and that coastal deposits are sometimes close to spawning areas for commercially exploited fish and shellfish stocks, or other areas of conservation interest, it was therefore assumed that an EA would be required for most Production Licence Applications under the current and proposed EC Directives.

In July 1998, DETR issued draft Regulations for consultation, which will implement the requirements of the amended EC Environmental Impact Assessment Directive. Unlike the earlier Consultation Papers, which set out the general principles for implementation, this consultation exercise related only to amendments to the Town and Country Planning system in England and Wales. Implementation would be under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988 (Statutory Instrument (SI) No 1199). Under these draft Regulations, and as a result of the previous consultation exercise, the Government propose to continue to rely primarily on a case-by-case judgement, detailing criteria under *Schedule* 2 with which the need for an EA is considered. However, with regard to the 'extraction of minerals by marine or fluvial dredging' EA was now considered mandatory for 'all development'.

In line with these requirements DETR and The Scottish Office have recently issued draft Regulations for consultation, which will introduce the proposed statutory procedures by 14th March 1999 (DETR, 1998b; Scottish Office, 1998). These Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations bring together the requirements of the EC Environmental Impact Assessment Directive and EC Directive 92/43/EEC (the conservation of natural habitats and of wild fauna and flora). Commonly known as The Habitats Directive, the introduction of these Regulations, will mean that the importance of marine habitats and the protection of sensitive areas from impact from marine dredging, as is required by the EC Environmental Impact Assessment Directive, will be recognised.

Whilst the practical approach to the application for marine aggregates extraction will not be fundamentally changed, in that EAs are already routinely undertaken, introduction of a statutory regime does mean that applications will be more carefully considered (through a scoping exercise), regulated and licensed. The potential route to public inquiry or informal hearing provided by the interim procedures will continue under the statutory procedures, as with public inquiry for any other terrestrial planning application.

Importantly, the Regulations recognise the significance of fully investigating the potential for trans-boundary impact, where relevant. If a proposal is likely to have a 'significant effect upon the environment' of another Member State it will be necessary to fully consider, inform, consult, advertise and notify that Member State during the EA process. This exercise will be critical in resolving both the individual and cumulative effects of projects impacting neighbouring EU countries.

VIII. Terms of Reference & Methodology for Environmental Assessment

Prior to the implementation of the 1988 EC Directive (85/337/EEC), the Ministry of Agriculture, Fisheries and Food (MAFF) had in the UK published a code of practice for the extraction of marine aggregates (MAFF, 1981). Whilst this document only focused on the avoidance of conflict between the fishing and marine aggregates industries during the extraction of marine aggregates, it was an important step in recognising and seeking to reconcile the operating difficulties that were being experienced on a routine basis.

Following the 1988 EC Directive, the Department of the Environment (now DETR), in conjunction with the Welsh Office, published in 1989 an explanatory booklet that described the legislation and criteria which trigger the requirement to provide an EA and provided guidance on the content of an EA.

In 1992, the International Council for the Exploration of the Sea (ICES) prepared a number of recommendations for the environmental assessment of marine aggregates dredging (ICES, 1992a). Furthermore, a Scoping Document for EA for a marine aggregates dredging proposal was also included as an Annex VI in an ICES Marine Environmental Quality Committee report of May 1993 (ICES, 1993).

As a result of these ICES guidelines, Campbell (1993) subsequently detailed the Terms of Reference which are recommended for the assessment of impact of marine aggregates dredging on coastal resources for which MAFF have a responsibility in the UK. Whilst these Terms of Reference have formed an effective framework for both the pre-licensing EA document and subsequent Monitoring Programme for the seabed extraction of marine aggregates in the UK in recent years, there is however no consensus on recommended Good Practice methodology on how these objectives should be achieved.

As a result of the lack of clear methodology, primarily as a result of the differing extent to which the EC Directive has been implemented in Member States, details of what are considered appropriate Terms of Reference and methodology for EA vary widely across the European Union. The number and frequency of environmental sampling points, the method of collection of the data and the subsequent interpretation and reporting, all require some conformity if they are to be incorporated into any understanding of the nature of coastal marine resources and their susceptibility to disturbance by man.

Guidelines on what constitutes effective monitoring of the impact of marine aggregates dredging and proposals on what level of environmental disturbance imposes a significant impact are also required before EA information and subsequent monitoring can be incorporated into realistic management objectives for the coastal zone. More recent work (ICES, 1998) has addressed the issue of the effects of extraction of marine sediments on a broader ‘marine ecosystem’ scale, within a framework of the requirements of the 1997 EC Directive.

Furthermore, as a result of the forthcoming statutory procedures in the UK, DETR will also be publishing a ‘Marine Planning Policy Guidance’ document for public consultation in early 1999. This will set out the Government’s policy on ‘marine dredging; the balance to be struck between meeting the need for marine sand and gravel and protecting the marine environment and coast; and the criteria by which dredging applications will be determined.

Whilst the authors are therefore conscious that techniques are in a continuous state of change, we do regard some agreed standardisation of the protocol for EA and subsequent Monitoring Programmes as an essential first stage in a comprehensive approach to coastal zone management. It will be important that Member States adopt such an approach in their implementation of the EC Directive.

However, it is adopting an approach for the assessment of cumulative effects that remains the primary area of interest for this research project. For, whilst the EC Directive makes reference to the assessment of cumulative effects, it provides no terms of reference for their implementation within EAs (Colombo *et al*, 1997). Therefore, whilst the UK government works towards the introduction of statutory procedures by the 14th March 1999 in the context of the EC Directive, there will in the UK still be no formulated approach to the assessment of cumulative effects for the marine aggregates dredging industry.

IX. Conclusion

It is the purpose of this research project therefore to develop a framework for the development of an approach to the assessment of cumulative effects within the marine aggregates dredging industry.

Following a world-wide literature review of the current status of the implementation of CEA, a framework is developed, based on the best practices identified. For Cumulative Effects Assessment (CEA) to be effectively placed within the EA process for developments within the coastal zone, it is necessary to review the complexity of issues that are involved in the management of coastal zone resources.

Having done this within the introduction, the CEA framework is then displayed using a pilot study area, using real data to provide an indicative level of information needed for the framework. The assessment of the impact of marine aggregates dredging and the development of a CEA approach will therefore combine best practice within a pilot study area for which the necessary data exists. Above all else, however, it will be based on the authors' experience gained in EA surveys in UK waters in recent years.

The development of such a framework will be especially important in areas where aggregates resources are currently under-exploited compared with those in the UK. Whilst the research project is focused on the marine aggregates dredging industry, it is, however, our intention that it can form the basis of a discussion document helpful to all with responsibilities for wider issues of environmental management in the coastal zone.

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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Section 1 – Overview & Perspectives

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1. OVERVIEW & PERSPECTIVES

1.1 Introduction

Marine dredged sand and gravel sources reduce pressure to exploit resources on land of agricultural or environmental value, but can at the same time conflict with other activities including amenity and recreation, shipping and fisheries exploitation of coastal zone resources. Furthermore, marine aggregate extraction areas tend to become concentrated in certain inshore areas, following the course of ancient river systems or beach structures.

Whilst the cumulative environmental effects of these ‘patchworks’ of dredging areas are the cause of some concern to industry regulators and other interested parties, to the authors’ knowledge no comprehensive methodology for the cumulative effect assessment of marine aggregate dredging has been described anywhere in the world. This project, known as the Strategic Cumulative Effects of Marine Aggregate Dredging (SCEMAD), will attempt to address this deficiency.

This paper provides an introduction to the issues that underlie the SCEMAD project. In doing so, it commences with an overview of the marine dredging industry and the location of exploitable deposits, a synopsis of the key effects of marine dredging and an examination of the environmental regulatory framework with specific regard to the cumulative effects of dredging.

Having defined the objective of the project and then considered the meaning of the term ‘cumulative effects’, a comprehensive literature review intended to select possible alternative approaches for developing a framework for the assessment of the cumulative effects on the marine and coastal environment is described. These suitable alternative approaches are identified, and their ideas and solutions are advanced further in a subsequent paper ‘A framework for implementation’.

1.2 Geographic & Economic Background to Marine Dredging

Marine aggregates comprise sands and gravels which are found in the coastal waters of the continental shelf. They are used principally in the construction industry, in infrastructure developments such as roads, railways and airports, and for land reclamation and coastal protection works. Significant quantities of such material are required for such schemes. A typical house construction, for example, requires approximately 60 tonnes of aggregate, whilst each mile of motorway can require as much as 200,000 tonnes of aggregate.

Taking the United Kingdom as an example, 240-300 million tonnes of aggregates are required annually to meet UK new project and repair and maintenance requirements. Currently approximately 18% of the national supply of aggregates for the construction industry in the UK is derived from marine sources. There are, however, significant regional differences in the availability of sands and gravels; the south and east of England comprising the main sources of sands and gravels, where up to 30% of the market is supplied from marine aggregates deposits (source: British Marine Aggregate Producers Association, London. 1995).

France, the Netherlands, Canada and Japan as well as the UK, derive a relatively large proportion of their sand and gravel from marine sources. Elsewhere in the world there are undoubtedly large deposits of exploitable aggregate, such as along the East Coast of the USA between Maine and Florida, but as yet these are largely undeveloped.

Marine dredged sand and gravel is likely to continue to provide a significant contribution to the overall demand for aggregates in the UK and elsewhere into the foreseeable future. These sources reduce pressure to exploit resources on land of agricultural or environmental value, but can at the same time conflict with other activities including amenity and recreation, shipping and fisheries exploitation of coastal zone resources.

1.3 Location of Marine Aggregates Deposits

An estimated 70% of the world's continental shelves are covered by dredgeable relict sediments, primarily in depths of less than 50m and where the velocity of currents ranges from 2 to 4 knots (Charlier and Charlier, 1992). Deposits are derived either from the erosion of cliffs, such as off the State of Oregon, USA, or from post-glacial river systems, as is the case off Washington State, USA and off the Isle of Wight, UK.

However, within any one country's coastal zone, the areas of exploitable marine gravels are often restricted geographically, and comprise a small area of exploitable resource remaining from what might have been an extensive alluvial terrace or beach structure.

There seems little realistic likelihood that entirely new alluvial and ancient beach terrace structures will be located since these are already well-documented. It is therefore not surprising to find that the marine aggregates industry is primarily sourced from well-identified geographical areas which have a long history of sands and gravels dredging. It is also clear that where suitable deposits occur, there may be a complex patchwork of aggregate extraction areas close to one another and following the course of ancient river systems or beach structures.

1.4 Overview of the Potential Effect of Marine Aggregates Exploitation

Whilst there are many advantages accruing from marine aggregate extraction, it is well recognised that there are also a number of adverse environmental impacts associated with dredging. A brief overview is provided below.

Physical impacts of dredging arise from substrate removal and alteration of sea bed topography, creation in the water column of a turbidity plume, and sediment redeposition from this and from the screening of dredged material. Dredging, by altering the sea bed and hence tidal currents and inshore wave climates, also has the potential to affect the stability of the coastline.

The biological impacts of dredging operations are largely dependent on the nature of the physical impact and the sensitivity to disturbance of the indigenous benthic community, fish species and other biological resources such as seabirds that are present. This is to a very large extent site specific.

Impacts upon the human environment primarily relate to the interaction with fishing activities and navigation, although there are in some instances other interests in exploited areas, such as sea disposal, recreation and maritime archaeology.

1.5 Existing Policy Framework

1.5.1 Marine aggregate extraction and the requirement for environmental assessment

Most developed coastal states have legislation and established review procedures for dealing with proposed aggregate extraction operations in the marine environment. Generally this is through specific legislation for the extraction of marine minerals, rather than the application of terrestrial legislation in an offshore context.

In much of Europe including the UK, Canada and the USA, the licensing procedures require the preparation of an environmental assessment of the proposed dredging operations. By completing an environmental assessment, the licensing procedure provides the means by which specific terms and conditions to minimise the impact on the environment are applied to dredging operations.

The environmental assessment accompanying an application dredge is normally subjected to review by relevant statutory agencies and public notification and review. In the UK this non-statutory process is known as the 'Government View' procedure. Following a recent review by the Department of the Environment, Transport and Regions (DETR), it was decided that statutory procedures would be introduced to replace the current process. However, until proposals for legislation can be brought forward, new non-statutory procedures were introduced in May 1998 as an interim measure. It is important to point out however that these revised procedures do not make reference to the assessment of cumulative effects.

Overlying this dredging-specific legislation, most countries have separate legislation that necessitates the preparation of environmental assessments of most projects that have the potential to significantly affect the environment, including the consideration of cumulative effects. The earliest legalisation of this kind was probably the National Environmental Policy Act (NEPA), 1969 of the United States. Also in North America, the requirement for cumulative environmental assessment is addressed in the Canadian Environmental Assessment Act (1992). Elsewhere in the world, other countries where cumulative effect assessment has been legislated for comprise New Zealand, under the Resource Management Act (1991), and Australia, which implements through state-based legislation.

Existing regulations governing US domestic marine mining, provide a framework for comprehensive environmental protection during prospecting and scientific research activities and postlease operations (Eg. 30 CFR Parts 280, 281, 282). Requirements exist for site specific and commodity evaluations and lease stipulations that include appropriate mitigation measures. The Minerals Management Service takes a case-by-case approach in conducting environmental analyses, as required by NEPA, CEQ and the Outer Continental Shelf (OCS) Lands Act (Hammer *et al*, 1993).

The Outer Continental Shelf (OCS) Lands Act Amendment (OCSLAA) of 1978, requires the Secretary of the Interior to submit annually to Congress, an assessment of the cumulative effects on the human, marine and coastal environments from the OCS Oil and Natural Gas Resource Management Program (OCS Program). In 1994, the OCSLAA for OCS Sand, Gravel and Shell Resources, sections 8(k) and 20(a), was amended for marine aggregates, authorising the Secretary of the Interior, to negotiate agreements for the use of OCS sand, gravel and shell resources for shore protection, beach, or coastal wetlands restoration projects. The Minerals Management Service anticipated that this could lead to an increase in the requests made to mine OCS sand, gravel and shell resources (Bornholdt and Lear, 1997). The cumulative effects have been identified, monitored and further surveys recommended. However, the cumulative effects of the OCS Program, have not been assessed in terms of threshold levels for each resource, or within the broader environment beyond the case-specific investigations.

In the case of Europe, the key legislation comprises European Union Environmental Impact Assessment Directive 85/337/EEC, which came into effect in July 1988, and was supplemented and amended by a new Directive (97/11/EC) (July 1997). It should be recognised that the extent to which this has been implemented by Member State legalisation varies widely, but more importantly, whilst the Directive makes reference to the assessment of cumulative effects, it provides no terms of reference for their implementation within environmental assessments (Colombo *et al*, 1997). Therefore whilst the UK government works towards the introduction of statutory procedures by March 1999 in the context of the EU Directive, there will in the UK still be no formulated approach to the assessment of cumulative effects for the marine aggregate dredging industry.

1.5.2 Terms of reference for the environmental assessment of marine dredging

Recommended Terms of Reference for assessment of the effects of individual marine aggregates dredging projects on coastal resources have been outlined by Campbell (1993). These have formed an effective framework for environmental effects assessment on a per-project basis in recent years in the UK.

Whilst there is an established set of legislation in Europe and elsewhere requiring the environmental assessment of a wide range of projects, there is however little consensus on a recommended good practice methodology on how this should be achieved with regard to the consideration of cumulative effects.

Partly for this reason, details of what is considered to be an appropriate environmental assessment differ widely across Europe, and the rest of the world. The number and frequency of environmental sampling points, the method of collection of the data and the subsequent interpretation and reporting, all require some conformity if they are to be incorporated into any understanding of the nature of coastal marine resources and their susceptibility to disturbance by man.

Guidelines on what constitutes effective monitoring of the impact of marine aggregates dredging, and proposals on what level of environmental disturbance imposes a significant impact, are also required before environmental assessment information and subsequent monitoring can be incorporated into realistic management objectives for the marine and coastal zone.

1.5.3 Implementation of cumulative effects assessment

Given that marine aggregate extraction tends to concentrate in relatively small areas, there is increasing concern that whilst the impact of individual licensed areas, considered as part of the licensing regime, may be small, there is the possibility of a cumulative effect arising from a number of licence areas. This cumulative effect is at present not recognised nor accounted for in the licensing process.

Furthermore, whilst the broader environmental assessment legalisation, going back several years in the case of many countries, makes provision for the consideration of cumulative effects, there are relatively few instances where this has been practically applied whether on land or in coastal waters (e.g. McCold and Holman, 1995).

Assessment of cumulative effects in the marine environment generally lags behind that for terrestrial cumulative effects assessments (CEA). For example, whilst the Cumulative Effects Working Group (CEWG) has prepared a Practitioners' Guide, outlining some of the requirements of CEA for terrestrial projects (CEWG, 1997),and Ludwig *et al* (1995) have made progress in developing and applying a cumulative impacts assessment protocol; to the authors' knowledge no comprehensive CEA for marine aggregate dredging has been attempted anywhere in the world. This is attributable in part to the absence of a recognised methodology by which such assessment can be undertaken, and also the relative infancy of strategic planning in the marine environment.

It was this absence of a recognised methodology or practical examples for areas affected by marine dredging that led to the development of this project, which will attempt to address some of these deficiencies.

1.6 Objectives of the Strategic Cumulative Effects Study

Marine aggregates are an important resource for many nations. An essential component in the exploitation of this resource is the dredging activity necessary to raise the aggregates from the seabed and transport them to the shore. These activities, and other nearshore human interventions, inevitably give rise to effects which impact on the physical and biological marine environment, which is itself subject to natural change.

The **Principal Objective** of this study is to produce a guidance document which sets out an appropriate and effective strategic framework for the environmental assessment of the potential cumulative effects of marine aggregates dredging in the context of the general exploitation of nearshore seas.

It is recognised that environmental assessment techniques are in a continuous state of change, but some agreed standardisation of the protocol for environmental assessment and subsequent monitoring programmes is essential as a first stage in a comprehensive approach to coastal zone management.

By reviewing the complexity of issues which are involved in the management of coastal zone resources and outlining a framework for the assessment of the cumulative effects of marine aggregates dredging, it is intended that this can then form the basis of a discussion document. This may be helpful to both the marine aggregates industry and those with responsibilities for wider issues of environmental management in the coastal zone, especially where aggregates resources are currently under-exploited compared with those in the UK.

1.7 Definition of cumulative effects

Before discussing how the objectives of this study will be met, it is first necessary to define the term *cumulative effects*. As a result of the legislation referred to previously, a significant body of scientific literature has developed, discussing the theoretical application of cumulative effect studies, within which the precise meaning of this term varies (e.g. Irwin and Rodes, 1991, which provides several definitions).

The level of research being undertaken reflects the evolutionary stage that the assessment of cumulative effects has reached at present. Definitions used differ in the emphasis different studies place on four aspects:

- actions (single, repeated or multiple);
- environmental processes, additive and interactive effects;
- temporal boundaries of the actions and of the effects;
- spatial boundaries of the actions and the effects.

For the purposes of this study, the definition of cumulative effects used is that issued by the US Council on Environmental Quality in 1978 (CEQ, 1997). This definition, although not without its limitations, has the great advantage of encompassing all four of these aspects. It places emphasis on actions within resources, ecosystems and the human environment. Although not repeated in full here, the definition also allows for the distinction between types of effect and temporal and spatial boundaries.
'…the effect on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.'

(Council on Environmental Quality -
Regulations implementing
National Environmental Policy Act,
40 CFR: 1508.7, 1508.8, 1508.25, 1978)

It is important to recognise that there are a number of ways in which a cumulative effect may arise. The most frequently cited comprise:

- *Time crowded perturbations* - repeated occurrence of one type of impact in the same area;
- *Space crowded perturbations* - a concentration of a number of different impacts in the same area;
- *Synergisms* - occurrence of more than one impact whose combined impact is greater than the sum of the individual parts;

- *Indirect impacts* - those caused by produced after or away from the initial perturbation;
- *Nibbling* - a combination of all of the above talking place slowly and incrementally or decrementally.

(National Research Council,
Ecological Knowledge and Environmental Problem Solving:
Concepts and Case Studies. Washington DC, 1986)

1.8 Methodology for the Strategic Cumulative Effects Study

This SCEMAD study has therefore been developed to investigate the pertinent issues relevant to the creation of procedural guidelines for the assessment of cumulative effects. The study has been split into six main task areas, each focusing on a set of clear objectives. These task areas were formulated in the opening months of the study, and comprise the following:

Task 1. Develop an overview and perspectives on the marine aggregates industry.

Task 2. Undertake a world-wide literature review to identify good practice that can be applied to the scientific objectives described above.

Task 3. Identify and develop a good practice methodology for cumulative assessment in the chosen pilot study area.

Task 4. Identify and develop a good practice methodology for monitoring and possible mitigation of cumulative effects.

Task 5. Identification of areas of uncertainty and future research needs.

Task 6. Reporting.

As all coastal areas have their own characteristics, and will thus all be special cases as far as environmental assessment is concerned, it is the intention of the authors to select one pilot study area to test and develop the framework formulated during the initial phase of Task 3. This final document represents the results of that initial phase. Using information from the literature review, it goes as far as detailing the tools and techniques likely to be suitable for CEA and goes some way toward developing a combined project oriented EA/CEA approach. Eventually Task 3 will, as a result of the pilot study, develop more extensively the good practice methodology, subdividing major resources into sections covering: Physical, Biological and Socio-Economic resources (i.e. Human exploitation and Amenity Use of the coastal environment).

Task 3 of the SCEMAD study will eventually conclude by addressing the question of the extent to which the impact of man on coastal zone resources can be adequately understood and predicted, the interaction between natural physical and biological factors, and the influence of man on such interactions. The need for standardisation of research methods, interpretation and recording procedures is likely to emerge from this review.

The Study Team will then develop specific recommendations for an environmental monitoring methodology (Task 4), interpretation and recording which recent experience has shown to be suitable for the marine aggregates dredging industry. These recommendations are intended as a basis for consultation and discussion both within the marine aggregates dredging industry and with those concerned with wider issues of coastal zone management.

1.9 Identification of Cumulative Effects Assessment Good Practice

1.9.1 Task Methodology

A comprehensive search was made of the available literature sources for all documents relevant to methodologies used for the assessment of cumulative environmental effects. A key element in this literature collection process involved searching the following databases for the words 'cumulative effect(s)' and/or 'cumulative impact(s)':

- BIDS (Bath Information and Data Services) Science Citation Index (covers approximately 5,000 science journals);
- BIOSIS (covers 6,000 life sciences journals);
- International Civil Engineering Abstracts (covers approximately 150 civil engineering journals).

In addition, a range of organisations were contacted directly for any relevant handbooks or guidelines, and an extensive internet search was carried out which identified an extremely useful list of references produced by the Canadian Environmental Assessment Agency. This provided a relatively up-to-date (1996) listing of cumulative effects and cumulative effects assessment literature.

All articles deemed to be relevant to this study were obtained and entered onto a database that had been specifically designed for the SCEMAD references. Each database record holds summary information, level of relevance to SCEMAD, geographical coverage, ecosystem type covered, international perspective of the article, and details of any further relevant publications referred to in the article to be followed up.

As a result of this search, from a list of 132 documents of provisional interest, a total of 67 documents covering a wide range of geographical areas were obtained and reviewed, and ranked in order of relevance to this project as summarised in Table 1.1 below:

Table 1.1: Geographical coverage and relevance of review references to SCEMAD

	Extremely relevant	Very relevant	Quite relevant	Slightly relevant	Not relevant	Total
Africa	-	-	-	-	1	**1**
Australia	1	-	-	-	-	**1**
Canada	2	2	-	-	1	**5**
Europe	-	-	-	1	1	**2**
New Zealand	-	-	-	3	-	**3**
UK	-	-	-	2	-	**2**
USA	8	7	14	13	1	**43**
USA/Canada	1	1	1	1	-	**4**
World	1	-	3	2	-	**6**
Total	**13**	**10**	**18**	**22**	**4**	**67**

Clearly, the relatively early implementation of legislation relating to cumulative effects assessment in the USA has made this country the key source of information on the subject. Unfortunately, there is relatively little marine dredging in the USA and there are therefore no known references that specifically relate to the cumulative effects assessment of dredging.

1.9.2 Findings of the literature review

Since the late 1970's, it has been acknowledged that there is a need to consider cumulative effects, beyond the traditional Environmental Assessment (EA) framework.

In 1978, Clark & Zinn, suggested a step-by-step procedure for Cumulative Effects Assessment (CEA), provided by the stages of assessment for permit review. The focus for the process was on identifying the activities and disturbances. Such an approach introduced the concept of the importance of temporal and spatial boundaries beyond the immediate limitations of a site with temporary development activities (Lee & Gosselink, 1988).

By the 1980's, there were several American groups investigating different techniques and developing further methodologies with a view to designing the ultimate approach suitable for application to all developments requiring an Environmental Assessment. In 1985, Vlachos classified the methods into three categories:

- **Retrospective assessment/"linear" approach**; emphasising historical information and development of present database;

- **Prospective assessment/"multipliers" approach**; based on prediction, and forecasting in terms of impacts and scenarios;

- **Policy analysis/"future environments" approach**; concentrating on risk and uncertainty, decision-making, and alternative considerations.

In a review of the EIA requirements for the offshore oil and gas industry, Beanlands and Duinker (1984) recommended that monitoring for cumulative impacts should be undertaken, and that a framework is required to standardise the EIA process.

In 1989, Contant & Wiggins reviewed the NEPA experience of CEA. Programmatic assessments were used to analyse a number of potential development activities and their collective impact on the environment. Despite a number of examples of its use for mining developments and natural gas explorations, this static point of assessment of developments did not prove effective for CEA.

In more recent years, a number of approaches for assessing cumulative effects have been suggested and evaluated. The focus of attention in studies of cumulative effects appears to be split between recording gradual changes and deciding on appropriate thresholds (Beanlands, 1992).

A comprehensive review of CEA in the US under the NEPA guidelines sets out many of the principles behind CEA;

- Cumulative effects are caused by the aggregate of past, present, and reasonably foreseeable future actions.
- Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken.
- Cumulative effects need to be analysed in terms of the specific resource, ecosystem, and human community being affected.
- It is not practical to analyse the cumulative effects of an action on the universe; the list of environmental effects must focus on those that are truly meaningful.
- Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.
- Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.
- Cumulative effects may last for many years beyond the life of the action that caused the effects.
- Each affected resource, ecosystem, and human community must be analysed in terms of its capacity to accommodate additional effects based on its own time and space parameters.

(CEQ, 1997)

Eleven categories of assessment techniques have been identified as useful for different stages of cumulative effect assessment. The techniques suggested by CEQ (1997) are as follows:

- **Questionnaires, and interviews *(Ad hoc* techniques)**; used in preliminary assemblages of social and environmental information in the early stages of scoping cumulative effects assessment;

- **Checklists**; used in initial documentation, to structure analysis and provide a format for the juxtaposition of multiple actions and resources to identify potential cumulative effects ;

- **Matrices**; used for presenting and manipulating quantitative results of modeling, mapping or subjective techniques, and identifying interactions between activities and specific environmental components;

- **Networks**; or system diagrams, used for classifying, organising, and displaying problems, processes, and interactions and to produce a causal analysis of the cumulative effects situation;

- **Cartographic techniques**; such as overlay mapping and Geographic Information Systems(GIS); used for displaying and evaluating the sum of natural succession, development and associated spatial landscape impacts due to multiple projects;

- **Mathematical modelling**; used to estimate and communicate in quantifiable terms long-term (future) and indirect effects in conjunction with other techniques;
- **Trends analysis (Evaluation techniques)**; used to compare effects of development alternatives, within an historical context ;

- **Carrying Capacity Analysis**; used to identify thresholds, potentially limiting factors and monitoring mechanisms, for resources and systems;

- **Ecosystem Analysis**; used to provide a broad regional perspective and holistic thinking;

- **Economic Impact Analysis**; used to model economic effects and determine the significance of the effects under each alternative;

- **Social Impact Analysis**; used to assess environmental stewardship by focusing on key social impact variables such as population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources;

Hunsaker and Williamson (1991 in Irwin and Rodes, 1991) also identified;

- **Adaptive methods**; which make the assumption that no single technique is capable of handling all aspects of impact assessment.

The first three methods are considered more applicable to the initial scoping stages, and the latter methods to the evaluation stages of the CEA process (Hunsaker & Williamson, 1991, *in* Irwin & Rodes, 1991).

Using examples from all over the USA, Williamson (1993) identified the key stages within CEA. The process includes an associated management planning process, following a scoping phase, an analysis phase, an interpretation phase, and a direction phase. A Canadian review of techniques came to similar conclusions; that for CEA it is recommended that several methods are used, depending on the nature of the study, purpose of the analysis, and the relevant data and human resources available (Spaling cited by Munn, 1994). Vestal & Rieser (1995) recommend using a technique that recognises complex ecosystem interactions and processes; choosing a methodology to identify potential environmental impacts, and using the most applicable and recent information to examine each impact to determine which cumulative effects are likely to occur.

Stakhiv (1988) introduced a *mathematical model* of CEA for American wetlands permits. The model determines physical constraints, decision objectives, and interactions between human activities and the environment. The model applies linear programming techniques and algorithms adapted from an approach by Hill (1977, cited by Stakhiv, 1988); linking economic-ecological impacts through input-output analysis. The model was based on the gradual development of a theoretical estuarine bay-wetlands system. Trade-offs between objectives can be examined when individual resource variations are understood within the ecosystem and the whole development. The formulation of the model itself may be seen as the most important action in the analysis.

The study of the interaction between the effects on resources, leads to the development of *networks and pathways* as a method for investigating CEA. Networks depict graphically the relationships and interactions among elements of an activity and components of an ecosystem. It differentiates between individual, additive, and synergistic interactions; and can illustrate what outputs affect which components of the system (Montz & Dixon, 1993).

With the implementation of the Resource Management Act, 1991 in New Zealand, planners in particular were faced with the development of CEA techniques for use in decision making on projects and plans. The methods discussed by Montz & Dixon (1993); layered matrices and combined networks, were chosen on the basis that scientific prediction based on systems modelling are unlikely to be used in every day circumstances.

Most methods for CEA include: some representation of interaction; incorporation of impacts as they occur over space; incorporation of impacts as they occur over time; and ability to trace impacts to second, third and fourth order indirect impacts. In general, CEA methods can be grouped into categories; those that model cause-and-effect relationships through matrices or flow diagrams, those that analyse trends in effects or changes in resources over time, and those that overlay features to identify areas of sensitivity, value, or past losses.

Lee & Gosselink (1988) based their network approach on an extension of research in bottomland hardwood forest in southeastern USA (Preston & Bedford, 1988 cited by Lee & Gosselink, 1988) and extrapolated onto data for US wetlands. Definitions of temporal and spatial scales, are critical to forming a framework for the major steps of CEA.

In New Zealand, a combined networks approach was reviewed by Montz & Dixon (1993) for a coastal area. The central network included biological, physical, and socio-economic components that defined the area. Networks for the different activities such as transport, industrial, recreation, residential, can then be developed and evaluated. Finally, the networks are combined to evaluate the separate and combined effects of activities in the area. However, it is a disadvantage of networks that they do not result in quantitative predictions of impacts (Montz & Dixon 1993).

The advantage of the *layered matrix* is that it allows the inclusion of different order impacts. The method given by Leopold *et al* (1971, cited by Montz & Dixon 1993) was for a proposed mining project. The elements to be included are identified through scoping. This method is suggested for use in New Zealand coastal marine areas, using parameters representing habitat, coastal erosion and deposition processes, fisheries and marine farming, and socio-economic trends. However, layered matrices also do not allow for quantification of the impacts, although this is not considered to be a problem. The scaled measurement of significance and magnitude complements the planning process and local/regional priorities can be incorporated.The layered matrices are similar to the *activity and systems matrix* presented by Sonntag *et al* (1987), cited by Montz & Dixon (1993), but are less complex in structure and in data requirements.

Questionnaire checklists have been used for EA studies for over 20 years (Canter & Kamath, 1995). They have a structured approach for identifying key impacts and environmental factors, facilitating an interdisciplinary approach for CEA planning and operation. Modifications can be made to the checklist in response to the project and site characteristics. However, the major limitations are that interaction and linkages are not identified, and impacts are not quantified. They can be useful however at the scoping stage of EA studies.

Carrying capacity studies have also been discussed. They focus on monitoring activities and impacts over time, although multimedia, interactive or synergistic effects cannot be dealt with (Contant & Wiggins, 1989). The carrying capacity approach is set out by Clark (1994), more as an extension of the EA process to involve cumulative effects, rather than as CEA as a separate process. Furthermore, the boundaries of the temporal and spatial scales are influenced by administrative boundaries, despite the NEPA legislation.

New research is developing more innovative approaches to CEA. A recent technique developed for terrestrial habitats in the US, by Theobald *et al* (1997), is based on the functional relationship between effect on wildlife and distance from development. The study investigates different development densities and patterns which could be extended for the marine environment.

Abbruzzese & Leibowitz (1997) suggest a synoptic approach, implying a broad perspective, rather than a detailed analysis, which may be more appropriate to an assessment of cumulative effects. A series of indices are used to create a framework to compare landscape sub-units. This permits cumulative effects to be included in management decisions.

Despite the advances made into CEA, further research is required to identify appropriate principles for the estuarine, coastal and in particular, marine environment. Transferring methodologies and techniques to the marine context may require overcoming obstacles such as a fragmented institutional structure, a lack of historical data, an absence of future goals for the use of marine resources, and differences in ownership patterns and economic incentives (Vestal & Rieser, 1995).

1.9.3 Conclusions from the literature review

Reviews of the various techniques have determined that in general, methods of CEA are good at describing or defining the individual problem but poor at quantifying cumulative effects. The general requirements for features of a methodology to assess the cumulative effects of marine aggregate dredging should include:

- a practicable methodology with comprehensible results that will aid the decision-making process;
- an adaptable approach to allow for a variety of possible site-resource-impact combinations;
- an ability to feature flexible boundaries in time and space;
- an ability for multiple developments or resource-use practices can be addressed;
- a mechanism for the aggregation of incremental and interactive effects to give an estimate of the overall impact to which environmental resources are being exposed;
- an ability for extensive analysis of the cumulative effects of all relevant developments, while still allowing intensive site and project specific impact analysis (Canter & Kamath 1995).

From the literature under review, there are several methods that seem to have indicated a greater level of suitability for use. The methods that are most applicable will be those that minimise the requirement of new data collection, using previously available data sources. Exploration of the boundaries of the project, both spatially and temporally is required. With reference, therefore, to the reviewed literature, the following methods are considered the most appropriate for further consideration towards a state-of-the-art Good Practice Strategic Cumulative Effects Assessment methodology:

Checklists:

- CANTER,L.W., KAMATH,J. 1995. Questionnaire Checklist for Cumulative Impacts. Environmental Impact Assessment Review, 15:311-339.

Matrices:
- IRWIN,F., RODES,B. 1991. Making Decisions on Cumulative Environmental Impacts. A Conceptual Framework. WWF.

Networks/Pathways:
- LEE, L.C., GOSSELINK, J.G. 1988. Cumulative Impacts on Wetlands linking scientific assessments and regulatory alternatives. Workshop on cumulative effects on landscape systems of wetlands: Scientific status, prospects and regulatory perspectives, Corvallis, Oregon, USA, January 13-15, 1987. Environ Manage, 12(5): 591-602.
- MONTZ, B.E., DIXON, J.E. 1993. From Law to Practice: EIA in New Zealand. Environmental Impact Assessment Review, 13: 89-108.

Ecosystem, Economic and Social Impact Analyses:
- COUNCIL ON ENVIRONMENTAL QUALITY 1997. Considering Cumulative Effects Under the National Environmental Policy Act. Executive Office of the President, council on Environmental Quality.
- VESTAL, B., RIESER, A. 1995. Methodologies and Mechanisms for Management of Cumulative Coastal Environmental Impacts. Part I. Synthesis, with Annotated Bibliography. NOAA Coastal Ocean Program; Decision Analysis Series No. 6.

Synoptic Approach:
- ABBRUZZESE, B., LEIBOWITZ, S.G. 1997. Environmental Auditing: A synoptic approach for assessing cumulative impacts to wetlands. Environmental Management, 21(3): 457-475.
- THEOBALD, D.M., MILLER, J.R., HOBBS, N.T. 1997. Estimating the cumulative effects of development on wildlife. Landscape and Urban Planning, 39 (1): 25-36.

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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Section 2 – A Framework for Implementation

LIST OF FIGURES

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2 A FRAMEWORK FOR IMPLEMENTATION

2.1 Introduction

Following a comprehensive data review, a selection of possible alternative approaches for developing a framework for the assessment of the cumulative effects on the marine and coastal environment have been considered. Having identified suitable alternative approaches, this paper aims to advance those ideas and solutions further, into a cohesive guidance document which sets out an appropriate and effective framework for the assessment of the potential cumulative effects within this environment. The resulting Cumulative Effects Assessment (CEA) methodology will form an integral part of any environmental assessment within the marine and coastal environment that requires an assessment of cumulative effects.

In making a reasoned choice from the documents reviewed, consideration has been given to the varying approaches developed over recent years by several countries, particularly the USA, Canada and Australia. In combining essentially complementary solutions such as these, it is hoped that this framework will represent a ‘good practice’ or ‘state of the art’ response to the problem of the assessment of cumulative effects in the marine and coastal environment, and in particular the marine aggregate dredging industry.

2.2 Aims & Objectives

In the UK a considerable number of environmental assessments (EAs) have been undertaken over recent years for the marine aggregate dredging industry, as a result of a considerable number of extraction licence applications. The UK’s existing policy framework for the marine aggregate dredging industry is already well documented, but it is important to remember that it is fundamentally driven by the requirements of the EU legislative system under Directive 85/337/EEC, amended by 97/11/EC. The Directive makes reference to the assessment of cumulative effects but provides no terms of reference for implementation within EAs. Recent concerns raised in the UK by coastal Local Authorities and other interest groups as to the possible cumulative effects resulting from an increasing number of extraction licences, means that a technique by which such effects can be assessed must be developed.

Whilst the US in particular does provide numerous documented examples of EAs for which not only direct and indirect project specific impacts but cumulative effects are considered (McCold and Holman, 1995), the level of treatment of cumulative effect assessment is apparently highly variable. The reason for such variability is primarily due to the lack of a recognised comprehensive cumulative effects assessment methodology. Furthermore, virtually all documented cases are terrestrial based assessments, for which there usually exists an extensive historic data source.

By its very nature, the marine and coastal environment is a much more dynamic and undocumented resource zone. Establishing comprehensive, consistent and valid data sources for use in environmental assessments is therefore considerably more difficult. As a result, defining suitable temporal and spatial boundaries, baseline levels and resource thresholds becomes problematic.

In an attempt to establish such criteria, a suitable methodology must be investigated. If such a methodology can be refined into a framework for the assessment of cumulative effects in the marine and coastal zone, then this approach can be adopted by the marine aggregate dredging industry.

It is the aim, therefore, of this paper to develop such a possible framework. The paper begins by summarising those techniques suggested as suitable tools for the assessment of cumulative effects and then identifies how such methods could be developed into a procedure for CEAs within marine and coastal environment EAs, whilst reporting tools and techniques are briefly discussed. Finally the way in which such a methodology could be incorporated either directly into the UK legislative system or, on a European level, as further amendments to the EU EA Directive, is considered.

2.3 Techniques

Of the papers reviewed, Irwin and Rodes (1991) summarise particularly well the impact assessment techniques likely to be useful in the assessment of cumulative effects. The paper concludes however that of the methods suggested, no one single method completely satisfied their criteria. Whilst most were good at describing or defining the individual problem, they were poor at actually quantifying cumulative impacts. The paper submits that a *regional risk assessment* approach provides both for the probability of an event happening and quantification of uncertainty in the analysis. This large scale and essentially strategic approach is however beyond the remit of this paper.

Of the techniques reviewed therefore, this paper considers a combination of the best available methods that may provide a possible practical methodology for assessing cumulative effects in the marine and coastal environment. They ideally will be brought together under a seamless framework, which it is suggested will be revisited on an iterative approach following consultation, as per existing EAs. It is likely that the procedural methodology can be visualised in three stages, as per Figure 2.1 over, that is Scoping, Cause/Effect Analysis and Interpretation/Solution/Mitigation, leading to final reporting of cumulative effects within the overall project EA. It is important that the role of the consultee is not underestimated during all stages of the CEA.

Indeed this is the approach suggested in the USA by Williamson (1993), who in identifying the key stages within CEA, considered that the process should include an associated management planning process following a scoping phase, an analysis phase, an interpretation phase, and a direction phase. A Canadian review of techniques came to similar conclusions, in that for CEA it recommended that several methods be used, depending on the nature of the study, purpose of the analysis, and the relevant data and human resources available (Spaling cited by Munn, 1994).

2.3.1 Questionnaires/Checklists/Matrices

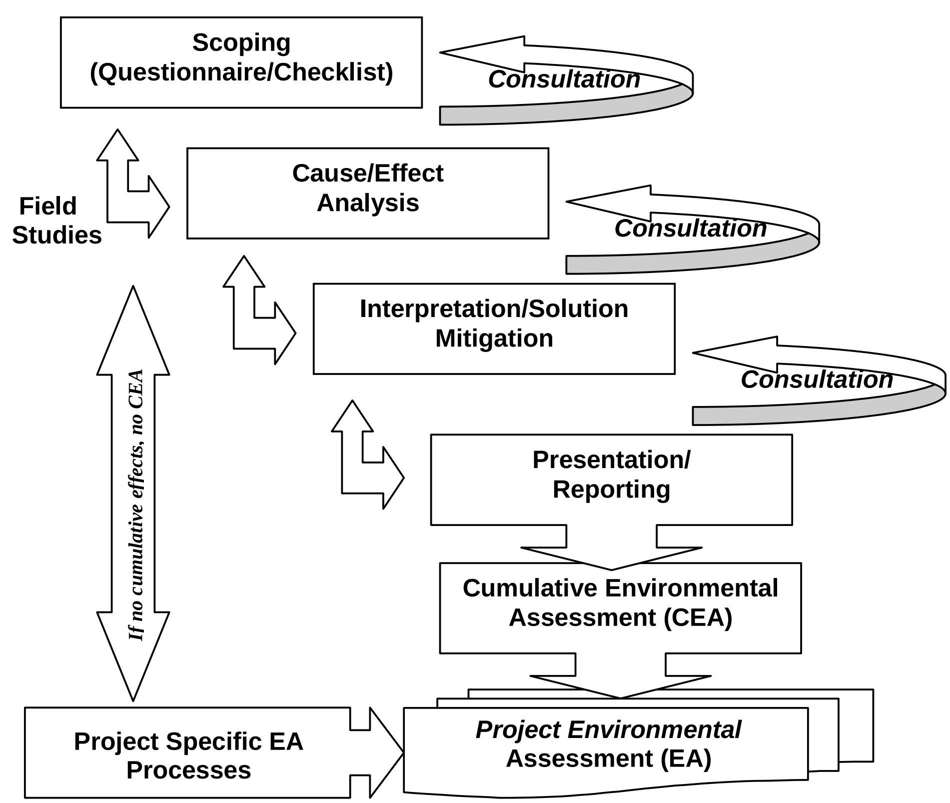
One of the results from McCold and Holman's 1995 study was that conclusions about cumulative effects should be supported by data and analyses. Data sets will have to be as exhaustive as possible and analyses rigorous. It is important therefore that the scoping stage of the EA considers cumulative effects and identifies all relevant data necessary to quantify cumulative effects. From the data review, it would appear that checklists are suitable tools for use during the scoping stage.

At the initial scoping stages, exhaustive checklists should be developed which identify all the biogeochemical and socio-economic resources likely to be affected by the proposal. An iterative approach to scoping will define the temporal or spatial boundaries, (see Section 2.4 below), over which effects from both project specific impacts and cumulative impacts of the project on the particular resource are to be assessed. As a result, the final checklist or matrix can not only be used as a source of information throughout the project, but as a possible presentation tool on completion of the assessment; within a non-technical summary for example. Particularly good examples are given in a recent US paper (Canter and Kamath, 1995).

This checklist approach can also be supplemented by a *layered matrix* methodology (Lee & Gosselink, 1988), (Montz & Dixon, 1993), which, although not giving a quantitative evaluation of effects and impacts, will provide a thorough review at the scoping stage of the areas for cumulative effects investigation.

Once complete, checklists and matrices should be used to identify areas where the level of available data is either of insufficient quantity or quality, such that it would affect the validity of the assessment, and thus define the nature and extent of further study requirements. As long as insufficiencies are identified and further studies commissioned at this stage, the results of the checklist can then progress towards the cause/effect analysis.

Figure 2.1: Suggested Stages of CEA within project EA



2.3.2 Cause/Effect Analysis

On completion of scoping, and identification of further studies that may be required, the next stage is to develop a cause/effect model, in order to assimilate the interactions between the proposal activities and specific environmental (resource) components. One traditional EA method is to use an impact matrix. However it has been shown that such an approach does not provide quantitative results.

Therefore an alternative is to use a network approach or pathway/system diagram. Networks and pathways depict graphically the relationships and interactions among elements of an activity and components of an ecosystem. They differentiate between individual, additive, and synergistic interactions; and can illustrate what outputs affect which components of the system (Montz & Dixon, 1995). Both methodologies should, if undertaken correctly, produce a causal analysis of the cumulative effects situation.

It is suggested that the matrix or network development process will follow a consultative and iterative route, the output of which may be updated at any time by new data. Clearly more advanced simulation modelling can be used to determine cumulative effects and impacts if more sophisticated options are viable or if datasets are extremely large or variable.

2.3.3 Ecosystem, Economic and Social Impact Analyses and Synoptic Approaches

Ecosystem analysis involves considering the full range of ecological resources and their interactions with the environment. Biological indicators are used as integrators of cumulative effects and landscape indices, and as measures of the cumulative degradation of ecosystem functioning. The principles of ecosystem analysis can be applied by extending considerations beyond species, to the ecosystem and investigating landscape-scale processes such as habitat fragmentation (CEQ, 1997). Habitat modification and assessment of exposure to impacts and effects, enable a determination of the level of risk or the probability of a negative impact to be quantified (Vestal & Rieser, 1995).

Economic impact analysis involves establishing the region of influence, modeling the economic effects, and determining the significance of the effects. Economic models are invaluable for analysing cumulative effects and are used to project effects under each alternative. Additional tools can be used with the model effects projections, to provide cost-effective evaluations of the significance of the effect (Huppertz & Bloomquist, 1993 cited in CEQ, 1997).

The use of economic impact models in combination with additional techniques has proven successful in addressing cumulative economic impacts. The most commonly used method in the USA for assessing regional economic effects, is the Economic Impact Forecast System (EIFS), based on three criteria; it has a basis in sound theory; acceptance by the scientific community; availability of data to drive model. The model has been used for analyses associated with Army Base Realignment and Closure (BRAC) (CEQ, 1997).

Considerable progress has been made in CEA relating to key social impact variables. Social impact analysis differs from other CEA as it deals with the subjective perception of effects, and determines the social meaning and significance of the objective changes produced by cumulative actions. The Interorganisational Committee on Guidelines and Principles (1994 cited in CEQ, 1997), identified the basic categories of social impact variables; population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources. It is important to incorporate multiple actions into projections of future social conditions; a number of methods are mentioned in CEQ 'Considering Cumulative Effects', 1997.

The synoptic approach is a framework for making comparisons between landscape subunits, allowing cumulative effects to be considered in management decisions. It is an appropriate method to use when; quantitative information is not available, the cost of improving existing information is high, the cost of a wrong answer is low, there is a high demand for the information, and the situation calls for setting priorities between multiple decisions and optimising for a single decision (Vestal & Rieser, 1995; Abbruzzese & Leibowitz, 1997).

The synoptic approach should be useful for resource managers because an assessment can be completed in 1 or 2 years at relatively low cost. The method can be improved over time and can be customised to specific needs. Abbruzzese & Leibowitz (1997) describe in detail the steps for conducting a synoptic assessment, using the Pearl River Basin in Mississippi and Louisiana as an example. The five steps identified are; define goals and criteria; define synoptic indices; select landscape indicators; conduct assessment; and prepare synoptic reports (Abbruzzese & Leibowitz, 1997). Theobald *et al* (1997) also used a synoptic approach to estimate the cumulative effects of land use change on wildlife habitat, using Summit County, CO, USA as a case study.

2.3.4 Reporting Tools

Cartographic tools, particularly Geographic Information Systems (GIS) are seen as ways of displaying data in layers such that the sum of, and interaction between layers can be determined. Such tools can also be used to develop temporal and spatial boundaries at the scoping stage. Using time series of aerial photographs for example, to determine coastal inundation and to visualise general shoreline processes in order to understand and assimilate likely cumulative effects over space and time.

2.4 Methodology

Having discussed the techniques and tools suggested for the assessment of cumulative effects, it is necessary to detail the methodology for assessing the boundaries and thresholds with which effects in the chosen environment are likely to occur. These guidelines will be applicable to any resource, and so the area of interest to this paper, i.e. the marine and coastal zone.

Using the definition of cumulative effects given in Irwin and Rodes (1991), (after NRC, 1986) the cause/effect analysis will need to consider those effects that are time and space crowded, those that are synergistic, those that are indirect and 'nibbling' effects. This philosophy considers a cumulative effect is either caused by:

- perturbations that are so close in time or space such that effects are not dissipated before the next impact;
- synergisms whereby different perturbations occurring in the same area interact to produce different resource responses;
- indirect effects whereby cumulative effect is produced after or away from initial perturbation, or;
- incremental or decremental effects.

Different definitions exist from both the Canadian perspective (Munn, 1994) and the Australian point of view (EPA, 1994), but all consider it critical to establish appropriate temporal and spatial boundaries, within which to determine time and space perturbations, and to consider likely resource thresholds.

2.4.1 Defining Temporal & Spatial Boundaries

McCold and Saulsbury (1996) suggest that the existing environment cannot be used as a boundary as it makes the past actions upon a particular resource part of the baseline. (As far as US legislation is concerned, the totality of cumulative effects are those from the 'past, present and reasonably foreseeable future'). McCold and Saulsbury therefore suggest that a suitable boundary is that time in the past when the particular environmental resource was most abundant. In other words, the marine and coastal environment will contain a variety of environmental resources upon which effects will be studied, and so it is likely that each resource will have a different temporal range.

The future extent of the temporal range is likely to be determined by project specific studies investigating the longevity of impact upon a resource expected to be impacted (i.e. an assessment of the temporal impact on the benthos from aggregate dredging before re-colonisation occurs).

Spatial boundaries may be more problematic to determine within the marine and coastal environment, as it is by its very nature a variable and dynamic system; containing resources that are mobile over large geographical areas. Irwin and Rodes (1991) state that selection of such boundaries can only be made with knowledge of 'the types and rates of (resource) release, movement, and transformation of materials and energy'. In particular this means 'understanding ecological processes, such as bioaccumulation, that control these rates'. The ecosytem approach uses natural boundaries such as ecological regions, to include ecosystem functioning and landscape-scale factors, for example, habitat fragmentation (CEQ, 1997). Regional and urban analysts prefer to use a functional area concept for defining the socio-economic spatial regions of a study (Fox and Kuman, 1965; cited by CEQ, 1997).

In order to set boundaries for assessing cumulative impacts in rivers and lakes, and estuaries for example, knowledge of the past releases which may have accumulated in the sediments and may be released in the future is required. Similarly knowledge of past and present, and on the basis of mathematical dispersion modelling, future water quality standards will be required.

2.4.2 Defining Resource Thresholds

From the previous section, it is clear that any one resource within an EA is likely to have different temporal and spatial constraints or boundaries. It stands, therefore, that each will have different threshold levels within which an impact will have an effect. In order to make a qualified decision on the likelihood of impact and the expected effects, it is necessary to have an understanding of these thresholds. Indeed it has been recognised that one definition of cumulative effects is 'threshold development' (Irwin and Rodes, 1991), those developments stimulating additional activity such as to pass a particular threshold and provide an overlapping effect.

It is beyond the remit of this paper to detail the threshold levels of all the relevant resources within the marine and coastal zone. Nonetheless to use an ecological analysis example, it is suggested that, in cumulative terms, the ability of certain marine biota to withstand impact may be limited to such an extent so as to impact critical links in the marine food chain. This will then give rise to a cumulative impact which, over both time and space, is considerably greater than the initial impact. Other more tolerant species may be less likely to have a causal effect on the food chain. Clearly the decision making process will again take an iterative route, with consultation from specialists, NGO's, academic organisations etc.

2.5 EA/CEA Development

In order to effectively report cumulative effects with the overall project EA, it will be important to assimilate direct project specific impacts with those cumulative effects and subsequent impacts identified during the CEA procedure. Several of the papers reviewed, (particularly McCold and Holman, 1995), submit that 'for each resource, the discussion of cumulative impacts should follow immediately after the discussion of direct impacts to that resource'. Hence it suggested that the output from the CEA be moulded seamlessly within the overall EA document, and not presented as a final chapter or 'afterthought'. All of the techniques discussed could be the necessary tools for completion of such a project specific CEA. However it has been shown that the concept of CEA is probably large enough both conceptually and financially to prevent many project specific EAs extending their boundaries to consider the effects of cumulative impacts. At present, the major scientific barriers to CEA in the marine environment are gaps in knowledge of the cause/effect relationships, limited historic records and the absence of accepted approaches (Vestal & Rieser, 1995).

So if this is the case, whose responsibility will it be to produce CEAs? Clearly research has shown that the status of CEA as a working tool varies considerably throughout the world. Therefore consistency is required. It has previously been stated that the ideal way forward for CEA is on a strategic level. As part of regional risk assessments, the only way ahead for CEA in the UK maybe on a regional level, within an agency or steering group led strategic scheme. It is suggested that such a nominated body or agency would be responsible for co-ordinating various governmental and commercial bodies recognised as being the best placed in their field to provide advice and resource information. It is envisaged that such organisations would be:

- *Ministry of Agriculture, Fisheries & Food (MAFF):* Fisheries;
- *Department of Trade and Industry (DTI):* Navigation;
- *Ministry of Defence (MoD):* Military, Hydrography;
- *Department of Culture, Media and Sport (DCMS):* Marine Archaeology
- *Crown Estate (CE):* Landowner, Consents;
- *English Nature (EN):* Conservation;
- *Environment Agency (EA):* Flood Prevention, Water & Sediment Quality
- *Local Authorities/Working Groups:* Coast Protection, Coastal Processes;
- *Academic/Specialist Consultants:* Specialist oceanographic, marine biological, fisheries, coastal process, archaeological and industry related expertise.

It is important that such a body progresses procedural guidelines, (ideally developed from industry led initiatives), to create a framework for the creation of a coherent and technically consistent central or regional resource dataset. It is only with such data that valid assumptions and decisions can be made as to the assessment of cumulative effects. Indeed this is the approach suggested by many of the papers reviewed, including McCold and Saulsbury (1996), who suggest that 'such an agency developed program addressing the actions contributing to cumulative impacts, can be used as a source of information from which project specific CEAs can be tiered'.

The following would therefore seem to define the ultimate aim of such a project; …to create a well documented and technically consistent central dataset of marine environmental information, which can be developed and managed by specialists in a layered approach such that multi-impacts can be assimilated. The dataset will need to have the functionality to be continually updated as new resource data becomes available. Above all else it will need to be readily and freely accessible, on a tiered down approach, to those whose task it is to address the assessment of cumulative effects. Only then will project specific CEAs be able to make valid cumulative effect decisions.

2.6 Legislative Framework

It is obviously in the interest of those working in the marine and coastal environment, and particular those in the marine aggregate dredging industry, to develop an industry led framework for the implementation of CEAs. If this is not the case, overly prescriptive legislative procedures may make assessment of cumulative effects more onerous than necessary and objectives impossible to meet.

It is clear nonetheless, that any legislative requirement in the UK is to be driven by the EU, under EC Directive 85/337/EEC, amended by 97/11/EC for existing Environmental Impact Assessments. Implementation by Member States is obviously at the discretion of the country in question. As detailed previously (*see* Chapter I – Introduction), in July 1998, DETR issued draft Regulations for consultation, which will implement in the UK the requirements of the amended EC Environmental Impact Assessment Directive. This consultation exercise related only to amendments to the Town and Country Planning system in England and Wales. Implementation would be under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988 (Statutory Instrument (SI) No 1199).

DETR and The Scottish Office have subsequently issued draft Regulations for consultation, which will introduce the proposed statutory procedures by 14th March 1999. These Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations bring together the requirements of the EC Environmental Impact Assessment Directive and EC Directive 92/43/EEC (the conservation of natural habitats and of wild fauna and flora). Commonly known as The Habitats Directive, the introduction of these Regulations, will mean that the importance of marine habitats and the protection of sensitive areas from impact from marine dredging, as is required by the EC Environmental Impact Assessment Directive, will be recognised.

Whilst the practical approach to the application for marine aggregates extraction will not be fundamentally changed, in that EAs are already routinely undertaken, introduction of a statutory regime does mean that applications will be more carefully considered (through a scoping exercise), regulated and licensed. The potential route to public inquiry or informal hearing provided by the interim procedures will continue under the statutory procedures, as with public inquiry for any other terrestrial planning application. Nonetheless a clear methodology for the assessment of cumulative effects remains absent.

However, the Regulations do recognise the significance of fully investigating the potential for trans-boundary impact, where relevant. If a proposal is likely to have a 'significant effect upon the environment' of another Member State it will be necessary to fully consider, inform, consult, advertise and notify that Member State during the EA process. This exercise will be critical in resolving both the individual and cumulative effects of projects impacting neighbouring EU countries.

Nonetheless, whilst the need for CEA within the EA process is indicated within the EC Directive, and whilst the marine aggregate dredging industry recognises the need for CEA, it is likely that further amendment to the Regulations will be required in order to reflect the requirements of CEA procedures. This will however only be likely once a proven framework for the assessment of cumulative effects is developed.

2.7 Conclusions

In summary, this document has, on the basis of current research, discussed the main framework requirements for cumulative effects assessment, has detailed the techniques used for such assessments, has reviewed current thinking on CEA world-wide and has suggested possible approaches in the UK for implementation of CEA.

Whilst this paper has suggested some of the tools necessary in the CEA process, it concludes that implementation of CEA procedures will always by its very nature be complex. In the marine and coastal environment, defining temporal and spatial study boundaries and resource thresholds will always be problematic due to the environmental dynamics of the zone.

It will without doubt therefore be up to those working within the marine and coastal field to develop, through detailed consultation, a practical working procedural framework. Such a procedure is likely to develop in a 'tier down' approach, and so the paper has suggested some of the features of a centralised resource dataset, from which project specific CEAs could be tiered. However, for such a scenario to exist, it is clearly in the interests of those working in the areas where assessment of cumulative effects is likely to become a major issue, to develop industry-led initiatives which will act as enablers for the approach suggested.

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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Section 3 – Good Practice Methodology

LIST OF FIGURES

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3 GOOD PRACTICE METHODOLOGY

3.1 Introduction

The exploitation of marine aggregate resources from coastal waters off the south and east of England has increased in recent years. This trend is set to continue partly due to environmental constraints on extraction transportation from land based sources and the high quality of marine aggregates and their use in structural concrete. The marine aggregate dredging in the Isle of Wight area alone accounts for a seaward area occupying as much as 310 km^2 of seabed over 10 licence areas, with a further 12 production licences pending. Similarly, off the east-coast of the UK there are 15 licence areas occupying a total of 350 km^2 offshore Lowestoft.

Under earlier licensing procedures not all licence applications benefited from the production of an environmental impact assessment within an Environmental Assessment (EA) process. There was no overall assessment of effects of dredging on the benthic community or commercial fisheries. Marine aggregate licences awarded post 1992 have included an EA taking account of the possible impact on coastal processors, effect of dredging on benthic communities and disturbance of commercial fisheries. Prospecting licences issued by the Crown Estate also do not require an environmental assessment. This has resulted historically in areas such as those to the east of the Isle of Wight being made up of a mosaic comprising old existing marine aggregate licences (with no EA undertaken), new licences awarded requiring EAs and prospecting licences.

The EU, within the EC Environmental Impact Assessment Directive (85/337/EEC), as supplemented and amended in 1997 by EC Directive 97/11/EC recognise the need to assess the cumulative effects of a proposed development. However the lack of clear methodology has resulted in the patchwork of marine aggregates dredging activity on the seabed in the UK being inadequately reviewed by the regulator: the Department of the Environment, Transport and the Regions (DETR); the scientific advisor: the Ministry of Agriculture, Fisheries and Food (MAFF), or the licensee and owner of the seabed: the Crown Estate. For under the current procedures, (and it is likely, under the forthcoming statutory procedures), no EAs produced will have adequately addressed the strategic or cumulative effects of the marine aggregates industries impact upon:

- benthic communities, fisheries and other marine biological resources;
- human activities, such as commercial fisheries, navigation, recreation and marine archaeology.

The aspect of cumulative effect on coastal processors has been addressed to some degree in the modelling and reports prepared by HR Wallingford, and further work is expected. Additionally, there are 3 major studies either running or complete:

- The South Coast Seabed Mobility Study (HR EX2795) - east of Isle of Wight (complete);
- The Seabed Sediment Mobility Study (CIRIA RP549) - west of Isle of Wight (in press);
- The Southern North Sea Sediment Transport Study.

Data collected during these studies and conclusions reached on seabed sediment mobility will contribute to the development of models. Although this latter research is well advanced the results will not be available for wider use until mid 1999.

There is an urgent need to address the way in which cumulative effects of marine aggregate dredging are assessed, the methodology used, together with tools and techniques and the need for a framework for wider consultation with Government Department Agencies, the Fisheries Industry and amenity groups.

The legal requirement to produce EAs to accompany applications, the guidance issued as part of the EC Directive on EAs and the UK interpretation of these Directives do not give clear advice to those preparing EAs taking account of cumulative effects. It is the need to address a coherent methodology for assessing, reporting and consulting on cumulative effects that has given rise to the development of this overall research project.

The necessity to define the term cumulative effects has been addressed in Task 2 (Literature Review – Chapter 1) and focuses on the differing emphasis placed by the theoretical application of cumulative effects studies. These focus on:

- Actions (single, repeated or multiple);
- Environmental processes, additive and interactive effects;
- Temporal boundaries of the actions and of the effects;
- Spatial boundaries of the actions and the effects.

After extensive review of scientific literature for the purpose of this study the definition of cumulative effects adopted is that issued by the US Council on Environmental Quality in 1978 (CEQ, 1997). This definition, although not without its limitations, has the great advantage of encompassing all four of these aspects. It places emphasis on actions within resources, ecosystems and the human environment. Although not repeated in full here, the definition also allows for the distinction between types of effect and temporal and spatial boundaries.

'…the effect on the environment which results from the incremental impact of the action when added to other past, present and reasonably foreseeable actions regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor but collectively significant actions taking place over a period of time.'
(Council on Environmental Quality – Regulations implementing National Environmental Policy Act, 40 CFR: 1508.7, 1508.8, 1508.25, 1978).

3.2 Objectives

The UK's legislative requirement for the production of environmental assessments is driven by the EU legislation under EC Directive 85/337/EEC, amended by 97/11/EC. This Directive makes reference to the *assessment of cumulative effects* but provides no Terms of Reference for implementation within EAs. The aim of this chapter is to provide a review of the EU and UK legal requirements for the production of environmental assessments including addressing the assessment of cumulative effects.

This chapter will also determine the good practices identified in the literature review of cumulative effects assessments in the terrestrial, aquatic and marine environment

(Chapter 1). This review of good practices and appropriate methodologies will be considered in light of the need to prepare assessments of cumulative effects in the marine environment relevant to marine aggregate extraction.

The tools and techniques identified for the assessment of cumulative effects within Chapter 2 sets out approaches within a suitable framework for implementation. It is against a background of both this international literature review and the identification of suitable frameworks and methods for assessing cumulative effects that this chapter addresses a review of appropriate approaches and methods. Such a Cumulative Effects Assessment (CEA) approach will be of use within the preparation of an EA and will ensure that the assessment of cumulative effects for marine aggregate dredging is included within the overall EA.

This chapter will also address a review of possible tools and techniques available to those preparing the assessment of cumulative effects, together with presentation graphics. This review will provide those responsible for preparing the assessment of cumulative effects with a range of techniques for defining suitable temporal and spatial boundaries, baseline levels, benchmarks and resource thresholds. There are many instances from international literature where assessment techniques have been successfully applied in the terrestrial environment , but there are very few examples, if any, in the marine sector. This chapter is one of the first attempts internationally to provide guidance to practitioners on the range of tools and techniques available for the assessment of cumulative effects within the marine environment, with examples provided from "*real life*" examples of EAs undertaken within the identified pilot study area.

3.3 Literature Review

A comprehensive search was made of available scientific literature sources to identify publications addressing cumulative effects or assessments of cumulative effects or impacts. Some 132 documents were identified to be of provisional interest and upon review, a total of 67 papers covering a wide geographical distribution were obtained and reviewed. This scientific literature review provided an understanding of the historical development of the assessment of cumulative effects world wide arising in the late 1970s with the establishment of the concept of importance of temporal and spatial boundaries beyond the limitations of the existing site under scrutiny (Lee & Gosselink, 1988).

Following further developments in the EIA requirements for offshore oil and gas projects, Beanlands and Duinkers (1984) recommended that monitoring of marine parameters should be undertaken to establish cumulative impacts and that a framework was necessary to standardise the preparation of EIAs to incorporate CEA. Beanlands (1992) has focused attention on studies of cumulative effects that have recorded gradual change or have set appropriate thresholds as the appropriate approach for assessing cumulative effects.

A key conclusion reached from the scientific literature review is that various techniques and methods for CEA are good at describing or defining individual problems but poor overall at quantifying cumulative effects. The general features of a methodology to assess the cumulative effects of marine aggregate dredging should therefore include:

- A practical methodology with comprehensible results capable of wide understanding;
- An adaptable approach to allow for a variety of possible site, resource and impact possibilities;
- The ability to reflect temporal and spatial boundaries;
- The ability to reflect multiple developments; and
- The ability for extensive analysis of cumulative effects for all relevant developments, whilst still allowing for a full review of the actual site and project specific impact assessment.

The literature review identified key methods considered worthy of further in depth consideration for recommendation as tools and techniques as part of the methodology for the assessment of cumulative effects. These included checklists, matrices, networks and pathways, ecosystems, economic and social impact analysis and the synoptic approach. These approaches will be carried forward into the framework for implementation and considered in some detail within the text of this chapter.

3.4 A Framework for Implementation

Consideration has been given to the possible alternative approaches highlighted as a result of the scientific literature review. The resulting CEA methodology should form an integral part of an overall EA within the coastal marine environment requiring an assessment of cumulative effects. The framework developed represents good practice or state of the art responses to the problems of cumulative effects covering recent developments in the USA, Canada and Australia. Tools and techniques highlighted by the range of scientific literature have been reviewed and include the *questionnaire, checklist and matrix approach*.

McCold and Holman's 1995 study concluded that CEA should be supported by *data and analysis*. These data sets will need to be as exhaustive as possible and their analysis rigorous. It is at the scoping stage of the EA that consideration should be given to cumulative effects and the identification of all relevant data necessary for their quantification. Exhaustive checklists should be developed which identify all marine resource and socio-economic issues likely to be affected by the project proposal. Ensuring that comprehensive data is collected will result in the final checklist or matrix providing a twin purpose. Firstly, as a source of information throughout the project and secondarily, as a possible presentation tool of the impacts arising. Other approaches analysed include the cause and effect analysis.

Considerable attention has been paid to the definition of *temporal and spatial boundaries* as McCold and Saulsbury (1996) suggest that the existing environment cannot be used as a boundary as it makes the past actions upon the particular resource part of the baseline. The most appropriate approach they find is a time in the past when the particular environmental resource was most abundant. It is likely in the marine environment that each resource will have a different temporal range.

Spatial boundaries are more problematic. Irwin and Rodes (1991) indicate that such boundaries can only be made with knowledge of 'the types and rates of (resource) release, movement and transformation of materials and energy'. This principally means understanding the ecological processes that control these rates. Defining resource thresholds will be an essential part of the iterative process.

One definition of cumulative effects is 'threshold development' (Irwin and Rodes, 1991). Not only will developing temporal and spatial boundaries be essential within CEA, but determination of the *resource threshold* to impact will therefore be required.

Ecosystem, economic and social impact analyses and synoptic approaches have also been identified as effective tools. Ecosystem analysis involves considering the full range of ecological resources and their interactions with the environment. Biological indicators are used as integrators of cumulative effects and landscape indices, and as measures of the cumulative degradation of ecosystem functioning. The principles of ecosystem analysis can be applied by extending considerations beyond species, to the ecosystem and investigating landscape-scale processes such as habitat fragmentation (CEQ, 1997). Habitat modification and assessment of exposure to impacts and effects, enable a determination of the level of risk or the probability of a negative impact to be quantified and conclusion drawn with regard to cumulative impact.

Fundamentally, effective reporting of cumulative effects within the overall EA should assimilate direct project specific impacts with those cumulative effects and subsequent impacts identified during the CEA procedure. It is considered essential by most scientific papers reviewed that with a review of each resource, a discussion of cumulative impacts should follow immediately after the discussion of direct impacts to that resource. In other words, at the conclusion of each chapter addressing resource based topics such as marine benthos or marine fisheries, the analysis of the cumulative effects of the project on that resource should be reviewed.

3.5 Good Practice Methodology

3.5.1 Preparation of the Environmental Assessment

The authors have prepared a large number of EAs over the last 20 years in the terrestrial, aquatic, coastal zone and marine environment. This work has been undertaken not only for the marine aggregate dredging industry, but the onshore and offshore oil and gas industry, for flood defence authorities and for water utilities promoting the development of new water resources. This extensive experience has provided the background to the recognition of the need for a comprehensive methodology for assessing cumulative effects focusing on the marine environment.

Throughout this period of time, the authors have striven to be at the forefront of the development of methodologies, often employing new tools and techniques, including the introduction of GIS Mapping and the production of the *first Scoping Document* issued for consultations in the UK in January 1991. These developments illustrate the need to move forward as part of an overall iterative approach in the development of both the methodology and the application of tools and techniques for EAs including the assessment of cumulative effects.

Whilst the legislative and regulatory regime within which marine aggregates dredging applications are licensed have been detailed previously (*see* Chapter I –Introduction), it is the purpose of the following sections to outline the staged approach to an EA and the suggested route for adoption of CEA.

3.5.2 Project Brief

Criticism is often levelled at projects that focus on a very limited range of topics within their EA, having dismissed or excluded a wider range of information, possibly as a result of a limited project brief. This artificial limitation is often either the result of the wish to reduce the overall project cost, through lack of or limited knowledge of the need to provide a comprehensive EA for the consenting authority, or a wish on the part of the client to limit discussions to those topics considered to be the most controversial. It is often the assessment of cumulative effects which provides the wider understanding of the possible range of impacts arising from proposed developments. It is therefore essential that a comprehensive project brief is developed in the first instance and, where necessary, consultants revisit the project brief with the client, highlighting the legal requirements to prepare an EA, its scope and content.

3.5.3 Scoping Exercise

The scoping of an EA is the vital component of the whole assessment process and will have a significant impact on how well a final Environmental Statement (ES) is ultimately received by consultees and the wider public. The purpose of the development of the scoping document is to identify those issues to be discussed within the EA and by what methodology they will be explored and analysed.

The importance of the scoping exercise has been recognised by the UK Government in the recently issued draft Regulations for consultation from DETR and The Scottish Office, in preparation for the introduction of statutory procedures by 14th March 1999 (DETR, 1998b; Scottish Office, 1998). Whilst the practical approach to the scoping for an application for marine aggregates extraction will not be fundamentally changed (indeed much in line with those adopted by the author in 1991) a formal opinion by the Secretary of State will be given if requested by the applicant. Furthermore, it is recognised that even though the Directive provides a compulsory requirement to offer such a position, the Government is itself not introducing a compulsory system because it recognises that the present system 'works very well in practice and should continue to do so'.

Importantly, the Regulations recognise the significance of fully investigating the potential for trans-boundary impact, where relevant. If a proposal is likely to have a 'significant effect upon the environment' of another Member State it will be necessary to fully consider, inform, consult, advertise and notify that Member State during the EA process. This exercise will be critical in resolving both the individual and cumulative effects of projects impacting neighbouring EU countries and will form an essential part of any scoping exercise for such proposals.

The main body of the scoping report of interest to the majority of consultees will be the overview of the existing environment including discussions of physical aspects, biological aspects (including wildlife resources and invertebrate fauna) and human aspects, including commercial fisheries and shell fisheries, wrecks and marine archaeology, shipping and navigation, waste disposal and other uses. A review of the Government View procedure under which licences for marine aggregate dredging are awarded should be included, along with a review of the EU and UK legislative regime that requires the production of the EA.

The scope of the environmental assessment, including the legal framework for the EA and the key issues to be considered are thus contained within:

- Project Details (including the project proposal, its area, tonnages to be extracted over time, alternatives and the present and future usage of the material);
- The Physical Environment;
- The Biological Environment;
- The Human Environment;
- Policy Framework;
- Mitigation; and
- Monitoring Measures.

Each of the sections of key issues to be considered by the EA will identify information sources and in some circumstances the lack of data available or the need to commission new surveys.

The extension of the EA methodology to adequately address the assessment of cumulative effects resulting from the proposed project will also be set out within the scoping document. The statement that cumulative effects of the overall project will be addressed together with the approach, methodology and a range of tools and techniques for CEA will highlight to consultees the range of possible issues and the need for specific data sets to address these issues. Equally important will be the need to highlight any potential contentious aspects that will not be covered within the EA.

3.5.4 Scoping Consultations

The development of the *Scoping Document* as a stand alone first stage in the public consultation process will have involved a review of the project proposal and the need for a wide range of data. The identification of consultees (both statutory and interested groups) is an important part of this process. The regulatory authority (DETR) will assist providing an initial list of Government departments and agencies and interested groups to be consulted within the broad list indicated in the previous section. Past experience of a geographical area has however shown that wider consultation than this initial list is more beneficial in the first instance.

The scoping consultation exercise should be run under broadly the same principles for EA consultation, and as defined by the DETR in both the present non-statutory procedures and the forthcoming statutory procedures. A letter of introduction addressed to named individuals within each of the organisations sets out the purpose and intent of the scoping document. Also highlighted is the time period in which the consultee should respond in writing their concerns, comments or raise issues.

The document will be circulated to a list of consultees agreed with the statutory authority. Consultees will be made aware of those areas where new survey work will be required to be commissioned and those areas where there will be a reliance on existing data sources. It is intended, by providing consultees with this level of information at an early stage, that they will be made to feel partners in the assessment process and contribute with information on the availability of data sources. Some of this data maybe in areas of grey literature or semi-confidential (yet unpublished) Government or commercial data.

Within the UK all 'identified interested parties' which are already, or will soon become statutory consultees under the procedures previously detailed (*see* Chapter I – Introduction), include:

- *DETR (and the Scottish Office Development Department (SODD) and the Welsh Office (WO), as appropriate):* Regulator;
- *Ministry of Agriculture, Fisheries & Food (MAFF):* Fisheries;
- *Department of Trade and Industry (DTI):* Navigation;
- *Ministry of Defence (MoD):* Military, Hydrography;
- *Department of Culture, Media and Sport (DCMS) and/or English Heritage:* Marine Archaeology;
- *Crown Estate (CE):* Landowner, Consents;
- *English Nature (EN):* Conservation;
- *Environment Agency (EA):* Flood Prevention, Water & Sediment Quality;
- *Local Authorities/Working Groups:* Coast Protection, Coastal Processes;
- *Academic/Specialist Consultants:* Specialist oceanographic, marine biological, fisheries, coastal process, archaeological and industry related expertise.

All should be circulated with the specifically designed scoping document as part of a consultation programme. Written responses received from the above consultees usually identify issues which they have a duty to regulate, areas of concern or overlap with other Government departments or agencies and often draw attention to possible new data sources. Responses received from consultees are most effectively used if entered onto a database that highlights categories of responses. A review should be undertaken of all responses received and a follow up contact by telephone or by letter to those organisations yet to respond to ensure that each organisation has had the opportunity to respond.

This scoping exercise is worthy of both the effort and expense as it sets in motion at an early project stage, contact with the regulatory authorities and consultees. Thus they are alerted to the ongoing data collection for the production of an EA to accompany a major application for a marine aggregate licence. Establishing early lines of communication with identified individuals within Government departments and agencies and other commercial bodies in this manner has a three- fold benefit:

- Establishes personal relationships;
- Provides opportunities for the early identification of areas of concern related to the application;
- Assists consultees feel partners in the EA process.

If, after the scoping exercise is complete, it is apparent that further data collection, including the commissioning of major benthic surveys, for example, are required, the Terms of Reference for these surveys should be forwarded to the relevant regulatory body to ensure that they are in agreement with its provisions. This will ensure that data collected is considered viable and will be taken into account during the EA/CEA process.

3.5.5 Data Collection

Through the scoping exercise, data sources for all topic areas will have been identified and where gaps in data exist, decisions have been reached to either commission new survey work which will result in site specific data or leave gaps in the data base. A comprehensive data collection programme should be organised, based upon the time-scale of the project, for the collection of data from identified sources. In some circumstances, data will require to be purchased from Government agencies. Advanced notice in writing should be given to these organisations so that they can compile site specific information from their comprehensive records. It will be important to highlight the format in which information should be presented, i.e. either in digital form or paper copies, to assist with data inputting and storage and inclusion within GIS Mapping.

Once the Terms of Reference of new surveys have been widely agreed with the appropriate regulatory consultees and the survey project commissioned these data gaps will have been addressed. The analysis of survey results and their reporting will be vital to fill data gaps and will provide important stand-alone survey reports. These reports can be circulated to a specific consultee with interest in a certain subject area (i.e. benthic ecology or marine fisheries), or an individual Government department which has a specific remit and interest in reviewing the initial scientific survey report, rather than a summary of the findings incorporated into the overall EA.

This approach is an important digression from the overall EA methodology, which from its outset intends to assimilate a large range of data to provide a comprehensive assessment of the project. It is the authors' experience, however, that Government Departments such as MAFF and particularly their fisheries scientists wish to have access to the original scientific report and the results of the benthic survey, prior to receiving the full EA document for their comment. The results of such surveys can of course therefore be of wider interest within the scientific community. In particular such data may establish, or expand upon, the scientific background data within a licence area, particularly where no site specific data is available.

As long as data sets and survey results are interpreted correctly they will be critical to the completion of a scientifically sound EA. Complex scientific information will have to be presented in a readily consumable format. (Examples of data presentation regularly used by the authors are included within Section 3.6, in order to visualise the data required for the example pilot study area). Data is much more usefully presented in a visual format. Large quantities of tabulated scientific information covering a diverse range of topics does not assist Government consultees or interest groups in the assessment of the overall project and its possible impacts, and certainly does not contribute to an assessment of cumulative effects.

The consideration given to specific data required for the assessment of cumulative effects during the scoping exercise will identify the need for historic data or a wider understanding of previous uses and practices carried out in the wider adjoining area. Local authorities and responsible Government departments often hold extensive historical information on past project files, which although in the area of *grey literature* should be made available for use and for referencing. Thus:

A comprehensive and integrated programme of data collection/assimilation within those areas where marine aggregates dredging takes place will be crucial to the overall success of CEA.

3.5.6 Preparation of Environmental Assessments

The preparation of the EA has begun with the development and issue of a scoping document as part of the initial consultation phase. This scoping exercise has identified the scope and content of the overall EA, together with the advice that the assessment of cumulative effects will be made. This has enabled consultees to reflect on issues and concerns they may have regarding the availability of data, the need for further studies or surveys and identifying data in areas of grey literature. The data collection will have been co-ordinated to ensure that all the data sources identified during the scoping exercise are systematically approached and data filed and its presentation considered.

It is not the purpose to define, in detail, the areas to be covered within the EA, as the process is well known and sufficiently documented. However, such areas will be indicated by real data from the pilot study area, in Section 3.6, contained within the subject areas indicated in Table 3.1 over. This detailed project contents list will provide a complete list of topics and issues to be considered within the preparation of a marine aggregate dredging EA, within which is contained an assessment of cumulative effects. Importantly, it indicates that following the assessment of individual effects for each of the physical, biological and human (socio-economic) environments the assessment of cumulative effects should be undertaken. On completion, mitigation and monitoring can therefore subsequently be considered not only in an individually, but within a cumulative framework.

Table 3.1: Structure of the Environmental Statement

A	*Non Technical Summary*	*1*	*Introduction*
(i)	Introduction	(i)	Background
(ii)	Existing Environment	(ii)	Environmental Assessment
(iii)	Impact Assessment	(iii)	Licensing of Marine Aggregates
(iv)	Mitigation Measures & Monitoring		
2	*Project Details*	*3.1*	*The Site and its Environment-Physical*
(i)	Location and Size of the Licence Area	(i)	Sea Bed Topography of the Area
(ii)	Quantity of Material to be Extracted	(ii)	Geological Aspects
(iii)	Type of Material to be Extracted	(iii)	Sea Bed Surface Characteristics
(iv)	Method of Dredging	(iv)	Aggregate Reserve Characteristics
(v)	Control of Dredging	(v)	Local Hydrography
(vi)	Discharging of Plumes	(vi)	Sea Bed Stability
(vii)	Onshore Proposals	*(vii)*	Surface Sediment and Water Quality
3.2	*The Site and its Environment-Biological*	*3.3*	*The Site and its Environment-Human*
(i)	Benthic Community Composition	(i)	Fisheries and Shellfisheries
(ii)	Fish and Shellfish Resource	(ii)	Other Dredging Activity
(iii)	Seabirds	(iii)	Disposal at Sea
(iv)	Marine Mammals & Large Sharks	(iv)	Offshore Oil and Gas
		(v)	Wrecks and Archaeology
		(vi)	Shipping and Navigation
		(vii)	Ministry of Defence Exclusion Zones
		(viii)	Leisure Activities
		(ix)	Sub-Sea Cables
3.4	*Policy Framework*	*3.5*	*Alternative Sources of Material*
(i)	Statutory Designations	(i)	National Level
(ii)	Relevant EC Directives	(ii)	Regional Level
(iii)	UK Govt Policy on Marine Aggregates	(iii)	Company Level
(iv)	County Minerals Policies		
4.1	*Assessment of Effects-Physical*	*4.2*	*Assessment of Effects-Biological*
(i)	Direct Effect of Dredging on the Seabed	(i)	Effect on the Benthos
(ii)	Effect on Sediment Movements	(ii)	Effect on Finfish and Shellfish
(iii)	Effect on Coastal Defences	(iii)	Effect on Seabirds
(iv)	Effect on Water Quality	(iv)	Effect on Sea Mammals & Large Sharks
(v)	**Cumulative Effect of Dredging**	**(v)**	**Cumulative Effect of Dredging**
4.3	*Assessment of Effects-Human*		
(i)	Effects on Commercial Fisheries		
(ii)	Effects on Other Dredging Activities		
(iii)	Effects on Waste Disposal		
(iv)	Effects on Oil and Gas Installations and Associated Offshore Activities		
(v)	Effects on Wrecks and Archaeology		
(vi)	Effects on Shipping and Navigation		
(vii)	Effects on MoD Operations		
(viii)	Effects on Leisure Activities		
(ix)	Effects on Sub-Sea Cables		
(x)	Effects on Policy Framework		
(xi)	**Cumulative Effect of Dredging**		
5	*Mitigation Measures*	*6*	*Monitoring Measures*
(i)	Physical Aspects	(i)	Physical Aspects
(ii)	Benthos and Fisheries Resources	(ii)	Benthos and Fisheries Resources
(iii)	Commercial Fisheries	(iii)	Commercial Fisheries
(iv)	Wrecks and Archaeology	(iv)	Wrecks and Archaeology
(v)	Shipping and Navigation	(v)	Shipping and Navigation
(vi)	**Cumulative Effect of Dredging**	**(vi)**	**Cumulative Effect of Dredging**
7	*Glossary*	*8*	*References & Bibliography*

3.5.7 Tools and Techniques for Assessing Cumulative Effects

Whilst the tools and techniques identified for the assessment of cumulative effects have already been identified within Chapter 2, it is important to briefly review them in the context of the following pilot study area data.

3.5.7.1 Questionnaires/Checklists/Matrices

Fundamentally, conclusions about cumulative effects need to be supported by data and analyses. If the scoping stage of the EA considers cumulative effects and identifies all relevant data necessary to quantify cumulative effects, subsequent data sets should become as exhaustive as possible and undergo rigorous analyses. At the scoping stage therefore, checklists should identify all the biogeochemical and socio-economic resources likely to be affected by the proposal. An iterative approach to scoping may also help to define the temporal or spatial boundaries, over which effects from both project specific impacts and cumulative impacts of the project on the particular resource are to be assessed. As a result, the final checklist or matrix can not only be used as a source of information throughout the project, but as a possible presentation tool on completion of the assessment; within a non-technical summary for example.

Once complete, checklists and matrices should be used to identify areas where the level of available data is either of insufficient quantity or quality, such that it would affect the validity of the assessment, and thus define the nature and extent of further study requirements. As long as insufficiencies are identified and further studies commissioned at this stage, the results of the checklist can then progress towards the cause/effect analysis.

3.5.7.2 Cause/Effect Analysis

On completion of scoping, and identification of further studies that may be required, the next stage is to develop a cause/effect model, in order to assimilate the interactions between the proposal activities and specific environmental (resource) components. One traditional EA method is to use an impact matrix. However it has been shown that such an approach does not provide quantitative results.

Therefore an alternative is to use a network approach or pathway/system diagram. Networks and pathways depict graphically the relationships and interactions among elements of an activity and components of an ecosystem. They differentiate between individual, additive, and synergistic interactions; and can illustrate what outputs affect which components of the system (Montz & Dixon, 1995).

Both methodologies should, if undertaken correctly, produce a causal analysis of the cumulative effects situation. This development process should follow a consultative and iterative route, the output of which may be updated at any time by new data. Clearly more advanced simulation modelling can be used to determine cumulative effects and impacts if more sophisticated options are viable or if datasets are extremely large or variable.

3.5.7.3 Ecosystem, Economic and Social Impact Analyses and Synoptic Approaches

A more recent approach is to use ecosystem analysis, which involves considering the full range of ecological resources and their interactions with the environment. Biological indicators are used as integrators of cumulative effects and landscape indices, and as measures of the cumulative degradation of ecosystem functioning. The principles of ecosystem analysis can be applied by extending considerations beyond species, to the ecosystem and investigating landscape-scale processes such as habitat fragmentation (CEQ, 1997). Habitat modification and assessment of exposure to impacts and effects, enable a determination of the level of risk or the probability of a negative impact to be quantified (Vestal & Rieser, 1995).

Economic impact analysis involves establishing the region of influence, modelling the economic effects, and determining the significance of the effects. Such an example would be to undertake economic impact analysis on a commercial fisheries fleet, by attributing value to the catch, and by determining the level of impact from the region of influence, a quantitative measure of impact can be derived. Economic models could become invaluable for analysing cumulative effects and for projecting effects under each alternative. The use of economic impact models in combination with additional techniques has proven successful in addressing cumulative economic impacts. The most commonly used method in the USA for assessing regional economic effects, is the Economic Impact Forecast System (EIFS), based on three criteria; it has a basis in sound theory; acceptance by the scientific community; availability of data to drive model.

Considerable progress has been made in CEA relating to key social impact variables. Social impact analysis differs from other CEA as it deals with the subjective perception of effects, and determines the social meaning and significance of the objective changes produced by cumulative actions. For example, the level of social impact upon a commercial fisheries fleet from dredging activity could become an important indicator of socio-economic disruption, for use within CEA. For that purpose, The Interorganisational Committee on Guidelines and Principles (1994 cited in CEQ, 1997), identified the basic categories of social impact variables; population characteristics, community and institutional structures, political and social resources, individual and family changes, and community resources. It is important to incorporate multiple actions into projections of future social conditions; a number of methods are mentioned in CEQ 'Considering Cumulative Effects', 1997.

The synoptic approach is a framework for making comparisons between landscape subunits, allowing cumulative effects to be considered in management decisions. However, it is only an appropriate method to use when; quantitative information is not available, the cost of improving existing information is high, the cost of a wrong answer is low, there is a high demand for the information, and the situation calls for setting priorities between multiple decisions and optimising for a single decision (Vestal & Rieser, 1995; Abbruzzese & Leibowitz, 1997). Whilst such an approach, could be useful for resource managers because an assessment can be completed in 1 or 2 years at relatively low cost, it is unlikely to be of use within the coastal zone, given the extensive datasets that need to be employed.

3.5.7.4 Temporal & Spatial Boundaries

Defining temporal and spatial boundaries is likely to be the most difficult part of the CEA process, for temporal limits extend from points in the past to points in the future, whilst the extensive and mobile nature of coastal zone resources create extremely variable spatial boundaries.

McCold and Saulsbury (1996) suggest that the existing environment cannot be used as a boundary as it makes the past actions upon a particular resource part of the baseline. (As far as US legislation is concerned, the totality of cumulative effects are those from the 'past, present and reasonably foreseeable future'). McCold and Saulsbury therefore suggest that a suitable boundary is that time in the past when the particular environmental resource was most abundant. In other words, the marine and coastal environment will contain a variety of environmental resources upon which effects will be studied, and so it is likely that each resource will have a different temporal range.

The future extent of the temporal range is likely to be determined by project specific studies investigating the longevity of impact upon a resource expected to be impacted (i.e. an assessment of the temporal impact on the benthos from aggregate dredging before re-colonisation occurs).

Spatial boundaries may be more problematic to determine within the marine and coastal environment, as it is by its very nature a variable and dynamic system; containing resources that are mobile over large geographical areas. Irwin and Rodes (1991) state that selection of such boundaries can only be made with knowledge of 'the types and rates of (resource) release, movement, and transformation of materials and energy'. In particular this means 'understanding ecological processes, such as bioaccumulation, that control these rates'. The ecosytem approach uses natural boundaries such as ecological regions, to include ecosystem functioning and landscape-scale factors, for example, habitat fragmentation (CEQ, 1997). Regional and urban analysts prefer to use a functional area concept for defining the socio-economic spatial regions of a study (Fox and Kuman, 1965; cited by CEQ, 1997).

Initial definition of temporal and spatial boundaries will likely result from scoping, the results of which can be subsequently quantified, or scored, through study of impact matrices results. For example, a longstanding migratory pelagic fishery will have greater temporal and spatial boundaries than a local and recently exploited shellfishery.

3.5.7.5 Defining Resource Thresholds

From the previous section, it is clear that any one resource with an EA is likely to have different temporal and spatial constraints or boundaries. It stands, therefore, that each will have different threshold levels within which an impact will have an effect. In order to make a qualified decision on the likelihood of impact and the expected effects, it is necessary to have an understanding of these thresholds. Indeed it has been recognised that one definition of cumulative effects is 'threshold development' (Irwin and Rodes, 1991), those developments stimulating additional activity such as to pass a particular threshold and provide an overlapping effect.

It is beyond the remit of this paper to detail the threshold levels of all the relevant resources within the marine and coastal zone. Nonetheless to use an ecological analysis example, it is suggested that, in cumulative terms, the ability of certain marine biota to withstand impact may be limited to such an extent so as to impact critical links in the marine food chain. This will then give rise to a cumulative impact which, over both time and space, is considerably greater than the initial impact. Other more tolerant species may be less likely to have a causal effect on the food chain. Clearly the decision making process will again take an iterative route, with consultation from specialists, NGO's, academic organisations etc.

3.5.8 Presentation of Cumulative Effects

Cartographic tools, particularly Geographic Information Systems (GIS) are seen as the most useful way of displaying data in layers such that the sum of, and interaction between layers can be determined. Such tools can also be used to develop temporal and spatial boundaries at the scoping stage. Using time series of aerial photographs for example, to determine coastal inundation and to visualise general shoreline processes in order to understand and assimilate likely cumulative effects over space and time. Typical examples of GIS requirements are given within Section 3.6.

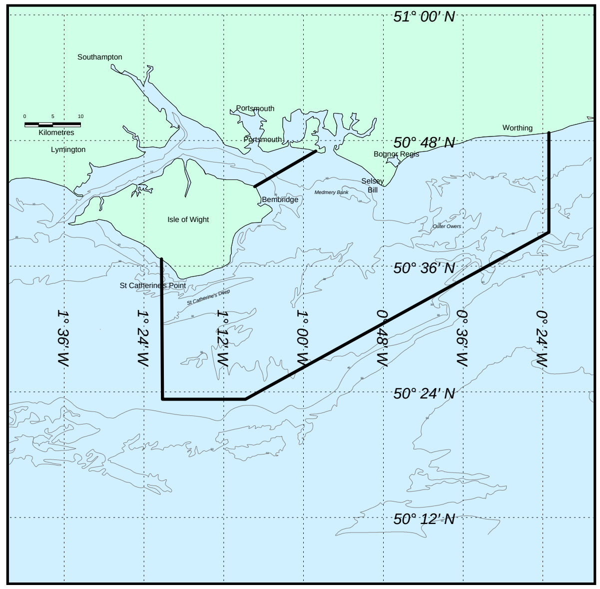
A pilot study area has been chosen to develop the framework formulated during the initial phase of Task 3 and to indicate how the tools and techniques identified are likely to be suitable for CEA. It is hoped that use of this study area will go some way toward developing a combined project oriented EA/CEA approach. It is not the intention for Section 3.6 to be CEA, but merely a review of the data required (real data that followed a scoping exercise). The final part of Task 3 will therefore comprise technical details on approaches to the assessment of baseline conditions in the coastal zone which are an essential prerequisite to understanding the impact of natural variations in environmental conditions and that of aggregates dredging on coastal resources. Within each section, or where appropriate, discussion on a suitable CEA approach will be included.

The pilot study area chosen is that adopted within the Sediment Mobility Study to the east of the Isle of Wight (Hydraulics Research, 1993). The area contains a patchwork of existing marine aggregates licences (not all are dredged) as well as areas under application, or consideration following prospecting. The area represents an extremely rich and varied physical, biological and socio-economic environment containing offshore, coastal, inshore and estuarine habitats. All have been well studied and much existing data is available for this research project, particularly given the authors' experience of the area. (Nonetheless considerably more exists in the form of *grey literature*). The datasets included within the following study are by way of example, in order to illustrate the complexity and interaction of resource information to those interested parties who will need to review marine aggregates licencing, or the development of any project, within the coastal zone, in terms of cumulative effects.

3.6 Pilot Study Area – Physical Environment & Effects

3.6.1 Sea Bed Topography

Figure 3.1: Pilot study area



The study area forms a region of uneven sea bed topography, south-east of the Isle of Wight. The water depth in the general area ranges from 0 to 30m.

The sea bed characteristics in the surrounding region and indeed that of the English Channel result from a complex geological evolution (Hamblin *et al*, 1992). The seabed is dominated by ancient features formed during or before the last Ice Age, when sea levels were much lower than at present. A well-developed break of slope up to some 30m in height runs east-west between the 30 and 50m contours around 12-15km south of the Isle of Wight (Figure 3.1). This is a submerged cliff-line of possible late Pliocene or early Pleistocene age (Stride, 1972). Several enclosed, largely sediment-free basins also exist: the deep channel along the centre of the East Solent, and the valley known as St. Catherine's Deep off the southern tip of the Isle of Wight (which reaches up to 80m below the adjacent sea bed and is beyond the study area) are the most obvious examples. The origin of these "deeps" is not known, but it is thought that they may be relict river valleys. Some have been infilled with sediments; however, others remain close to their original level, indicating little or no recent sediment movement in these areas.

Several areas of the region exhibit a particularly uneven sea bed, for example, the Outer Owers, to the north-east of the study area. In this region, minimum depths are 2m above lowest tidal level whereas maximum depths in a number of the depressions reach 65m below lowest tidal level. The sea bed slope in this area is also extremely variable, some areas being almost flat, with others having gradients steeper than 1 to 5. The fact that this uneven sea bed topography has not been infilled by sediments indicates that sediment movement over the area is probably negligible.

3.6.2 Geological Aspects

The oldest rocks found in the Isle of Wight area are clay deposits formed between 100 and 135 million years ago. These are overlain by limestones, sandstones and more recent clays. Overlying chalk was formed around 55 million years ago and there have been further deposits of sands and clays.

During the coldest phases of the Pleistocene period, sea level was as much as 120m lower than at present, so that the coastal and terrestrial drainage configurations were very different. The Atlantic coast lay between Brittany and Cornwall and a major river drained westward over the centre of the English Channel. The ancient rivers were flanked by gravel terraces; the gravel being a product of glaciation. As the ice retreated and sea level rose, separating England from the European mainland, some of the gravel in the river channels was redistributed by waves and tidal currents to form beaches on the coastline, while the remainder was left as deposits on the sea bed. This history of erosion by rivers swollen by melt-water from glaciers further north, and of massive sea level rise at the end of the last Ice Age, has resulted in the deposition of large quantities of gravel, pebbles, sand and mud on the sea bed.

3.6.3 Sea Bed Surface Characteristics

There is a considerable variation of sediment types within the study area. Hamblin *et al* (1989a & b), indicates that, in general, much of the nearshore zone (3-8km offshore) is covered by deposits of sand and gravelly sand. These modern sea bed sediments are reported to be thin, generally not exceeding 0.5 to 1.0m in thickness. Coarse sands and gravels form restricted accumulations seawards of the sand deposits, with gravel between the accumulations (Figure 3.2). Sand and gravel patches in the region may terminate abruptly giving way to clay or mud deposits, particularly towards the entrance of the Eastern Solent.

The patchy distribution of sediment and sediment types was confirmed by HR Wallingford Ltd in a study of the sea bed mobility of the area (Hydraulics Research, 1993). Surveys indicated that sediments are unevenly distributed with areas of exposed bedrock. Areas also exist in which a mixture of different sizes and types of material prevail, i.e. where muds and clays surround an area of sand, as an indication that the material is not generally mobile.

Four types of bedform: megaripples, sandwaves, sand ribbons and gravel furrows exist within the study area (Bray *et al*, 1991; Hydraulics Research, 1993). There are complex patterns of bedforms indicating complex sediment movement paths. Almost all of the bedforms are sandwaves or megaripples and occur where the bed material is sand or gravelly sand. These well developed, abundant sandwaves occur mainly in distinct groupings in the approaches to the Solent and up to 15km offshore east of Littlehampton. Bedforms are indicative of sediment transport pathways, which in turn have a relationship within prevailing significant wave heights (Figure 3.3).

3.6.4 Local Hydrography

3.6.4.1 Tide levels

Tidal levels are published by the Hydrographer of the Navy in the Admiralty Tide Tables for inshore waters around the British Isles (Hydrographer of the Navy, 1995a). The propagation of tides in the central portion of the English Channel is complex due to the shape and changing depth of the sea bed which creates a quarter-diurnal tidal oscillation in addition to the dominant semi-diurnal tidal oscillation. This additional oscillation is best observed in the reaches of the Solent, where a second high water is produced approximately 2 hours after the first, leading to a prolonged high water period and consequently a shortened ebb duration. However, this effect is more pronounced on springs than neaps, and its significance diminishes in the outer reaches of the Solent. Representative tidal data is given in Table 3.2 below.

Table 3.2: Tidal levels for representative locations adjacent to the pilot study area

	Portsmouth		**Ventnor**		**Sandown**		**Chichester Harbour**		**Selsey Bill**	
Height (m)	**CD** (Chart Datum)	**OD** (Ordnance Datum)	**CD**	**OD**	**CD**	**OD**	**CD**	**OD**	**CD**	**OD**
HAT (Highest Astronomical Tide)	5.2	2.5	4.2	1.8	4.5	2.0	5.4	2.7	5.8	2.9
MHWS (Mean High Water Spring)	4.7	2.0	3.9	1.5	4.1	1.7	4.9	2.2	5.3	2.4
MHWN (Mean High Water Neap)	3.8	1.1	3.2	0.8	3.3	0.9	4.0	1.3	4.4	1.5
MSL (Mean Sea Level)	2.9	0.2	2.3	-0.1	2.4	0.0	2.8	0.1	2.9	0.0
MLWN (Mean Low Water Neap)	1.9	-0.8	1.7	-0.7	1.7	-0.7	1.9	-0.8	1.9	-1.0
MLWS (Mean Low Water Spring)	0.8	-1.9	1.0	-1.4	0.8	-1.6	0.9	-1.8	0.8	-2.1
LAT (Lowest Astronomical Tide)	0.0	-2.7	0.2	-2.2	0.0	-2.4	0.0	-2.7	-0.2	-2.7

Source: Hydrographer of the Navy (1995a)

3.6.4.2 Tidal currents

Tidal stream data given for the pilot study area on Admiralty Chart 2045 are given in Table 3.3 below.

Table 3.3: Tidal current velocities for the pilot study area from Admiralty Chart 2045

Hours from HW at Portsmouth	Direction (deg)	Spring Rate (knots)	Neap Rate (knots)	Spring Rate (ms^{-1})	Neap Rate (ms^{-1})
-6	083	0.9	0.5	0.5	0.3
-5	076	1.9	0.9	1	0.5
-4	070	1.9	1.0	1	0.5
-3	066	1.8	0.9	0.9	0.5
-2	065	1.2	0.6	0.6	0.3
-1	046	0.3	0.1	0.2	0.1
HW	268	0.9	0.4	0.5	0.2
+1	260	1.7	0.9	0.9	0.5
+2	253	2.1	1.0	1.1	0.5
+3	245	1.8	0.9	0.9	0.5
+4	241	1.3	0.6	0.7	0.3
+5	234	0.7	0.3	0.4	0.2
+6	083	0.5	0.3	0.3	0.2

Source: Hydrographer of the Navy (1990)

Tidal currents have been numerically modelled by the French research institute, IFREMER (Salomon and Breton, 1991a, 1991b). Model results, verified by measured current data, provide a comprehensive picture of depth averaged tidal flows in the region. Currents in this region are typically strong and tend to decrease from west to east. Strongest currents occur in St. Catherine's Deep to the south of the Isle of Wight where the sea bed topography channels the tidal flow, while currents weaken in shallower water where sea bed friction becomes important.

To the north-west of the pilot study area, there is a strong flow in and out of the eastern arm of the Solent, flowing west-north-west on the flood and east-south-east on the ebb. As a consequence, flow patterns in the shallow water off the eastern tip of the Isle of Wight are more complex than in deeper water; model results show that current directions rotate over the tidal cycle in this region. Currents in the central part of the pilot study area are strongly rectilinear, flowing approximately north-east on the flood and south-west on the ebb.

Admiralty Diamond tidal flow velocities and 2D numerical modelled velocities do not demonstrate changes in current speed and direction occurring through the water column. ABP Southampton measured current velocities throughout the water column in the region of the Nab Tower disposal site. Results show that, on the ebb of a neap tide, although near surface velocities can reach $0.75ms^{-1}$, they reduce to $0.4ms^{-1}$ or less near the bed, with the greatest reduction in velocity occurring in the bottom 10m of water. Flow directions varied with time but remained consistent throughout the depth except for a short period at the turn of the tide.

3.6.4.3 Waves

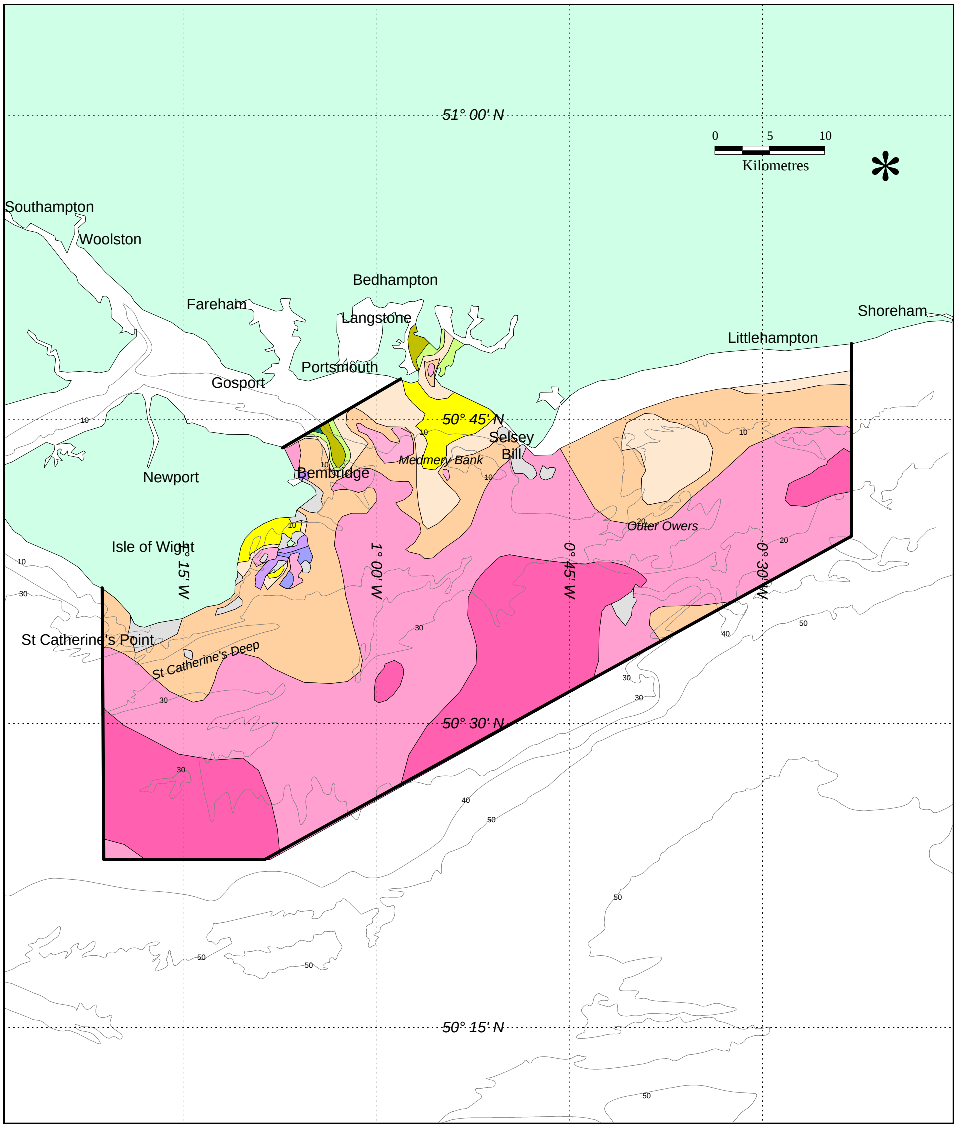
In general, the dominant waves in the English Channel approach from the west and south-west; the prevailing wind and swell directions. The Isle of Wight provides some shelter from these waves for coasts to its north-east; however, waves can be refracted around the island by changing sea bed depths and may travel into the Solent. Winds from the south, south-east and east can occasionally produce storm wave conditions; however, due to the limited fetch for these directions, such waves are limited in height and wavelength and thus in their ability to move sediment.

Measured wave data for the region are limited; however, HR Wallingford Ltd have modelled and conclude the potential for impact from extreme offshore wave conditions (Hydraulics Research, 1996b). The model indicates that largest waves approach from the south and south-west, the directions having the longest fetch lengths. Significant wave heights are likely to be between 3.7 to 5.7m, for return periods between 0.1 and 100 years.

3.6.4.4 Meteorological surges

Variations from the predicted astronomical tide are caused by the passage of low or high pressure systems (causing positive and negative surges respectively). Predicted 1 in 50 year extreme storm surges around the UK coast range from 1m off Cornwall to 3m in the Thames Estuary. The English Channel is prone to surges attributable to vigorous low pressure systems moving in a west-east direction along the autumn weather path. The predicted 1 in 50 year surge for the pilot study area is approximately 1.3m.

Figure 3.2: Surface sediment type in the pilot study area



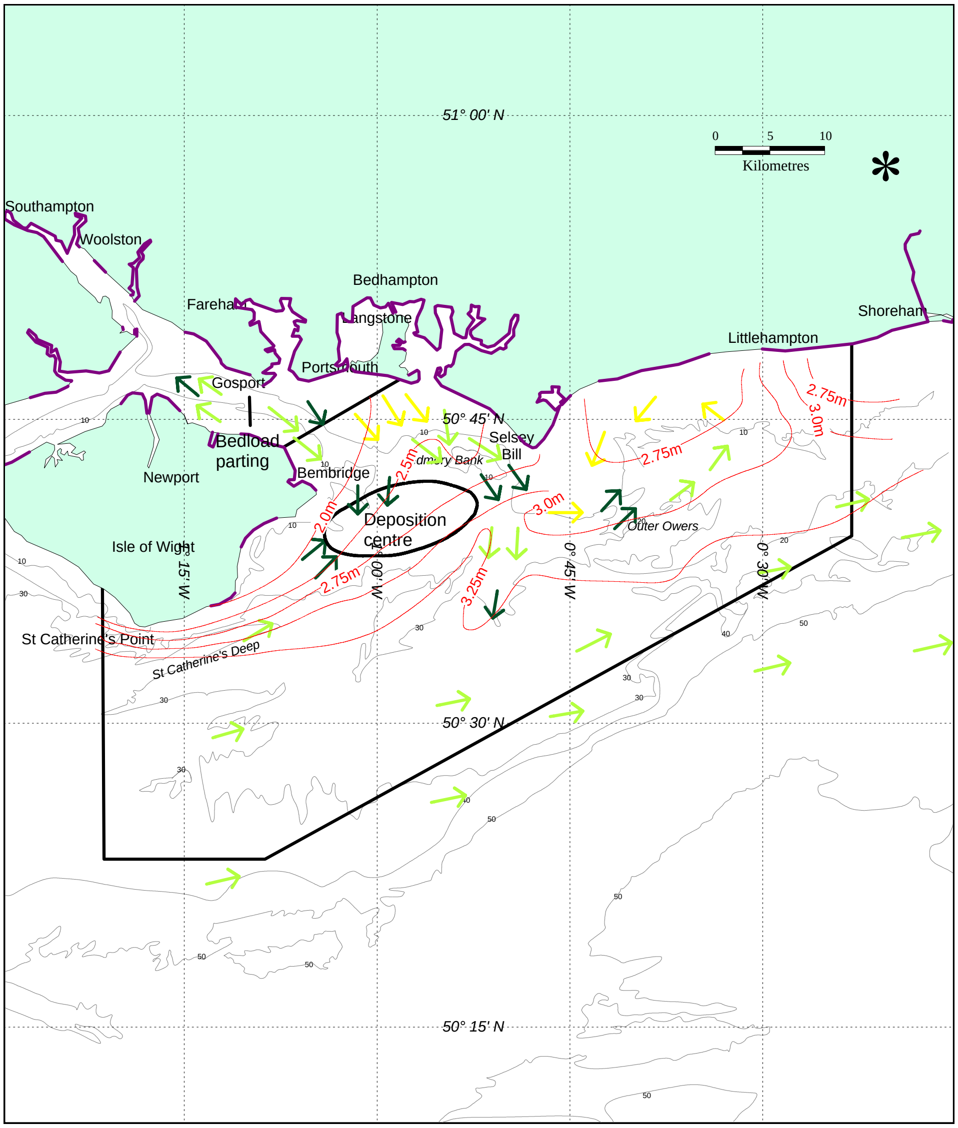
Oakwood Environmental Ltd
February 1999
Datum: OSGB36

Key:

- Pilot Study Area
- Sand - S
- Gravelly sand - gS
- Slightly gravelly sand - (g)S
- Gravelly muddy sand - gmS
- Slightly gravelly muddy sand - (g)mS
- Gravel - G
- Sandy gravel - sG
- Muddy sandy gravel - msG
- Sandy mud - sM
- Slightly gravelly sandy mud - (g)sM
- Outcrop of bedrock

Source: British Geological Survey, 1990

Figure 3.3: Sediment transport pathways, significant wave heights and coastal defence sites in the pilot study area



Key:

- Pilot Survey Area
- Sea defence / coastal protection works
- Sand transport direction (high confidence)
- Sand transport direction (medium confidence)
- Sand transport direction (low confidence)
- Significant wave height

Source: Barne *et al* (1996, 1998), HR Wallingford (1993)

3.6.5 Sea Bed Stability

3.6.5.1 Bedload Transport

There have been several studies of sediment mobility in the English Channel (Bray *et al*, 1991; Hydraulics Research, 1993). Transport pathways (Figure 3.3) have in the past been estimated using modelling techniques, direct observations and have also been inferred from the bedforms which make up the sea bed relief. There is, therefore, a good understanding of the general transport of sea bed sediments induced by wave and tidal action in this area.

The combined action of wave induced peak bottom orbital velocity and tidal currents produces a shear stress on the bed. When this shear stress exceeds a threshold value, the bed sediment will be mobilised. Using numerical modelling of wave and tidal currents and assuming the sea bed to be covered with sediments, HR Wallingford Ltd (Hydraulics Research, 1993) calculated the likelihood of mobility of the sea bed materials. Results suggest that gravel is only mobile in water depths less than around 20m where wave action significantly adds to the effects of tidal currents. Calculations of critical shear stress confirm that, as expected, sand is more mobile than gravel, and is mobilised by tidal currents alone. Movement of gravel through the area is very limited and only occurs under extreme wave conditions. In relatively deep water, seaward of the 20m depth contour, however, evidence suggests that tides form the main sediment transport mechanism. Sand is transported in roughly south-west and north-easterly directions, depending on the state of the tide. In shallow, coastal waters, wave action rather than tidal currents is the dominant factor in the transport process, and as a result sediment transport paths are more complex in the nearshore zone. An area of sediment deposition is evident off the eastern tip of the Isle of Wight where sediment paths converge. HR Wallingford Ltd estimated potential bedload movements in the region (Hydraulics Research, 1994). Results indicated that the net bedload transport is from west to east up the English Channel.

Direct observations from radioactive tracer studies off Worthing (Hydraulics Research, 1991) showed that when placed at 18m depth, gravel did not move. At 12m depth gravel moved only very slowly and only in the period soon after its placement.

Inferred transport conclusions may be drawn from bedforms such as sand and gravel waves, gravel furrows and sand ridges which may be interpreted as evidence of the mobility of sediments under tidal current induced transport. The bedforms identified in the region south and east of the Isle of Wight suggest a complex pattern of sediment movement. In deep water outside the 20m depth contour, bedforms in sandy areas generally show little asymmetry suggesting little or no net sediment transport. In shallower areas, asymmetric sand waves and megaripples show more consistent signs of net sediment transport, and suggest that sand transport directions align closely with the ebb and flow of tidal currents.

The uneven sea bed surface, absence of infill in the "deeps" and the patchiness and poor sorting of sea bed sediments also indicate little contemporary net sediment transport in waters deeper than 20m. Direct observations suggest that there is little or no movement of gravel when the seabed is 20m or more below Chart Datum

(Hydraulics Research, 1991). Transport of gravel is therefore likely to be limited in those parts of the study area shallower than this depth. Sand is obviously more mobile, travelling, in zones seaward of 20m, roughly in a north-east (flood) and south-west (ebb) direction. Although there is evidence of complex sand transport paths inshore, there is no evidence of shoreward transport of sediment from water greater than 20m in depth. The only area of onshore transport would appear to be in the region of the Owers Bank.

3.6.5.2 Suspended Sediment

Field studies indicate that background concentrations of fine sediment in suspension range between 5 and 10 mgl^{-1} with tidal peaks of 20 to 30 mgl^{-1}, which may be increased typically by an order of magnitude by severe weather. If it is considered at all likely that increased suspended sediment concentrations resulting from either the direct or indirect impact of the dredge plume will impact the benthos, or effect sediment transport pathways, then further field measurements should be undertaken (*see* Chapter I – Introduction *and* Chapter 4 – Mitigation & Monitoring). Although application specific modelling and fieldwork (Hydraulics Research, 1996a & c) has already been undertaken and working data been made available as to the *likely* extent and impact of the dredge plume (Hitchcock *et al*, 1997; Hitchcock and Drucker, 1996; Whiteside *et al*, 1995), more studies to provide regional data may be required.

With regard to the pilot study area, a sediment quality monitoring programme is carried out by MAFF in the region of the Nab Tower disposal site, a naturally dispersive site which is situated centrally to the area (MAFF 1989, 1991a-c, 1992, 1993, 1994b, CEFAS, 1997). Over the period 1985 to 1994, between 0.5 and 1.44 million tonnes of dredged spoil and 0.27 million tonnes of sewage sludge were deposited annually at the Nab Tower site. Sample sites are located to monitor the accumulation of contaminated material placed at the disposal site. Mean concentrations of metals in the fine sediment fraction sampled in 1989, 1991 and 1992 at the site lie within the ranges found at other UK sewage sludge disposal sites. In the absence of existing standards for contaminants in marine sediments, the sediment quality data may only be compared with data for other areas of the UK. In 1979, MAFF published a report on the chemical composition of marine sediments in near-shore areas and dredged spoils from a large number of estuaries (Murray *et al*, 1979).

With regard to water quality and dissolved metals data, the Environment Agency routinely samples coastal waters at sites approximately 5km from the shore. Mean values for sites around the Isle of Wight and Hampshire coast are available from this dataset (NRA Southern Region, 1995). Whilst values indicate that dissolved metals are present in the pilot study area at higher concentrations than that typical of the English Channel as a whole (Reid *et al*, 1993), they do not in general present a significant hazard to marine wildlife (Gardiner and Zabel, 1989). The exception to this is the relatively high concentration of copper at the West Princessa Buoy site.

Any dredging activity should avoid the potential for the re-suspension of known contaminant material if levels are shown to be potentially damaging to the benthic and fisheries resources of the area. It is unlikely, nonetheless, that dredging companies will target such areas, in order to avoid contaminated cargoes. Monitoring measures indicated in Chapter 4 should ensure that this remains the case.

3.7 Pilot Study Area – Biological Aspects & Effects

3.7.1 Benthic Community Structure

3.7.1.1 Introduction

Research into the environmental effects of aggregate dredging has been carried out in a number of areas in UK coastal waters, including some within the pilot study area. Studies in the English Channel include those of Shelton & Rolfe (1972), Dickson & Lee (1972) and Lees *et al* (1990). Studies in the southern North Sea include those of Millner & Dickson (1977) and, more recently, that of Kenny & Rees (1994, 1996).

Reviews on the impact of dredging in the Isle of Wight region (Licence areas 213, 340, 351) are also summarised in the MAFF Aquatic Monitoring Report No. 26 (MAFF, 1991a). The impact of spoils disposal in the region are also discussed in the MAFF Aquatic Monitoring Report No. 27 (MAFF, 1991b).

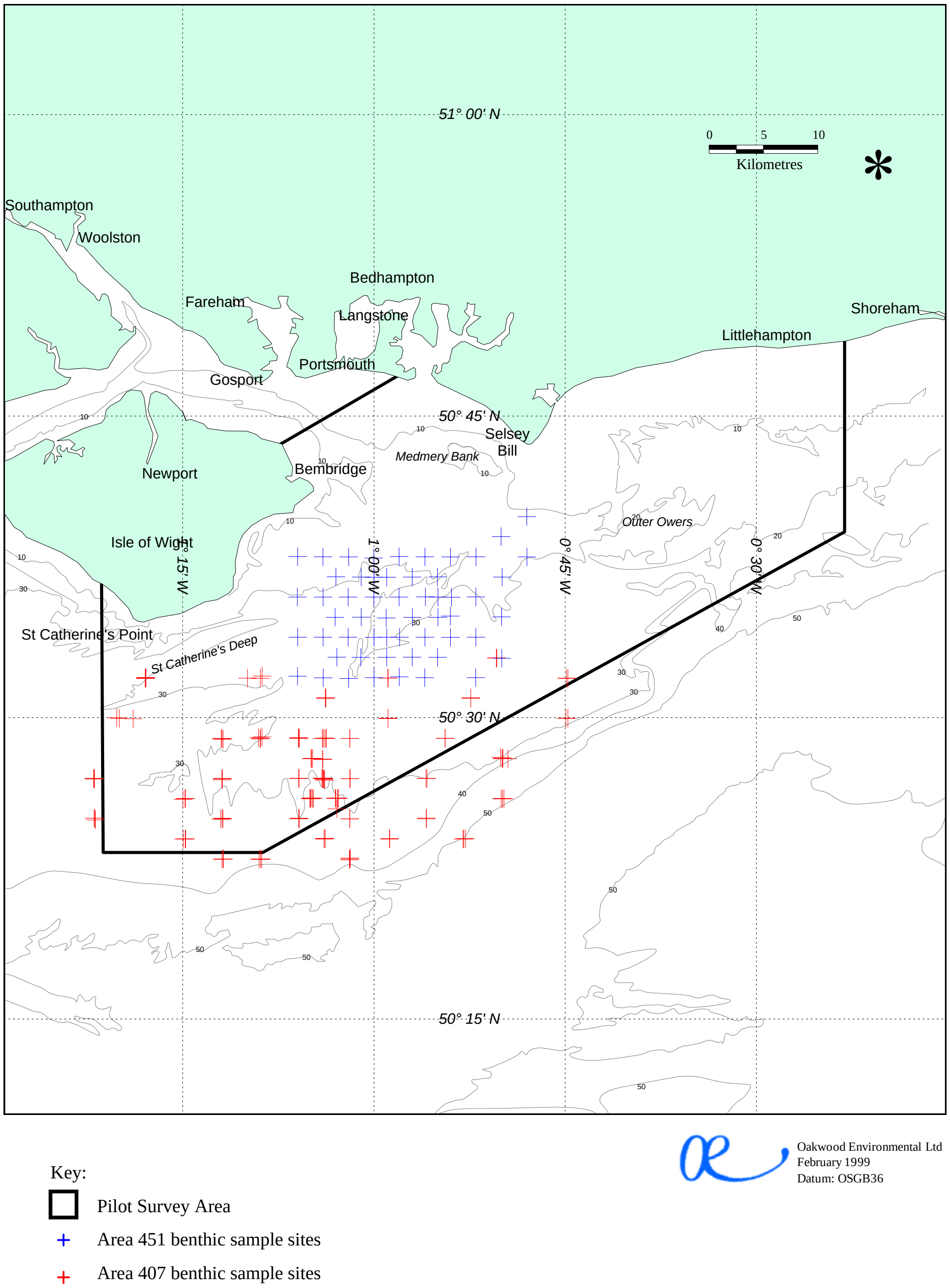
A number of detailed quantitative benthic surveys have been undertaken by the authors within the pilot study area (Figure 3.4 indicates two), which along with other commercially available data and routine Government agency data should begin to provide a regional assessment of benthic community composition and distribution. This information will also need expanding with grey (unpublished) literature.

An example of such a survey was carried out in September 1995. Its purpose was to determine benthic community composition, to assess its sensitivity to disturbance and its significance both for conservation, and as a potential food resource for fish (Unicomarine, 1996). The methods used both in the sampling and subsequent extraction and analysis are similar to those used by Kenny & Rees (1994). Such results should be fully described in a separate survey report which should be made available to specific consultees upon request as good practice, in order to supplement and expand upon the the ES.

Terms of Reference should be approved by the relevant bodies (i.e. MAFF) before commissioning of the survey. Survey stations should be chosen on the basis of the direction and velocity of tidal streams and an assessment of the likely settlement time of "fines" discharged into the water column during the dredging process. The sampling grid should cover not only the licence area, but a zone of potential "secondary" impact resulting from dredging activities, and a series of control stations outside the area where its is considered unlikely that there will be impact from dredging activity.

Consideration should also be given to the nature of the substrate and therefore the method of sampling to ensure maximum data return, which should include trawl sampling of the epibenthos, to return a measure of the faunal food resource available to higher predators.

Figure 3.4: Location of OE benthic sample sites within the pilot study area



Source: Oakwood Environmental Ltd (1997, 1998)

3.7.1.2 Types of benthic communities in the pilot study area

The fauna of the pilot study area as a whole is very diverse, with as many as 390 taxa from 14 phyla being recorded in the 1995 from the central area alone. The dominant groups in terms of numbers of species from this survey were Polychaeta (37.8% of the taxa recorded), Crustacea (28.6%) followed by Mollusca (12.5%). In terms of population density, the Polychaeta represented 42.0% of the total, Crustacea 31.5% and Mollusca 13.7% with other groups individually representing <7% of the species variety and population density.

Data should be summarised from the benthic survey report and presented within the ES in tabular form, indicating the number and percentage of each taxa, and the number and percentage of individuals. For clarity, data should be presented using GIS and benthic community type mapping in order that the composition and distribution of the benthos can be easily visualised.

From such data population density can be determined. For example, the 1995 survey recorded up to 158 taxa and almost 2,600 individuals at individual stations, but with reduced numbers of both taxa and population density to the central northern part of the survey area and in the most southerly stations. It is probable that this reduced species variety and population density reflects areas of bedrock where grab samples were poor for sediment dwelling biota, although this may not be the case for rocky substrate biota which are not effectively sampled by grab.

A detailed analysis of the community composition was carried out using two kinds of multivariate techniques, classification analysis and non-metric multi-dimensional scaling (MDS) (Clark & Warwick, 1994). These methods of analysis showed that the fauna at most of the stations in the survey area are relatively homogeneous with little evidence of distinct groups such as occur, for example, when there are major spatial differences in environmental conditions in a survey area.

Essentially, most of the 1995 survey area is characterised by *Sabellaria spinulosa* reefs, associated with large numbers of the slipper limpet, *Crepidula fornicata*, and hydroids such as *Sertularia cupressina*. Many of the smaller worms and Crustacea are found amongst the interstices of the epifauna and worm tubes. The most abundant of these include the amphipod, *Unciola crenatipalma*, the Ophiuroid, *Amphipholis squamata* and the polychaete, *Typosyllis variegata*. These organisms are typical "cryptofaunal" species which characterise *Sabellaria* communities. Finally, there are several true burrowing (infaunal) species including the bivalve, *Nucula nucleus* and the polychaete, *Lumbrinereis gracilis*.

Other groups, or assemblages, represent *Sabellaria* communities which border on rocky or more muddy substrata. Where scouring is prevalent, increasing numbers of barnacles, *Balanus crenatus* and *Elminius modestus* and the serpulid worm, *Pomatoceros lamarcki*, occur. The burrowing worm, *Aonides paucibranchiata*, becomes also more important than the bivalve *Nucula* and indicates more sandy deposits where wave scouring is intense. The assemblage in these transitional areas is, however, still rich and shows at present little evidence of disturbance. In areas which border on more muddy deposits, there is an increasing proportion of burrowing (infaunal) animals such as *Nucula*, the worm *Lumbrinereis gracilis* and the cirratulid worm *Caulleriella zetlandica*.

Other communities show an increased importance of stones as a substratum and, apart from *Sabellaria*, support varying populations of barnacles, ascidians and serpulid tubeworms depending, among other factors, on the size of the boulders and amount of sand which is deposited on them. Finally, there are fairly large sub-groups of communities which are characteristic of unstable substrata such as gravels. The few stable stones are colonised by the barnacle, *Balanus*, whilst the polychaetes *Aonides* and *Ophelia borealis* are found in the gravel.

In summary, communities found during the 1995 survey showed that the survey area was relatively species rich with high population densities, which reflected the wide variety of habitat types available within the reef-building *Sabellaria* habitat. Associated species may be living on the surface of stones (epifauna), in the protected environment of crevices (cryptofauna) or true burrowing organisms (infauna) which require a proportion of silt or sand for survival.

These data are, of course provided by way of an example, and is not the picture throughout the whole pilot study area, where considerable variability in benthic community composition occurs. Nonetheless, it is indicative of the methodology to be employed, and of the nature of the benthos in the central part of the study area. As has been previously stated, the collection of a comprehensive baseline dataset will be critical for CEA. This is beyond the remit of this research project, but it will fall upon bodies such as MAFF to collect and compile such data, and for wider dissemination of both available and unpublished data from commercial and academic sources, to bring together such a dataset.

3.7.1.3 Factors affecting spatial distribution

The general conclusion from the 1995 benthic survey was that the broad distribution of the biotopes is very patchy and is not easily related to chart features such as depth or dominant sediments. The distribution of benthic communities within the survey area is likely to be controlled by a complex array of physio-chemical factors which interact with biological factors such as the presence of the reef-forming species *Sabellaria*. This genus has a relatively narrow range of habitat preferences, requiring vigorous water movement and a firm bedrock substratum, although the animal will settle on other substrate types (Holt *et al*, 1997), and undergoes a natural cycle of accretion and destruction over a period of up to 10 years (Wilson, 1971; Gruet, 1986).

Most of the main communities in the survey area had *Sabellaria* as a component of the assemblage. The presence of associated species is evidently controlled by the presence of larger boulders for the attachment of epifauna such as barnacles; the presence of smaller stones, allowing an increased cryptofauna to occur in the crevices; and the presence of sands or silts which allow colonisation by burrowing infauna such as bivalves and polychaetes.

Therefore, analysis of the occurrence of faunal groups does show some association with sediment type, but the correlation is obscured by the complexity of biological interactions between *Sabellaria* and the associated communities.

Most of the common large and sessile animals recorded in the trawl samples were typical of the region. It was difficult to correlate the distribution of the epifauna with the benthos at any of the particular sampling stations because of the same patchiness which was seen in the benthos. Some of the dredge samples contained many more *Crepidula* than others, and these appear to be correlated with the main *Sabellaria* community. Other species were recorded from the dredge samples that had not been recorded in the quantitative grab survey of the benthos. These included the nudibranch sea slug, *Archidoris pseudoargus*, and the swimming crab, *Liocarcinus puber*, as well as a number of fish including spotted ray (*Raja montagui*), sole (*Solea solea*), poor cod (*Trisopterus minutus*) and dogfish egg cases. More spiny spider crabs (*Maja squinado*) were found in the dredge and trawl survey than in the grabs, and it is likely that this species is seasonally common in the Area.

3.7.1.4 Likely temporal variations in benthic communities

The *Sabellaria* reef community has been referred to as "Faunal Accretion" by Holt *et al* (1995). Essentially, these comprise aggregations of the tube-dwelling polychaete *Sabellaria alveolata* on rocky shores, or of the related species *Sabellaria spinulosa* on subtidal bedrock substrate such as occur in the survey area. *Sabellaria alveolata* (and, by assumption, *S. spinulosa*) tends to occur where relatively strong currents exist and undergo natural cycles which are generally reported to last from 5-7 years (Wilson, 1971) or up to 10 years (Gruet, 1986). It is important to understand the natural cycle of accretion and destruction of the reef system as the presence of *Sabellaria* is probably the dominant biological factor controlling the presence of associated species, and so is likely to influence the temporal variability of communities in the survey area.

The cycle begins with a settlement phase where the larvae have a highly site-specific preference for particular substrata and current speeds. The larvae settle preferentially on old reefs where previous *Sabellaria* colonies have occurred (for review, see Newell, 1979). A reef platform develops from the combined tubes of huge quantities of individuals and then becomes vulnerable to erosion. The subsequent destruction of the *Sabellaria* reef then brings the cycle back to dead eroded reefs on which new larvae settle preferentially. This cycle appears to be independent of whether the living population is young or old (Gruet, 1986).

Although *Sabellaria* is fecund and capable of rapid recolonisation compared with some of the slow growing members of reef communities (Taylor & Parker, 1993), the reefs themselves appear to be susceptible to disturbance by trawling, dredging for oysters, or trampling in the intertidal zone. Records in the Waddensea have shown that harvesting of mussels and other fishing activities have severely damaged *Sabellaria spinulosa* reefs, leading to their replacement by other species such as mussels (Reise & Schubert, 1987; Holt *et al* 1995). Destruction of *Sabellaria* by fishing disturbance has also been reported for Morecambe Bay where the disappearance of *Sabellaria* has been implicated in the decline of the pink shrimp industry (Taylor & Parker, 1993). *Sabellaria* reefs are, however, apparently tolerant of sedimentation caused by sewage effluent such as has occurred in Dublin Bay (Walker & Rees, 1980), provided sedimentation is not so great that it prevents contact of the larvae with bedrock during the important settlement phase of reef accretion (Hiscock, 1991).

Finally, it is important to note that although *Sabellaria* has a relatively long breeding cycle from March-April and again in June-September in northern France, it is near the northern limit of its distribution in UK waters. This can result in a reduced breeding season, and extensive mortality during cold winters such as occurred in 1963. Periodic significant mortality is therefore to be anticipated following periods of exceptionally cold winters in UK waters.

Again, it must be stressed that this data is provided by way of an example, and is not the picture throughout the whole pilot study area. However determination of sensitive benthic receptors, such as Sabellaria, will be critical in limiting any potential impact from dredging activity. Furthermore, this data is provided as one example of the determination of temporal and spatial distribution, which as previously indicated, should, along with determination of threshold to impact, be a critical part of CEA.

3.7.1.5 Significance as a food resource and nursery ground for young fish

The wide range of species and high population densities of Polychaete worms, Crustacea and Mollusca represent an important potential food resource for demersal fish. *Sabellaria* reefs are generally considered to be important as a food resource and nursery ground for shrimps (Taylor & Parker, 1993).

3.7.1.6 Conservation importance

Sabellaria reefs are regarded as important because the reef assemblage allows a wide variety of habitat types and these in turn support a greatly increased species diversity than would occur in a more uniform substrate type. The occurrence of high numbers of taxa from several phyla during the 1995 survey is largely associated with the presence of *Sabellaria* as a dominant component of the marine communities in the survey area.

The potential importance of the subtidal reefs to the south of the Isle of Wight has also been highlighted by English Nature under their initiative "*Managing England's Marine Wildlife*". The Solent and Isle of Wight Sensitive Marine Area (English Nature, 1994) covers the Solent and associated habitats, the intertidal rock platforms of the Isle of Wight, and areas of the subtidal zone to the south of the Isle of Wight. Part of the region has also been proposed as a Marine Special Area of Conservation (SAC) designated under the European Union Habitats Directive. The network of proposed conservation sites set up throughout Europe is to be known as the *Natura 2000* series. The conservation of the communities adjacent to the south coast of the Isle of Wight is likely to be regarded as important in the context of the *Natura 2000* programme in the future.

Reference should also be made to the JNCC rarity assessment for benthic species, which is a list of nationally rare and scarce species (JNCC, 1998). This information is not necessarily definitive, but is nevertheless the most comprehensive account of benthic marine species carried out to date and should therefore be taken into consideration where species are assessed to be rare to scarce.

3.7.2 Fish and Shellfish Resource

3.7.2.1 Introduction

The fish and shellfish resource within the pilot study area forms a small part of a much wider resource within the English Channel. The composition of the fish and shellfish resource within the area is to a certain extent determined by local physical and biological factors, and fishing activity (ICES, 1993). This review of the fish and shellfish resource will therefore concentrate on those commercial species which, according to these factors, are most likely to be found therein.

The physical environment is reflected in the benthic communities found there and the diversity of fauna will in turn be reflected in the fish and shellfish resource. The main biological factor influencing the composition of the fish resource will clearly be the size of the fish stock for each species in the wider region. This in itself can be highly variable, for example recruitment by bass can show six-fold fluctuations from year to year (Pickett *et al*, 1995). Fish show seasonally related activities such as migration and spawning, and the composition of fish species within the area will therefore also be influenced by the time of year (Figure 3.5 is provided as an example).

Fishing intensity for any particular species fluctuates according to the current stock size and market price of that species, quota allocations and the season. (Commercial fishing aspects are fully discussed in following sections). Both natural and human factors determining the distribution of fish species are by no means fully understood, and fish stocks frequently show wide fluctuations attributable to these and other, unknown, factors. With this reservation, the importance of the pilot study area to the local and wider fishery resource is based on a review of the biology and life history of the component species of the fisheries resource and an understanding of known factors influencing fish distribution.

For convenience, and as the fisheries resource for the area is well documented elsewhere, a comprehensive review (normally included as an Appendix to the ES or as a separate report) is not included within this study. Nonetheless, the potential for impact from dredging activity is considerable and so the fisheries resource and commercial fisheries are reviewed below.

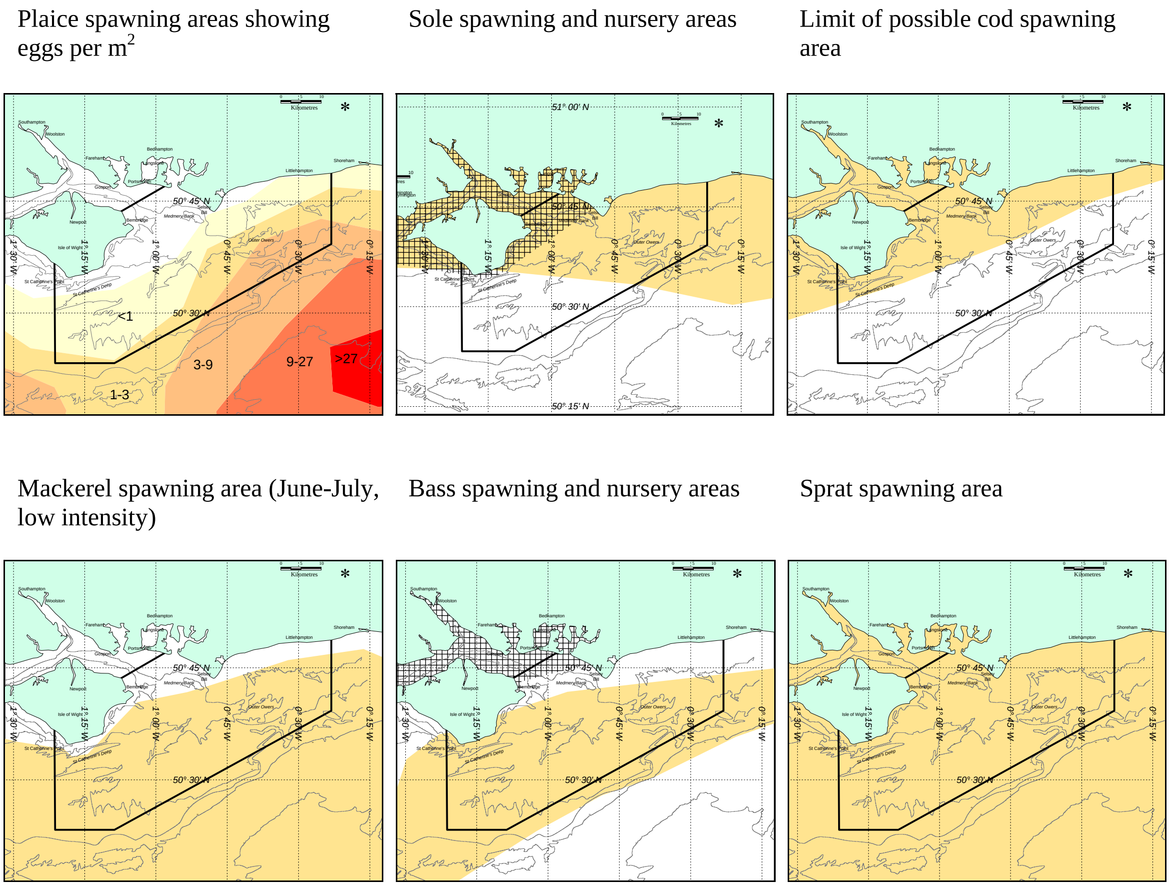
3.7.2.2 Regional significance of the pilot study area for the fishery resource

The relative importance of the pilot study area should be determined by placing the fishery resource in the context of the eastern English Channel. Since the area forms a small part of the eastern Channel, in many ways its significance in terms of the Channel's fishery resource as a whole is similarly small. However, for some of the fish species present, there are aspects where the area may be of relative importance.

<u>Resource Distribution</u>

Commercial landings figures indicate that the pilot study area supports relatively high concentrations of adult edible crab, lobster, spider crab and bass. MAFF trawl surveys indicate that the region also supports relatively high abundance of black bream (Anon., 1995), with large black bream fisheries to the north of the Owers Bank.

Figure 3.5: Fish spawning and nursery areas in the pilot study area



Key:

- Pilot Study Area
- Spawning area
- Nursery area

Oakwood Environmental Ltd
February 1999
Datum: OSGB36

Sources: NERC (1992), Barne *et al* (1996, 1998), Pawson (1995)

Spawning

Egg-bearing female lobster are likely to be present in relatively high numbers in the pilot study area. Surveys of crab larvae have indicated the major spawning areas are located in the extreme eastern and western Channel (Thompson *et al*, 1995). Black bream and cuttlefish are likely to show some demersal spawning in the area, whilst bass and sole show notable spawning in this part of the eastern Channel (Figure 3.5), but with eggs planktonically released it is impossible to *precisely* attribute spawning activity within the area (Thompson *et al* 1987). Plaice, cod and mackerel also show some degree of spawning activity in the area (Brander, 1994; Houghton *et al*, 1976).

Nursery Areas

The pilot study area is a relatively important settlement and nursery area for edible crab and lobster. Furthermore maturing juveniles of many fish species including bass, sole, rays, turbot, brill, dogfish and black bream migrate offshore from their inshore spawning areas on the south coast, and may therefore be found in the area.

Migrations

Sole may pass through this region when making annual migrations to their spawning grounds in the eastern Channel. Fish spawning in inshore areas on the English coast, (as above), may also pass through the area when making their inshore migrations for this activity. However, despite considerable sampling programmes (Riley *et al*, 1986; Rogers *et al*, 1998) there still remains practical difficulties when attempting to elucidate exact juvenile fish migration pathways. The regional significance of the pilot study area to this activity is therefore difficult to quantify.

Pre-adult sole and plaice, and adult crab, are believed to make a westerly to south-westerly migration parallel to the English coast, and may therefore pass through the pilot study area during this activity (Millner and Whiting, 1990). Adult bass (Pawson *et al*, 1987), black bream and scad (Eaton, 1983) make an annual westerly migration to overwintering grounds in the western Channel returning in spring, and may therefore pass through the pilot study area during this activity. There is also the possibility of crab migration pathways throughout the area (Bennet and Brown, 1983).

3.7.2.3 Predator-Prey Relationships

Introduction

The large majority of fish within the pilot study area prey upon animal material from the sea bed and to a lesser extent plankton. Fish are largely opportunistic in their feeding habits, taking whatever prey they can, even of the same species. There is therefore considerable overlap in the prey taken by each species, with food choice to a great extent based upon availability, size and behaviour of the predator and its prey.

Primary productivity

Within a marine ecosystem such as that found within the pilot study area, there are two sources of primary productivity. These comprise photosynthetic plankton and detritus derived from dead animal matter falling to the seabed. There are also complex interactions with the highly productive estuarine regions to the north of the area, i.e. The Solent and Southampton Water and Portsmouth, Langstone and Chichester Harbours. Thus, the predator-prey relationships within the pilot study area cannot be viewed as a closed system.

<u>Predator - prey relationships</u>

Sea bed detritus and phytoplankton are exploited by the benthic communities within the Area, which the benthic survey has demonstrated are rich and diverse. These communities will support adult and juvenile edible crab and lobster, and also small demersal fish including juvenile commercial species such as sole, and non-commercial fish such as gobies. Zooplankton feeding on phytoplankton will provide a food source for the smaller pelagic fish such as sprat and cuttlefish, mollusca and crustacea. Larger predators of commercial significance such as rays and bass will feed on the pelagic and demersal smaller fish.

The usual food of mature fish within the pilot study area are listed in Table 3.4 below. Only the major species are listed, there being several hundred species of fish, crustacea, mollusca and other invertebrates likely to be present within the area. This demonstrates that the above description is a simplification of the highly complex food relationships within such an area.

Table 3.4: Food taken by some fish species found within the pilot study area

Predator (adult form)	Prey
Edible crab	Probably dying or dead animal tissue of all kinds like bait in crab pots, soft benthic animals e.g. polychaeta, mollusca, crustacea and seaweed
Lobster	Similar to edible crab
Bass	Fish, esp. herring family (*clupeidae*), cuttlefish, crustacea
Spider crab	Scavenger of animal material, grazing on attached benthos, mollusca and crustacea.
Skates and rays	Crustacea, shore and swimming crabs, fish (sand eels, *clupeidae*, cod family (*gadidae*) and small flatfish)
Turbot	Fish, sand eels, *clupeidae*, *gadidae*, flatfish, dragonets, gobies etc.
Sole	Small crustacea and worms, sometimes small mollusca and fish
Plaice	Sea bed species, esp. mollusca, crustacea and worms, sometimes Brittlestars and sand eels
Brill	Sand eels, smaller gadoids, cuttlefish and crustacea
Dogfish	Crustacea, mollusca and bottom living fishes, worms
Cod	Crustacea (shrimps and small crabs), worms, brittlestars, fish (incl. herring, sand eels, smaller gadoid fish, juvenile flatfish)
Cuttlefish	Prawns, shrimps and small fish
Lemon sole	Polychaete worms mainly but also crustacea and mollusca
Mackerel	Varied. Planktonic crustaceans, small pelagic fish e.g. herring, sprat, sand eels
Black bream	Fish, large bream also eat decapod crustacea (crabs and lobsters) squid and cuttlefish
Scad	Fish, crustacea, small schooling fish (e.g. sprats), cuttlefish
Whiting	Small fish (sand eels, herring, sprats, gadoids), crustacea
Clupeidae	Planktonic crustacea (esp. copepods), other zooplankton
Gobies	Small crustacea (e.g. copepods, amphipods and young brown shrimps)

3.7.3 Seabirds

3.7.3.1 Introduction

For the purposes of this study, seabirds are divided into three groups according to their primary foraging area. Offshore seabirds regularly feed more than 30km offshore, inshore species feed within sight of land, and coastal seabirds feed intertidally or very close to the shore.

3.7.3.2 Coastal seabirds

The coastal seabirds class comprises wildfowl and waders such as redshank, ringed plover and shelduck. They use the estuaries and harbours on the south coast for overwintering, and also during migration periods in autumn and spring.

Extremely important coastal seabird habitats exist within the pilot study area, on the mainland at Langstone, Chichester and Pagham Harbours (all three are Ramsar and SPA sites) and at estuarine habitats on the Isle of Wight (included within the proposed Solent and Southampton Water SPA/Ramsar site). A more detailed review of coastal seabird populations is given in Barne *et al*, 1996. Only if dredging is to be undertaken in coastal zones, which is only likely to be for maintenance purposes are there likely to be significant impacts. Therefore, no significant individual or cumulative impacts are considered likely.

3.7.3.3 Inshore seabirds

Colonies of inshore seabirds occur all along the south coast of England including the Isle of Wight, with major colonies located in Chichester and Langstone Harbours, and in the Solent and Southampton Water area. These areas support major breeding populations of little, sandwich, common and roseate tern. Minor breeding populations of cormorant, herring gull and lesser and greater black backed gull are also located on the eastern coast of the Isle of Wight (Lloyd *et al*, 1991). Shags are regularly seen off Bembridge in winter months (Aspinall and Tasker, 1992).

Several species of gull are present in the vicinity of the area throughout the year, but increasing in numbers during winter. These include common and herring gull (Stone et al, 1995). Distribution of the lesser and greater black-backed gull, which are present in the region throughout the year at low densities, are linked to scavenging activity around fishing vessels (Stone *et al*, 1995). Large numbers of black headed gull roost on Ryde Sands just to the north of Bembridge in winter (Aspinall and Tasker, 1992). Small numbers of little gull and red breasted merganser are present in the area during winter, and terns during the summer. Considerable numbers of divers can be observed on passage at St Catherine's Point in autumn and spring.

Although inshore seabirds typically forage within sight of land, this cannot be treated as an absolute characteristic. The bird species listed above are frequently sighted over 50km from the British coastline (Stone *et al*, 1995), and in general the availability of prey species is as likely at distance from the coast to determine the probability of encountering such birds in any given area. However, surveying information for the Solent (Aspinall and Tasker, 1992) indicates that individuals from the major breeding populations of tern described above are rarely found in offshore areas. Only therefore, if dredging is to be undertaken in inshore areas, should potential significant individual or cumulative impacts be expected.

3.7.3.4 Offshore seabirds

The English Channel does not support major breeding populations of offshore seabirds, which may be partly attributable to the relatively limited number of suitable breeding sites on this coast, such as cliffs or islands free of mammalian predators (Reid *et al* 1993). As a result, there are few offshore seabirds present in the region around the pilot study area during the breeding months (March to August). The nearest colonies of note are those of guillemot located on cliffs at the western end of the Solent (English Nature, 1994). Small numbers of fulmar do however breed on the eastern Isle of Wight (Lloyd *et al*, 1991).

The pilot study area is of marginally greater importance to offshore birds during winter months (October to March) as a feeding ground. Guillemots, razorbills and kittiwakes are present in this region in moderate to low numbers at this time of year (Stone et al, 1995). In addition, low densities of fulmar, gannets and kittiwakes are present throughout the year (Skov *et al* 1995). Nonetheless, no significant individual or cumulative impacts from dredging activity are considered likely.

An indication of the typical prey organisms of these birds is given Table 3.5 below.

Table 3.5: Typical prey organisms for selected seabirds

Seabird Category	Typical diving depth /m	Prey
Divers e.g. Red Throated Diver	2-9m	**Fish**, e.g. cod, sprat, & herring. Sometimes **crustaceans** e.g. crabs and shrimps
Terns e.g Common Tern	0.2-2.0m	**Fish** e.g. herring, sprat, sand eels, pollock, haddock, cod & whiting. Also flatfish and **crustaceans** e.g. shrimp (not sandwich tern)
Auks e.g. Guillemot	2-60m	**Fish**, e.g. herring, sprat, capelin, sand eels, cod, haddock, other Gadidae, Gobidae, Blennidae, & Cottidae. **Crustaceans**, polychaete worms and squid also taken
Kittiwake	1-2m	**Fish** e.g. herring, sprat, & sand eels. Offal from fishing boats
Razorbill	5-120m	**Fish**, e.g. sprat and sand eels. **Crustaceans**, polychaete worms and squid also taken
Gannet	Not known	**Shoaling fish**, e.g. herring, sprat, sand eels, mackerel, also offal from fishing boats
Fulmar	1-2m	**Small Fish**, e.g. sprat and sand eels. **Crustaceans, and cephalopoda**
Gulls e.g. Herring Gull	1-2m	**Foraging** in intertidal zone and sometimes inland, also offal from fishing boats

Source: Cramp, 1983 and Lloyd *et al*, 1991

3.7.4 Marine Mammals and Large Sharks

3.7.4.1 Seals

Both common (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) are occasionally recorded within the pilot study area, although there are no significant haul-out or breeding sites within the area for either species. No significant individual or cumulative impacts are therefore likely.

3.7.4.2 Cetaceans

Cetaceans (whales, dolphins and porpoises) tend to be rare or occasional visitors to the South Coast (NERC, 1992), with the most important sites for cetaceans around Britain and Ireland being the Outer Hebrides and eastern Shetland (Evans *et al*, 1986). Only 4 of the 25 cetacean species found in UK waters have been regularly sighted in this area of The English Channel since 1980. The great majority of cetacean sightings in this region are of the bottlenosed dolphin (*Tursiops truncatus*), with the remainder comprising (in order of decreasing relative abundance) long-finned pilot whale (*Globicephala melas*), harbour porpoise (*Phococena phococena*), and the common dolphin (*Delphinius delphis*) (Barne *et al,* 1996). These animals are most abundant in coastal waters from April to October.

With the pilot study area in water of less than 50m deep, it will therefore tend to be frequented in relatively low numbers by those species associated with shallow continental seas i.e. the harbour porpoise and the bottlenosed dolphin. The latter is known to favour exposed headlands and enclosed bays, with small numbers of bottlenosed dolphin annually sighted off St Catherine's Point on the Isle of Wight in late summer (Barne *et al*, 1996). Pilot whales are also increasingly sighted close inshore off St Catherine's Point (English Nature, 1994). Overall however, no significant individual or cumulative impacts are likely.

3.7.4.3 Sharks

The basking shark (*Centorhinus maximum*), Britain's largest fish, is sometimes observed off the south and south-east coast of the Isle of Wight during warm weather (English Nature, 1994). The shark's main populations however are found some distance away, off northern and western British coasts (Gubbay, 1988). No significant individual or cumulative impacts are therefore likely.

3.8 Pilot Study Area – Human Environment & Effects

3.8.1 Economic Importance of Fisheries and Shellfisheries

3.8.1.1 Background

This section comprises the current investigations into current commercial fishing activities employed by the authors and used within the pilot study area.

It is recognised by both those undertaking EAs and by consultees that there are difficulties in defining the scope, and quantifying fisheries in discrete areas such as individual licence areas, and in evaluating the contribution of the resource in such areas to the regional fishery. It has become apparent therefore that close co-operation between those undertaking the EA, MAFF and Fishermen's Organisations, in the form of open dialogue and consultation exercises is necessary. Such consultations have in the past identified the need for additional investigations of fishing activity and on that basis, the authors developed a new technique, based on the analysis and GIS presentation of MAFF's aerial surveillance data, to supplement and corroborate the field research previously undertaken. Along with the MAFF data, landings (which are attributed a value based on current prices) and log-book information can ultimately be used to provide a biological and socio-economic analysis technique for the assessment of potential impact upon commercial fisheries from dredging activity.

3.8.1.2 Consultations and sources of information

Information sources used to assemble a picture of the fisheries in the pilot study area comprise published landings statistics, consultation with fishermen and MAFF Fishery Officers and MAFF aerial survellance data.

The limitations of published landings statistics are well known, but nonetheless MAFF landings figures are available for the nearby ports on the Hampshire, West Sussex and Isle of Wight coasts (MAFF, 1994a). Published data within Sea Fish Industry Reports (Nicholson and Mounce, 1989 and Myers, 1992), a JNCC report on the south coast environment (Barne *at al*, 1996) and a MAFF review (Gray, 1995) relating to the fishing industry on this coast are useful sources.

The importance of extensive fisheries consultations, particularly multiple licence areas should not be overlooked. Typical associations with the pilot study area include:

Gosport Commercial Fishermen's Association
Hamble River Professional Fishermen's Association
Hardway Fishermen's Association
Isle of Wight Commercial Fishermen's Association
Mudeford and District Fishermen's Association
Selsey Fishermen's Association
Southampton Water Fishermen's Association
Southern Commercial Fishermen
Wittersham & Bracklesham Fishermen's Association

In addition, meetings should be held or contact otherwise made with MAFF Fishery Officers, Sussex Sea Fisheries Committee, Viviers (UK) and other shellfish merchants at locations such as Bembridge and Selsey, and certain other interested fishermen. The information gained from these consultations should also be supplemented with direct observations of fishing activity.

3.8.1.3 Background to the regional fishery

The productive rocky and gravelly ground between Selsey and the Isle of Wight contains a large proportion of sheltered water. This enables many smaller boats to fish high value resources such as lobster, edible crab and bass. These stocks are consequently heavily exploited (Gray, 1995), with most areas particularly to the east of the Isle of Wight saturated with pots to the extent that there is little space for new pots. Furthermore, a significant proportion of the seabed in this region is licensed for mineral extraction.

There have been as many as 400 registered fishing vessels based on the coast from Selsey to the Isle of Wight. However, not all of these are active on a full time basis (Myers 1992, Gray 1995, Nicholson & Mounce 1989)

Demand for previously under-exploited species such as spider crab has increased, and the fishing fleet in this region is very versatile using a number of fishing methods corresponding to seasonal fisheries throughout the year (Gray, 1995).

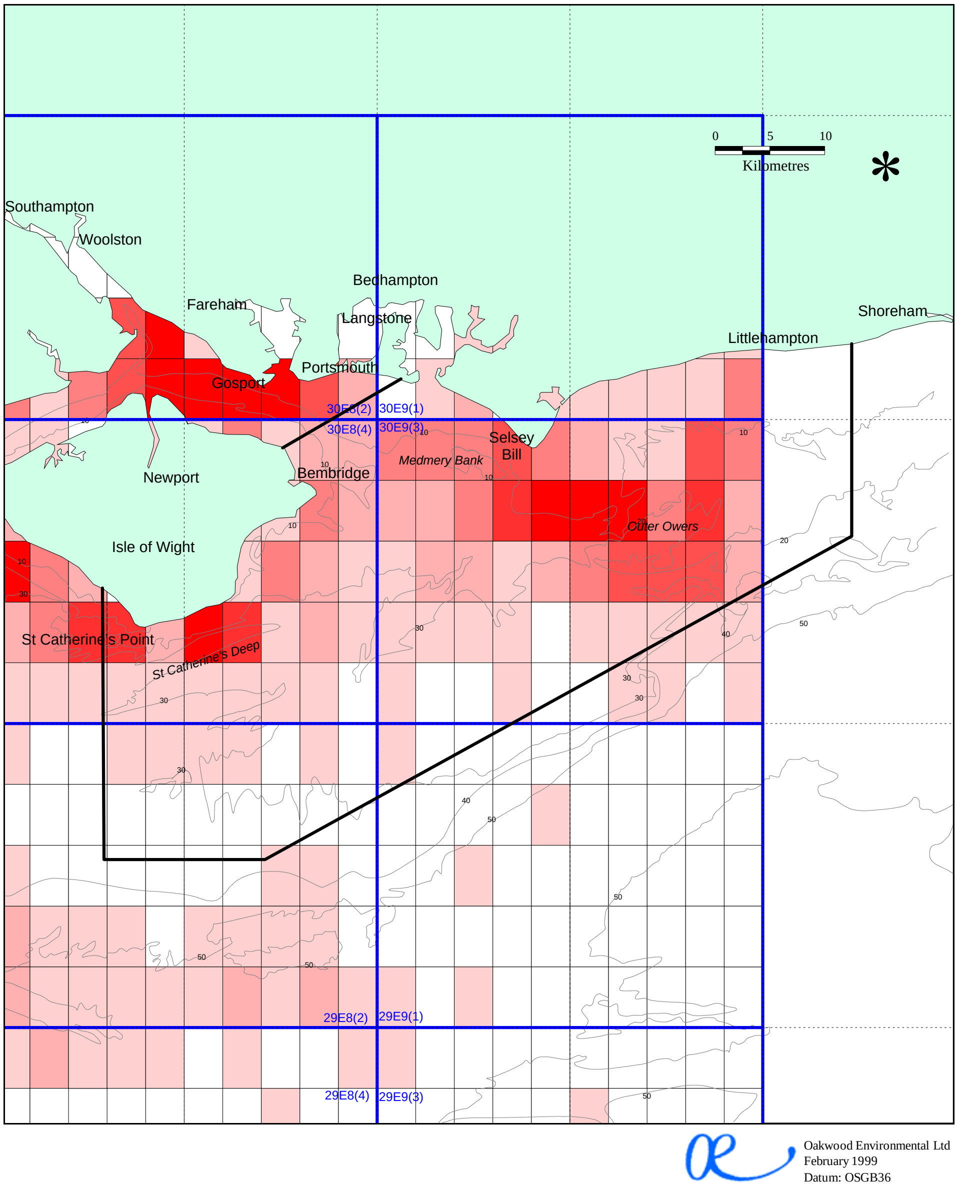
The fishery is close to the large and lucrative south-eastern coastal market, and also has good links with other markets by road to London and the many cross-Channel ferries to Continental Europe (Nicholson and Mounce, 1989).

3.8.1.4 Distribution of fishing activity in the pilot study area from MAFF Aerial Surveillance Data

MAFF surveillance aircraft survey the sea surrounding the UK regularly throughout the year recording gear type, nationality and size of any fishing vessel sighted during survey flights. Such data, presented using GIS techniques, can therefore be used to develop an understanding of the distribution of fishing activity in the region, with the intensity of observations of the different vessel types recorded acting as an indicator of fishing activity. Data can be presented for all forms of fishing activity, that is: potters, anglers, trawlers, netters and liners, along with summary plots of all UK and foreign vessels. An example is presented in Figures 3.6.

For administrative purposes, the region covered by surveillance craft is divided into areas of sea called ICES sub-rectangles. Aerial surveillance data for the period January 1990 to October 1997 has been used in this example, comprising a total of 1683 vessel sightings. As can be seen from Table 3.6, surveying effort varies between ICES sub-rectangles. Data from each sub-rectangle is therefore adjusted to take account of this and hence allow visual comparison of data from different sub-rectangles. Figures for different types of fishing activity can therefore be used to compare relative importance of different parts of the pilot study area and different types of fishing activity in the region, whilst not showing actual levels of fishing activity.

Figure 3.6: Relative fishing activity for all UK vessels in the pilot study area, recorded by MAFF Jan 1990 – Oct 1997



Key:

Pilot Survey Area

ICES rectangle

Number of vessels sighted has been standardised to allow for variation in surveying effort in each ICES sub-rectangle

No of vessels sighted (standardised) 1990-1997

- 0
- 0.01 to 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- 10+

Source: MAFF, 1997

Table 3.6: MAFF Aerial surveillance visits to the pilot study area

	Number of visits (surveillance effort)								
ICES Sub-rectangle	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997 (Jan to Oct)**	**Total**
30 E8 - sub rectangle 2	19	14	11	14	23	11	15	16	**123**
30 E8 - sub rectangle 4	57	48	63	52	58	48	51	56	**433**
30 E9 - sub rectangle 1	34	21	32	31	40	17	21	20	**216**
30 E9 - sub rectangle 3	86	79	78	72	72	67	79	70	**603**
29 E8 - sub rectangle 2	22	15	22	27	15	12	27	18	**158**
29 E8 - sub rectangle 4	18	12	17	24	12	9	19	16	**127**
29 E9 - sub rectangle 1	26	32	27	30	25	22	37	29	**228**
29 E9 - sub rectangle 3	14	15	21	26	20	13	26	20	**155**

Source: MAFF (1997)

A full description of the analysis of the MAFF aerial surveillance data is not given here. In summary however, the main fishing activity, in relative terms, taking place within the pilot study area appears, on the basis of MAFF aerial surveillance data, to be potting, with lower levels of angling, trawling and netting, although higher levels of trawling activity is apparent in the eastern Solent. Overall therefore the highest level of activity appears to be in this area, off the south coast of the Isle of Wight and in the region of the Owers Bank (Figure 3.6).

3.8.1.5 Fishing effort within the pilot study area

There are highly productive fishing grounds within the pilot study area, from the south of the Isle of Wight to the south coast ports of Selsey, Yarmouth, Portsmouth and Chichester, and also other grounds further out to sea. These factors, together with a reported decline in the productivity of the region around the central part of the pilot study area (e.g. Fishing News, 10/2/95), indicate that vessels are fishing further afield. This is supported by examination of aerial surveillance data for the last seven years.

As stated previously, the majority of fishing activity within the pilot study area is directed at potting, for crab and lobster, and to a lesser extent, whelks, whilst trawling is focused on the eastern Solent (outside the study area), but exists at a lower effort throughout the area. An active bass rod and line fishery exists within the area, with the area generally of some importance for sea angling, targeting species such as bass, black bream, tope, smooth hound and spurdog.

The level of fishing effort and the value of the fishery within the pilot study are important to consider. Given the difficulty in obtaining direct evidence from individual fishermen as to the fishing effort, catch, and hence landings value, it is suggested that annual landings, and the fishing effort, of vessels fishing in the area can be estimated using a variety of sources. These include consultation with for example, fishermen, MAFF Fisheries Officers, Sussex Sea Fisheries Committee officers, shellfish merchants, along with the examination of published papers (i.e. Nicholson and Mounce 1989, Myers 1992, Gray 1995). The percentage of total fishing effort expended can then be used as a direct estimate of the catch taken.

As an example, the annual gross landings value per crab and lobster potting vessel within the pilot study area for 1995 has been estimated at between £50,000 and £100,000. This estimate, combined with the effort apportioned between the various target species revealed during consultation, gives typical landings for a potting vessel in Table 3.7.

Table 3.7: Projected typical landings: potting vessel based Selsey-Eastern IOW

Species	No. days fishing/year *	Range for average daily catch (kg)	Range for yearly catch (kg)	Maximum value £/year	Median value £/year	Minimum value £/year
Edible Crab	150	100-200	15-30,000	30,000	22,500	15,000
Lobster	240	10-20	2,400-4,800	48,000	36,000	24,000
Spider Crab	100	100-200	10-20,000	20,000	15,000	10,000
Total/year	-	-	-	98,000	73,500	49,000

* Gear can catch more than one species per day fishing.
Source: Oakwood Environmental Ltd consultations (1996)

Fishing patterns vary according to the time of year, with edible crab taken from August to April. Effort then switches to lobster during the spring/summer, with spider crab also taken between June and November. As a consequence, a steady return is available to the adaptable fisherman throughout the year. (Relatively little fishing takes place within the Nab Tower spoil ground, although there is some trawling and charter angling activity there).

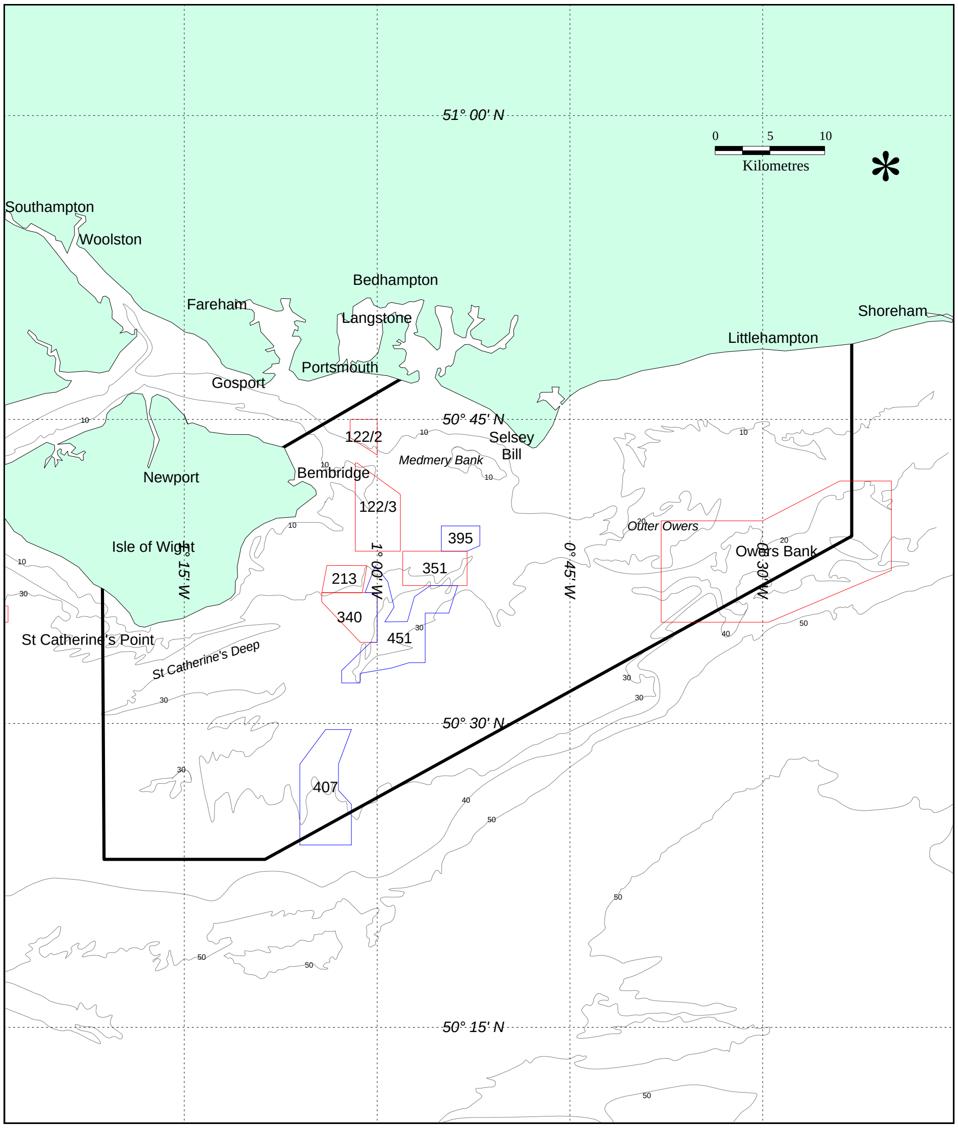
Following the success of angling for bass, a commercial summer offshore fishery has recently developed in the area. Only dedicated and well found craft (10m) are likely to operate in area on a regular basis, though smaller craft may fish the area occasionally. Boats from Selsey, Bembridge and Portsmouth region, regularly visit the area. It seems likely that between 8 - 10 boats, from the Gosport/Portsmouth region, also regularly visit the central part of the study area to prosecute the bass fishery, using rods baited with live sand eels. It is not, however, known how much effort is expended by these vessels and thus it is not possible to estimate its value.

The total landings from any one fishery (fin fish or shellfishery) within the pilot study area will depend on the amount of effort expended within the Area, and on that basis the value of the catch as a percentage of the total landings can be determined for each fishery. This data can then be used in an economic and social impact study to determine the potential level of impact upon the fishery as a result of dredging activity.

3.8.2 Other Dredging Activity

As has been previously stated (*see* Chapter I – Introduction) extensive sand and gravel sheets and banks are located in the vicinity of the Isle of Wight. As a consequence there are 9 existing licensed dredging areas in the South Coast Region, from Worthing to Christchurch, of which 5 are within the pilot study area (Figure 3.7). Additionally, 3 more licence applications are in the public domain, with a further number either imminent or pending, centred around the Owers Bank and Nab Tower.

Figure 3.7: Location of existing licence areas within the pilot study area



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February 1999
Datum: OSGB36

Key:

- Pilot Survey Area
- Existing licence Areas
- Application Areas in the public domain

Source: Crown Estate, 1998

It is becoming increasingly important for data to be made available to those undertaking EAs with which an assessment can be made, in percentage terms and using GIS tools, of the proportion of the seabed actually dredged from that licenced. GIS tools can then be used to graphically interpret and display this information, as pie-charts for example. This information is critical to an assessment of cumulative effects, as it goes someway in determining the potential of a cumulative effect, given the proportions of seabed directly impact with respect to the region as a whole.

3.8.3 Disposal at Sea

3.8.3.1 Munitions

Owing to the recent history of the pilot study area, munitions may be found on the seabed due to loss during wartime. These could include World War II mines, bombs and torpedoes. The distribution may be localised at certain sites, for example at wreck sites, or scattered widely across the area. Information from the MoD (pers comm, 1995a) confirms that munitions have been retrieved by dredgers working in the east Solent area. The sizes and types of munitions recovered have normally been 3" to 6" and occasionally 12" shells. Approximately 50% of munitions recovered in this way are live (MoD, pers. comm. 1995a), i.e. fused and therefore potentially capable of detonating. By the nature of their loss, the locations of these munitions are not associated with a particular area, except in the case of wrecks, and their positions are therefore in most cases unknown. It is therefore difficult to predict the likelihood of dredging within any area encountering lost munitions.

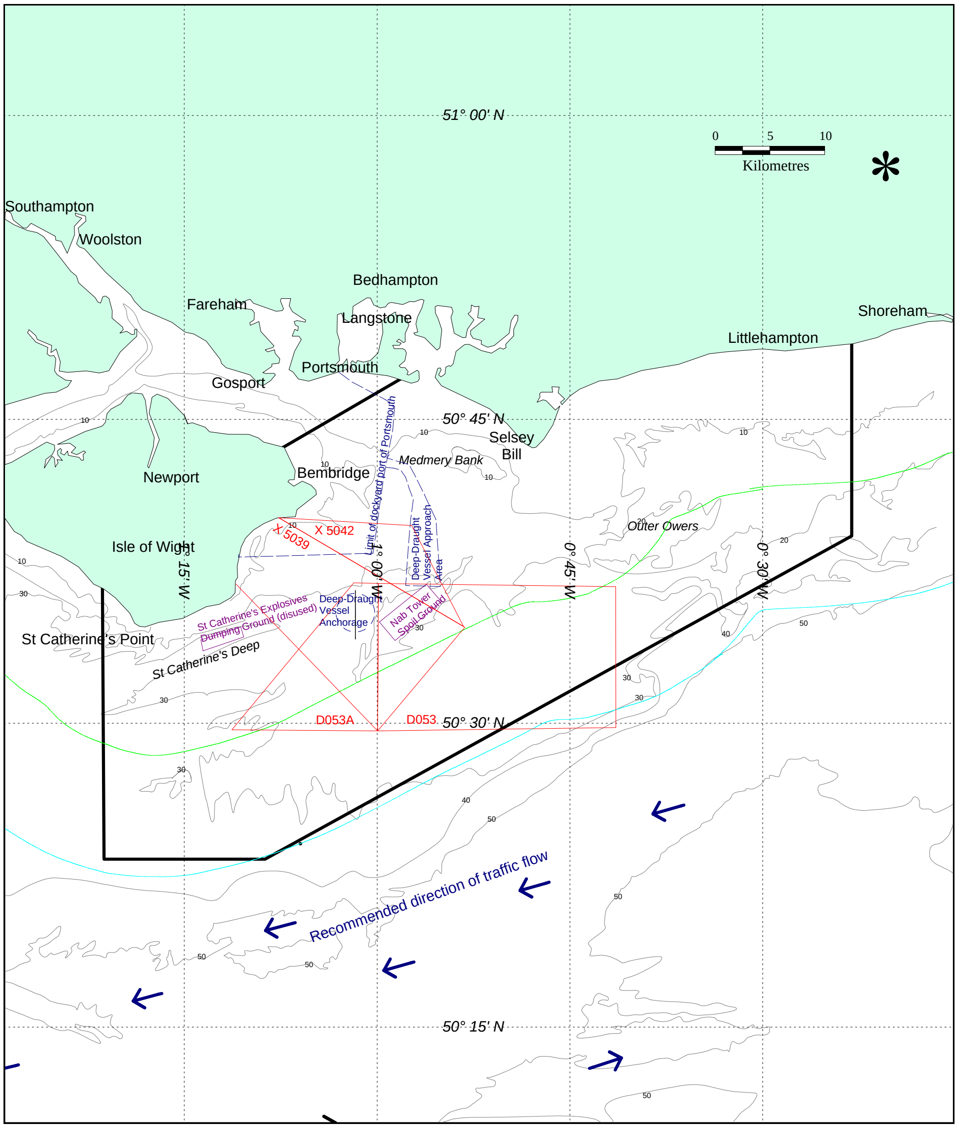
A defined explosives dumping ground called the St Catherine's Deep Dumping Ground (Figure 3.8) is located off the south-east coast of the Isle of Wight. The dumping ground occupies $3.7km^2$ of seabed. There are no surviving records that indicate the nature of material dumped here, but it is known that it is now disused, and was not a major disposal site for redundant munitions. It is likely that munitions found here are of a naval origin (MoD, pers. comm. 1995b).

3.8.3.2 Licensed Sea Disposal Sites

There are nine waste disposal sites located along the south coast from Brighton to Poole. However, the site of primary interest with regard to the pilot study area is waste disposal site WI060, called the Nab Tower (Figure 3.8). The Nab Tower disposal ground, located in the eastern approach to the Solent, is rectangular in shape and orientated in a north-east to south-west direction. It lies in a channel with a water depth of around 40m with the exception of a small area in its south-west corner which is less than 30m deep. The hydrodynamic conditions at the disposal site are such that material dumped there is rapidly dispersed over a wide area, which is routinely monitored by MAFF for accumulation of contaminant material (*see* section 3.6.5.2).

As stated previously, dredging activity should nonetheless avoid the potential for the re-suspension of known contaminant material if levels are shown to be potentially damaging to the benthic and fisheries resources of the area. It is unlikely, however, that dredging will target such areas, in order to avoid contaminated cargoes. Monitoring measures indicated in Chapter 4 should ensure that this remains the case.

Figure 3.8: Location of navigational features, fishing limits, waste disposal sites and MoD exercise areas in the pilot study area



Oakwood Environmental Ltd
February 1999
Datum: OSGB36

Key:
- Pilot Survey Area
- Labelled navigational feature
- Waste disposal site
- MOD exercise area
- 6 mile fishing limit
- 12 mile fishing limit

Source: Hydrographer of the Navy (1990, 1993)

Four categories of material have been licensed for disposal at the Nab Tower. These include capital dredgings, maintenance dredgings, sewage sludge and sediment washings from the processing of aggregate. The quantities of each of these four categories dumped over the period 1990-1994 are given in Table 3.8 below. Since 1994, a further estimated 10 million tonnes of dredged material has also been dumped here, derived from a major capital dredging scheme to deepen the navigational channel at the approaches to the Port of Southampton in 1996 and 1997.

Table 3.8: Quantities of material dumped at the Nab Tower (WI060) 1990-1994

Year	**Dumped Tonnage**			
	Capital Dredgings	Maintenance Dredgings	Sediment Washings	Sewage Sludge
1990	36,544	644,607	-	252,860
1991	166,166	632,163	-	262,194
1992	49,517	550,371	9,190	262,593
1993	591,337	570,687	29,025	268,016
1994	107,936	644,279	28,374	264,405

Source: MAFF Pers. Comm. 1996

MAFF issues licences for the disposal of waste at sea under the Food and Environment Protection Act (1985) Part II. During the period 1990-1996, there were 39 licence holders with a total of 169 licences for dumping at the Nab Tower. Of these, 46 licences were for the disposal of capital dredgings, 93 licences were for the disposal of maintenance dredgings, 23 licences were for the disposal of sediment washings and 7 licences were for the disposal of sewage sludge.

Licensing records indicate that the capital and maintenance dredgings material is derived from about 80 sites on the south coast and the Isle of Wight. The sources of dredged material on the south coast include the River Itchen, River Hamble, River Test, Southampton Water, the Solent, Portsmouth Harbour, Chichester Harbour and Langstone Harbour. The sources of dredged material on the Isle of Wight include the Medina River, Cowes and Bembridge Harbour.

Sediment washings are derived from aggregate processing facilities on the South Coast including those operated by Kendall Bros. at Portsmouth; Hall Aggregates at Cowes, Southampton and Chichester; United Marine Aggregates at Chichester; Solent Aggregates at Southampton and Northwood (Fareham) Ltd at Fareham.

Sewage sludge is derived from 4 local sewage treatment works in the region, operated by Southern Water Services. Although sewage sludge dumping will cease in 1998, those presently using the Nab Tower (ABP Southampton, Kendall Bros. and Portsmouth Commercial Port) anticipate a continued need for the site for the disposal of sediment washings and/or dredgings.

As with all sites where sewage sludge is dumped, the Nab Tower is regularly monitored, in this case by MAFF.

3.8.4 Offshore Oil and Gas

The pilot study area lies in offshore blocks 98/10&14-15 and 99/6-8&11-13 which are currently not licensed and have not been previously licensed, although blocks 99/16-17 in the deeper water to the south-east are licensed. Redundant oil and gas installations or any oil and gas production activity are therefore not expected. Only following consultation with oil and gas operators, regarding their strategic development plans can exploration or future offshore facilities be discounted, within a CEA context.

3.8.5 Wrecks And Archaeology

As previously stated (*see* Chapter I – Introduction), the archaeology of the pilot study area, and in particular the gravel rich fluvial deposits off the south-east coast which are of interest to the marine aggregates industry, is an issue of particular concern to local councils and the Royal Commission on the Historic Monuments of England (RCHME). The authors have recently commissioned specific project based desk studies to investigate further the archaeology of the offshore and central sections of the area (Wessex Archaeology, 1998a) and it is with conclusions reached in such reports that mitigation and monitoring measures have been developed (*see* Chapter 4 – Mitigation and Monitoring). The archaeology of the area is concentrated on two aspects: the potential for Palaeolithic and Mesolithic remains, and the presence of shipwrecks.

It must be noted that when discussing the potential for the presence of archaeological artefacts below, the discussion is primarily focused upon those areas adjacent to the offshore fluvial aggregates deposits. The following is provided as a brief review and should not be considered as a thorough archaeological assessment of the pilot study area. Reference should be made to the original report for further details.

3.8.5.1 Palaeolithic and Mesolithic remains

The deep channel at approximately 40m below Chart Datum (CD) trending roughly north-east to south-west across the pilot study area appears to coincide with the former course of the Solent River prior to the most recent inundation of the south coast, initiated c. 13,000 years BP (before present). As sea level rose, the area became submerged, preserving the topography of the former river valley in the current bathymetry of the Area. Taking from the current bathymetry the depth of fluvial deposit, an assessment of the topography prior to sea level rise can be made. The current bathymetry is assumed to represent the pre-inundation topography, and it is primarily this pre-inundation topography that is used to assess the degree of archaeological potential. It should be borne in mind, however, that the pre-inundation topography may have been masked or eroded in the course of inundation.

<u>Lower (c. 500,000 - 150,000 BP) and Middle (c. 150,000 - 30,000 BP) Palaeolithic</u>

It is estimated that the gravel deposits within the main valley are relatively recent deposits (c. 11,400-13,000 BP) and may be among the most recent deposits associated with the former course of the Solent. It is therefore unlikely that the deposits contain any Lower Palaeolithic material other than that which has been eroded from a much earlier terrace upstream and re-deposited. Although the presence of such material cannot be ruled out, its derivation substantially reduces its archaeological significance.

The potential for *in situ* Lower Palaeolithic remains is uncertain, but likely to be limited to any deposits that have not been disturbed by subsequent fluvial or marine action. Such deposits are likely to occur in the shallower water to either side of the main palaeo-valley, and perhaps more importantly, the east-west aligned ridge across to the south of the area. The potential for Middle Palaeolithic material is also uncertain, although most studies relating to this period indicate that there was probably only sporadic occupation of Britain by *Homo neanderthalensis* (neanderthal man) during this time.

In view of the fact that substantial assemblages of at least Lower Palaeolithic material have been discovered within the catchment of the Solent River, any finds dating to these periods are likely to be only of regional significance.

<u>Upper Palaeolithic (30,000 BP - 8,500 BC) and Mesolithic (8,500-4,000 BC)</u>

During these periods, sea levels changed markedly as the last glaciation finished around 11,000 years BP. This alteration of sea level had a profound influence on the location of areas of high archaeological potential within the pilot study area.

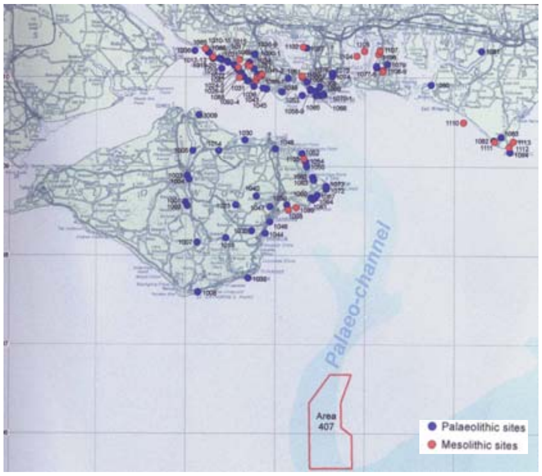
The topography during the Upper Palaeolithic period shows that the cliff tops and spurs to the east of the valley of The Solent River would have served as favourable locations overlooking the developing estuary for a period of perhaps 2000 years (i.e. between 9,000 and 11,000 years BP), while the broad inter-tidal margin to the west of the valley would have become increasingly uninhabitable. Similarly, the spurs either side of the narrow gorge to the south may have served as focal points in exploiting and controlling the natural resources of the area for the semi-nomadic hunter-gatherers that were known to be present in Britain during this period.

There is therefore limited potential for the presence of Early Upper Palaeolithic material in the offshore, but some potential for assemblages of Late Upper Palaeolithic and Early Mesolithic material. By the Middle to Late Mesolithic the entire area would have become uninhabitable due to sea level rise. The regions of highest potential are those to the east and south, overlooking the main palaeo-valley, predominantly outside the limits of accessible sand and gravel reserves in the area. The potential for *in situ* Late Upper Palaeolithic and Early Mesolithic assemblages is augmented by the presence of alluvial and organic deposits to the north of the area, as demonstrated by the fluvio-estuarine deposits found in a recent borehole.

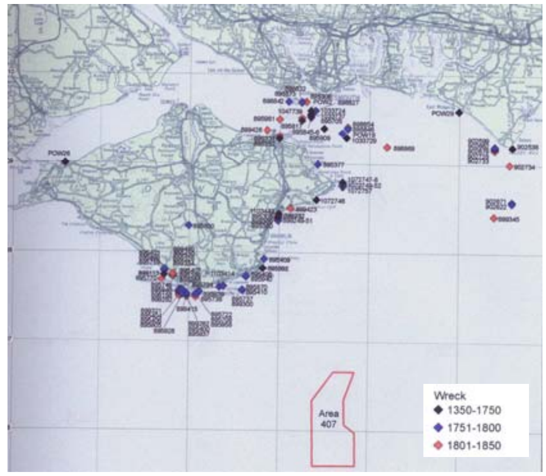
In considering the significance of any Late Upper Palaeolithic or Early Mesolithic assemblages within the area, it is worth noting that the Solent River was the largest fluvial system in Britain wholly outside the limits of glaciation (Bridgeland, 1996). As such, any demonstrated human occupation in the Late Upper Palaeolithic and/or Early Mesolithic would be of regional and national significance. Furthermore, as no such assemblages have been investigated *in situ* within UK territorial waters, the demonstrated presence of Late Upper Palaeolithic or Early Mesolithic assemblages in such depths would be of national and possibly international significance.

Figure 3.9: Sites of archaeological interest in the pilot study area

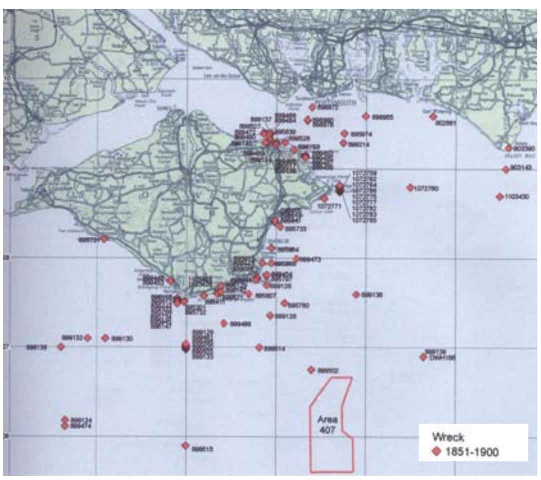
a) Palaeolithic and Mesolithic sites



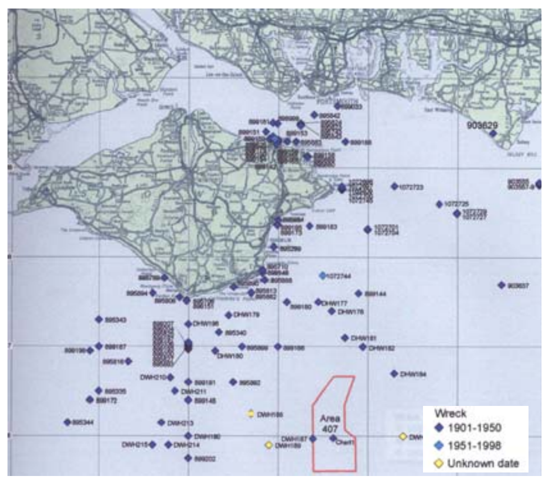
b) Shipwrecks: 1350-1850



c) Shipwrecks: 1851 – 1900



d) Shipwrecks: 1901-1998 and those of unknown date



Source: Wessex Archaeology, 1998b

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February 1999
Datum: OSGB36

3.8.5.2 Shipwrecks (7,000 BC - present day)

Known wrecks

The Hydrographic Office hold information on all wrecks in UK waters. Following a database search (Hydrographic Office, 1996) for charted and uncharted wrecks, wreck data is plotted (Figure 3.9). The search revealed numerous wrecks within the pilot study area, including many, and in particular foreign vessels, sunk during wartime activity. In accordance with the practice of affording protection to foreign war graves in UK waters, any such wrecks should not be disturbed. With regard to dredging activities therefore, exclusion zones of at least 100m should be afforded such sites.

The Protection of Wrecks Act 1973 provides for the designation of shipwrecks of national importance for their archaeological or historic value. One designated wreck within the pilot study area includes the Invincible, a 74 gun third rate naval vessel that sank in 1758 in the East Solent. Since there are only 43 designated UK wrecks in total, it cannot however be taken as a guide to the archaeological resource of the area.

Documented losses

273 records of documented losses held by the National Monuments Record are referenced to points along the adjacent coastline between Walpen on the Isle of Wight, and Selsey Bill, West Sussex, corresponding to some or all of the unidentified known wrecks recorded on the Hydrographic Office database.

Archaeological potential of wrecks

Wrecks recorded by both the Hydrographic Office and National Monuments Record include predominantly wrecks from Post-medieval and Modern periods. However the potential for wrecks within the area possibly dates back as far as the inundation of the site in the Early Mesolithic period. Although the potential for the survival of wrecks of stone age boats in UK waters is speculative, and all Bronze Age boats discovered to date have been close inshore, it is likely that remains of any undiscovered wrecks, possibly dating back to the Iron Age, may survive in quite good condition within the areas of the fluvial aggregates deposits.

It should be noted that wrecks often occupy an extended area beyond the confines of any remaining hull, depending on the circumstances of loss and the effects of post depositional processes. The extended area may contain significant elements of structure, artifacts and stratified deposits and has to be considered as an integral part of the wreck site. Furthermore, in addition to the potential for shipwrecks of many periods, the area also potentially contains items lost or thrown overboard, an indicator of preferred sea routes through the centuries.

3.8.6 Shipping and Navigation

The limits of the Port of Portsmouth lie within the pilot study area, as do the Nab Channel Deep Draught Vessel Approach Area and a Deep Draught Vessel Anchorage (Figure 3.8). To the north lie the major commercial ports of Portsmouth and

Southampton, which along with the Naval Dockyard at Portsmouth result in a considerable amount of maritime traffic passing through the area. To the north-west lies Bembridge Harbour and to the north, Portsmouth, Chichester and Langstone Harbours, all of which provide a great deal of local commercial and leisure traffic passing through the area.

Consultation with the relevant Harbour Masters should be undertaken as a matter of course prior to, and during the EA process, to ensure that the cumulative effect of all this shipping activity is considered. The following information is provided for the guidance of those undertaking the EA process within the pilot study area. Broader mitigation measures, to be adopted where relevant, are included within Chapter 4 – Mitigation & Monitoring. If such measures are employed, no individual, or therefore, cumulative impacts should occur.

3.8.6.1 Portsmouth

The Competent Harbour Authority for Portsmouth, whose responsibility it is to regulate commercial pilotage to and from Portsmouth has in the past stated that they could foresee no reasons why additional dredging in offshore areas should cause any significant hazard to vessels entering or leaving Portsmouth Commercial Docks. The presence of additional vessels (assuming they show the required signals appropriate to their operations) should not represent any hazard to commercial vessels using Portsmouth Harbour. The Queen's Harbour Master, HM Naval Base, Portsmouth, however only has the responsibility to respond to any areas within his jurisdiction (Figure 3.8).

P&O European Ferries, Portsmouth confirmed that at the time of consultation crossings on their Portsmouth-Le Havre route represented five vessel movements a day through the Area. However P&O do not consider that dredging will present a problem to their ferries, provided that dredging vessels exhibit the appropriate Colreg (The International Regulations for the Prevention of Collisions at Sea) signals at all times during dredging. Furthermore P&O request prior notice of dredging operations commencing. Similarly Commodore Ferries, Portsmouth could see no reason for any objection as long as similar conditions are met.

3.8.6.2 Southampton

Associated British Ports (ABP), Southampton envisage operational dredgers to be of no great concern, provided that the Colregs were followed, but do emphasise the potential for large numbers of commercial vessels approaching the port via the Nab Channel, both from the south-east and south-west. Particular advice should be adopted by operational dredgers whereby they should note large vessels constrained by their draught and displaying three red lights and/or embarking their pilot and restricted in their ability to manoeuvre.

3.8.6.3 Chichester

The Conservancy Manager and Harbour Master should be contacted so that any concerns can be addressed within the ES. No concerns have in the past been raised with regard to the direct impact of dredging activity. Figures provided indicate that 3 fishing vessels operate from Chichester Harbour and occasionally fish within the area.

In addition, average figures for the number of leisure vessels crossing the area per day during suitable weather periods can be provided upon request.

3.8.6.4 Langstone

The Harbour Manager should be contacted so that any concerns can be addressed within the ES. No concerns have been raised in the past when considering the potential for dredging activity to cause adverse affect on Langstone Harbour, although other concerns of the harbour were voiced, which are addressed later. However it should be noted that the Harbour has recently become a Conservancy (along the lines of Chichester Harbour) and similar regulatory and conservation powers now exist within the Harbour.

3.8.6.5 Bembridge

The General Manager and Harbour Master should be contacted so that any concerns can be addressed within the ES. Previously they could foresee no problem with dredging activity provided the International Colregs were observed, although other concerns of the harbour were voiced, which are addressed later.

3.8.7 Ministry of Defence Exclusion Zones

Four naval exercise areas: X5039, X5042, D053A, and D053 lie within the pilot study area (Hydrographer of the Navy 1995b) (Figure 3.8). Consultation with the relevant military authorities should be ensured so that any significant individual or cumulative impacts are avoided with regard to the movement of military traffic through the proposed dredging area. Nonetheless, the Navy has in the past indicated that, due to the nature of the exercises conducted in these areas, they do not perceive any impact from dredging activities.

3.8.8 Leisure Activities

The Solent and Southampton Water region, by virtue of having an extensive coastline, sheltered water, easy accessibility to the south-east conurbations and reputation for good weather, is popular for recreational activity.

Leisure activities in this region can be broadly split into those restricted to the coast or near coastal waters, and those that can occur in coastal and open water. Coastal activities include water skiing, jet skiing, windsurfing and bathing. Open water activities can include yachting, angling and diving. The description below is restricted to those activities associated with open water, and therefore most likely to occur within the offshore licence areas of the pilot study area.

3.8.8.1 Yachting

Yachting is a major leisure activity in this region, with 43 marinas located on the coasts of Hampshire, West Sussex and the Isle of Wight, providing berths for 20,100 vessels (Reid *et al*, 1993). Consultation with the Royal Yachting Association (RYA) has indicated that as many as 30,000 vessels may be based in the Solent area. Yachts may pass through the pilot study area en-route to the French coast from marinas in Bembridge, Chichester, Pagham and Hayling Island area. As with commercial traffic, precise figures are not available for the numbers of craft that use this route, although RYA indicated in 1995 that of the order of 3,000 yachts based in the Solent area are capable of making such a journey, primarily in summer.

As long as the mitigation measures indicated in Section 4 relating to navigation are adopted however, no significant individual or cumulative impacts upon yachting from dredging activity are likely.

3.8.8.2 Sea Angling

Sea angling is a popular sport, practised by over 2 million people in Great Britain (Fowler, 1992). The sport has three main forms: angling from the shore, inshore fishing within about 5km of the coast, and deep sea angling.

The main organisations representing charter sea angling skippers that undertake angling trips in the pilot study area are the Langstone Harbour Licensed Boatmen's Association and the Gosport and Portsmouth Licensed Charter Fishermen's Association, representing in total at least 30 skippers. In addition, the Bembridge Angling Club on the Isle of Wight represents amateur anglers, including over 50 boat owners. One commercial sea angling skipper is also based at Bembridge Harbour. To these vessels must be added a large number of private boat owners, the number of which is virtually impossible to ascertain.

The species targeted by deep sea anglers varies according to the time of year. Sharks, skates and rays (notably tope, smooth hound, spurdog, lesser spotted dogfish and various rays) together with plaice, bass, mackerel and black bream form the main target fish during spring and summer. In winter, angling effort shifts to whiting and cod. A wide range of other fish will also be taken, such as conger eel over wrecks. The majority of sharks caught by anglers are released rather than landed for weighing (Vas, 1995). Fishing tackle used is generally rod and line.

Licences are issued by the DETR that permit charter skippers to carry passengers either up to 20 or 60 miles from the coast, i.e. the pilot study area is within the range of skippers based on the South Coast who hold either licence type. Unlike the muddy substrate found in much of the eastern Solent, the stable rocky/gravelly/sandy ground of the fluvial aggregates deposits will support crustacea and other benthos that would attract popular target species such as tope. Skippers indicate that the pilot study area occupies part of a major deep sea angling area east of the Isle of Wight between the Nab Tower and Dunnose Head, and wholly within a wider area of frequently visited water between 50°30'N and 50°40'N. This area is popular because it is relatively sheltered, with low tidal flow rates in comparison to the west of St Catherine's Point.

MAFF aerial surveillance data should therefore be mapped using GIS (as Figure 3.6) to indicate the boundaries of the sea area most frequently fished by anglers. As with commercial fisheries, consultation can be used to set temporal boundaries, i.e. for how long a certain area has been used for angling, and socio-economic studies used to determine the impact threshold of the angling industry, i.e. the level of commercial and financial vulnerability to change resulting from dredging activity.

However, it is recognised that the economic value of charter angling specifically attributable to any one area is extremely difficult to quantify. This is primarily because there are very little data regarding important components of angling activity such as the scale of shark fisheries in the British Isles (Vas, 1995). With regard to the whole region (i.e. the sea area south of Hampshire and east of the Isle of Wight), consultation with charter anglers indicates that a minimum of 30 charter vessels are active, typically making 100 angling trips/vessel/year, carrying 8 anglers per vessel. This gives a conservative estimate of 3,000 vessel visits to the region per year. In addition, there will be angling activity by amateur clubs, notably Bembridge Angling Club on the Isle of Wight.

Deep sea angling is clearly therefore a major commercial and leisure activity in the area and of significant economic value, both directly and indirectly, through the ancillary industries that service the charter skippers and amateur anglers. The pilot study area lies within a major charter angling zone which is already perceived by charter angler skippers to be under pressure from existing aggregate extraction licence areas in the region. Consultation is therefore clearly important to the EA/CEA approach. As long as the mitigation measures indicated in Section 4 relating to navigation are adopted however, no significant individual or cumulative impacts upon angling from dredging activity are likely. Furthermore, if the mitigative provisions relating to archaeology are adopted, potential impact will be lessened further, as wreck sites are particularly popular for angling.

3.8.8.3 Diving

The very large number of wrecks present within the pilot study area also make it popular for diving (Pritchard and McDonald, 1991) with at least 23 diving clubs, two diving schools and three diving charter boats based in the Solent region. Sports divers organisations, the southern region of the British Sub-Aqua club and the local coaches for the Solent area indicate that many of the wrecks of the area are dived regularly by clubs and schools operating out of the Portsmouth and Southampton area. Furthermore divers operate out of Littlehampton, and, from other clubs on a less frequent basis, the coastal ports stretching from the Solent to Brighton.

With many of the wrecks only accessible to the sports diver by boat, consultation with diving organisations will be very important if any potential impact is to be avoided. Increased water turbidity can temporarily reduce visibility and so restrict diving and boats may operate in the vicinity of dredging operations. However if the mitigative provisions relating to archaeology are adopted, potential impact will be lessened further, as wreck sites are obviously particularly popular for divers.

3.8.9 Sub-Sea Cables

There are no sub-sea cables within the pilot study area, and therefore no individual, or cumulative, impacts are expected. Nonetheless, communication with the relevant authorities, i.e. British Telecom, should ensure that open dialogue prevents potential commercial and operational conflict.

3.9 Pilot Study Area – Policy Framework

3.9.1 Statutory Designations

There are no statutory designations covering the offshore part of the pilot study area itself. However, there are a number of areas on this stretch of coast that are covered by various types of statutory designation (Figure 3.10). These are the areas where coastal Local Authorities, Conservancies and Conservation Bodies will be most focused regarding the potential for impact from dredging activities. Confirmation that a patchwork of licences will not result in a cumulative effect upon those physical processes forming the coastline will go a long way in resolving such concerns.

However it will still be important to consider the licence applications more carefully within the context of coastal planning issues and the protection of sensitive habitat receptors, as defined by the various designations. This requirement is due to the forthcoming statutory procedures (*see* Chapter I – Introduction), the Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations (DETR, 1998b; Scottish Office, 1998). These bring together the requirements of the EC Environmental Impact Assessment Directive and EC Directive 92/43/EEC (the conservation of natural habitats and of wild fauna and flora), commonly known as The Habitats Directive. The introduction of these Regulations will mean that the importance of marine habitats and the protection of sensitive areas from impact by marine dredging will be recognised.

The principles of ecosystem analysis could therefore be applied in order to quantify the level of potential impact from dredging activity, by extending considerations beyond species to the ecosystem and investigating landscape-scale processes such as habitat fragmentation (CEQ, 1997). Habitat modification and assessment of exposure should help determine resource thresholds beyond which environmental stress to damaging levels will occur, as well as impact boundaries. For if the dredging activity is to potentially directly impact fish or seabird populations upon which sites are designated, then the geographical zone of potential impact may extend to the coast where such sites are situated.

Sites with conservation interest under the following international and national statutory and national non-statutory designations should all be considered within an EA/CEA approach, whether adjacent, or in the region of the proposal.

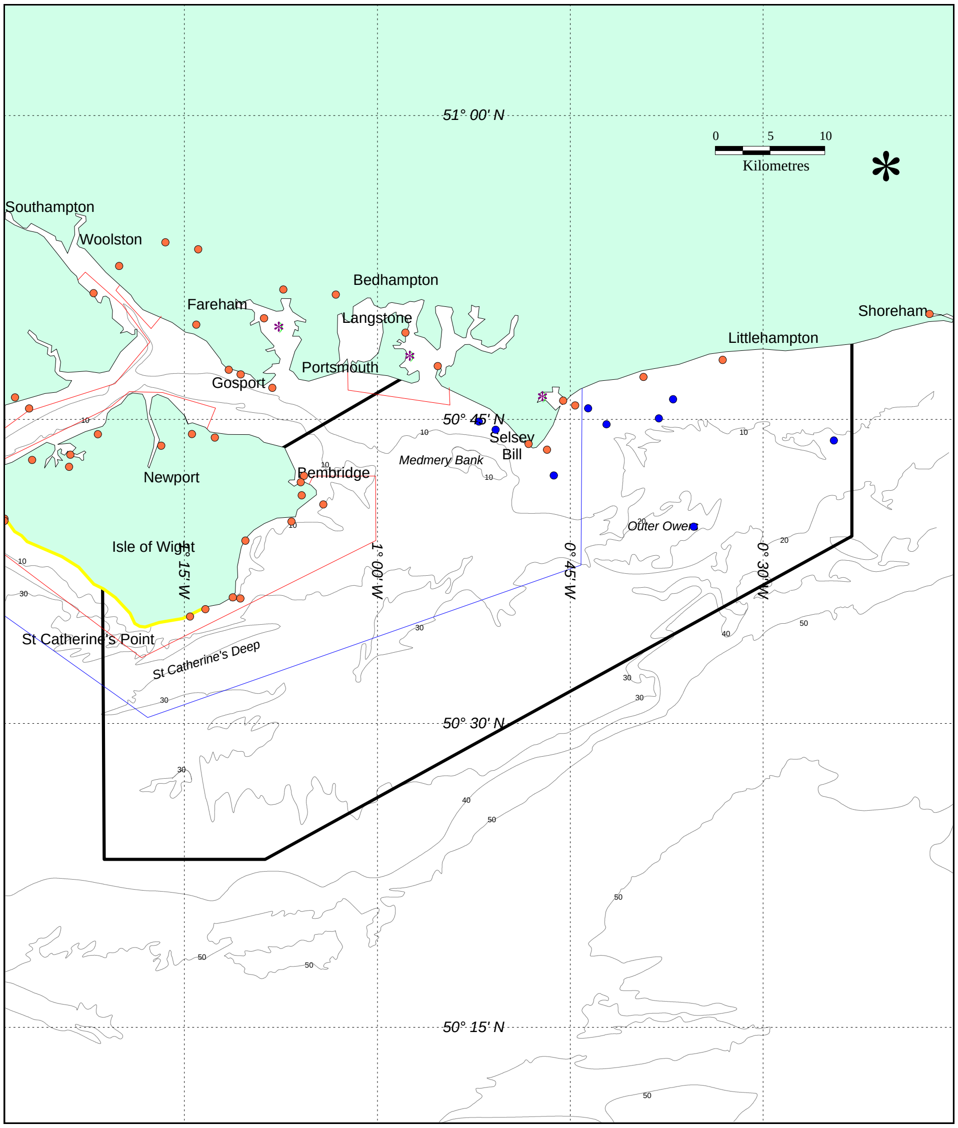
3.9.1.1 Sites designated under International Conventions and Directives

<u>Wetlands of International Importance (Ramsar sites)</u>

The Ramsar Convention on the Conservation of Wetlands of International Importance was ratified by the British Government in 1976. Such sites hold over 20,000 waterfowl, or regularly support 1% of the population of one species (or sub-species) of water fowl.

Portsmouth, Langstone and Chichester Harbours are Ramsar sites (Figure 3.10). The south coast of Hampshire and the north coast of the Isle of Wight are proposed for designation as the Solent and Southampton Water Ramsar site.

Figure 3.10: Location of sites of nature conservation importance in the pilot study area



Key:

- Pilot Study Area
- Important Area for Marine Wildlife (Sensitive Marine Area)
- Seaward boundary of South Wight Maritime, and Solent Maritime Candidate SACs
- Heritage Coast
- Ramsar Site
- Special Protection Area
- Site of Special Scientific Interest
- Marine Site of Nature Conservation Importance

Sources: English Nature (1994, 1996, 1997), Barne *et al* (1996), Fowler (1995), West Sussex County Council (1997), JNCC (1998)

Special Protection Areas (SPA)

Under the EC Wild Birds Directive (EC 409/79), Special Protection Areas (SPAs) are selected by English Nature and are designated as such for the protection of particularly sensitive species, or for regularly migrating birds.

Portsmouth, Langstone and Chichester Harbours are SPAs (Figure 3.10). The south coast of Hampshire and the north coast of the Isle of Wight are proposed for designation as the Solent and Southampton Water SPA.

Special Areas of Conservation (SAC)

Areas designated under the EC Habitats Directive (92/43/EEC) as SACs are considered outstanding examples of selected habitat types or areas important for the continued well-being or survival of non-avian species. It is with particular regard to SACs that the forthcoming statutory Regulations will focus upon.

There are two sites currently designated as SACs within the pilot study area (Figure 3.10): the South Wight Maritime SAC, which includes sub-tidal rock or biological reefs, and the Solent Maritime SAC (JNCC, 1996).

3.9.1.2 Sites established under National Statute

National Nature Reserves (NNR)

National Nature Reserves are declared by English Nature under the National Parks and Access to the Countryside Act, 1949, or the Wildlife and Countryside Act, 1981. One of the main functions of National Nature Reserves is to protect key areas representative of the major natural and semi-natural habitats in the UK. There are, however, no NNRs within the pilot study area.

Sites of Special Scientific Interest (SSSI)

These are sites, while not managed as nature reserves, which have special interest by reason of their flora, fauna, geographical or physiographical features. They are designated under the Wildlife and Countryside Act, 1981.

Numerous SSSIs with some marine interest are located on the coastline of the pilot study area as listed below.

Chichester Harbour
Pagham and Church Norton Spits
Selsey East Beach
Bracklesham Bay
Bonchurch Landslips
Bembridge Down
Whitecliff Bay and Bembridge Ledges
Brading Marshes
St Helen's Duver
St Helen's Ledges
Hanover Point to St Catherine's Point

Local Nature Reserves (LNRs)

These are owned, leased or managed by Local Authorities under the National Parks and Access to the Countryside Act 1949. Rew Down is the only LNR within the pilot study area.

Areas of Outstanding Natural Beauty (AONB)

AONBs are designated by the Countryside Commission under the National Parks and Access to the Countryside Act 1949. The primary purpose of designation is to conserve natural beauty. Much of the southern coast of the Isle of Wight falls within an AONB.

3.9.1.3 Sites with no statutory protection

Heritage Coast

The designation of coastline as Heritage Coast by the Countryside Commission and local authorities aims to preserve coastline of exceptionally fine scenic quality. Within the pilot study area, the coastline between St Catherine's Point and Ventnor is designated as such.

Sensitive Marine Areas (SMA)

English Nature has identified 27 areas in UK which were seen to be important areas for marine wildlife around England (English Nature, 1994). These areas are also known as Important Areas for Marine Wildlife.

The seaward boundary of the Solent and Isle of Wight SMA passes through the pilot study area. Sub-tidal habitats of note within the SMA include chalk bedrock off the south and east coasts of the Isle of Wight which are considered to be of international importance (Fowler, 1995).

It will be important to consider the percentage of the SMA, from its total sea area, that is both presently licenced, and dredged, in an assessment of the cumulative effects from the patchwork of licences that exist. Not only will be the area potentially impacted be important to consider, but a knowledge of the nature of the marine ecosystem within it will be critical to resolving the level of potential impact. Only with this knowledge will an ecosystem analysis, as described in 3.9.1 be possible.

National Trust Sites

There are four coastal National Trust sites on the south-eastern coast of the Isle of Wight:

St Helen's Duver
Bembridge and Culver Downs
Luccombe Farm
Knowles Farm and St Catherine's Point

<u>County Conservation Trust Reserves</u>

These reserves are managed by local county conservation trusts and are representative of their habitat type on a local scale. There are two Hampshire and Isle of Wight Wildlife Trust reserves on the southern coast of the Isle of Wight: Niton Undercliff and St Lawrence Bank.

<u>Marine Sites of Nature Conservation Importance (mSNCI)</u>

These are sites of nature conservation interest identified by Local Authorities to protect their habitats and wildlife and encourage sensitive management. A total of 12 marine SNCIs have been recognised by West and East Sussex County Councils, with the most westerly located just off Selsey Bill.

3.9.2 Relevant EC Directives

A number of European Community Directives are relevant to the management of coastal waters. These are:

- 76/160/EEC — Bathing Water Directive
- 79/409/EEC — Conservation of Wild Birds Directive
- 79/923/EEC — Shellfish Waters Directive
- 91/492/EEC — Shellfish Hygiene Directive
- 92/43/EEC — Conservation of Natural Habitats and of Wild Fauna and Flora Directive ('The Habitats Directive')

The Government is responsible for implementing these Directives and has now incorporated most of the requirements into legislation or policy. Although the above Directives have a general relevance to marine aggregates licence applications, there are no relevant specific requirements.

The exception to this will be the realisation by the UK Government of the need to combine and implement the requirements of The Habitats Directive within the forthcoming statutory procedures for the control of marine dredging (*see* Chapter I – Introduction). The Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations will mean that the importance of marine habitats and the protection of sensitive areas from impact by marine dredging, as is required by the EC Environmental Impact Assessment Directive, will therefore be recognised.

3.9.3 UK Government Policy on Marine Aggregates

Current Government Policy relating to aggregate provision is primarily contained in Minerals Planning Guidance Note 6 - Guidelines for Aggregate Provision in England (MPG6), published in 1994 (Department of the Environment). MPG6 covers the 15 year period from 1992 - 2006.

Furthermore in early 1999, as a result of the forthcoming statutory procedures in the UK, DETR will also be publishing a 'Marine Planning Policy Guidance' document for public consultation. This will set out the Government's future policy on marine dredging; the balance to be struck between meeting the need for marine sand and gravel and protecting the marine environment and coast; and the criteria by which dredging applications will be determined.

Until such time, the purpose of MPG6 remains in its advise to mineral planning authorities and the industry on what needs to be done to ensure that the construction industry continues to receive an adequate and steady supply of minerals at the best balance of social, environmental and economic costs.

The policy on marine dredging states:

> "Marine dredged sand and gravel is an important source of aggregates for the construction industry. In 1989, it made up 18% (20mt) of the total consumption of sand and gravel in England and Wales. It is a particularly important source of supply for south-east England. This source reduces the pressure to work land of agricultural or environmental value and it can often be landed close to the point of demand. The Government is aware of the special need for marine aggregates in soft coastal defence schemes, where it is often impossible to make use of material from non-marine sources. Where appropriate sources of supply can be identified, marine aggregates will continue to contribute to maintaining supplies of aggregates for the construction industry."

MPG6 sets out specific guidance on minerals provision in each region. MPG6 guidelines for primary aggregate production in the South-East (1992-2006) is:

Primary won land sources	450 mt
Marine Dredged Aggregate (26%)	260 mt
Imports from outside England and Wales	145 mt
Imports from Wales	5 mt
Secondary and Recycled Aggregates	140 mt
Total	**1000 mt**

No account is taken in MPG6 for requirements of marine dredged material for beach nourishment, contract fill or for exports. MPG6 also states that the figures should not be regarded as a target or a ceiling, and that the respective proportions of aggregate source will vary according to market forces.

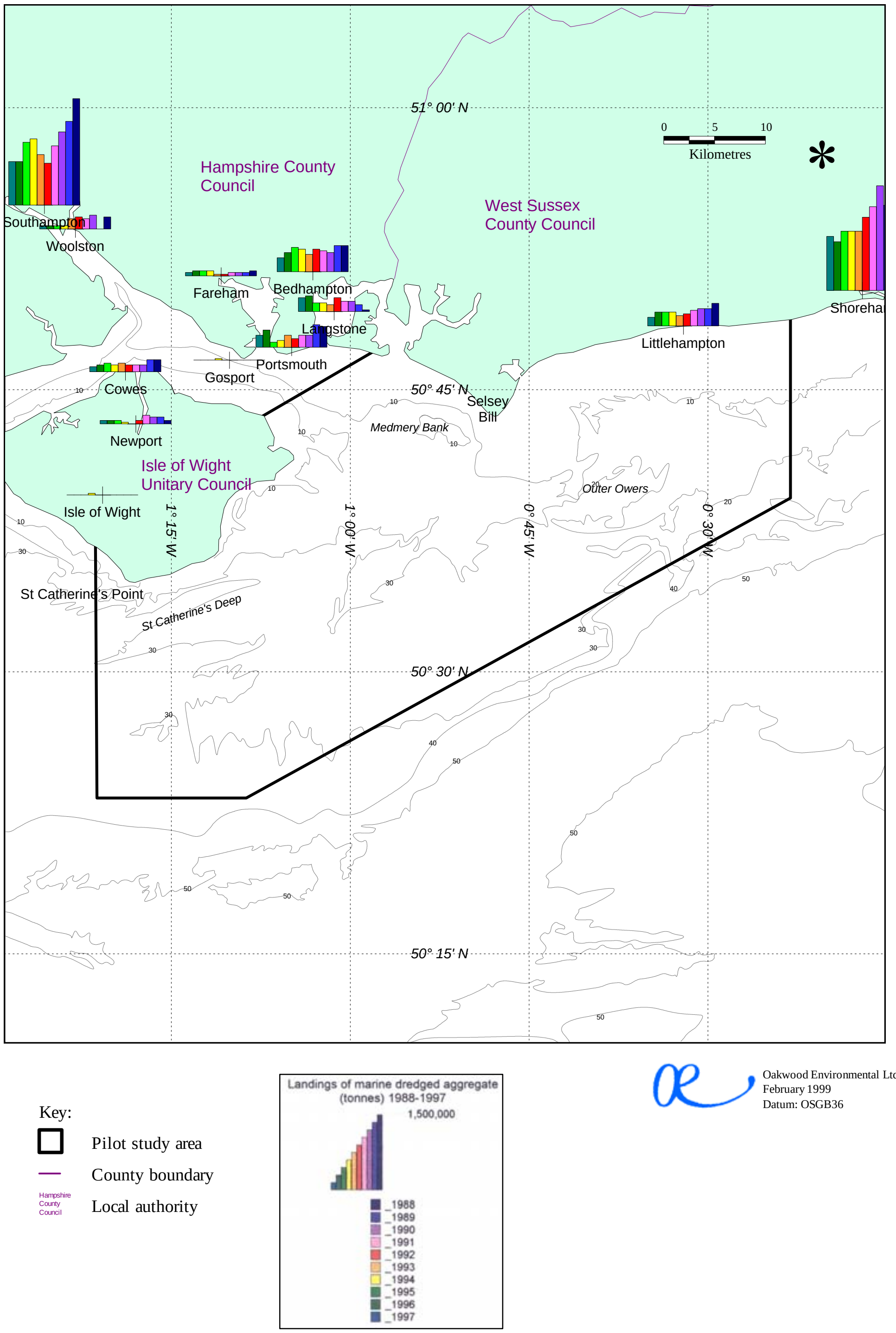
3.9.4 County Minerals Policies

3.9.4.1 West Sussex County Council

West Sussex County Council has issued a Deposit Draft for the West Sussex Minerals Local Plan (West Sussex County Council, 1997). This draft document states that the Council has no responsibility for the licensing of new reserves, but is a consultee during the Government View procedure.

The document states that "The County Council is charged by the Government with safeguarding existing aggregates wharves in West Sussex. There are currently four active wharves; three at Shoreham and one at Littlehampton (Figure 3.11). The authorities at both ports have made clear their wish to expand trade generally but they are constrained by poor transport links at Shoreham and by problems with maintaining the channel at Littlehampton."

Figure 3.11: Landings of marine dredged aggregates in the pilot study area between 1988 and 1997



Source: Crown Estate (1988-1997)

The current stated policy on the provision of minerals supply for West Sussex is given in the 1993 West Sussex Structure Plan (West Sussex County Council, 1993) where policy M1 states:

> "An increase will be sought in the proportion of local demand for aggregates met from marine, rail-borne or sea-borne sources."

The South East Regional Aggregates Working Party (SERAWP) has provided a sub-regional apportionment of the MPG6 requirement for aggregates (RPC2705). The apportionment to be supplied by West Sussex (to 2006) is 1.4 million tonnes per annum. This will require an additional 82-167 hectares of land for gravel and 25-42 hectares of land for sand (West Sussex County Council, 1994). Any increase in marine supplies will reduce pressure on land-won materials.

3.9.4.2 East Sussex County Council

East Sussex County Council (ESCC) have lodged the Minerals Local Plan Deposit Plan for final comment (East Sussex County Council, 1996a).

Relevant policies to marine aggregates are policies 9-12, covering developments at Shoreham, Newhaven, and Rye for the import of marine aggregates.

The East Sussex Structure Plan (East Sussex County Council, 1996b) gives the policy on marine dredged minerals as:

> "MIN 9 The import trade in marine dredged material and crushed rock aggregates will be supported and encouraged to increase by the following means:
>
> a) action to secure and maintain the supply of marine dredged material from appropriate off shore deposits will be supported where other marine interests are properly safeguarded;
>
> b) facilities to receive and process seaborne aggregates imports should be retained and developed at the ports of Shoreham, Newhaven and Rye consistent with the environmental infrastructure, and port capacity constraints. Proposals should accord with agreed port development policies and, in the case of Shoreham, appropriate access improvements will be supported;
>
> c) an enhanced role for the port of Newhaven in the importation of aggregates will be encouraged including greater use of the rail link for the distribution of aggregates;
>
> d) the establishment of rail depots to receive and process imported aggregates will be encouraged where such facilities are consistent with the other policies of this Plan."

ESCC estimate that the maximum current annual capacity at the three aggregate handling plants at Shoreham, Newhaven and Rye to be 3 million tonnes per annum (including Shoreham facilities in West Sussex). According to SERAWP, the apportionment of land-won sands and gravels for production in East Sussex is 0.3 mtpa. Their adopted policy is to provide a landbank of 7 years above the 10 year policy plan period, equivalent to 5 mt for the period 1996-2013. Land extraction permissions are such that the import of marine dredged aggregates will be required for this entire period in order to supplement the contribution from land-won sources.

3.9.4.3 Hampshire County Council

Hampshire County Councils Minerals and Waste local plan: Deposit Plan (Hampshire County Council, 1993) contains several policies regarding marine aggregates.

Policy 25 states that:

> "The County Council will seek, encourage and support appropriate action to ensure that any need for aggregates to be supplied within Hampshire over and above the levels of supply provided for by Policies 18-20 (*land-supplies*) is met by:
>
> (ii) marine dredged sand and gravel landed at wharves in Hampshire."

Policy 26 covers safeguards for 11 wharves in Hampshire (landings are shown on Figure 3.11) and designates two additional sites for potential aggregate wharves:

a) Drivers Wharf, Northam, Southampton, and
b) Dock Gate 20, Millbrook, Southampton.

New wharves or developments of existing wharves will be supported provided that the location is suitable, and that the development would not be likely to cause unacceptable environmental, traffic, or other impact.

The Deposit Plan (Hampshire County Council, 1993) was published before the new MPG6 Policy. There is to the authors' knowledge no further information available at the time of writing on County aggregate provision.

3.9.4.4 Isle of Wight Unitary Council

The Isle of Wight was given unitary status in April 1995. A draft Unitary Development Plan (UDP) was published in February 1996 (Isle of Wight Council, 1996).

Within the UDP, Policy M2 refers to marine aggregate wharves:

> "M2 The Council will seek to safeguard and will normally permit the improvement, modernisation and extension of imported and marine aggregate wharves at the following locations, provided that the development would not result in increased disturbances, visual intrusion, and are acceptable in highway access terms:
>
> a) West Medina, Stag Lane, Newport,
> b) PD Fuels Depot, Medina Wharf, Arctic Rd, Cowes,
> c) Kingston, East Cowes."

The Council considers that landings of marine dredged sand and gravel will increase over the next decade and improvements may be needed within existing wharves to accommodate this.

Gravel aggregates are unloaded at specific quays within the River Medina, and at Blackhouse Quay, Newport (Figure 3.11).

3.10 Pilot Study Area – Alternative Sources of Material

3.10.1 National Level

Current guidelines for the sourcing of aggregates in England as detailed in Section 3.9.3 are set out in MPG6 (DoE, 1994). MPG6 strategy is that marine aggregate should continue to supply some 7% of the nation's requirements. Over the plan period (to 2006), alternative sources providing the remaining 93% include land-won primary aggregate (natural sand, natural gravel and crushed rock), secondary aggregates (mineral waste, recycled aggregates) and imports of crushed rock from Scotland and Wales. In early 1999, as a result of the forthcoming statutory procedures in the UK, DETR will be publishing a 'Marine Planning Policy Guidance' document for public consultation. This will set out the Government's future policy on 'marine dredging and it is presumed will include guidance on alternative sources.

Before that time however the statutory procedures by which the licencing of marine aggregates will be regulated in the future will be introduced. The Environmental Assessment and Habitats (Extraction of Minerals by Marine Dredging) Regulations draft consultation document (DETR, 1998b; Scottish Office, 1998) states that: "operators will need to include in the ES an outline of any main alternatives studied for the proposed dredging that they intend to carry out".

The document does recognise however that such a process already occurs at present as best practice in respect of other forms of development project. Nonetheless it has been the authors' practice to routinely include such an assessment within an ES, as the need to study alternatives to the proposal within a policy context is considered to be intrinsic to the success of the application. It will of course go a long way, if developed further within the CEA approach, in addressing, on a regional scale, the alternatives in areas of multiple applications.

3.10.2 Regional Level

3.10.2.1 Introduction

Alternative sources of aggregate material that may be available on a regional level are considered below. These can be broadly divided between land-based sources, navigation dredgings and other marine aggregate licence areas.

3.10.2.2 Land-based sources

Land based sources of material have three main origins - natural sand and gravel deposits, crushed rock, and secondary aggregate. These are reviewed in detail in `Beach recharge materials - demand and resources' (CIRIA, 1996).

<u>Sand and gravel workings</u>

There are significant superficial (Quaternary) sand and gravel deposits in the south-east region that provide an alternative source of supply to marine dredged gravel.

These include three sand and gravel quarries on the Hampshire coast, and five on the Isle of Wight (Barne *et al*, 1996).

Land-based mineral extraction has significant potential impacts on the natural environment due to possible alteration of landscape and ecology, and also may affect air and water quality through emissions during extraction and transport (Owens & Cowell, 1996). Noise, dust and the visual intrusion upon the landscape by the pit and any associated waste tip are also of concern to the local population.

The main consideration limiting aggregate mineral extraction is not the abundance of this resource, but the impact of aggregates extraction, transport and end uses on other environmental assets: "Very large quantities of minerals resources exist, sufficient, in many cases, to last far into the foreseeable future. Nevertheless, it is becoming increasingly difficult to find sites that can be worked without damaging the environment to an extent that people find unacceptable." (Secretary of State for the Environment *et al*, 1994).

Assuming that land-based deposits could have a typical depth of 5m, one hectare (ha) of land quarry could yield approximately 90,000 tonnes of material. To extract an equivalent tonnage of material covered by this licence application (2.5 million tonnes of concreting quality material per annum) from land based sources, approximately 28ha per annum of land quarry would be required.

It has been proposed that coastal superquarries have the following potential benefits in comparison to other land-based sources of primary aggregates (Owens and Cowell, 1996):

- Sea transport of aggregate has environmental benefits over road;
- the concentration of production into a single high output site means lower environmental impacts per tonne of rock produced (in terms of noise, dust, vibration) compared to an equivalent output from many smaller inland sand and gravel pits;
- remote rural locations means that fewer people will be directly affected;
- the development of such sites would help reserve sand, gravel and high grade limestone resources elsewhere for future use.

<u>Crushed rock aggregates</u>

There are few sources of high quality rock suitable for use in road pavements and structural concrete located in the South East. Seven quarries on the Isle of Wight and Hampshire coasts provide minor quantities of crushed chalk aggregate (Barne *et al*, 1996). The environmental issues associated with sand and gravel workings also apply to sources of crushed rock aggregate.

<u>Secondary aggregates</u>

Secondary aggregates comprise mineral waste material such as colliery waste, china clay waste, slate waste, power station ashes, metalliferous slags, demolition waste, road planings and recycled aggregates. In the South East region, there are few sources of secondary aggregate with the exception of power station ash, demolition waste and road planings. These secondary sources are primarily used as constructional fill or lightweight aggregate and cannot therefore be considered a direct alternative to the material recoverable from the fluvial aggregates deposits in the pilot study area, which are primarily for use in concrete.

3.10.2.3 Navigation dredgings

There are two types of navigation dredgings: maintenance dredged and capital dredged material. At present, the majority of dredgings are disposed of by dumping at sea, with nearly 1 million tonnes dumped per year over the period 1985-1992 in the Isle of Wight region (CIRIA, 1996).

Maintenance dredging

The majority of material derived from maintenance dredging is cohesive. Although the material has some beneficial use, it cannot be considered an alternative to the fluvial aggregates deposits within the pilot study area, other than as non-granular fill.

Capital dredging

Since capital dredging is more likely to produce coarse material, it has greater potential to act as an alternative source of material. However, capital dredging schemes are not evenly distributed through time and are of variable quality, and so cannot be relied upon as a source of material.

For example, a capital dredging scheme at Southampton Water by ABP generated approximately 10 million tonnes of material in 1996/7. Superficially, this material could have acted as an alternative to that of the fluvial aggregates deposits within the pilot study area. However, a review of options by ABP Southampton (ABP, 1995) indicated that the material was largely unsuitable for use in concreting applications, and the only realistic option was to dump the material at the Nab Tower disposal site.

3.10.2.4 Marine aggregate dredging

Approximately 1 to 1.5 million more tonnes per annum is extracted from the south coast than is landed at south coast ports. This is primarily due to the landing of material derived from this region at Thames and other UK ports, its use in beach replenishment, or its export to continental Europe. (Table 3.9).

There is also a marked difference between permitted extraction tonnages for the south coast and actual extraction tonnages (between 32 and 61% has been extracted in the years 1988 and 1997 giving an average of 43%). This potentially leaves scope for these existing licence areas to act as alternatives to extraction from newly proposed sites. However with the difference due to variations in market demand, quality of material and location of extraction area in relation to demand, and fleet capacity of licensees to land material, use of alternative sites becomes a commercially oriented decision. There may be therefore less scope for increasing the supply of marine aggregate from existing sources than would at first appear.

In order to increase the volume of marine aggregates landed without increasing the area of seabed licenced, it may therefore be suitable to give up existing, and possibly un-worked licences, for new, more attractive licences. Such a mitigative measure could obviously not only lead to a reduction in the overall area of the seabed licenced but to an increase in the area available to commercial fisheries, along with a reduction of the potential for large scale impact to the benthic and fisheries resource of a region.

Table 3.9: Permitted and actual removals within the UK and landings at South Coast Ports

Region	***1997***	***1996***	***1995***	***1994***	***1993***	***1992***	***1991***	***1990***	***1989***	***1988***
Permitted (millions of tonnes)										
Humber	3.4	3.9	3.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0
East Coast	13.3	14.6	13.0	13.0	16.3	16.4	16.4	16.4	16.8	15.8
Thames Estuary	6.0	6.7	6.9	6.4	6.4	6.4	6.4	6.4	6.4	6.4
South Coast	**12.9**	**13.3**	**13.5**	**9.7**	**10.2**	**13.5**	**12.1**	**13.8**	**10.9**	**9.0**
South West	4.5	4.6	4.8	4.8	5.1	5.2	5.2	5.0	5.0	5.0
North West	0.7	0.7	0.8	0.8	0.7	1.4	1.3	2.1	2.1	2.1
Actual (millions of tonnes)										
Humber	2.35	1.90	1.79	1.91	0.00	0.00	0.00	0.00	0.00	0.00
East Coast	9.40	9.31	10.50	9.38	9.81	10.26	9.22	10.90	10.90	10.00
Thames Estuary	1.13	1.12	1.66	2.00	1.22	1.50	1.51	2.10	3.60	2.95
South Coast	**4.73**	**4.74**	**4.43**	**4.93**	**4.36**	**4.79**	**5.28**	**6.19**	**5.70**	**5.53**
South West	2.05	2.02	2.29	2.26	2.17	2.39	2.07	3.25	2.91	2.96
North West	0.28	0.29	0.28	0.29	0.38	0.31	0.31	0.49	0.47	0.43
Study Area Ports (millions of tonnes)										
Bedhampton	0.19	0.28	0.34	0.33	0.26	0.33	0.30	0.28	0.36	0.37
Cowes	0.07	0.09	0.12	0.10	0.13	0.10	0.09	0.10	0.18	0.17
Fareham	0.06	0.08	0.08	0.07	0.02	0.03	0.04	0.04	0.05	0.07
Gosport	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Langstone	0.21	0.21	0.13	0.12	0.09	0.19	0.15	0.15	0.10	0.03
Isle of Wight	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
Littlehampton	0.12	0.19	0.20	0.20	0.15	0.17	0.23	0.25	0.26	0.31
Newport	0.04	0.04	0.05	0.03	0.00	0.04	0.11	0.11	0.11	0.06
Portsmouth	0.17	0.24	0.06	0.10	0.18	0.14	0.17	0.16	0.32	0.30
Shoreham	0.77	0.69	0.85	0.83	0.84	1.03	1.18	1.47	1.22	1.10
Southampton	0.61	0.62	0.88	0.93	0.72	0.58	0.84	1.03	1.19	1.49
Woolston	0.06	0.06	0.04	0.05	0.14	0.17	0.14	0.19	0.00	0.18
Total	**2.29**	**2.48**	**2.75**	**2.79**	**2.53**	**2.77**	**3.25**	**3.78**	**3.78**	**4.07**

Source: Crown Estate, 1988-1997

3.11 Pilot Study Area – The Future

It will therefore be in the interest of dredging companies, dredging consortia and the industry as a whole, to work with, rather than against, the environment and those who rely on it. By promoting itself as a professional, proactive industry, extracting a resource with a clearly defined need, and undertaking whatever measure required to limit impact on the natural and socio-economic environment that drives the coastal and inshore zone it should continue to operate successfully. In order to win the approval of all relevant organisations and individuals with an interest in the natural environment of the pilot study area, the industry will have to follow at the least the EA framework contained within this research project.

If those ideas can be developed further into CEA for the areas where a patchwork of licences exist, some of the questions pertaining to the assessment of cumulative effects can begin to be answered. In order for such an approach to be successful however, any EA/CEA needs careful consideration of mitigative measures and monitoring proposals to ensure that the level of impact is within tolerable limits.

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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Section 4 – Mitigation and Monitoring

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4 MITIGATION & MONITORING

4.1 Potential Impacts

In this context, mitigation measures are those steps taken to make the predicted effects of dredging activity less severe. A wide range of potential impacts should have been examined in the ES. From those, impacts warranting detailed consideration of appropriate mitigation measures should now be investigated.

Firstly it is important to review the potential impacts examined:

- the potential for the physical effects of dredging to extend beyond dredged resource blocks by altering nearshore wave conditions or as a result of the generation of sediment plumes;
- the impact upon the benthic community within and beyond the licence area and the fish it supports, during and after dredging operations at the site;
- the impacts of the dredging operation on commercial fisheries, during and after dredging operations at the site;
- the potential impact upon wrecks and other areas of archaeological interest within and beyond the licence area;
- the potential for disruption to navigation in and around the licence area;
- the potential for a licence area to add to the total seabed dredged in the pilot study area;

and, most importantly:

- **the potential for dredging activity to have a cumulative effect on the region surrounding the licence area,** *(as defined by investigating the individual impacts, and using the tools and techniques suggested, i.e. determining spatial and temporal boundaries and resource thresholds, combine into a CEA to be contained within the 'Effects' section of the ES).*

Suggestions for measures to mitigate impacts are described below, with the section on each measure concluding with an outline of the residual impact assuming that the measure is successfully implemented. This is provided as a reasonably comprehensive list, from which mitigation measures can be derived, depending on the individual, and cumulative impacts identified within the 'Effects' section of the ES.

4.2 Mitigating Physical Effects Beyond The Boundaries Of The Licence Area

4.2.1 Nearshore Wave Conditions & Beach Drawdown

Much of the work undertaken to investigate the impact upon nearshore wave conditions and beach drawdown has been undertaken by HR Wallingford Ltd. To date, few, if any applications have individually shown to have a potential for significant impact on the height of waves reaching the coast, based upon maximum dredging depths. Dredging will not therefore be undertaken to greater depths than this without first confirming with HR Wallingford that their findings would be unchanged.

Some initial conclusions have been made regarding combined application areas, but it is recognised that further work by HR Wallingford, including modelling, is necessary to satisfy, in particular coastal local authorities, that there will be no cumulative effects from marine aggregates extraction.

4.2.2 Sediment Plumes

Studies of sediment plume generation by suction dredgers suggest that the finer the particle size of the material dredged, the greater the extent of the plume generated. Recent studies in the vicinity of marine aggregate dredging activity suggest that suspended solids concentrations are reduced to background levels within 450m downstream of a dredger (and within a period of perhaps 20-30 minutes) during normal loading operations (Hitchcock and Drucker, 1996, HR Wallingford, 1996b).

Silt deposits and other fine materials occur naturally in some parts of the pilot study area and are also dumped at the Nab Tower disposal site. Marine aggregates dredging companies should implement operational measures to minimise the extent of the sediment plume, comprising:

- the Dredger Master continually monitors loadings and ceases dredging if silt contamination is above normal levels for sand/gravel deposits, and will advise his company’s operations controller;
- the receiving wharf will advise the appropriate operations controller, who will then advise his central control office, if a cargo shows signs of excessive silt contamination;
- the central control office will record locations where silt contaminated cargoes have been loaded and will advise Dredger Masters through their appropriate operations controller to avoid these locations in the future.

It should be noted that significant contamination of aggregate cargoes by silt reduces its value, and that companies therefore require little incentive to avoid such deposits.

On the basis that these measures are implemented, the residual impact of the plume should be minor, with elevated turbidity and sediment deposition negligible beyond a few hundred metres from a working dredger.

4.3 Mitigating The Impacts on Benthos and Fisheries

There are a number of measures that can be adopted to minimise as far as practicable the impact upon benthos and fish, both in the short- and long-term. The detail of these mitigation measures should usually be developed in consultation with MAFF/CEFAS and other interested parties to reduce as far as possible the impact of dredging both within the pilot study area and on the surrounding seabed, whilst maintaining the viability of the resource. The extent of these measures are nonetheless outlined below.

4.3.1 Optimising recolonisation of the seabed after dredging

Recolonisation of the seabed after dredging should proceed relatively rapidly provided a few simple measures are adopted. These primarily relate to the state of the seabed once dredging ceases.

Whilst recent studies suggest that the particle size distribution of the seabed sediment after dredging need not be identical to that existing formerly (Marine Ecological Surveys, 1997c, Seiderer and Newell, in press), the dredging company, following the cessation of dredging, should endeavour to ensure that an adequate depth of surface sediment, of approximately similar particle size distribution to that existing formerly, remains on the seabed surface.

Areas with very thin layers of sand or gravel over bedrock should not therefore be dredged and should be 'zoned' out. Areas of undisturbed deposits between dredged areas may also provide an important source of colonising species which enable a faster recovery than might otherwise occur solely by larval settlement and growth. Reporting arrangements whilst dredging operations are ongoing, and similar to those described in section 4.2.2. (for silt), should also be adopted to avoid clay deposit exposure.

Sabellaria spinulosa, a benthic animal of some conservation interest, has been recorded in many dredged areas, including the pilot study area. 'Refuge areas' with a 100m radius centred sample stations that have the highest recorded abundance of this animal should therefore also be left undredged. This will provide potential centres for recolonisation after the cessation of dredging operations. The value of refuge areas for *Sabellaria* in close proximity to dredged areas is emphasised by the possibility that colonising *Sabellaria* larvae may be stimulated to settle by the presence of adults nearby (Holt *et al*, 1997). Any nationally rare or scarce marine benthic species for the British Isles present within the zone of impact should have similar 'refuge areas' designated around them.

That dredging will always result in the loss of some benthic animals is not in doubt. However, on the basis that these measures are implemented, after the cessation of dredging residual impacts will comprise rapid benthic recolonisation, with a diverse range of species present within dredged blocks after approximately 3 years. Biomass may take a few years longer to recover to levels comparable with those in unexploited deposits, based on recovery rates recorded for a wide range of deposits worldwide (Newell *et al*, 1998).

4.3.2 Mitigating impact upon fish resources

A typical heterogeneous sandy gravels fauna should recover from the kind of disturbance caused by dredging over the course of approximately 3 years, and recovery of the demersal fish resource dependent on this benthic community should occur over a similar time-scale. In making this assessment, it has been assumed that dredging operations are managed to ensure that marked changes in the physical habitat, particularly the exposure of clay bedrock, do not occur.

Beyond the immediate proximity of a working dredger, physical assessments have shown that the rates of sediment deposition attributable to dredging will be sufficiently low such that the effects on fish will be relatively modest outside the area actually dredged. This assessment is important to consider when viewed in the context of an assessment of cumulative effects.

Measures to minimise the exposure of clay or dredging of fine deposits, that would also mitigate the impact upon fish, have been previously described. In broad terms the degree of impact upon benthic communities and therefore fisheries will largely be a function of the area of seabed disturbed. The concept of zoning should therefore be seriously considered to restrict the area of seabed dredged at any one time.

Most mobile fish and shellfish will be displaced for the duration of dredging activity. On the basis that these measures are implemented, residual impacts after the cessation of dredging should comprise benthic recolonisation, taking approximately 3 years, with the fish communities that this resource supports recovering over a similar timescale.

4.4 Mitigating Impacts On Commercial Fisheries

4.4.1 Introduction

The impact of dredging operations on commercial fishing activity will result from a complex combination of physical, biological and human effects. Mitigation measures described in previous sections, by reducing the biological impact both in the short and long-term, will also mitigate the impact of dredging upon commercial fisheries. However, the impacts upon commercial fisheries do not solely arise from an impact upon the exploited biological resource.

Major alterations to the bottom topography can impede fishing activities, notably trawling, in the long-term. Dredging may also have an effect upon commercial fishing by influencing fishermen’s behaviour: fear of gear loss or damage will prevent them setting gear in active dredging areas. Socio-economic impact may also result in loss of earnings from reduced catches. Tools for determining the level of such impact have been described previously in Sections 2.3.3. and 3.5.7.3.

4.4.2 Alteration to bottom topography

At certain times of the year, trawling will be a major type of fishing activity, whilst other gear comprise netting and lining, and potting over the wrecks. Successful beam and otter trawling is mainly undertaken in areas of relatively flat seabed free of obstructions known as ‘fasteners’; whereas netting and lining are less reliant on an even seabed.

The nature of fluvioglacial deposits suggest that dredging may result in significant localised lowering of the seabed. Experience elsewhere suggests that where anchor dredging plant is deployed in small resource blocks, the subsequent bottom topography could potentially impede trawling activity after the cessation of dredging operations. Where dredging to depths of several metres is undertaken, it is therefore necessary to ensure that the seabed topography is altered in such a way that trawling is not impeded in the long-term. This will undoubtedly require consultation with local fishermen and MAFF to determine how this can best be achieved.

4.4.3 Reducing risk of fishing gear loss

Having defined, in terms of both individual and combined licence areas to be dredged, the total area of seabed to be licensed for extraction and that to be dredged, as result of ‘zoning’, the area to be worked at any one time should be calculated.

The time spent by vessels operating at any one time will obviously vary widely according to demand and the nature of the end use and the nature and number of dredgers working at any one time. On the basis of maximum extraction rates and mean hopper capacities, the time spent by dredgers within the licence area(s) should be calculated. An assessment can then be made as to the proportion of licensed seabed directly affected by dredging for all or part of the duration of the licence. This will result in an estimation of the time available to fishermen without fear of gear loss, with any variations in dredging activity viewed in the context of seasonal commercial fisheries operations.

Fishermen should be made aware of those undredged areas through liaison arrangements. These will be agreed in consultation with MAFF and local fishermen’s associations, and when implemented will be co-ordinated through standard Fishing Liaison procedures. It may also be necessary to employ the services of a Fisheries Liaison Officer on board the dredger during dredging operations, where appropriate.

In areas where there may be significant localised lowering of the seabed, possibly as a result of anchor dredging, there will also be the need to ensure that the seabed after dredging shows shallow gradients in order to minimise the potential for fishing gear loss or damage.

4.4.4 Residual impacts on commercial fisheries

These measures are primarily intended to ensure that assumptions used to formulate individual, and cumulative impact hypotheses are sufficiently conservative. The residual impact on commercial fisheries should result in no, or negligible estimated annual reduction in landings, according to the fleet and combination of areas dredged.

4.5 Mitigating Impacts On Wrecks And Archaeology

In order to mitigate impacts on wrecks and archaeology, dredgers should avoid all of the known wrecks in or very close to the licence area, to ensure that they do not suffer destabilisation or other damage. All these wrecks should be protected by a 100m radius dredging exclusion zone to ensure that they are at negligible risk of disturbance. The positions of all known wrecks should also be confirmed during bathymetric survey work that will in any case be undertaken prior to dredging operations as part of the physical monitoring programme.

In order to ensure that due regard is shown to any other undocumented archaeological aspects of the area, a remote sensing survey of the area to be dredged using sidescan sonar, interpreted using archaeological expertise, and magnetometer could help to identify areas of possible archaeological interest. Where areas of definite archaeological interest are found to lie in areas to be dredged, consideration will be given, where practical, to either;

(a) implementation of a dredging exclusion zone, or;
(b) seabed inspection, and subsequent implementation of a dredging exclusion zone, as appropriate.

Recent archaeological studies investigating the potential for recovery of archaeological artifacts both on the dredger and once ashore at the unloading point have concluded that it would not be possible to, with any degree of certainty, recover and classify archaeological remains once they have been removed from the seabed. Nonetheless, it could prove advantageous to assign an appropriately trained member of staff to be responsible for recording features of possible archaeological interest encountered during dredging. Any finds should then be reported to:

- ensure that the regulations set out under the Merchant Shipping Act 1995 are complied with in the handling of any artifacts recovered;

- offer up any items raised from the seabed to the Receiver of Wreck in the Marine General Division of the Department of the Environment, Transport and the Regions;

- ensure that the provisions of the Joint Nautical Archaeological Policy Committee (JNAPC) Code of Practice for Seabed Developers are observed.

The likelihood of dredging encountering archaeological remains is hard to predict. However, on the basis that these measures are implemented, the residual impact on archaeology should be minimised by ensuring that should any deposits be found, the appropriate mechanisms are in place for their appropriate treatment.

4.6 Mitigating Impacts On Navigation

Navigational issues that require mitigation relate to the avoidance of large vessels and disruption to buoyage.

4.6.1 Avoidance of large vessels

Following consultation with the local Harbour Authorities and Naval Dockyards (as appropriate), it is recommended that the following practices should be adopted to achieve safe dredging operations in licence areas:

1. All dredgers should carry up to date editions of the relevant Admiralty Chart, on which are clearly marked the limits of the dredging areas.

2. The dredging area should be divided into practical dredging sub-areas (zone) within which a vessel might be contained on any single loading operation. These should be individually identified by a code, and a copy supplied to the local Harbour Authority for liaison purposes.

3. A weekly schedule should be provided in advance to the local Harbour Authority, indicating the areas to be dredged and the vessels expected to take part. Changes to this plan can then be advised by the dredgers concerned.

4. Details of proposed dredging activity should be published in 'Notices to Mariners'.

5. An effective reporting system/good liaison with the local Harbour Authority should be maintained. All dredging vessels should contact them on a pre-defined working VHF Channel at least one hour before entering the dredging areas, giving the following information:
   ETA on site;
   Block to be dredged;
   Estimated duration on site;
   Direction of approach.

6. The pre-defined working VHF Channel should be monitored until loading is completed and the vessel reports herself clear of the area. The relevant Harbour Radio should also keep dredgers fully informed of all vessel movements expected in the vicinity, and of any special requirements at that time. Particular care should be taken to avoid high speed, and regular ferry movements and other dredgers involved in similar activity, or capital or maintenance activities.

7. Concentration of several dredgers in a close geographical area should fundamentally be avoided.

8. Dredgers should display the appropriate lights and shapes required by the International Regulations for the Prevention of Collisions at Sea.

9. Priority should be given at all times to large vessels constrained by the their draught (10m+) entering, leaving or turning into buoyed Deep Water Channels. Particularly busy turning locations and buoys should be protected by dredging exclusion zones.

4.7 Mitigating Impacts Resulting From Multiple Application Areas

In areas where there are multiple licences, the combined effect of these licences in combination with the proposed licence areas will have been determined through CEA. CEA will develop through the impact hypothesis and the tools previously detailed, the degree of impact upon both benthos and fisheries. This will, of course, be dictated by the area of seabed dredged. If impacts are determined as a result of cumulative effects, then the applicant will have to give consideration to the relinquishment of an area of currently licensed seabed equivalent to that occupied by active resource blocks. The residual impact would be to reduce the likelihood of an increase in the cumulative effects of dredging in the area potentially impacted.

4.8 Monitoring

4.8.1 Introduction

Monitoring is the repeated measurement of an environmental variable, and as such can provide the evidence necessary to demonstrate that dredging activities, with mitigation measures as appropriate, have not resulted in, or are likely to cause individual, or cumulative impacts causing lasting damage to the marine environment. Monitoring operations can be extremely expensive exercises, requiring the expenditure of considerable resources both at sea and in subsequent sample analysis and data interpretation. It is therefore essential that the need for monitoring is clearly demonstrated, and those monitoring measures that are adopted have precisely defined objectives. The results of monitoring work should be periodically reviewed and the monitoring programme continued, revised or terminated as a consequence.

Whilst the **single** objective of monitoring measures is to demonstrate that dredging has not caused, nor is likely to cause, long-term damage to the environment, monitoring can also be used to improve the scientific understanding of the field effects of dredging. If such an understanding is not readily estimated by laboratory or literature assessment, then monitoring can therefore enable an assessment to be made. Nonetheless, it has already been demonstrated that for CEA to be successfully deployed, a comprehensive dataset should exist prior to issue of a licence. Continued monitoring will therefore help to expand this dataset, and if disseminated correctly, could eventually lead to an overall reduction in the level of pre- and post- licence survey and monitoring necessary. Any monitoring measures adopted as part of a licence will therefore have to be the subject of detailed consultation with a range of interested parties, i.e. MAFF/CEFAS if they are to be efficiently utilised.

As a result, monitoring can provide the necessary information to regulatory authorities to assist their determination, when licences are periodically reviewed or on drafting of licence conditions, as to whether or not dredging operations should continue.

4.8.2 Monitoring the physical environment

4.8.2.1 Bathymetry

Modelling studies are usually implemented to predict whether any significant adverse physical effects will arise from dredging activity. As a precaution, bathymetric monitoring of the seabed in and around areas dredged has usually been recommended, to determine whether there is any evidence of dredging disrupting sediment transport pathways and/or alterations to the seabed outside the area. Such surveys should be undertaken before dredging commences and then repeated at regular intervals (for example, every 1-2 years) over the area dredged and throughout the period of the licence during which dredging takes place.

Following the first surveys, a comparison with the latest Admiralty surveys should be undertaken and analysis be carried out after each subsequent survey so that bathymetric changes can be detected. Attention should be drawn to areas where changes in depth since the last survey are greater than errors to be expected in the bathymetric surveys. Particular regard should be given to the depth of dredging, with the intention of ensuring that depth of dredging does not deviate by more than 0.5m from the average dredging depth, up to the maximum depth modelled prior to issue of the licence. Importantly, surveys and subsequent analysis should be carried out by a competent hydrographic survey team.

4.8.2.2 Sediment plumes

Although considerable work has already been undertaken to determine the temporal and spatial extent of the dredge plume, more work is likely, on a regional scale. It is expected that the results from these surveys will form the baseline of future physical monitoring criteria regarding the dredge plume. Nonetheless, such work should also consider the monitoring of the degree to which dredged areas trap sediment moving through the licenced area.

4.8.2.3 Resource thickness

A resource survey comprising a seismic survey and grab and/or vibrocore sampling as appropriate should be undertaken in conjunction with the periodic bathymetric survey to confirm that a sufficient depth of suitable material still exists over bedrock.

4.8.2.4 Out of area dredging

An Electronic Monitoring System (EMS) is already deployed on dredgers, to ensure that when approaching or manoeuvring in the region, outside the permitted dredging area, the draghead is raised clear of the seabed. The EMS record of the position of vessels during dredging is forwarded monthly to the Crown Estate by the applicant to ensure that dredging only takes place within that area licenced.

4.8.3 Monitoring the impacts on benthos and fish

4.8.3.1 Introduction

Benthic survey information compiled during the ES should provide information on the species composition, community structure and biomass of invertebrate communities within and adjacent to the licence area. These data form the baseline for assessing the impact of dredging within and outside the dredged areas, and provide a reference against which the recovery process can be monitored after cessation of dredging. Thus it should be possible to demonstrate whether dredging has, has not, or is likely to cause, long-term damage to the benthic community.

As previously stated, it is likely that benthic monitoring programmes will therefore be developed in consultation with MAFF/CEFAS and other interested parties in order to effectively assess the impact of dredging both within the licenced area and also on the surrounding seabed, during and after dredging operations.

4.8.3.2 Outline benthic monitoring methodology

Although quantitative methods for the analysis of marine community structure are highly sensitive, they are dependent on time-consuming and expensive evaluation of the fauna which, in typical gravel deposits, can comprise very large numbers of species. There are therefore practical advantages in carrying out rapid and cost-effective qualitative methods to assess the main characteristics of the benthic community in a particular area, before deciding whether to embark on a fully quantitative survey.

One such ‘rapid assessment’ method of marine benthic communities is to sample the seabed with a convenient grab, perhaps that used for related physical surveys. The variety of the main macrofaunal species and their relative abundance is then assessed aboard the survey vessel and the abundance and variety of macrofauna species of each sample allocated a relative qualitative score to allow inter-sample station comparison. This procedure will rapidly identify the zone of impact, and the results can be made available within a few days of the survey, supported by a species list for each station and the relative abundance of each species after confirmation of representative samples in the laboratory.

Such surveys should be undertaken at regular intervals over the area dredged and throughout the period of dredging, the objective being to provide early warning of any gross impact on benthic biological resources beyond the immediate vicinity of dredged resource blocks. This method will be used to cover a grid of stations similar to that covered in the initial baseline survey. It is likely that the benthic survey periodicity will be resolved as part of the licence conditions.

Only where the rapid assessment indicates that the impact footprint extends significantly beyond the dredged resource blocks, should a full quantitative survey be carried out of the biological resources and sediments in the area surrounding the dredged site. Such a quantitative survey will reveal subtle changes in community composition, and thus indicate with greater certainty whether dredging is indeed the cause of such changes, as well as adding to the overall dataset available to a wider commercial, academic and Governmental audience.

In line with the overall objective of the monitoring programme, it is also necessary to demonstrate that the benthic community has recovered following the cessation of dredging operations. Even assuming the mitigation measures previously outlined are adopted, it is unlikely that the re-established benthic community will be of exactly the same composition or age structure as that which was present before dredging; nor will it be possible to say whether the re-established benthic community is the same or different to that which would be present had dredging not occurred. To overcome these difficulties, recovery is defined as:

> ‘the re-establishment of a heterogeneous sandy gravels invertebrate community in which the animals characteristic of that community are present and are functioning normally’.
> (after IPIECA, 1990).

To demonstrate this recovery, a fully quantitative survey should therefore be carried out of the biological resources and sediments in the area within and surrounding the dredged areas. These data can then be compared specifically with those for the baseline (pre-dredged) area, and used to assess the potential for the benthic community to develop into a healthy benthic community. The survey should be undertaken three years after the cessation of dredging, with the need for subsequent surveys reviewed after the results of this survey are known.

4.8.3.3 Monitoring the impact upon fish resources

Fish populations naturally show wide fluctuations, and there are great difficulties associated with separating-out natural variation from those potentially caused by dredging (Barne *et al*, 1998). Sampling methods should ideally demonstrate explicitly that dredging has not caused long-term damage to fish resources. Any direct monitoring of fish resource is therefore unlikely to prove cost-effective and may be best undertaken on a regional scale, particularly in multiple licence areas. Such an approach will aid greatly the assessment of cumulative effects.

Nonetheless, it is considered that fish resources within dredged areas will recover in tandem with the recovery of the benthic community. Inferences with regard to recovery of fish populations can therefore be made from interpretation of the benthic monitoring work outlined previously.

4.8.4 Monitoring the impacts on commercial fisheries

The degree of impact of dredging upon fishing activity will be a function of the effects on the diversity and abundance of biological resources in the region and also the extent to which dredging inhibits normal fishing activity. Overlying this are a large number of factors unrelated to dredging that influence fish catches in the region.

A reduction in fish catches inside dredged areas, for the duration and shortly after dredging operations, relative to control sites is anticipated whilst dredging is ongoing. Whilst there are recognised risks associated with direct fisheries monitoring work, an understanding of the impact upon fisheries can be derived from the interpretation of data generated by the benthic monitoring surveys.

In order to try and quantify any level of impact however, it is likely that any single technique alone, such as a log-book schemes or any other commonly-used comparative method will not prove representative. Therefore a combination of the log-book approach, landings data (levels and value), GIS mapping of MAFF aerial surveillance data (as previously demonstrated) and economic and social impact studies will be required. Overall, it will be to the advantage of all concerned that such an approach has the full support and acceptance of the commercial fisheries in question.

4.8.5 Monitoring the impacts on archaeology

Preliminary bathymetric surveys should determine the precise position of known wrecks within areas to be dredged and thus help to define the location of exclusion zones. Subsequent resource surveys should subsequently help to determine locations of previously unknown areas of archaeological interest. Any newly discovered finds reported to the National Monuments Record (NMR) under the JNAPC Code of Practice should also be protected by an appropriately sized exclusion zone. Compliance with this zone may be monitored using the EMS system to ensure that the find does not suffer physical damage or destabilisation and jeopardise the wrecks in the long-term.

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STRATEGIC CUMULATIVE EFFECTS OF MARINE AGGREGATES DREDGING (SCEMAD)

Research Project Prepared for

US Department of the Interior, Minerals Management Service

By

OAKWOOD ENVIRONMENTAL LTD

Section 5 – Future Research Needs

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5 FUTURE RESEARCH NEEDS

5.1 Introduction

It is recommended that the Good Practice methodology previously determined could be summarised and the scope of the original methodology broadened to develop a Good Practice Guide to include all proposed projects and developments in the coastal zone.

A Good Practice Guide is a useful and logical end product of the SCEMAD study. Guidelines will be more widely utilised, enabling a widely accepted framework to be established and practitioners with guidance in the assessment of cumulative effects. As a result, guidelines should assist Government bodies, such as MMS, to standardise Cumulative Effects Assessment (CEA) in the future.

Guidelines will result in the ability to address the strategic or cumulative effects of the marine aggregates industries, and any other coastal zone development, impact upon:

- benthic communities, fisheries and other marine biological resources, or upon;
- human activities, such as commercial fisheries, navigation, recreation and marine archaeology.

(the aspect of cumulative effect on coastal processes has been addressed to some degree in the modelling and reports prepared by HR Wallingford in the UK and others in the US, and further work is expected).

By broadening the remit of the proposed guidelines to consider the potential for cumulative effects within the wider coastal zone, it is hoped that they may provide a basis for CEA in both the UK and US alike. It is recommended that a two stage approach be adopted in order to most effectively cover the different legislative regimes of the UK and US.

5.2 Aims & Objectives

The aim of the Good Practice Guide will be to focus attention on the many issues that currently affect the coastal zone, based upon the experience of the dredging industry. Along with the tools and techniques previously identified, it will indicate the information required to undertake CEA. In essence, it will in the UK, update and expand upon the work of Campbell (1993) whose ‘Guidelines for Assessing Marine Aggregate Extraction’ has until recently proved adequate for marine aggregate EAs.

The objective of the final document would therefore be to represent a concise and easy-to-follow practitioner’s handbook providing:

- Emphasis on scoping consultations to determine the main issues and identify the key issues and impacts;

- A regional and strategic approach to EA and CEA;

- Suggestions of sources to assist in the provision of comprehensive data sets;

- Good Practice Terms of Reference for CEA;
- Good Practice Table of Contents for CEA;
- Potential subject areas for consideration, such as physical, biological, social/cultural, and legislative;
- Detailed ecological analysis approach for each resource, with suggested tools and techniques to aid assessment;
- Recommendations for the tools and techniques used to assess the spatial and temporal boundaries for each resource;
- Recommendations for the tools and techniques used to assess the impact thresholds beyond which damage becomes significant for each resource;
- Clear approach to assessing CE on a broad, regional scale;
- Recommendations for mitigation and monitoring programmes, to assess the long-term and cumulative effects of developments in the coastal zone;
- Recommendations for the consultation process and consultees.

5.3 Scope of Work

The preparation of guidelines for CEA follows on directly from the SCEMAD study, which proposed a Good Practice Methodology for CEA for the dredging industry, practitioners and Government.

The Good Practice Methodology could be summarised into a series of guidelines forming a Good Practice Guide. The guidelines produced would also be relevant to all coastal zone developments. Each topic within the CEA would be addressed and recommendations made on the information required and the tools and techniques available, for a full CEA for development within the coastal zone.

It is proposed that a two stage approach be adopted in the preparation of the Good Practice Guide, in order to most effectively cover the different legislative regimes of the UK and US. Stage 1 would consider the UK and European basis and Stage 2 would provide a document within a US legislative framework, to cover Federal, State, County or local jurisdiction. Both would provide examples of relevant CEA consultees.

The guidelines would therefore focus, in the first instance, on the UK coastal zone. It is proposed that a draft copy of these Stage 1 guidelines would be issued as an illustrated document (produced using desk top publishing) to MMS and the following relevant UK Government organisations for consultation:

- Department of Environment, Transport and Regions (DETR) (Minerals division)
- Crown Estate (CE)

- MAFF Chief Scientists Group (CSG)
- MAFF Rural and Marine Environment Division (RME)
- Centre for Environment, Fisheries & Aquaculture Science (CEFAS)

Following consultation, the final guidelines would be made available for circulation to a wider audience with interests within the coastal zone. This document would form the Good Practice Guide for use within the UK.

On completion of Stage 1, the UK Good Practice Guide could then be transposed into the US legislative framework for circulation to relevant US consultees.

5.4 Methodology - Stage 1 - UK and European Guidelines

5.4.1 UK and European legislation of the coastal zone

The UK's legislative requirement for the production of environmental assessments is driven by the EU legislation under EC Directive 85/337/EEC, amended by 97/11/EC. This Directive makes reference to the *assessment of cumulative effects* but provides no Terms of Reference for implementation within EAs. The aim of this section would be to provide a review of the EU and UK legal requirements for the production of environmental assessments including CEA.

5.4.2 Scoping exercise to determine subject areas

This section would detail the subject areas to be included within CEA. It would cover physical processes, biological processes; marine biology, fisheries and ornithology, and the human environment; commercial fisheries, navigation, archaeology and recreation for example.

5.4.3 Methodology for assessing cumulative effects

This section would provide a review of possible tools and techniques available to those preparing CEA, together with presentational graphics. This review would provide those responsible for preparing the assessment of cumulative effects with a range of techniques for defining suitable temporal and spatial boundaries, baseline levels, benchmarks and resource thresholds.

There are many instances from international literature where assessment techniques have been successfully applied in the terrestrial environment, but there are very few examples, if any, in the marine sector. It is hoped that this section would therefore be one of the first attempts internationally to provide guidance to practitioners on the range of tools and techniques available for the assessment of cumulative effects within the marine environment. Examples would be provided from "*real life*" examples of EAs undertaken.

5.4.4 Mitigation & Monitoring

Mitigation measures are those steps taken to make the predicted effects of dredging activity less severe, whilst monitoring is the repeated measurement of an environmental variable. Monitoring can therefore provide the evidence necessary to demonstrate that activities, with mitigation measures as appropriate, have not resulted in, or are likely to cause individual, or cumulative impacts causing lasting damage to the marine environment. This section would therefore identify typical mitigation measures and monitoring techniques resulting from CEA, given the most likely causes for potential impact from cumulative effects.

5.4.5 Bibliography

This final section would provide, by way of a bibliography, a comprehensive list of references, which will act as a central database of relevant information for all practitioners, as based on that within the SCEMAD study.

5.4.6 Consultation within CEA

This section would, as an appendix, list those relevant UK bodies with whom consultation should take place during the CEA. This list would obviously be replaced with a relevant US consultee database within the US Good Practice Guide.

5.5 Methodology - Stage 2 - US Guidelines

Finally, it will obviously be important to MMS that the Good Practice Guide be transposed into the US legislative framework (to cover Federal, State, County or local jurisdiction) and to consider US consultee requirements. Following completion of Stage 1 a final Good Practice Guide for use within the US could be prepared. The UK Good Practice Guide should form the basis of this document.

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