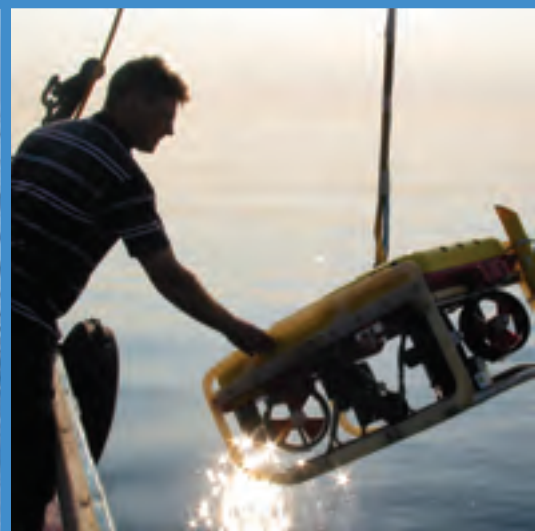
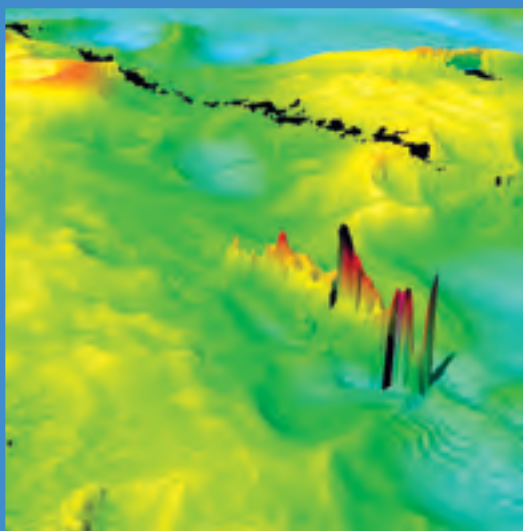
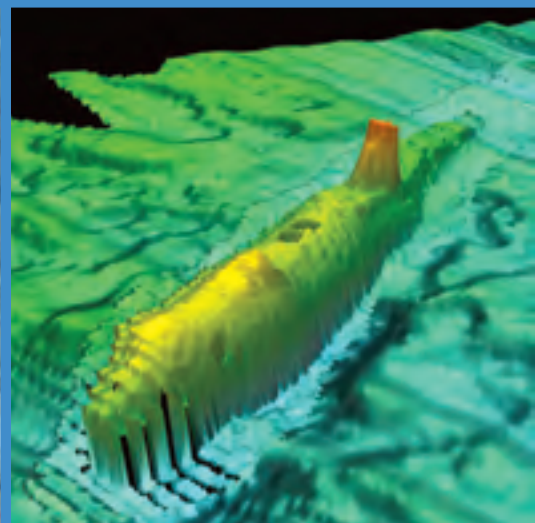


Marine aggregate extraction

Helping to determine good practice



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MARINE AGGREGATE DREDGING: HELPING TO DETERMINE GOOD PRACTICE

MARINE AGGREGATE LEVY SUSTAINABILITY FUND (ALSF)

CONFERENCE PROCEEDINGS:

SEPTEMBER 2006

Edited by

R.C. Newell D.Sc(Lond.)^{1,2} and D.J. Garner M.Sc²

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A limited number of copies of this publication are available from Kate Francis, E-mail kate.francis@cefas.co.uk

¹ Marine ALSF Science Co-ordinator

² Marine Ecological Surveys Limited, 24A Monmouth Place, Bath BA1 2AY



FOREWORD

Much of Britain's infrastructure has been built using marine aggregates. They are in homes and hospitals, shops and schools, roads, and even the Channel Tunnel. In some cases they are in the fabric of the very defences that protect our coastal communities from the sea.

But their extraction inevitably comes at a price for the marine environment. Some of the impacts of aggregate dredging may, over time, be repaired. Some species may return to a dredged area, but others may not, and geological or archaeological resources can be lost forever in the extraction process.

Government has long recognised that it is essential to balance the needs of the environment with the social and economic needs of the nation. It is what that well worn phrase 'sustainable development' is all about. We have to ensure that, in taking natural resources, we minimise the impact of our actions on both the surrounding environment and on future generations. In short, we have to live within our means.

With this in mind, the Government launched the Aggregates Levy, and the Aggregates Levy Sustainability Fund in 2002. The Aggregates Levy is an environmental tax on industry for the extraction of aggregates. It reduces demand for primary aggregates by increasing their cost, making the use of recycled materials more viable.

The Aggregates Levy Sustainability Fund provides money to reduce the environmental impacts of extraction, supporting research to assess and mitigate damage caused by dredging. Since the Fund's creation, Defra has allocated around £9 million on marine-related research.

The range of research has been wide, it has needed to be because historically we have had relatively limited knowledge of the ability of the sea to recover from the aggregate dredging process. We have got little baseline information on what can recover and what could be lost forever. Without this information, it's very difficult to assess where aggregate extraction is acceptable, where it is not, and where its impact can be minimised.

Another gap in our knowledge is knowing what variety of marine resources are actually in the areas where extraction is proposed. After all, neither industry, conservationists, nor regulators can make informed decisions on where dredging can go ahead, unless they have information on what is happening in that area and what the potential impacts may be. The Fund has therefore supported projects like the British Geological Survey (BGS) seabed habitat mapping in the eastern English Channel, and surveys of archaeological finds from the southern North Sea.

In the Marine area, in particular, we have placed considerable emphasis on sharing the information the Funds projects have collected, with the wider world. This book is in that tradition and forms both a valuable record of the work undertaken and a reference source for those working in this area.

A handwritten signature in blue ink, appearing to read 'Ben Bradshaw'.

Ben Bradshaw MP, Minister of State for Local Environment, Marine and Animal Welfare

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PREFACE

Roger Bright, Chief Executive, The Crown Estate

As the major owner of UK seabed minerals, The Crown Estate has taken a strong interest in the research and other projects which have been funded by the Marine component of the Aggregate Levy Sustainability Fund. We are pleased to see the programme reach this major dissemination stage, making the results of the individual projects available to the industry, regulators, the marine science community, other user groups and the public.

Overall, the outputs of the programme are impressive and have advanced understanding and reduced uncertainties of the impacts of this extractive industry.

The demand in the UK for marine aggregates is driven mainly by society's demands for a built environment and, to a lesser extent, for coast protection via beach recharge schemes. In responding to these demands, the dredging companies, who are The Crown Estate's customers, are required to demonstrate to the Government, as regulator, that their proposals are carried out in such a way that environmental impacts are minimised. It is nevertheless recognised that the preparation of such evidence and its assessment by the regulator has to take account of significant uncertainties. These are due to the scientific community's limited understanding of the impact of various activities on the marine environment and the general lack of awareness of the detailed condition of the wider UK seabed as a result of limited surveys.

The results presented in this publication, however, make a timely and significant contribution to reducing this lack of knowledge and hence have the potential to be enormously useful to all stakeholders. Extraction of marine aggregates does rightly raise concerns about the long-term impact on the areas of the seabed. I am pleased to note that some of the research projects have addressed these issues, and that the emerging picture is one of faster seabed recovery after the completion of dredging activity than was previously thought. These findings, taken together with the statistics surrounding the extraction of marine aggregates, have the potential to defuse what is sometimes a highly-charged debate about the long term future of this industry.

The Crown Estate is fully committed to sustainable development and aims to achieve the highest standards of environmental stewardship in all its commercial activities. Consequently, The Crown Estate continues to invest in research related to marine aggregate extraction to assist these aims.

We also publish annually details of aggregate dredging in the previous year and we periodically update a trends document. The most recent statistics show that in 2005, 90% of total dredging operations occupied an area equivalent to just less than 46 square kilometres – approximately one 200th of 1% of the UK seabed. This is a very small area and the trends over 5 years show a steady decrease in the area of intensive dredging activity. This is a clear sign that the industry is responding to the environmental challenges.

We welcome the publication of the Marine ALSF research programme findings as a significant milestone. They will assist The Crown Estate in fulfilling its obligations under The Crown Estate Act 1961, to maintain and enhance the value of the estate and the return obtained from it, whilst demonstrating responsible management.

The Marine Aggregate Levy Sustainability Fund (ALSF) – Objectives & achievements

INTRODUCTION

Marine aggregates play an important part in the provision of high quality raw materials for both the UK construction industry and for coastal protection. Sand and gravel are generally taken from the seabed by trailer suction hopper dredgers that are capable of transporting cargoes of up to 9,000 tonnes from offshore dredge sites direct to the wharves located close to the point of end use. The dredge areas are licensed from The Crown Estate following an extensive Environmental Impact Assessment (EIA) and stakeholder consultation process formerly regulated through Communities & Local Government (CLG) and Defra and now through the Marine and Fisheries Agency (MFA), an executive agency of Defra.

Delivery of sands and gravels into coastal towns and cities direct from the dredge site by ship reduces the need for road transport and thus confers some environmental advantages as far as transport is concerned, compared with aggregates derived from land quarries. Nevertheless there has been an increasing awareness that removal of dredged material from the relatively small areas of the seabed around the coasts of England that are under licence for aggregate extraction may have potential impacts on the biodiversity of marine communities of conservation significance, and on fisheries resources of economic importance. With the development of increasingly sophisticated methods of mapping and evaluating the seabed, it is also becoming clear that the shallow waters surrounding our coastline contain archaeological and historic resources of considerable importance that warrant protection.

Our understanding of the nature and distribution of these resources, and on improved methods of minimising impacts from aggregate dredging has in the past been limited mainly by both the level of funding available to support appropriate research, and by technical difficulties of research in the marine environment. Studies on the impacts of aggregate dredging has in the past mainly been supported through Defra Research & Development funds¹ and on a voluntary basis by the aggregates industry both through the British Marine Aggregate Producers Association (BMAPA), by The Crown Estate and by individual operating companies. In 2002 the Government provided an additional source of funding by the imposition of a levy on primary aggregates from both land-won and marine sources. This Aggregate Levy Sustainability Fund (ALSF) has four main objectives:

1. Minimising demand for primary aggregates
2. Promoting environmentally friendly extraction & transport
3. Addressing the environmental impacts of past aggregates extraction
4. Compensating local communities for the impacts of aggregates extraction

In all, approximately £30m per year is potentially available through the ALSF in England, of which about 10% of the net amount released from the Treasury to Defra has been allocated to projects relating to the marine environment – reflecting the proportion of the English aggregate requirements derived from marine sources. The remaining 90% of the fund is allocated to terrestrial-based projects.

THE MARINE ALSF PROGRAMME (MALSF).

The marine ALSF programme falls under the second objective of the ALSF. The main aim of the marine ALSF programme is to promote environmentally friendly extraction in the marine environment in England. Defra allocates funds to four delivery partners to support this work in the marine environment. These are:

- The Centre for Environment Fisheries & Aquaculture Science (CEFAS).
- Communities & Local Government (CLG) - formerly the Department of Communities & Local Government (DCLG), formerly the Office of the Deputy Prime Minister (ODPM). These funds are administered by the Mineral Industry Research Organisation (MIRO)
- Natural England (NE: Formerly English Nature (EN)).
- English Heritage (EH).

¹ Recent Defra R&D projects relevant to marine aggregate dredging are summarised in appendix table 2

Delivery Partner Priorities

CEFAS

The allocation to CEFAS under the ALSF forms the Marine Environment Protection Fund (MEPF). The objectives of the MEPF are to ensure that the ALSF is used to procure projects which deliver programmes that:

- Promote environmentally-friendly practices for the extraction of marine aggregates
- Undertake strategic research into the environmental consequences of marine aggregate extraction
- Reduce the local effects of marine aggregate extraction
- Reduce the environmental impacts of using marine aggregate in coastal protection schemes

The MEPF is administered by CEFAS (e-mail contact: kate.francis@cefass.co.uk. Tel: 01502-524361).

CLG

The main focus of marine projects funded from the ALSF by CLG is centred on the general question of the impacts of aggregate dredging on the marine environment.

Further information can be obtained from MIRO (e-mail contact: dclg@miro.co.uk. Tel: 0121 635 5225). A review of all projects managed on behalf of CLG by MIRO is given in the Annual Reports of the ALSF Sustainable Land-Won & Marine Dredged Aggregate Minerals Programme. The Final Reports for projects carried out through MIRO are available both as hard copy summaries and on CD from MIRO: www.dclgaggregatefund.co.uk and www.mi-st.org.uk/

ENGLISH HERITAGE

The main focus of marine projects disbursed from the ALSF by English Heritage is on the marine historic environment. Key priorities include:

- baseline information and characterisation of the resource
- techniques of prediction and evaluation
- mitigation strategies
- training, awareness and information exchange

It includes the following main areas:

- Developing the capacity to manage aggregate extraction landscapes in the future
- Delivering to public and professional audiences the full benefits of knowledge gained through past work in advance of aggregates extraction
- Reducing the physical impacts of current extraction where these lie beyond current planning controls and the normal obligations placed on minerals operators
- Addressing the effects of old mineral planning permissions
- Promoting understanding of the conservation issues arising from the impacts of aggregates extraction on the historic environment

Details on marine research priorities, information on current projects and application guidelines can be obtained from the following website: www.english-heritage.org.uk/server/show/nav.1315. Further information can be obtained from English Heritage (e-mail contact: maritime@english-heritage.org.uk. Tel: 020-7973-3107).

NATURAL ENGLAND (FORMERLY ENGLISH NATURE)

The focus of marine ALSF funds disbursed by Natural England is on the following priorities:

- The nature, understanding and awareness of the biodiversity resource of marine sand and gravel habitats, together with the protection and recovery of the resource prior to, during and after aggregate extraction
- Addressing the social and environmental legacy of marine aggregate extraction
- Seabed features of geological and geomorphological interest which are affected by marine aggregate extraction

Further information can be obtained from Natural England (e-mail contact: alsfgrants@naturalengland.org.uk Tel: 01476-584821). Note that as from 1st of April 2007 Natural England is no longer a Delivery Partner for marine ALSF projects.

The marine component of the ALSF is currently administered by Cefas through the Marine Environment Protection Fund and by English Heritage.

The Marine Aggregate Levy Sustainability Fund (ALSF) – Objectives & achievements

OVERVIEW OF RESEARCH EXPENDITURE THROUGH THE ALSF.

Approximately £9 million has been spent through the ALSF on marine research related to the aggregates industry since inception of the scheme in 2002. A list of the projects that have been funded to date is summarised in Appendix Table 1. The appendices also include a summary of non-ALSF research on marine aggregates. Project details are summarised in appendix Tables 2a & 2b.

Of the £9 million spent through the ALSF since 2002, £2.4 million has been allocated by CEFAS through the Marine Environment Protection Fund (MEPF), and £2.1 million by the Minerals Industry Research Organisation (MIRO) through the Sustainable Land-Won and Marine Dredged Aggregate Minerals Programme (SAMP) and the Mineral Industry Sustainable Technology Programme (MIST) on behalf of Communities and Local Government (CLG). A total of £1.5 million has been allocated to marine research on the natural environment by Natural England and £2.9 million to projects on the historic environment by English Heritage acting as Delivery Partner for the ALSF.

The relative allocation of funds through each of the Delivery Partners since the start of the ALSF in 2002 is shown in Figure 1. This also includes a small component of £62,500 of joint funding between English Heritage

and the British Marine Aggregate Producers Association (BMAPA), mainly related to the development and dissemination of an appropriate protocol for reporting of historic and archaeological finds. The aggregates industry has also supplied substantial funding 'in kind' by provision of data in support of several of the research projects supported by the ALSF. Indirect funding of this type has not been included in the financial breakdown shown in Figure 1.

RESEARCH THEMES & PRIORITIES.

The marine ALSF in England was initiated mainly to support research that leads to a greater understanding of the nature and sensitivity of marine resources to disturbance by aggregate dredging, and how such impacts may be minimised. Essentially any assessment of the impacts of aggregate dredging on marine resources, and proposals on how such impacts can be minimised, is dependent on an understanding of the natural and historic resources that occur in the vicinity of deposits that are likely to be exploited for marine aggregates. Bearing in mind that some localised impacts of aggregate dredging on seabed resources are unavoidable, it is clearly important to have an understanding of how unique the resources are that may be impacted by dredging within a licence area, and the extent to which these resources are capable of recovery over time.

**Delivery Partner Relative Expenditure 2000 – 2007
Rounds 1 & 2**

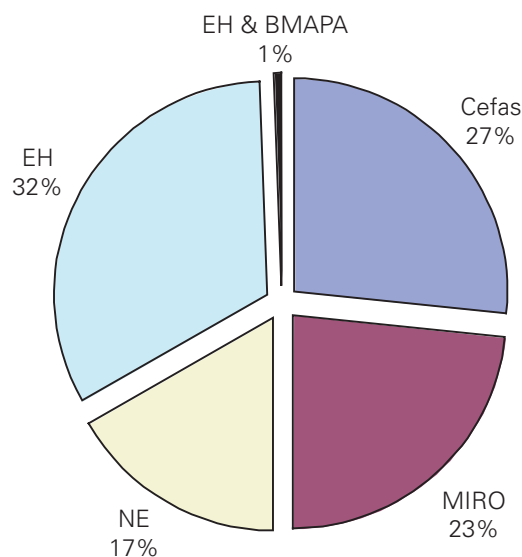


Figure 1: Diagram showing the relative expenditure by the Delivery Partners on projects approved for funding through the ALSF from 2002 to projects that end in March 2007.

There is a good deal of overlap between projects that essentially define environmental resources that warrant protection, and projects that assess the sensitivity of natural and historic resources to disturbance or damage by marine aggregate dredging. Despite this overlap, projects approved for funding by the Delivery Partners fall into four broad themes. These comprise:

- Identification of marine resources, natural and historic
- Impacts of aggregate dredging
- Management of aggregate dredging
- Co-ordination, dissemination and outreach

The relative allocation of funding into the four main themes outlined above is shown in Figure 2. The theme of 'identification of marine resources' has been subdivided into Biological, Geological and Historic resources each of which is expressed as a percentage of the total sum of over £9 million allocated through the ALSF since 2002.

From this it is clear that a total of approximately £4.46m or nearly 50% of the ALSF has been allocated to furthering our understanding of the nature and distribution of Biological, Geological and Historic-archaeological resources on the seabed. This reflects the major investment that has been required to understand the resources that warrant protection and management in our coastal waters. It is also clear from

Figure 2 that approximately £2.5m or approximately 28% of the fund has been used to support studies on the impacts of marine aggregate dredging on seabed resources. These relatively large sums reflect the high cost of research at sea, many of the studies requiring extensive use of survey vessels capable of operating on a 24h basis for several weeks.

A smaller sum of approximately £1.1m has been spent through the ALSF since 2002 on development of appropriate management approaches to minimise the impacts of aggregate dredging on marine resources. This relatively smaller sum reflects the need initially to define the nature and distribution of the resources that warrant protection before appropriate management strategies can be put in place. It is worth mentioning, however, that several of the more recent (Round 2) projects have been mainly concerned with appropriate management to minimise impacts on seabed resources. These include development of appropriate exclusion zones around wreck sites and with industry-led protocols for reporting finds of archaeological and historic significance.

A similar sum of approximately £1m has been spent on dissemination and outreach programmes. Throughout the ALSF scheme, considerable emphasis has been placed by the Delivery Partners on the importance of effective dissemination of the results of the work to a wide range of stakeholders. Some projects have been specifically devoted to outreach programmes that make

**Relative Expenditure on Research Themes 2000 – 2007
Rounds 1 & 2**

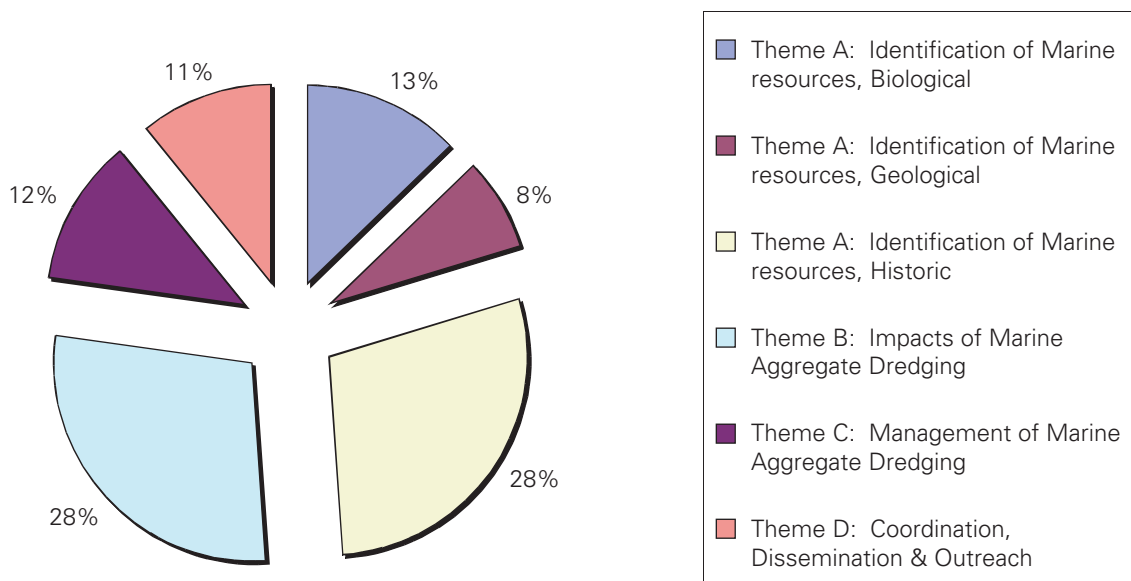


Figure 2: Diagram showing the relative expenditure on different research themes by the Delivery Partners from 2002 to 2007



The Marine Aggregate Levy Sustainability Fund (ALSF) – Objectives & achievements

the results of ALSF work available to a wide variety of stakeholders including schools and the public. Most of the projects also include proposals to make the results of the projects available outside of the immediate specialist areas of research. With that in mind, in addition to workshops and Partnership Events arranged by the respective Delivery Partners, Defra have arranged marine ALSF Technical Conferences in 2005 and in 2006 to bring the results of the ALSF programme to as wide a range of stakeholders as possible.

The marine ALSF Technical Conferences held in 2005 and 2006 were notable successes. The interest in the marine ALSF has, however, not been confined to specialist audiences. Several of the highly successful dissemination projects have been targeted at specific groups including schools and the industry. All of the Delivery Partners require participants in the ALSF programme to make specific proposals on how the results of their work will be disseminated. In some cases, such as the Outer Bristol Channel Marine Habitat Study (SAMP 1.044) an education pack 'Explore the Sea Floor' has been developed and has been successful in supporting National Curriculum Keystages 2-4 in schools. Others have been aimed at a broad range of stakeholders through museum displays and other permanent exhibitions including one on 'Mineral Wealth, Seabed Health' at the National Marine Aquarium at Plymouth. A recent 'Time Team' programme on Channel 4 on 25th April 2007 included extensive reference to several projects on the archaeological significance of submerged landscapes in the North Sea funded from the ALSF through English Heritage. This emphasises the interest that has been generated through the work of the marine ALSF.

TAKE-UP OF ALSF RESEARCH OUTPUTS INTO MANAGEMENT

One of the features of the marine environment is that we have much less direct information on the nature and distribution of resources of conservation and potential economic significance than we have on land. This is partly a reflection of the difficulties and costs of research at sea. However, partly as a result of rapid advances in technology and partly reflecting the major investment in marine research made possible through the ALSF, we now have a much clearer understanding of the key issues relating to protection of environmental resources in the vicinity of aggregate dredge sites than was the case a decade ago. To a large extent, these advances have been rapidly incorporated by the industry into good

practice and into regulatory policy through the advice given by CEFAS, Defra and others to the regulatory departments (CLG and MFA).

Some of the work that has been recently completed with support from the ALSF is summarised in the following chapters. These illustrate the wide range of research that has been successfully completed through the Delivery Partners with support from ALSF funds mainly between 2004-2007. Not all of the work completed through ALSF projects is reported here. The following key areas have been enhanced by support from the ALSF in recent years. These enhancements are likely to lead to improved management of aggregate dredging:

- Understanding the nature & scale of physical impacts of aggregate dredging
- Definition of the nature and scale of impacts on the biodiversity of seabed communities
- Improved understanding of the nature and rate of recolonisation and 'recovery' of biological communities
- Development of techniques for identification of archaeological landscapes
- Development of techniques for assessment of historic wrecks
- Development of appropriate management protocols for reporting archaeological and historic finds
- Improved monitoring requirements to protect environmental resources in the vicinity of dredge sites
- Improved understanding of the regional 'context' against which the impacts of aggregate dredging should be set
- Improved understanding of the nature and distribution of natural and historic resources of conservation significance in UK coastal waters
- Improved public understanding of the importance of marine resources and the issues that are involved in the sustainable management of UK coastal waters

CONCLUSION

A principal objective of the marine ALSF has been to seek practical ways in which the impacts of aggregate dredging can be minimised. An essential first step was to develop our understanding of the nature and distribution of environmental resources in the vicinity of aggregate licence sites, and their sensitivity to potential impacts from dredging. This has assisted in an evidence-based approach to licensing by the regulators and in the development of appropriate management tools that protect environmental resources in the vicinity of dredge sites. Much remains to be done. The marine ALSF has, however, represented a considerable 'success story' as far as achieving the broad objectives of the fund are concerned, and it is difficult to over-estimate the importance of dedicated funding provided by the ALSF to target specific environmental issues related to the marine aggregate industry.

This work could not have been carried out without the support and encouragement of Defra or without the active co-operation of the aggregate industry. We are particularly grateful for the encouragement and assistance received from the British Marine Aggregate Producers Association (BMAPA), The Crown Estate and from the individual licence holders who have at all times gone to considerable lengths to advise and assist in the successful completion of many of the projects summarised in this book.

The image shows a detailed view of a rocky seabed. The rocks are of various sizes and colors, ranging from light tan to dark brown. Several brittle stars are scattered across the rocks, their long, feathery arms extending outwards. The arms are primarily light-colored with distinct red or purple spots along their length. A small, reddish-brown crab is visible in the lower-left quadrant, partially obscured by the brittle stars. The overall scene is a rich, textured representation of a natural seabed environment.

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Identification of seabed resources

T. Tew
Chief Scientist, Natural England,
Northminster House, Peterborough, PE1 1UA

We know far less about seabed mineral resources than land resources. Evaluation of the available seabed resource is critical for both commercial and environmental reasons. A better understanding of the resource will enhance assessments of impacts arising from activities associated with marine aggregates extraction. This is important, not only for effective management of the sand and gravel resource, but also for biological, geological and human heritage interest features.

The development of good practice for marine aggregate extraction initially requires three things: Knowledge of the location, extent and quality of the aggregate resource; determination of the distribution, extent and significance of associated environmental features and; effects from aggregate removal. Only with these data, and knowledge of the interactions between them, can good, well-informed decisions be made.

This section of the proceedings from the MALSF conference, held in September 2006, is concerned with identifying the distribution and significance of the environmental features. It focuses particularly on issues relating to nature conservation, geodiversity, fisheries, national heritage and environmental monitoring.

Projects supported by the marine component of the fund have enabled identification of best-practice rationales and protocols for baseline survey and monitoring of seabed impacts. These relate to techniques at sea as well as analysis and interpretation of spatial data. A review of project outputs has indicated that synergies exist between survey techniques, and resolution of data capture, utilised to identify different environmental features. This can result in multi-

disciplinary survey and monitoring programmes being delivered in more cost-effective and efficient ways. This could benefit all parties with an interest in marine aggregate resources and their associated interest features.

Spatial data are essential in enabling identification of areas of significance or importance: not only in meeting marine nature conservation obligations on the UK from European legislation, but also in delivering protection and enhanced understanding of geological and national heritage features. There is also an urgent need to better understand the location, dynamics and sensitivity of areas that provide ecosystem services or functions. The fund is assisting scientists, regulators and the industry to improve their understanding of these processes; in particular links to areas of fisheries importance such as spawning and nursery areas.

It is becoming increasingly appropriate to identify marine resources, uses and pressures within a marine (spatial) planning framework. This ensures that the consideration and management of the marine environment is sustainable. In its strategic direction Natural England has indicated that it will work with marine industries to promote sustainable use of the marine environment. As a delivery partner, Natural England believes that the funds provided through the marine component of the ALSF have delivered; new knowledge, techniques, and understanding, contributing to a better understanding of aggregate and environmental resources around our coasts and in our seas. Sound procedures are now required to interpret this knowledge into transparent and well-informed decision-making processes.





Selection of typical epifauna from the seabed
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A summary of the Defra R&D research project 'The role of seabed mapping techniques in environmental monitoring and management'

This paper summarises work carried out by the Centre for Environment, Fisheries & Aquaculture Science (Cefas), The British Geological Survey (BGS) and Envision Ltd over the course of a 4-year research programme (Boyd *et al.*, 2005). The overall aim of the programme was to evaluate an array of 'state of the art' seabed mapping techniques to establish their suitability for application in areas impacted by man-made activities. The rapid pace of developments in the field of habitat mapping, driven by continuous improvements in acoustic techniques (sidescan sonar, multibeam bathymetry, acoustic ground discrimination systems), has the potential to radically alter approaches to the assessment of anthropogenic impacts at the seabed. In addition to their utility in wide-scale reconnaissance

surveys (e.g. in a resource or conservation context), a number of site specific applications of relevance to Defra and other Government Departments (e.g. dredged material disposal, aggregate extraction, construction activities, oil and gas exploitation, fishing impacts) could also benefit from the use of these techniques. A range of 'state of the art' methodology was therefore evaluated through a programme of rigorous field testing (Figure 1) in order to establish the most cost-effective strategies to meet both site specific and generic (reconnaissance-type) objectives.

Experience of techniques developed in a previous Defra funded programme (Brown *et al.*, 2001), which focused on gravelly sediments, was extended to sites covering

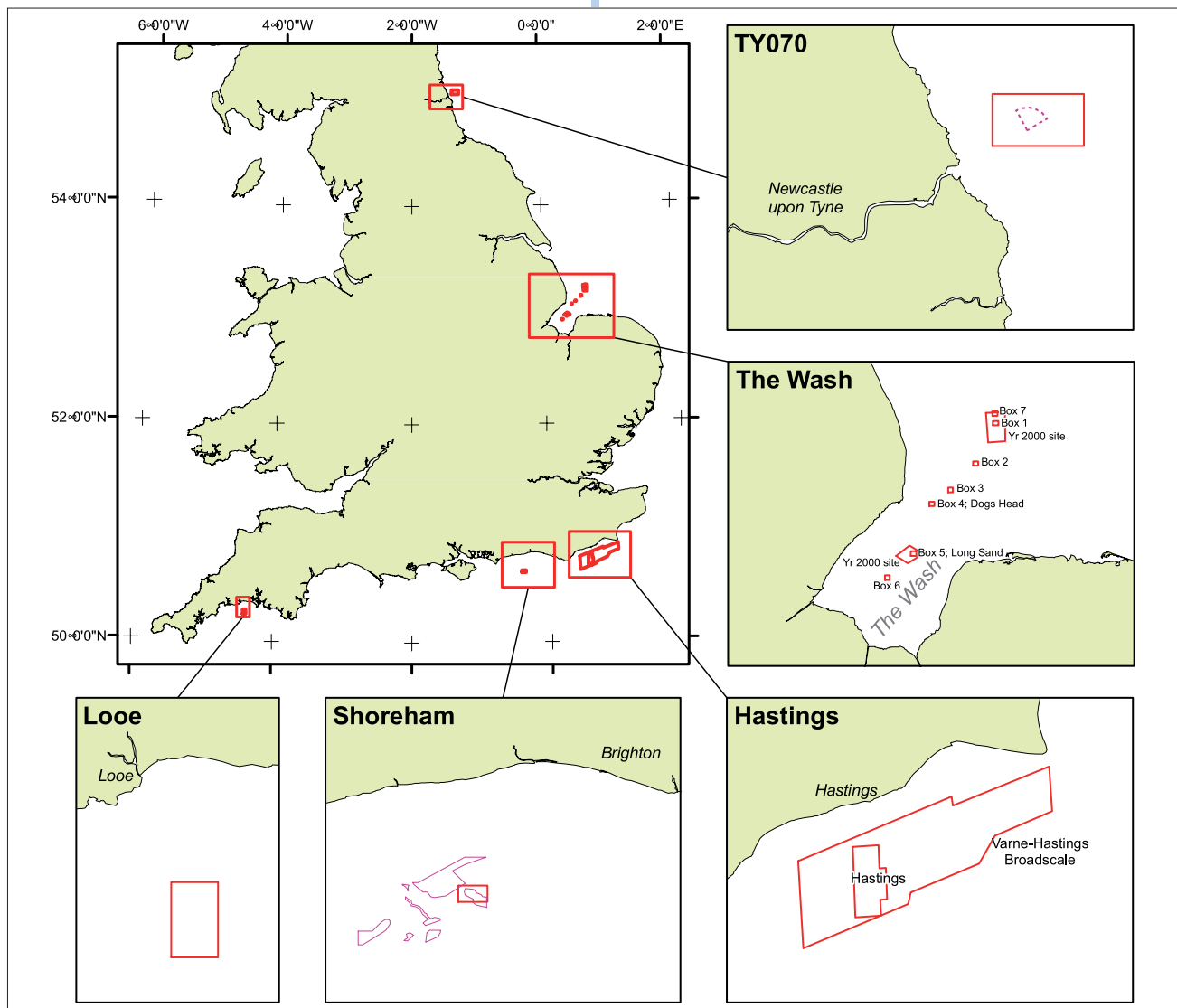


Figure 1: Map showing the location of sites surveyed during this study.

both a broader range of sediments and a wider variety of anthropogenic impacts (dredged material disposal and aggregate extraction). Survey techniques were trialled at a number of sites over the four years of study (Figure 1). Typically, an acoustic survey combining sidescan sonar, multibeam bathymetry and acoustic ground discrimination system (AGDS) was conducted over a study site to identify acoustically distinct areas of the seabed which were then ground-truthed, using grabs, trawls, Sediment Profile Imagery (SPI) and underwater photography, to determine their physical and biological characteristics. This structured approach to surveying the physical and biological conditions of the seabed can be adapted to suit a range of spatial scales and was found to be suitable for both local and broadscale application.

Repeat annual surveys were conducted at two sites, a dredged material disposal site offshore of the Tyne Estuary, in the North Sea (TY070) and an aggregate extraction site off Shoreham (Owers Bank) in the Eastern English Channel. This work was undertaken to investigate the temporal changes in benthic community structure and the status of physical habitats. At TY070, a soft sediment dredged material disposal site, there was considerable agreement between the sidescan sonar and QTC™ (an AGDS technique) output, the latter even proving sensitive to small features (<100 m across) evident on the sidescan sonar record. Several acoustically distinct areas were recognised, one showing characteristics of disposal activity (i.e. a disposal 'footprint'). Benthic communities and sediments were ground-truthed using a Hamon grab fitted with a video camera. Results indicated a reduction in species richness and total abundance of organisms in the vicinity of the disposal site, but these effects were not widespread. The use of SPI also provided useful additional ground-truth information on the status of the sediments and biogenic activities (Birchenough *et al.*, 2006).

At Owers Bank, a coarse sediment aggregate extraction site off Shoreham, the sidescan sonar record showed that trailer suction dredging activity had encroached northward over time, into an active area of static suction dredging. Both studies demonstrated the benefits of combining conventional methods, acoustic techniques and optical imaging devices when assessing anthropogenic effects. Their collective contribution allowed a thorough ecological assessment following anthropogenic activities at the seabed, which was found to offer greater utility than individual approaches. The sidescan sonar and multibeam imagery enabled rapid coverage of large areas of seafloor, providing information on the physical characteristics of the seabed and the footprint of disposal and aggregate extraction activity

(Figure 2). The use of such an integrated mapping approach appears to be of particular value when assessing anthropogenic effects in areas of known habitat heterogeneity, and for providing baseline information for future monitoring exercises. The approach to habitat mapping, developed during this research project, has now been successfully applied at various disposal sites around the U.K coast as part of routine monitoring programmes undertaken by Cefas on behalf of Defra.

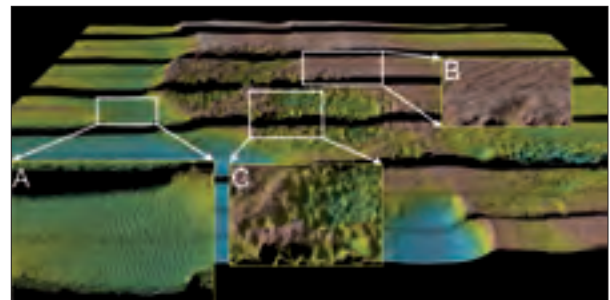


Figure 2: Multibeam sonar image of the seabed around the aggregate extraction site at Owers Bank, highlighting characteristic 'signatures' of A) an undisturbed megaripple field, B) static suction dredging, C) trailer suction dredging. The area covered in the image is approximately 3 x 3 km.

Continuous improvements in affordable, acoustic techniques have also led to increased interest in their use for the detection and monitoring of particular features of nature conservation interest. The results of a number of surveys conducted in the Wash and its environs over many years have been reviewed in order to assess the utility of different habitat mapping techniques for assessing the spatial extent, heterogeneity and temporal variability of one biotope of nature conservation significance, namely *Sabellaria spinulosa* biogenic reef.

Acoustic surveys were also undertaken at a study site in the eastern English Channel with the aim of developing a strategy for mapping at different spatial scales (Coggan, 2006). The site comprised a broadscale area (40 x 15 km) between Dungeness and Hastings, within which was nested a smaller study box (4 x 12 km), containing an area licensed for aggregate extraction (Figure 1, 'Hastings' inset). During the previous Defra project, a basic (low resolution) interpretation was made of 100% sidescan coverage of the smaller study box. This resulted in the identification of four acoustically distinct areas, which were ground-truthed and classified as four distinct biotopes. The present study made a more detailed (high resolution) interpretation of the same sidescan mosaic, recognising nine different seabed facies (distinct combinations of sediment type and bedform) and mapping the area into ~20 regions

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(Figure 3). Each of the original acoustically distinct areas contained multiple seabed sediment classes, accounting for the high variability between replicate ground-truth samples noted previously. Consequently, the site was re-visited to ground-truth the seabed facies map. As part of this ground-truthing exercise, a novel spiral sampling strategy was developed and tested. This design proved successful for assessing physical and biological variability within different sediment facies. Spatial analysis also established the facies as having distinct spatial trends in sediment particle size and faunal composition. Furthermore, the faunal assemblages within each of the sampled facies were found to be significantly different. Together, these results demonstrate that seabed facies are ecologically significant units and validate their use in mapping seabed habitats.

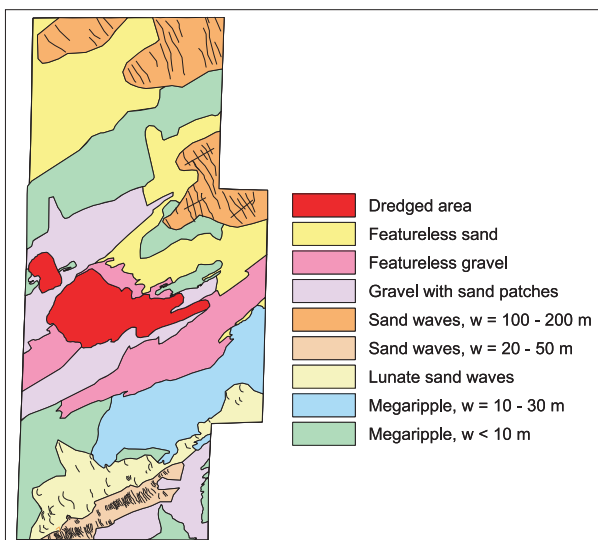


Figure 3: Seabed facies map for the Hastings study site, approximately 10 x 4 km, centered on the licensed aggregate extraction site (dredged area). The key describes the sediment type and bedform, as determined from a full-coverage sidescan sonar survey (w = wavelength). Lines on the map indicate wave crests and transport indicators.

The cost of ship time limits the density of sidescan coverage in broadscale areas. We therefore attempted to find an optimum acoustic line spacing that would give a reasonably confident interpretation of seabed facies in a cost-effective way. Within the broadscale study area (Figure 1, ‘Hastings’ inset), sidescan sonar lines spaced at 2 km intervals were gradually augmented with additional ‘in-fill’ lines to achieve progressively greater density of acoustic coverage. The relationship between density of acoustic coverage and confidence in interpreting broadscale patterns and features was then explored (Figure 4). There was extreme linearity of the

interpreted map of seabed sediments and bedforms at 4 km acoustic line spacing and this reduced, as the line spacing got closer. A disturbed area of seabed associated with an extraction site at Hastings was first discernible at 2 km acoustic line spacing but was more accurately represented at 1 km spacing, while a significant area of sand only became apparent at 1 km line spacing. Analysis of further ‘in-fill’ lines giving 100% acoustic coverage resulted in only marginal improvement in resolution. It was concluded that, at this site, acoustic line spacing of 1 km gave acceptable results; data from any further ‘infill’ lines seemed to be redundant at this spatial scale and did not appear to warrant the doubling of survey time and additional costs associated with mapping at this resolution over this broad spatial scale.

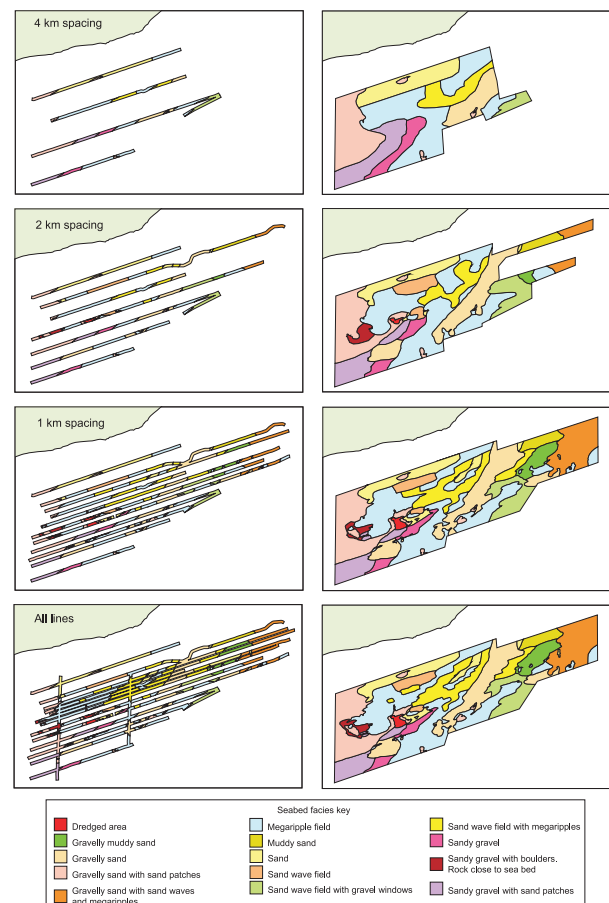


Figure 4: Sequence of seabed facies maps (right column) derived by interpolation of interpreted sidescan lines (left column), showing the effect of progressively closer line spacing (top to bottom).

Developing this strategy further, we examined the comparability of estimates of the abundance of two species derived from samples collected using different

sampling equipment. Samples collected by different gears often arrive at different estimates of the relative abundance of the same species, since the sampling gears are employed over varying spatial scales and have differing sampling efficiencies. However, unless data from different gears can be compared directly, biological classifications will differ according to the source of the data, and complicate any resulting habitat classifications. Establishing how surveys conducted at different spatial scales can be linked together is therefore another important consideration in mapping studies. We therefore set out to examine whether associations between key environmental variables and patterns of species distributions strengthen as the spatial extent of the area surveyed increases. Associations between two representative species (the queen scallop and the hermit crab) and two environmental factors (depth and shear stress) from the broadscale 4 m beam trawl groundfish surveys were compared with species-habitat associations developed from the more localised 2 m beam trawl sampling. For the two species considered here, there is little firm evidence to suggest that species-habitat correlations strengthen as the spatial extent of the area surveyed increases. Correlations remained relatively invariant for scallop and were difficult to detect for the hermit crab regardless of the survey size. The importance of this outcome for mapping studies is that species-habitat relationships quantified at one spatial scale may not necessarily be transferable to another. Notions of habitat drivers for patterns of species distributions may therefore be dependent on the spatial scale of the investigation.

As part of an assessment of the significance of biogeographical variations and their implications for predictive habitat mapping, four sites in the English Channel having similar substratum characteristics were sampled using a Hamon grab (Figure 1, Looe to Hastings). The results confirm that a biogeographic variation exists between sites of similar sediment in the western and eastern English Channel and indicate that the majority of this variability was accounted for by the rarer benthic species. Removing these rarer species from the data-set resulted in the identification of a core set of species. This sub-set was less prone to biogeographic variability thus providing a better basis for confident prediction of the composition of the more common species in the English Channel.

We also tested alternatives to ground-truthed acoustic maps of the seabed (see above) for constructing maps of marine species and community distributions. The first approach combines multivariate classification, Bayesian statistics, and geostatistics to arrive at a series of continuous representations of the distribution of each biological community (Eastwood, 2006). Acoustic data

(100% sidescan coverage) and biological data (from ground-truth sampling) collected from the Shoreham site were used to assess the validity of the approach and demonstrate its application. A biotope map for the study area was produced showing the maximum likelihood of encountering a particular assemblage at each grab site. Maps developed using a purely objective classification of the biological data were compared with one developed from a supervised classification where the grab samples were assigned to one of eight acoustically distinct regions of the seabed (Figure 5). Whilst the latter approach arrived at a set of biotopes with better spatial definition, biological associations within each biotope were found to be slightly weaker.

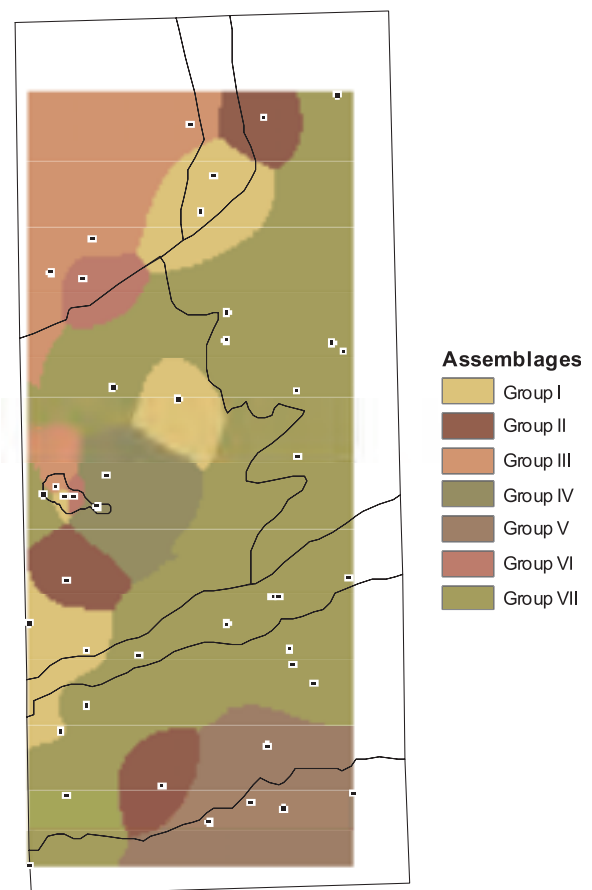


Figure 5: Comparison of subjective and objective mapping for a study site off Shoreham. The lines delineate eight acoustically distinct areas derived from full coverage sidescan sonar survey (subjective mapping) that were subsequently sampled by Hamon grabs (white spots). Multivariate analysis of the grab samples identified seven infaunal assemblages (Groups I to VII), the probable distribution of which were then mapped using Bayesian and geostatistics (objective mapping).

Another modelling technique, quantile regression, was used to predict the distribution of adult sole in the eastern English Channel from discrete trawl samples, collected as part of Cefas' annual 4 m groundfish survey,

A summary of the Defra R&D research project 'The role of seabed mapping techniques in environmental monitoring and management'

along with the associated physical parameters. Highest catch densities of sole were found to be consistently located in shallow inshore waters where sandier sediments predominate. This agrees with the known habitat requirements of sole and therefore validates this modelling approach for predicting this species' distribution. Both modelling techniques were successful in producing robust maps of marine species from point sample data, thus demonstrating their application for underpinning marine spatial plans.

Finally, experience of various habitat mapping techniques gained over the course of this research programme has been synthesised into a set of interactive guidelines (Figure 6). It is hoped that these guidelines will be of benefit to Government Departments, in discharging their responsibilities under environmental protection legislation, marine scientists

working on behalf of various industries or regulators and those involved in undertaking R&D programmes aimed at holistic (ecosystem-level) assessments.

The full report is available from the corresponding author as a CD (including the interactive guidelines for scoping and designing seabed habitat surveys) and printed copy.

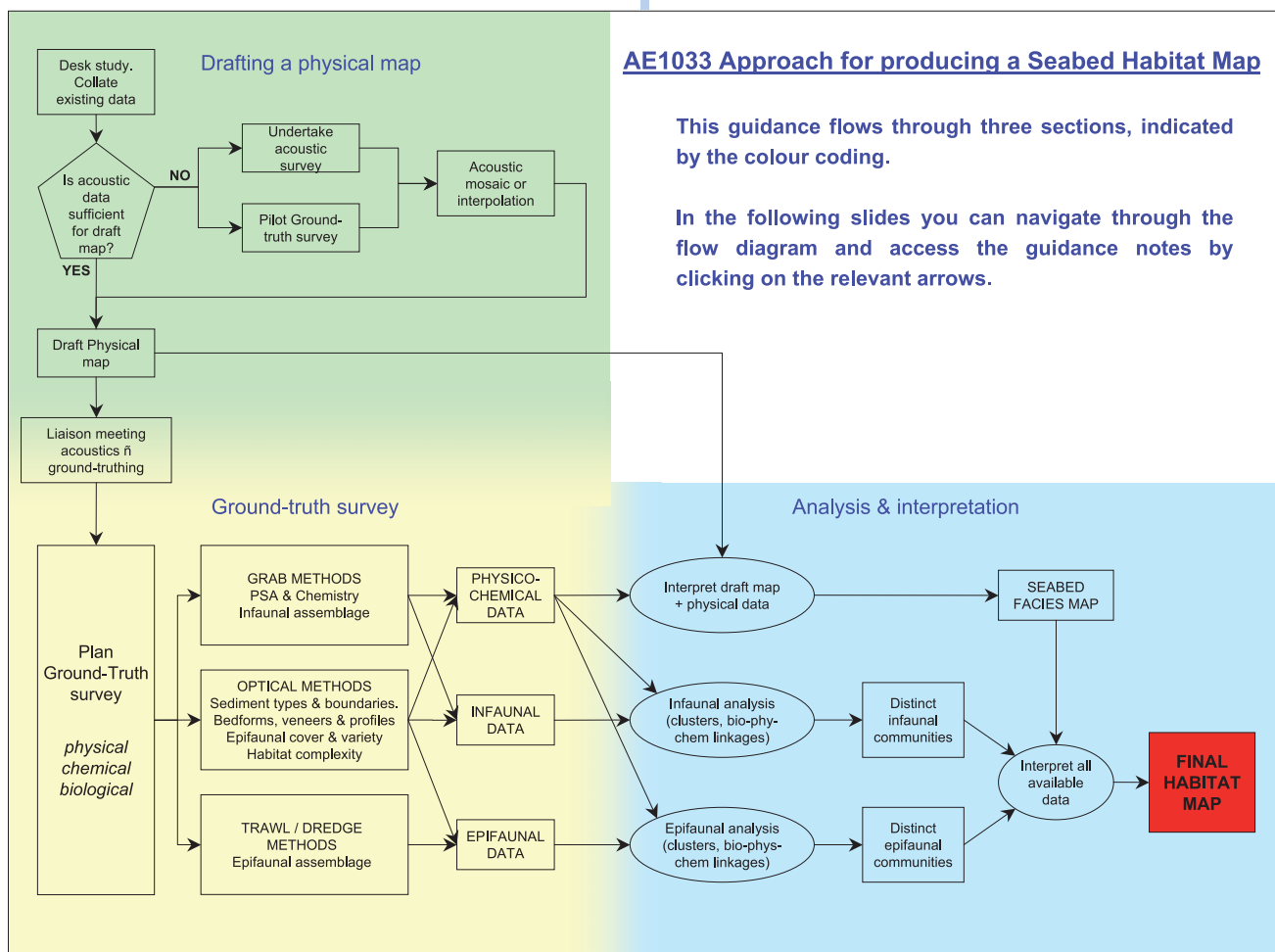


Figure 6: Schematic approach to seabed habitat mapping developed by this project, and presented as a set of interactive guidelines on the CD of the full report.

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Title: The Role Of Seabed Mapping Techniques In Environmental Monitoring And Management

Contractor: Cefas

Contact: Sian Boyd

Telephone: 01621 787200

E-mail: sian.boyd@cefas.co.uk

Full Report Site:
<http://www.cefas.co.uk/Publications/techrep/techrep127.pdf>



Eastern English Channel marine habitat map

INTRODUCTION

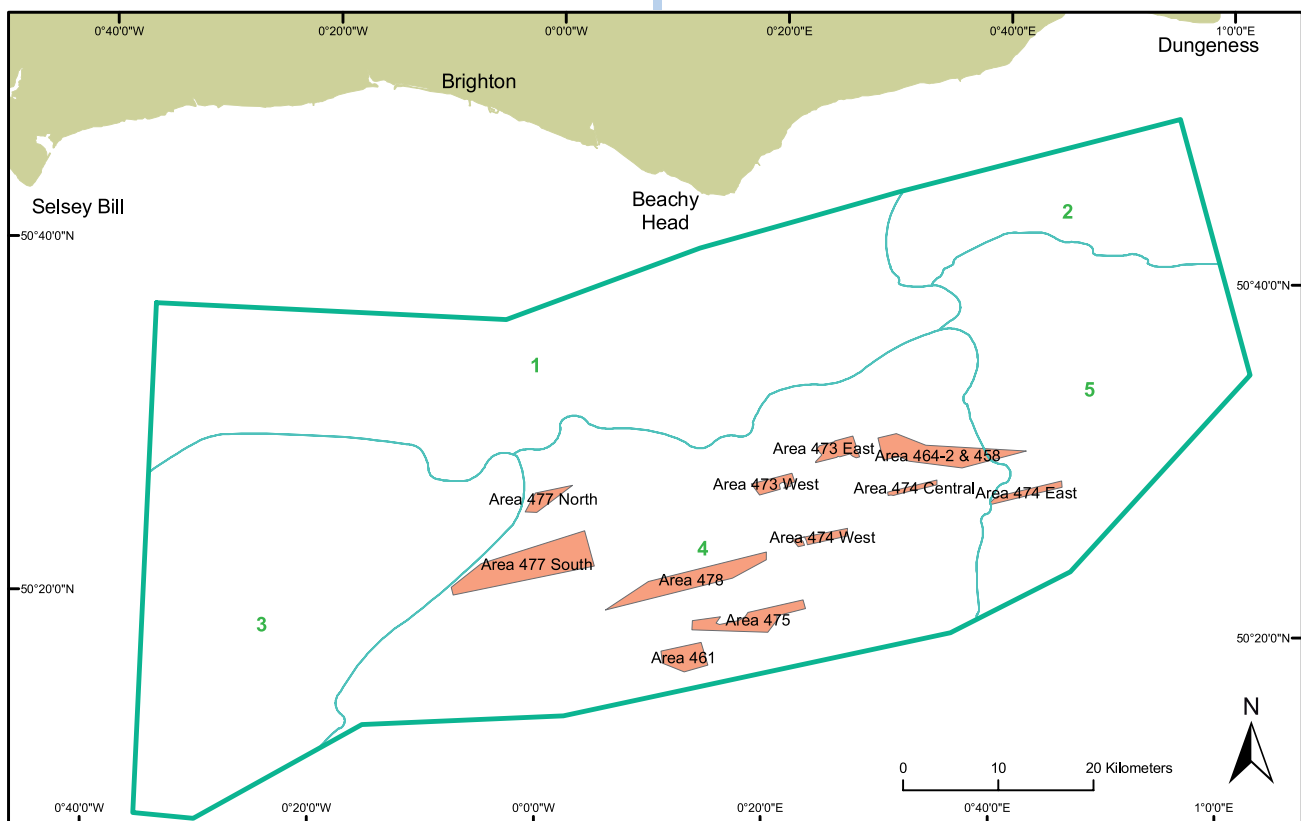
The aim of the Eastern English Channel Marine Habitat Map (EECMHM) study is to provide integrated regional habitat maps for an extensive area within the central part of the Eastern English Channel. The principal driver is the discovery and planned exploitation of substantial marine aggregate resources in this area and the requirement to manage the development of this resource and minimise potential impacts.

The area of aggregate resource needs to be assessed within the broader context of the Eastern English Channel. This study aims to supply regional scale interpretations of geological and biological data to provide this context.

The government wishes to promote effective stewardship of the marine environment through a policy of integrated management, balancing the requirements for development with nature conservation and legislation. The implementation of the EU Habitats directive also requires a significant knowledge of the

nature and character of the sea bed. The data, interpretations and maps produced by the study will provide a better basis for marine spatial planning, now and in the future and will also help resolve conflicts regarding seafloor use.

Currently (March 2007) ten independent licence applications (Figure 1) have been made by six aggregate companies and some of these have been granted. The six companies created a consortium, the East Channel Association (ECA), which commissioned a Regional Environment Assessment (REA) of the East Channel Region (ECR) (Posford Haskoning, 2003). The REA data and findings primarily relate to the ECR area which covers 1132 km² within and adjacent to the licence applications and do not address the wider surrounding area in detail. The ECA have also commissioned further regional environmental studies (EMU & MarineSpace, 2006)



- 1 Physical Region Boundary
- ECA Licence Application Areas (Oct. 2006)

Figure 1: Aggregate licence application areas (October 2006) and physical regions

J.W.C. James¹, R.A. Coggan², V.J. Blyth-Skyrme³, A. Morando¹, S.N.R. Birchenough², E. Bee¹, D.L. Limpenny², E. Verling³, K. Vanstaen⁴, B. Pearce⁵, C.M. Johnston³, K.F. Rocks¹, S.L. Philpott¹, H.L. Rees².
¹British Geological Survey, Kingsley Dunham Centre, Nicker Hill, Keyworth, Nottingham NG12 5GG
²Cefas, Burnham Laboratory, Remembrance Ave, Burnham-on-Crouch, Essex, CM0 8HA
³Joint Nature Conservation Committee (JNCC), Monkstone House, City Road, Peterborough, PE1 1JY
⁴Cefas, Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT
⁵Marine Ecological Surveys Ltd (MES), 24a Monmouth Place, Bath, BA1 2AY

EECMHM STUDY AREA

The study area boundary (Figure 1) was drawn to provide a wider perspective of the nature of the sea bed in and around the area originally prospected by the East Channel Association (ECA). The study area covers approximately 5090 km², having a west-east extent of about 115 km and a north-south extent of about 45 km. The southern limit is the political boundary of the UK – France median line.

The limits of the study area, apart from the political boundary, were also drawn from the perspective of its bathymetry, geology, sediment, biology and hydrodynamics, with the aim of providing a wider context of these parameters for the ECA prospecting and licensing areas.

SURVEY METHODS

The survey design and strategy adopted for this study reflected the requirement to cover a very large area, showing the broad distribution of dominant habitat types with some detailed information on the nature of the biotopes encountered. The approach used a 'corridor grid' survey design to provide equitable coverage of the area and a strategy of geophysical surveys followed by directed ground-truth sampling to provide information on the physical nature of the seabed and the variety of biological communities.

GEOPHYSICAL SURVEYS

The geophysical survey acquired high-resolution multibeam bathymetry (MBES), side scan sonar and shallow sub-bottom seismic data as this was fundamental to providing the physical and regional

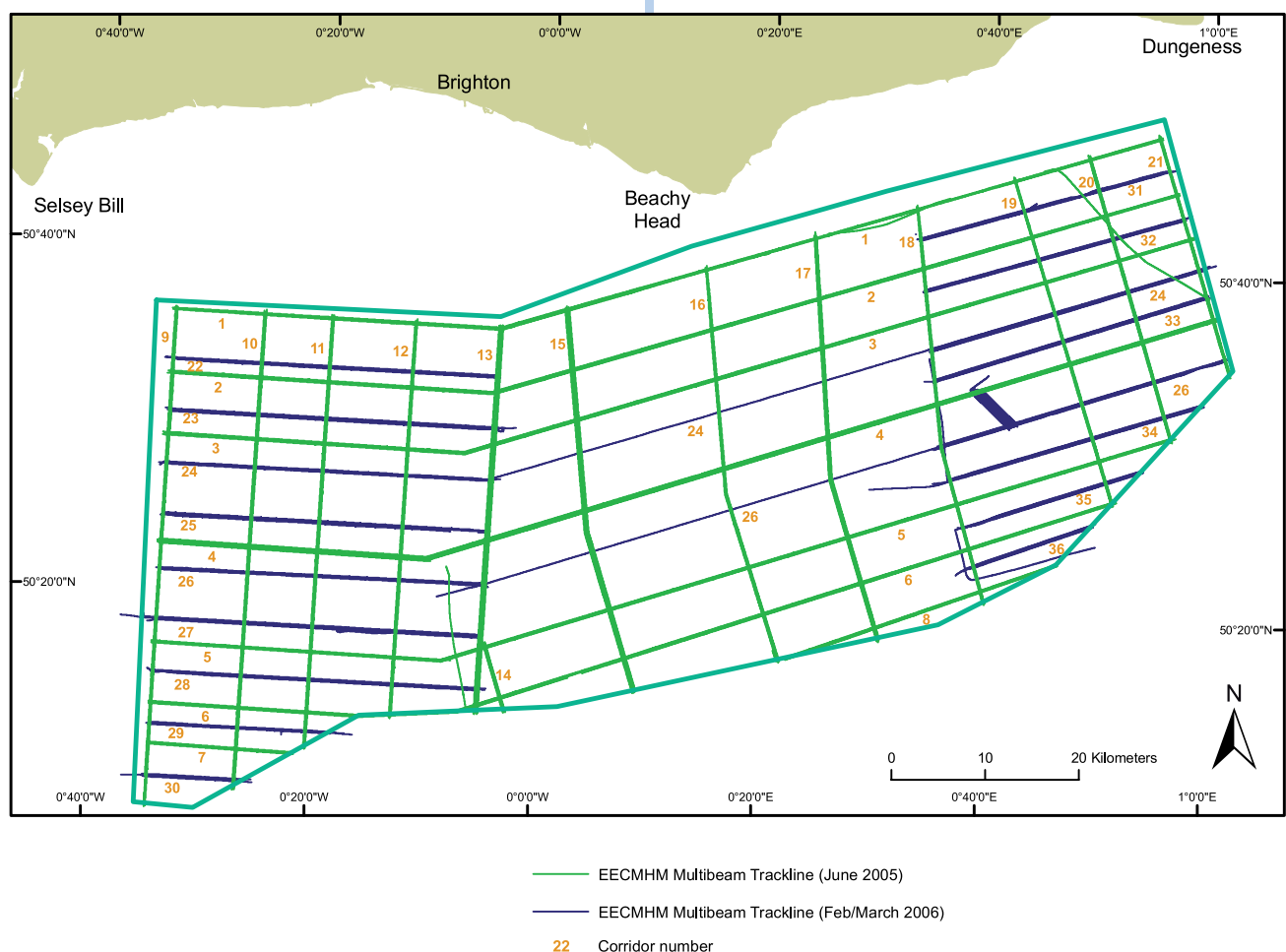


Figure 2: Multibeam survey tracklines and corridors

Eastern English Channel marine habitat map

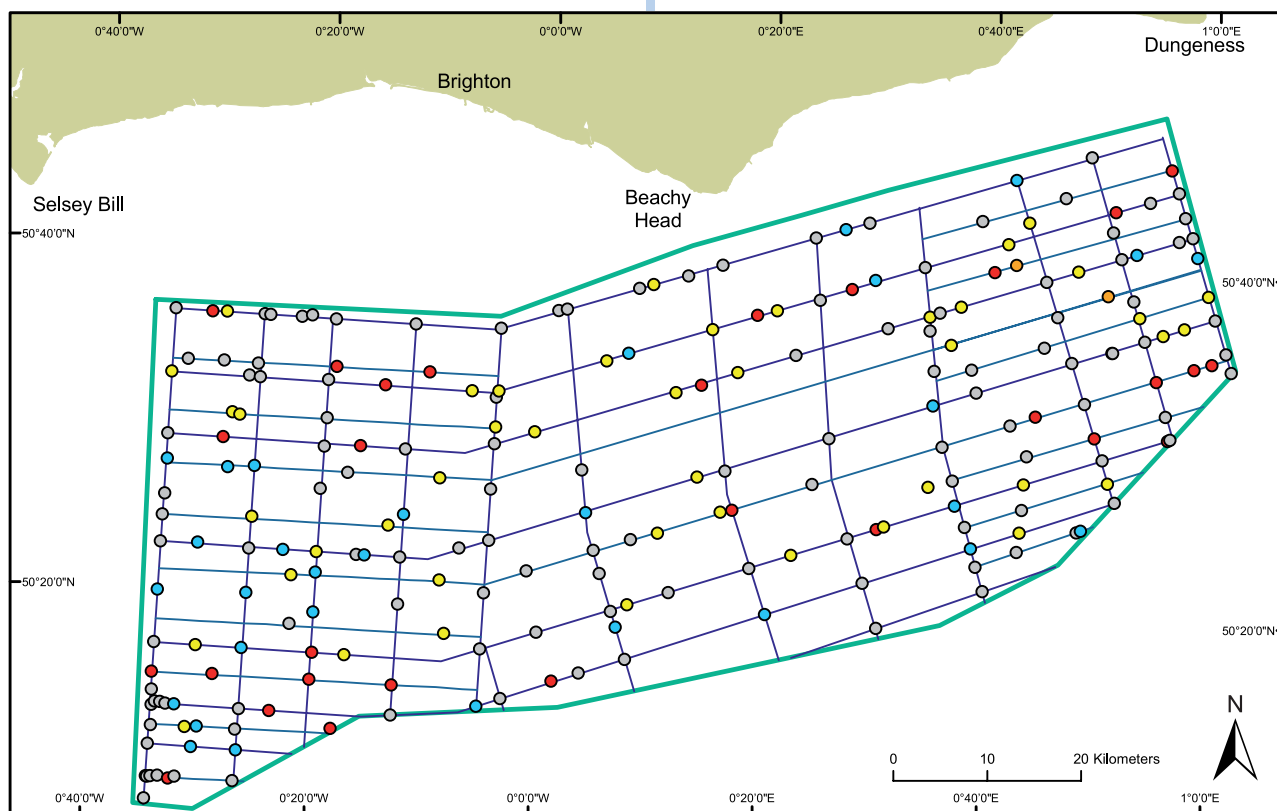
framework on which to develop the biological sampling programme and the interpretation of sea bed habitats. The survey strategy was devised to acquire three parallel lines with side scan sonar and multibeam deployed simultaneously, aiming to provide a sea bed swath width of up to 500m across each corridor, and to acquire shallow sub-sea bed seismic data with a surface towed boomer along the centre line of each corridor. The W-E corridors were up to 120 km long and generally ran parallel to the peak tide direction. These lines and the N-S lines were designed to cross the major geological and morphological features present in the study area. The N-S lines range in length from 27 km to 55 km.

Two geophysical surveys were carried out (Figure 2). The primary survey in 2005 covering the main grid, and a second survey in 2006 (without surface towed boomer) providing in-filling lines. The first survey completed 4085 line km of Multibeam Echo Sounder (MBES), ~4000 line km of sidescan sonar producing 21 corridors of swath

coverage and ~1232 line km of boomer sub-bottom data. Approximately 2,000 line km along 17 corridors were completed in the second survey. The final corridor spacing with both surveys ranges from ~2 km to 16 km apart.

GROUND-TRUTH SURVEYS

Sea bed sampling took place only within the geophysical corridors, to maximise the interpretation and correlation of physical, geological and biological datasets to describe, differentiate and characterise sea bed habitats. Sampling sites were selected to ground truth acoustically distinct areas related to changes in sediment type, bedforms and morphology, and to establish the presence or absence of Annex 1 habitats listed under the EU Habitats Directive (e.g. rock or cobble reefs).



- | | | |
|----------------------------|---|----------------------------|
| — Geophysical survey lines | EECMHM Sample types | |
| | ○ Hamon grab only | ● Hamon grab and video tow |
| | ● Hamon Grab and 2m beam trawl | ● Video tow only |
| | ● Hamon grab, 2m beam trawl and video tow | |

Figure 3: Location of ground-truth sampling and combinations, relative to the geophysical survey grid.

A suite of complementary sampling techniques was selected, comprising a 0.1m² Hamon grab, a 2-metre beam trawl and an underwater video/still camera system (mounted on a sledge or drop frame). To optimise the effectiveness and spatial coverage of the ground truth sampling, the total sampling effort was roughly apportioned (*a-priori*) among the gears, giving ~60% to grab sampling, as this provided quantitative data on both sediment type and infaunal species, and about 20% each to trawl and camera techniques, which provide semi-quantitative data on epifauna and ground type.

The location and sampling regime for each sampling site was determined by a team of geologists and biologists following interpretation of the results of the geophysical surveys. Some sites were placed at the nodes of the survey grid to provide N-S and E-W correlations and continuity, while others targeted specific features of interest. Few sites were placed inside the ECR as data for this area was available from the REA. Figure 3 shows the location of the EECMHM ground-truth sites and the combination of gears used at each. In total, there were 225 grab samples, 73 beam trawls and 65 video tows (52 on a sledge, 13 on a drop frame).

Grab samples were subject to both particle size and biological analysis. A sub sample of ~ 500 ml of the < 64 mm sediment fraction was collected for PSA analysis, while the weight and volume of the >64 mm fraction (i.e. cobbles) was determined on board. Biological analysis was performed on the fraction of the sample retained by a 1 mm sieve, recording abundance and biomass of the species found. For trawl samples, abundance and biomass were recorded for all species retained by a 5 mm sieve. Video footage was reviewed to assess the physical and biological characteristics of the seabed, with the abundance of visible benthic fauna (excluding fish) being recorded using the semi-quantitative MNCR SACFOR scale (<http://www.jncc.gov.uk/page-2684>). Fully quantitative analysis was undertaken on a representative selection of still images from each tow, enumerating discrete taxa and assessing the % cover of encrusting and colonial taxa.

GEOLOGY - INTERPRETATION

Physical features which include geology, sediment and morphology of the sea bed greatly influence the distribution and range of species and biological communities and together comprise the marine habitat at the sea bed. However, in terms of habitat, only the physical characteristics of the sea bed surface and its underlying geology and sediment down to a depth of ~0.5 m is thought to be significant, so the principal aim of the geological investigations was to characterise the

physical nature of the sea bed and the processes which have contributed to form and maintain its present day character.

The diversity of processes and events that have contributed to producing the sea bed geology and sediments within the EECMHM area required a systematic approach to the analysis in order to provide a framework on which to build an integrated interpretation and produce a series of themed geological and sediment maps. The systematic approach involved a sequence of interpretive steps: -

1. To understand and interpret the sub-sea bed geology and distinguish and map those areas where rock outcropped at the sea bed, identifying the type and age of the rock, and areas with palaeochannels filled with Quaternary sediment. This sub-sea bed geological framework was provided by the interpretation of boomer seismic records to produce a simplified isopach map of Quaternary sediment thickness.
2. To integrate the boomer interpretation with multibeam and sidescan sonar data especially in those areas where Quaternary sediments were thin (0-1.5 m thick) and bedrock was exposed or virtually at the sea bed. These areas have been copied on to the sea bed character map (Figure 5) and distinguished as rock and thin sediment
3. To interpret multibeam and sidescan data for morphology and bedforms. These were included in the sea bed character map (Figure 5). Video and still pictures from the ground-truth surveys were analysed to examine bedforms and sea bed character and verify the composition of thin veneer sediment and confirm the presence of bedrock at the seabed.
4. To interpret particle size analysis (PSA) data to produce a series of maps including sea bed sediment distribution based on the Folk classification (Figure 4), and other statistical parameters such as mean grain size, d_{50} – median grain size and sorting.

Eastern English Channel marine habitat map

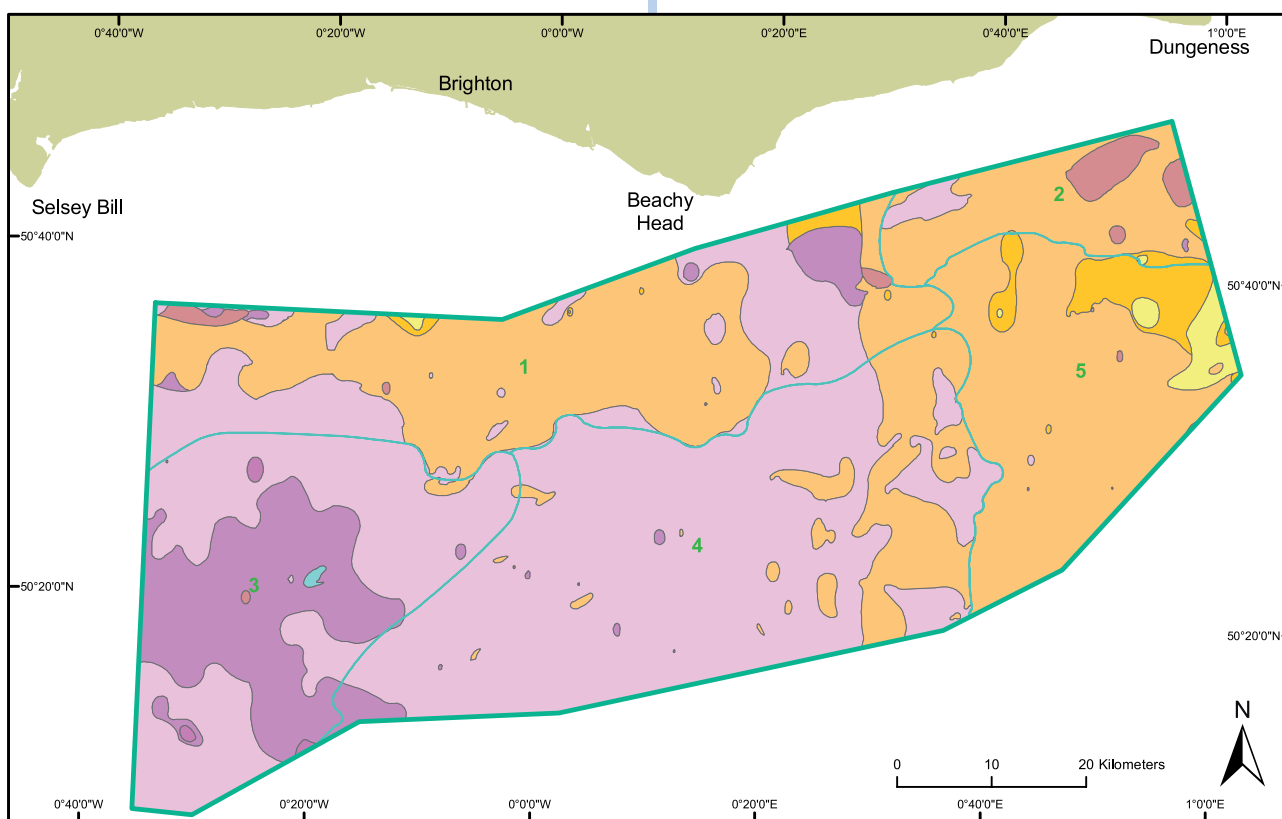
PHYSICAL REGIONS

The interpretation of the geophysical and geological data gathered by or made available to the study indicated that certain areas had characteristic or common physical and geological features which distinguished them. These areas have been classified as physical regions and five in all have been delineated (Figure 4 and others). Their boundaries are drawn on a number of criteria and include: -

- Water depth and sea bed morphology
- Sea bed sediment classification
- Bedforms
- Sea bed character and sediment thickness

These criteria are not common to all boundaries between regions. Some may be the primary criteria at a number of boundaries and at others they will not be significant. For some criteria the boundaries can be transitional or gradational e.g. a fining or coarsening of sediment, elsewhere they can be relatively fixed e.g. a break of slope or channel margin.

- The physical regions are: -
- Region 1 - Northern Palaeovalley and Margin
 - Region 2 - North-East Platform and Margin
 - Region 3 - Western Axial Platform
 - Region 4 - Central Axial Platform
 - Region 5 - Greater Bassurelle Sands



Physical Regions

- 1 Northern Palaeovalley and Margin
- 2 North-East Platform and Margin
- 3 Western Axial Platform
- 4 Central Axial Platform
- 5 Greater Bassurelle Sands

Sea Bed Sediment Folk Classification

- | | |
|---|--|
| S - Sand | gM - gravelly Mud |
| (g)S - slightly gravelly Sand | sG - sandy Gravel |
| gS - gravelly Sand | msG - muddy sandy Gravel |
| gmS - gravelly muddy Sand | G - Gravel |

Figure 4: Sea bed sediments and physical regions

SOLID GEOLOGY - BEDROCK

Although the bedrock of solid geology underlies the whole EECMHM study area it is only in those areas of sea bed underlain by rock and thin sediment (Figure 5) where the nature, lithology and form of the bedrock is likely to have any impact on marine habitat. Elsewhere the thicker Quaternary and mobile sediment cover provides the sea bed surface for habitat.

Tertiary rocks within the NW - SE trending Hampshire – Dieppe Basin (Hamblin et al, 1992.) dominate the study area, specifically in the western half of Region 1 and over much of the southern half of the EECMHM study area which includes Regions 3, 4 and 5. The Tertiary are bordered to the west and east by older Cretaceous rocks, namely Chalk, Gault – Greensand and Wealden Group with underlying Upper Jurassic rocks only occurring in the north east. The EECMHM study area boundaries were deliberately drawn to include these older Cretaceous and Jurassic strata to investigate

whether there were any habitat relationships and associations specific to sea bed on Tertiary, Cretaceous or Jurassic bedrock. The ECA licence application areas are purposely sited on sand and gravel deposits not bedrock and these sand and gravel deposits are all underlain at depth by Tertiary bedrock.

QUATERNARY SEDIMENTS

A series of palaeochannels cut into bedrock during the Quaternary period, and now infilled with sediment, lie beneath Region 4 – Central Axial Platform and Region 5 – Greater Bassurelle Sands. Outside these regions Quaternary sediment generally thins to the north and west. The sub-sea bed Quaternary deposits over the palaeochannel systems generally constitute the resource material for marine aggregate in most of the licence application areas.

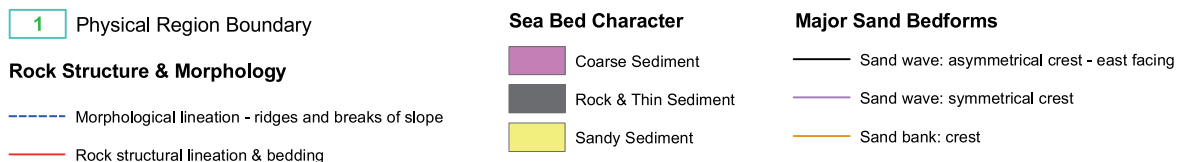
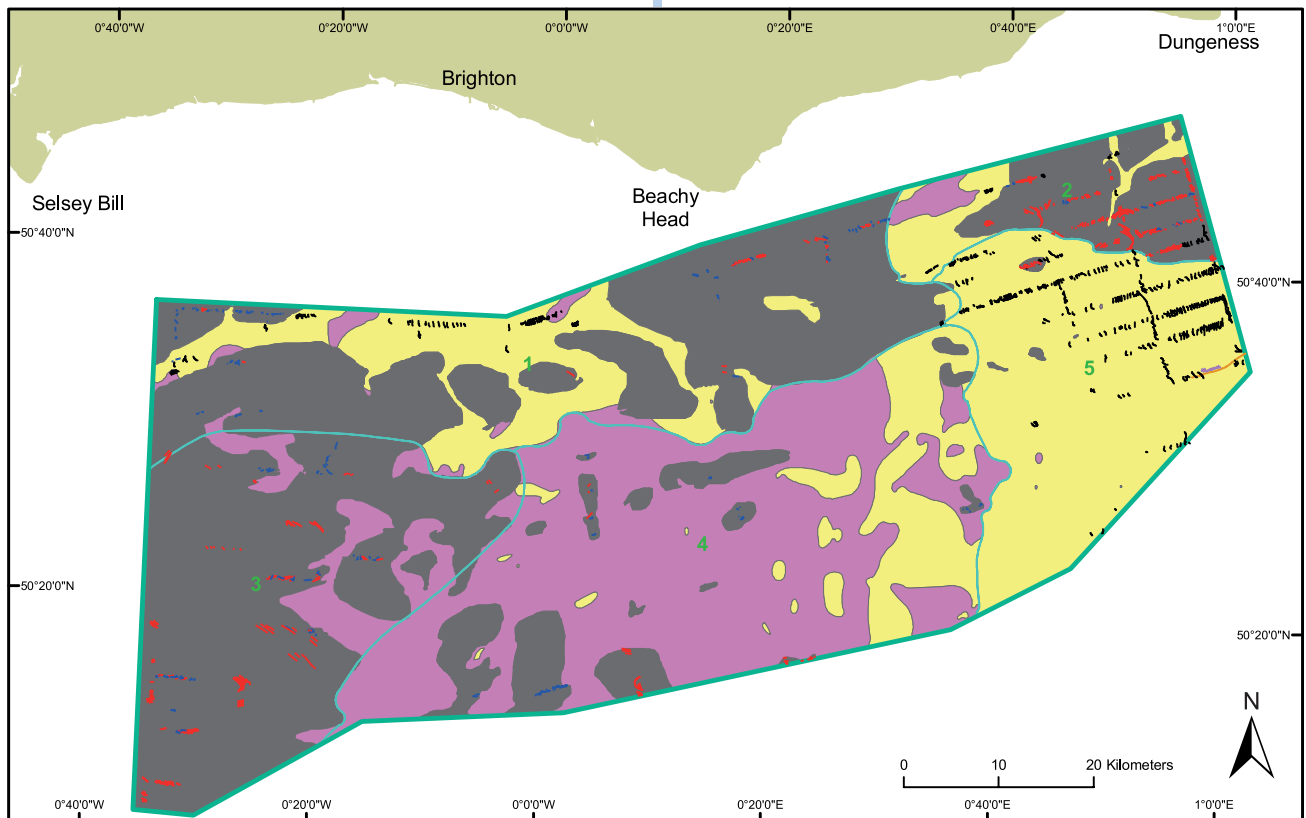


Figure 5: Sea bed character & bedforms

Eastern English Channel marine habitat map

Sea level rise since the last glaciation and its associated marine transgression, plus strong tidal currents has winnowed fine sediment from gravel and rock surfaces and transported sediment to the east in the English Channel. In the central area of Region 5 – Greater Bassurelle Sands seismic records provide evidence of this eastward movement with the deposition of a thin transgressive sand sheet immediately beneath the sea bed. Further to the east in the Greater Bassurelle Sands, the transgressive sand sheet unit becomes thicker, >5 m, and merges into an extensive sand wave field (Figure 5)

SEA BED CHARACTER AND BEDFORMS (SBCB)

Sea bed character and bedforms (Figure 5) marries the dynamic process-driven morphological elements which occur on the sea bed as sandy bedforms, including sand waves, ribbons and banks, with those morphological elements which are stable and immobile such as rock scarps, bedding, lineation and channel margins. These morphological elements have been mapped in-situ along the geophysical corridors and they are superimposed on a substrate that has been divided into a threefold classification of sea bed character: -

- Sandy sediment
- Coarse sediment
- Rock and thin sediment

The interpretation of sea bed character is based on an integrated analysis of data provided by multibeam, sidescan sonar, boomer seismic reflection, grab sediment sampling, video and still photo imagery. The sea bed character interpretation (Figure 5) has also been completed in conjunction with the sea bed sediment Folk classification map (Figure 4). These interpretations are complimentary and should be read in tandem to gain a fuller understanding of the character of the sea bed.

The present character of the sea bed is the result of both ancient and modern processes.

- Ancient processes include Glacial/Interglacial cycles during the Quaternary that eroded and infilled channel systems, and folding and faulting of Tertiary to Jurassic rocks.
- Modern processes include the marine transgression which swept eastwards across the English Channel as sea level rose from >100m after the last glacial maximum, eroding, reworking and transporting sediment along its path, - and the effects of marine tides and currents over the last 5000 years since sea level attained its modern day level.

The nature and occurrence of sand bedforms in the EECMHM study area have been divided into four categories

- Sand bank
- Sand wave field
- Sand streaks, patches, ribbons and megaripple trains
- Scarce bedforms to featureless

Their form and extent are controlled by sediment supply, tidal current velocity, duration and orientation, and in some areas sea bed morphology such as rock outcrop and channels.

In areas of rock and thin sediment two types of lineation have been interpreted

- Morphological lineation - ridges and breaks of slope associated with channel margins, interfluvial erosion, possibly Quaternary river sediment bars and beach ridges.
- Rock structural lineation – scarps, ridges and breaks of slope formed by differential erosion of bedrock.

The mapping of sea bed character and bedforms is an attempt to indicate the variety of physical elements, features and processes, not simply sediment, which can impact the nature and occurrence of habitat and biotope assemblages.

In terms of sea bed character around 43% of the study area's 5090 km² is covered by rock and thin sediment. 27% by coarse sediment and 30% by sandy sediment. Rock and thin sediment extends over much of the sea bed in the north in Regions 1 and 2, and is particularly extensive in the west in Region 3. Coarse sediment dominates Region 4 in the central south of the study area with sandy sediment increasing in significance to the east and encompassing all of Region 5 in the south-east.

Both the areas of coarse sediment and much of rock and thin sediment are particularly scarce in sandy bedforms. Sand waves are confined to the far east of the study area where they are numerous, some parts of the Northern Palaeovalley and isolated examples in the north-east. Sand streaks, patches, sand ribbons and megaripple trains are also more common in both northern regions.

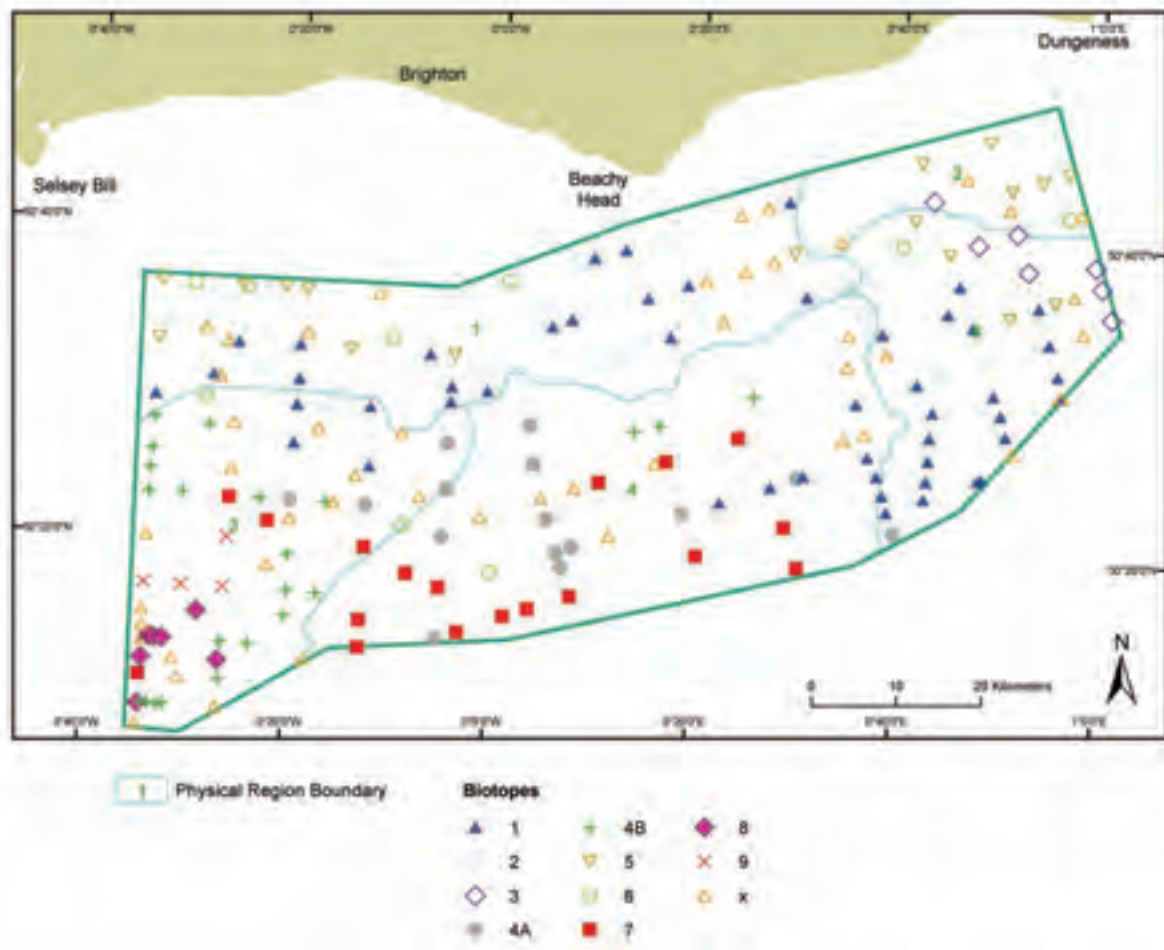


Figure 6: Distribution of principal infaunal biotope classes according to the MNCR classification

SEA BED SEDIMENTS

Sediment collected by Hamon grab at 225 EECMHM and 468 ECA sample stations have been used in the analysis of sediment particle size for each sample station. Each sample has been classified by grain size using the Folk classification system (Folk, 1954) and an interpolated map produced of the whole EECMHM study area (Figure 4). It should be noted that this map takes little or no account of evidence from multibeam, sidescan, sub-bottom or camera data, for example, outcrops of rock are not shown..

Three of the five physical regions are dominated by sandy sediment, predominantly gravelly sand. These are the Northern Palaeovalley and Margin (Region 1), the North-East Platform and Margin (Region 2), and the Greater Bassurelle Sands (Region 5). Region 1 and 2 include some areas of sandy gravel but this is more extensive in the Central Axial Platform (Region 4). This sandy gravel extends westward into the Western Axial Platform (Region 3), which also has an extensive area of muddy sandy gravel at its core.

In the two northern regions (1 & 2) there are large areas where sand comprises over 70% of the analysed sediment, although the distribution of sand is patchy reflecting the relatively complex nature of the sea bed with rock and thin sediment, and intermittent sandy bedforms common.

From west to east across the three southern regions (3, 4 & 5) there is a grain size trend of increasing sand content and decreasing gravel content. In the Western Axial Platform (Region 3) there are a number of areas with <40% sand - >60% gravel. Sand content increases across the Central Axial Platform (Region 4) from around 50%-60% to 70%-80% at its eastern boundary with the Greater Bassurelle Sands (Region 5). In Region 5 itself, the sand content reaches over 90% in the sand wave field and the Bassurelle Sand Bank.

Eastern English Channel marine habitat map

The west to east sediment fining trend in the southern regions is also reflected in the values for d_{50} - median grain size, mean grain size, skewness, and sorting and can be related to a number of factors including: -

- The extensive area of immobile rock and coarse sediment substrate with cobbles in the west in Region 3
- Quaternary sediment infilling the channel systems in the Central Axial Platform providing a predominantly gravelly substrate beneath the sea bed.
- The winnowing of sediment by strong tidal currents from these coarse substrates, particularly sediment <1mm in grain size, and their transport to the north and east and deposition as sand sheets and bedforms including sand waves and sand banks.

The results from the camera sledge video and still photographs provides excellent supporting evidence for the statistical results obtained from the analysis of sediment grab samples and generally confirms the overall pattern and distribution of sea bed sediment produced in the Folk sea bed sediment map (Figure 4). In those areas of sea bed where rock and thin sediment are extensive it was apparent from video and photographs that sediment sampling was only providing some part of the evidence for the nature of the sea bed, especially with regard to defining the abundance of large cobbles and boulders.

The Western Axial Platform (Region 3) is the only region with a significant number of video tows which show >7 cobbles per photo, many photos have over 60% cobble cover. None of the four other regions had tows with cobbles >3-4 per photo, most were just 1 or 2, or almost zero in sandy areas such as the Greater Bassurelle Sands.

No systematic interpretation and counting of the type of gravel lithologies seen on video and photos or sampled by grab has been undertaken. It is an assumption that within the English Channel, gravel at the sea bed is dominated by flint and commonly comprises up to 80% of the total (Hamblin et al, 1992).

Gravels at the sea bed within the Central Axial Platform appear to be dominated by subrounded flint, consistent with the fact that Region 4 is underlain by palaeochannel systems infilled with fluvial gravels whose principal component is likely to be flint.

The evidence from the camera sledge tows in the Western Axial Platform (Region 3) suggests that flints are not as common as in the other regions. Instead, the area is characterised by a cobble-rich sediment veneer

on Tertiary to Chalk rock outcrop, exposed in parts, and the underlying rock provides the source for a significant proportion of the sea bed gravel, particularly the cobbles and boulders.

BIOLOGICAL INTERPRETATION – INFAUNA

The cluster analysis for grab samples identified nine principal groups that could reasonably be interpreted as biotopes. The infaunal biotope IB4 was also sub-divided into 4a and 4b, due to their similar community composition, with the addition of higher numbers of *Glycymeris* in IB4b. The clusters considered as main groups contained a minimum of 5 stations. The analysis actually showed many more groups (about 50 in all), but the majority of these represented only single sites, or a few that showed no spatial pattern, so could not be considered representative of a regional scale biotope. Figure 6 shows the geographical distribution of the sites assigned to the ten biotope classes (1-9 including 4a & 4b), and of the unassigned stations (class X).

The distribution of these biotope classes was considered in relation to the available physical data and geological interpretation of the study area. The biological and physical information was cross-referenced to The Marine Habitat Classification for Britain and Ireland' (version 04.05, Connor et al. 2004, hereafter referred to as the 'MNCR' biotope classification) to find a matching biotope class. Only two matches were found, other groups showing notable similarities to existing biotope classes but having differences in the characterising fauna. Descriptions of the ten biotope classes are given below, and are referred to as Infaunal Biotope classes in recognition that grab samples primarily target infaunal taxa. An MNCR-style biotope code is given and, in square parenthesis, the nearest existing equivalent MNCR habitat code (including exact matches).

Infaunal Biotope 1.

SS.SSA.CFiSa.EpusPomGal.

[SS.SSA.CFiSa.EpusOborApr]

Echinocyamus pusillus, *Pomatoceros* and *Galathea* in circalittoral fine sand.

This group contains a variety of crustaceans and polychaetes. A slightly coarser element to the substrata gives rise to the presence of species more typical of gravel biotopes such as *Galathea* and *Pomatoceros*. This group is most closely related to the *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand classification.

Infaunal Biotope 2.

SS.SSA.CFiSa.EpusNephGlyc.

[SS.SSA.CFiSa.EpusOborApr]

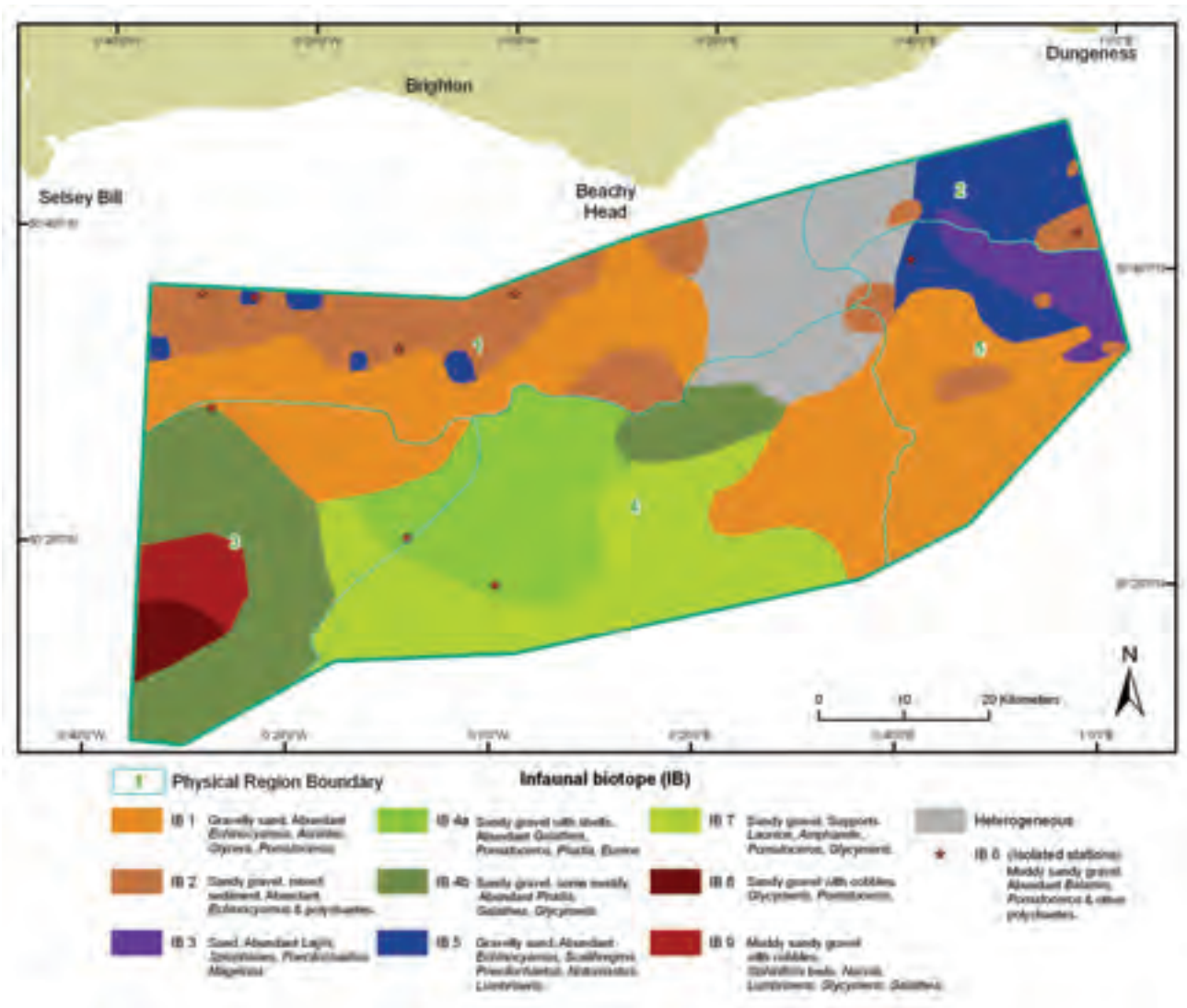


Figure 7: Regional distribution map of infaunal biotopes (IB)

Echinocyamus pusillus, *Nephtys* and *Glycera* in circalittoral fine sand.

This group is most closely related to the existing biotope formed by *Echinocyamus pusillus*, *Ophelia borealis* and *Abra prismatica* in circalittoral fine sand. Differences in the fauna compared with the original classification may be attributable to the more limited information available at the time. The species present could still fit into a more 'relaxed' version of this biotope.

Infaunal Biotope 3.

SS.SSA.CFiSa.Lkor.Ens. [SS.SMU.CSaMu.Lkor.Ppel]
Lagis koreni and *Ensis* found in circalittoral fine sand.
 This group is very closely related to the existing description with *Lagis koreni* and *Phaxas pellucidus* in circalittoral sandy mud.

Infaunal Biotope 4a.

SS.SCS.CCS.Gal.Pom.Pis(Eun). [SS.SCS.CCS.PomB]
Galathea and *Pomatoceros* with *Pisidia* and *Eunice* in circalittoral coarse sediment.

There is no real match with the existing MNCR biotope classification: the nearest category is the *Pomatoceros triquetus* with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles. It is likely to be a similar predominantly coarse sediment biotope but a small amount of finer sediment is indicated by the lack of attached epifauna (attributed to scour effects).

Infaunal Biotope 4b.

SS.SCS.CCS.Gal.Pom.Pis(Gly). [SS.SCS.CCS.PomB]
Galathea and *Pomatoceros* with *Pisidia* and *Glycymeris* in circalittoral coarse sediment.

Very similar community composition to 4a with the addition of *Glycymeris* although great significance should not be placed on this difference as *Glycymeris*

Eastern English Channel marine habitat map

are very widely separated spatially and not sampled effectively using the grab. No real match with existing MNCR biotope classification.

Infaunal Biotope 5.
 SS.SCS.CCS.Not.Lum. [SS.SCS.CCS.MedLumVen]
Mediomastus fragilis, *Lumbrineris spp.* and venerid bivalves in circalittoral coarse sand or gravel.
 This biotope has low numbers of venerid bivalves and *Notomastus*. The polychaete *Mediomastus* is performing the same function in the community. Generally agrees well with the existing MNCR classification, a more 'relaxed' version of which would better match the current data (i.e. *Capitellids* with *Lumbrineris* and occasional venerid bivalves).

Infaunal Biotope 6.
 SS.SCS.CCS.PomB. [SS.SCS.CCS.PomB]
Pomatoceros triqueter with barnacles and encrusting bryozoans on unstable circalittoral cobbles and pebbles.
 This biotope relates to a cluster of nine stations that were spatially scattered across the study area.

Infaunal Biotope 7.
 SS.SMX.OMx.Po. [SS.SMX.OMx.PoVen]
 Polychaete-rich offshore mixed sediments.
 This group is very closely related to a Polychaete-rich deep *Venus* community in offshore mixed sediments, but there was a minimal occurrence of venerid bivalves in the samples; a more 'relaxed' version of this biotope would better match the current data.

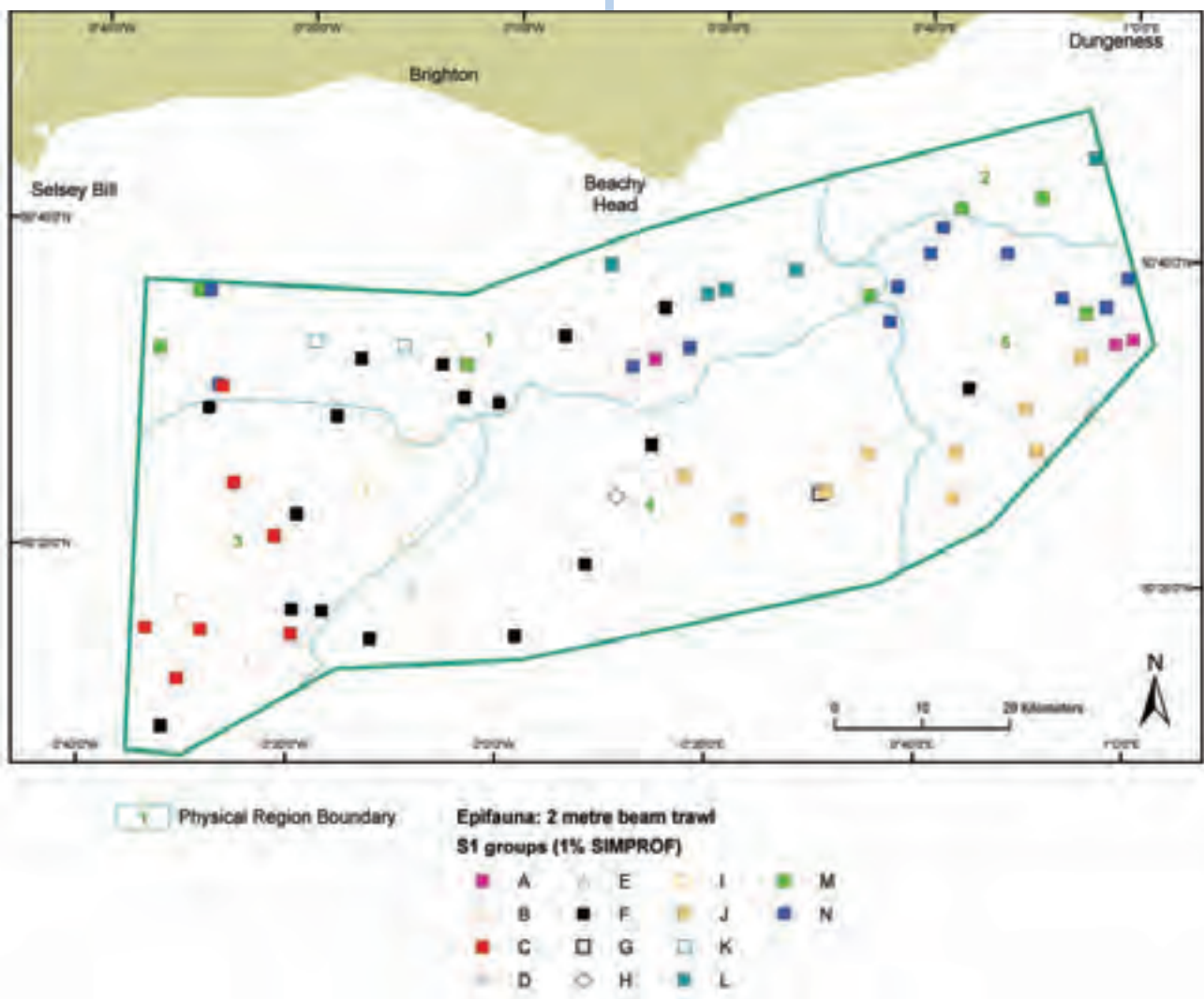


Figure 8: Distribution of epifaunal biotopes sampled by 2 m beam trawls

Infaunal Biotope 8.

SS.SMX.OMx.PoGlyEpi. [SS.SMX.OMx.PoVen]

Polychaete-rich offshore mixed sediments with *Glycymeris* and attached epifauna.

Most closely related to a Polychaete-rich deep *Venus* community in offshore mixed sediments. Limited occurrence of venerid bivalves, strongly characterised by *Glycymeris* and attached epifauna including the ascidians *Dendrodoa* and *Pyura* and the tubicolous polychaete *Pomatoceros*.

Infaunal Biotope 9.

SS.SMX.CMx.OphMX. [SS.SMX.CMx.OphMX]

A small but distinct biotope group, located in circalittoral coarse sediment with *Harmothoe*, *Ophiothrix*, *Nucula*, *Lumbrineris*, *Glycymeris* and *Galathea*. The existing MNCR biotope classification only describes the presence of *Ophiothrix* and epifauna. The allocation of this biotope code was based on sediment type and the abundant presence of *Ophiothrix*.

Figure 7 presents the EECMHM Infauna Biotope map, which represents an integrated assessment of the Infaunal Biotopes and associated geological information, using expert judgement to place and interpolate boundaries between the biotope classes.

BIOLOGICAL INTERPRETATION – EPIFAUNA

The cluster analysis for beam trawl samples identified 14 epifaunal groups, 9 of which contained three or more stations and displayed a spatial relationship that suggested they were giving some insight into the geographical distribution of regional epifaunal biotopes (Figure 8). This was complemented by a consolidated interpretation of the video and stills analyses that grouped the observed stations into seven broad biotope classes (Figure 9). A notable resemblance between the spatial patterns displayed by the trawl and video/stills analyses (compare Fig 8 and 9) provided corroborating evidence that the observed patterns were real rather than artefact.

The different sampling characteristics of trawl and video techniques precluded the pooling of data for joint analysis. Instead, the evidence from the trawl and video/stills analyses was considered in conjunction with the available geological interpretations, and used to describe and map a series of eleven 'Epifaunal Biotope Complexes' (EBC) (Figure 10). This approach reflects a consensus that while the samples acquired could be matched to the existing MNCR biotope classification (even though sometimes at a rudimentary level), the process of mapping boundaries was to a large extent speculative due to the relatively low frequency of

sampling stations and evidence of sea bed heterogeneity and extensive transition zones between some sea bed-types, while others were more clearly defined e.g. the Bassurelle Bank. The term Epifaunal Biotope Complex was selected to impart a sense that multiple biotopes are likely to exist within any one of the mapped regions and that the map is indicative of regional distribution trends.

Details of the EBCs are provided below, giving a general description of the sea bed substrate and listing prominent genera. Examples of MNCR biotope classes and other characterising species noted in the trawl and/or video analyses are included for illustration.

EBC 1

Dense *Ophiothrix* beds on pebbles and cobbles, some bedrock

SS.SMX.CMx.OphMx

Pagurus prideaux, *Hyas coarctatus*, *Aequipecten opercularis*, *Flustra foliacea*.

EBC 2

Pebbles and cobbles, some bedrock; sponge beds, *Pentapora* and *Ophiothrix*

SS.SMX.CMx.OphMx; SS.SCS.CCS.PomB;

SS.SMX.CMx.FluHyd

Pomatoceros spp., *Pagurus bernhardus*, *Hyas coarctatus*, *Macropodia* spp., *Psammechinus miliaris*, *Calliostoma zizyphinum*, *Phrynorhombus regius*, *Flustra foliacea*, *Abietinaria* spp., *Nemertesia* spp., *Ebalia* spp., *Pisidia longicornis*.

EBC 3

Coarse, featureless sandy gravel with reduced epifauna; *Psammechinus*, *Aequipecten*, *Hydrallmania*,

Pomatoceros

SS.SCS.CCS; SS.SCS.CCS.PomB; SS.SMX.CMx.FluHyd

Pagurus spp., *Ophiothrix fragilis*, *Aequipecten opercularis*, *Nemertesia antenina*, *Galathea intermedia*, *Alcyonium digitatum*, *Liocarcinus pusillus*, *Anomia ephippium*, *Pomatoschistus* spp., *Pisidia longicornis*

EBC 4

Gravelly sand, some sandwaves; sparse infauna, including *Psammechinus* and *Aequipecten*

S.SCS.CCS; SS.SCS.CCS.PomB

Ophiura albida, *Asterias rubens*, *Paguridae*

EBC 5

Sandy gravel, granules; *Psammechinus*, *Aequipecten*, *Pagurus* and *Galathea*

SS.SCS.CCS; SS.SCS.CCS.PomB; SS.SMX.CMx.FluHyd

Ophiura albida, *Ascidia conchilega*, *Abietinaria abietina*, *Hydrallmania falcata*, *Pomatoceros triqueter*, *Flustra*

Eastern English Channel marine habitat map

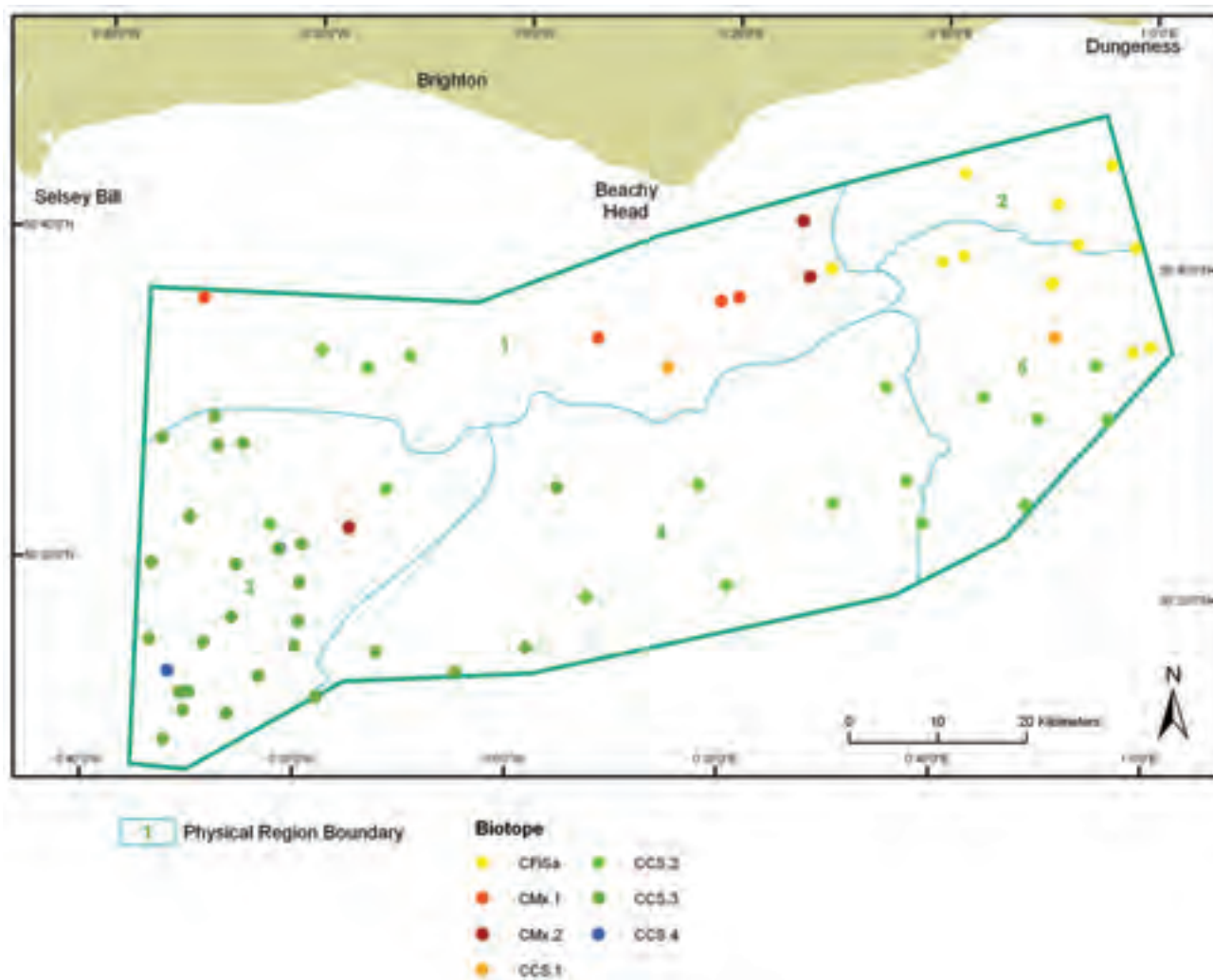


Figure 9: Distribution of video/still epifaunal biotopes

foliacea

Discriminated from EB6 by far fewer *Pomatoceros* and *Psammechinus*, and more uniform gravel size.

EBC 6

Poorly sorted, thick deposits of featureless gravelly sand/sandy gravel; *Psammechinus*, *Pomatoceros*, *Aequipecten*, *Ophiura* SS.SCS.CCS; SS.SCS.CCS.PomB; SS.SMX.CMx.FluHyd *Ophiura albida*, *Asterias rubens*, *Balanus crenatus*, *Anomia ephippium*, *Galathea intermedia*, *Alcyonium digitatum*, *Ophiothrix fragilis*, *Pagurus bernhardus*, *Pagurus prideaux*, *Hydrallmania falcata*, *Liocarcinus pusillus*.

EBC 7

Gravel patches in sandy sediments; *Balanus*, *Hydrallmania*, *Alcyonidium* SS.SMX.CMx.FluHyd; SS.SSA.IFiSa.ScupHyd *Pagurus bernhardus*, *Liocarcinus holsatus*, *Anapagurus*

laevis, *Macropodia tenuirostris*, *Pagurus prideaux*, *Ophiura albida*, *Psammechinus miliaris*, *Aequipecten opercularis*

EBC 8

Sand patches in gravelly sand; *Spisula*, *Ammodytes* and *Paguridae* SS.SSa.IFiSa.ImoSa; SS.SSa.NcirBat *Hydrallmania falcata*, *Ammodytes tobianus*, *Pagurus bernhardus*, *Liocarcinus holsatus*, *Anapagurus laevis*, *Echiichthys vipera*.

EBC 9

Sand bank; with *Ammodytes* and *Echiichthys* SS.SSa.IFiSa.ImoSa; SS.SSa.NcirBat *Pagurus bernhardus*, *Liocarcinus holsatus*

EBC 10

Sand sheets and waves, some bedrock; sparse epifauna; *Paguridae* and *Liocarcinus*

SS.SCS.CCS; SS.SSa.CFiSa; SS.SMX.CMx.FluHyd;
SS.SSA.IFiSa.ScupHyd

Pagurus bernhardus, *Liocarcinus holsatus*, *Hydrallmania falcata*, *Ophiura albida*, *Pagurus prideaux*, *Anapagurus laevis*, *Callionymus lyra*, *Crangon allmanni*, *Trisopterus minutus*, *Inachus dorsettensis*, *Macropodia rostrata*, *Macropodia tenuirostris*, *Pomatoschistus* spp. and *Echiichthys vipera*.

EBC 11

Heterogeneous area, Mixed coarse sediment with occasional boulder; some bedrock; *Pomatosceros*, *Balanus*, Hydroids and *Flustra*

SS.SMX; SS.SCS.

Alcyonium digitatum, *Asterias rubens*, *Psammechinus miliaris*, *Aequipecten opercularis*, *Hydrallmania falcata*, *Sertularia* sp. *Macropodia rostrata*, *Macropodia tenuirostris*

CONCLUSIONS

1. The study covered a large area, over 5000 km², of the Eastern English Channel. The survey strategy within the funding provided was adequate to provide an overall perspective of the regional character of the geology and biology of the sea bed in the area, but the large > 5 km survey line and sample station spacing in some areas meant only gross interpolations could be made in terms of mapping geological and biological parameters and producing biotope maps. The survey results are suitable only for placing the aggregate industry's East Channel Region (ECR) in a wider spatial context.
2. Sediment and sea bed substrate type is the principal physical/environmental factor controlling the nature

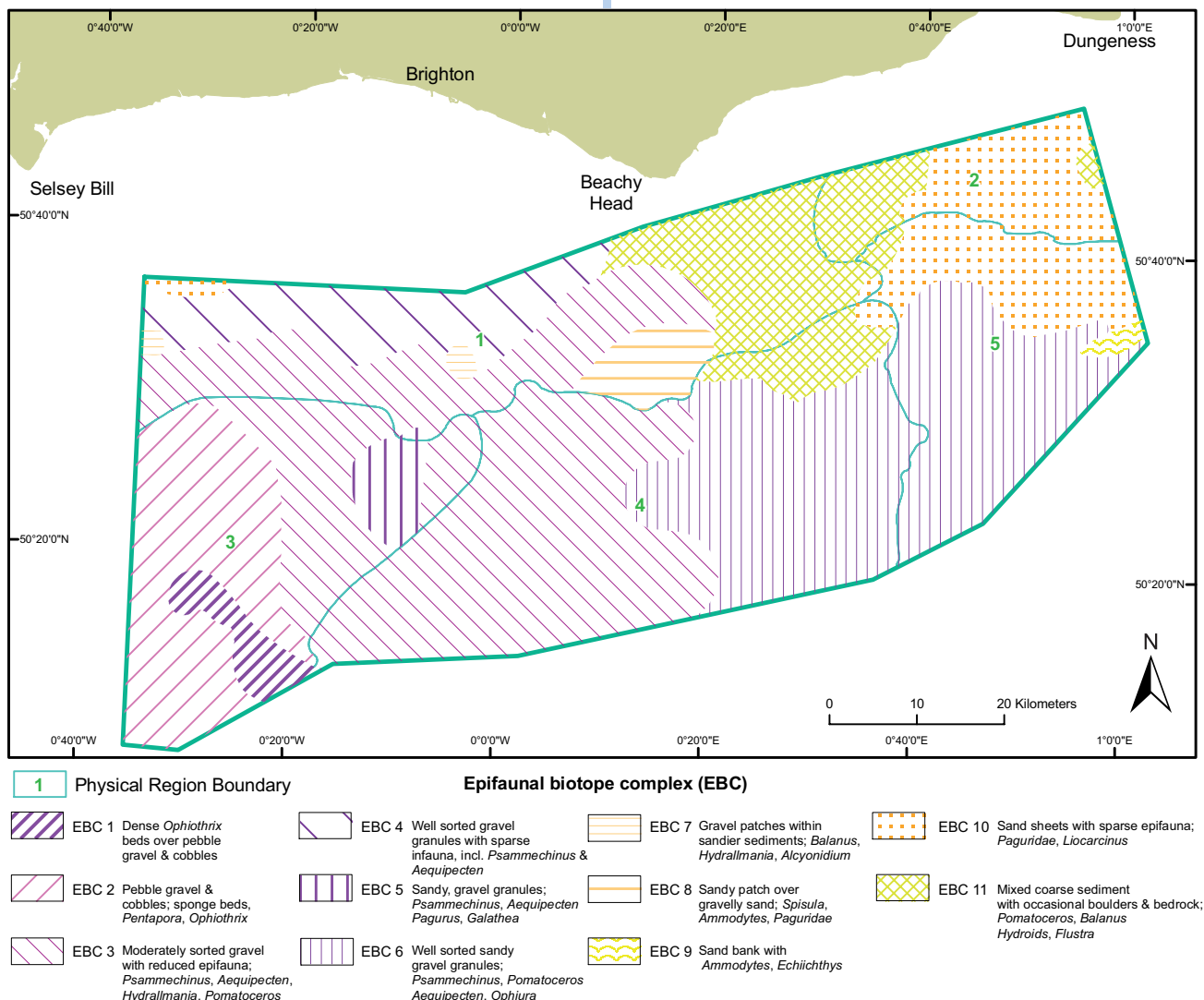


Figure 10: Regional distribution map of epifaunal biotope complexes (EBC)

Eastern English Channel marine habitat map

and composition of benthic communities. The presence of encrusting and colonial fauna increased notably on cobble substrates, and there was a concomitant increase in diversity and abundance of motile infauna and epifaunal. Distinctive communities were also found on sand in the east.

3. From west to east across the southern half of the study area there is a grain size trend of increasing sand content and decreasing gravel content. In the west there are extensive areas of immobile coarse sediment with cobbles, and rock outcrop. Quaternary sediment associated with palaeochannel systems in the central region provides a predominantly gravelly substrate beneath the sea bed.
4. There has been a long term process in the Eastern English Channel of fine and sandy sediment being swept by tidal currents, and to some extent wave action, to the north and east, with the shallower coastal margins and eastern sand wave fields and banks acting as sinks and conduits for these sediments. The potential impact of the proposed aggregate dredging in mobilising finer grain material should be considered in relation to this large-scale, long-term process.
5. A significant issue was the difficulty of assigning biotopes to the infaunal and epifaunal assemblages identified by this study using The Marine Habitat Classification for Britain and Ireland v 04.05 (Connor *et al.*, 2004). The latter requires further development in this area. There was a lack of suitable biotopes within the existing classification to describe the habitats encountered. Data collected within this study, has been used to improve existing and produce new biotopes for incorporation in the classification.
6. Techniques for rigorous, quantitative sampling of coarse cobble and rock substrates for fauna or sediments are not well developed. Further work to assess existing tools and to develop new tools would be beneficial
7. No extensive areas of potential annex I reef habitat were noted.

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Title: MEPF 04/01 Eastern English Channel
Marine Habitat Map

Contractor: British Geological Survey

Contact: Ceri James

Telephone: 01159 363467

E-mail: jwcj@bgs.ac.uk

Full Report Site:

<http://www.bgs.ac.uk/eecmhm>

<http://www.alsf-mepf.org.uk/>



Outer Bristol Channel marine habitat study

INTRODUCTION

The Outer Bristol Channel Marine Habitat Study (OBCMHS) was undertaken to collect data and provide interpretations on the current physical state of the area's sea bed environment in terms of: biology, sediments, geology, morphology, the natural processes which influence the sea bed, and how all of these elements interact.

In addition to providing data and interpretations through maps, reports and scientific publications, the project has made its results available to a wider audience through a bilingual multimedia CD-ROM, web pages, museum exhibition, and full time education officer providing outreach awareness sessions at schools, colleges, societies and interest groups.

The study was led jointly by the British Geological Survey (BGS) and the National Museum Wales (NMW). The principal funding was provided by the Aggregate Levy Sustainability Fund for Wales, which is administered by the Welsh Assembly Government, and the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme, administered by the Mineral Industry Research Organisation, one of the distributing bodies for the ALSF in England. The NMW, BGS and NERC have contributed money and data from their own research programmes including making funding available for ship time. The Crown Estate and the British Marine Aggregate Producers Association also provided funding and contributed data.

Marine aggregates are a major industry in the Bristol Channel and they provide over 85% of the sand and gravel for the South Wales market (James *et al*, 2005). The Welsh Assembly Government has published an Interim Marine Aggregates Dredging Policy (IMADP) (WA Government, 2004). The Outer Bristol Channel is recognised in the IMADP as an area that has the potential to become a source of marine aggregates in the future. Currently there are two marine aggregate licence application areas (Area 476 and 486) in the Outer Bristol Channel. Area 476 has been granted a licence.

The Outer Bristol Channel lies at the western end the Bristol Channel. The area covered by the study (Figure 1) includes approximately 2400 km² of the sea bed from Carmarthen Bay in the north to Lundy Island 60 km to the south. Its east-west extent is about 35 to 40 km. Water depths in the area range from 6 m to 60 m.

SURVEY METHODS

In total five research cruises were conducted during the three-year study. The cruises were designed around collecting high resolution geophysics and ground truthing the geophysical interpretation with grabs, trawls and sea bed video and photography.

The geophysical survey strategy was based on eleven parallel corridors, 30–45 km long and about 5 km apart (Figure 2). The corridors were surveyed by a suite of three complementary geophysical systems (Figure 3), multibeam (MBES) (B), sidescan sonar (SSS)(D) and sub-bottom profiling (boomer)(E&C). MBES and SSS provided swath coverage across a whole corridor up to km wide with a single boomer line down the centre. MBES provides high resolution sea bed morphology, it is good at mapping bedforms like sand waves, and rock outcrops. The SSS provides an indication of the character of the sea bed, distinguishing fine and coarse sediment and small thin bedforms such as ripples, patches and streaks. The Boomer provides a profile of geology beneath the sea bed, indicating the form and thickness of sediment and rock at depth, as well as the relationship to sediments at the sea bed. The multibeam data was augmented by single beam echo sounder data provided under licence by UKHO which enabled the morphology of the major sand wave field to be delineated (Figure 2). In total 2177 line km of multibeam, 1436 line km of sidescan and 330 line km of boomer were collected.

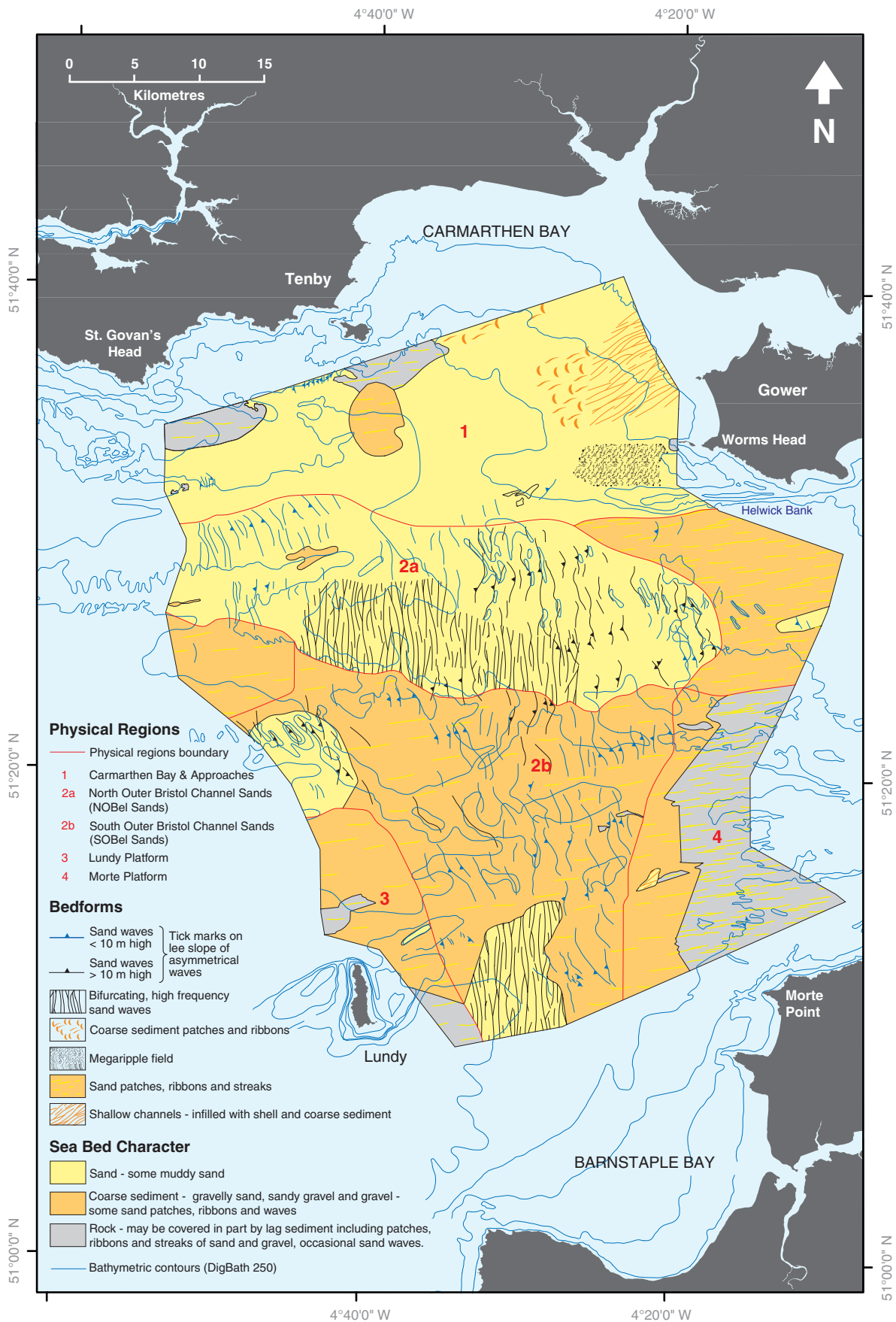


Figure 1: Study area: Sea bed character and bedforms

Outer Bristol Channel marine habitat study

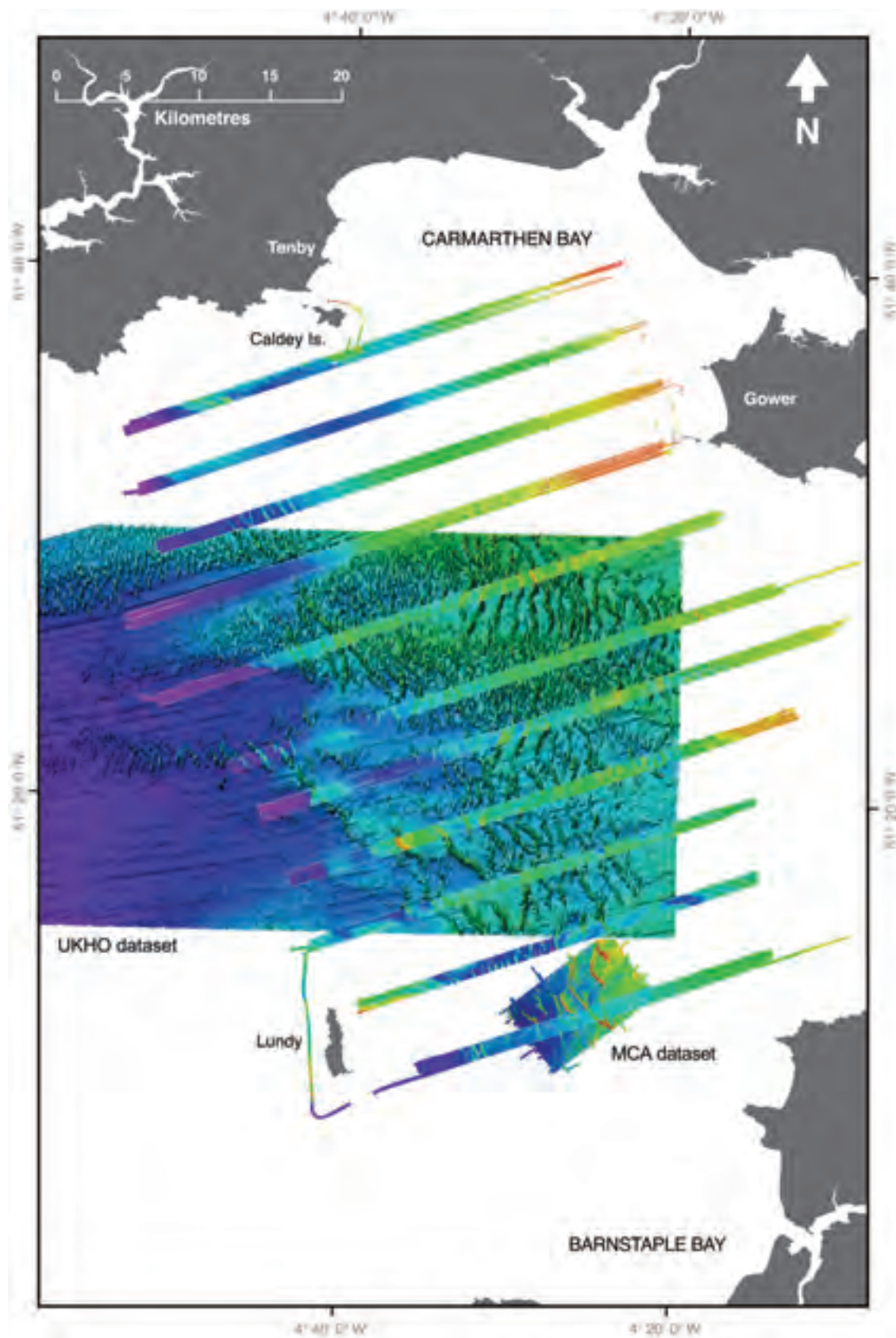


Figure 2: Sea bed morphology processed from multibeam and single beam data. (Source:1 OBCMHS corridor multibeam.2 Maritime and Coastguard Agency (MCA) multibeam trial. 3 UKHO single beam data derived in part from material obtained from the UKHO with the permission of the Controller of Her Majesty's Stationery Office and UKHO. © British Crown & SeaZone Solutions Ltd. 2004. All rights reserved. Data Licence No. 112005.006

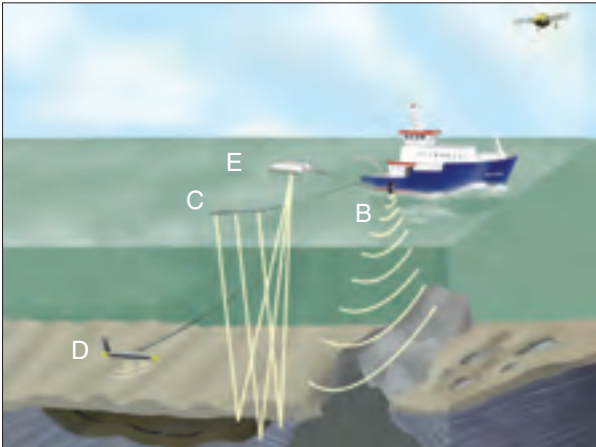


Figure 3: Geophysical survey equipment. Multibeam (B) Boomer (E) & hydrophone (C), sidescan sonar (D)

Sea bed samples were collected using a 92 kg 0.1m² modified Van Veen grab. 148 stations were occupied and provided 137 macrofaunal stations (129 with quantitative samples) and 142 sediment samples (Figure 4). A 2 m beam trawl was deployed at 13 trawl box locations and completed 53 tows. The video and camera sledge was towed across the sea bed at 24 locations and was particularly useful in ground truthing the multibeam and sidescan data and interpretations.

INTERPRETATION

There are a number of processes and features that control and influence present day sea bed marine habitat. The principal amongst these include the physical nature of the sea bed in terms of geology and sediment, and the sedimentation and hydrodynamic processes which impact on the sea bed. These include not only present day conditions in terms of water quality, salinity, tides, currents, waves, sediment mobility, grain size, bedforms and rock outcrop but also previous environments in geological time which have left their imprint on the sea bed.

The present day distribution of sediments in the Outer Bristol Channel appears to be the product of sedimentation processes associated with two major geological environments. The first is glacial and glacio-fluvial associated with the Quaternary Last Devensian Glaciation when an ice lobe extended south out into Carmarthen Bay and initially deposited **Late Pleistocene Sediments**, subsequently overlain by **Basal Sand and Gravel** within the Bay and out across the axial centre of the Outer Bristol Channel. These deposits appear to have remained in relatively close proximity to their original depositional source, although some reworking and transport has occurred subsequently. At the glacial maximum, around 22,000 years ago, sea level would

| Biotope Code | Description |
|----------------------|---|
| Infauna | |
| SS.SSa.IFiSa.IMoSa | Infralittoral mobile clean sand with sparse fauna |
| SS.SSa.IFiSa.NcirBat | <i>Nephtys cirrosa</i> and <i>Bathyporeia</i> spp. in infralittoral sand |
| SS.SSa.IMuSa.FfabMag | <i>Fabulina fabula</i> and <i>Magelona mirabilis</i> with venerid bivalves and amphipods in infralittoral compacted fine muddy sand |
| SS.SSa.CMuSa.AalbNuc | <i>Abra alba</i> and <i>Nucula nitidosa</i> in circalittoral muddy sand or slightly mixed sediment |
| SS.SSa.OSa.OfusAfil | <i>Owenia fusiformis</i> and <i>Amphiura filiformis</i> in offshore circalittoral sand or muddy sand |
| SS.SCS.ICS.HeloMsim | <i>Hesionura elongata</i> and <i>Microphthalmus similis</i> with other interstitial polychaetes in infralittoral mobile coarse sand |
| SS.SCS.CCS.MedLumVen | <i>Mediomastus fragilis</i> , <i>Lumbrineris</i> spp. and venerid bivalves in circalittoral coarse sand or gravel |
| SS.SMx.OMx.PoVen | Polychaete-rich deep <i>Venus</i> community in offshore mixed sediment |
| Epifauna | |
| SS.SBR.PoR.SspiMx | <i>Sabellaria spinulosa</i> on stable circalittoral mixed sediment |
| SS.SMx.CMx.FluHyd | <i>Flustra foliacea</i> and <i>Hydrallmania falcata</i> on tide-swept circalittoral mixed sediment |
| SS.SSa.lfiSa.ScupHyd | <i>Sertularia cupressina</i> and <i>Hydrallmania falcata</i> on tide-swept sublittoral sand with cobbles or pebbles |

Table 1: Guide to benthic biotopes present in the Outer Bristol Channel (following definitions in Connor et al, 2004)

have been at least 100 m lower than the present day with the Outer Bristol Channel a marginal glaciated terrestrial environment. The subsequent amelioration of climate brought on the development of the second major geological environment with the gradual rise in sea level culminating in a fully marine environment by around 5000 years ago. The morphology of the Outer Bristol Channel underwent a considerable metamorphosis as sea level rose and wave and tidal

Outer Bristol Channel marine habitat study

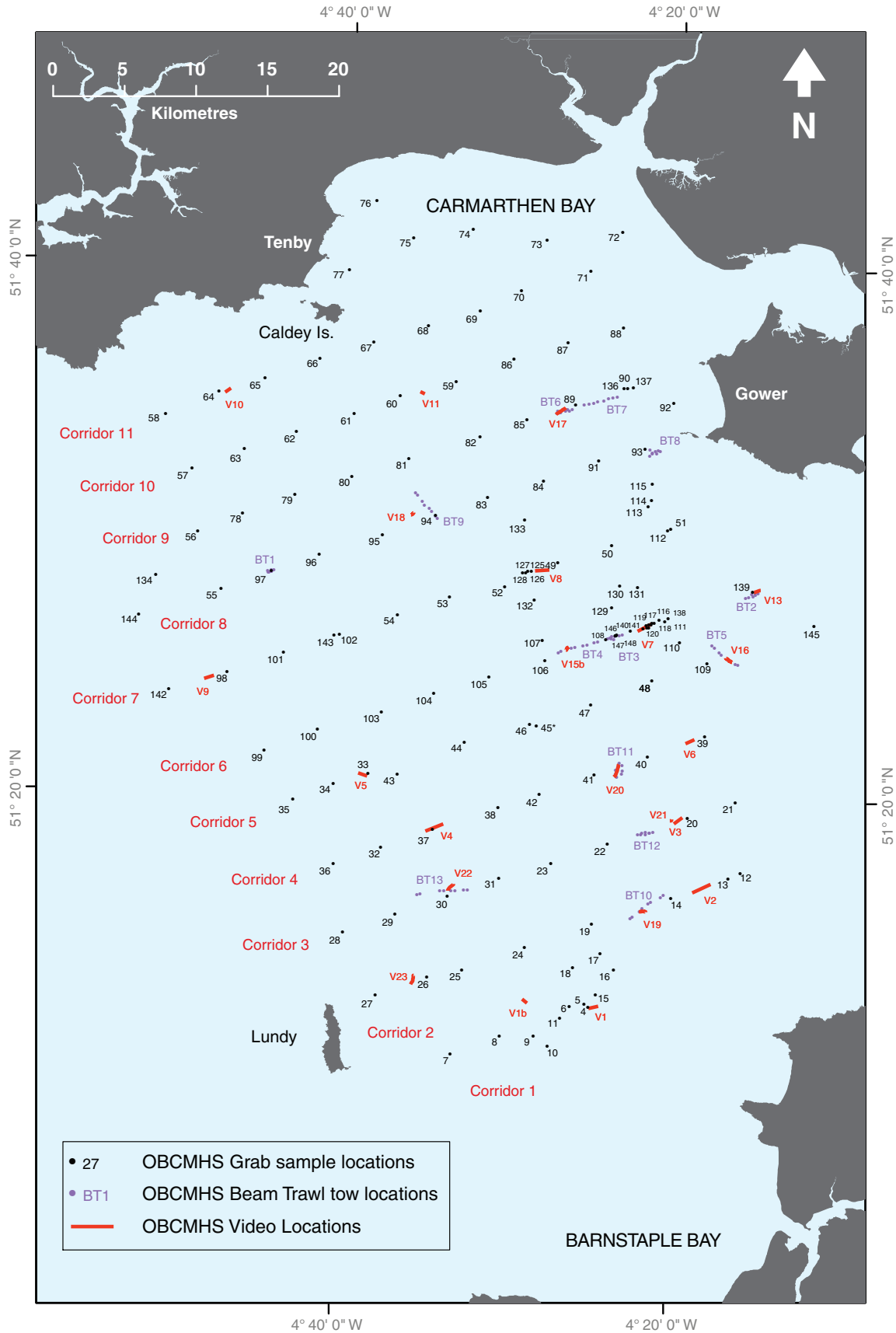


Figure 4: Grab, Beam Trawl and Video locations

currents began to fashion mobile sandy sediments into a major **Sand Waves** unit and produce one of the most significant sand wave fields on the UK continental shelf.

The modern present day marine environment is characterised by strong tidal currents and one of the largest tidal ranges in the world with a mean spring tidal range up to 8 m. Apart from Carmarthen Bay, depth averaged mean spring tidal currents are $>1.0 \text{ m s}^{-1}$ over the area and capable of entraining and moving sandy sediment in an environment of relatively high bed shear stress. The tidal streams are commonly rectilinear with the western ebb tidal constituent being dominant. This tidal asymmetry is also matched by the dominance of west facing asymmetry in the large sand waves of the area, commonly indicative of net sand transport to the west.

In simple terms the sea bed of the study area has a northern half which is dominated by sand and a southern half where gravelly sediments are common, and sand although present is less significant. Rock is notable at the margins of the area in the north west, south west and south east.

The Outer Bristol Channel has been divided into four physical regions.

Region 1 – Carmarthen Bay & Approaches

Region 2 – Outer Bristol Channel Sands (OBel Sands)

- a. North Sector (NOBel Sands)
- b. South Sector (SOBel Sands)

Region 3 – Lundy Platform

Region 4 – Morte Platform

These regions support five benthic faunal assemblages, The three major faunal assemblages, designated II, III and IV, respectively dominate regions 1, 2a and 2b. Assemblage I is confined to Helwick Bank and assemblage V covers small rock outcrops. None of the assemblages are unique within UK waters. The assemblages and their subgroups correspond to eight infaunal and three epifaunal biotopes as described in the *2004 Marine Habitat Classification for Britain and Ireland (Conner et al, 2004)*. The epifaunal biotopes are present as overlays on some infaunal biotopes and can occur in combination (Figure 5, Table 1).

Region 1 - Carmarthen Bay and Approaches.

Dominantly smooth sea bed of fine to medium sand with some small ripples. Few bedforms and some muddy, coarse, and shelly patches and channels. Waves are important as a transport mechanism in shallow water as tidal current energy decreases. The inner Bay acts as a store for sediment. Dominated by macrofaunal Assemblage II with low to moderate numbers of species all indicative of stable sand or muddy sand habitats. Main biotope is **FfabMag**. Macrofaunal abundance decreases from the Approaches into the shallower waters of the Bay. Epifauna numbers also generally low. Very low species numbers and lowest abundances occur at and around Helwick Bank and Worms Head. Higher species richness and colonial taxa associated with rock and coarser sediment around Caldey Island.

Region 2a – NOBel Sands. Extensive sand wave field with an area of around 440 km². Includes large sand waves in east, 12–14 m high with maximum height of 19 m. They are <10 m high in west. The sand waves are strongly asymmetrical with steep west facing lee slopes. Also includes an area of bifurcating high frequency sand waves in south of the region. These include primary waves generally 4–10 m high with both

west facing asymmetrical waves and symmetrical waves, and secondary waves up to 4 m high. Surfaces of the large sand waves covered by mobile sediment in the form of megaripples and ripples, but the position and form of these large sand waves appears to have remained static in recent times (Figure 2). Hence, large sand waves may be in a state of *in situ* equilibrium. Sea bed sediments are generally medium sand. Gravelly sand and sandy gravel visible in some large sand wave troughs. The large sand wave field and high frequency sand waves predominantly host macrofaunal Assemblage III. Main biotope is **HeloMsim**. Low to moderate numbers of species.

Region 2b – SOBel Sands. Field of isolated sand waves on relatively flat sea bed of gravelly sand and sandy gravel covering an area of about 480 km². Sand waves are generally asymmetrical and west facing, < 10 m high. Double crested waves common in south of region. Sand waves appear to be relatively static and in state of *in situ* equilibrium. Assemblage III fauna (**HeloMsim** biotope) associated with sand waves. Assemblage IV on coarse sediment corresponds to **MedLumVen** biotope, often overlain with one or two epifaunal biotopes. Richer assemblages IV subgroups at boundaries with Platforms to east and west. Very rich fauna with many colonial epifaunal species. Coarser sediment and stony areas more diverse than sandy areas.

Outer Bristol Channel marine habitat study

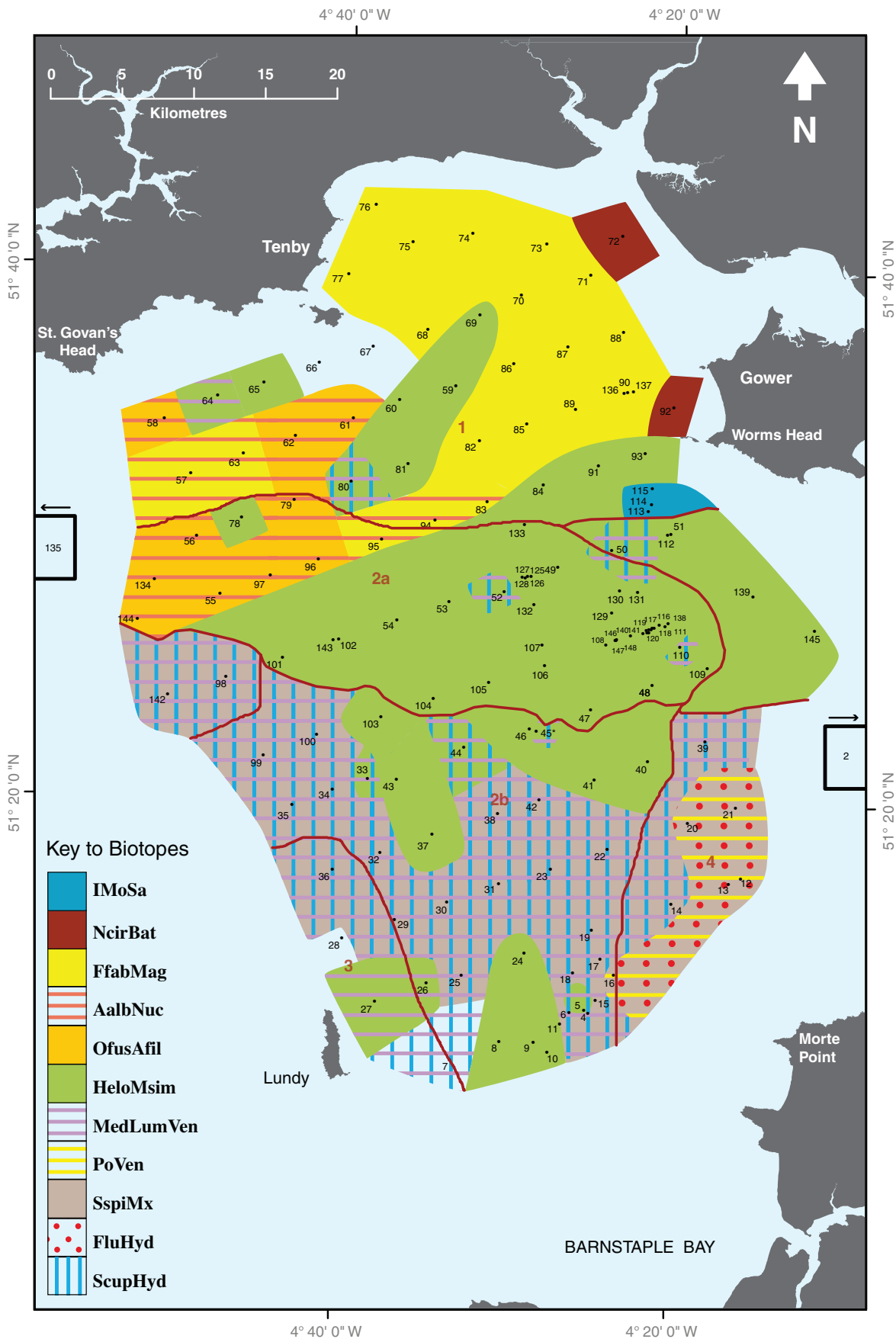


Figure 5: Distribution of benthic biotopes (and combinations thereof). See Table 1 for biotope definitions.

Region 3 – Lundy Platform. Apart from the Stanley Bank sand bank the area has coarse sediment pavement with rock outcrops. No single dominant biotope with a range of abundances and moderate to high species richness, and variable number of colonial taxa.

Region 4 – Morte Platform. A coarse sediment pavement in west and north with rock outcrops to east. Some sand patches, ribbons and isolated sand waves. Rich Assemblage IV subgroups associated with rocky areas and gravelly sediments. Sediments between epifaunal dominated rock corresponding to **PoVen** biotope. High species richness and abundance across region.

Species diversity is generally low over most of the study area except in the coarse sediment pavement of the SOBel Sands, and on the Lundy and Morte Platform. These coarse sediments and rock outcrops provide habitat for a variety of colonial epifauna and exhibit high biodiversity. They offer more microhabitats for infauna and gravel and rock surfaces can be colonised by attached and encrusting epifauna. Hence, species richness is highest where gravelly sediments and rock outcrops co-occur.

Areas of sand with mobile surface sediment and extensive large and small bedforms such as NOBel Sands support a reduced complement of infaunal species which are adaptable to stressful, current dominated conditions. Colonial epifaunal biotope overlays are less well developed, as any gravel suitable for providing surfaces for attachment could be frequently scoured or buried by mobile sand. There is no evidence that faunal composition or diversity differs in relation to location on a sand wave.

Species assemblages derived from trawls correspond well with macrofaunal assemblages II-IV identified from grab sampling. There is some evidence from the trawls and videos that some areas near the southeast margin of Carmarthen Bay possess more starfish and hermit crabs. Catches from sand wave areas are generally small. Sand Eels are relatively infrequent in grabs and sporadic in trawls taken in daytime. However, they may possibly be more abundant if sampling took place at night. Brittle-stars are very abundant on some stable sediments in west NOBel Sands, east SOBel Sands and Morte Platform areas. Whelks are infrequently found on the sand waves of the NOBel Sands, being most numerous on the sands of outer Carmarthen Bay and the coarser gravelly sediments of the SOBel Sands.

A BIOENV analysis indicated fauna was found to be 'best' correlated ($p_s=0.615$) with water depth and the sediment attributes of sand, mud, carbonate, mean phi

and sorting. The study has developed a tool using a Linktree procedure capable of predicting faunal characteristics relative to primary environmental variables established with the BIOENV analysis. This predictive tool could be utilised in future habitat research in the Outer Bristol Channel.

CONCLUSIONS

The area of the Outer Bristol Channel covered by the study is around 2400 km². The scale at which an integrated interpretation can be produced has to take into account the density and coverage of the geological and biological data collected by the study, which form the primary source for the interpretation, plus other published and unpublished data. The multibeam corridors, which are the largest geological data set, cover about 15% of the study area sea bed surface (Figure 2). The principal biological dataset are about 140 grab samples, the majority of which are sited at about 5 km spacing along the multibeam corridors (Figure 3). Although we have produced a great deal of detailed data, for example, in terms of sea bed morphology and bedforms along each corridor, and species and assemblages at each sample station the interpolation of this detailed data to produce an integrated assessment across the Outer Bristol Channel has to be at a much smaller, less precise, scale producing a broad regional coverage.

What also has to be borne in mind is the variability of the marine environment on a temporal scale and its impact on sea bed habitat. These can be on a daily basis with flood and ebb tides or night and day e.g. sand eel activity, longer lunar cycles of neap and spring tides, and seasonal variations such as sea temperature, salinity and biological productivity. Therefore a survey provides a snapshot at the time of survey. Further surveys over time and different seasons can build up a picture of those features which are stable and those that are more ephemeral or seasonal. We have been able to compare some of our data with previous surveys and these have enabled us to assess variability and change over time and provide confidence in our interpretations. For example, comparison of sand waves on multibeam data collected by this study in 2003 with bathymetric data surveyed in 1977 shows remarkable uniformity in the sea bed indicating long term stability of large sand waves in the NOBel and SOBel Sands. We also sampled in 2003 at 42 benthic survey locations previously sampled and analysed by Warwick & Davies (1977) and found for each study there was broad agreement between the composition and distribution of the major benthic macrofaunal assemblages. It was not possible to discern definite temporal differences between the two benthic surveys though there were indications, when

Outer Bristol Channel marine habitat study

considered alongside recent studies (Woolmer, 2003), of some changes in the benthos of Carmarthen Bay at the time of the 2003 OBCMHS survey. More time-series data would be required to determine whether this was a transient situation or part of a longer-term change.

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Title: SAMP 2.06 Outer Bristol Channel Marine Habitat Study

Contractor: British Geological Survey

Contact: Ceri James

Telephone: 01159 363467

E-mail: jwcj@bgs.ac.uk

Full Report Site:

<http://www.bgs.ac.uk/obc>

<http://www.dclgaggregatefund.co.uk/themea.htm>





Hermit Crab (*Pagurus bernhardus*)

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Building GIS and environmental data management capabilities of the sea fisheries committees

The marine environment is under increasing pressure from human activities, particularly in inshore waters and coastal zones. This project arose from a direct need to provide better advice on the spatial interrelationships between aggregate dredging and inshore fisheries.

Our current knowledge of the spatial distribution of inshore fishing is patchy and based on limited information acquired during fisheries consultation or scoping studies conducted as part of environmental impact assessments. Sources of information such as these contain large anomalies and are inherently subjective; they consequently do little to promote transparency and objectivity in the advisory process.

The purpose of this project was to encourage the collection of a more objective source of data on inshore fisheries by those best able to collect it, namely the Sea Fisheries Committees (SFC) of England and Wales.

Aggregate dredging occurs in a number of Committee districts and often leads to serious conflict with local fishing interests. SFCs are consequently under some obligation to provide advice on the degree of conflict between fishing and aggregate dredging licence applications. The advice provided by SFCs would ideally be objective and accurately reflect local fishing activity. Key to this process is sound knowledge of the spatial distribution of inshore fishing effort, which is best obtained from records of sightings and boardings from fisheries surveillance programmes. To ensure the advice is effective and credible, fishing activity data needs to be up-to-date, based on standard data collection protocols, and easily transferable amongst all relevant parties.

Defra are responsible for monitoring fisheries outside of 6 nautical miles, whereas SFCs monitor activity within 6 nm. Offshore surveillance data from the Defra fisheries monitoring programme is collected and stored in digital format and can be readily converted into estimates of fishing effort. By contrast, comparable data for inshore fishing activity (i.e. within 6 nm) is not readily accessible, as SFCs invariably collect and store fisheries surveillance data on paper logs and not in digital format. Geographic Information Systems (GIS) technologies would facilitate transferability and transparency, and act as an impetus for the improved management, analysis and visualisation of fisheries geospatial data.

The aim of this project was to coordinate and harmonise the development of GIS and environmental data management capabilities across a number of SFCs in a pilot project. Committees that agreed to participate in

this pilot were Sussex, Southern, Devon, Cornwall, North Eastern, and Northumberland. To achieve the project aim a number of objectives were set:

- Objective 1 - Ensure that all participating SFCs have access to essential GIS equipment and resources
- Objective 2 - Ensure that all participating SFCs have skills in GIS and in the management, handling and analysis of electronic fishing activity information
- Objective 3 - Develop a set of agreed standards for the capture, storage, management and analysis of fishing activity information

Objective 1 involved the supply of GIS software and data resources to all participating Committees, while Objective 2 comprised of a centralised GIS technical training workshop followed by a series of on-site training sessions. The outcome of Objective 3 was a set of recommended standards that were considered broadly applicable to SFC operations. These standards are set out below:

| 1. DATA CAPTURE – MINIMUM REQUIREMENTS | | |
|--|---|--|
| | Fishing activity | Surveillance effort |
| i. Patrol boat surveillance | <ul style="list-style-type: none"> • Date • Positional information using vessel's electronic navigational equipment • Method of fishing activity using standard codes | <ul style="list-style-type: none"> • Date • Note position every 30 mins using vessel's electronic navigational equipment |
| ii. RIB surveillance | <ul style="list-style-type: none"> • Date • Positional information using information from GPS on board vessels being inspected or by using hand-held GPS • Method of fishing activity using standard codes | <ul style="list-style-type: none"> • Date • Note position every 15 mins using hand held GPS |
| iii. Shore based surveillance | <ul style="list-style-type: none"> • Date • Positional information using compass bearings • Method of fishing activity using standard codes | <ul style="list-style-type: none"> • Date • Note position using hand held GPS when sightings are taken. This position should relate to a standard assumed surveillance interval, e.g. 15 or 30 mins, which needs to be agreed upon at the outset |
| Notes on data formats <ol style="list-style-type: none"> Date – record as dd/mm/yyyy Position – WGS84 datum; negative longitudes if west of the 0°; decimal degrees to minimum of 4 decimal places Use codes listed in Annex 3 of project final report | | |

2. DATA STORAGE AND MANAGEMENT

At present the majority of SFCs store fisheries activity data on spreadsheets. This format allows data to be quickly mapped in MapInfo GIS. In the medium term (< 5 years) all SFCs should endeavour to transfer their data holdings into database format, such as MS Access.

3. EFFORT ESTIMATION

- Use methodology described in Annex 4 of project final report
- Base calculation on:

$$\text{Sightings per unit effort (SPUE)} = \frac{\text{No of sightings}}{\text{Surveillance effort}}$$

- All SFCs should aim to adopt a standardised unit of SPUE that explicitly accounts for the number of sightings per unit area (e.g. per km²) and per unit time of surveillance effort (e.g. per hour). This requires some additional calculations to those described in Annex 4 to account for variability in the area of each spatial unit, in this case a 400th ICES rectangle, and to standardise surveillance effort to a common time unit.

Building GIS and environmental data management capabilities of the sea fisheries committees

The project succeeded in improving the capacity of the 6 participating SFCs to better handle fishing activity data. All 6 Committees now have the resources, skills, and knowledge to implement harmonised programmes for collecting sightings data, and the standards developed during the project can be used as a reference source by other Committees in the future. All 6 SFCs are committed to modifying their fisheries surveillance programmes using the recommended standards as the benchmark. For a number of Committees, implementing the necessary changes may take some time. For others, procedures will only require slight modification. Further coordination will be critical to help facilitate the move towards harmonised programmes of data collection, and a continued programme of training will provide SFC fishery officers with the necessary skills to manage and manipulate their fisheries data according to nationally agreed standards.

A major outcome of the project is that inshore fisheries data is now available for the 6 districts of the participating Committees, and the standards exist to ensure that the data can be compared across districts. This will greatly improve assessments of the spatial interrelationships between newly applied for aggregate dredging licences and historic and contemporary patterns of inshore fishing effort, and has the potential to reduce spatial conflict between competing uses of inshore waters.

To ensure a continued supply of standardised inshore fishing activity for use in marine aggregate environmental assessments, this relatively short programme of work would benefit from continued efforts in the following areas:

- Further skills training in GIS and spatial data manipulation through centralised workshops and on-site visits.
- Facilitate discussions between SFI and the SFCs on standard systems of recording fisheries surveillance data through centralised workshops.
- Develop implementation strategies for standard systems of recording fisheries surveillance data, particularly for RIB and shore based surveillance programmes.
- Develop a centralised, web-based system for the distribution of inshore fishing effort summary maps, to ensure wide uptake by marine developers and regulators.

Title: SAMP 2.25 Building GIS and Environmental Data Management Capabilities of the Sea Fisheries Committees

Contractor: Cefas

Contact: Paul Eastwood

Telephone: 01159 363467

E-mail: paul.eastwood@cefas.co.uk

Full Report Site:
<http://www.dclgaggregatefund.co.uk/research.htm>





Sussex sea fisheries committee patrol vessel 'Watchful'
© Sussex sea fisheries committee

The seabed and inshore fishing activity: Assessment and relationships

INTRODUCTION AND OVERVIEW

Our capacity to manage marine activities and protect the marine environment depends on accurate information at appropriate resolutions which demonstrate the spatial extent and intensity of anthropogenic activities at sea. Fishing activity in the Sussex Sea Fisheries District is closely related to seabed types which determine which kind of fishing activity is prevalent.

Mineral extraction and other activities in inshore waters may cause changes in these fishing patterns and cause conflict between fishers by redistributing effort. Maps of fishing effort along with maps of seabed ground types would help to inform mitigation measures as well as informing other spatial fisheries policies such as the conservation of important or rare habitats or equally the identification of new fishing grounds.

The aim of this project was therefore to revisit existing data on seabed habitats and fishing effort and investigate the potential of using the Sea Fisheries Committee's patrol vessel to collect further data on the seabed in an opportunistic fashion during routine patrols in an attempt to better understand the relationships between fishing activity and seabed ground types.

The principle data sources utilised and developed during the project are outlined below:

ACOUSTIC GROUND DISCRIMINATION SYSTEMS

During this project two AGDS systems were used, a QTC™ View V and an Olex™ plotter recording data from a Simrad™ EQ60 echosounder. An archived RoxAnn™ AGDS dataset was also available to the project from a survey undertaken in the district a decade previously. As part of this project Envision outlined guidelines on the collection of data using an Acoustic Ground Discrimination System and interpretation of AGDS data with ground validation data for use in the mapping of habitats for fisheries management.

OLEX™ & SIMRAD™ EQ60

When connected to a Simrad™ EQ60 echosounder Olex™ software can be set up to record information on the hardness of the seabed. In addition each depth value recorded by the Olex™ software determines the depth data recorded over a 5x5m area and is corrected using a tidal variation model. The data recorded by the Olex™ plotter was collected during routine fisheries patrols and was the most extensive dataset available to the Sea Fisheries Committee for analysis.

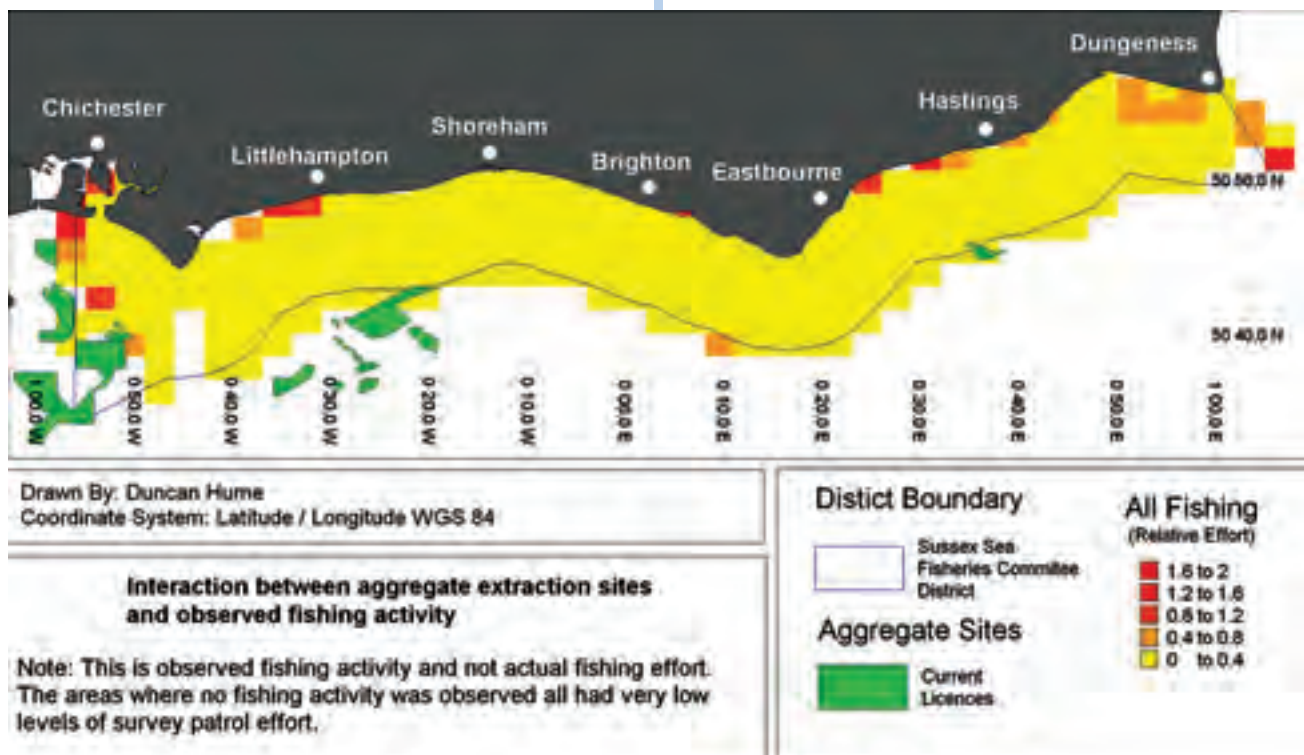


Figure 1: Interaction Between Aggregate Extraction Sites and Observed Fishing Activity

R.W. Clark¹, T.M. Dapling¹, R.L. Foster-Smith², D.R. Hume³, R. Irving⁴ & K. Rhynas⁵

¹ Sussex Sea Fisheries Committee, Unit 6, Highdown House, Shoreham Airport, Shoreham-by-Sea, West Sussex, BN43 5PB

²Envision, 6 Stephenson House, Horsley Business Centre, Horsley, Northumberland, NE15 0NS

³Reefmap, 18 Poole Road, Upton, Poole, Dorset, BH16 5JB

⁴Sea-Scope, Combe Lodge, Bampton, Tiverton, Devon, EX16 9LB

⁵Quester Tangent Corporation, Suite 201, 9865 West Saanich Road, Sidney, BC, Canada, V8L 5Y8

QTC™ VIEW

A QTC™ View AGDS measures variations in the first acoustic waveform reflected off the seabed by an echosounder pulse. The system includes bespoke software for processing that data to produce a map of acoustically distinct seabed types. Quester Tangent Corporation describe the process of developing an unsupervised classification using the QTC™ view data collected in Sussex Sea Fisheries Committee (SFFC) District. In addition Envision assess the potential of using QTC™ view to produce a supervised classification using data collected during routine patrols by the SSFC patrol vessel Watchful. The reports both concluded that opportunistic collection of QTC™ View V data can be a successful approach to data collection but more extensive acoustic data as well as data on ground types are required in order produce a map of use to fisheries management. In order to develop such a map, further work should also include a focus on the development of a suitable ground classification scheme which focuses on ground types which are important from a fisheries management perspective.

ROXANN™

A RoxAnn™ AGDS calculates measures of the roughness and hardness of the seabed by interpreting the first and second echo reflections from an echo pulse. Envision revisited an archived RoxAnn™ dataset which was collected by the Seemap Research Group (now Envision) between 1995 and 1997. Their examination of the RoxAnn™ data in the light of observations on fishing activity demonstrated that the observed fishing activity correlates closely with the seabed life forms originally mapped with the RoxAnn™ unit. The RoxAnn™ data was not collected in a systematic fashion as might be expected by today's survey standards and because RoxAnn™ and QTC™ suffer from similar limitations the report concludes that opportunistic collection of QTC™ data would be expected to produce similar results. The report recommends that future work which aims to produce a map of ground types for fisheries management should use a classification system which reflects preferred fish habitats.

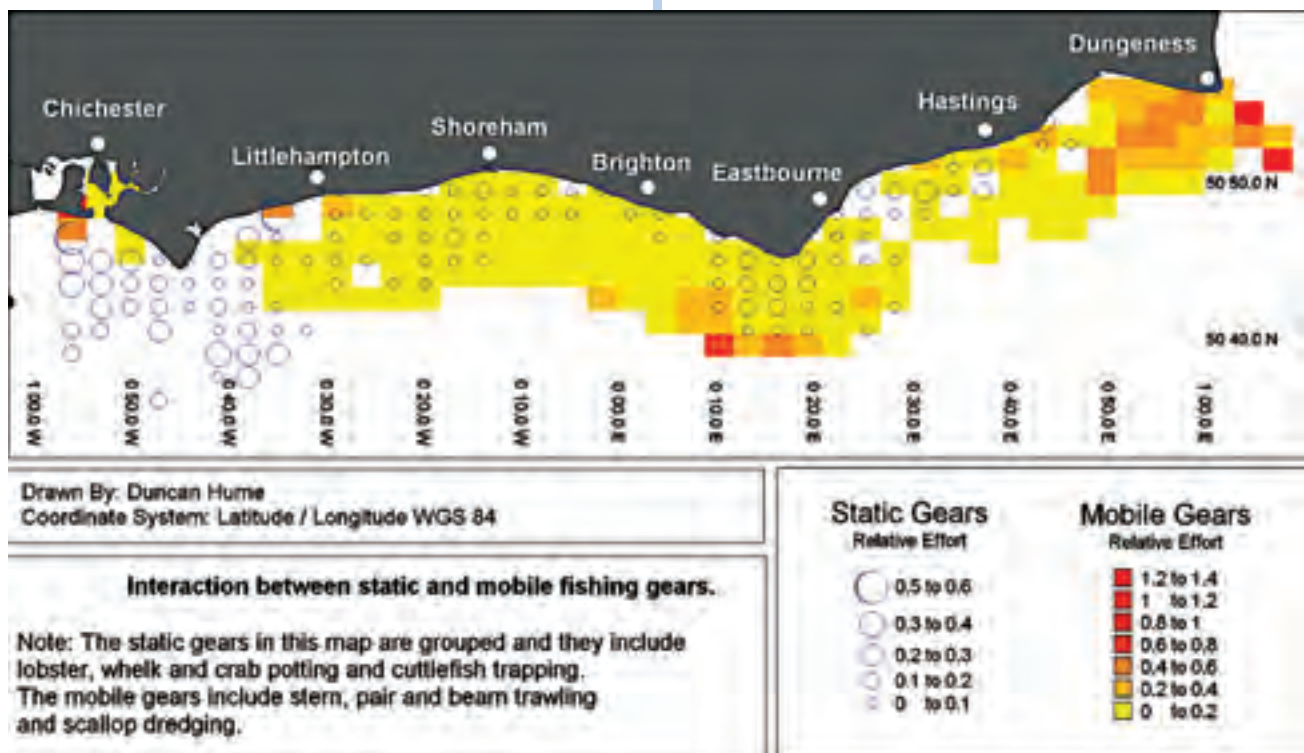


Figure 2: Interaction Between Static and Mobile Fishing Gears

The seabed and inshore fishing activity: Assessment and relationships

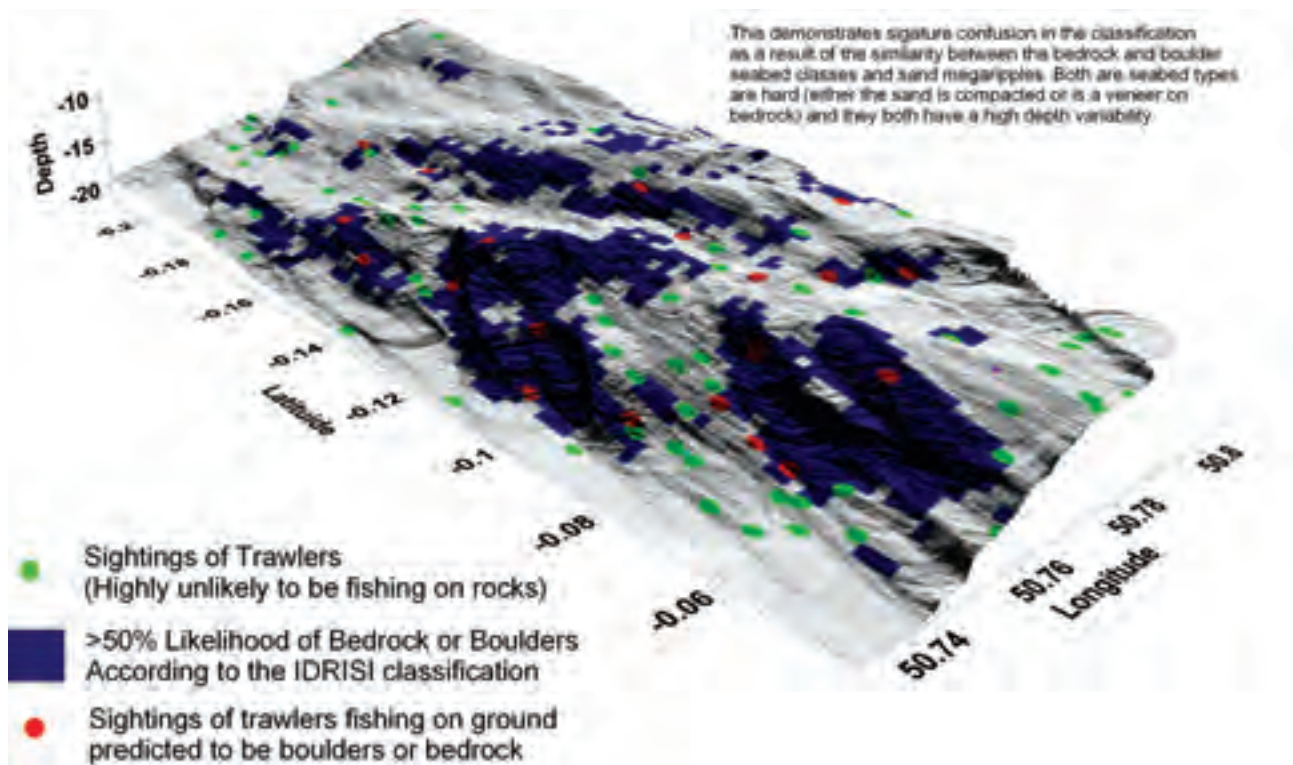


Figure 3: A Megaripple Field Offshore From Brighton

SEASEARCH DIVE SURVEY DATA

Seasearch is a volunteer underwater survey project for recreational divers. The divers record observations of marine habitats and the life they support on standardised forms which are designed to provide baseline information for the description and mapping of marine biotopes. The Sussex Seasearch Project has been operating for 15 years and during that time its many participating divers have recorded a large amount of information about the various types of seabed and the associated species. The project examined the Seasearch data for the Sussex Sea Fisheries district and considers the potential and the problems associated with using Seasearch data for the development of a habitat classification scheme for the ground validation of acoustic data collected using the Sea Fisheries Committee's acoustic ground discrimination systems. It was concluded that further work is required to develop a classification scheme which can be used to group Seasearch records attributed to biotope classes according to acoustically distinct biotope groups and the Sea Fisheries Committee might be an ideal partner in working with Seasearch on marine resource mapping activities.

FISHERIES SIGHTINGS OBSERVATIONS

The inshore fishery off Sussex is described using data derived from the inshore patrol vessels operated by the Sussex Sea Fisheries Committee. In order to quantify fishing activity a method is used that standardises observed fishing activity according to the 'effort' associated with the collection of that data. The patrol vessels operated by the sea fisheries committee routinely collect information on the location and type of fishing activity they observe. By combining this information with the effort associated with its collection, quantitative assessments of the spatial distribution of fishing activity have been undertaken.

ANALYSIS: INVESTIGATION OF THE POTENTIAL OF USING EXISTING DATA TO PRODUCE A MARINE RESOURCE MAP FOR THE SUSSEX SEA FISHERIES DISTRICT

The process of creating a classified map requires the availability of an acoustic dataset and ground validation data for the survey area. The Olex™ / Simrad™ EQ60 dataset for the Sussex Sea Fisheries Committee District was the only acoustic data source which provided sufficient coverage to be useable in classification. As outlined in the section on this data source the

information that the system provides is much less refined than survey grade AGDS systems such as QTC™ or RoxAnn™. In addition there are significant limitations in the use of Seasearch data for ground validation as mentioned previously. However data quality aside, an assessment of the limitations of utilising limited accuracy data sources in a supervised classification provides some valuable lessons on acoustic classification, and gives a clear rationale for the conclusions and recommendations of this project.

CONCLUSIONS

- Olex™ when connected to a Simrad EQ60 echosounder can provide useful data on the variability of the seabed which can be used in seabed classification.
- The data does not provide enough descriptive resolution to enable the production of an accurate resource map but can be used to predict where resources might be found.
- Seasearch data is useful in the ground validation of acoustic data for the purpose of supervised classification but care should be taken to ensure that the records chosen are positionally accurate.
- A classification scheme which merges biotopes into acoustically distinct groups is likely to reduce signature overlap as well as ensuring that the positional fix on that biotope is as accurate as possible.

RECOMMENDATIONS

1. Develop a simple but focused classification scheme which integrates information requirements for fisheries management but includes detail which is likely to influence the acoustic properties of the seabed.
2. Work with Seasearch to develop a sampling method that improves the positional accuracy of the data recorded to make it more useable in classification.
3. Continue to collect QTC™ data for the district because more detail on the intermediate acoustic variation of the seabed is required to enhance the classification by better defining the class signatures.

Title: MAL0020 The Seabed and Inshore Fishing Activity: Assessment and Relationship

Contractor: Sussex Sea Fisheries Committee

Contact: Tim Dapling & Robert Clark

Telephone: 01273 454407

E-mail: dapling@sussex-sfc.gov.uk & rclark@sussex-sfc.gov.uk

Full Report Site:
www.sussex-sfc.gov.uk/malsf.htm



Sand banks and offshore river channels: Examples of geodiversity from aggregate industry sites

INTRODUCTION

Over the past few years research into marine habitats has expanded as conservation issues have come to the fore and this research has utilised the most modern acoustic technology and statistical evaluation of the biological data.

Regional mapping of the seabed of UK waters commenced during the 1960s and 70s when the relationship was determined between tidal currents and the grade and form of seabed sediments. However, consistent mapping of the seabed sediments did not commence until the 1980s when the British Geological Survey (BGS) produced a series of maps of the UK continental shelf at a scale of 1:250 000.

In the last ten years a broad strategy has addressed marine conservation issues. Two approaches of interest to the strategy are the mapping of marine landscapes

and marine habitats. The former leans towards a morphological/geological approach and aims to describe the *geodiversity* of the sea bed and its substrate, whilst the latter incorporates greater biological input and describes the *biodiversity* of the waters. Geodiversity is defined as "the range (or diversity) of geological (bedrock) geomorphological (landform) and soil features, systems and processes.

The first attempts at mapping marine landscapes (the Irish Sea by JNCC) were of a regional nature largely using data from BGS maps. Over the past decade areas in UK waters have been investigated in detail by commercial and academic studies, using state of the art technology.

This ALSF project was initiated by Hanson Aggregates-Marine, one of the largest extractors of marine aggregate in the U.K. waters. During the course of their exploration, resource and environmental assessments,

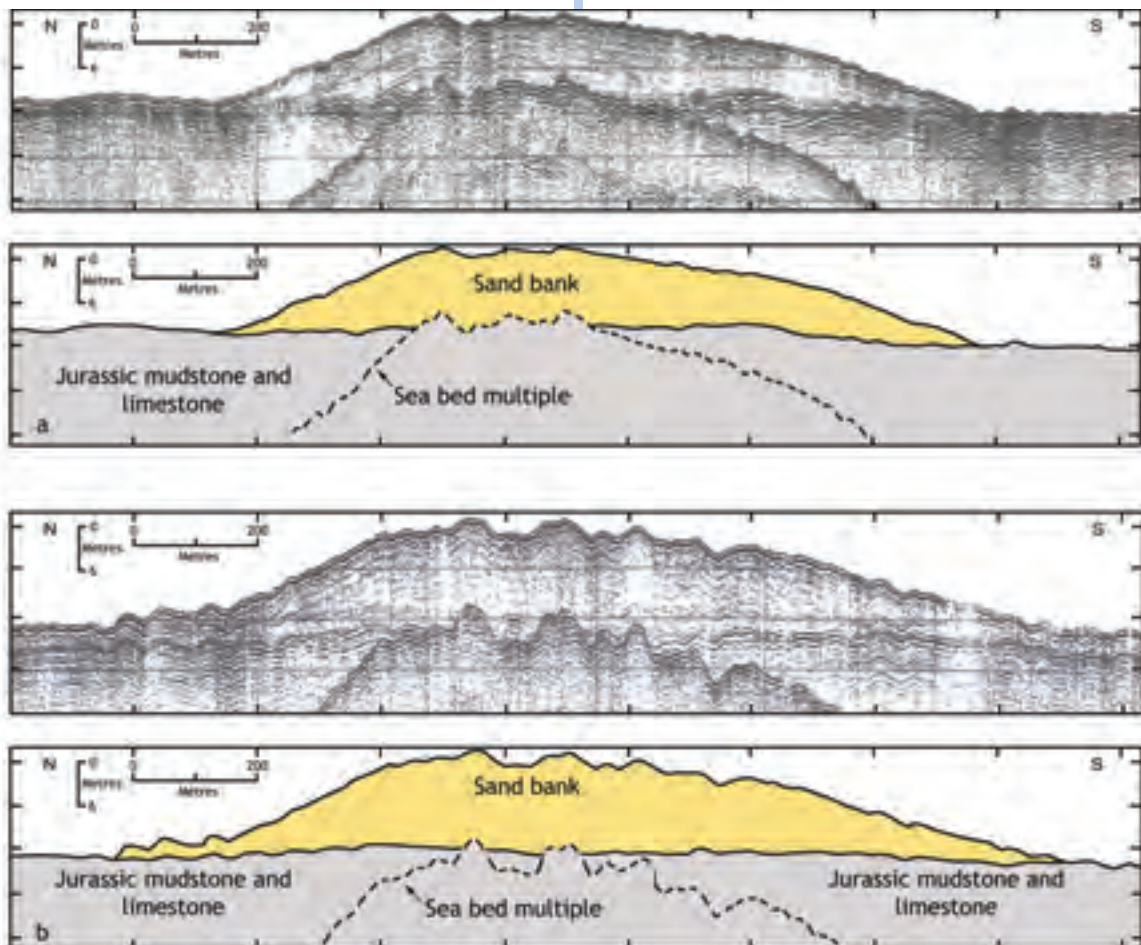


Figure 1: Seismic profiles across Nash Sand, shown as locations 25a and 25b on Figure 3.

C.D.R. Evans

Independent consultant, Bryneos, Llangoedmor, Cardigan, Ceredigion SA43 2LB

Hanson and other companies have acquired data, most of which are not in the public domain. The report synthesises the data from four of these licenced areas to provide a more detailed description of their sea bed than has hitherto been available. The project aims to describe the *geodiversity* of these areas in order to assist mapping marine landscapes in a manner that is more accessible and useful to biologists attempting to map marine habitats.

To describe the geodiversity, the study areas are divided into *facies* a concept familiar to geologists. A *facies* being an environment of deposition displaying a specific range of characteristics. This is considered more appropriate than defining a landscape simply by its grain size, tidal regime, water depth, or other closely defined parameter.

Two geological setting have been investigated in this project, namely sand banks and offshore river channels. Nash Bank (376), a major sand bank in the Bristol Channel, and Cross Sand (436 and 202) off the East Anglian coast are the chosen sand banks, and Inner Owers (435), south of the Sussex coast and the Overfalls (372/2) east of the Isle of Wight represent the river channels and their flanks. The numbers relate to

the Crown Estate aggregate extraction licences. This summary carries limited information from three of these areas.

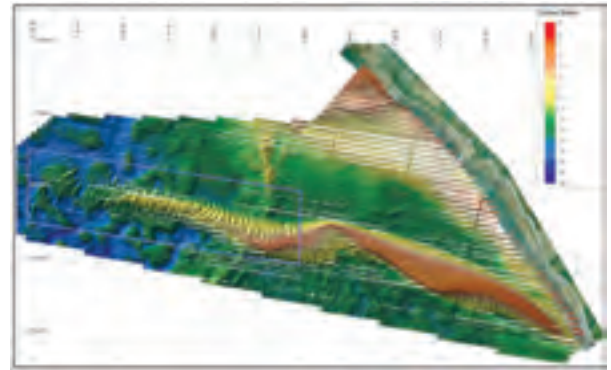


Figure 2: Sun illuminated multibeam bathymetry across Nash Sand collected in February 2005 and adjacent coast (from aerial photographs).

NASH SAND (376)

Nash Sand is a banner sand bank off the northern coast of the Bristol Channel. The bank, which is some 13km long and 1.5km wide, is aligned parallel to the tidal stream in the Bristol Channel. The bank has a surface of clean, very well sorted, medium-grained sand. Tidal

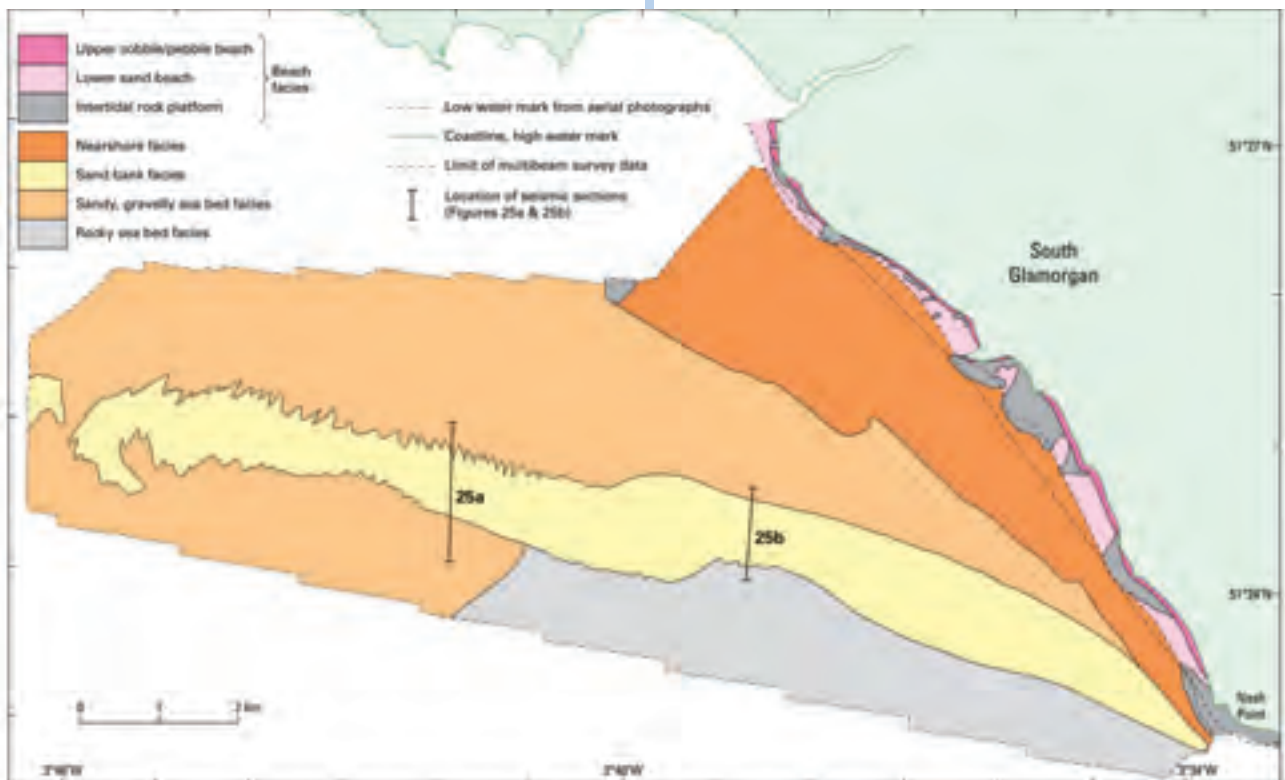


Figure 3: Marine facies across Nash Sand and adjacent coast

Sand banks and offshore river channels: Examples of geodiversity from aggregate industry sites

range across the bank is about 8.9m. The bank sits on a planar bedrock surface at a depth of between 12m and 19m (Figure 1). Figure 2 shows a sun illuminated multibeam bathymetry of the bank and its surrounds collected in February 2005. Similar surveys across the bank have been collected bi-annually since February 2003, and their digital format allows for the first time accurate evaluation of temporal changes in bank form. The bank is covered by sand ripples, megaripples and sand waves (Figure 2) and the asymmetry of the larger bedforms provides an indication of the direction of net sand transport on the bank. The first analyses of the bedforms in the 70s suggested a clockwise movement of sand around the bank flanks but examination of Figure 2 shows a more complex situation with cross bank movement important across East and Middle Nash.

The bank has been dredged since 1926 and during this time an estimated 10% of the bank volume has been removed. Concerns over the bank stability and coastal erosion have led to a detailed and varied monitoring programme to be put in place over the past decade. This report summarises the data and shows that the bank is in a state of dynamic equilibrium. The bank and its surrounds are divided into a series of facies which assist mapping the marine habitats of the area (Figure 3).

OVERFALLS (372/2)

The Overfalls is located about 22km east of the southern most point of the Isle of Wight, it covers an area of about 15 km² and lies in water depths of between 17m and 35m. The area lies in an interfluvial between the palaeo-Solent valley to the west and a more open, unnamed valley to the east, and the overfalls are due to large N-S trending sand waves that traverse the area.

The region is underlain by mudstones and sandstones with some harder sandstone beds that dip southwards at an inclination of 2° to 4°. This variation in rock type across the area influences the sea bed topography. The clays and silts result in a smooth flat seabed, the harder sandstones form upraised scarps, and the more extensive sandstones and chalk to the south, have a flat but rougher seabed. Three types of features stand out on the sun illuminated multibeam bathymetry of the area. The east-west linear scarps marking hard bands within bedrock (Figure 4), the sinuous N-S very large sand dunes with a radiating subset of smaller dunes, and the flatter intervening sea bed. Analysis of the bathymetry, seismic sidescan and sample data allows the division of the area into rocky seabed, uniform gravely sandy plain and sandy dune facies (Figure 5).

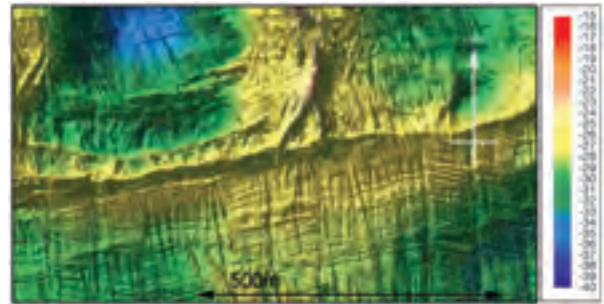


Figure 4: Section of sun illuminated multibeam bathymetry across The Overfalls showing an E-W ridge of sandstone, dipping gently to the south, with a N-S sand wave in the middle of the figure.

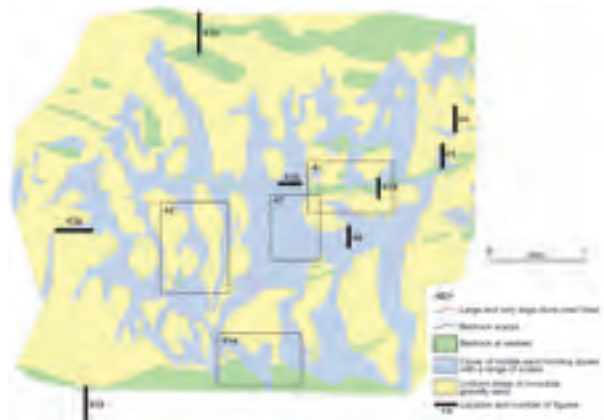


Figure 5: Facies map of The Overfalls area. Numbered squares and lines refer to figures in the main report.

PALAEO-ARUN OFFSHORE RIVER CHANNEL (INNER OWERS 435)

The River Arun rises in the central Weald and flows into the English Channel where its course can be traced southwards for many tens of kilometres. The sea bed for some 10km south of the river mouth, is an almost smooth plain, but a valley-like form appears in deeper water further south. Seismic profiling across the southern deeper water part of the infilled valley (Figure 6) shows a smooth seabed providing almost no indication of the buried complex alluvial fill. This indicates that features of geodiversity interest need not have a bathymetric expression and may have little significance with respect to marine habitats.

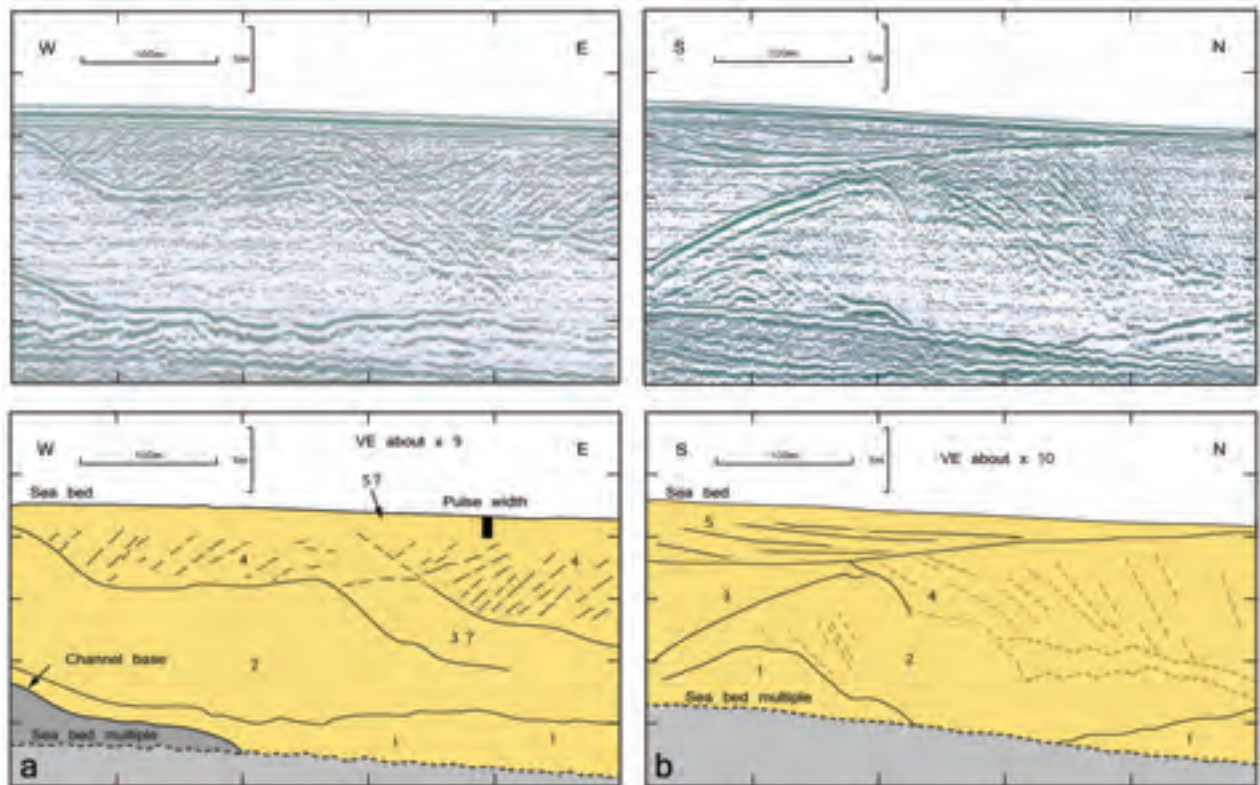


Figure 6: Seismic profiles across the Palaeo Arun river channel south of Littlehampton. Numbers refer to units described in the main report.

CONCLUSION

The data held by aggregate companies on their licence areas provide a valuable source of detailed information that can be used to map the geodiversity of parts of UK waters. The temporal range of the data provides an indication of change across the areas and the range of data collected provides an opportunity to integrate both biological and geological approaches. The seabed data required to map marine habitats is of limited commercial sensitivity and in many instances may be made available by the aggregate companies.

A unified approach is necessary to the mapping of marine landscapes in UK waters. This approach and classification developed must be adaptable to a range of mapping scales and must be useful and relevant to biologists mapping marine habitats.

Geodiversity and landscape mapping should use the facies concept for classification rather than a single closely defined parameter. Marine landscape maps based on facies should be prepared before, and form the broad basis of subsequent marine habitat maps.

Title: MAL0002 Sand Banks and Offshore River Channels: Examples of Geodiversity From Aggregate Industry Sites

Contractor: C.D.R. Evans, Independent consultant

Contact: Chris Evans

E-mail: bryneos@btinternet.com

Full Report Site:
<http://www.marinealsf.org.uk>



Marine aggregates and biodiversity in both a 2 and 3 dimensional context

INTRODUCTION

Although we know many of the organisms that live in sand and gravel beds, the ecology of these habitats is still not fully understood. Importantly, we do not know if the biotopes which occur within and on veneer deposits alter as the substrata becomes deeper, particularly within palaeochannels that are targeted by the aggregate industry. If the principal resource areas for the marine aggregates industry were found to contain unique biotopes, which are very different from the more extensive veneer deposits, then this would have important implications for the potential impact of aggregate extraction on marine biodiversity. The project is considered to have value, in terms of providing data sufficient to inform Environmental Impact Assessment (EIA) and the regulatory decision making processes, including the appropriate selection of aggregate extraction sites.

Emu Ltd was, therefore, funded through the ALSF in 2005-2006 to investigate the relationship between biodiversity and thickness of gravel deposits.

AIM

The two year project entitled 'Marine Biodiversity and Aggregate Dredging in both a Two and Three Dimensional Context' surveyed veneer and thick deposits of sand and gravels in the Eastern English Channel in order to address two fundamental questions:

Do the faunal communities in the superficial sediments correspond to the depth of the underlying substrata?

Do deep aggregate resources support benthic communities unique to those areas?

OBJECTIVES

To answer these questions, three principal objectives were set, namely to:

- Sample substrata from three discrete areas within the English Channel where gravel based sediments, of known depths, are known to exist.
- Place these detailed survey sites within a wider context by sampling over a wide spatial array in the English Channel.
- Analyse the data to determine if any relationships exist between benthic communities and substrate depth.

The outcomes from these objectives were intended to allow a description to be made of the sensitivity and uniqueness of biotopes associated with sediments from areas of palaeochannel infill, compared to adjacent sediment veneers.

METHODOLOGY

The basic field and laboratory methodologies employed during the execution of this study adhere to industry standards and are described in Emu Ltd, (2005). Several variations to the methods were employed for the presentation of the current report and these may be found in Emu Ltd, (2006).

DETERMINATION OF SAMPLE ARRAYS

With respect to the survey arrays, site locations in the detailed survey areas were determined by BGS based on specific requirements made by the ecologists from Emu Ltd. who had no prior knowledge of the subsurface geology. The basic principle was to sample using grabs from a representative number of sites, located in sediments with differing depths of subsurface particulate material. A nominal five different classes were specified.

However, due to the character of each of the individual detailed survey sites, this principle could not be followed exactly. In particular, location B, consisted of large areas of shallow sediments with various bedforms, hence the survey arrays were designed by BGS around these features, rather than the poorly defined sediment depth ranges available at the time (see Philpott, James, & Poulton, 2005).

The 3 detailed survey areas selected were:

| | |
|-------------------|---|
| Location A | Inner Owers, south of Littlehampton |
| Location B | South east of the Isle of Wight |
| Location C | West Bassurelle, Eastern English Channel |

These sites are shown together with the wide sampling array in Figure 1.

The data presented in the final report includes analysis based on the full data sets, comprising quantified infaunal and epifaunal data, revised geological isopach data and new bathymetry and sidescan data from locations A and B. The process of analysis has followed the following steps:

N. Thomas¹, J.W.C. James²

¹EMU Ltd, 1 Mill Court, The Sawmills, Durley, Southampton, Hampshire, SO32 2EJ

²British Geological Survey, Kingsley Dunham Centre, Nicker Hill, Keyworth, Nottingham NG12 5GG

- Primer analysis (Clarke & Warwick, 2001) of all faunal data from all sites with identification of clearly separable clusters of sites. The analysis process has employed Bray Curtis Classification using untransformed data (trials indicated greater definition of clusters was possible using untransformed data).
- SIMPROF which is a subroutine used to identify at what level clusters of sites can be considered to be statistically separate from adjacent sites ($P < 5\%$).
- Univariate analysis of physical measures including depth to seabed, sediment particle size variables (percentage gravel, sand and silt) and depth of underlying particulate material against primary variables, species number per site and abundance per site.
- Description of biotopes for all clusters in each of the detailed studies including comparison of physical conditions pertaining in each cluster. The data includes additional video interpretation from hard ground sites where benthic grabs could not be collected.
- Overlay of biological clusters over the wider array area.

- Overlay of biological clusters over the physical conditions in each detailed location.
- Comparison of physical and biological conditions in each of the clusters within each detailed location area.

PRINCIPAL RESULTS

Do the faunal communities in the superficial sediments correspond to the depth of the underlying substrata?

Faunal communities were found to respond to the underlying substrata but, importantly, differences in faunal communities only occurred when the superficial depth of substrata was less than 2m.

The deep aggregate resources which occur, for example, at the centre of palaeochannels, contained similar communities to those which occur widely in shallower sediments.

Where sediment depth is less than 2m, communities may develop that are only found in these areas. These conditions correspond to the occurrence of coarse gravels and cobbles that are stable in nature and have considerable, physical structural diversity.

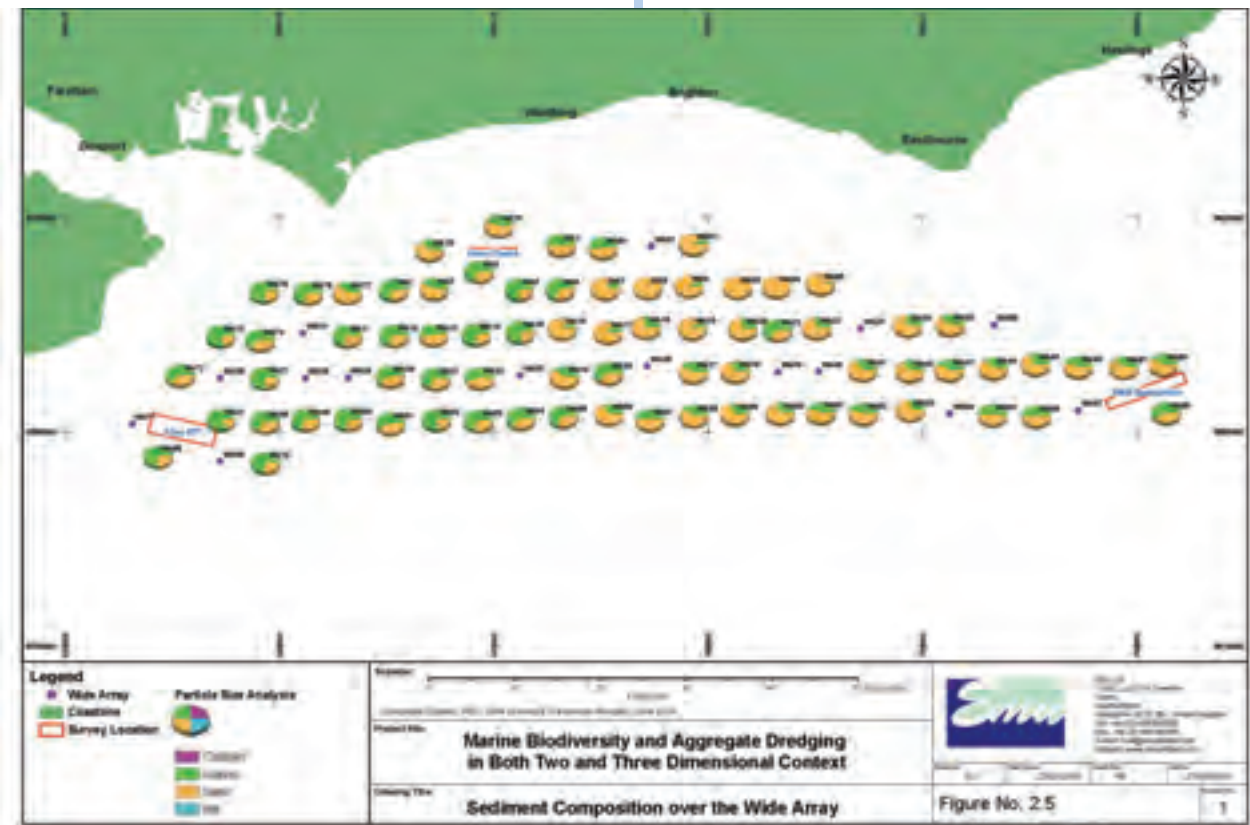


Figure 1: Sampling array including particle size data

Marine aggregates and biodiversity in both a 2 and 3 dimensional context

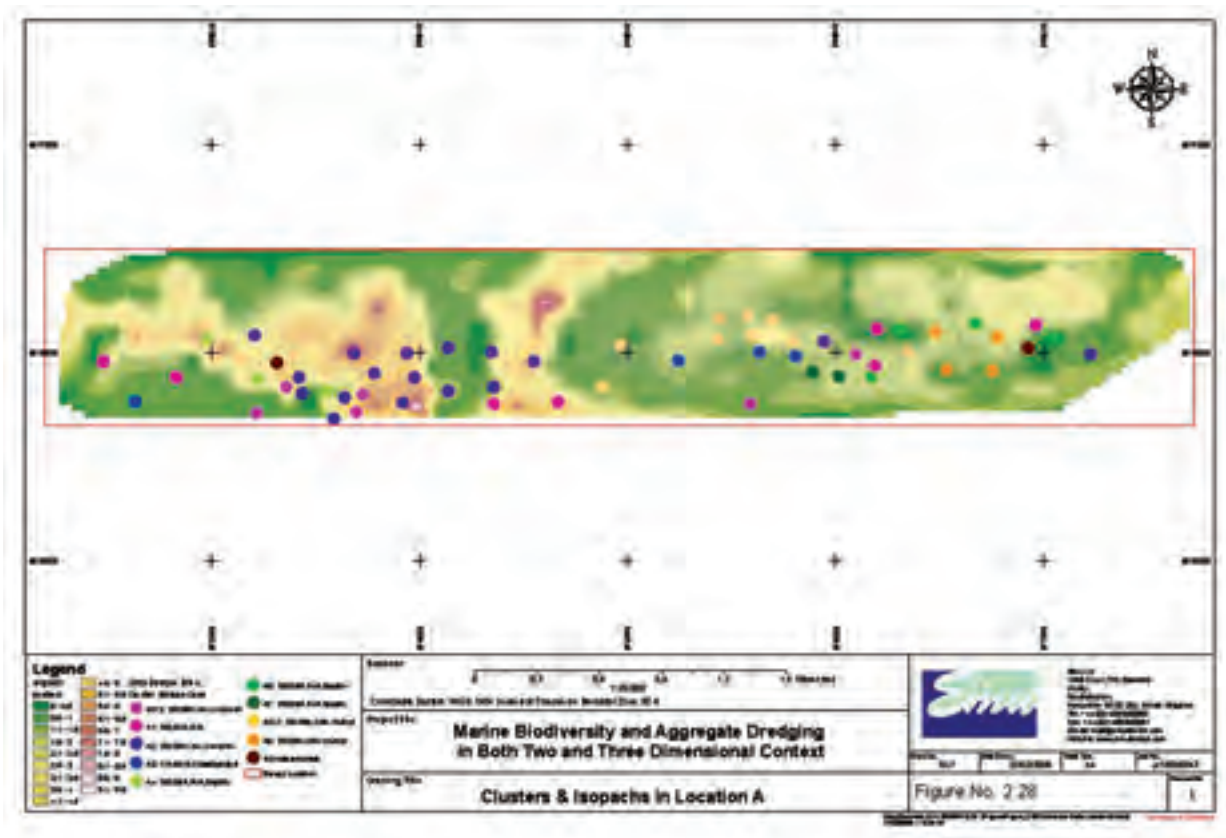


Figure 2: Biotopes in the Inner Owers (Location A) study area.

These conclusions are based on the faunal analysis undertaken in all three detailed study locations.

Location A (Inner Owers) demonstrated the greatest variability in both physical conditions and associated benthic community. A uniform biotope, comprising a *Crepidula* based community (Figure 2, purple dots), was found across much of the area including both deep and shallow sediments. Most other biotopes were evident in both deep and shallow sediments; this included biotopes based on what were defined as hard ground areas. Only one cluster was found exclusively in shallow sediments and this was cluster 3, (dark blue dots) which was characterised by a diverse *Sabellaria* based biotope.

Within this location the importance of biogenic reef and other species-modified habitats is thought to be significant, with both *Sabellaria spinulosa* and *Crepidula fornicata* affecting overall community composition through stabilisation of sediment conditions (see Plate 1 below). Importantly, changes in these communities do not appear to correspond to depth of sediment substrata, once a superficial layer is present.

Examples where faunal cover is heavily influenced by *Crepidula* occurred across a range of sediment depths, including cluster A2 and HG3 (see Figure 2 above). Similarly, *Sabellaria spinulosa* was present in significant numbers in clusters A2, A3, A4, A5 and A7 although only cluster A7 included *Sabellaria* in sufficient numbers to suggest the presence of coherent crusts.



Plate1: Hard Ground Biotope (SS.SMX.IMx.CreAsAn) in Location A.

Location B is illustrated in Figure 3 (below) with a plot of faunal clusters overlain on the depth of sediment. Much of this area was hard ground and could not be sampled.

No clear biotope could be ascribed to the clusters defined in the analysis, although differences in species and physical conditions were identified. Cluster B2 (light blue dots), in particular, only occurred in <2m sediment. The sediment comprised gravel-dominated sandy gravels, with a significant proportion of cobbles. The fauna was generally very diverse, supporting high overall abundance with exceptionally high numbers of the barnacle, *Verruca stroemia* and the seasquirt *Dendrodoa grossularia* as well as a range of other species including, decapod crustacea, molluscs, echinoderms and bryozoa, all present both frequently and in abundance. Due to the lack of fine sediments the polychaeta were poorly represented.

Cluster B1 (pink dots), in contrast, occurred across a range of sediment depths from 1m to 7.2m. The sedimentary characteristics were in other respects similar to cluster B2 – gravel-dominated with cobbles. The faunal community was more limited than that in B2, with reduced numbers of species and reduced abundances, although it did include many encrusting epifaunal species such as the bryozoan *Escharella immersa*. Clusters B3 and B4 were only found in two locations and represented impoverished versions of the other communities found.

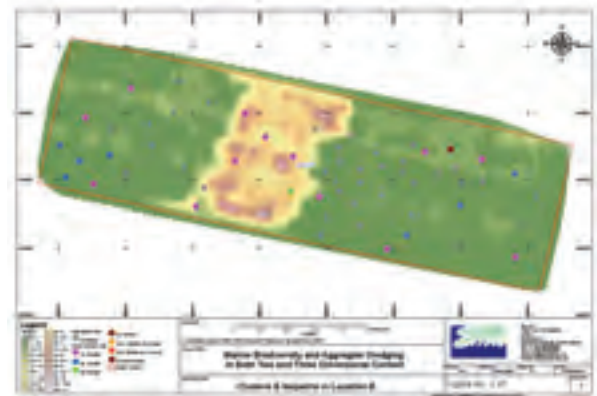


Figure 3: Biotopes in Location B, south east of the Isle of Wight.

Location C (West Basurrelle) provided another good example of the communities that are be found over deeper sediments, which can also occur over shallow sediments. In contrast to Location B, the site comprised uniform surface conditions despite the presence of both very shallow surface sediments and relatively deep sediments (Figure 4 below). The sediment type across the whole area is gravelly sands

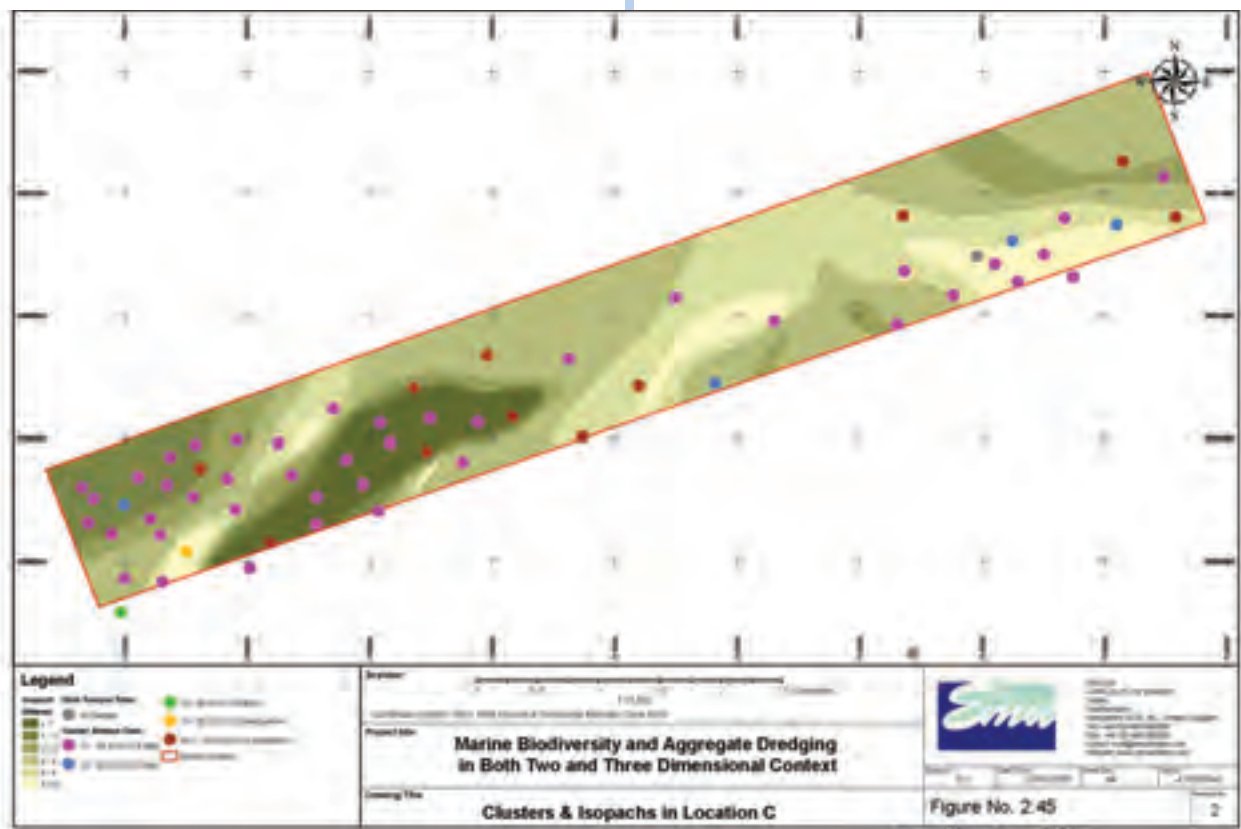


Figure 4: Biotopes in Location C, West Basurrelle.

The above example is from Location A. The absence of any clear relationship between deep sediments and faunal communities is clearly demonstrated in the profile, which incorporates isopach data, bathymetry and biotope information. Cluster A2 (purple), comprising the *Crepidula* dominated biotope, is seen to occur across the palaeochannel but is also found in the areas where the rock is just below the surface, including patches in shallow sediment to the east of the area. The complexity of the biotopes over the shallow sediments is also illustrated, with the greatest degree of variation evident to the east. An example of the boundary communities is also evident with the occurrence of HG2 (yellow) the *Flustra* and Hydroid-dominated, mixed coarse sediments, emerging to the east of the deepest palaeochannel, although in this instance the rock does not outcrop and the biotope also persists over an area of slightly deeper sediments.

CONCLUSIONS

- Faunal communities were only found to respond to the depth of underlying substrata when the superficial depth of sediments was less than 2m. In the context of the aggregate dredging industry, a key finding was that communities which are found in targeted deep resources are also widely found in shallower sediments. Different communities were found to occur at the natural boundary between predominantly particulate and bedrock areas, notably at the edge of former palaeochannels.
- Deep aggregates were not found to support unique biological communities. However, the biotopes found immediately adjacent to deep resources are likely to be well-defined spatially and to comprise a different community from that found in the sedimentary areas.

The findings have important implications for marine aggregate extraction in that unique biotopes are not associated with the deeper deposits which form the targeted resource. However, further investigation of the biotopes that occur at the edge of palaeochannels at the natural boundary between particulate and bedrock areas would prove valuable, as they may be important to the ecology of gravel communities and, while unlikely to be subject to direct impact from aggregate extraction, could be subject to peripheral impacts as a result of local changes in both hydrodynamic and sediment transport conditions.

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Title: ALSF Grant ref no 2004/345. Marine Biodiversity and Aggregate Dredging in Both Two and Three Dimensional Context.

Contractor: Emu Limited.

Contact: Dr. Nigel Thomas

Telephone: 01489 860070

E-mail: Nigel.Thomas@emulimited.com

Full Report Site:
<http://www.biodiversityingravels.org.uk/>



Recoverability of *Sabellaria spinulosa* following aggregate extraction

INTRODUCTION & BACKGROUND TO THE STUDY

The polychaete *Sabellaria spinulosa* can have a significant impact on the nature of the sea floor by turning large quantities of sand into intricate though often disorderly tube colonies that have frequently been compared to reef structures. The habitat created by these sand grain structures have been widely reported as supporting a unique and diverse fauna that would not otherwise be found on the seabed (UKBAP, 2007), and as such is protected under Annex I of the habitats directive (Jackson & Hiscock, 2006). Aggregate dredging is known to cause physical damage to this habitat although prior to this study there was little information on the longevity and therefore significance of these impacts. There have been conflicting reports between those that have reported that *S.spinulosa* aggregations could take many years to recover (UKBAP, 2007) and those that have reported it to exhibit high recoverability (Jackson & Hiscock, 2006).

These conflicting reports have arisen from the paucity of research into this species and in particular its life history traits. Comparatively extensive research has been

carried out on *Sabellaria alveolata*, an intertidal relative of *S.spinulosa* and there are many instances in the literature where the differences between the two species is blurred (Vorberg, 2000). This has further complicated the situation with assumptions being made on the basis of these two species having the same or closely mirrored life history traits. Management of this important marine resource has become a complex issue and the gaps in our current knowledge have forced a contentious precautionary approach.

The main objective of this investigation was to provide sound scientific information on the recoverability or colonisation potential of *Sabellaria spinulosa* following aggregate extraction, whilst clarifying some of the life history traits of this animal. In addition to this a detailed investigation into the biodiversity associated with the aggregations was carried out. The quality and physical properties of the aggregations were recorded and an attempt was made to understand the environmental conditions most likely to be conducive of colonisation. It is hoped that the results of this research will be used to inform regulatory policies on the management of this species, leading to more effective and informed protection strategies.



Figure 1: Chart section of the study site showing the June-July 2005 Side Scan Sonar interpretation carried out by the Resource Management Association (RMA) as part of the licence renewal for Area 366-370. The areas identified as *Sabellaria spinulosa* aggregations are shown in green. Also shown is the Licence Area, the seabed sediment types, the areas of current dredging and historic dredging, seabed features, and the Lines at which side scan sonar images were obtained in 2005 © CEMEX UK Marine Ltd, Hanson Aggregates Marine Ltd & United Marine Dredging Ltd.

B. Pearce¹, J.A. Taylor² & L.J. Seiderer¹

¹Marine Ecological Surveys Limited, 24a Monmouth Place, Bath, BA1 2AY

²Compass Hydrographic Services Limited, 91 Olive Avenue, Leigh on Sea, Essex, SS9 3PX

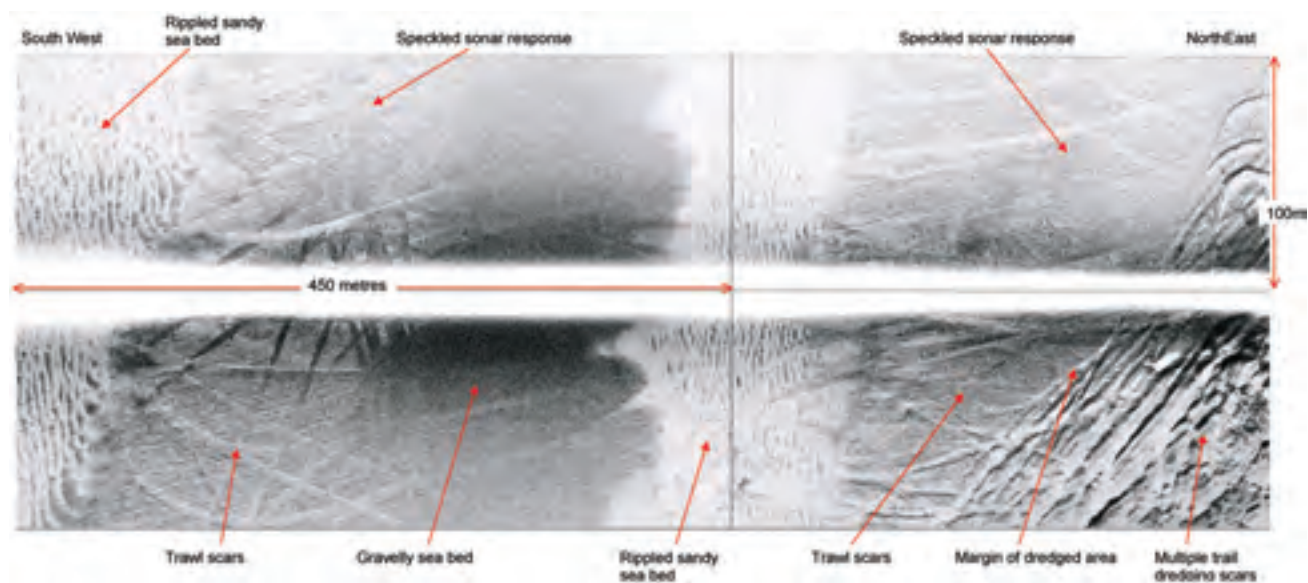


Figure 2: Side scan sonar image of Line 19a running through the exclusion zone to the west of the study site (See Figure 1) produced by the RMA as part of the licence renewal for Area 366-370 in June - July 2005. © CEMEX UK Marine Ltd, Hanson Aggregates Marine Ltd & United Marine Dredging Ltd.

THE STUDY SITE AT HASTINGS SHINGLE BANK

Hastings Shingle Bank was chosen as the research study site after a number of *S. spinulosa* aggregations were identified within and surrounding the active aggregate extraction area. Of particular interest was an aggregation identified next to Line 31 (Figure 1), less than a year after dredging had ceased. These aggregations were identified in high-resolution side-scan sonar data collected by the Resources Management Association (CEMEX UK Marine Ltd, Hanson Aggregates Marine Ltd and United Marine Dredging Ltd) as part of their licence renewal for Areas 366-370 and licence application for Area 460. A chart based on the interpreted side-scan sonar data is shown in Figure 1, where the *Sabellaria spinulosa* aggregations are illustrated by areas of green. The *Sabellaria spinulosa* aggregations occur all around the active extraction area but appear to be limited to the gravel and sandy gravel deposits, which presumably provide sufficient stability upon which the worms are able to settle and build their sand grain structures.

An extract of the side scan sonar data collected from Line 19a is shown in Figure 2. This line runs through an exclusion zone to the west of the licence area and beyond (Figure 1). The speckled signature of *Sabellaria spinulosa* aggregations is clearly visible and their presence was confirmed using a clam shell grab. The seabed is disrupted with multiple trawl scars, something that was common across the area. The western margin of the dredging activities is also shown clearly on this line, marked by the turning manoeuvres in the dredge

trails. The irregular furrows caused by the dredging activities are a notable feature on this and other images taken across the dredged area.

SURVEY DESIGN

A comprehensive biological survey was undertaken at the site based on a blocked sampling grid shown in Figure 3. Blocks were positioned in four of the *Sabellaria spinulosa* aggregations identified in the area as well as in the adjacent substrata and actively dredged part of the licence area. This design facilitates direct comparisons between the different aggregations and the dredged area as well as between each aggregation and the substrata immediately adjacent to them so that an assessment could be made of their influence on biodiversity. A number of physical parameters were measured at each of the grab stations in order to better understand the environmental conditions which favour colonisation by this species.

The individual worms were extracted from all of the samples taken within these blocks and biometric measurements were made to examine the size structure and growth patterns of each of the aggregations. Historic grab data and the history of dredging in the area were then used to make inferences about the longevity of the aggregations and hence the rates of colonisation or 'recovery'. The community structure associated with the four aggregations was then examined using standard multivariate techniques within the PRIMER software (Clarke & Gorley, 2006). *Sabellaria spinulosa* was excluded from the datasets and samples were classified according to their relative

Recoverability of *Sabellaria spinulosa* following aggregate extraction

S. spinulosa abundance in order to investigate the differences in the faunal complements associated with the aggregations. All of this information was then combined to make an assessment of the 'quality' of the aggregations.

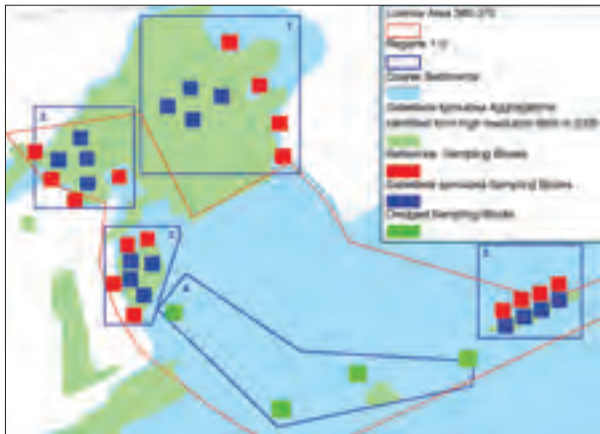


Figure 3: Chart showing the study area at Hastings Shingle Bank, including the current licence boundary for Area 366-370, the five sampling regions and the targeted grab sampling blocks therein. These have been overlain on a chart showing the extent of the Gravel deposit in blue, the *Sabellaria* aggregations in green.

In order to gain an understanding of the movements of water and associated suspended solids across the study area at Hastings Shingle Bank an oceanographic survey was undertaken. A vessel mounted Acoustic Doppler Current Profiler (ADCP) was used to acquire quantitative measurements of the speed and direction of water movements in the area, from a top down perspective. This was complimented with regular Conductivity, Temperature and Depth (CTD) measurements and was calibrated using suspended particulate matter (SPM) readings collected from a beam transmissometer attached to the CTD unit as well as *in situ* water samples.

The vessel mounted ADCP survey was supplemented with measurements taken with a Nortek Acoustic Doppler Velocimeter (ADV), deployed on the seabed along with a Seapoint Optical Backscatter sensor (OBS). Deployments were made at a site within a *Sabellaria spinulosa* aggregation as well as at an adjacent site where *S. spinulosa* aggregations were not found. This facilitated comparisons between nearbed current flows as well as turbidity levels at the two sites, which again were calibrated using the SPM levels recorded in the *in situ* water samples.

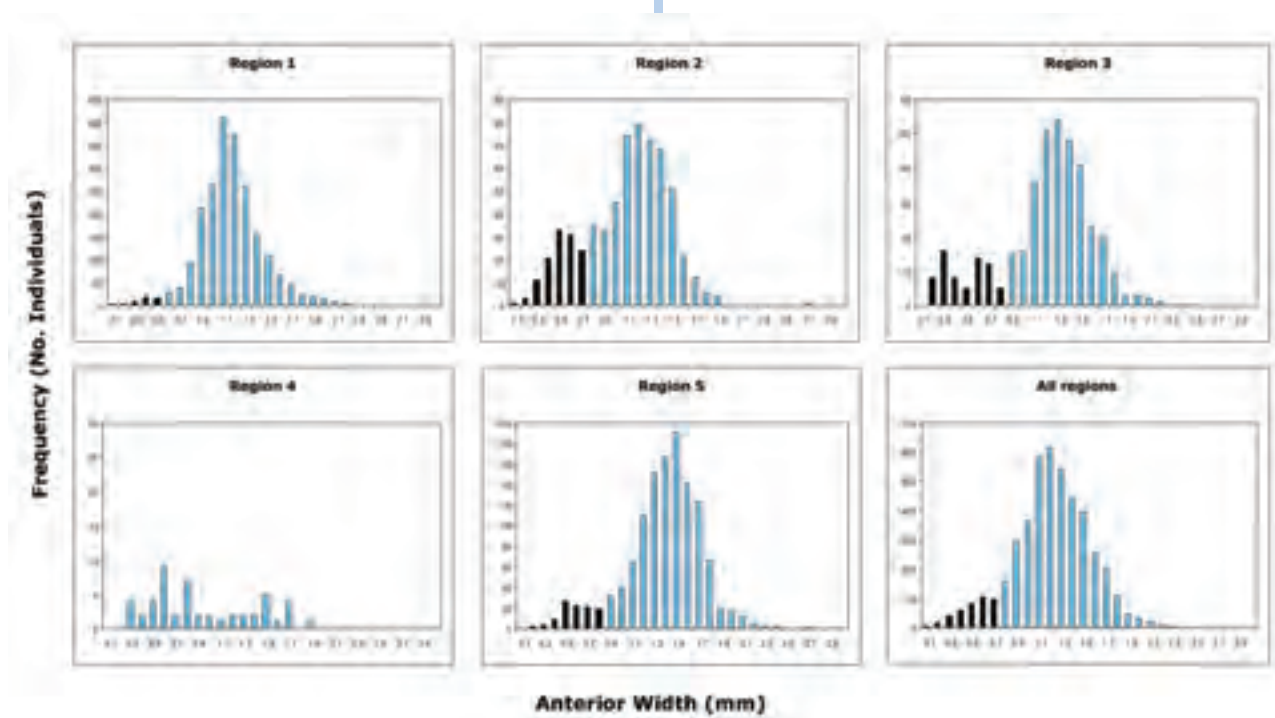


Figure 4: Size frequency histograms of the anterior width (mm) of *Sabellaria spinulosa* individuals collected in five different regions within the study site at Hastings Shingle bank, in September 2006. Early developmental cohorts are coloured black and the main adult cohort coloured blue. Cohorts have not been assigned to individuals recorded from Region 4 which is actively dredged, as the occurrence of *Sabellaria spinulosa* here is sporadic at best

ESTABLISHING COLONISATION RATES & AGEING THE SABELLARIA SPINULOSA AGGREGATIONS

Two cohorts were identified consistently across the four *Sabellaria spinulosa* aggregations as is illustrated in Figure 4. The majority of animals belonged to a large adult cohort peaking at 1.2mm, with the rest belonging to a smaller early developmental cohort peaking between 0.3 and 0.5mm. The shape of the cohort graphs suggested that *S.spinulosa* grows very rapidly in the early stages of development so that they merge with the adult cohort well within a year. After this stage growth slows dramatically and the adult body size and biomass does not exhibit much change. These results were corroborated by earlier work undertaken on the production rates of this species in the Bristol Channel by George & Warwick (1985).

It was possible to age the four aggregations with some degree of certainty using these cohort analyses in conjunction with historic abundance records and the history of aggregate extraction in the area and these results are summarised below;

Region 1 – 4-5yrs

<1hr dredging between 1993 and 2000
High *S.spinulosa* abundances (> 2000m²) first recorded in 2002

Region 2 – 3-4yrs

Dredging ceased completely in 2003
High *S.spinulosa* abundances (> 2000m²) first recorded in 2004

Region 3 – 4-5yrs

<1hr dredging between 1993 and 2000
High *S.spinulosa* abundances (> 2000m²) first recorded in 2002

Region 5 – 16-18mths

Dredging activities reduced after February 2005 and stopped by the end of May 2005
High *S.spinulosa* abundances (> 2000m²) first recorded in 2006 but aggregations visible on side scan sonar in summer 2005

The process of colonisation appears to be relatively rapid and certainly must have started in a matter of months if not weeks following the cessation of aggregate extraction in Region 5 and also in Region 2. Settlement appears to have started between February and May, although there is no direct record of this. This agrees with other observed settlements of this species (George, 1985, Wilson, 1970), although the larvae have

also been recorded from the water column between September and August (MBA, 1957). Although the exact timing of larval settlement could not be deduced, the success of recruitment in this area is evident by the presence of early developmental cohorts across the area. If this level of recruitment is maintained, aggregations could be expected to reach the abundances observed in the oldest aggregations found in Region 1 within 3 years.

Trawling activities were evident across the area and it is very likely that damage caused by this is limiting the development of the aggregations. In an area with less or no trawling the aggregations could be expected to develop at a faster rate and also reach a more consolidated state.

BIODIVERSITY ASSOCIATED WITH THE SABELLARIA SPINULOSA AGGREGATIONS

The benthic faunal diversity was high across the area with a polychaete-rich community typical of mixed sand and gravel deposits. A continuum exists between the benthic communities associated with *Sabellaria spinulosa* aggregations and the adjacent substrata. The *Sabellaria spinulosa* aggregations were associated with an increase in abundance of most species found in the surrounding deposits, but most notably a major increase in the abundance of the porcelain crab *Pisidia longicornis*. This significantly alters the dominance of the community to the point that *S.spinulosa* aggregations exhibit many features in common with communities that are subjected to a moderate level of disturbance.

Only a very slight increase in species diversity was associated with the *S.spinulosa* aggregations at Hastings Shingle Bank. These communities were characterised by an increase in abundance of species found in adjacent substrata rather than a different complement of species as has previously been reported (UKBAP, 2007). Some species, particularly those with similar habitat requirements such as *Pomatoceros*, a worm which also lives in tubes which it builds on hard substrata, were starting to be excluded by the more developed *S.spinulosa* aggregations. It is likely as the aggregations continue to develop and become more consolidated that this exclusion will extend to species which inhabit the pockets of sediment in between the patches of *S.spinulosa* growth. Biodiversity is therefore likely to peak in areas of patchy interspersed aggregations and then tail off where the aggregations develop, consolidating sediments and monopolising the available hard surfaces.

Recoverability of *Sabellaria spinulosa* following aggregate extraction

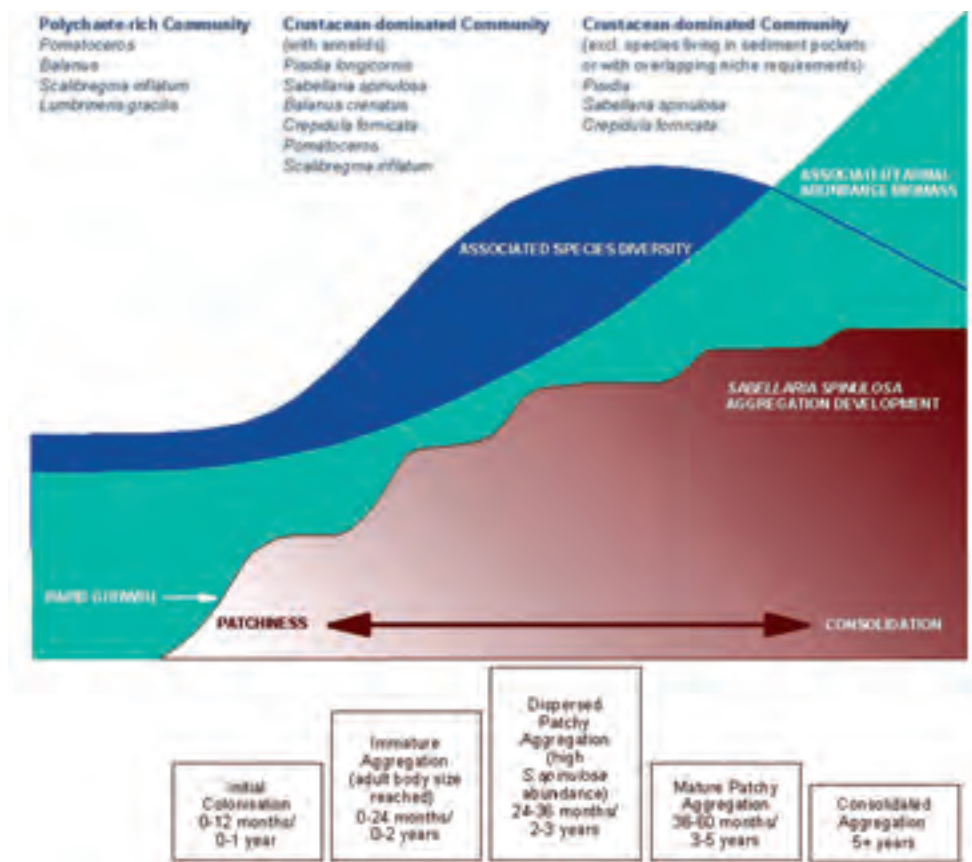


Figure 5: Schematic diagram showing the sequence of colonisation and development of *Sabellaria spinulosa* aggregations at Hastings Shingle Bank.

The epibenthos and fish communities were equally rich across the area and were dominated by queen scallop (*Aequipecten opercularis*) beds with associated barnacles (*Balanus crenatus*) and the epilithic polychaete *Pomatoceros*. Video footage revealed that these scallop beds were interspersed between the patches of *S. spinulosa* and it is likely that there is some degree of competition between the two for space as well as food resources. The American slipper limpet *Crepidula fornicata* appeared in higher numbers in association with the *Sabellaria spinulosa* aggregations although it was not clear from observations whether the structures were providing a surface upon which the limpets could attach or if they were occurring in the gaps between the aggregations. This species is often associated with high levels of organic material so it is possible that the faecal material produced by the *Sabellaria spinulosa* aggregations and their associated fauna could be being utilised by this species.

By far the most significant faunal association observed with the *Sabellaria spinulosa* aggregations at Hastings Shingle Bank is that with the porcelain crab *Pisidia longicornis*. This association will have a significant importance in terms of the food web as it is likely to become an important source of food for fish and possibly

larger invertebrates as well. Whilst this association is a site-specific one, associations with high numbers of crustaceans have been observed at other locations including a widely-documented association with the pink shrimp *Pandalus montagui* (Warren & Sheldon, 1967). It is therefore postulated that *Sabellaria spinulosa* aggregations are more significant in their ability to support an enhanced abundance of certain crustean species than their ability to significantly heighten species diversity.

MAPPING THE 'QUALITY' OF THE SABELLARIA SPINULOSA AGGREGATIONS

An assessment was made of some physical and biological aspects of the four *Sabellaria spinulosa* aggregations that could be used as indicators of their 'quality'. The elevation proved difficult to assess using samples collected with the mini Hamon grab as the tubes were largely broken up during sampling. The height of tubes recorded is likely also to be limited by the maximum sampling depth of the mini Hamon grab which has been reported as being 10cm (Eleftheriou & Holme, 1984). As the maximum tube length recorded was 11cm

it is likely that this sampling method is limited to the top section of the aggregation and therefore will give an underestimation of the actual height.

The aggregations in this area were all very patchy and in some cases the patches were highly interspersed, although assessing the actual percentage cover and extent of the aggregations was difficult with only a limited number of video tows. Trawl damage was evident in the side scan sonar and it is likely that these activities have increased the patchiness and may even be preventing further development of the aggregations. As ground discrimination techniques such as side scan sonar continue to develop along with our knowledge of the signatures expressed by these and other structures it is likely to become possible to make a more accurate assessment of the extent and patchiness of *S.spinulosa* aggregations.

The physical features of the aggregations and the worms themselves revealed only slight differences between the *Sabellaria spinulosa* aggregations in this area and it seems likely that the biological status of the aggregations may be more useful in terms of any future 'quality' definitions. The aggregations were aged using historic grab data as well as the dredging history for the area. The aggregations identified in Region 1 and 3 were estimated as being the same age but were very different in terms of their 'quality'. The aggregations in Region 3 are the most interspersed of those investigated and showed the most intensive trawl damage. The aggregations in this region also differed in terms of their biology with much lower abundances of both *S.spinulosa* and the associated porcelain crab *Pisidia longicornis*.

A simple and easily achievable assessment of the quality of *Sabellaria spinulosa* aggregations could be made by investigating the associated fauna and in particular the associated crustacean community. Faunal data recorded from grab samples can be used to construct Abundance Biomass Comparison (ABC) curves and also to derive the W statistic as a measurement of dominance. A combination of the abundance of *Sabellaria spinulosa* and the associated crustacean with the overall dominance could be used to categorise and define aggregations in terms of the 'quality' which could then be used to assist in their management.

FACTORS INFLUENCING COLONISATION

The study site at Hastings Shingle Bank was characterised by mixed gravel and sand deposits with Sandy gravel and Muddy sandy gravel being the most

dominant sediment classifications according to the Folk system. The sand component increased in the substrata adjacent to the *Sabellaria spinulosa* aggregations which could reflect a preference for colonisation on coarser substrate or the removal of this material through tube building activities. There was also a slight increase in the levels of organic carbon in the sediments associated with the *Sabellaria spinulosa* aggregations which again may indicate a preference but could also reflect the increase in organic faecal material. Levels of Suspended Particulate Matter (SPM) recorded from water samples taken across the area were very low and variable and showed no correlation with the *S.spinulosa* aggregations, this may be an artefact of the sampling method though and future work in this area should be concentrated on collecting water samples closer to the seabed

Water circulation in the area exhibits a strong flood tide in a north easterly direction and a weaker ebb tide in a south westerly direction with a combined flood/ebb tidal extent of 10km on Spring tides and 7km on Neap tides. The tidal ellipse is rotary rather than simply reversing and there is an underlying residual current of approximately 2cm/s which is generally directed towards the north east but which changes direction in response to prevailing wind conditions. There is therefore several mechanisms for sediment released during aggregate extraction to be transported not only along the NE-SW axis of the ellipse but also around the site so that it may eventually settle out to the NW or SE.

The major axis of the tidal ellipse exhibited a subtle shift around to the east where *Sabellaria spinulosa* aggregations were present indicating that the aggregations may be inflicting some drag on the currents. Concentrations of SPM in the water column correlated strongly with current speeds, with peaks in turbidity appearing concurrently with peaks of velocity. However, there was an increase in nearbed turbidity of 15-20% at the site with *S.spinulosa* aggregations despite the apparent slowing of the nearbed water flow.

Subtle differences in the relationship between SPM and current velocity exist between the *Sabellaria spinulosa* aggregation and the adjacent reference site indicating that material is less susceptible to resuspension where *S.spinulosa* aggregations exist. This may reflect differences in the sedimentology between the two sites but may also be caused by the armouring effect of the aggregations. Sand is used for tube building and organic material may be removed as food reducing the amount of fine material available for resuspension. The aggregations may also trap sediment in gaps and crevices and may also modify the nearbed water flow further reducing entrainment potential.

Recoverability of *Sabellaria spinulosa* following aggregate extraction

SUMMARY OF CONCLUSIONS AND MANAGEMENT IMPLICATIONS

Seabed conditions were suitable for colonisation by *Sabellaria spinulosa* following aggregate extraction at the Hastings Shingle Bank site, and this process started within a matter of months. A similar pattern could be expected in other extraction areas if there is a supply of larvae in the plankton. Dredging activities do not therefore alter the seabed in a way that is detrimental to recolonisation by this species, and may even be acting to improve conditions given the high recruitment levels observed in this area.

Sabellaria spinulosa showed a high recruitment success at the Hastings Shingle Bank study site and exhibited a period of rapid growth soon after settlement. These traits are characteristic of an opportunistic or *r*-selected species which is unlikely to be vulnerable to dredging disturbances in that they will exhibit high recoverability.

Initial colonisation and development of a significant *S. spinulosa* aggregation was observed at Hastings Shingle Bank within 18 months and development to a stage equivalent to the oldest aggregations observed in the area was assessed as likely to be complete within 3 years. The development of the *S. spinulosa* aggregations in this area appears to be hampered by high levels of trawling activities. It is possible that development would be significantly quicker in areas not subject to this disturbance. Therefore 1-5 yrs gives a relatively conservative estimate of the time taken for *S. spinulosa* recovery, allowing for likely differences in recruitment rates.

Sabellaria spinulosa aggregations are associated with a very slight increase in species diversity but are characterised by an increase in abundance of the species complement found in the surrounding substrata. The main difference between the fauna associated with *S. spinulosa* aggregations and the surrounding substrata is the super abundance of the porcelain crab *Pisidia longicornis*. This relationship is almost certainly mirrored in other areas although the exact species may differ. This will have implications for the food web as these crustaceans are likely to be an important component in the diet of fish and possible large invertebrates. The removal of *S. spinulosa* aggregations may therefore have repercussions for fish populations and so exclusion zones for this species are likely to continue to be an important feature in the management of resources.

The high density of *Pisidia longicornis* associated with the *S. spinulosa* aggregations caused a marked increase in the dominance exhibited by these communities and

this may prove to be a useful tool in defining or categorising the aggregations for a more targeted approach to their management.

S. spinulosa aggregations were patchy in this area and the patchiness appeared to correlate with the amount of trawl scars visible on side scan sonar. It also seems likely that fishing activity is hampering development of the aggregations preventing further consolidation. Excluding fishing activities may therefore become an important consideration for future management plans.

The environmental conditions at Hastings Shingle Bank seem to be very favourable for the development of *S. spinulosa* aggregations. The mixed gravel and sand deposits provide stable surfaces for attachment with a good supply of sand from surrounding sand wave fields and possibly also from material disturbed during the dredging activities themselves. Rotational currents and residual currents which vary with the prevailing wind conditions facilitate the movement of sediment, organic material and larvae around the site, which almost certainly must be contributing to the spread of aggregations around the site.

The aggregations themselves appear to alter the environment in subtle ways which may increase their chances of survival. An element of drag appears to be exerted by the aggregations, slowing water movements. This may aid filter feeding and also prevent early developmental stages from being washed away. The aggregations appear also to alter the sediment available for re-suspension probably through a number of mechanisms including the use of such materials for building.

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Title: MAL0027 Recoverability of *Sabellaria spinulosa* Aggregations Following Aggregate Extraction

Contractor: Marine Ecological Surveys Ltd

Contact: Bryony Pearce

Telephone: 01225 442211

E-mail: bryony@seasurvey.co.uk

Full Report Site:
www.seasurvey.co.uk



Best methods for identifying and evaluating biogenic and cobbley reefs

INTRODUCTION

The primary purpose of the project was to provide guidance on the most appropriate ways to detect, map and evaluate biogenic and cobbley reefs. This included not only remote sensing techniques but also methods for observing and sampling the habitats to assess the degree to which Annex I reef habitat characteristics are expressed (in particular *Sabellaria spinulosa* reefs).

Ideally, the association between the reef habitat (as observed) and the remote data should be clear and unequivocal. Although reefs are characterised in part by their topographic features, it is known that biogenic reef structures and cobbles may present small targets amongst the other habitats in which they occur and detection of potentially fine scale features presents a technological challenge. Can reefs, no matter whether of low elevation or not, be detected? Can they be discriminated from the other background sediments with a high level of confidence? If they cannot be detected successfully using remote sensing techniques with minimal reliance on sampling methods that are time consuming and, in some cases, damaging to the reefs then there is a risk of reefs remaining undetected unless surveys incorporate an extensive sampling program.

Although there are many reports of the detection of hitherto unreported *Sabellaria* reefs through the inspection of side scan images (and possibly multibeam images) and the identification of unusual textures thought to be caused by the reefs, the discovery of reefs in this way has been largely serendipitous and no previous study has adopted a structured and methodical approach to testing the success of side scan for this purpose.

Of the ground truthing techniques, those based on video and stills camera are considered most suitable for seeing reef structures, but grab samples may also be needed to confirm the presence of characterising reef species, such as *Sabellaria*, and sampling small tube structures that might escape detection by the former method.

The survey work attempted to trial the above techniques in a structured way to test their ability for detection and assessment. The sites used for testing were aggregate extraction site 107, Saturn reef off the Lincolnshire coast and another aggregate extraction site near Hastings all of which were reported to have (or have had) well developed *Sabellaria* reef.

PERFORMANCE OF SWATH SYSTEMS

Four different systems were available for the inter-system comparison covering a wide range of different types of sonar devices: A Kongsberg EM 3000D shallow water multibeam sonar, and three sidescan systems: a GeoAcoustics SS941 (analogue), a Benthos SIS 1500 digital chirp and a Benthos SIS1624 digital chirp dual-frequency. Except for the parameters being investigated (e.g. altitude, speed and range), the others were kept constant for comparative purposes (with the exception of the hull-mounted multibeam). The results and below summarise the main findings and are presented and discussed in detail in the project reports.

Comparison of systems: The comparison clearly showed that the backscatter (sidescan image) from the multibeam sonar was poorer in detecting *Sabellaria* reef compared to the dedicated sidescan sonar systems. It also failed to detect characteristic dredge furrows, which (importantly) were readily visible in the sun-illuminated

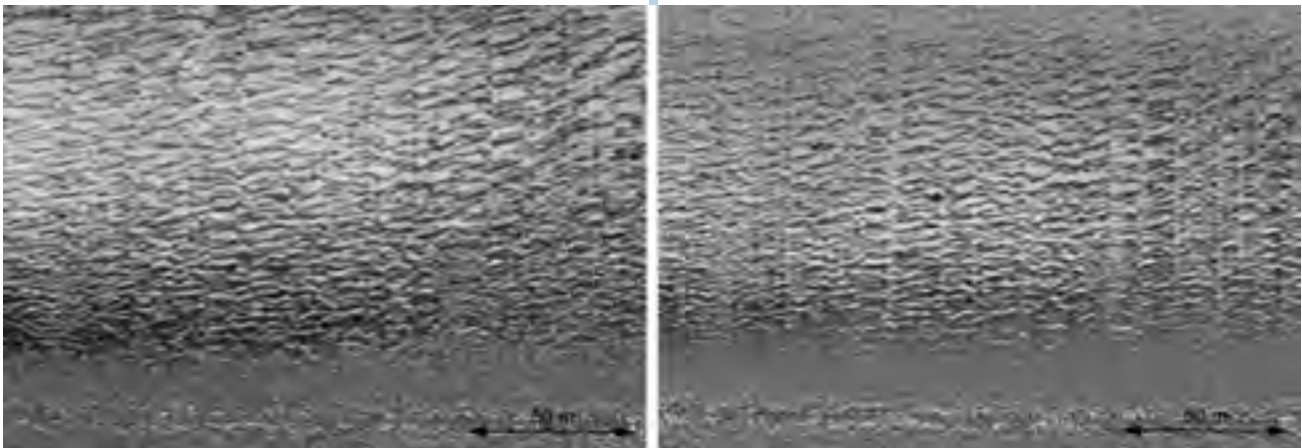


Figure 1: Influence of frequency on *Sabellaria* reef detectability: The left image 100 kHz, right image 400 kHz

D. Limpenny¹, R.L. Foster-Smith², W. Meadows¹, J. Eggleton¹ & Z. Crutchfield³

¹Cefas Burnham Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA

²Envision, 6 Stephenson House, Horsley Business Centre, Horsley, Northumberland, NE15 0NS

³JNCC, Monkstone House, City Road, Peterborough, PE1 1JY

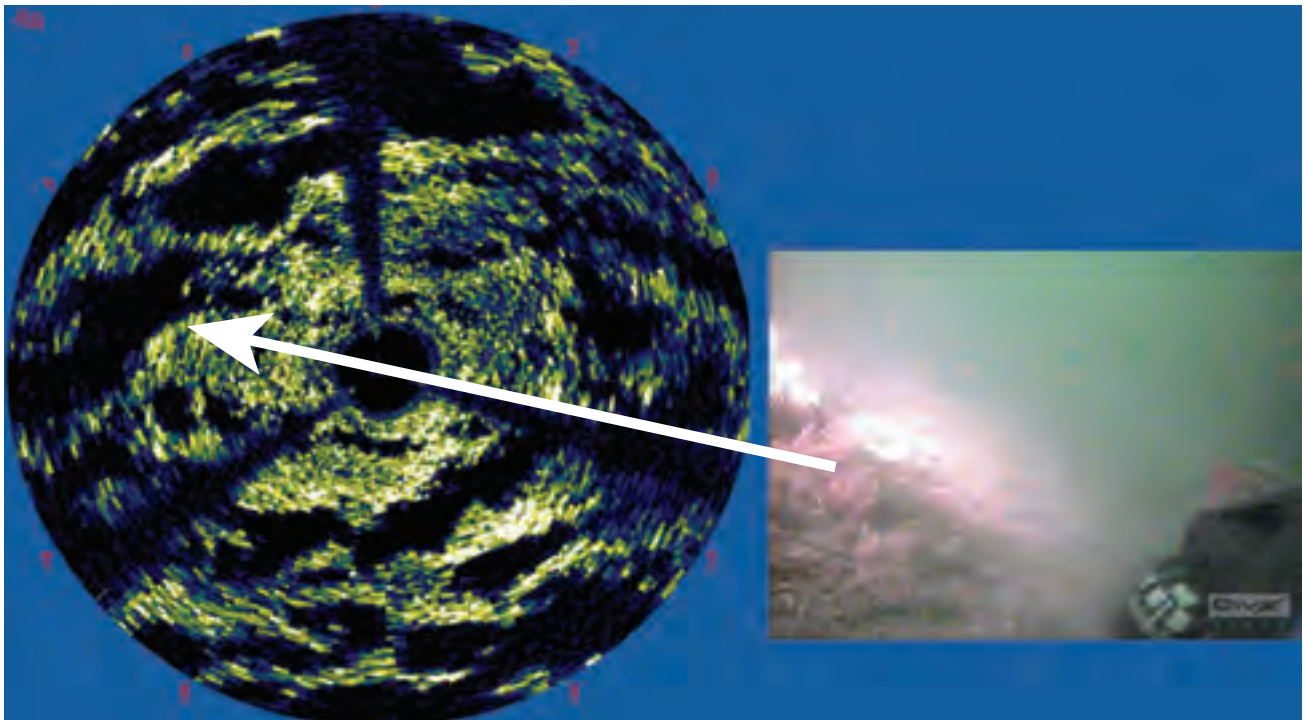


Figure 2: Example of a scanning sonar image of a *Sabellaria* reef. The inset image is a frame grab of part of the reef seen in the scan. A compass was used to determine orientation.

images of the multibeam bathymetric data (there is more discussion on multibeam systems in the project reports). The differences in performance between the three sidescan sonars were much less pronounced. In particular, there was no clear difference between digital and analogue systems at the scale appropriate for the features observed.

The dual frequency Benthos SIS 1624 sidescan sonar was used for subsequent work because of its simultaneous high and low frequency capability.

Tow speed: No significant differences are discernable with a range of 50 m but at 150 m higher tow speeds reduce the detectability of *Sabellaria* reefs.

Altitude: At a range of 50 m the lower altitude of 6 m produces better results irrespective of frequency. In the case of the longer range (150 m) the opposite holds true: Better results are produced with the higher altitude of 12 m, especially in the far range.

Frequency: All comparisons showed that there was no significant difference in the detectability of *Sabellaria* reef (Figure 1). This result was surprising as it is generally assumed that the frequency determines the resolution of the sonar system. The possible reasons are discussed in the report.



Figure 3: Video mosaic of a low, patchy *Sabellaria* reef in a muddy, gravelly, sandy substrate. The mosaic represents a patch of seabed approximately 5m long by 1m wide.

Best methods for identifying and evaluating biogenic and cobbly reefs

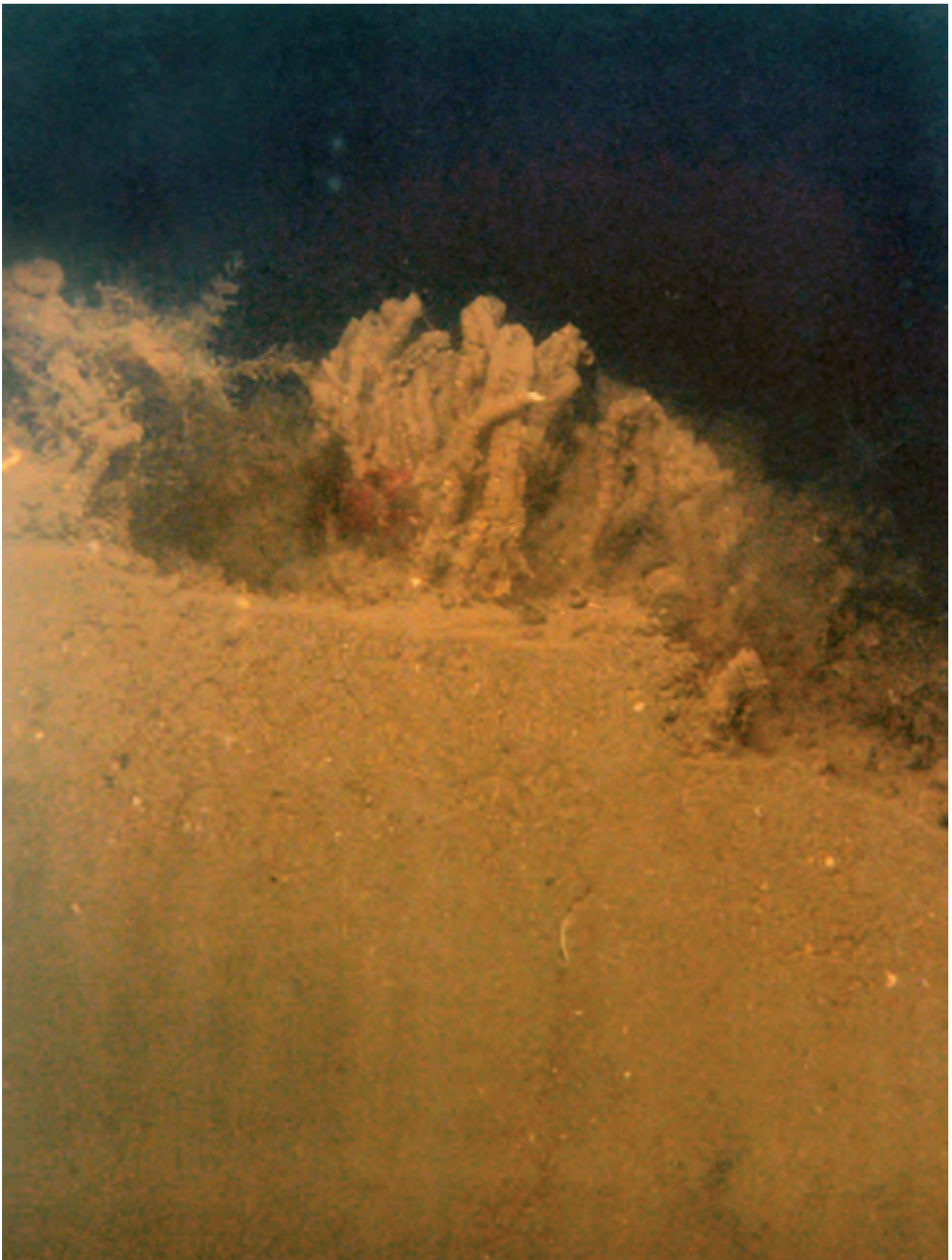


Figure 4: Sabellaria tubes approximately 5cm in height on sand. The SPI was dropped onto a reef that was estimated from video attached to the frame to be in excess of 20 cm.

Range: There was no significant differences at all in the detectability of *Sabellaria* reefs between short ranges (50m) and long ranges (150m) despite the fact that range settings affect ping rate and hence along-track resolution.

Course: Running courses parallel to the long axis of elongate reef features generally enhances the detectability.

SCANNING SONAR

Scanning sonar has a rotating head that, in this study, was fixed to a 1m high lander which enables it to produce much higher definition images than towed sidescan. Videos were attached to the lander to ground truth the sonar images and there was good correlation between the acoustic images and reef and sand wave features. Despite the high resolution, the limits of even this system become apparent if the reef is low lying and the sonar images cannot be reliably interpreted without direct observation.

VIDEO AND STILL SYSTEMS

A variety of systems have been used throughout this project. Vertical still cameras produce high quality images of quadrats but a towed camera system provides the best information for an assessment of reef topography, extent and patchiness. It is also possible to 'stitch' the video together to form a continuous strip which, although not properly georeferenced in this study proved that it is capable of providing images showing reef patchiness.

The Sediment Profiling Imagery (SPI) system is a rapid method for characterising the benthic habitat at and below the surface of the seabed. The system consists of a camera mounted above a wedge shaped prism with

a plexiglass faceplate. This has been used to great effect within the project and it has shown that many high reefs (30cm) were, in fact, composed of low tubes (5 cm) that have colonised sand waves.

GRABS

Although a destructive technique (arguably only minimally), grabs are the only way to ascertain if tubes are occupied by living worms, the abundance of reef-building fauna and associated species diversity. Also, grabs may be the only way to sample in poor visibility. However, grabs only sample a very limited area of the sea floor and there remains an issue of representativeness. A video mounted on a grab may provide some broader contextual information.

SUMMARY

Habitat detection and mapping is done through a combination of remote sensing and ground truthing: sampling on its own does not give sufficient coverage for mapping and remotely sensed data cannot be interpreted without adequate ground truthing. None of the remote detection systems can be considered to be reliable enough to detect reefs without ground truthing, especially for reefs with less well developed topographic features.

Survey planning requires that the selection of the most appropriate combination of techniques given the strategy of the survey. These strategies can vary widely from a very broad scale survey where reefs may or may not be expected to fine scale survey where reefs have been reported. The performance of the various techniques for the detection and mapping should be considered in the context of the survey in which they are used.

Title: MAL0008 Best Methods for Identifying and Evaluating Biogenic and Cobble Reef

Contractor: JNCC

Contact: David Limpenny

Telephone: 01621 787240

E-mail: david.limpenny@cefas.co.uk

Full Report Site:
<http://www.jncc.gov.uk>



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The importance of archaeological & historic resources

It is widely recognised that the seas around Britain contain an immense wealth of archaeological sites and remains, potentially without equal elsewhere in the world in terms of their number and diversity (Roberts and Trow, 2002). These remains include extensive submerged landscapes, primarily relating to the earlier prehistoric period during which Britain was separated from mainland Europe by rising sea levels, as well as remains deriving from the subsequent history of the British Isles and its inhabitants' exploitation of the sea. From those early periods to the modern era, evidence of the gradual rise in technological sophistication of watercraft, from dugouts to the steamships, can also be found on, or in, our seabed in the form of wrecks.

As an island that has experienced successive waves of settlement over many centuries and as a major naval, mercantile, industrial and imperial power, the history of Britain – and the everyday experience of many of its inhabitants – has been inextricably linked to its surrounding seas. To realise the values of this heritage, to stakeholders and the wider community, it is important to promote a "heritage cycle" where an increasing understanding of the historic environment leads to people valuing it more, and as a consequence caring for it better (Figure 1; English Heritage, 2005). An environment cared for will be enjoyed, and enjoyment normally brings a thirst to learn more.

English Heritage is therefore committed to:

- helping people develop their understanding of the historic environment;
- working to get the historic environment on to other people's agenda;
- enabling and promoting sustainable change to England's historic environment;
- assisting local communities to care for their historic environment;
- stimulating and harnessing enthusiasm for England's historic environment, land and sea.

We can further these aims through developing new approaches that rely on more partnerships, strategic engagement, speed and flexibility, clarity and consistency of advice, commercial awareness and customer service. This is where the important and exciting opportunities of the Marine ALSF programme has delivered great benefits because we recognise that our baseline information to promote effective management of marine historic and natural environment resources is relatively poor, and the intrusive nature of marine aggregate extraction can represent a potential impact to these assets.



Figure 1: The 'heritage cycle' (Source: English Heritage 2005: 8)

The marine environment as a whole represents an important resource available for research, education and amenity, but in contrast to species and habitats, historic and archaeological sites and features are unique and non-renewable (see Forrest, 2002; ICOMOS, 1998; O'Keefe, 1996; UNESCO, 2005). They cannot be replaced, restored or re-generated through careful husbandry. The historic environment, which is our common heritage, is fragile and finite. The intrusive nature of quarrying and dredging activities on land as well as sea has an impact on areas of archaeological potential and once that historic environment resource is destroyed it is lost forever.

The Marine ALSF programme together with the constructive engagement of industry and regulators has enabled the Distributing Bodies (Cefas, English Heritage, and Natural England) to address these challenges.

One way of reducing impact is by developing capacity and methodologies to carry out the extraction process, and its licensing system, in ways sensitive to historic environment management. For example, new research into marine evaluation and the development of mitigation techniques is being undertaken through Southern North Sea Palaeolandscapes project by Birmingham University (see this volume). The Submerged Palaeo Arun and Solent Rivers: Reconstruction of Prehistoric Landscapes by Imperial College has reconstructed the palaeo-morphology of submerged and buried landscapes of palaeo-Arun valley on the northern English Channel, integrating geophysical, geomorphological and sedimentological investigation of offshore river systems (Gupta *et al.*, 2004). *Seabed in Prehistory* by Wessex Archaeology aims to inform best practice for the assessment and evaluation of prehistoric deposits on or beneath the seabed in the course of the aggregate dredging licence application process (Wessex Archaeology, 2004; Wessex Archaeology, 2006a; Wessex Archaeology, 2006b). *A Re-assessment of the Archaeological Potential of Continental Shelves* by Southampton University has contributed to improve our understanding on the scale and character of the historic environment by analysing poorly understood landscapes (Dix *et al.*, 2004). *Innovative Approaches to Rapid Archaeological Site Surveying and Evaluation* by St. Andrews University seeks to exploit the potential of geophysical, remote survey equipment to allow rapid detailed investigation of submerged archaeological sites and their immediate surroundings for enhanced understanding of the environmental settings in which sites are located (Bates *et al.*, 2007). *Modelling Exclusion Zones for Marine Aggregate Dredging* by Southampton University analyses, from an interdisciplinary perspective, archaeological site formation studies, sediment and fluid

dynamics (both in the field and in the laboratory), numerical modelling of dredge plume and coastal zone impacts to provide accurate, appropriate and most importantly, cost-effective, recommendations for defining exclusion zones in the future (see this volume). *Wrecks on the Seabed* by Wessex Archaeology has successfully developed and tested a range of methodologies for the assessment, evaluation and recording of wreck sites, and collated records that provided sufficient information to establish extent, character, date and importance of a number of wreck sites off the coast of England (Wessex Archaeology, 2007).

Recent research demonstrates that areas suitable for marine aggregate extraction often contain shipwrecks within their boundaries, and wrecks are considered as part of the Environmental Assessment that accompanies applications to dredge marine aggregates. A wide variety of existing datasets, secondary sources and geophysical surveys can be used to estimate their likely presence, extent, character and period. However, these sources in isolation cannot establish the relative or absolute importance of known or potential wrecks because the 'importance' of a wreck arises from a context that is wider than the aggregates area under consideration. For example, **Enhancing Our Understanding: Shipwreck Importance** by Bournemouth University is testing the framework developed by Wessex Archaeology (**On the Importance of Shipwrecks**) by applying it to located wrecks within the National Monuments Record (NMR) and to identify the presence of 'important' shipwrecks within aggregate extraction areas (see this volume). This enhanced understanding of the shipwreck resource will allow regulators, advisors and industry to make informed decision about how to best manage and mitigate for any impact on sites that lie within aggregate extraction areas. **Mapping Navigational Hazards as Areas of Maritime Archaeological Potential** by Bournemouth University enabled the compilation of baseline information and characterisation of the aggregate resource. More importantly, it will assist industry, regulators and curators in giving guidance on the possible impact on the marine historic environment through the regulation of dredging for sand and gravel (Merritt *et al.*, 2007). The **England's Historic Seascapes** programme has developed a methodology for extending our application of historic landscape characterisation to encompass marine landscapes from the coast to the limit of England's UK Controlled Waters. An initial pilot in Liverpool Bay was undertaken. Four further pilots (Solent and Isle of Wight, Southwold to Clacton, Withernsea to Skegness, and Scarborough to Hartlepool) have refined this initial methodology. This

The importance of archaeological & historic resources

programme has provided a framework giving context to our individual site records and predictive assessments of areas beyond our current knowledge (see this volume).

One of the most important roles of the ALSF scheme is to fund projects that raise awareness of conservation issues across the historic environment sector, aggregate extraction industry, and the wider community. The **BMAPA/EH Protocol**, developed by Wessex Archaeology, seeks to reduce any adverse effects of marine aggregate dredging on the historic environment by enabling people working in the industry to report their finds in a manner that is both convenient and effective (Wessex Archaeology, 2005). In addition, **Solent Aggregates to Outreach**, by Hampshire and Wight Trust for Maritime Archaeology, assesses and develops integrated presentation and teaching packs based around aggregates and the marine historic environment as an information resource for schools, home educators, local archaeology groups and community groups. This aim therefore contributes to the raising of awareness and understanding of the marine cultural heritage, heritage conservation issues, and marine aggregate dredging and effects on the historic environment (Causser and Satchell, 2007).

In summary, historic environment marine ALSF work has involved the gathering of baseline information as well as the development of methodologies to enable better informed decisions to be made during the licensing process. More importantly, dissemination of this work to the wider public has been a major component within the English Heritage ALSF programme. Presentations to national and international conferences; publication in academic and non-academic journals and magazines; organisation of stakeholder meetings, technical seminars, and work in progress meetings; and wide dissemination of projects on the web have been undertaken in all English Heritage commissioned projects. Finally, the Archaeology Data Service is currently undertaking a project to disseminate information about the Aggregates Levy Sustainability Fund on the web. The aim of the project is to disseminate and secure for the long term a key set of research and management documents produced for English Heritage by a wide range of ALSF funded projects. Therefore, all the English Heritage ALSF funded projects and their respective reports can be accessed through <http://ads.ahds.ac.uk/project/alsf/>.

The wide variety of projects, managed by English Heritage, illustrates the relevance of the ALSF scheme by demonstrating how these projects are directly reducing the impact of aggregate extraction on the historic environment. More importantly, it shows the importance of this resource for all sectors of the society

and shows that collaboration between industry, government agencies and academic institutions is possible and beneficial, contributing to a sustainable management of the historic environment for present and future generations.

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ENGLISH HERITAGE

The seabed prehistory project

Wessex Archaeology was commissioned in Round 1 and Round 2 of the Aggregate Levy Sustainability Fund (ALSF) to undertake the project 'Seabed Prehistory – gauging the effects of marine aggregate dredging'. The project sought to demonstrate the scope for assessing prehistoric archaeology that has been covered by rising sea levels in aggregate dredging areas.

The main aim of the Seabed Prehistory project was to better understand the extent and character of prehistoric seabed deposits which could be affected by the aggregate dredging process. While the current procedures for applying for aggregate extraction licences seek to assess and minimise the impact of the dredging process on archaeologically sensitive deposits, there are difficulties inherent in the gathering of data regarding the archaeological potential of the marine environment.

At present, archaeologists assess the potential submerged prehistoric archaeology of a licence application area using a variety of sources such as geological mapping, industry survey data, prehistoric population models, models of palaeolandscapes and comparisons to Mesolithic and Palaeolithic sites on the present day coastline. Archaeologists are therefore often faced with a limited amount of archaeological evidence covering a broad area, rather than direct evidence for the licence application area in question. As a result, the assessment of the archaeological potential can often be reliant on the survey material collected on behalf of the marine aggregate company. However, the survey work undertaken by the aggregate company for an extraction licence application is primarily aimed at assessing the aggregate resource, and the survey strategy and specifications are therefore not always suitable for gathering data specific to archaeology.

The Seabed Prehistory project aimed to address these issues and maximise the archaeological information available from survey data collected as part of the environmental assessment process. Industry-standard survey techniques were employed and methods and specifications assessed in terms of their suitability for archaeological data gathering, from different dredging zones around the coast of England (**Figure 1**). The data that was collected as part of the project also provided baseline information from the different areas, from which future studies can build.



Figure 1: Location map

METHODOLOGY

The methodology for the project involved carrying out geophysical and geotechnical surveys to map the seafloor and identify different sediment layers beneath the seabed, and to determine the character and nature of the deposits.

The interpretation of the geophysical survey data was used to inform the sampling strategy for the geotechnical surveys. Geotechnical surveys involved the retrieval of vibrocores, and for some study areas, benthic grab samples. Samples were taken to Wessex Archaeology's headquarters and subjected to geoarchaeological logging and recording, and environmental sub-samples were analysed for pollen, diatoms, ostracods and foraminifera. Sediments were dated using radiocarbon and Optically Stimulated Luminescence (OSL) techniques.

The project started in 2003, funded through Round 1 of the ALSF and administered by the Mineral Industry Research Organisation (MIRO) on behalf of Defra. The Owers Bank dredging area off the coast of Sussex was selected for investigation for this phase of the project. The study area was adjacent to the dredging area and incorporated the palaeo-Arun river system.

The prospecting stage of the survey identified a large palaeochannel which became the focus of the study area because of its potential for the survival of archaeological material.

In Round 2 MIRO commissioned the production of a 3D computer animated visualisation to reflect the Arun palaeolandscape in the Mesolithic period reconstructed from the data gathered in Round 1. English Heritage (EH) also expanded upon the work carried out in Round 1 by commissioning an extended grab sampling survey in the palaeo-Arun area. This was intended to provide a larger statistical sample to investigate the possibility of a relationship between struck flint and palaeogeographic features.

In Round 2 of the ALSF Wessex Archaeology were commissioned to investigate four new study areas using the same methodology. Funding was received by MIRO and English Heritage in the form of two discrete projects. The East English Channel and Humber regions were funded by MIRO, and the Great Yarmouth and the cliff exposures at Happisburgh and Pakefield were funded by English Heritage. Each of these new study areas presented a different environment in which to trial the project methodology.

PALAEO-ARUN

The geotechnical samples retrieved from the palaeo-Arun study area produced a wealth of environmental data. Boreal pollen assemblages were revealed; containing a strong woodland component with fewer herbs, dominated by pine, oak, elm and hazel. They also indicated the presence of saline or brackish water or fully marine conditions in the locale. The main source of evidence for palaeolandscapes related to a series of peat horizons dating from around 9,600 to 9,000 BP (Figure 2). The evidence suggests that this period can be divided into three broad vegetation phases. The final phase, beginning around 9,100 BP, formed the basis for the 3D computer animated visualisation.

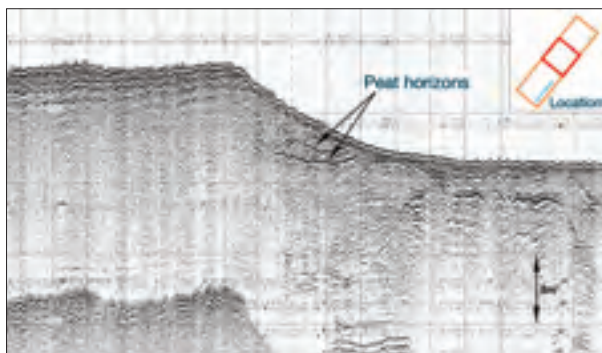


Figure 2: Peat layers identified on the sub-bottom profiler data from the Arun study site

The palaeolandscape was reconstructed primarily from environmental and seismic data. While sources of evidence for the vegetation came predominately from the pollen analysis, it was taken into consideration that the topography of any area has a substantial bearing on the distribution of its vegetation. Reconstruction of the area's ecology was therefore considerably influenced by evidence for the nature of both the terrain and hydrology. The surface terrain was modelled directly from the sub-bottom profiler data, mapping the prehistoric topography from the seismic survey results. In terms of reconstructing these hydrological patterns the main sources of information come from foraminifera and diatoms as well as the sediments themselves.

The extended grab sampling survey, commissioned by EH, recovered 507 benthic grab samples. The survey was designed to test the hypothesis that the spatial distribution of the flints was related to the palaeogeographic features in the study area. A total of 858 were recovered and determined to be of improbable, possible, probable or highly probable anthropogenic origin.

As well as the recovery of flint material an unexpected quantity of organic sediment (peat) was recovered. The provenance of this material could have been *in situ* exposures on the seabed or from rafted or reworked material from larger deposits. The majority of the samples were recovered from the palaeovalley area identified from the geophysics and geotechnical data where *in situ* Mesolithic sedimentary deposits were recovered.

Approximate stratigraphic relationships could be identified from intact samples (lumps). Their vertical alignment could be determined by the position of the intrusive boring molluscs *Pholas Dactylus* within the lumps.

Two finds of particular interest were recovered from the samples: the remains of a frog or toad pelvis, and a piece of charcoal. The frog pelvis would have been deposited in a terrestrial or freshwater context. The charcoal may be the first direct evidence of human occupation in the area. The charcoal dates to 8893 ± 30 BP which is within c. 240 years of the latest date of *in situ* material recovered from the Round 1 vibrocore survey. The proximity in date between the two deposits suggests that there may be a relationship between them and may inform current knowledge on sea level rise in the area.

The seabed prehistory project

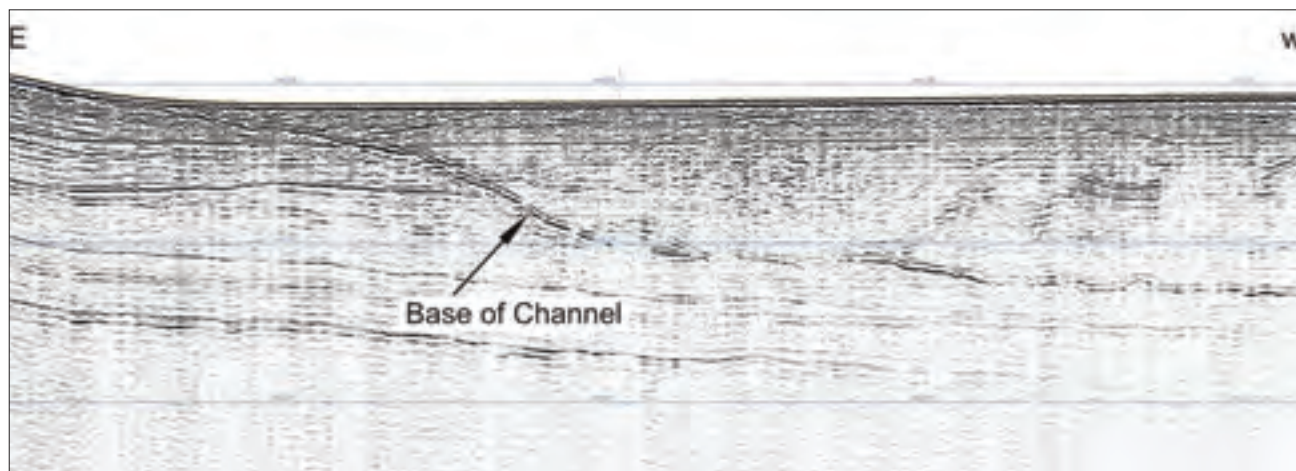


Figure 3: Palaeochannel cut and fill sequence identified on sub-bottom profiler data at the Eastern English Channel study site.

EAST ENGLISH CHANNEL

The Round 2 investigation of the East English Channel study area showed a complex sedimentary sequence mostly relating to fluvial activity ranging in date from the Hoxnian to the Holocene period (Figure 3). Surface gravels displaying sub-aerial exposure were cut by a sequence of palaeochannels. Radiocarbon dating suggested the final phases of palaeochannels were active during the Early Mesolithic period and that the area was inundated by $8,442 \pm 35$ BP.

HAPPISBURGH AND PAKEFIELD

At Pakefield, sediment units were observed on the geophysical data that matched the extent and form of those described at the base of the cliff exposures, where terrestrial investigations have recovered artefacts dating to c.700,000 years ago. These are the earliest evidence of human activity in Northern Europe to date (Parfitt *et al.* 2005). Vibrocore analysis and environmental assessments and analyses enhanced the geophysical data interpretation and enabled a better understanding of the sediments depositional environments. This facilitated correlation between onshore and offshore sediments. Although sediments of the Cromer Forest-bed Formation no longer exist offshore within the study area, older sediments interpreted as the Wroxham Crag Formation were identified. It was within the upper part of the Wroxham Crag Formation that worked flint was found onshore (Parfitt *et al.* 2005).

The survey at Pakefield successfully demonstrated that fine grained sediment units identified onshore can be traced offshore, and that sediments of this character may survive in areas that are now submerged and may not have been removed by glacial processes and/or marine erosion.

At Happisburgh, the survey was carried out further from the coast in deeper water to that of Pakefield due to the presence of beach defences that posed a risk to the navigation of the survey vessel and the towed equipment. The geophysical interpretation identified geological horizons that are thought to predate the sediments of archaeological interest in the cliff exposures onshore. However, it is possible that younger sediments relating to the Cromer Forest-bed Formation observed on the foreshore and related early Middle Pleistocene sediments may be preserved closer to the shoreline.

GREAT YARMOUTH

Previous work in this area has highlighted peat and clay deposits close to the seabed occurring as part of a fine-grained sediment unit closely associated with the aggregate deposits within dredging area 254. These sediments are considered to be infill deposits within the Yare Palaeovalley (Bellamy 1998; Wessex Archaeology 2002). The River Yare was cut prior to the most recent marine transgression and is known to have extended offshore during periods of lowered sea level.

The results of the Great Yarmouth survey confirmed the presence of a mound of fine grained sediment sitting on sands and gravels. The finer grained sediments show freshwater sediments superseded by estuarine environments and a marine "lag" gravel deposit indicative of sea level rise. This is confirmed by diatom, foraminifera and ostracod analysis of the sediments. The presence of freshwater deposits and oxidation of the estuarine silts and clays demonstrates that terrestrial environments were present in this area.

HUMBER

This study area was focussed on an area south of the Humber Estuary, off the Lincolnshire coast. Surveying an area close to the Humber active dredging areas aided in understanding the varying archaeological contexts in which aggregates are found.

The geophysical and geotechnical data show a sedimentary sequence dating from the Devensian glaciation. The data shows deposition of fluvio-glacial sediments deposited as the ice sheet retreated, and subsequent reworking and deposition of sediments associated with the continuing inundation associated with the marine transgression.

CONCLUSIONS

The Seabed Prehistory project was designed to address the difficulties faced by archaeologists gathering data on the potential impact of aggregate dredging on submerged prehistoric archaeological material. This involved assessing different survey specifications to maximise the possibility of identification of palaeogeographic features and/or sediment types of archaeological interest, and the recovery of artefactual material within aggregate dredging areas as part of the environmental assessment process.

The project has demonstrated that industry-standard survey tools and environmental assessment practises can be used for archaeological purposes.

The results have demonstrated the widespread survival of evidence of sedimentary deposits of archaeological interest.

The results of this project have further informed our knowledge of marine inundation in the past, and proved the survival of terrestrial and fluvial deposits offshore. This promotes the argument of the existence of terrestrial landscapes with the potential for exploitation by humans in offshore areas from an in principle argument to a position where we have direct evidence of those landscapes. Consequently, the potential to impact these landscapes through the aggregate dredging process is a reality.

This project directly contributes to the sustainable exploitation of the aggregate resource and demonstrates the benefits of ALSF funded research to provide a better informed environmental assessment of licence areas which in turn will enable long term strategic planning of the resource.

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Title: SAMP1.042, SAMP2.43 The Seabed Prehistory Project

Contractor: Wessex Archaeology

Contact: Stuart Leather

Telephone: 01722 326867

E-mail: s.leather@wessexarch.co.uk

Full Report Site:

www.wessexarch.co.uk/projects/marine

<http://ads.ahds.ac.uk/project/alsf/>

www.dclgaggregatefund.co.uk/themea.htm



Archaeology of continental shelves: a submerged pre-history

Dramatic fluctuations in sea level over the Quaternary period have resulted in the submergence of prehistoric archaeological material on the continental shelves of the world. From an archaeological point of view, these submerged landscapes are exceptionally important as the prehistoric and palaeo-environmental evidence they contain will provide insights into fundamental issues surrounding the development of the human species.

In particular, submerged landscapes have been strongly implicated in the large-scale dispersal of modern humans and ancestral hominids across the globe. During sea level lowstands enhanced continental interconnectivity would have allowed entry into and occupation of currently inaccessible areas, while coastlines themselves could have provided important migration corridors compared to hinterland routes. Further, there are important questions concerning the antiquity of maritime adaptations; such as whether this was solely the preserve of *Homo sapiens sapiens* and if so what this could mean in terms of the cognitive and technical abilities of our hominid ancestors. Linked to this are questions of whether separate 'coastal' or 'inland' populations existed in these early periods, or whether a more fluid adaptation combining both coastal and inland usage, for instance on a seasonal basis, was present? Finally, did the adoption of a coastally oriented style of living allow for increased social 'complexity' in these early periods of prehistory as has been seen in later epochs? None of these issues can be conclusively solved on the basis of the known terrestrial archaeological record, for the simple reason that it only provides information about the continental interior at times when sea levels were much lower than at present, a situation which prevailed throughout the majority of the Quaternary. Hence, the answers to the above questions must be sought on the continental shelves.

In tandem with the recognition that the continental shelves may provide a wealth of data on global, regional and local prehistory there has also been increased awareness of the threat to this potential resource. The last three decades have seen a significant increase in the exploitation of the shelves for resources as diverse as oil, gas, precious minerals, aggregates and certain forms of renewable energy such as wind farms. This increased development has been recognised and responded to by the heritage agencies on a national and international level. For instance in 2002 English Heritage's boundaries of responsibility changed from the Low Water Mark to England's 12 mile limit. Such changes echo international recognition of the problem as outlined in ICOMOS (1998).

Despite the undeniable academic and commercial importance of submerged landscapes, and the fact that their existence has been acknowledged since the 19th Century (e.g. Lyell, 1832), archaeological studies that directly address them have, over the past century, been somewhat sporadic and often unsystematic. This is reflected by the relative dearth of publications compared to more mainstream topics in archaeology. The extant published literature has tended to veer between regional or site specific case studies, and larger scale, "speculative" overviews. Examples of the former include the detailed work that has taken place in the Scandinavian archipelago (e.g. Pedersen *et al*, 1997), while examples of the latter include Coles's (1998): "*Doggerland: a speculative survey*" which dealt with a prehistoric reconstruction of the pre-submergence North Sea Basin. Naturally, works in the former category cannot be translated to different periods and regions, while the "speculative" nature of the latter restricts its use for practical applications. While some attempts have been made to fill the gap between these two extremes (e.g. Flemming 1998; Flemming, 2004), these works were not intended to cover the fundamental concepts and methodologies of submerged continental shelf archaeology. Issues that require specific attention paid to them include the manner in which the palaeo-geography of these landscapes is reconstructed; and the impact that sea level, palaeoceanography and climate change would have had both on the landscapes themselves, the people that occupied them and as importantly the archaeological material they contain.

It was thus apparent that an important niche exists within the, academic and commercial, extant literature. Indeed the lack of a suitable reference volume prevents easy access to the subject and inhibits familiarity with some of the important non-archaeological issues associated with it (e.g. sea level change). The most widely available volumes which partially fulfil this purpose; Masters & Flemming (1983) and Johnson & Stright (1992) were both published some time ago, since when there have been significant changes in our understanding of both the archaeology and palaeo-environments of submerged shelves.

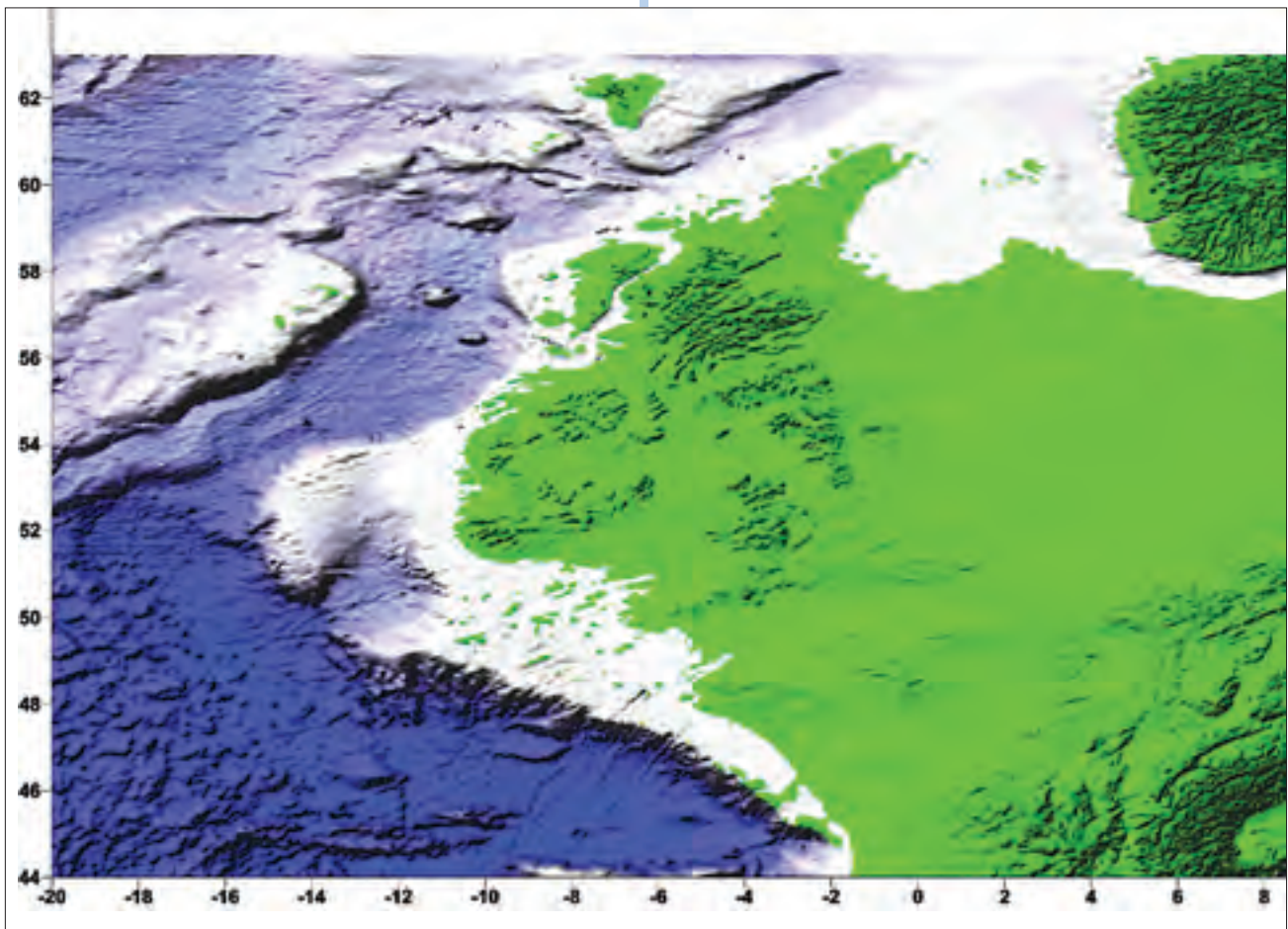
During the first round of Aggregate Levy Sustainability Funding we produced a document for English Heritage entitled "A Re-assessment of the Archaeological Potential of Continental Shelves" (Westley *et al*, 2004). Following the positive response from English Heritage, we submitted a prospectus to Oxford University Press for the proposed publication of a volume including this work and with the intention of filling the gap in the literature identified above. OUP accepted the proposed book, entitled "The Archaeology of Continental Shelves:

J. Dix & K. Westley

School of Ocean and Earth Science, National Oceanography Centre, European Way, Southampton, SO14 3ZH

A submerged pre-history". During the process of getting the book accepted by OUP and following the extensive but constructive reviewer's comments it became apparent that it would not be feasible to simply re-package the original report, but to produce a more extended version of this document. ALSF has funded part of the essential work required to fulfil the brief from OUP, the book will finally be submitted to OUP later this year and will have a release date of 2008. We anticipate though that this volume will represent a significant output from the ALSF project and will be of significant benefit to the target audience especially those in the aggregate and associated industries.

The image shows a palaeogeographic reconstruction of North West Europe at 16 ka BP (calibrated). The image was created by applying two different approximations of glacio-eustatic sea level change to the present day bathymetry of the North-West European continental shelf. The shoreline is based on data from Lambeck *et al* (2002) and the green shoreline is that of Bard *et al* (1990). Bathymetry is based on the ETOPO-2 (2 minute resolution of 2 minutes of lat/long) dataset (Sandwell & Smith, 2003). The shoreline positions relative to present sea level are -102m (Bard *et al*) and -113m (Lambeck *et al*). X and Y axes show latitude and longitude in decimal degrees, colour scale depicts elevation in metres relative to present mean sea level.



Archaeology of continental shelves: a submerged pre-history

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Title: A Reassessment of The
Archaeological Potential of Continental Shelves

Contractor: University of Southampton

Contact: Justin Dix

Telephone: 02380 593057

E-mail: jkd@noc.soton.ac.uk

Full Report Site:
<http://www.arch.soton.ac.uk/Research/Aggregates/shelve-intro.htm>
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE



Radial Engine from WW II B17 Flying Fortress
© Wessex Archaeology & English Heritage

Submerged palaeo-Arun & Solent rivers: Reconstruction of prehistoric landscapes

INTRODUCTION

Late Quaternary sea-level fluctuations exposed large expanses of the continental shelf during glacial periods resulting in the formation and preservation of distinctive relict subaerial and coastal geomorphic and sedimentary features in areas presently submerged by the Holocene sea-level rise. These extensive exposed shelf regions are likely to have provided environments suitable for early human occupation. Thus there is significant potential for the discovery of prehistoric archaeological resources either on the submerged seafloor or within sediments laid down during subaerial exposure.

Submerged and buried fluvial valley systems form important, but poorly understood, palaeo-landscapes on the shelf. River systems are also environmental settings conducive to preservation of archaeological remains, partly because early humans commonly inhabited areas adjacent to watercourses, but also because they provide the topographic conditions necessary for site preservation during sea-level rise. Fluvial terrace deposits associated with onshore valley systems on the South Coast of England contain some of the finest records of early human occupation in Britain (Wymer, 1999). As a result, it is likely that palaeo-land surfaces and sedimentary units in their offshore counterparts contain important information to help constrain the palaeoenvironmental ('palaeo-landscape') evolution of the region, which is pertinent to reconstructing the environments early humans inhabited. Moreover, there is also the likelihood that these systems contain important archaeological data to help constrain the history of early human occupation of Britain. However, the very same late Quaternary sediment bodies associated with these valley systems also hold considerable potential as aggregate resources. Thus, there is a critical need to assess the archaeological significance of these offshore fluvial systems, prior to extensive aggregate extraction.

The aim of the project was to reconstruct the palaeogeomorphology and palaeoenvironmental evolution of the offshore extension of the River Arun on the northern English Channel shelf using high-resolution geophysical imaging sonars and to assess the potential for preservation of prehistoric archaeological resources on relict palaeo-land surfaces and within valley-fill sedimentary deposits. The major objective was to determine the morphology and internal stratigraphy of the offshore extension of the River Arun in order to develop models for the sediment deposit distribution and palaeogeographic evolution of the Arun River during times of lowered sea-levels. The second primary objective of the study was to identify seabed geomorphic elements and sedimentary architectures

with potential to contain prehistoric archaeological resources. The wider purpose of the study was to provide baseline information to English Heritage, which will facilitate future research and management of archaeological resources on the continental shelf.

The study involved: (1) the analysis and interpretation of extensive seismic and core datasets made available to us by our aggregate industry collaborators, Hanson Aggregate Marine Ltd., United Marine Aggregates Ltd, and RMC Marine Ltd., and (2) the acquisition, processing, and analysis of our own high-resolution marine geophysical data. The study area, the offshore course of the palaeo-Arun river, is located on the inner shelf off the south coast of Sussex extending approximately 20 km offshore (Figure 1). This area contains relict, filled and unfilled valley systems of late Quaternary-age

The new data and technical developments provided by this study contribute to the emerging field of prehistoric marine archaeology, in particular with regard to developing protocols to assess archaeological resource potential in offshore areas, and to the development of conservation strategies (English Heritage, 2002).

STUDY AREA

The English Channel is a shallow shelf seaway that separates the south coast of England from France. The floor of the Channel forms a low-gradient bedrock surface that is locally overlain by a thin cover of loose sediments. Incised into this bedrock floor is a complex network of paleovalleys that are interpreted to have formed at times of lowered sea-level during the Quaternary (Dingwall, 1975; Hamblin *et al.*, 1992; Antoine *et al.*, 2003). Our study area is the shelf region in the eastern English Channel immediately offshore of the county of Sussex (southern England) (Fig. 1). Here, a series of onshore river valleys extend offshore, forming tributaries of the east-west-oriented Northern Paleovalley, a major valley axis in the Channel (Bellamy, 1995; BGS, 1989)). Our study focuses on the Arun paleovalley, which forms the offshore extension of the River Arun (Fig. 1).



Figure 1: Location of the palaeo-Arun study area. This shows relationship of study area to northern English Channel region and the relationship of the Arun valley to the Northern Palaeovalley. The Arun palaeovalley is boxed.

DATA AND METHODS

We mapped the offshore extension of the river Arun from the present day coastline to its confluence with the Northern Paleovalley using a combination of single-beam and multibeam bathymetry data, and high-resolution seismic-reflection data. The UK Hydrographic Office provided the single-beam data. The multibeam data were collected across an 8 by 17 km patch of seafloor off Littlehampton, UK (Fig. 1) using a Reson 8101, 240 kHz multibeam echosounder. These data were gridded at a 3 m cell size. High-resolution seismic reflection data included extensive commercial single channel analogue data together with digital multichannel boomer data collected for this study. Full details of geophysical data collection and processing methods are provided in Gupta *et al.* (2004).

RESULTS

LARGE-SCALE MORPHOLOGY OF THE PALAEO-ARUN

The first step in the reconstruction of a buried shelf valley for archaeological resource assessment is to map the overall location and distribution of the valley system, and to determine its large-scale morphology. The upstream reach of the Arun is entirely infilled with sediment. In order to constrain the valley morphology we mapped the basal bedrock erosion surface of the valley in seismic profiles throughout the study area. A map showing thicknesses of valley-fill sediments permits the planview geometry of the valley to be determined (Fig. 2). This shows that the paleo-Arun forms a distinct valley-fill unit incised into bedrock that commences immediately seaward of the present river mouth at Littlehampton and extends 25 km to the southeast, where it is confluent with the ENE-WSW-trending Northern Paleovalley (Hamblin *et al.*, 1992). The

margins of the valley have been clearly defined, and a number of minor tributaries identified. Our study is the first to accurately map the geometry of the palaeo-Arun, thus providing baseline survey information for future maritime archaeological studies.

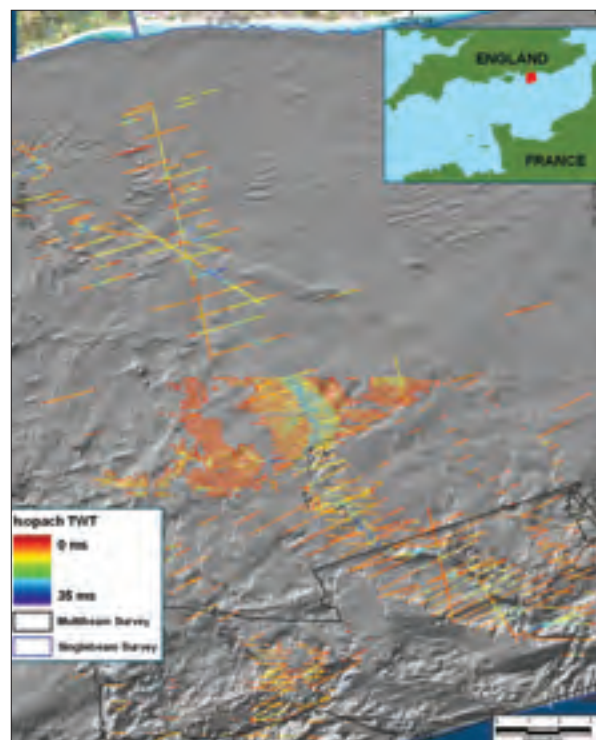


Figure 2: Isopach thickness (TWT from sea floor to base of valley) of paleo-Arun stratigraphic valley and minor tributaries (superimposed on greyscale shaded relief image of single beam bathymetry). Colors indicate thickness of valley-fill sediments along survey tracklines. Box shows location of multibeam survey area.

SEAFLOOR MORPHOLOGY OF THE DOWNSTREAM PALAEO-ARUN

One of the primary aims of our project was to use multibeam swath bathymetry to map the morphology of the underfilled downstream reach of the palaeo-Arun in high resolution. Our data reveal a complex submarine topography (Figure 3). The most prominent morphological feature on the seabed is a NW-SE-oriented, 6-km-long, linear elongate bathymetric low, which represents the Arun palaeovalley. Up to 2.5 km wide in its uppermost section, it narrows to less than 200 m at its southern limit. The multibeam data have enabled us to identify and map detailed geomorphic features such as drowned fluvial terraces, tributary channels, and a narrow valley outlet where the Arun is confluent with the Northern palaeovalley.

Submerged palaeo-Arun & Solent rivers: Reconstruction of prehistoric landscapes

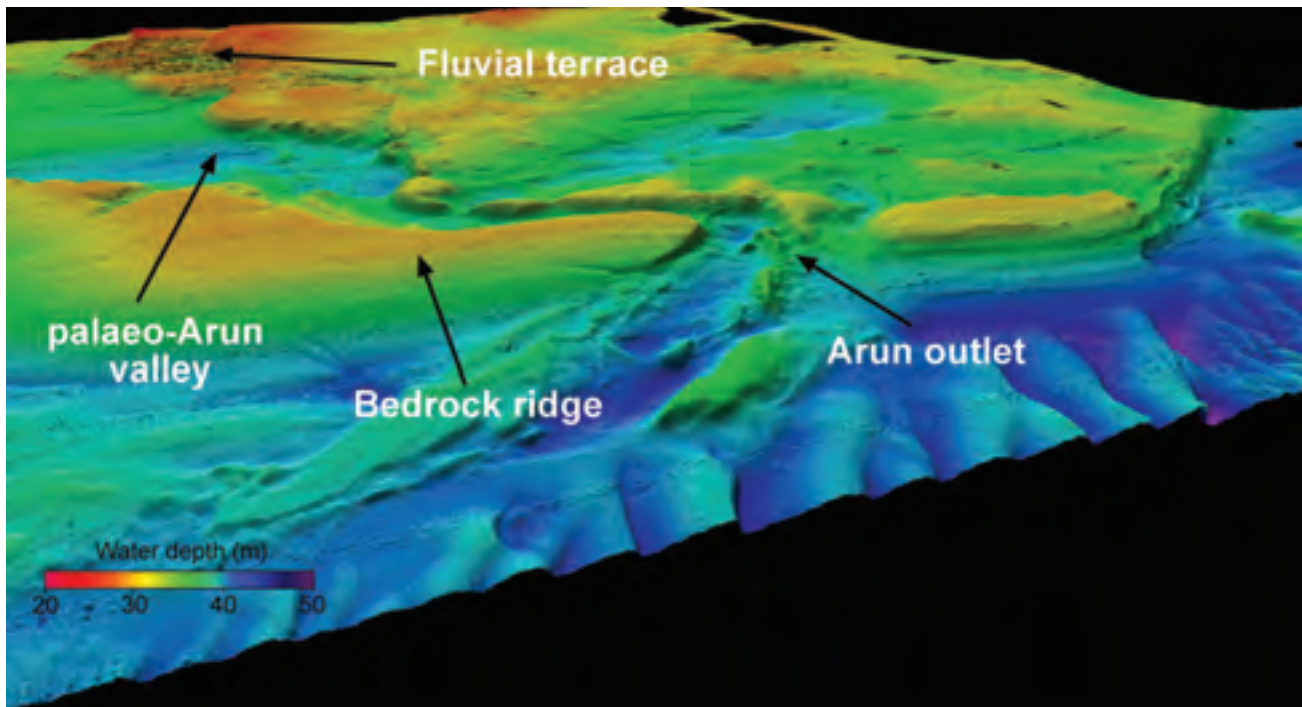


Figure 3: Perspective view derived from multibeam bathymetry looking northeast of Arun palaeovalley. Vertical exaggeration is x6. The outlet of the Arun valley through the bedrock ridge is 600 m wide.

SEISMIC STRATIGRAPHY OF THE ARUN VALLEY INFILL

In order to constrain the internal architecture of Arun Valley sediment infill, we analysed pre-existing seismic profiles obtained from the aggregates industry, and also acquired our own multichannel boomer seismic data. Using these data we have been able to reconstruct the sedimentary architecture of the valley fill using seismic stratigraphic techniques. This analysis has enabled us to identify the key seismic facies of the valley fill succession and determine key architectural elements that build the valley-fill stratigraphy, for example, lateral accretion elements. Such analysis is crucial to determine which sedimentary units may have potential to contain archaeological resources. The seismic interpretations have been supplemented with vibrocore data to provide groundtruthing.

IMPLICATIONS FOR ARCHAEOLOGICAL RESOURCE MANAGEMENT

The primary objective of this study was to reconstruct the regional-scale morphology and internal sedimentary architecture of the offshore extension of the Arun River, offshore Sussex. We focussed on geophysical and geological data collection and assimilation. This is a necessary requirement when investigating a new study area in the marine realm where the palaeogeomorphology and environmental history are poorly constrained. Our approach provides a firm data-

led foundation for the development of mature, archaeologically focussed landscape evolution models. The project results provide clear guidance on the methods and approach involved for future assessments of shelf palaeovalley systems and their enclosed prehistoric archaeology. A secondary objective of our study was to make provisional assessments of what geomorphic and sedimentary elements identified in our reconstruction of the palaeo-Arun might hold potential for containing prehistoric archaeological resources. We identified a variety of geomorphic locales and sedimentary architectural elements that we believe may have potential to yield prehistoric archaeological material. These include sheltered tributary valleys, submerged fluvial terraces, gravel-bed point bar deposits, and peat horizons indicative of former subaerial landsurfaces. Our geophysical and geological data collection and analysis provides the primary baseline data to direct further archaeological exploration or to make management decisions with regard to archaeological resource management.

SUMMARY

In summary, our study demonstrates the application of multibeam swath mapping and high-resolution seismics for reconstructing the submarine geomorphology of drowned valley topography on the continental shelf and for characterising their valley-fill sedimentary architecture. These data permit identification of

submerged fluvial geomorphic features and sedimentary geometries that provide environmental context for reconstruction of shelf drainage systems with potential to hold archaeological resources. Furthermore, we are able to identify with high resolution geomorphic locales and sedimentary deposits with potential to contain prehistoric archaeological material

ACKNOWLEDGEMENTS

Research was funded by English Heritage through the Aggregates Levy Sustainability Fund, and by the Joint Research Equipment Initiative (HEFCE/HEFCW). Singlebeam data were provided courtesy of the Maritime Coastguard Agency and the UK Hydrographic Office. Seismic and core data were provided courtesy of Hanson Aggregate Marine Ltd., United Marine Aggregates Ltd. and RMC Marine Ltd. I. Selby and A. Bellamy are thanked for their extensive input.

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Title: Submerged palaeo Arun & Solent rivers: Reconstruction of prehistoric landscapes

Contractor: Imperial College

Contact: Sanjeev Gupta & Jenny Collier

Telephone: 0207 5946527/0207 5946443

E-mail: s.gupta@ic.ac.uk & jenny.collier@ic.ac.uk

Full Report Site:

<http://www.english-heritage.org.uk/server/show/ConWebDoc.5426>
<http://ads.ahds.ac.uk/project/alsf/index.cfm>



ENGLISH HERITAGE

Mapping marine historic environment character: England's historic seascapes programme



Figure 1: Windfarm under construction off the Norfolk Coast, one of many pressures on our coastal and marine historic environment.
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D. Hooley

Characterisation Team, English Heritage, Home-based office: Sale Skerry, Downgate, Carrington, Cornwall PL17 8JY

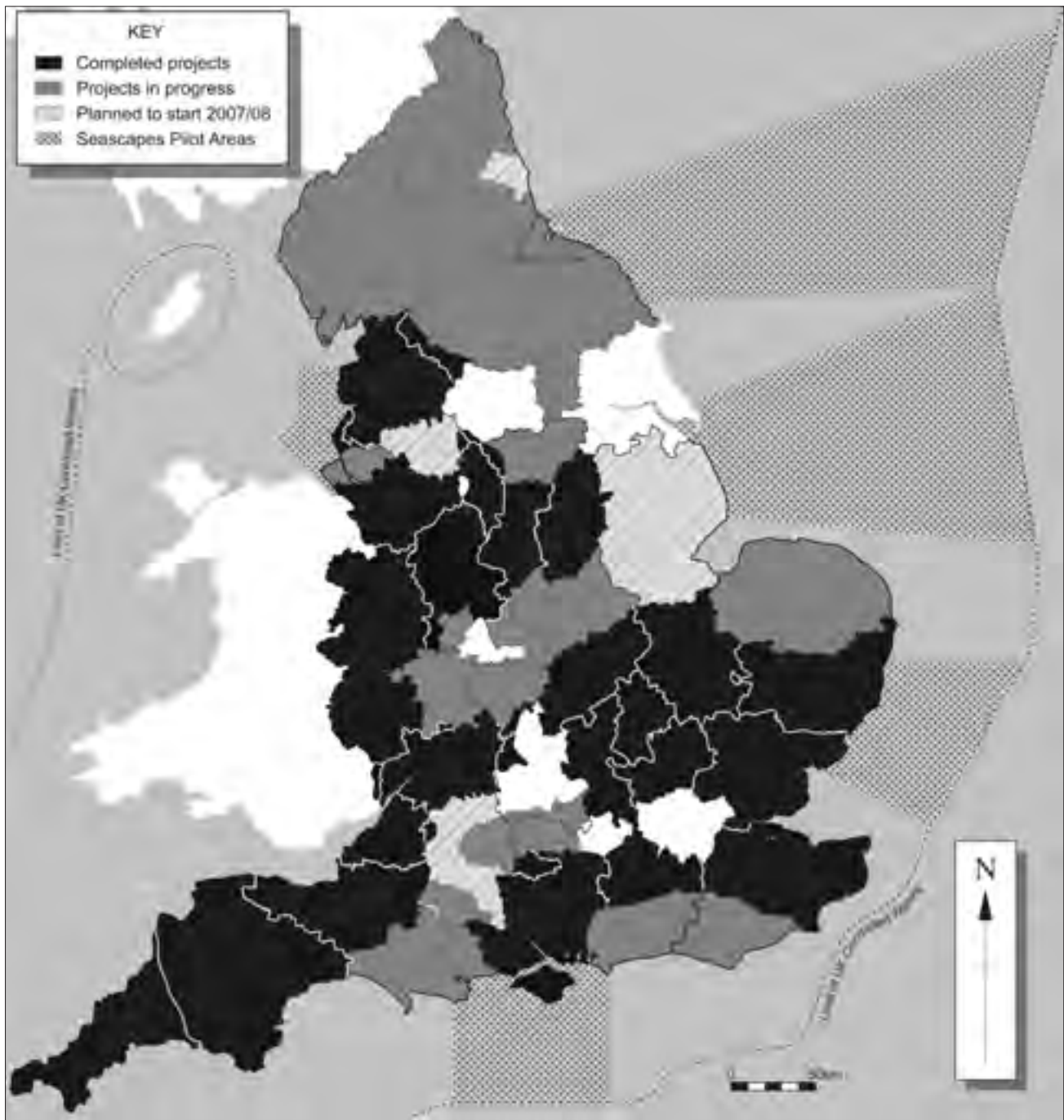


Figure 2: England's Historic Seascapes pilot areas and current coverage on land of Historic Landscape Characterisation. © English Heritage

Faced with rapidly increasing pressures on our coast and seas (figure 1), including society's growing demand for marine aggregates, our ability to assess and respond to their impacts on the coastal and marine historic environment currently relies extensively on mapped locations of specific features and recorded findspots. While such locational point-data will always be invaluable in minimising impacts on the rare or otherwise special, inevitably they focus on the particular, the atypical and the known. They are far less effective at

conveying the typical historic development of areas or the role of human activity in shaping our environment at landscape scale. Yet an area-based understanding of the characteristic is essential if the historic dimension of our environment is to play its full role in the management of change, whether in reactive assessment and mitigation of developmental impact, in informing Strategic Environmental Assessments (SEAs) and other forward-planning procedures or, in a pan-environmental sense, to bring more fully into view the human influences on

Mapping marine historic environment character: England's historic seascapes programme

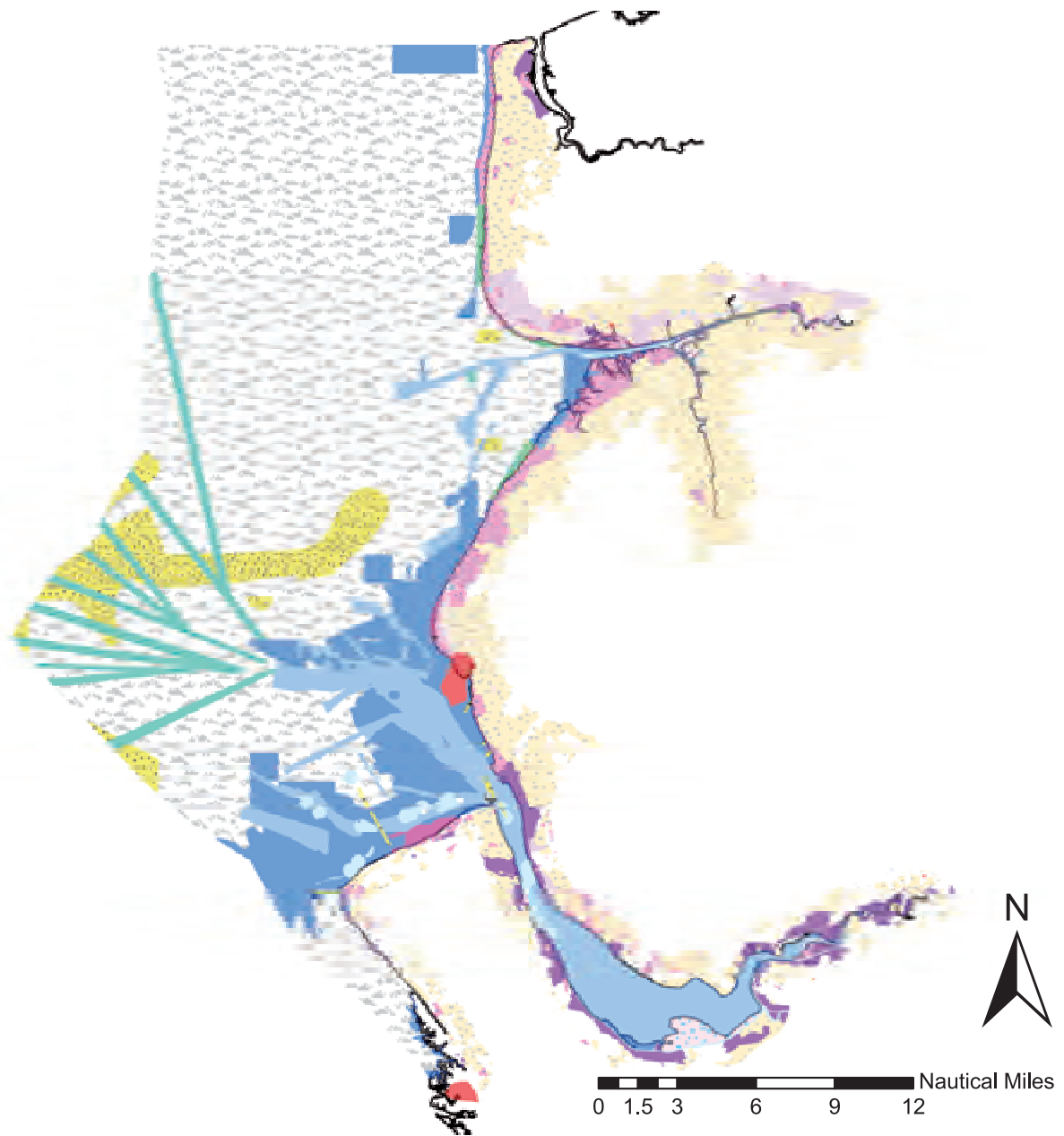


Figure 3: Character type mapping from the Liverpool Bay Seascapes pilot project. © Wessex Archaeology/English Heritage

processes producing the current disposition of many natural environmental data. The commitment for the Marine Bill to introduce a system of marine spatial planning gives added force to our need to develop area-based understandings of the historic environment alongside those for the natural environment: spatial planning is most effectively informed by spatial data.

Addressing this need in the practical context of informing the regulatory process for marine aggregates licencing, our England's Historic Seascapes Programme is refining a method for mapping the historic character of

England's coastal and marine environment using GIS technology, building on a Historic Landscape Characterisation (HLC) Programme now covering most of England's land area (Figure 2). The five projects to date in the Seascapes Programme have been selected to ensure the method's development against a broad diversity of environmental and management contexts and complexities. Their methodological outcomes will be consolidated in a succeeding phase of the Programme and the pilot databases upgraded to the resulting national Seascapes methodology.

While retaining HLC principles now established on land, this extension of characterisation involves many significant challenges. The scale of three-dimensionality of human activity, its impacts and material expressions in the marine historic environment, is generally far greater than on land, requiring novel approaches and data structures to accommodate it. The marine zone lacks the comprehensive network of mapped fixed boundaries within which we express historic character on land so alternative means are needed to define and delimit areas of shared character. On land, our landscape perceptions are primarily visual and land HLC emphasises character of the surface veneer of the terrestrial landscape. But our landscape-scale perceptions of the marine historic environment are not primarily visual: they tend to be constructs derived from a range of data sources with that greater three-dimensional expression noted above, not merely a 'surface veneer' of the sea-floor (Figure 3). So what are the relevant 'seascapes' to characterise to inform most effectively our future forward planning, development control and research needs? These and many other challenges form tasks being overcome in the methodology being developed, trialled and refined through this programme's pilot projects.

England's Historic Seascapes also has a major awareness-raising role among the wider public concerning the marine environment beyond the historic. Characterisation treats the historic environment as a dimension permeating the whole environment, encompassing the whole of its project area and the impacts from human activity up to the present: a wider field of view and relevance for the coastal and marine historic environment than has perhaps traditionally been adopted. Such broad coverage and clear connection of the past with the present gives these characterisations a point of contact, a relevance, to all who may be familiar with portions of our coastline or who use the sea. Making that connection among coastal users and communities has important implications both for the way in which we treat the sea and for the public accountability of future marine spatial planning.

For further information visit:
www.english-heritage.org.uk/characterisation



ENGLISH HERITAGE

England's historic seascapes: Liverpool Bay pilot project

This project, funded through the ALSF and commissioned by English Heritage, developed an initial methodology for extending the principles of Historic Landscape Characterisation (HLC), as now established on land, into the inter-tidal and marine zones.

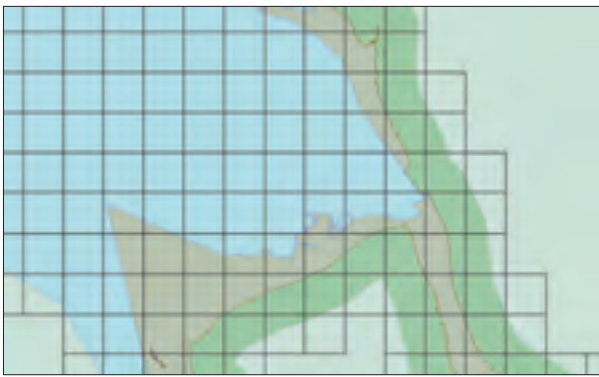


Figure 1: The gridded approach to dividing the Study Area for the Attribute Analysis Map

The main objective of this pilot project was to develop a methodology to map the historic character for the intertidal and marine zones in a manner that was transparent and repeatable around the coast of England. The project team undertook a review of terrestrial HLC

projects to identify aspects of good practice. They also undertook interviews with potential end-users to explore their aspirations for the Seascapes pilot.

A significant challenge to seascape characterisation is the lack of identifiable boundaries to define different activities. Some human activity on the sea is fixed and visible, for example oil and gas platforms. However, many human activities overlap: fishing, commercial cargo routes and recreational use can all, for example, operate in the same stretch of water. To address this problem, three methods were explored for dividing the study area into parcels that could hold the character assessments.

One method was to create a grid, dividing the study area into equal squares (see **Figure 1**). Datasets could be analysed and manipulated using each grid square as a processing unit. Analysis and comparison of these datasets would reveal patterns of use or associations with past activities. These patterns or associations could be used to establish a predominant character for the relevant grid square. This gridded visual quality of the resulting map would make it immediately obvious to the end-user that the characterisation reflected approximate abstract boundaries rather than true spatial demarcations of the extent of a particular character.

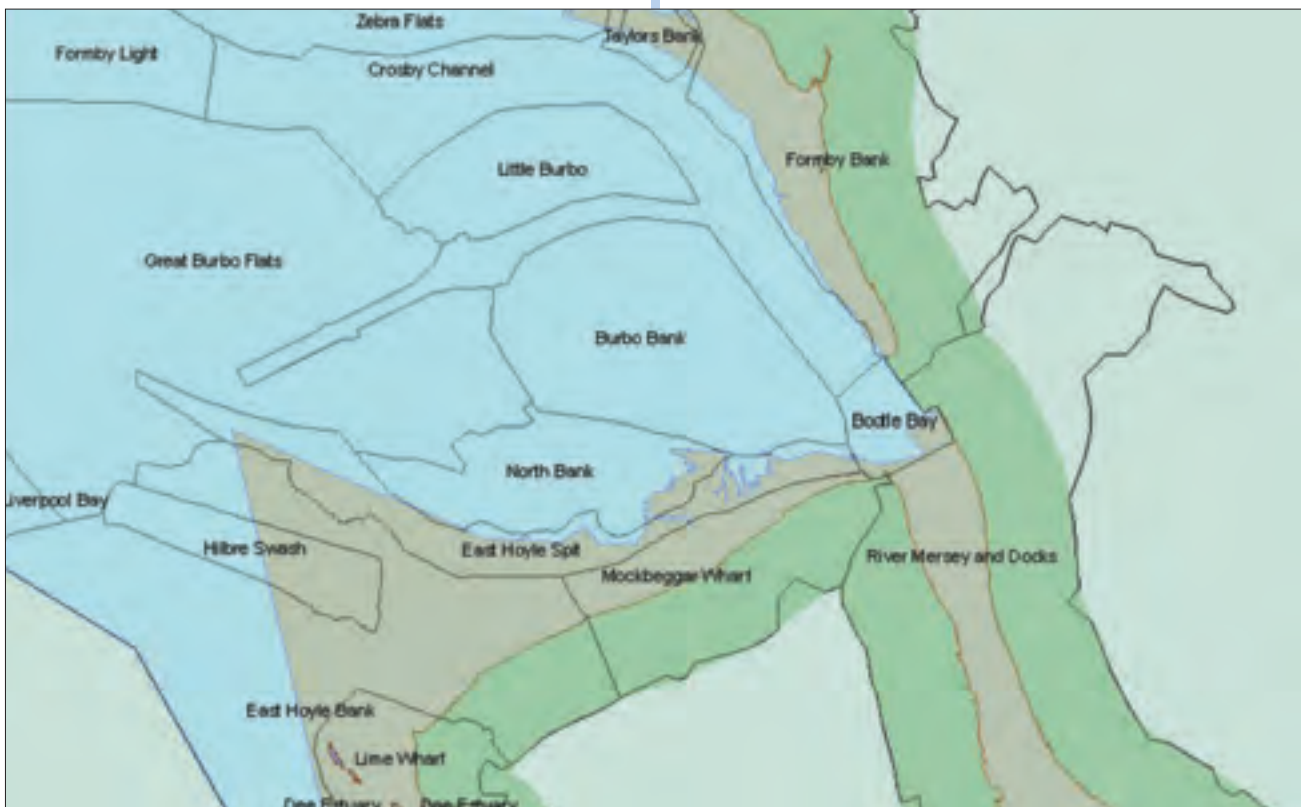


Figure 2: The place-names approach to dividing the Study Area for the Attribute Analysis Map

Another method considered was the use of place-names for areas (see **Figure 2**). Place-names at sea often denote major physiographic features such as banks and channels familiar to sea-users. Such place-names often have a wealth of humanly defined associations. Once the extents of such features had been digitised, these place-name polygons were tested as units for accessing and querying different datasets. This method produced a character map with large polygons, which contrasted markedly with the fine grain of terrestrial characterisations at the coast edge. A perceived significant disadvantage with this method was the decline in the number of place-names as one gets further from the shore and, again, the subjective nature of boundaries between physiographic features.

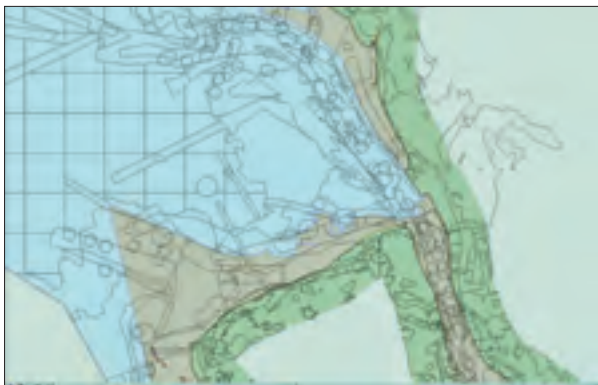


Figure 3: The 'multi-mode' conceptual model explored for the data structure of the GIS project

The method finally taken forward for development of the Attribute Analysis Map included the creation of intermediate 'themed' mapping, collating information by period and by the human activities which often feature also in land-based HLC, such as 'military' and 'industry' (see **Figure 3**). The mapping was grouped under broad headings reflecting modern use of the sea and coast, past use of the sea and coast, and environmental characteristics such as natural habitats and palaeo-environmental contexts. A model of coastal change was also compiled to help assess the potential for submerged landscapes. These maps were then amalgamated into the Attribute Analysis Map retaining all of the extents from the component themed maps using the union tool in the project GIS (see **Figure 4**).

The resulting map required a great deal of manipulation or 'cleaning' to remove 'slivers' (polygons too small to be used effectively) or fill holes in total area coverage. Once the Attribute Analysis Map had been created and cleaned it was noted that, because of the large scale of primary datasets and a general lack of detailed mapping

for the area, the northern section of the Study Area consisted of a large undifferentiated polygon. This was subdivided using the gridding method described above.



Figure 4: The 'union approach' to dividing the Study Area for the Attribute Analysis Map

The patterns of polygons displayed within the Attribute Analysis Map were assessed to find areas where polygons of similar characteristics were found in close proximity. These areas were then defined as 'Character Areas' and text was generated summarising Present Day Form, Present Sea Use, Past Sea Use, Archaeological Potential, and Perceptions of Place for each area. The texts were accompanied by a listing of bibliographic references, and a broad scale assessment of the likely impacts of human activities. Presented as .html pages, these texts will be accessible via the GIS software or as a standalone .html application.

England's historic seascapes: Liverpool Bay pilot project

North Shore

Character Area

North Shore /

- North Shore
- Cleveleys Sea Defences
- Rossall Point Promenade
- Blackpool
- Rossall Point Golf Course
- Cleveleys Promenade

Sensitivity

Multimedia

Present Day Form

The North Shore character is delineated by Rossall Point, Rossall Oyster Grounds and Crusader Bank to the south. The area is rich in fisheries and mariculture, exemplified by where plaice is exploited; and as a navigable area where the sand and mudflats which are historic features. There are also two environmental areas in the area, exemplified by submerged forests and drying areas in Blackpool and Shell Wharf, which are used for recreational uses, being adjacent to the sea. The area also contains popular sandy beaches that run along the Fylde coast. In addition, the area has substantial settlement with a strong recreational character, such as boating areas and golf courses. The series of coastal defences running from Cleveleys to Blackpool is represented by sand (marine sediment) and fine sediment plans.

The foreshore of the North Shore consists of sandy beaches, which in contrast to the wide expanses of sand and mud banks of the shorelines south of the Ribble are relatively narrow and seldom dry to a height of 3 metres. Much of the shoreline is lined with groynes to halt the removal of the sand which makes the beach less attractive to visitors.

Sea Use: present

The area is developed, with Blackpool to the north east. The sea is used primarily for recreation. The Joint Nature Conservation Committee recorded the area as a habitat for plaice and other fish. The sea is used for fishing by boats from the harbour at Fleetwood at the north east coast as well as from the coast. The fishing fleet at Fleetwood has recently lost most of its fleet following the Icelandic Cod quotas in fishing quotas during the 1990s.

The character area also has a strong recreational character, with a sailing area near Blackpool and a golf course. Cleveleys also offers seaside entertainment and bingo halls. The town of Fleetwood has been founded since its foundation (Curtis, 1985, 1990).

North Shore

Character Area

North Shore / Multimedia

QuickTime 6 or above is required to view these media files.

Index to Multimedia Resources

North Shore

Character Area

North Shore / Cleveleys Sea Defences

- North Shore
- Cleveleys Sea Defences
- Rossall Point Promenade
- Blackpool
- Rossall Point Golf Course
- Cleveleys Promenade

Sensitivity

Multimedia

Name of place: Cleveleys on the Fylde Coast

Caption: A view of the sea defences looking north at Cleveleys, with a groyne in the foreground. The foreshore is covered by similar groynes that are intended to stabilise the foreshore and prevent excessive movement of the beach materials along the coast. Cleveleys Promenade runs along the top of the sea defences and is used by boats and visitors alike.

Photographer: S. Heston

Date taken: October 2005

Reference no.: WMS0376_20051022

Collection: Wessex Archaeology Ltd.

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Image Caption Page

North Shore

Character Area

North Shore / Sensitivity

- North Shore
- Sensitivity
- Multimedia

A broad scale assessment of the likely impacts of human activities

| Impact Caused by Human Activity | Human Activities | Vulnerability | Sensitivity |
|---------------------------------|-------------------------|---------------|-------------|
| Sedimentation Loss | Coastal Development | High | High |
| | Subsidence | Moderate | Moderate |
| Physical Disturbance | Boat Trawling | Low | Low |
| | Fisheries Offshore | Low | Low |
| | Travelling | Moderate | Low |
| | Recreational Activities | High | Low |

Vulnerability/Sensitivity Analysis Page

Figure 5: An example of the offline .html resource for the North Shore character Area

To provide additional information for the more intangible aspects of character such as the sense of place, a multi-media component was added to the characterisation. Historic images, digital stills, panoramas, and video footage was linked to the character areas via the .html pages (see **Figure 5**).

The review of Seascapes characterisation undertaken at the end of the project included an assessment of the benefits and drawbacks of each method, and used case studies to assess the ways in which Seascapes might be useful as an information resource and management tool. The case studies included Rapid Coastal Zone Assessment Surveys, the revision of Shoreline Management Plans, and development proposals for an offshore windfarm and a marine aggregates extraction area.

Title: 3783MAIN. England's Historic Seascapes: Liverpool Bay Pilot.

Contractor: Wessex Archaeology

Contact: Anthony Firth

Telephone: 01722 326867

E-mail: a.firth@wessexarch.co.uk

Full Report Site:

<http://www.wessexarch.co.uk/projects/marine/eh/seascapes/index.html>

<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

England's historic seascapes: Solent and Wight and adjacent marine zone pilot area

THE SOLENT REGION

The Solent and Wight Seascapes pilot study area stretches across four counties: Dorset, West Sussex, Hampshire, and the Isle of Wight and offshore up to the median line with France (Figure 1). This area includes a wide variety of cultural and natural features which combine to make the Solent a diverse and active region for applying the Seascapes methodology.

The cultural heritage of the area includes a legacy of submerged prehistoric landscapes and associated occupation evidence from times when sea level was lower. Human populations have exploited the marine and coastal zone for many millennia and there is evidence of this in the region dating from all prehistoric periods to modern day. The historic past has been characterised by the Solent as a significant tidal waterway which has attracted waves of settlers, traders and invaders. The modern Solent sustains a wide variety and diversity of marine related industries, prominent examples are ports, marine aggregates extraction, oil installations, commercial fishing, capital and maintenance dredging operations and shipping trade.

This marine and coastal landscape is one that faces a number of human and natural pressures from erosion, climate change, development, extraction and recreation. These all contribute to management challenges and issues for cultural heritage.

SOLENT SEASCAPES

The project has brought together the Hampshire & Wight Trust for Maritime Archaeology, Bournemouth University and Southampton University, organisations which specialise in the study of the Solent, marine cultural heritage and digital data management. The combined experience of the team has enabled the unique challenges of adapting historic landscape characterisation methodology developed for the terrestrial environment to the marine environment, to be tackled.

The range of evidence for human activity in the intertidal and marine zones is varied and complex and includes examples such as submerged prehistoric occupation sites, shipwrecks, shipping routes, industrial structures and processing areas, dredging, fishing, and recreation areas, and anchorage debris on the seabed (Figure 2). During data collection and collation the three dimensional nature of the marine zone and dramatic differences in availability and coverage were highlighted.

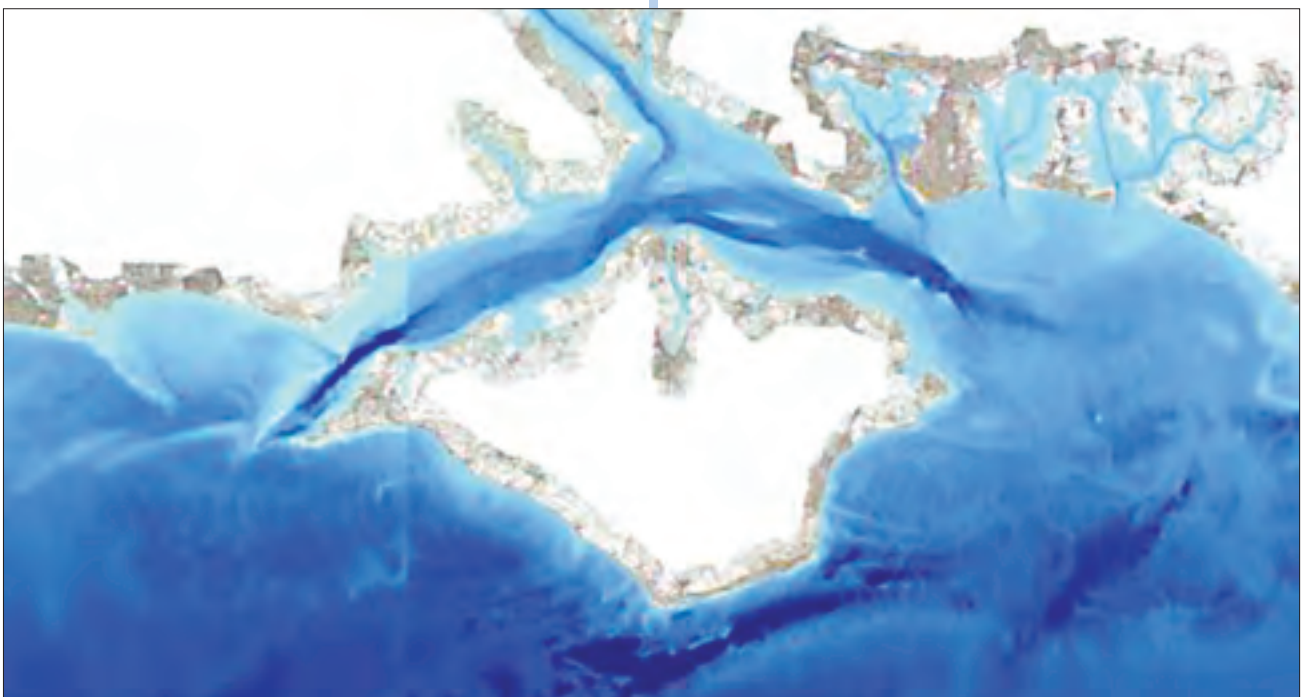


Figure 1: The Solent and Wight Seascapes Pilot study area showing the 2km landward buffer zone.

N. Pee & J. Satchell

Hampshire and Wight Trust for Maritime Archaeology, Room W1/95, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH



Figure 2: The view of Portsmouth Harbour from Spinnaker Tower; showing shipping activity and harbour facilities.

After analysis of the available marine datasets for the Solent, a multi-level approach was devised based around four principle layers: sea surface, seabed surface, seabed subsurface and coastal. This approach allowed the full character of the marine and coastal environments of the region to be expressed with some sites and activities being represented in multiple levels, and others in only one. The project has involved building

a GIS model with an attached database, from this a top level of 'broad characterisation' polygons has been developed which reflect the primary character traits of the lower multiple levels in the seascapes database. Text descriptions along with images and links to further information about each character area are attached to each top level polygon.

The Solent Seascapes product represents a stratified GIS which is required for the adaptation of HLC to the marine environment. It is an important tool which can be used in a range of marine management situations, it can help facilitate an integrated approach to spatial planning, provide context to inform curatorial decisions and highlight research or data gathering priorities for the future.

Title: 4728MAIN. England's Historic Seascapes: Solent and Wight and Adjacent Marine Zone Pilot Area.

Contractor: Hampshire & Wight Trust for Maritime Archaeology (HWTMA), Bournemouth University and Southampton University

Contact: HWTMA.

Telephone: 02380 237300

E-mail: info@hwtma.org.uk

Full Report Site:
www.hwtma.org.uk/publications/download.htm
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

England's historic seascapes: Scarborough to Hartlepool pilot

The whole study area is an historic seascape altered, transformed and affected by human activities. Seeking an archaeological understanding of the historical and cultural development of the present marine, inter-tidal and coastal areas, this pilot project maps the historic character and maritime sea-use within a GIS, using historic charts, maps and associated documentary sources alongside modern marine data.

Source-led and guided by current terrestrial multi-mode HLC methodology (Aldred and Fairclough, 2003) it defines areas that share similar and repeating historic character as Historic Seascape Character 'Types', allowing historic trends and processes to inform and frame the broader sustainable management of change, through marine spatial planning, outreach and research projects.

To reflect the three-dimensional nature of the marine environment (ie. the seabed, seafloor and water column environs) a fine grid of cells, with tiered attributes, is used to record the present and dominant historic character for each marine layer. Inter-tidal and coastal areas are captured as polygons. From this database a single, conflated HSC layer is derived. Types are further explained by brief texts describing different aspects of the historic character including identifying distinguishing attributes and principal locations; their constituent components, features and variability; the values and perceptions that people have of these areas; the research, amenity and education potential they offer; their present condition and forces for change affecting them, which in turn inform statements on their rarity and vulnerability allowing broad recommendations to be suggested for their management.

For the greater part of its southern length, the coastline is sheer, rocky and inhospitable. Capped by glacial tills, cliffs of Jurassic sedimentary rocks - in places mineral-lodged and fossil-laden, are interspersed by narrow and steeply cut watercourses, some wooded, and small sheltered bays and prominent headlands. Though comparatively safe when the wind blows offshore, it is treacherous in northerly and easterly gales, with hazardous 'scars' and shoals nearshore, as thousands of inshore wrecks bear testament. Further north in the sweep of Tees Bay and at the mouth of the Tees Estuary the coast is low and flat, once extensive tidal sand flats and saltmarsh, with some peripheral rough grazing but mostly reclaimed for vast industrial complexes.

The central-southern North Sea, 'Doggerland', once formed a living landscape (Coles, 1998), a low-lying topography indented with rivers, inlets, archipelagos, lagoons, wetlands and marshlands. As Holocene sea-

levels rose, often imperceptibly but sometimes catastrophically, this landscape was submerged by c5000BC. Late Devensian sands and gravels hold potential for *in situ* Middle and Upper Palaeolithic deposits and Mesolithic palaeo-geographies are well known though imprecisely defined. Trawled seabed close to Dogger Bank has offered up numerous flora and faunal remains and the potential for further prehistoric landscapes, finds and environmental material is significant (Flemming, 2004). The inter-tidal and estuarine sediments of the area also conceal palaeo-environmental deposits of considerable potential.

Historically the area has been dominated by coastal trade, mineral extraction, ship building and fisheries. Throughout prehistory rivers, such as the Tees and Esk, have been important access points to and from the region's agricultural hinterlands, linking into wider North Sea networks of trade and communication. During the Roman and Anglo-Saxon periods these networks became highways of invasion, immigration and trade (Clarke, 1985).

The important medieval coal and alum trades established early shipyards such as at Stockton and Whitby. In many places coastal mining for ironstone, alum, and jet and quarrying for building stone has left the cliffs and foreshore cut, tunnelled and rent whilst dredging has channelled and scoured rivers of accumulated sediment and cleared harbours of sand driven onshore. Since the 19th century Teesside and Hartlepool Ports have been one of the foremost industrial and commercial shipping areas in Britain, founded on coal, iron and shipbuilding but later steel, chemical and hydrocarbon industries (Le Guillou, 1975).

The fishing communities perched and tucked along the coast traditionally farmed inshore waters, trapping for salmon, potting for shellfish and crustacea, and netting for seasonal herring in distinctive local craft such as cobbles, yawls and mules with Scarborough, Whitby, Staithes and Hartlepool leading. They also sought distant offshore cod with long-lines, about Dogger Bank and further, before the advent of trawling methods and the late C19th adoption of steamers heralded the era of extensive and intensive exploitation of pelagic and demersal fisheries alike (Frank, 2002). Once internationally important medieval fishing grounds are today in a state of remittance as strategies for conservation of fish-stocks limit seasons and catch size.

Settlements are generally dispersed excepting industrial Teesside. Historic areas and routes of navigation strike out from these ports and harbours, negotiating notorious local hazards, before immediately entering the open sea,

B. Tapper

Historic Environment Service, Environment and Heritage, Cornwall County Council, Kennall Building, Old County Hall, Station Road, Truro, Cornwall, TR1 3AY

warded by the numerous landmarks and navigation aids and innovation of life-saving institutions. Railways, tramways and road networks link mineral industry to the sea. Recreational spas, gardens, trails and links cluster about Victorian seaside resorts such as Scarborough and Redcar. Defensive military positions cluster on defensive headlands and listening devices dot the cliff tops.

Though modern impositions such as aggregate dredging, spoil dumping, hydrocarbon extraction, telecommunications cables and renewable energy industries pressure historic seascape character they nevertheless reflect it and offer opportunities to investigate and understand it further. Throughout the past the North Sea has served more as a unifier than a barrier. The peoples living around its coasts exploited the sea as a means of trade and communication, and were linked closely together culturally, economically, and even politically.

The historic seascape is a contested place. Various communities and interests, from particular localities and from particular opinion, have a concern in ongoing developments or activities that are potentially or actually damaging, diluting, distorting or destroying important or well-regarded features or character. Such challenges should be welcomed as a way of opening dialogues about the sustainable management of the marine historic environment as a whole (Herring, 1998).

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Title: Historic Seascape Characterisation:
Scarborough to Hartlepool Pilot

Contractor: Cornwall Historic Environment Service

Contact: Bryn Tapper

Telephone: 01872 323603

E-mail:

Charlie Johns chjohns@cornwall.gov.uk
Megan Val Baker mvalbaker@cornwall.gov.uk
Bryn Tapper btapper@cornwall.gov.uk
Peter Herring pherring@cornwall.gov.uk

Full Report Site:

<http://www.cornwall.gov.uk/>
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

England's historic seascapes: Southwold to Clacton and adjacent marine zone pilot area

Oxford Archaeology has been engaged in the assessment of an area stretching from Southwold to Clacton. The study area is located on the East Anglian coast, straddling the border between Suffolk and Essex. The seaward limit is the UK continental shelf, which at this point follows the median line with Holland. The region is significantly varied in its environment, present day character and historical character to make it a fascinating area for Marine Historic Landscape Characterisation.

The study area currently supports a wide range of industry and other commercial activity. Its predominantly sand and gravel geology offshore means it is a prime area for aggregate dredging. Recently the offshore area has also been recognised as a suitable area for the construction of renewable energy installations. To the south the multi-purpose container and passenger ports of Harwich and Felixstowe are key. Consequently the marine environment within the area is dominated by heavy shipping and ferry traffic. The area off the East Anglian coastline has also long been used as a naval practise ground.

The coastal area supports a large leisure and tourism industry, central to which are the towns of Clacton and Walton on the Naze in Essex and smaller settlements of Southwold and Aldeburgh in Suffolk. The coast is particularly popular for leisure sailing and fishing and is used regularly for recreational diving. Additionally the whole coastline has long supported a small fishing fleet. The combination of cliffs, marsh, and estuarine environments amongst others supports a variety of

wildlife and much of the coastline is protected. This is increasingly under threat from the encroachment of the sea and coastal squeeze, causing severe erosion in places.

The entire seascape was land prior to c 8000 BP meaning the potential for submerged prehistoric landscapes is high. Prehistoric settlements dating from the Neolithic to the Bronze Age have been discovered on the coast. Historically the current position of the shoreline has left the area open to foreign influence. This has been particularly significant in times of close contact with the continent such as the early Medieval period, during which time thriving ports existed along the coast growing rich on profits of the wool trade. Later coastal trade became important, supplying grain to London and importing coal from the north. The east coast has of course been vital during times of conflict and many 17th century Anglo-Dutch battles were conducted in these waters. More recently the area was heavily defended during both World Wars, leaving an imprint on the character of the region.

OA has compiled a large amount of data about the study area from a variety of sources, both digital and paper based, which has then been used to create a GIS database. A total of 41 broad character areas have been formulated on the basis of this evidence. OA have produced detailed, illustrated descriptions of each of the character areas. These will ultimately be available on the project website for public use. In addition OA have compiled a technical report to accompany the GIS database. This project will contribute refining the



Figure 1: The Southwold to Clacton Study Area showing the character areas outlined in red. Colours represent the dominant sub character type eg. Cables and pipelines are shown in light blue, shipping channels in green

K. Powell

Oxford Archaeology, Janus House, Osney Mead, Oxford, OX2 0ES

existing methodology of the first pilot project in Liverpool Bay and form a significant part of the subsequent methodological development.



Figure 2: Taken from near Languard looking west. This shows Felixstowe docks and across the waters of the Orwell estuary Harwich docks.



Figure 3: A view east over the landscape of the Naze at sunrise.



Figure 4: The view north up Dunwich beach. The Roman and medieval settlement at Dunwich lies to the west of the shoreline.



Figure 5: View of the Woodbridge Tidemill at the top of Deben estuary.

Title: 4729MAIN. England's Historic Seascapes: Southwold to Clacton and Adjacent Marine Zone Pilot Area

Contractor: Oxford Archaeology (OA)

Contact: Kelly Powell

Telephone: 01865 263800

E-mail: k.powell@oxfordarch.co.uk

Full Report Site:
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

England's historic seascapes: Withernsea to Skegness pilot

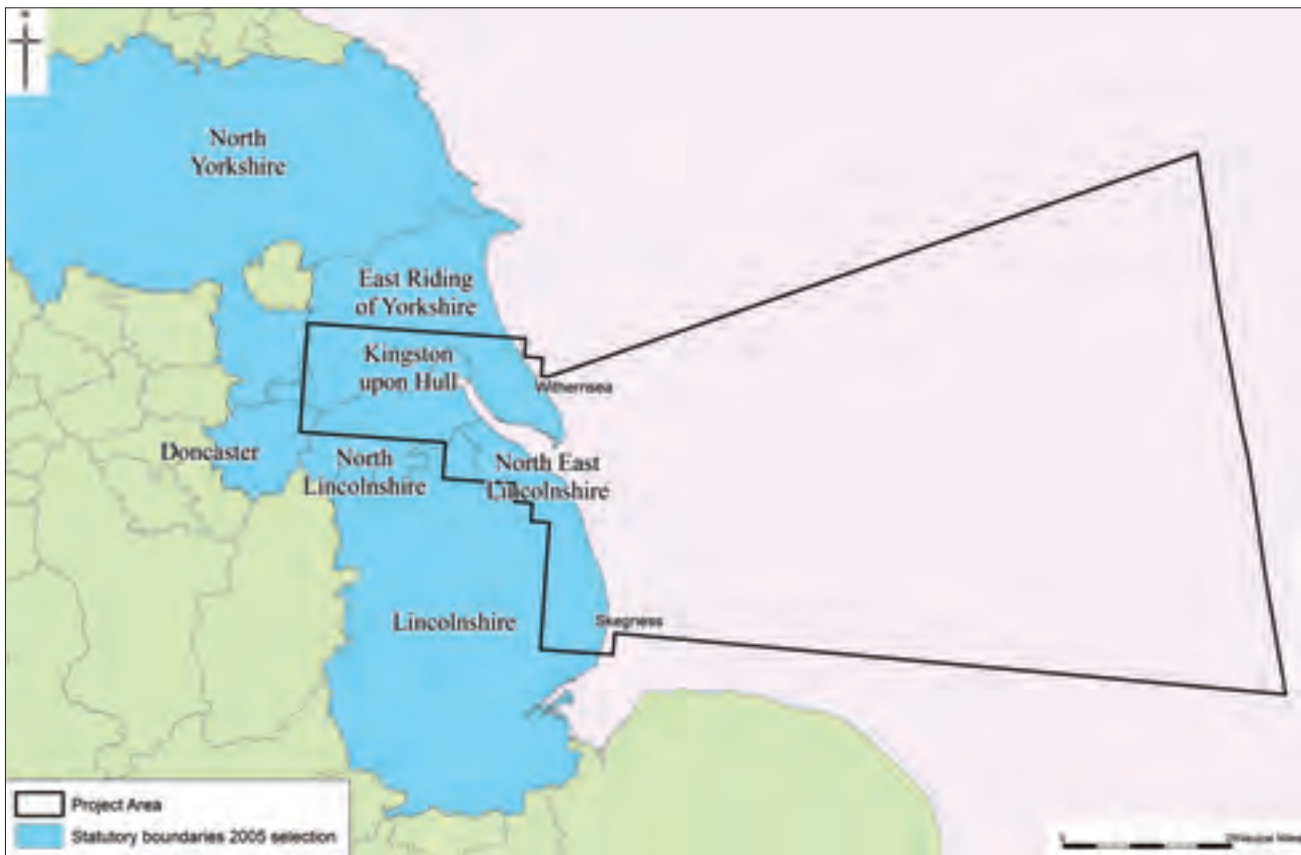


Figure 1: Withernsea to Skegness project study area

The Museum of London Archaeological Service (MoLAS) Seascapes project runs between Withernsea in Yorkshire to Skegness in Lincolnshire and extends out into the open sea as far as the median line with Holland (Figure 1).

Although the study is focused on human use of the sea, it also includes those parts of the coast, and areas further inland, that are directly related to the maritime environment, such as ports, etc. Only the areas of dry land that have been identified as being maritime in character or relating in specific ways to the maritime environment have been included in the final characterisation layer. This is in contrast to the open sea which has been 100% characterised, with no gaps.

Seascapes is informed by principles of Historic Landscape Characterisation (see Hooley, this volume). The main difference is that this Seascapes project identifies and records the *maritime* aspects of people's lives and the surrounding and land/sea alone.

The most challenging factor about this project has been the fact that the sea consists of three main zones: the sea surface, the water column and the sea bed. Characterisation of our project area has been influenced by nature of use in all three of these zones as we have

found that mapping evidence of tangible human activities on the sea bed alone is not sufficient in illustrating the cultural significance of how the sea is being used. This means that in some areas, the uses of the sea that have been recorded are not necessarily tangible. We have taken this approach in order to fully answer the central research question: what is the current use of the sea and the time depth of those uses and how this could/should affect the management of the archaeological resource? As a result of this approach the character map tends to flit between mapping evidence of use on the sea-bed, column and surface, depending on what is considered to be the dominant characteristic in each case.

Our GIS project works on the principle that human use of the sea falls into a number of broad cultural categories: Coastal industry, Offshore industry, Flood defence and reclamation, Military, Navigation, Settlement and Recreation, and that these can be sub-divided into finer categories of use (Figure 2). The GIS project we have produced is structured to display by the most dominant characteristics of the seascape, but can also be displayed by secondary (or other) characteristics. In our study area the most dominant characteristics of the seascape are considered to be Coastal and Offshore industries, represented by the heavily industrial docklands of Hull, Grimsby and Immingham and

J. Lyon

Museum of London Archaeological Service, Mortimer Wheeler House, 46 Eagle Wharf Road, London, N1 7ED

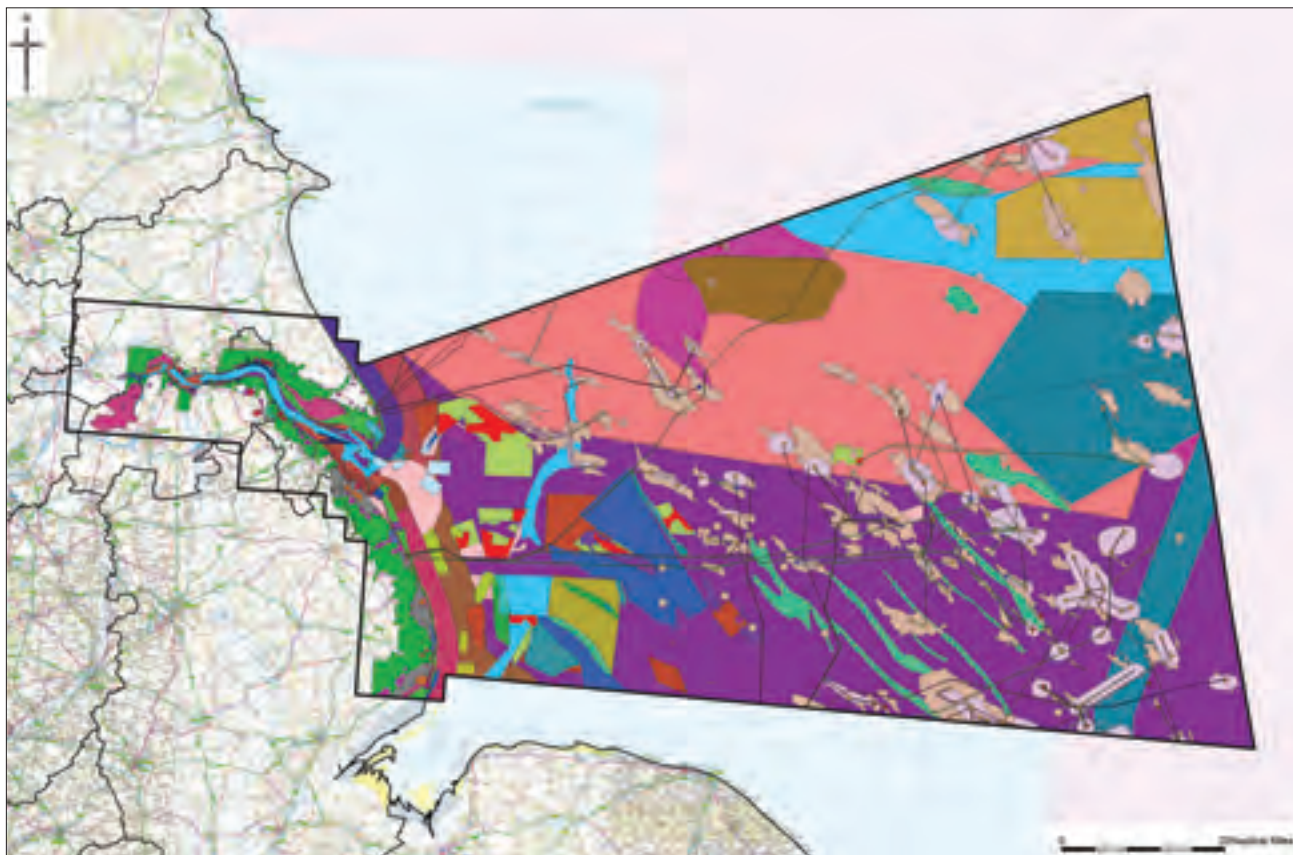


Figure 2: Characterisation polygons displayed at Sub-Character level (the finest level of characterisation)

associated offshore pipelines, aggregates and oil extraction activities. Navigation is also a major characteristic, because of the significance of the Humber Estuary in providing historic access to the sea via its ports. The coastline between Cleethorpes and Skegness is strongly defined by Recreation activities, particularly since the advent of the railways in the 19th century.

The potential uses of the GIS project range from giving a useful overview of maritime influences in the study area, perhaps with a view to stimulating further research, to providing detailed information in specific areas on a range of different topics.

Title: 4730MAIN. England's Historic Seascapes: Withernsea to Skegness and Adjacent Marine Zone Pilot Area.

Contractor: Museums of London Archaeological Service (MoLAS)

Contact: Jo Lyon

Telephone: 0207 4102200

E-mail: joly@molas.org.uk
dickm@molas.org.uk

Full Report Site:
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

The North Sea palaeolandscapes project

INTRODUCTION

Following the end of the last Ice Age rising sea levels across the area that became the North Sea resulted in the inundation of an inhabited prehistoric landscape larger than the surface area of the United Kingdom. The last great period of climate change experienced by mankind effectively resulted in the equivalent loss of an entire, populated European country. Consequently, this marine region contains one of the most comprehensive records of the Late Quaternary and Holocene landscapes in Europe along with may be one of the most extensive and best preserved prehistoric landscapes. The extreme depths of water and sediment have, however, meant that this globally important archaeological resource was also lost to our knowledge and largely placed beyond the reach of modern archaeological prospection, exploration or heritage management.

Despite this, recent research at the University of Birmingham has allowed archaeologists and geomorphologists to begin to map and explore this lost world and the results are likely to fundamentally change our interpretation of the archaeology of north-western

Europe and to impact the heritage strategies of every country that possesses a North Sea coastline. Few archaeological projects can make such a claim without being accused of hyperbole but in the case of the North Sea Palaeolandscapes Project the claim is both accurate and demonstrable. Unfortunately, at the very point that this major advance is taking place the region is under intensive developmental pressure from trawling, aggregate and other mineral extraction and infrastructural development. Most recently, the requirement to develop clean energy technologies, in response to the most recent phases of global warming, have led to plans to construct extensive wind farms with the potential of serious damage to Europe's most pristine but least explored archaeological landscape (Figure 1). The imperative to map the cultural deposits of the North Sea in order to provide management plans that permit sustainable exploitation and support heritage management is clearly of benefit to all stakeholders, including aggregate groups.

In anticipation of some of these threats, the University of Birmingham, supported by the Aggregates Levy Sustainability Fund and managed by English Heritage, has completed an exploration of the archaeological



Figure 1: Holocene shorelines

V.L. Gaffney¹ & K. Thomson²

¹Institute for Archaeology and Antiquity, University of Birmingham, Edgbaston, B15 2TT

²School of Geography, Earth & Environmental Sciences, University of Birmingham, Edgbaston, B15 2TT

heritage of the North Sea through a donation from (Petroleum Geo-Services -<http://www.pgs.com>) of c.23,000 km² of marine seismic data collected over decades and integrated at the cost of many millions of pounds. This has allowed the detailed mapping of a uniquely preserved, but largely unknown, Mesolithic landscape over an area equivalent to that of Wales. The rivers, streams, lakes and coastlines of a European country, lost more than 8,000 years ago, are now being explored for the very first time by European archaeologists and the methodologies for such work disseminated to colleagues working in similar landscapes in the Arabian Gulf, the Gulf of Mexico and the Black Sea.



Figure 2: Current extent of Southern North Sea Megasurvey 3D seismic data

ARCHAEOLOGICAL CONTEXT

The landscape of the Southern North Sea is unique regionally. This extensive area was populated by humans but rapidly inundated during the Mesolithic as a consequence of rapid climate change and rising sea levels. Researchers have long appreciated the area as a heartland of Mesolithic activity and realised that inundation may have preserved topographic, cultural and environmental data which, if located and sampled, may be unparalleled by terrestrial sites. However, the location of potential deposits, deep beneath the sea or buried by marine silts, has prevented any adequate assessment of their extent or even location. Consequently, the archaeology of the North Sea, whilst clearly important, lay beyond the reach of traditional archaeological exploration technologies or excavation.

Despite this, there have been a number of attempts at historic landscape reconstruction within what was clearly an important archaeological region. Clement Reid in his book *Submerged Forests*, published in 1913, based his knowledge of the region on the distribution of submerged forests as well as information obtained from

trawlers and dredgers. Following this Clark's (1936) Mesolithic Europe largely reflects an increased knowledge and understanding of the emergent plain of the North Sea following Reid's publication (notably in respect of the 1931 discovery of the Leman and Ower point, as well as environmental evidence in the form of pollen provided from associated peat samples).

Although much archaeological material continued to be recovered from the North Sea, especially from trawlers operating out of Holland, British interest in the Southern North Sea as a landscape was reinvigorated by the publication of Coles' (1998) *Doggerland: a Speculative Survey*. This seminal work drew upon all the available knowledge at the time to produce a series of speculative maps, and terms the Southern North Sea "Doggerland". However, this publication concluded that "we have little more in the way of firm archaeological evidence than Clark had to hand in 1936".

The most recent, published pan-European synthesis edited by Nic Fleming (*The Submarine Archaeology of the North sea*, published 2004) emphasises that our lack of knowledge was the result of the combined effects of the technical difficulties related to exploration of such an environment and the potential cost, and uncertain outcome, of carrying out exploratory work without prior evidence for the nature, distribution or extent of cultural and environmental deposits. Consequently, as recently as 2004, Fleming concluded that the inundated landscapes of the North Sea were essentially terra incognita.

TOWARDS A GREATER UNDERSTANDING OF THE ARCHAEOLOGY OF THE SOUTHERN NORTH SEA

Our previous understanding of the morphology and, indirectly, the archaeology of the Holocene landscape of the Southern North Sea has been largely based on bathymetry. Whilst this approach has provided an overview to the area, the current understanding of the palaeogeography of the region remains fundamentally lacking in detail and prevents understanding or management of this important resource. Whilst recent researchers have used isostatic rebound models to help constrain and improve the present bathymetry-based models, the lack of detail within the landscape, and the failure to incorporate late Holocene and recent sedimentation, still remain issues as these have the effect of masking the true relief of the palaeo-landscapes.

The North Sea palaeolandscapes project

The 3D seismic datasets acquired on the United Kingdom continental shelf for exploring deep geology represent a major resource for understanding Late Pleistocene and Holocene geology. With extensive regional coverage (>23,000km² for the Southern North Sea) and spatial resolutions of 12.5m these datasets provide the opportunity of mapping relatively recent geology at a regional scale and with relative speed. Standard geophysical interpretation techniques usually used on such data to explore deeper features provide significant advantages in reconstructing palaeogeographies and allow the true 3D architecture of Late Pleistocene and Holocene systems to be established.

Commercial 3D seismic data from the Southern North Sea, provided by PGS (figure 2), allow the application of a range of techniques pioneered by the oil industry to extract accurate topographic maps of the subsurface and to precisely locate sedimentary features such as palaeochannel deposits or tidal sand bars. This large seismic data set (figure 3) has been used for timeslicing the data and mapping chronostratigraphically important horizons. In effect, we are able to produce geological and topographic maps of these inundated lands



Figure 3: Study area in relation to North Western Europe

The first results of this process are now available and represent little less than a "quantum leap" in terms of our understanding of the landscapes of the southern North Sea. First pass analysis has demonstrated that the use of 3D seismic data can generate fine topographic detail of the inundated landscape including river channels, tributary streams and basins that may be associated with marsh or lakes (figure 4).

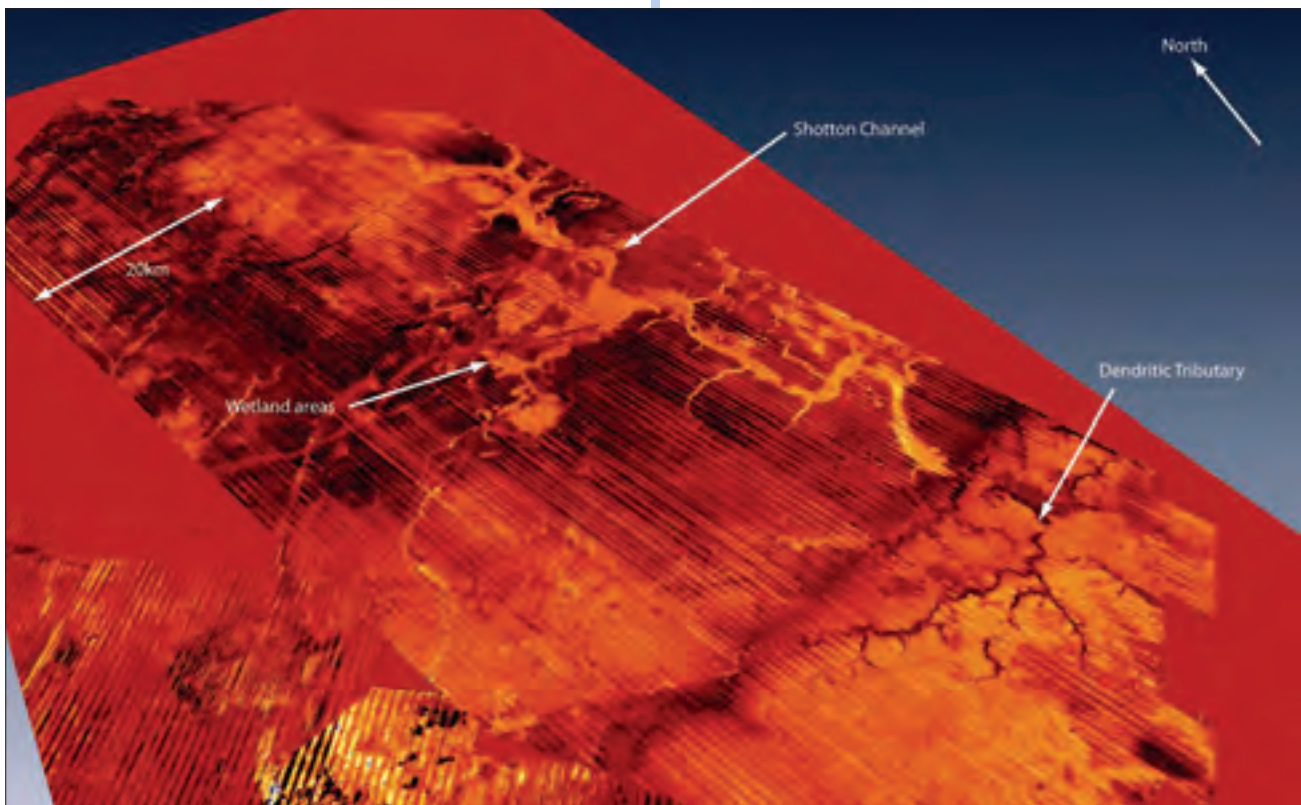


Figure 4: Detail of extensive river system stretching more than 30 km and provisionally named the "Shotton River" (after the famous Birmingham geologist Fred Shotton - <http://www.arch-ant.bham.ac.uk/shottonproject/profshotton.htm>).

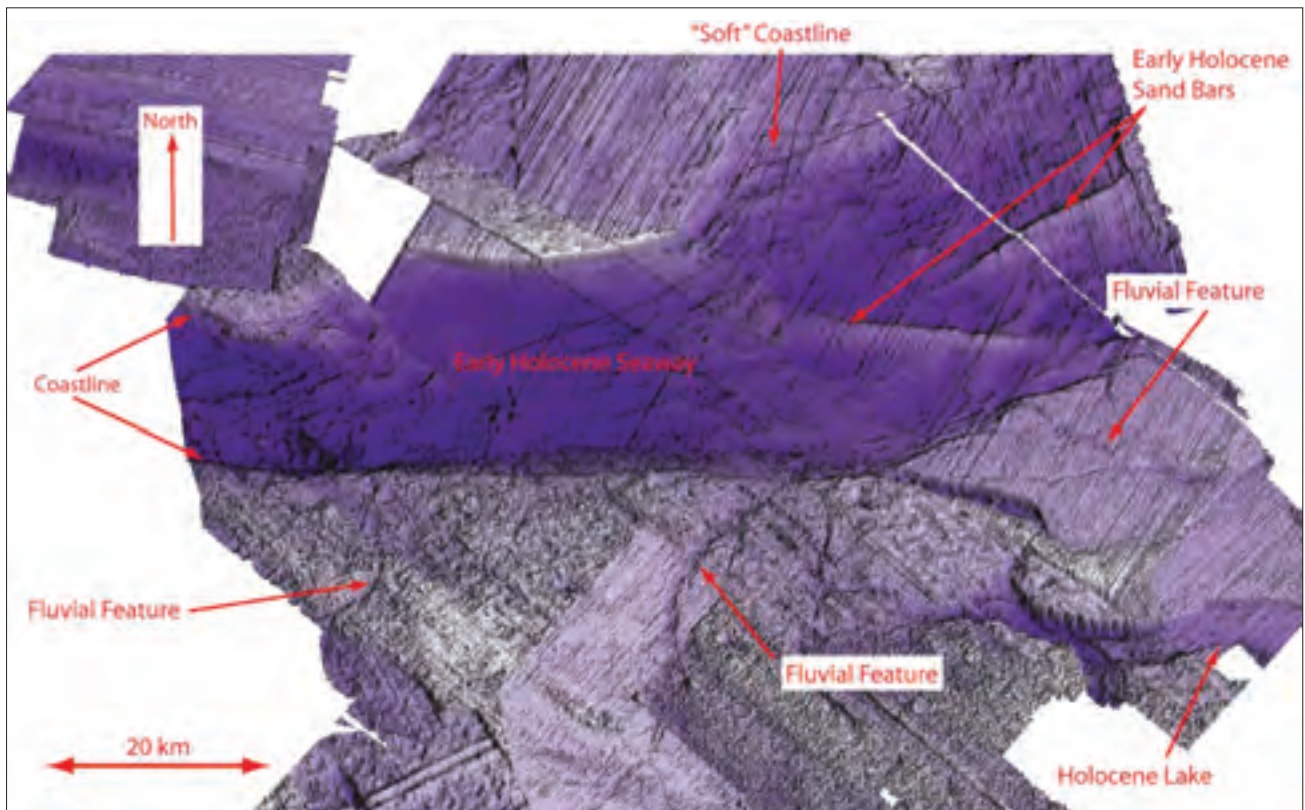


Figure 5: Holocene coastline, lakes and drainage features associated with the Silver Pit

Detailed coastlines are also identifiable within the data as well as internal features including sandbanks and other erosional features (see figure 5). It is now also possible to provide a stratigraphic sequence for the area separating the Holocene landscapes from earlier episodes, opening the possibility that earlier landscapes may be amenable to similar analysis (figure 6).

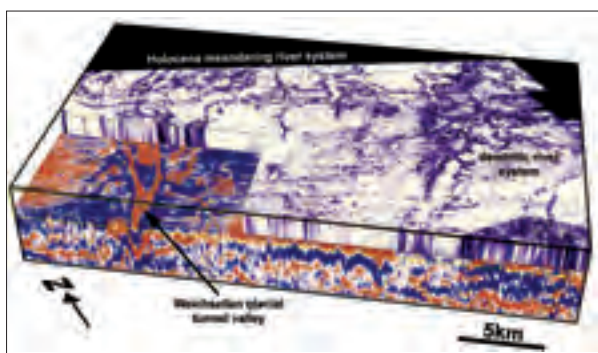


Figure 6: Data cube illustrating the stratigraphic relationship between Holocene drainage and earlier tunnel valleys

The primary mapping for this vast unexplored area was completed in 2006 and an illustration showing the extent of the results is provided in figure 7. The data has also been re-presented as a VR world with simulated vegetation for public use (Figure 8).

It is not hyperbole to state that the North Sea Palaeolandscapes Project has completely transformed our knowledge of the archaeology of the Southern North Sea and therefore the archaeologies of all the countries that surround the North Sea. Archaeologists are, for the first time, able to explore the historic landscapes of the North Sea over a massive area and to provide 3D maps of its topographic features. This ability to map the countryside of the Mesolithic in such detail will now allow us model past human occupation of the region and also to manage its hidden archaeology. The latter point is particularly important as the work has transformed the prehistoric landscapes of the Southern North Sea from being, essentially, "terra incognita" to an area that we may demonstrate contains the most extensive, preserved prehistoric landscape in Europe. Perhaps equal in importance is the fact that the project is raising the awareness of communities around the North sea to the fact that mankind has experienced global warming in the past and that the effects of significantly raised sea levels for North western Europe were, in the past, disastrous. Although primarily a project designed to support responsible exploitation of the marine aggregate resource, few projects will actually ever have provided such a valuable and fundamentally important gift to Europe as a whole.

The North Sea palaeolandscapes project



Figure 7: General map of the palaeo-rivers of the Southern North Sea



Figures 8a and 8b: Virtual Reality model for part of the study area reconstructed from seismic terrain data and seeded with contemporary vegetation using an artificial life engine (Eugene Ch'ng)

ACKNOWLEDGEMENTS

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PROJECT WEBSITE

http://www.iaa.bham.ac.uk/research/fieldwork_research_themes/projects/North_Sea_Palaeolandscapes/index.htm

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Title: 4613 MAIN. 3D Seismics As A Source For Mitigation Mapping Of The Late Pleistocene And Holocene Depositional Systems And Palaeogeography Of The Southern North Sea.

Contractor: Birmingham University

Contact: Prof. Vince Gaffney

Telephone: 0121 4147632

E-mail: v.l.gaffney@bham.ac.uk

Full Report Site:

http://www.archant.bham.ac.uk/research/fieldwork_research_themes/projects/North_Sea_Palaeolandscapes/

<http://ads.ahds.ac.uk/project/alsf/>

http://www.iaa.bham.ac.uk/research/fieldwork_research_themes/projects/North_Sea_Palaeolandscapes/index.htm



ENGLISH HERITAGE

Rapid archaeological site surveying and evaluation

The rapid archaeological site surveying and evaluation (RASSE) project was undertaken by the University of St Andrews with partners as part of the three year research project funded by Round 2 of the Marine Aggregates Levy Sustainability Fund (MALSF) administered by English Heritage (EH). The principal aim of the project was to test and develop rapid and quantitative, remote (geophysical) sensing techniques for the enhanced investigation of maritime archaeological sites in sensitive aggregate extraction areas. Furthermore, the project attempted to improve temporal and environmental assessment methods for sites and areas of high archaeological importance. The project addressed issues of direct relevance to the aggregate industry, to managers and curators of the marine historic environment, and to academia. The work complemented Round 1 ALSF funded projects administered by EH and Round 2 projects by Wessex Archaeology; and the University of Southampton.

The project involved analysis of historical data sets, and the construction of a test site in Plymouth Sound to enable development of protocols to maximise the potential of geophysical techniques in monitoring submerged archaeological sites. Following this

background work, methodologies for the enhanced use of multibeam sonar with a spar-buoy, deep-tow arrangement were tested. The resulting increased spatial resolution obtained for data over wreck sites, together with enhanced rendition of the geophysical data, provides both a new level of investigation and also a new forum for visualisation of submerged archaeology. Both of these achievements are of immediate relevance to the offshore aggregate industry and the archaeological community, allowing better site investigation practice, quantitative site monitoring and far wider dissemination of site information to the general public.

BACKGROUND

In recent years, the successful application of investigation technologies currently used in other marine survey industries has aided better understanding of complex environmental parameters that influence submerged cultural material lying on or buried just beneath the seabed surface. Case studies on specific technologies include ultra high resolution, full coverage 3D bathymetry (Dean & Frazer, 2004), single beam acoustic classification using acoustic ground

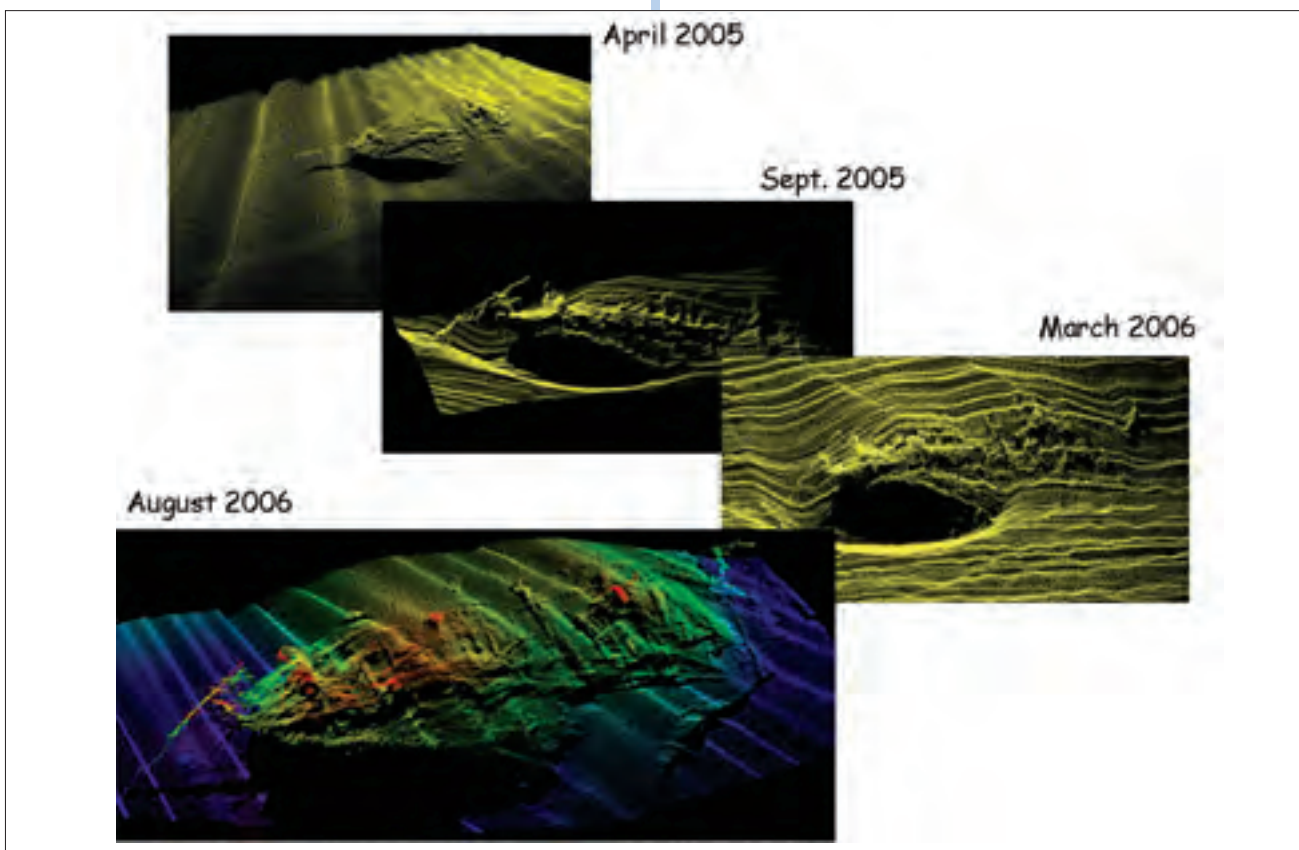


Figure 1: Three point cloud views of the Bow Sprit wreck site taken from the 3D visualisations of the site: note the fallen bowsprit which occurred between April and September 2005

R. Bates¹, M. Lawrence¹, M. Dean¹, P. Robertson¹, L. Atallah²

¹University of St. Andrews, School of Geography and Geosciences, St. Andrews, Fife, KY16 9AL

²Imperial College, Department of Computing, 180 Queen's Gate, South Kensington, London, SW7 2AZ

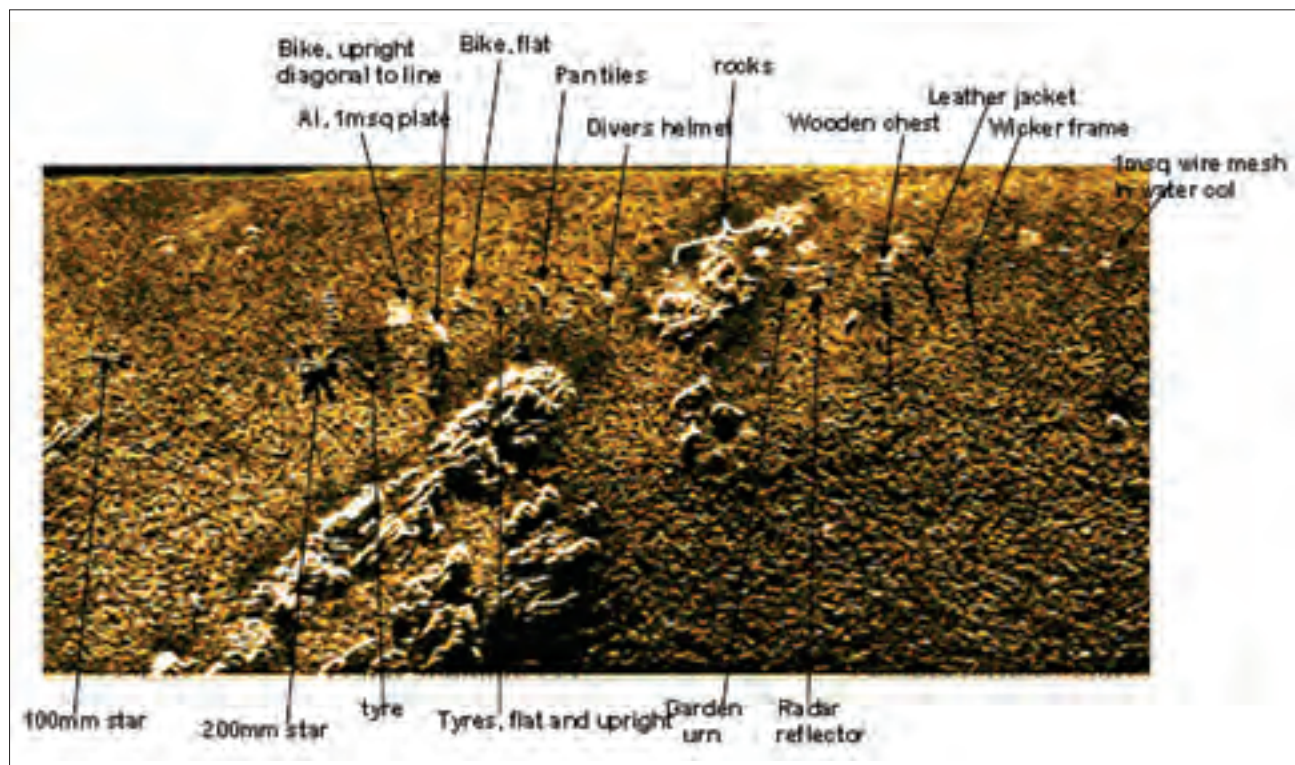


Figure 2a: Klein 3000 sidescan sonar image of the Plymouth test site

discrimination sonar AGDS (Lawrence and Bates, 2002), classified sidescan seafloor object recognition (Quinn *et al.*, 2005) and acoustic based sediment identification (Bates and Moore, 2002). The distribution of sediment types determined from sidescan sonar images has been recognised as having important archaeological implications (Duck, 1995). The effect on the acoustic response of the seabed (altered backscatter levels) from buried archaeological material has also been recognised (Fish and Carr, 2001). The field of marine acoustics is one of rapidly advancing technology and it was a major goal of the project to take best advantage of this in both hardware and software developments.

ENHANCED PROCESSING AND IMAGING METHODOLOGIES

Object detection and manual processing in sonar imaging can represent a considerable challenge because sidescan images vary in terms of intensity, scale and rotation, and are generally blurred with noise. Image 'denoising' is therefore necessary to remove the added noise while retaining as much as possible the important image features. Existing datasets from Belfast Lough were initially selected for use in testing advanced algorithms for automated data processing including scale saliency matching and scale-invariant feature transform techniques (Atallah *et al.*, 2005). Seafloor classification methods tested including Questar Tangent, and Sideview. The automated routines all proved to have

some utility in identifying anomalous areas but each technique still suffered from problems of noise contamination. Further testing on larger data sets is recommended for an evaluation of their full potential.

Through collaboration with Dundee University, new visualisation methods were tested on the data from the *Stirling Castle* and neighbouring wrecks. The basis of these methods has its roots in digital cinematography and the enhanced visualisations proved extremely beneficial to final data presentation. Furthermore, the output video can be easily viewed through a web-based front and it is therefore anticipated that it will be important in future information dissemination. Visualisations can be down loaded from the project web pages and example screen shots are given in figure 1 for four different surveys of the "Bowsprit Wreck" on the Goodwin Sands.

PLYMOUTH TEST SITE

In order to test the limits of different geophysical acoustic survey methods and to provide data for the development of automatic object recognition techniques an artificial test site was constructed in Plymouth outer harbour area in 2005. The site contained objects that might be found on maritime archaeological sites together with other easily identifiable target shapes. Following deployment the site was surveyed with multibeam sonar, sidescan sonar, swath bathymetry and

Rapid archaeological site surveying and evaluation

acoustic ground discrimination systems. The results showed not only the potential of the geophysical techniques but also highlighted a number of important procedural lessons for ensuring high quality data of a type that is most useful for archaeological evaluation. Figure 2a and 2b show the multibeam data and sidescan sonar image of the objects on the seafloor.

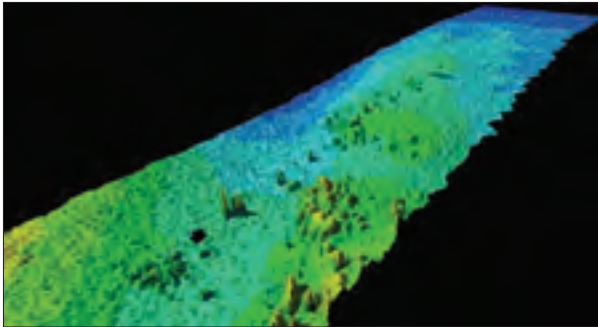


Figure 2b: Reson 8125 image of the Plymouth test site

It was found that the combination of ultra high resolution acoustic data types allows rapid and accurate modelling of exposed archaeological material on the seabed. Important lessons were learned from this investigation, in particular with the advanced use of the Reson Seabat 8125 multibeam sonar. With this instrument the advantages of reducing survey height above objects was clearly demonstrated. Following this investigation a series of recommendations were formulated for the use of acoustic techniques in order to obtain best results.

STIRLING CASTLE

Subsequent to the test site programme, the methodologies were deployed on a well known wreck site on the Goodwin Sands – the *Stirling Castle*. The *Stirling Castle*, lost in the Great Gale of 1703, is located on the Goodwin Sands, a series of banks off the East Kent coast that dry at low water and change shape on a periodic basis. Previous acoustic data collected over the site includes sidescan sonar and a high resolution multibeam data set collected in 2002 using a Reson Seabat 8125 sonar. Two further data sets were collected over the site in 2005 and two in 2006. Based on a comparison between the data sets it is possible to attribute changes in elevation of the surrounding seabed level to real effects, *i.e.*, the movement of sediment surrounding the site. It is also possible to monitor changes (deterioration) within the wreck site resulting from the wreck exposure.

The datasets suggest that between 2002 and 2005 several metres of sediment have accreted in places around the stern and to the north east of the wreck with a loss of sediment to the south (figure 3). This is most likely due to the ongoing collapse of hull structure at the stern port quarter of the wreck presenting less of an obstruction to the dominant north-easterly tidal flow and thereby diminishing scouring at the stern. Between 2005-2006 however relatively little change is apparent at the *Stirling Castle*. Conversely there was significant change at the 'bowsprit' wreck site located 700m to the south-west of the *Stirling Castle* during the period 2005-2006. It is clear that in addition to the larger scale changes in sediment regimes on the Goodwins which were responsible for the exposure of the wreck in the first instance, subsequent localised, site specific sediment movements are evident. The data evaluated for the wide area shows spatially different change on the site but the periodicity of change is still unclear. Environmental data for the site suggest the cause of changes over the time periods studied to be due to changes in current, wind and wave action. Despite the extensive use of multibeam on this site, understanding the true timescale of change would involve not only geophysical techniques but also the use of *in situ* instrumentation on the site for continuous recording of environmental parameters.

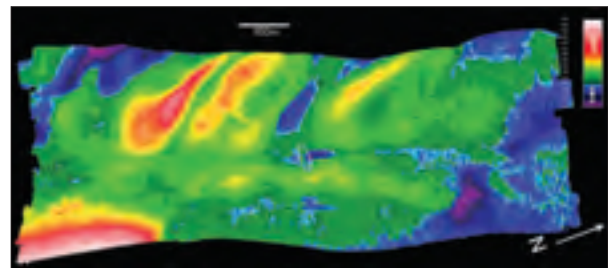


Figure 3: *Stirling Castle*-Area difference map August 2006 minus July 2002

In 2006 a new method of multibeam sonar deployment was built that allowed the acoustic head to be lowered closer to the target. The independent sonar head attitude and positioning system (ISHAP) provided an increase in the fidelity of the data thus giving far higher resolution images (figure 4). From the results of trials of this technique it is proposed that a method of routinely achieving a closer inspection of a survey site in the future would be a major advance for rapid marine archaeological survey and site management. Investigation of such methods including remotely operated vehicles (ROVs) and autonomous underwater vehicles (AUVs) is recommended for the future.

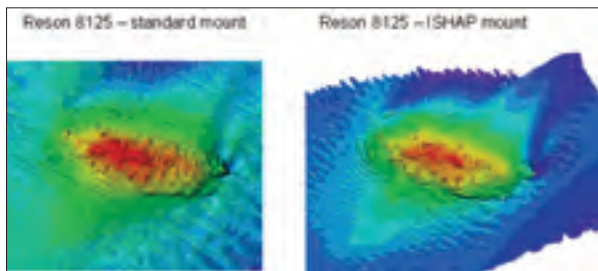


Figure 4: Difference of ISHAP sonar deployment to standard sonar deployment

CONCLUSIONS

The RASSE project has demonstrated that acoustic techniques can be used to investigate and monitor marine archaeological sites with the resolution necessary to quantitatively evaluate small changes on a site that ultimately could lead to site deterioration. In the future these techniques should form a routine aspect of wide-area investigation and detailed archaeological site investigation in order that the potential impact of anthropogenic activity such as aggregate extraction and natural cycles of change can be assessed more effectively. Furthermore, advances in acoustic processing techniques demonstrated the potential to provide new insights into the acoustic data that could offer not only enhanced discrimination of archaeological material but also offer significantly increased site investigation efficiency. In the future, these new techniques will provide crucial information for the long-term management of the submerged archaeological resource in UK coastal waters where there is increasing pressure from aggregate extraction as well as other commercial and recreational activities.

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Title: 3837 MAIN. Innovative approaches to Rapid Archaeological Site Surveying and Evaluation.

Contractor: University of St Andrews

Contact: Richard Bates

Telephone: 01334 463997

E-mail: crb@st-and.ac.uk

Full Report Site:

<http://www.st-andrews.ac.uk/rasse/>

<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

Wrecks on the seabed: Assessment, evaluation and recording

The 'Wrecks on the Seabed' project, funded through the ALSF and commissioned by English Heritage, had its origins in Wessex Archaeology's experience in the licence application process for marine aggregate dredging. This experience indicated that while methods for identifying actual and potential wreck sites from desk-based and geophysical prospecting data are fairly well-established, methodologies for subsequent stages of archaeological investigation are less well-developed.

'Wrecks on the Seabed' therefore focussed on trialling frameworks for the archaeological assessment, evaluation and recording of wreck sites within the context of marine aggregate dredging. Its primary aim has been to provide industry, regulators and contractors with a methodological framework and archaeological guidance relevant to the strategic requirements of industry for incremental, decision-oriented investigations of wreck sites encountered in the course of marine aggregate dredging. The availability of an efficient and cost-effective framework for archaeological assessment, evaluation and recording is particularly relevant when considering the cost and time implications of marine investigations. It is also important in promoting effective communication between industry, regulators and contractors regarding underwater cultural heritage.

Using a range of geophysical survey techniques, divers and Remotely Operated Vehicles (ROV) the project has addressed three levels of wreck investigation:

- Field assessment;
- Non-intrusive site evaluation;
- Rapid *in situ* recording.

The project was underpinned by a scheme of Recording Levels developed by Wessex Archaeology at the start of the project and based on the Royal Commission on the Historic Monuments of England's *Recording Historic Buildings*. Wessex Archaeology's Recording Levels define five levels of archaeological site assessment, evaluation and recording, each with different objectives and degrees of detail corresponding to the level of investigation. It is envisaged that these recording levels will provide regulators, curators and industry with a common standard for wreck assessments, and for briefs, specifications, project designs and method statements.

The research area for 'Wrecks on the Seabed' was defined taking into account proximity to existing or intended aggregate extraction areas off the coasts of Hampshire and Sussex, UK. This was in order to produce results that would be of relevance to the

aggregate industry, by addressing wreck sites where the environmental and seabed conditions would closely resemble the conditions that prevail in the nearby dredging areas.

Initial desk-based research in 2002 identified a sample of 22 generally unidentified wrecks, including both metal and wooden-hulled vessels, and aircraft, within the records of the United Kingdom Hydrographic Office. The subsequent fieldwork component of Round 1 of the project entailed geophysical investigations, including sidescan and magnetometer surveys, to produce baseline site data for 17 of these sites. This was followed by diving investigations and the assessment of nine sites by surface-supplied divers equipped with video, digital still cameras and underwater acoustic tracking.



Figure 1: Diver carrying out rapid recording of elements of the wreck of the SS Concha

In 2003, detailed magnetometer, sub-bottom and multibeam surveys of seven sites extended the geophysical fieldwork, whilst further *in situ* recording was carried out by diving archaeologists on three sites during the same year. The fieldwork conducted during Round 1 identified a number of logistical issues that hampered the efficiency of archaeological site assessment work.

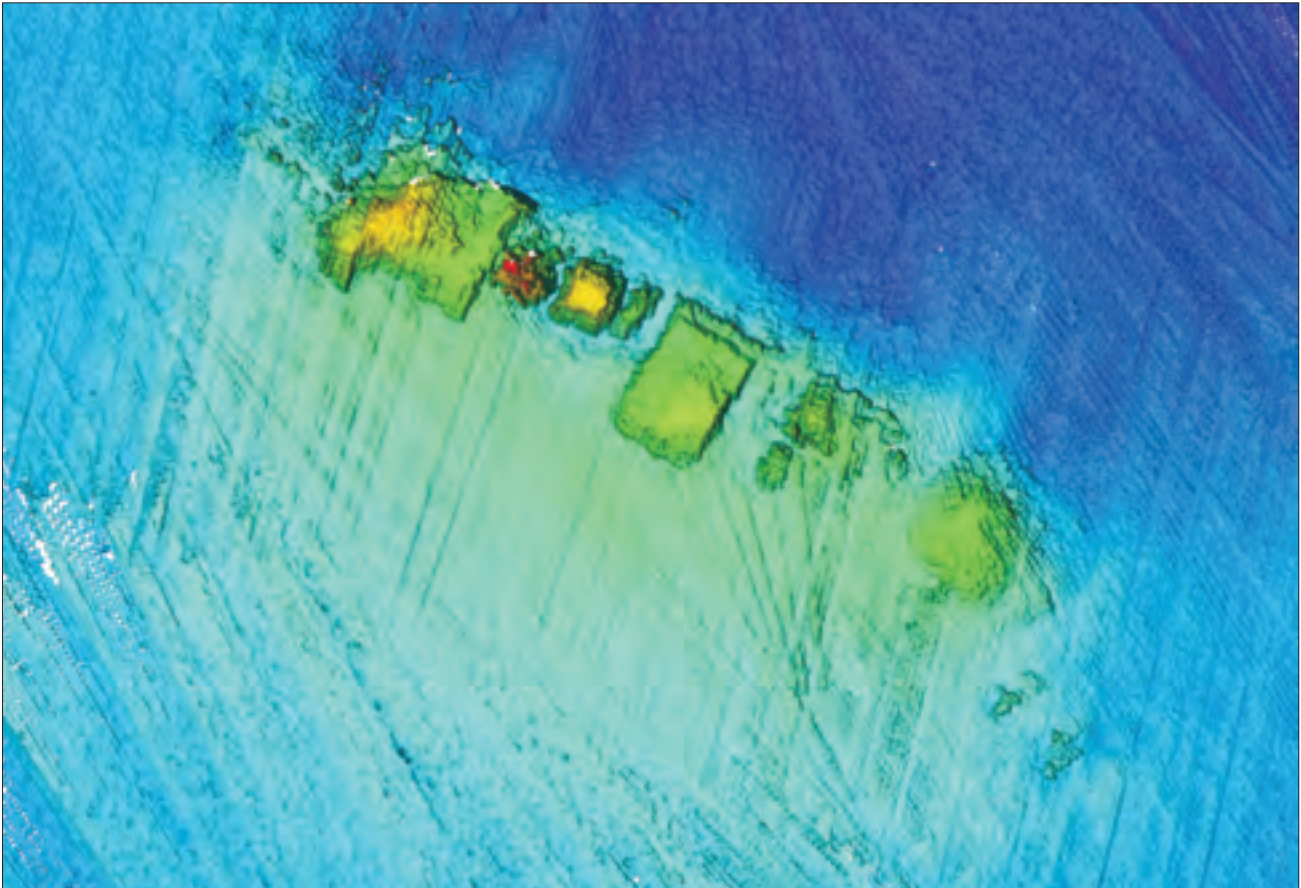


Figure 2: Multibeam image of the wreck of the SS Concha

Round 2 of 'Wrecks on the Seabed' took place in 2005 and 2006, during which the following aspects of wreck site investigation were addressed:

- The development of geophysical methodologies for surveying ephemeral wreck sites, based on a survey of a 2x2 km area of seabed off the Hastings Shingle Bank.
- The use of a larger ROV/diving support vessel to solve problems related to platform size encountered during diving fieldwork in Round 1.
- The ROV survey of four of the wreck sites investigated by divers in Round 1 – and further diver survey work on other sites – to compare the relative merits of ROV as opposed to diver-based methods of site evaluation and recording.
- The extension of both the geophysical survey and ROV assessment techniques developed earlier in the project to wreck sites in more than 45m of water as a basis for the development of effective methods for assessing, evaluating and recording wreck sites in deeper water.

The 2x2 km area survey trialled different geophysical survey equipment and specifications over a variety of charted wreck sites within a specified area, and also over an area of the seabed thought to contain an ephemeral wreck site; the Thomas Lawrence, lost in 1862. Sidescan sonar surveys were conducted at a variety of ranges and frequencies to find the optimum settings for the detection of archaeological anomalies, whilst balancing survey costs and data quality. The work has allowed comparison of sidescan and magnetometer survey specifications and further development of methodologies for identifying ephemeral wreck sites.

As most of the problems encountered in diving fieldwork during Round 1 were related to the size of the diving vessel, a larger ROV/diving support vessel was employed in Round 2. It was found that the increased cost of the larger vessel was outweighed by the benefits derived from being able to keep the vessel and diving/ROV teams on station for extended periods in a wider range of weather and sea states. Fieldwork time was also optimised by the reduction in transit times, and the opportunity to exploit more of the available slack water diving windows.

Wrecks on the seabed: Assessment, evaluation and recording



Figure 3: Launching the ROV. Note the USBL transponder attached to the rear of the ROV

Round 2 ROV and diving operations were conducted on seven wreck sites. The ROV surveys were carried out with a view to developing methodologies for the archaeological use of ROVs and to compare the effectiveness and cost efficiency of ROV- against diver-based methods. Diving operations evaluated the infrastructure needed for rapid, cost-effective archaeological site surveys. This fieldwork developed improvements to diver-based recording methods, including underwater videography and photography.

Throughout the project a Sonardyne SCOUT Ultra Short Baseline (USBL) acoustic tracking system was successfully used for positioning divers and the ROV. Wessex Archaeology also used a Microsoft Access-based diver recording system known as 'DIVA' which it developed as part of the project to manage and record archaeological diving operations in real time and three-dimensions, integrating tracking and geophysical data with diver observations and records.

The geophysical and ROV survey of three sites in deeper water in Round 2 highlighted constraints in the gathering of geophysical data for such sites, which Wessex Archaeology hopes to address further in future. It also demonstrated that the methods developed for rapid ROV surveys of shallow water sites are transferable to deep wrecks and confirmed that a ROV survey can be an effective method for archaeologically assessing, evaluating and recording wreck sites to a certain level of detail.

Draft guidelines for the rapid assessment and evaluation of wreck sites were produced following both rounds of the project, and it is anticipated that they will be formally published to provide assistance to industry, regulators and contractors in specifying and designing projects that have an archaeological component.

A series of six Diver Information Packs have been produced from the results of the project. Each pack consists of a brochure on the history of the site in question, a Diver Report Form, a waterproof site plan and a multimedia CD. The Diver Report Form consists of an annotated site plan of each wreck and a site recording form. The site plan will serve as a guide for divers when visiting the site, whilst the recording form is aimed at encouraging divers to record further information about the site that can be included in archaeological records. It is hoped that these packs will serve not only as a means of disseminating archaeological information about the sites to the diving and non-diving public alike, but also as a mechanism for collecting further archaeological and environmental information about the sites concerned, which will improve the existing record of these sites and aid in their long term management.



Figure 4: Diver and/or ROV tracking and recording

CONCLUSIONS

'Wrecks on the Seabed' set out to provide industry and regulators with a framework for the incremental, decision oriented investigation of wreck sites and with guidance methodologies for their rapid archaeological assessment, evaluation and recording. Using the idea of a staged approach to shipwreck assessment, evaluation and recording, the project addressed every level of this process, from initial desk-based assessment to geophysical survey and diver/ROV survey.

The geophysical aspects of the project have helped to develop guidelines and specifications relating to wide area geophysical surveys such as are generally carried out in advance of marine aggregate extraction, and to deep geophysical surveys. The project has attempted to develop survey specifications that are commercially viable but which will produce data that is detailed enough for archaeological purposes.

The diving and ROV sections of the project have demonstrated the relative merits of each and suggested that an idealised scenario would be the combined use of ROV and divers for site assessments. The time consuming task of obtaining an overview of a wreck and defining its extents is most efficiently carried out by the ROV, allowing divers to then concentrate on the detailed recording of selected elements which are not as effectively recorded using the ROV. Such detailed wreck survey - to Level 2a/3a of the Recording Levels - can help to establish the character, date and extents of a site which, using the Importance criteria developed in another Wessex Archaeology ALSF project - 'On the Importance of Shipwrecks' - are central to the creation of statements of significance for wrecks.

Title: 3877MAIN. Wrecks on the Seabed:
Assessment, Evaluation & Recording

Contractor: Wessex Archaeology Ltd

Contact: John Gribble

Telephone: 01722 326867

E-mail: j.gribble@wessexarch.co.uk

Full Report Site:

http://www.wessexarch.co.uk/projects/marine/alsf/wrecks_seabed/index.html.

<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

Enhancing our understanding of the marine historic environment: Mapping navigational hazards as areas of maritime archaeological potential

INTRODUCTION

Bournemouth University was commissioned in 2005 by English Heritage, and funded by the Aggregate Levy Sustainability Fund, to undertake a project entitled *Mapping Navigational Hazards as Areas of Maritime Archaeological Potential*.

The project used historical records of navigational hazards to interpret and characterise the hazardous nature of the marine environment. The trends identified from historical records have been mapped as character areas and combined with a model of the preservation potential of marine sediments in order to identify areas where a high potential for ship losses coincides with a high potential for preservation of archaeological materials. These areas, known as *Areas of Maritime Archaeological Potential* (AMAPs), and the characterisation on which their interpretation was based, has provided the basis for developing an interpretative spatial tool for assessing the potential for shipwreck debris on the seabed.

MEETING GOVERNMENT PRIORITIES AND ALSF OBJECTIVES

The development of a method for characterising the potential for the maritime archaeological resource to exist and survive in different seabed environments is vital to improving the assessment of potential impacts of aggregate extraction on the historic environment and developing a long-term strategic approach to the management of marine historical assets. The results of the Navigational Hazards project represent the foundations for the development of a GIS-based, quantitative method for assessing the archaeological potential for shipwreck material in the marine environment.

The core objective of the English Heritage ALSF scheme is to reduce the impact of aggregate extraction on the marine historic environment. The Navigational Hazards project has provided a firm basis for the characterisation of the potential for the presence of archaeological materials in different marine environments, by developing a management tool to assist industry, regulators and curators in giving guidance on the possible impact of different types of aggregate extraction on the marine historic environment.

The project output will significantly improve our understanding and ability to *assess the potential impact and the significance of aggregate extraction on maritime heritage assets, thus improving efficiency during the planning process, enabling areas of increased archaeological potential to be identified and promoting a better understanding of the processes which affect historical assets within aggregate licensed areas* by integrating known archaeological evidence with environmental data which affect how wrecksites degrade.

The project aim addresses the following priorities listed in Taking to the Water which sets out English Heritage's strategic priorities for the marine historic environment (Roberts & Trow, 2002):

- (a) to enhance and validate the Maritime Record through desk based survey (para 12.5 point 1)
- (b) to undertake National evaluation studies to characterize poorly recorded or little understood elements of the seamless maritime cultural landscape (para 12.5 point 7)
- (c) to develop methodologies that can help seabed developers meet their obligation under the Environmental Impact Regulations to identify underwater cultural heritage and mitigate damage incurred in the course of their activities (para 12.5 point 9)

SYSTEM DEVELOPMENT

The aim of the project was to use the UK's extensive hydrographic archives, including charts, sailing directions and pilotage notes, and modern seabed geology mapping to identify and map Areas of Maritime Archaeological Potential (AMAP), areas where high potential for shipwreck losses coincide with areas of high preservation potential.

This was achieved by designing a staged methodological approach to drawing data from sources which informs us on the nature, recording and historical importance of navigational hazards in English waters and creating a format which allows the data to be combined with a sediment stability model in order to produce AMAPs. The data has been translated into a modern context and presented in a format which is compatible with modern

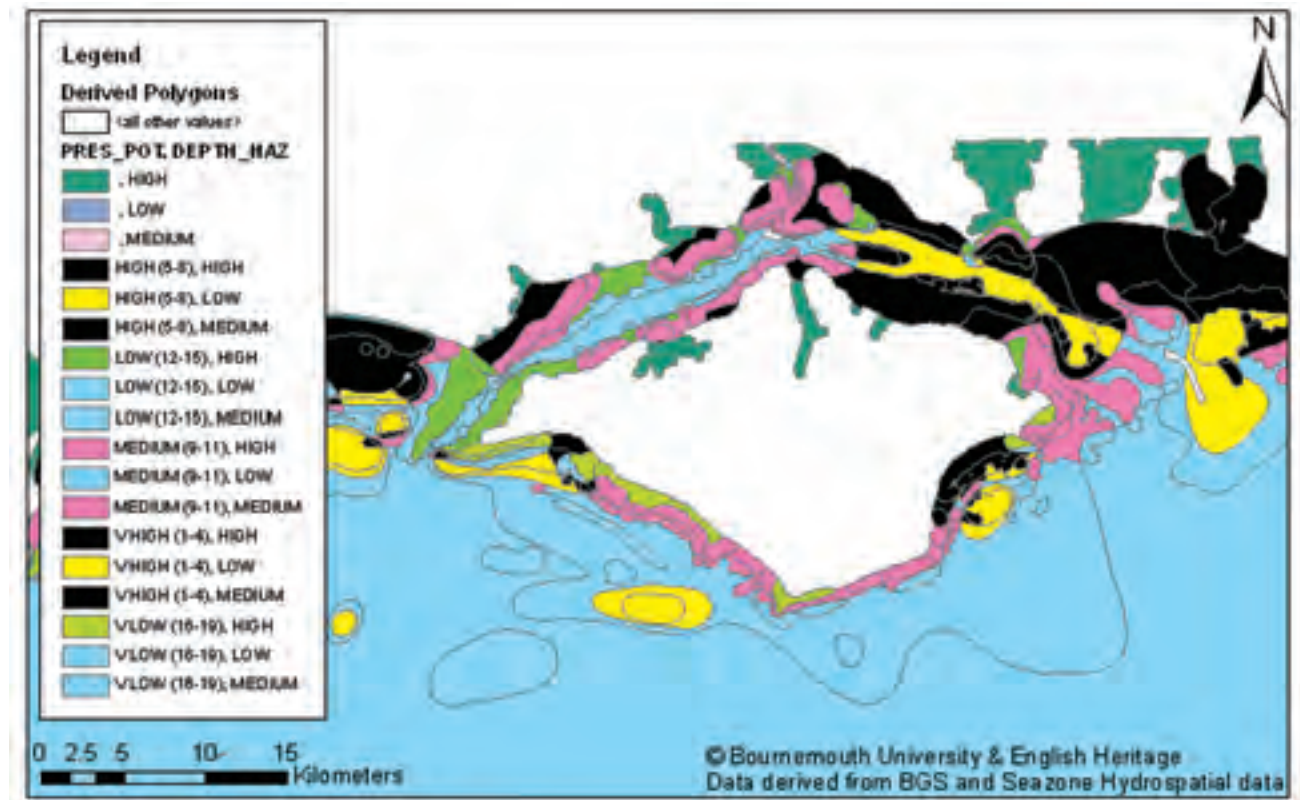


Figure 1: Character polygons derived from Seazone and BGS data showing areas graded by their preservation potential and level of hazard from shallow waters*

marine spatial planning datasets so that it can be integrated with them for the process of marine spatial planning.

The overall aim of the project was achieved by meeting the following objectives:

- Identifying and mapping navigational hazards from historical records within the project area and relating them to their modern equivalent features within the project geodatabase
- creating character polygons to reflect the interpretation of navigational hazards to characterise the hazardous nature of different marine environments
- Developing a model to reflect the preservation potential of the various geological forms shown on the BGS offshore seabed mapping
- Identifying areas of seabed where high potential for shipwreck losses coincide with high potential for preservation of archaeological materials

The project has produced a GIS system which can be put to immediate use in informing industry, regulators and curators on the potential impact of aggregate extraction and other intrusive industrial activities on the

unrecorded archaeological resource on the seabed. In addition to being in use in its current form, the results are being used as the basis for a continuation project which will further refine the interpretation of AMAPs through the integration of additional marine data.

PROJECT RESULTS

Following the completion of a Source Appraisal (Merritt *et al.*, 2005) and a pilot study (Merritt *et al.*, 2006) focusing on the Solent area, a method has been developed which identifies areas with a high potential for ship losses based on historical data. This model has been combined with a sediment stability model produced for the project in order to highlight *Areas of Maritime Archaeological Potential* (AMAPs).

The results of the Source Appraisal highlighted the spatial inaccuracies of historical data sources, suggesting that charts preceeding 1800 cannot be accurately georeferenced. Data from inaccurate historical sources can be mapped if a method is put in place to translate them into an accurate modern spatial context.

Enhancing our understanding of the marine historic environment: Mapping navigational hazards as areas of maritime archaeological potential

The accuracy issues were linking the historical data to their modern equivalent features in the project database. Only the modern features and the character polygons produced for the interpretation of trends in navigational hazards have been displayed in the project GIS as the display of inaccurate historical data would be misleading to the end-user.

Two sets of character areas have been produced to display the results of the project. A set of drawn character polygons were produced to reflect a summary of the trends in navigational hazards recorded in historical sources. The identification of trends has enabled a typology of broad hazard character areas to be developed to provide a basis for the development of AMAPs.

A second set of polygons were derived from Seazone Depth-areas and BGS DigMapGB – Offshore250 Seabed Sediments theme (SBS) to reflect the potential for preservation and direct risk from shallow waters (Figure 1). The AMAP polygons were extracted from this data layer to produce a more refined set of polygons which reflect the variables that define them and could be overlaid with the drawn character polygons (Figure 2).

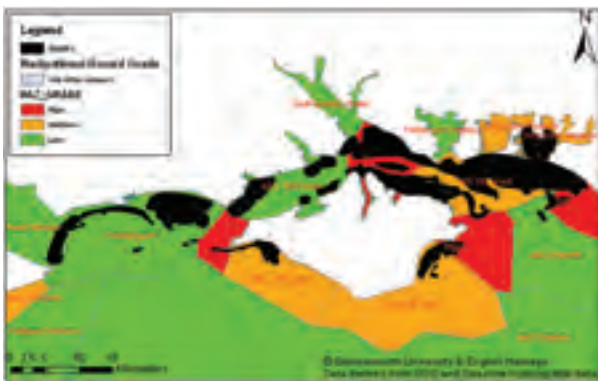


Figure 2: Areas of Maritime Archaeological Potential (AMAPs) shown in the context of the overall grade of hazard of different sea areas*

The results of the assessment suggested that areas where risk from shallow bathymetry, high numbers of hazards and exposed coastlines coincide with the presence of fine grained sediments, such as muds and sands, have a higher potential for the presence of archaeological materials within seabed sediments.

Therefore, the areas identified as AMAPs, within the scope of the project and the data used, include approaches to estuaries, offshore mobile sandbank areas and some coastal areas where a high density of navigational hazards coincides with the presence of fine grained sediments. Areas characterised by coarse grained sediments with high gravel content will have a comparatively lower potential for preservation than sediments with a high sand content, due primarily to the reduced potential for rapid burial of shipwreck remains (Merritt *et al.*, 2007, Appendix 1).

It is however important to note that there are limitations to such a model. The areas reflected in the results highlight areas with particular potential for loss and preservation, and the project takes into account the hazardous character of different sea areas. The model cannot however quantify the potential for loss in deeper areas where the risks to navigation are more likely to be due to large storm events and, with the advent of steam driven vessels from the 19th century onwards, collisions. The model also does not take into account the potential for losses through human action such as warfare. The potential both for ships losses and for preservation of materials also depend on other variables than sediment type and the nature of hazards in a sea area.

The results of the data will be produced for the National Monument Record, the public archive of English Heritage. The system has already been put to use for characterising and informing the English heritage Maritime team on the potential for loss and preservation of archaeological materials for areas surrounding designated wreck sites. It is also being proposed that the system be independently trialled for development-led impact assessments by the *Hampshire and Wight Trust for Maritime Archaeology*, in order to provide feedback which can be used to enhance the ALSF-funded AMAP1 project methodology. The feedback received will be used in the development of the AMAP1 project.

FURTHER RESEARCH

A proposal has been put forward to continue to develop and refine the method for assessing archaeological potential through the identification of AMAPs. The AMAP1 project will build on the conclusions of the Navigational Hazards project, integrating the results with

available data on the preservation potential of marine environments and with a quantitative analysis of the potential significance of shipwrecks scatters.

This will make best use of results of Hazards project to further refine the assessment and characterisation of the potential for shipwreck remains within different types of marine environment. In addition, the results will be integrated with those of the ALSF project "*Development of a Regional Sediment-Erosion Model for submerged Archaeological Sites*" undertaken by Southampton University, in order to highlight further research.

From the perspective of potential for preservation, key variable which need to be taken into account include seabed mobility and the depth of sediments mapped by the BGS. The results may prove different if a shallow layer of sand has been recorded (using shallow grab samples) over a deeper gravel substrate.

From the perspective of risk to shipping, it is also vital to take into account the potential for shipping to be travelling within an area of seabed. Although there are inevitably isolated occurrences of vessels making unscheduled stops in ports and harbours due to human error or for emergency purposes, the potential for shipping in an area is primarily dependent on the presence of ports and harbours, the scale of activity and the size of vessels frequenting them. The incorporation of additional datasets reflecting scales and nature of harbour activities and a reclassified wrecks and obstructions dataset which takes into account potential biases in data gathering can only enhance a dataset which has proven to highlight recurring trends in environmental parameters which do affect the potential for AMAPs.

The results of this quantitative approach to mapping archaeological potential, based on the spatial analysis of the relationships between archaeological records of shipwreck data and available environmental data, will complement the qualitative assessments of the perceived human character of the marine environment, undertaken via the Seascapes initiatives. Providing a rounded set of planning resources for assessing the potential impact of aggregate extraction on the unrecorded archaeological assets.

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Title: 3917MAIN. Enhancing our Understanding of the Marine Historic Environment: Mapping Navigational Hazards as Areas of Maritime Archaeological Potential

Contractor: Bournemouth University

Contact: Olivia Merritt

Telephone: 01202 965452

E-mail: omerritt@bournemouth.ac.uk

Full Report Site:
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

Identification of historically important shipwrecks

The aim of the Identifying Shipwreck of Historic Importance project (ISHI) was to use the copious, fairly consistent and relatively easily accessible historic data which surrounds England's post c1760 shipwrecks to enhance our understanding of the English Shipwreck record (ESR) and thus to facilitate the identification of the archaeologically important sites which lie within England Marine Historic Environment. This enhanced understanding will allow the industry to make informed decisions about how to best manage, and mitigate against the destruction of sites that lie within aggregate extraction areas.

The maritime component of the National Monument Record (NMR) was compiled from non-archaeological sources during between 1991 and 1996 and involved in excess of 10 person years of research and data entry. It is split into three basic components of data type, located wreck sites, which form approximately 19% of the record, unchecked features and anomalies regarded as potential wreck sites which form approximately 27% of the record and documentary record of casualties for which no archaeological evidence is currently available, which form approximately 54% of the record (Trow, 1999). The major archaeological component of the record therefore are the located shipwreck sites of which 95% are primarily large upstanding relatively modern iron/steel structures whose size has enabled relative ease of detection. These sites are the remains of ships mainly lost between 1845 - 1945 and although some of these sites may be nothing but scrap metal, many could just as easily be important industrial structures or the remains of ships that played a major part in world history.

The National Monument Record for these located sites consists primarily of a list of known wreck sites with some very limited accompanying data. This includes a position and some very brief details which are largely orientated around the loss event. Where the name of the site is known, which is in approximately 50% of cases, this is given as well as a date of loss, either to a single day, a year or group of years. For example for the site of the Orchis the record tell us that the site consists of the 'Remains of British cargo vessel lost on 30th November 1935 close to Owen Rock near Pencarrow Head in position 50 16.68N 04 34.43W whilst carrying a cargo of china clay from Par to Aberdeen via Dundee'. In addition a number of sites are known to be missing, for example, the two sites that form the wreck of HMS Warspite, arguably the most famous British warship of the 20th century, are not contained within the record.

In 2005 English Heritage commissioned another ALSF project to be undertaken by Wessex Archaeology entitled On the Importance of Shipwrecks project (OIS) (Wessex Archaeology, 2005). They defined five criteria that represented all phases of a ship's 'career' covering build, loss, survival and investigation on which the relative significance of a site could be judged. The OIS project set out to establish the importance of individual sites by asking a series of questions relating to the criteria listed above which were designed to consider the full range of possible areas of interest that may be associated with a shipwreck. These questions, such as 'Were there any significant features or innovations in the methods employed to build the vessel', whilst relatively simple in themselves they require a great deal of research before they can be answered. In order to establish these significant features the intended purpose of design, time and location of construction, and builder of the vessel need to be established. In addition to these, the place of that design in shipbuilding development, the builder's reputation and the number of other surviving vessels of similar design also need to be identified.

The completion of the OIS project created a situation where the maritime archaeological community had a set of criteria with which to establish the significance of individual shipwrecks and a list of known shipwrecks which did not contain the information needed to use these criteria. In addition the OIS project also demonstrated that the broad knowledge required to make these judgments is very rare in the UK's maritime archaeological community.

No structured attempt has been made to provide a base level of information about English (or indeed British) shipwrecks in the way proposed by the ISHI project. The project used a methodology adopted from smaller projects by using data extrapolated from shipping registers and other documentary sources to enhance the current record to the point where it is capable of answering the questions posed by the criteria detailed above. Importantly it aims to do this on a national scale as the moveable and international nature of shipping means that the significance of individual sites can only be established by reference to other comparative sites that may be spatially well removed from each other. Because of the large volume of data to be collated and classified for this work, the project was originally split into a number of self contained stages, the first of which – started in March 2006 for conclusion in March 2007 - involved the initial capture of data from primary and secondary sources. Only those sources which were believed to be relevant to vessels known to be lost in English waters were to be used. These sources were

chosen to provide information about the criteria listed in the OIS project. This process seemed easy enough at the outset of the ISHI project. But as the project developed the experience of those working on it grew and relationships with staff at maritime archives were established it became clear that because of the breath of the ESR there were many other primary or secondary sources that should also be consulted. The consequences of this were that much more time than initially was considered would be needed to be spent on data capture and input.

Once this position was taken into consideration, the sources utilised are listed as: Lloyd's Register of British and Foreign Shipping, Lloyd's War Losses – The Second World War, The Mercantile Navy List, Shipwreck Index of the British Isles, British Vessels Lost at Sea (1914-18 & 1939-1945), Ships of the Royal Navy, World War One Channel Wrecks, Wartime Disasters at Sea, British Merchant Ships sunk by U-Boats in the 1914-1918 War, (County) Diver Guides.

Once this position had been established it was hoped that data capture would run smoothly from this point onwards. However further problems were encountered with the quality of the NMR data. A considerable amount of the data present within the record was often problematic, either being incorrect, too general either by name or date of the loss, and far too often the information about the ship were missing or too vague, when cross-checked with some of the sources mentioned above.

In order to explain only a few of the problems encountered first we should explain how the basic reference guide for merchant ships, Lloyd's Register of Shipping works. The first existing volume of the register dates from 1764, other surviving volumes date from 1768 (letters M-Z only, updated in manuscript to 1771), 1775-1784, 1786-87, 1789-1802, 1803, 1804-1806, 1807, 1808-1816, and 1818 to date. Between 1800 and 1833, two separate registers were issued, but in 1884 steamers are in roman and sailing vessels in italics, in 1885 there is only one volume which doesn't specify what category is including, in 1878 sailing vessels weren't included and further changes are found again later on when 3 volumes appear (1888-89 for example). Within these volumes the order and division of the vessels also changes, going from all inclusive to a division between steamers of more or less than 300 tons, and sailing vessels. Lloyd's Register has been published annually since at least 1775 and since 1834 it has been published in the middle of the year, covering the following period 1 July through 30 June. Again very often in the NMR this information is missing or entered wrongly and therefore the search for matching the right

vessel to the right wreck is lengthy, and requires the consultation of different volumes in subsequent years. Between 1786 and 1871 British vessels were forbidden from changing names; but from 1875 the volumes include the list of name changes. This of course raises the point of retrieving information from the sources before and after the change happened as these changes are not always reported. In addition it was common to find spelling differences between the NMR list and the sources consulted. Often, but not always these differences involved foreign vessels and this lack of clarity caused doubt if it the same wreck/vessel. Examples included Oil Trader (NMR) and Oiltrader (Lloyds), Arina (NMR) or Arinia (Lloyds), Broad Main and Broadmayne (alphabetically not close in the list), and so on, but perhaps is more confusing and time wasting exercise to try to understand if Marie Marguerite (NMR) and Marie Margaretha (Lloyds) are the same vessel. If the names do not help much, the information provided helps even less as on the database is described generally described as "possible remains of cargo vessel, 1924". If the true identity or character of the shipwreck cannot be established any use of historic data to establish its significance could be very misleading.

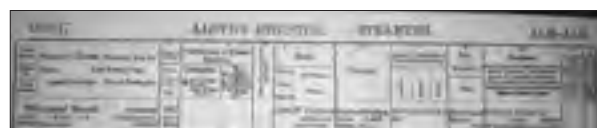


Figure 1: Lloyd's 1917 entry for the Almond Branch

The collection and collation of the data from the Lloyd's Shipping Registers has therefore proved to be not straightforward and smooth to start with, but once the right vessel had been positively identified, the entry of the information in the new database, would run without major hiccups. On the other hand, this could not be said for the extrapolation of the data from sources like dive site guides produced by the diving community: here, the vessels were easily identified but the volume of unformatted free text included within these sources made the extraction of relevant useable data very lengthy, but never the less a key part of the data collection process.

The ISHI project has overcome these problems in a relatively short period of time. It has dramatically increased the level of data held within the NMR to a point where it has been expanded beyond a list and the basic details of most of the sites contained within it. In the example of the Orchis referred to above, we know that this British cargo vessel was in fact a 483ton 45m long coastal cargo vessel built by R Cock & Sons of Appledore in Devon in 1918 and owned at the time of loss by British Isles Coasters Ltd of Cardigan in South

Identification of historically important shipwrecks



Figure 2: Image of the Steamer Orchis

Wales. Her remains lie in 45m water and are semi intact with her stern heavily damaged and her midships and bow reasonably intact for a vessel that sank 71 years ago. She may in fact be one of most intact surviving examples of a type of vessel that carrying much of the UK internal maritime trade for the bulk of the 20th century. This point could only be established by reference to the other vessels of a similar type, of which there are as many as 100 currently in the record. Her date of build and type suggests that she may in fact be development that was fundamental to the survival of the United Kingdom in the 20th centuries two world wars, (arguably more that the Spitfire but that's a point for another time) and her loss may hint at changes in social norms within the seafaring community brought on by the depression of the 1930's, again only further research could establish these points.

In less than 2 person years the project has potentially turned the NMR known shipwreck record from a list of names and dates to a dataset on which the foundations of a system to with which we can start to make

judgements as to the individual significance of shipwreck sites. Further work is needed in order to fully examine the record against the significance criteria already set, but we have more than passed the position where this has started.

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Title: 3916MAIN. Identifying Shipwrecks of Historic Importance lying within Deposits of Marine Aggregate

Contractor: Bournemouth University

Contact: David Parham

Telephone: 01202 965452

E-mail: dparham@bournemouth.ac.uk

Full Report Site:
<http://ads.ahds.ac.uk/project/alsf/>



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Mitigation & management of marine aggregate dredging

INTRODUCTION

The extraction of marine aggregate from the waters around England and Wales can be traced back to the 1700's. Barges were beached at low water, and gangs of men used shovels to load them with sand and gravel for use as ballast in unladen sailing ships. This activity was licensed by Trinity House, and for a period of time marine sand and gravel extraction represented one of the organisations main sources of income.

Three hundred years later, the British marine aggregate industry represents a mature offshore development sector, with over 70 production licence areas totalling a.1250km² from which over 20 million tonnes of marine sand and gravel are dredged each year. Rather than providing ballast for sailing ships, the sand and gravel won by the modern industry supports the maintenance and development of the modern built environment in which we all live. Increasingly, marine sand and gravel are also being used to protect both built and natural environments, by supplying large scale coast protection schemes.

The ability of the industry to supply large volumes of a low value bulk material close to the point of demand results in some important environmental benefits to be

realised – not least of which is a reduction in lorry traffic on the roads. However, marine sand and gravel extraction comes with its own set of environmental impacts and is by no means an easy or soft option when it comes to supplying the construction aggregates required to underpin our modern society. While there may be a perception that the activity takes place 'out of sight, out of mind', the assessment and management techniques which are employed ensure that the activity is subject to a degree of rigour which is comparable to any other industry sector.

THE ROLE OF THE MARINE ALSF AND KNOWLEDGE

Although the industry is a mature sector, concern, knowledge and understanding of the environmental issues associated with marine aggregate extraction have continued to develop. While this evolution could be interpreted as a threat, the marine aggregate sector has in fact viewed this as an opportunity as it provides confidence in the future and results in adjustment – probably reduction - of regulatory concerns. This development of confidence in understanding is good for both industry and regulators. For industry it allows sound operational practice to be developed and robust company and investment planning decisions to be

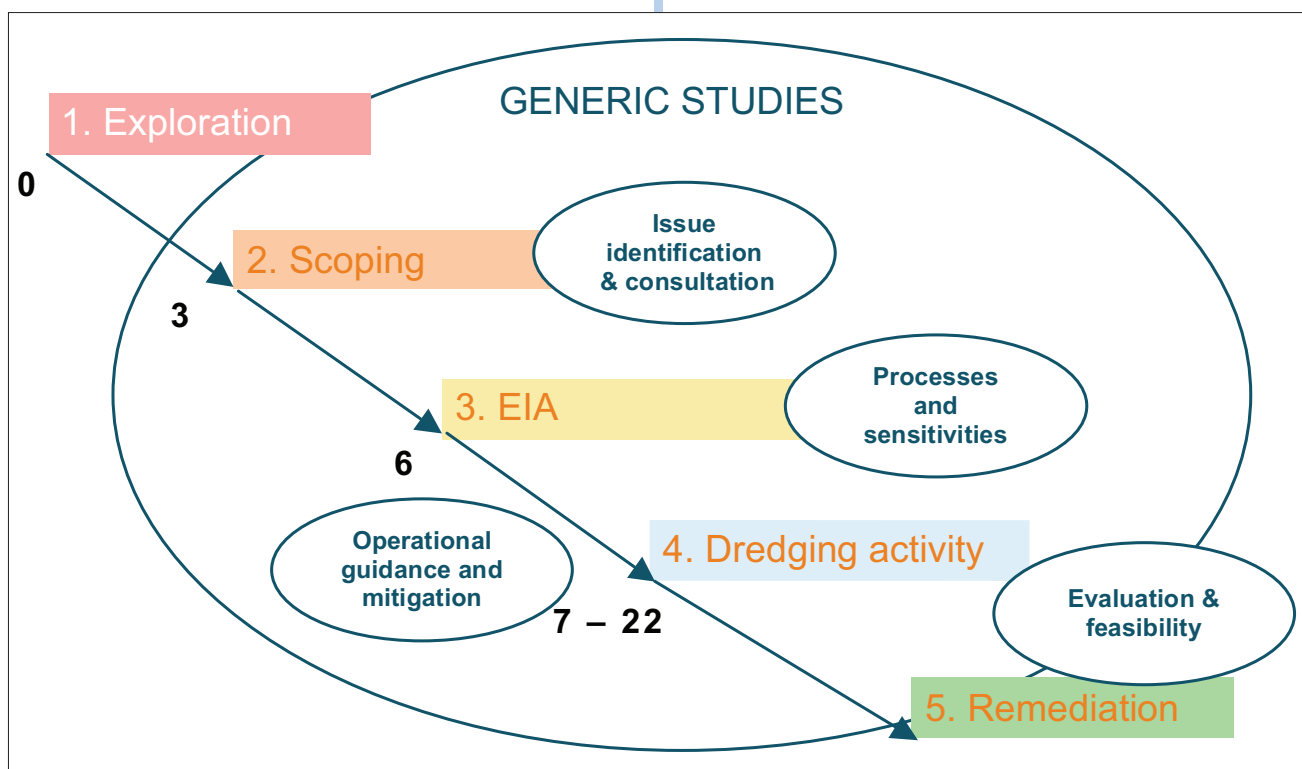


Figure 1: The activity lifecycle of marine aggregates, highlighting key issues against a timescale in years.

| Activity stage | Project examples | Focus |
|----------------------|--|---|
| 2. Scoping | Seabed Prehistory (SAMP 2.43) Regional Marine Landscape Characterisation Seabed and Inshore Fishing (MAL 0020) Regional Mapping Studies (SAMP 2.06, MEPF 04/01) | Background context – either generic or specific – against which a range of potential issues can be considered, including heritage, fisheries, habitats, and sea bed sediments and processes |
| 3. EIA | Recovery of habitats (MEPF 04/00, 04/02) Detecting reef/cobble features (MAL 0008, 0027) | Site specific significance and determination of risk |
| 4. Dredging activity | Modelling exclusion zones Protocol for reporting archaeological finds | Methods for site specific management and mitigation |
| 5. Remediation | Use of shell to speed recovery (MAL 0004) Potential of gravel seeding for restoration | Feasibility testing |
| Across stages 1-5 | Marine aggregates & biodiversity (MAL 0018) Mineral Wealth Seabed Health (MAL 0007) Solent aggregates to outreach | Contribution to wider stakeholder awareness and understanding |

Table 1. Examples of projects and their relevance to the marine aggregate activity lifecycle.

made. From a regulators perspective it results in impacts being minimised and ensures protection of key marine features, habitats and species. The Marine Aggregate Levy Sustainability Fund (MALSF) has therefore contributed significantly to the environmental knowledge and understanding of marine aggregate dredging.

Elements of the evolution of understanding have been driven by concerns and the increased awareness of the government regulators and their scientific advisors. Other aspects have been driven by the industry themselves. In both cases, the end result is essentially the same – continuous improvement of the way in which marine aggregate activity is managed. Knowledge is important at all phases of the activity lifecycle of the marine aggregate business and the MALSF has contributed to understanding in a range of areas (Figure 1). Research increases our understanding in both the short- and longer term, provides a regional perspective in places and complements the detailed analyses already undertaken by the dredging industry for environmental statements and monitoring programmes, for example in the eastern English Channel. Some specific examples are outlined in Table 1, although many projects have relevance across various stages of the activity lifecycle in a range of locations.

ENVIRONMENTAL IMPACTS

The effects of marine aggregate extraction are essentially disturbance related – whether directly, as a result of the removal of seabed sediments, or indirectly as a result of sediment returned to the seabed through plumes. Although the scale of production activity is managed to minimise the spatial footprint (a.130km² seabed dredged in a typical year), the location of many production licence areas in the congested nearshore zone means that the potential for spatial conflict with other marine users also remains a key issue which has to be managed.

The final aspect that has to be considered by the industry is that of stakeholder engagement. The regulatory process relies upon multiple phases of consultation in order to identify issues that need to be addressed through the assessment process. Therefore, the ability to clearly demonstrate the risk and significance associated with a development based on robust scientific evidence is essential, as is the ability to clearly communicate often complicated scientific results in a manner which is both accurate and understandable to a wider non-scientific audience.

Mitigation & management of marine aggregate dredging

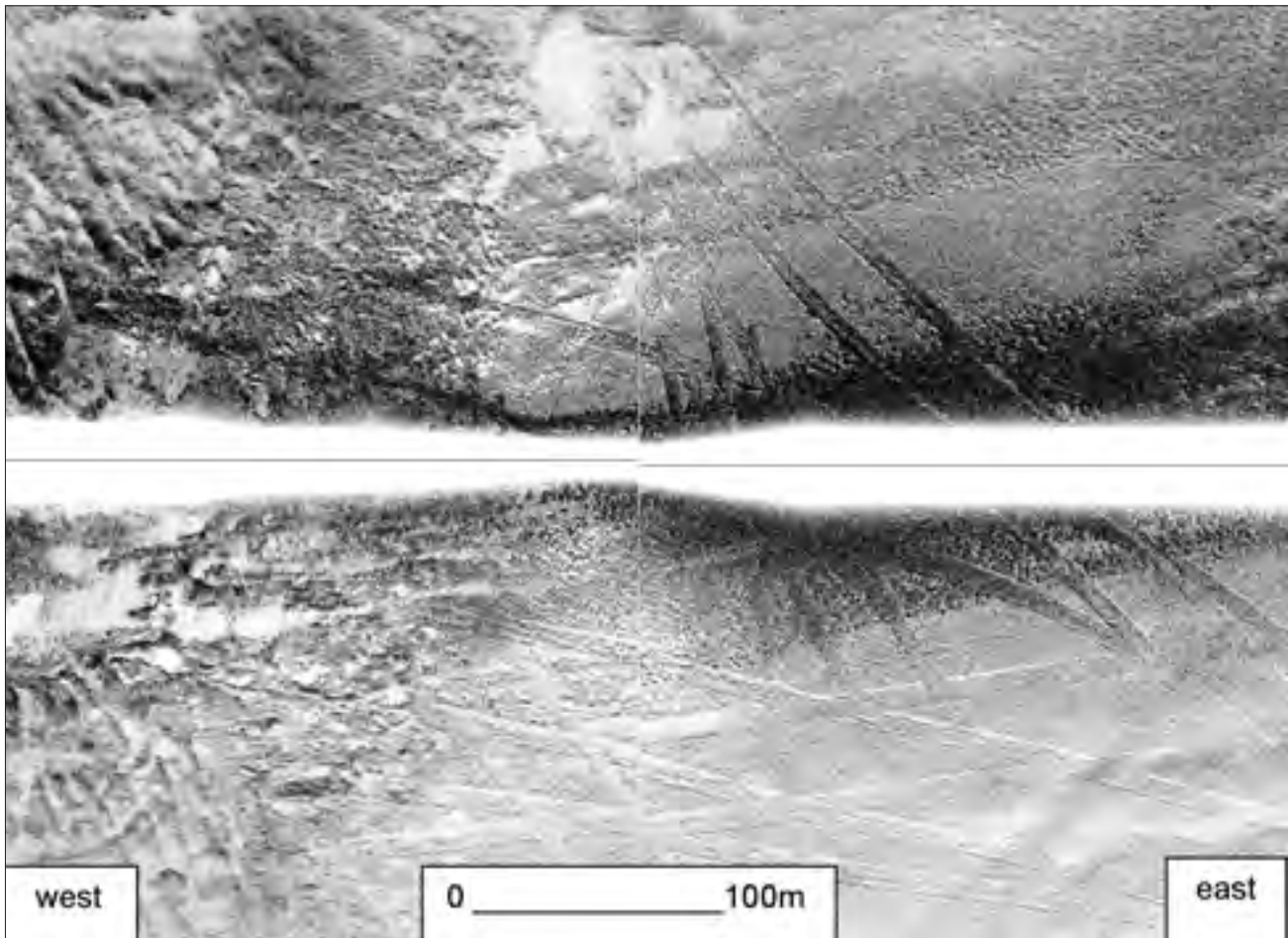


Figure 2: High resolution side scan sonar image of the Hastings aggregate dredging licence. Note the aggregate dredging to the west, mottled sea bed reflecting the *Sabellaria* sp. and beam trawling possibly targeting the reef (image © RMA).

OTHER BENEFITS

In addition to increasing our scientific understanding, the MALSF also has made a wider contribution to the way in which marine aggregate extraction is viewed to the benefit of not only industry and regulators, but also the wider stakeholder audience.

Conflict minimisation – the way in which the studies have been managed through Defra, the heritage and conservation agencies and MIRO has resulted in exposure to a wide, but complementary range of stakeholders. There has been a healthy exchange of ideas and information resulting in a transparent and frank debate. This has helped to defuse some of the distrust surrounding the business and therefore has reduced the likelihood of conflicts developing.

Stakeholders and relationships – the studies have brought regulators, academics, industry and NGOs together with a common purpose. This has promoted new levels of common understanding between parties that would normally rarely meet. As a result, the value of

the studies goes beyond the individual components by generating positive relationships which will form the foundation for future development and sound regulation.

Capacity and capability development – the marine scientific and environmental community has benefited through the opportunity to analyse new marine data and train a wide range of marine scientists capable of understanding and balancing environmental issues to ensure the management of the marine environment.

Knowledge transfer – the knowledge generated through the MALSF will undoubtedly influence the way other industries are regulated. This represents a significant opportunity for added value to be derived from the outputs, by assisting the prioritisation of the environmental regulatory agenda. With the move to a more integrated and holistic approach to marine planning and management, the contribution of the MALSF to the UK marine knowledge bank cannot be underestimated.

CASE STUDY – SABELLARIA ON HASTINGS DREDGING LICENCE

The presence of *Sabellaria spinulosa* in and around the Hastings Bank (Figure 2) provides a good example of the focus for a MALSF study. Whilst *Sabellaria* is present in places locally, there is evidence that the existence, extent and health of the *Sabellaria* adjacent to the dredging licence has been promoted by aggregate dredging activity which contributes a supply of sand moving across the sea bed. This finding challenges the notion that dredging activity is always destructive and is a reminder that our understanding is incomplete and that perceived sensitivities surrounding aggregate dredging may be misplaced at times

CONCLUSION

From an industry perspective, the effective development and management of marine aggregate activity is primarily driven by knowledge of key issues and an understanding of their background context. In turn, this allows operators to actively seek to minimise the potential for conflicts – whether by introducing measures which reduce the potential for effects, or by using measures which reduce known effects. Management tools have to be effective and appropriate, with positive feedback mechanisms to allow the measures to be modified in light of the observed results. This allows the management of marine aggregate activities to evolve alongside the knowledge base.

The MALSF has resulted in a clearer understanding of the environmental sensitivities surrounding dredging which in turn has influenced the way the industry manages their applications, how impacts are mitigated and the way licensed areas are dredged. It has promoted scientific understanding and the aspiration has to be that it will result in best practice from both an industry and regulatory viewpoint.

The research supported by MALSF can be viewed as an investment in environmental knowledge which will influence dredging activity over the next decade and beyond. From this viewpoint, not only does the Fund have a direct impact, but there is also a delayed contribution which will be realised as new applications are developed and new permissions granted.

The Fund is already a success in terms of the new science it has acquired, and whilst there is undoubtedly more to learn the sensible application of this knowledge is arguably the greatest challenge now facing everyone involved in the management of British marine aggregate extraction.



Marine aggregate extraction – Risk assessment (MARA) framework

INTRODUCTION

The Marine Aggregate Extraction Risk Assessment (MARA) Framework has been developed to help assess risks to the marine environment arising from dredging of the seabed. The approach helps decision-makers evaluate dredging licence applications and supports dredging operators to manage the dredging activity.

Risk Assessment involves analysis of the probability of potentially harmful events occurring and the consequences of these. Environmental impacts have traditionally been assessed by considering either a “worst case” or a “typical” scenario of physical changes that dredging causes and the nature of the impacts. The risk assessment approach gives a more holistic representation of the potential outcome by considering high frequency, low impact events as well as low frequency, high impact events. Risk assessment also improves the representation of spatial variation in physical changes and risk.

The MARA Framework is designed for use by consultants for carrying out an Environmental Impact Assessment (EIA) or a Regional Environmental Assessment (REA). MARA provides an audit trail of the assumptions and enhances transparency and consistency in approach.

RISK CONCEPTS

Risk has two components – the chance (or *probability*) of an event and the impact (or *consequence*) associated with it. The relationship is usually defined as:

Risk = Probability × Consequence

This basic relationship is used within the MARA Framework by considering “hazards” and “receptors”. These are defined as:

- A “hazard” is a physical event, phenomenon or human activity with the potential to result in harm.
- A “receptor” is a physical, ecological or social feature or activity (e.g. seabed morphology, fish species, benthic ecosystem, fisheries) that may experience a consequence due to a hazard, if the receptor is exposed and sensitive to the hazard.

Risk Assessment helps to evaluate uncertainty. In assessing the impact of marine aggregate extraction it is difficult to determine the likelihood of some hazards occurring, the location of receptors and how they will respond to the hazard. The MARA Framework can handle unsure judgements and shows how much uncertainty there is in each risk result.

THE MARA FRAMEWORK

The MARA Framework is tiered so that it can be applied to assess risks at any spatial scale and for any level of detail or certainty. MARA can be used to assess risks from:

- Single licence sites (e.g. for an EIA).
- Cumulative effects from dredging at multiple licence sites (e.g. for an REA).
- In-combination effects from dredging activities and all other uses of the marine environment (such as fishing, wind farms, pipelines and communications cables).

MARA can use any relevant type of qualitative and quantitative information, from numerical model output to expert judgment.

Figure 1 shows an overview of the processes within the MARA Framework which are:

- Steps 1 - 3: Giving information on the proposed dredging activity, the location of potential risks and the time scale for the risk assessment.
- Steps 4 – 6: Assess the probability of hazards occurring, the exposure of receptors to hazards and the consequences to receptors if they are exposed to hazards.
- Steps 7 – 9: Calculate risk using all the information from steps 4 – 6, taking due account of uncertainty, recovery of receptors and cumulative and in-combination impacts.
- Step 10 (outside MARA): Deciding whether to allow the proposed dredging activity requires consideration of the risks in the context of receptor importance, relevant policies and legislation etc. This step is outside the scope of the MARA Framework.

OUTPUTS FROM MARA

The MARA Framework has been tested with three case studies; a single site application, a broad scale application and assessment of the combined effects of dredging and enhanced fishing activity. The case studies test the Framework and demonstrate the type of outputs it gives, rather than provide generic values of hazard probability or receptor sensitivity etc. for future risk assessments. In this context, the case studies should be regarded as hypothetical demonstrations only and the figures and values used in these examples should most definitely not be applied elsewhere.

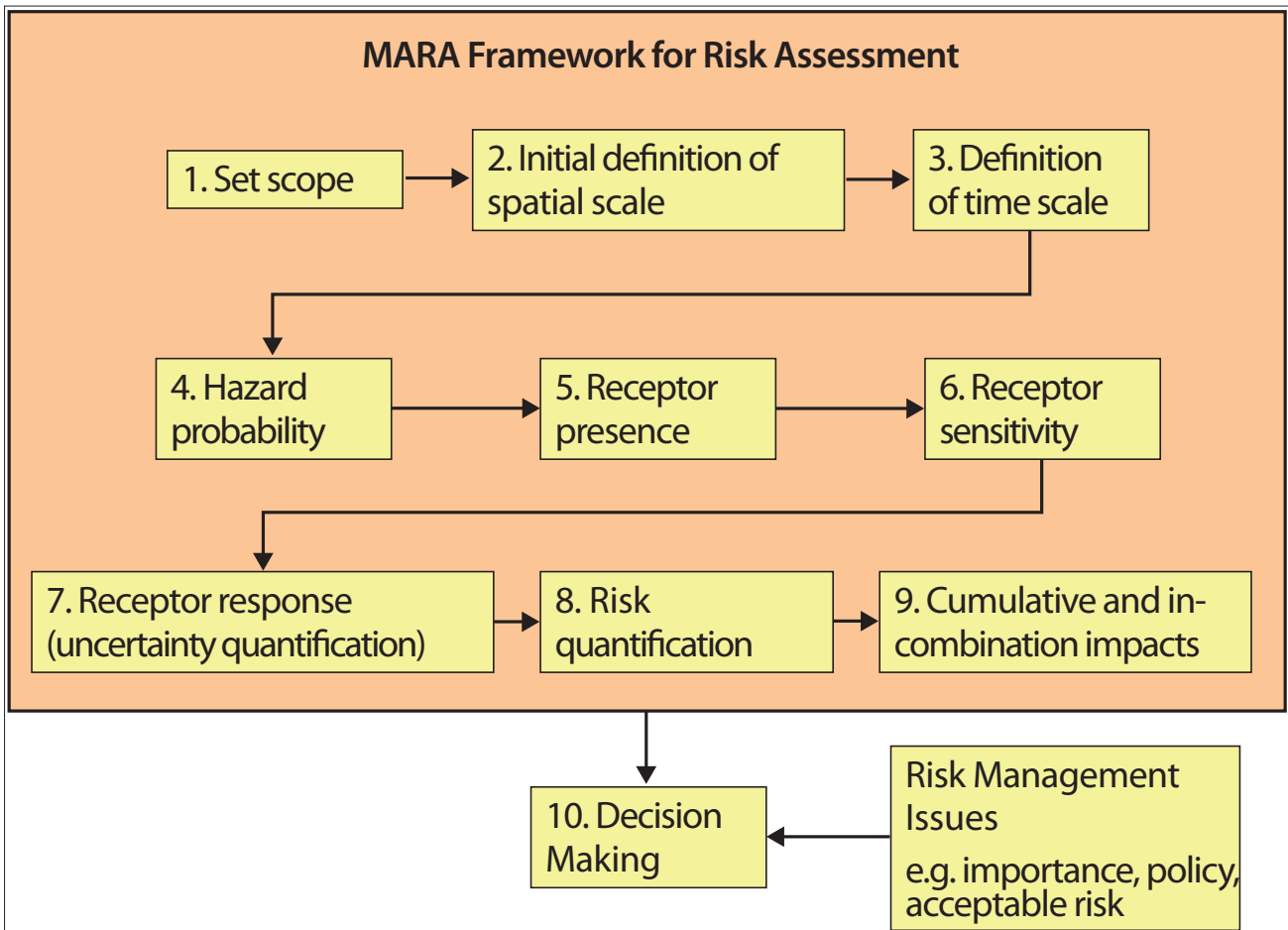


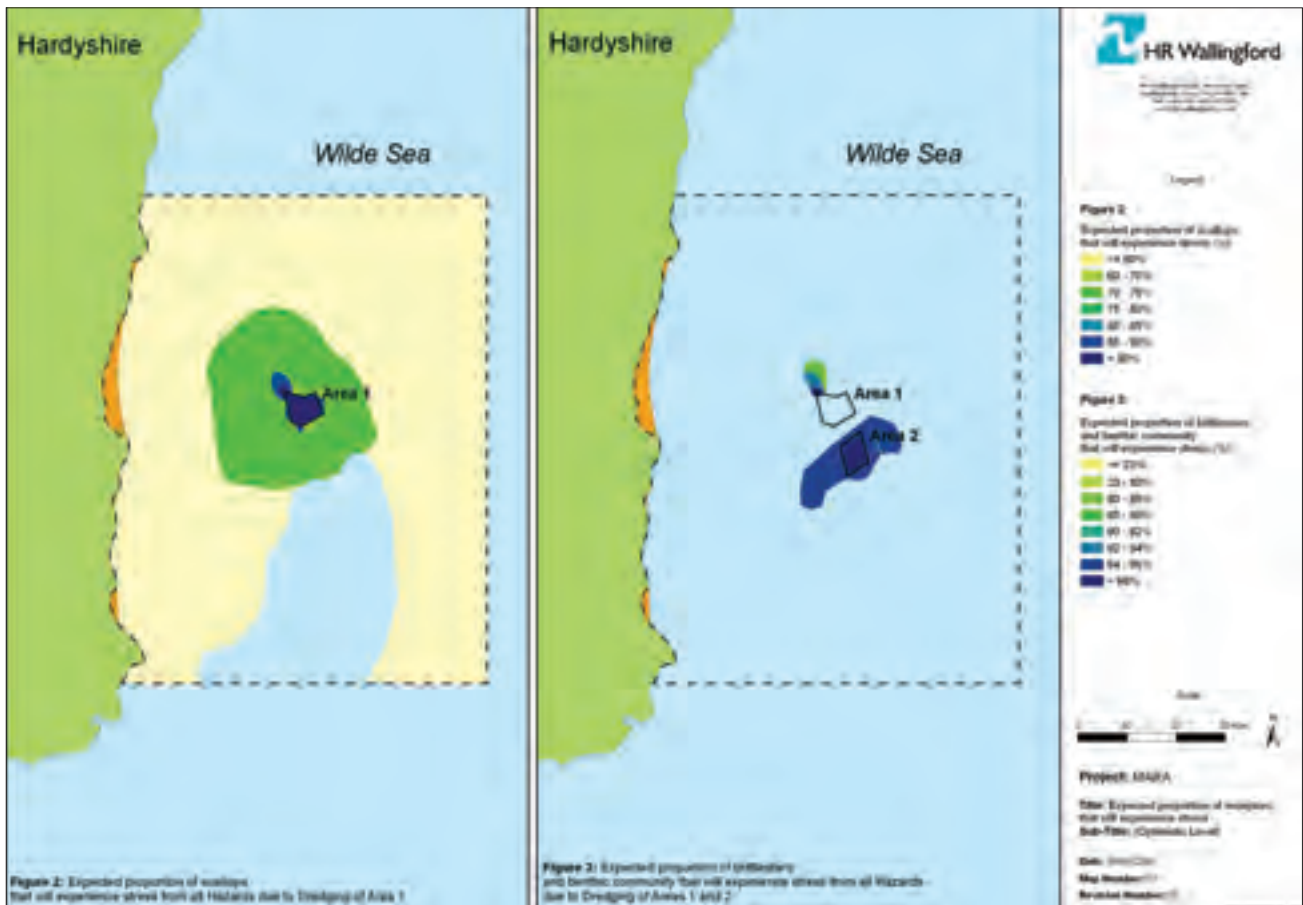
Figure 1: Overview of the MARA framework

The case studies consider proposed dredging activities in Area 1 and Area 2 in the Wilde Sea, 40 km from the coastline of Hardyshire. The case studies examine typical hazards and receptors. Tables 1 and 2 give example results from the single site and broad scale application respectively. Both tables give the expected proportion of the receptor population that will be influenced by the combined effect of all hazards arising from the dredging activity. The outputs of the MARA Framework can be mapped as shown in Figures 2 and 3. The tables represent the uncertainty in the assessment process by providing upper and lower estimates of impact.

| Receptor | Type of response | Expected proportion of population affected (%) | |
|-------------------|----------------------------|--|-------------|
| | | Optimistic | Pessimistic |
| Shipwreck | Damage | 38 | 61 |
| | Destruction | 0 | 0 |
| Benthic Community | Stress | 64 | 100 |
| | Death | 7 | 60 |
| Bivalves | Stress | 68 | 100 |
| | Death | 36 | 63 |
| Scallops | Stress | 20 | 23 |
| | Death | 15 | 20 |
| Fishing | Loss of revenue | 36 | 44 |
| Benches | Length of shoreline winter | 0 | 0 |

Table 1: Proportion of total receptor population at risk from proposed aggregate extraction in Area 1

Marine aggregate extraction – Risk assessment (MARA) framework



Figures 2 & 3: (combined) Expected proportion of receptors that will experience stress

| Receptor | Type of response | Expected proportion of population affected (%) | |
|-------------------|-----------------------------|--|-------------|
| | | Optimistic | Pessimistic |
| Shipwreck | Damage | 38 | 100 |
| | Disturbance | 0 | 0 |
| Benthic Community | Stress | 85 | 100 |
| | Death | 24 | 71 |
| Brillstar | Stress | 89 | 100 |
| | Death | 36 | 63 |
| Scallops | Stress | 20 | 23 |
| | Death | 16 | 20 |
| Fishing | Loss of revenue | 36 | 45 |
| Beaches | Length of shoreline erosion | 0 | 0 |

Table 2: Proportion of total receptor population at risk from proposed aggregate extraction in Area 1 and Area 2

AUDIT AND QUALITY CONTROL

One of the most important benefits of the MARA Framework is that it records each step of the assessment so that there is a clear audit trail showing how the final risk outcome has been derived. Furthermore, it promotes a common approach and improves consistency between assessments.

The MARA Framework enables testing of the sensitivity of risk to variations in the input parameters. This identifies the parameters that have most influence on risk and therefore where to focus effort to reduce uncertainty through further investigation and scientific research.

CONCLUSIONS

The MARA Framework provides a structured assessment of the risks of marine aggregate extraction at a range of spatial and temporal scales. It handles incomplete data, complex interactions and cumulative and in-combination impacts. It requires explicit representation of judgements of hazard assessment, receptor exposure and receptor sensitivity. Uncertainty is represented through upper and lower estimates of each parameter, which propagate through the calculations to the final risk.

The Risk Assessment Framework has the following benefits:

- **Transparency:** MARA records the stages of the risk calculations.
- **Uncertainty handling:** MARA captures uncertainty explicitly and propagates it into the assessed risk.
- **Efficiency:** knowledge can be retained for use in future assessments where appropriate.
- **Identification of knowledge gaps:** sensitivity testing shows what parts of the assessment have most influence on the final risk result and shows where to focus future research efforts.
- **Easy to update:** risks can be rapidly re-assessed during dredging operations using data from monitoring.
- **Flexibility:** MARA can be applied at any spatial and temporal scale and can handle numerical model results and expert judgement.

The benefits outlined above are advantageous to regulators, consultees, consultants, the dredging industry and wider stakeholders.

The next steps are to develop a GIS-based tool so that MARA can be used more easily by different organisations and to apply the framework to a real pilot study area.

Title: MEPF 04/03 Development of a Risk Assessment Framework

Contractor: HR Wallingford

Contact: Valerie Bain

Telephone: 01491 822333

E-mail: v.bain@hrwallingford.co.uk

Full Report Site:

<http://www.mara-framework.org.uk>

http://www.alsf-epf.org.uk/projects/projects_db.asp



An environmental context to the effects of marine aggregate dredging

INTRODUCTION

Benthic communities in our coastal seas face a suite of pressures from a variety of sources. These range from the relatively localised effects of marine aggregate dredging to the more wide ranging effects of demersal fishing and changes in sea water temperature as a result of global climate change. It is imperative in any study of the localised impacts of aggregate dredging on benthic communities that change is viewed in the context of other causative factors. There is currently little understanding of how different localised anthropogenic impacts interact with environmental fluctuations, whether natural or in the case of climate change, induced by human activities. Long term datasets are increasingly recognised as an invaluable resource in understanding temporal change in marine ecosystems over decadal scales. Such datasets are enabling understanding of spatial and temporal variation in marine communities and provide a baseline against which changes due to human activities can be measured. The Marine Biological Association of the UK has a long history of benthic research in the English Channel dating back to 1899. More recently the benthic fauna was sampled extensively over a large spatial scale between

1959 and 1985 by the late Dr Norman Holme. The largest raw data set comes from Holme's survey of 324 stations sampled throughout the length and breadth of the English Channel where the community composition and distribution of dominant species, particularly molluscs and echinoderms was described.

The objectives of the current work were:

- To transcribe Holme's broad-scale data from archived notebooks into a modern database to provide a baseline of community composition with which contemporary data may be compared.
- To re-analyse data using modern multivariate techniques to confirm the community classifications of Holme.
- Using the output from contemporary analyses identify a subset of Holme's sampling sites to re-survey using comparable methodology, focusing both on adequately sampling areas in the vicinity of aggregate extraction sites and maintaining a broad scale Channel-wide view to potentially identify broad scale climate change effects.

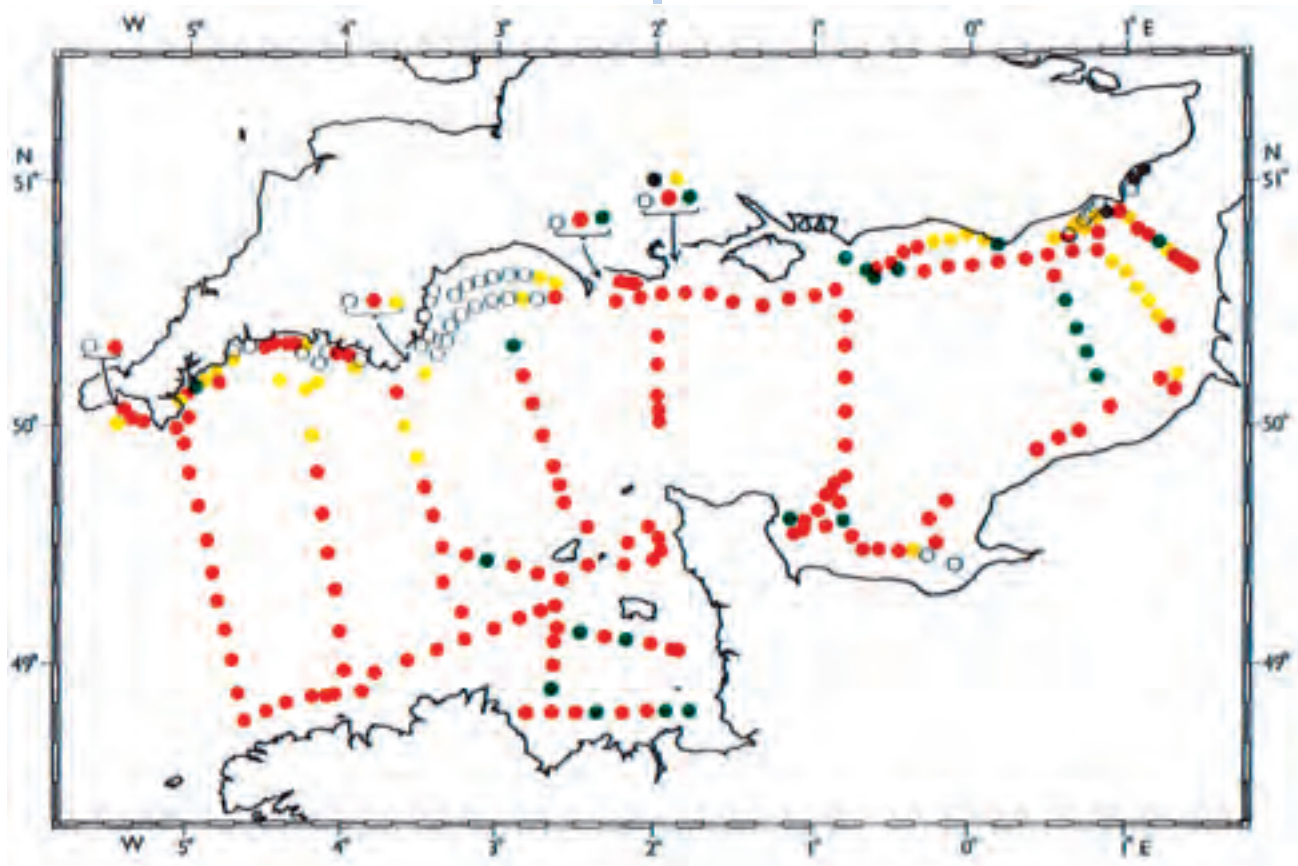


Figure 1: Assemblages identified by Holme (1966). Solid black circles, mud association; open black circles, muddy sand association; yellow, sand association; green, muddy gravel association; red, gravel association (including stony ground and *Ophiothrix* beds).

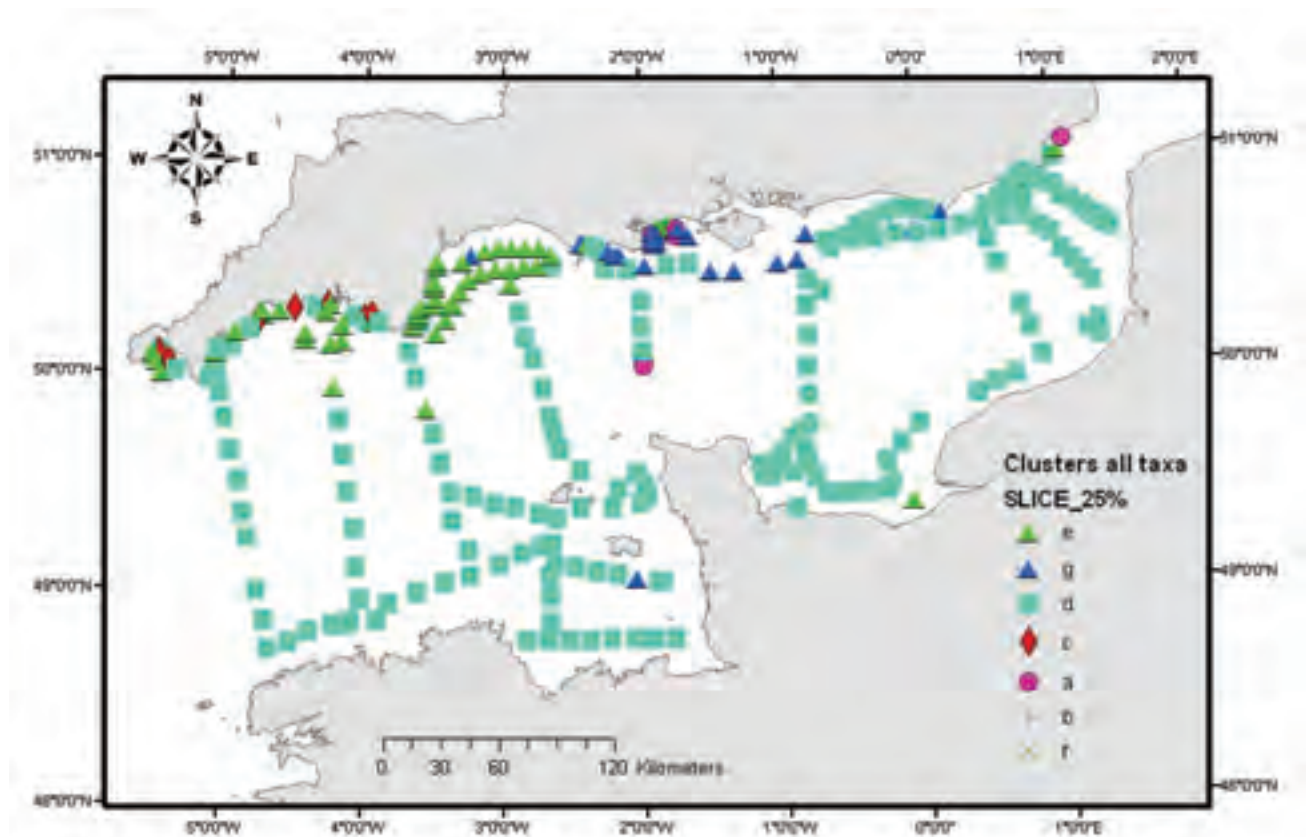


Figure 2: Geographic distribution of 5 main clusters (e,g,d,c,a) and 2 individual stations (b,f) identified from cluster analysis using all taxa.

- Analyse new survey data taking into account known patterns of fishing pressure, aggregate extraction and predictions based on recent warming trends.

RE-ANALYSIS OF HOLME'S HISTORIC DATA WITH MODERN STATISTICAL TOOLS

Modern multivariate techniques were used to refine the analyses made by Holme to understand the relationship between sediment composition, faunal communities and biogeographic zones over an English Channel scale and to provide a baseline of community composition with which recent or new data may be compared. Norman Holme used his benthic dredge surveys (Holme 1961 & 1966) to create a picture of the distribution of species within the English Channel. Species along the English coast were classified and described in Holme (1961). These distributions were subsequently added to and re-analysed in Holme (1966). In his first paper Holme grouped species into geographic regions whilst in his second he grouped taxa into five assemblages in relation to the sediment characteristics of these areas (Figure 1).

Comparing the groupings of Holme with those identified through the multivariate analyses show broad similarities between these classifications, indicating the validity of Holme's original findings and descriptions. In particular, the areas described as gravel communities and muddy sand communities (Figure 1) correspond well with the two largest clusters identified in the multivariate analysis (Figure 2). However, some obvious differences do exist between these classifications. For example Holme's sand association was not clearly evident in the multivariate analysis. In addition cluster analysis did also reveal that a further classification of the gravel community into sub-clusters may be possible and might add an additional layer of information. Preliminary analyses suggest such sub-clusters are positively related to levels of shear stress throughout the Channel. Further linking of biological data to environmental parameters is required to elucidate the relationship between the physical environment and the structure of benthic assemblages.

An environmental context to the effects of marine aggregate dredging

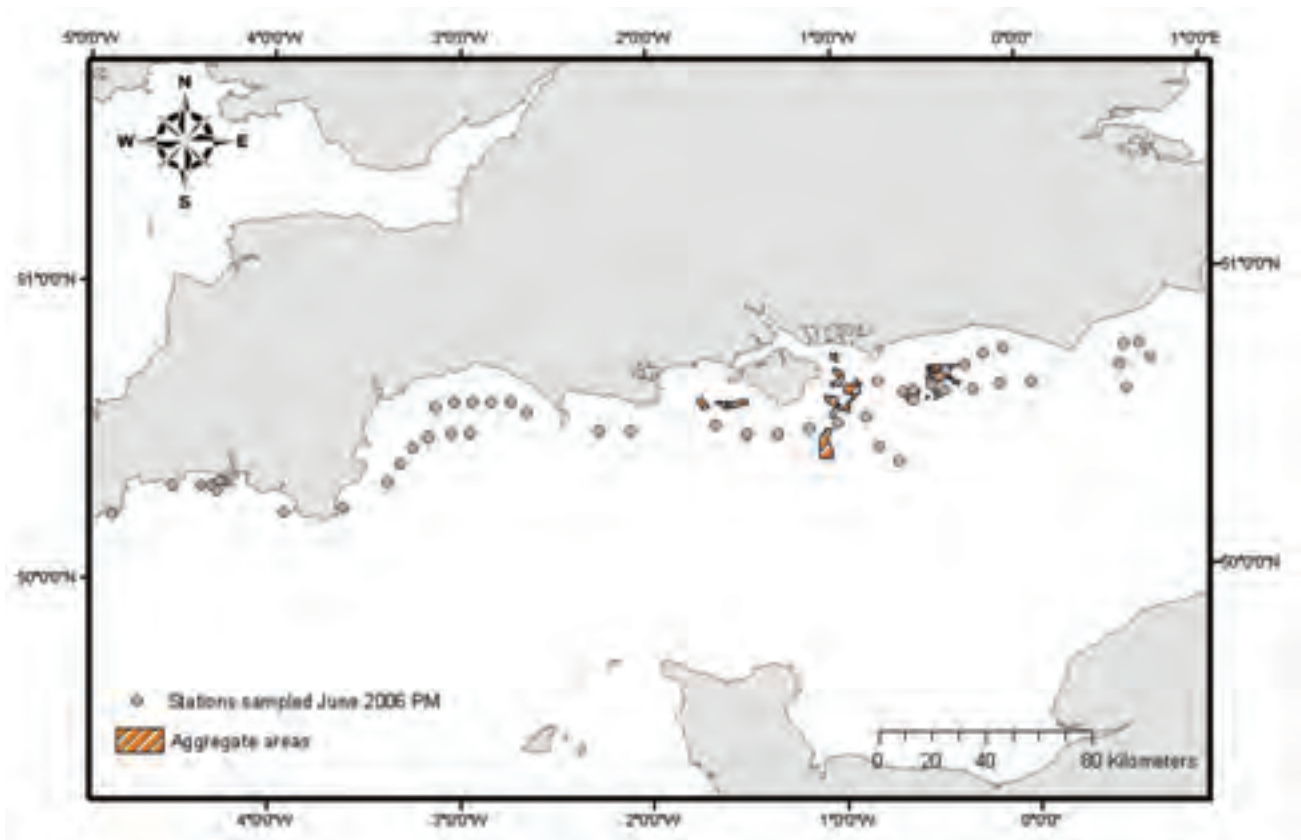


Figure 3: Stations re-surveyed in June-September using the research vessels *Prince Madog* and *Plymouth Quest*.

RE-SURVEY OF A SUBSET OF HOLME'S SAMPLING SITES, INCLUDING THOSE POTENTIALLY IMPACTED BY AGGREGATE DREDGING AND A NUMBER OF CONTROL SITES

Part of Holme's first anchor dredge survey along the English coastline was re-sampled during a two week research cruise in June 2006 onboard the research vessel *Prince Madog*. The core sampling area was located between Falmouth and Hastings. Overall, 45 stations were sampled along this stretch of the UK coast. Particular focus was placed on the aggregate extraction sites off the Isle of Wight. A further 4 stations were sampled west of Plymouth using the Research Vessel *Plymouth Quest*. Thus a total of 49 sampling stations were surveyed (Figure 3).

At each sampling station five anchor dredges were deployed. Of these one was taken at the position given for that particular station and four were positioned approximately 500m around this central position. Taking replicate samples at each site will allow for a formal multivariate comparison of community composition, with the single sample taken by Holme. Multivariate ordination techniques of each site, comparing Holme's

and our data, should be an appropriate tool to ascertain if the species composition of a site has changed significantly over the past 50 years, or if differences are of similar magnitude to local spatial variation of the site. The magnitude of change of the sampled sites can subsequently be examined in relation to the proximity of aggregate extraction sites.

Samples obtained from these operations were emptied on deck and a 20-litre sub-sample was taken, which was sieved over 5 and 2 mm. In most instances samples had a volume of over 60 litres of sediment. The 5 mm fraction was sorted onboard while the 2mm was retained and fixed in 4% buffered formalin solution for later identification in the laboratory. The remaining catch was sorted for large animals on deck, and subsequently hosed back into the sea. Overall 245 anchor dredge samples were taken during the survey.

At most sites, additional to the five anchor dredges, three 0.2 m² Hamon grab samples were taken. This gear was deployed to update the survey to modern standards, using a quantitative gear type. Hamon grab samples were sieved over 5 and 1 mm. The 5 mm fraction was sorted on board and animals were fixed in

formalin, together with the 1 mm fraction. Although not currently analysed these Hamon grab samples may be a valuable resource for future projects.

Samples brought back to the laboratory were identified to the highest possible taxonomic resolution. Overall, 412 taxa have been identified. Besides this, a reference collection of specimens was established and most species were photographed to create an identification record.

DETERMINATION OF THE DEGREE OF CHANGE IN BENTHIC COMMUNITIES OVER A 30-50 YEAR TIME-SCALE IN RELATION TO POTENTIAL CHANGES DUE TO AGGREGATE DREDGING, FISHING EFFECTS AND CLIMATE CHANGE

This part of the project is still underway. However it is anticipated that the large number of samples taken over a broad spatial scale will allow effective determination of the degree of change of benthic communities along the Channel coast in relation to both aggregate extraction activities and other known anthropogenic impacts, chiefly demersal fishing activities. The Channel wide coverage of sampling will also allow determination of any changes in geographic distribution of benthic fauna as a potential consequence of recent rises in seawater temperature.

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Title: MAL0022 An Environmental Context to the Effects of Aggregate Dredging

Contractor: Marine Biological Association

Contact: Dr Stuart Jenkins

Telephone: 01248 382896

E-mail: s.jenkins@bangor.ac.uk

Full Report Site:
<http://www.mba.ac.uk/ALSF/>



Dredge lane management – Computational fluid dynamic simulations

ISSUE

The management of aggregate extraction areas and their associated dredge lanes relies on a good understanding of the potential impacts of the dredge tracks (generated by the action of the drag-head) and the wider sediment transport regime. Anecdotal evidence indicates that dredge tracks are associated with apparently enhanced accumulations of sand. If dredge tracks are acting as potential sand sinks, this has implications for both the management and restoration of the site and sediment transport through the aggregate extraction region.

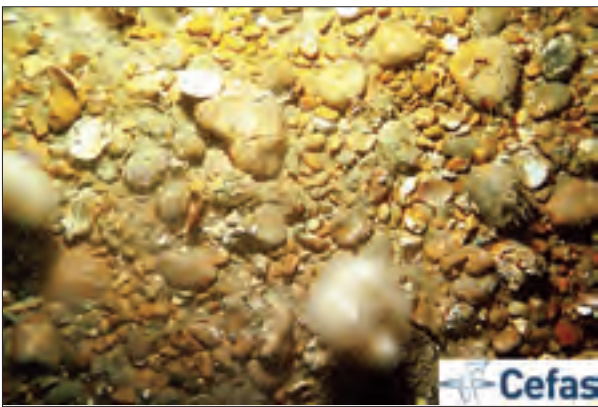


Plate 1: Pristine Aggregates

WORK PERFORMED

The objective of this study was to investigate tidal flows and suspended sediment transport associated with dredge tracks in dredging lanes arising from aggregate extraction, with the ultimate aim of providing advice on minimising changes to sediment transport.

The study required modifying and validating an existing computational fluid dynamics (CFD) code (Sajjadi and Aldridge, 1995; Sajjadi et al., 1995; Sajjadi and Waywell, 1997) in order to simulate tidal flows and suspended sediment transport over bed features typical of aggregate extraction dredging. Changes to the code were made to include pressure-gradient forcing and to enable rough boundaries to be simulated. A sediment-transport module involving resuspension, transport and deposition was also developed, allowing budgets of material to be computed. Model results have been compared with analytic solutions and with previous model studies over flat beds.

After consultation with stakeholders, a series of simplified scenarios was developed that could be modeled using the CFD code. These included the dredge-track orientation with respect to the principal axis of the tidal ellipse, dredge-track morphology and particle

size. Other scenarios identified but not modelled included curved dredge tracks, sequence of dredge tracks occupation and static dredge pits.

CONCLUSIONS

This project has produced a robust CFD numerical model capable of describing the velocity flows within complex areas of morphology such as found in aggregate extraction areas. These flow fields have been utilised within numerical suspended sediment models to predict re-suspension and deposition of sediment within the model domain.

The results of the CFD simulations clearly indicate a mechanism for retention of sands by dredge tracks, arising from the reduced bed shear stress within the tracks compared to the surrounding higher flat regions. Three points are worthy of note:

- This mechanism appears to be relatively insensitive to track orientation with respect to the main tidal axis.
- The mechanism is size selective, preferentially trapping coarser particles.
- It is plausible that a similar mechanism will hold for particles transported as bedload, as well as the suspended load case considered here.

The preliminary practical implications of this work are that suspended sediment transport associated with the dredge track is relatively insensitive to the orientation of the dredge tracks compared to the principal tidal axis. Some aspects of dredge track morphology are probably more significant, and in particular, isolated dredge tracks with a large depth/width ratio (i.e. deep and narrow) are more likely to accumulate sediment than tracks with a small depth/width ratio (i.e. shallow and wide).

Due to problems encountered in setting-up and validating the CFD model, a limited number of scenarios have been tested, and further work will be required to examine these conclusions further. One of the potential main deliverables from this project was practical "Best Practice Guidance" for the marine aggregate extraction industry on the management of dredging lanes to minimise environmental impact, if the work's findings were found to be significant. A limited number of scenarios have been investigated to date, so it has been considered inappropriate to create such guidance notes at this stage.

J. Rees

Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT



Plate 2: Aggregates after extraction

RECOMMENDATIONS

To improve our confidence in improving dredging practice, a number of further improvements to the model and scenarios should be undertaken. Further runs and development of the model will allow a greater understanding of the interactions of dredging practice and the associated sediment dynamics. Further dialogue with stakeholders (BMAPA, regulatory bodies and NGOs) should be sought to ensure take-up of any

potential recommendations. Funding should be provided to progress this work to achieve the development of a practical "Best Practice Guidance" document for use by the industry.

Title: SAMP2.24 Dredge Lane Management
– Computational Fluid Dynamic Simulations

Contractor: Cefas Lowestoft Laboratory

Contact: Jon Rees

Telephone: 01502 524383

E-mail: jon.rees@cefas.co.uk

Full Report Site:
<http://www.dclgaggregatefund.co.uk/themea.htm>



Use of shell to speed recovery of dredged aggregate seabed

INTRODUCTION

English Channel sand and gravel deposits are derived from rivers flowing into the English Channel during the Holocene when sea-levels were considerably lower (Velegrakis, 2000). Being riverine these deposits contained no shell. The Flandrian Transgression progressively inundated these deposits. During the past few thousand years of sea level rise the aggregate seabed fauna developed leaving a surface veneer of shells from deceased molluscs. With aggregate extraction this surface layer is removed, along with the deposits below, leaving a purely mineral seabed. The basic tenet of this project is that shell is an important component of the natural seabed and contributes to its biodiversity. Thus restoring shell to extracted seabed would replace that fraction which has taken thousands of years to accumulate.

There is a long history of using waste shell "cultch" to improve the settlement of spat on managed shellfish grounds (Guay and Himmelman, 2004). Bellew and Drabble (2004) reviewing aggregate site restoration and enhancement include the addition of gravel, shell and artificial reefs to impacted areas as possible measures. Archer *et al.* (2005) highlighted the legislative and financial hurdles that the shellfish processing industry have to overcome in order to dispose of waste shell. The authors have extensive experience with the use of artificial reefs in fishery enhancement (Jensen *et al.*,

2000) and particularly the beneficial use of waste materials in their construction: coal ash (Collins *et al.*, 1994) and tyres (Collins *et al.*, 2002). With this background, a study was conceived between the University of Southampton and the Shellfish Association of Great Britain, with two aims:

- (i) To establish the significance of shell fragments as a micro habitat within sand and gravel seabeds in Poole Bay and to the east of the Isle of Wight.
- (ii) To undertake a demonstration project laying shell material in a recently dredged area east of the Isle of Wight and track its colonisation.

NATURAL SEABED

Holme (1961) undertook an extensive survey of the English Channel by dredge and grab. Analysis of his data (56 sampling stations) for the section off the Dorset coast yields a total of 4115 live shell bearing molluscs, an average of some 74 specimens per station.

Within this current study 4 sites of undisturbed sand and gravel seabed within Poole Bay (Fig.1) have been studied by diving to compare the colonization of stone surfaces with that of shell, along with photography to record the percentage surface cover of shell. Typically, shell covered some 30% of the seabed. Assessment was made difficult by the fact that the shell was often so heavily colonized by algae and macrofauna that it was

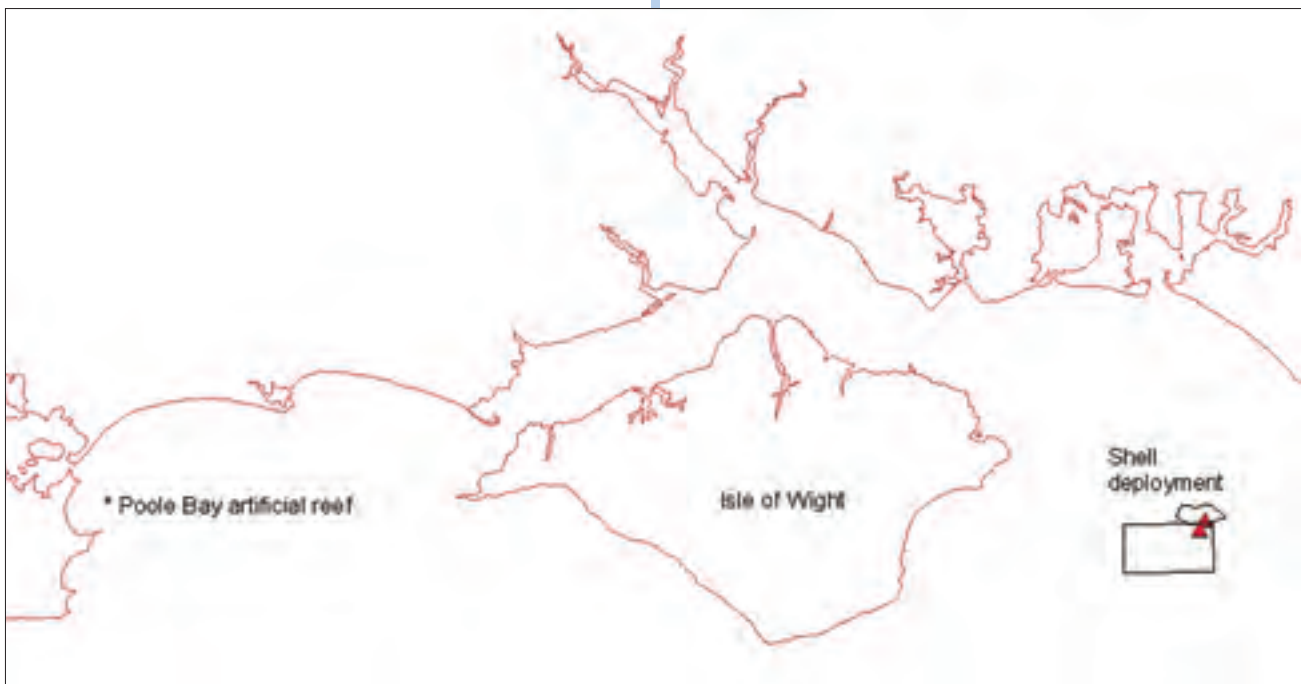


Fig 1: Study areas, showing experimental shell deployment sites in licensed dredging areas 395/1 and 351 (red triangles) to the east of the Isle of Wight.

difficult to determine its exact extent. Of 86 species of macrofauna and flora, 19 spp. were common to both shell and stone whilst 25 spp. were associated with stone only and 32 spp. were found on shell only. Reasons for the difference between the colonization of shells vs stone, include:

- Calcium carbonate (shell) vs silica (flints/sand)
- Biogenic vs mineral
- Complex shape vs solid, rounded
- Variety of surface roughness vs single texture

Sampling of a transect of stations away from an aggregate extraction zone to the east of the Isle of Wight was undertaken by pipe dredge to obtain unbiased samples of the seabed surface. This showed clearly the lack of shell in the extracted areas.



Fig.2: Photograph of diver inspecting 1m² experimental settlement plots (clockwise from top: 20mm stone, scallop shell, 50mm stone, crushed whelk) one month after deployment within the Poole Bay artificial reef site.

COLONISATION EXPERIMENT

To compare shell vs stone colonization directly, a replicated set of 1m² settlement plots (50mm stone, scallop shell, 20mm stone, crushed whelk shell) were deployed within the Poole Bay artificial reef site (Fig.2). These were monitored from August to November 2005. Both the larger stone and scallop shell were colonised with a similar number of species, though the latter was more densely settled and providing habitat niches for mobile fauna. Most notable was the settlement by large numbers of juvenile slipper limpets, *Crepidula fornicata*, on the undersides of the scallop shells (Fig.3). The small stone and crushed whelk shell were colonized by half the number of species, demonstrating the value of larger size in providing a stable surface which is less likely be tuner over or inundated by mobile sand.

SHELL DEPLOYMENT

Sites for deployment of the shell enhancement experiment were identified in recently dredged areas which were unlikely to be further dredged, within licensed areas 395(UMA Ltd.) and 351(Northwood (Fareham) Ltd.) to the east of the Isle of Wight (Fig.1). An application was made to Defra Marine Consents and Environment Unit for a FEPA licence (No. 33033/05/0) to deposit the shell experiment. Within each area some 200kg of crushed whelk and scallop flat were deployed 20m apart in January 2006, on extracted aggregate (mixed sand and gravel) seabed at a depth of 18mCD.

The sites were studied by SCUBA diving on four occasions June-August 2006, recording and collecting macrofauna plus photography and video of the shell plots and surrounding aggregate seabed. One complication was the fact that the seabed around the experimental deployment showed various stages of recovery post dredging. It ranged from that colonized only by barnacles and a few hydroids from the previous year through to mature colonization denoted by sponge fauna, which from experience with artificial reef studies in Poole Bay, takes a minimum of 5 years to establish. The evidently mature recolonised dredged areas were still devoid of shell material. As with the Poole Bay experiment the scallop shells were most densely colonized (barnacles, hydroids and bryozoans, see Fig 3) especially where tides and storm wave action had formed them into "toast racks" with the shells upright and ranked, firmly embedded in the sand and gravel. These provided ideal habitat for squat lobsters (*Galathea squamifera* and *G. intermedia*, see Fig.3) and prawns. Shells lying flat on the seabed provided shelter for porcelain crabs and small fish (gobies and cling fish). Of 102 macrofaunal species identified at the deployment sites including the mature extracted seabed 48 species were common to both the shell and stone. 40 species were found only on the stone but these included sponge associations on large stones which would have taken >5years to develop. Of note is the fact that 14 species were only found on the newly deployed shell. In only 7 months the shell species richness had achieved 70% of that on mature recovering dredged aggregate seabed.

The crushed whelk shell was too mobile to be successfully colonized by epifauna, but the remaining tips of the whelk shells were utilised by the hermit crab population (*Pagurus bernhardus*, *P. cuanensis* *P. prideaux*). The deployed shells, having been boiled during processing were pure white, so it was evident which occupied shells were derived from the experimental deployment. Crabs in such shells were found more than 30m from the experimental site much further than the scattering by water movement.

Use of shell to speed recovery of dredged aggregate seabed

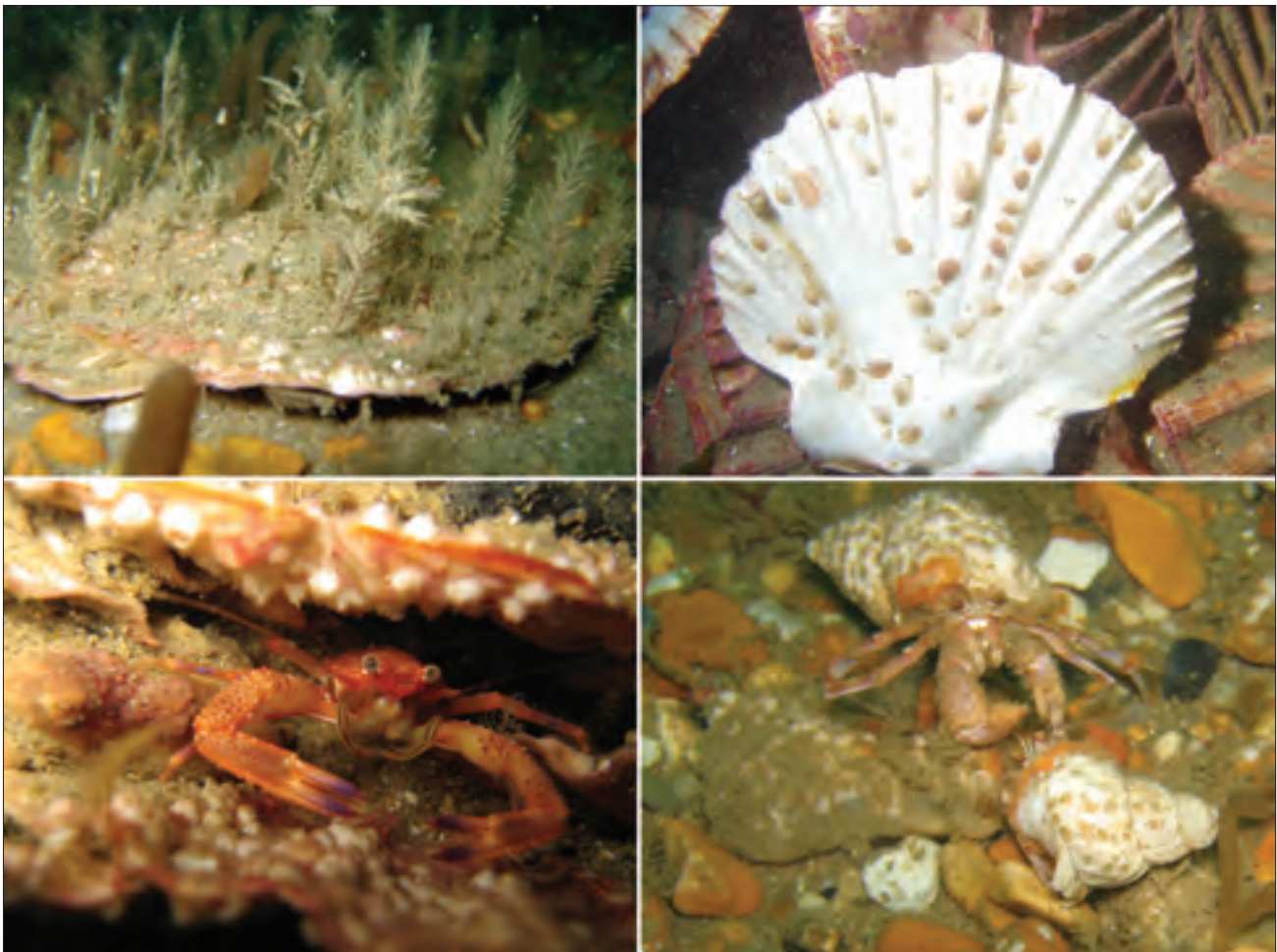


Fig.3: Top left - Colonisation of upper surface of scallop shell by hydroids, *Sertularia argentea*; bryozoa, *Alcyonidium diaphanum* and barnacles, *Balanus crenatus*. Top right - Juvenile slipper limpets, *Crepidula fornicata* on the underside of a scallop shell. Bottom left - Squat lobster, *Galathea squamifera* between scallop shells. Bottom right - Hermit crabs, *Pagurus prideaux*, in processed whelk shell.

Rodrigue (2006) made a particular study of the hermit crabs in the experimental area measuring the shell size of specimens from a 20m radius around the deployment sites. This demonstrated a lack of local shell above 3cm length shells on the mature extracted seabed, creating a bottleneck in hermit crab growth, which the newly deployed shell relieved.

Taking into account the dispersion of the shell deployment by tides and storm action the final density of seabed coverage was in the order of 1kg m^{-2} .

DISCUSSION

Larger objects (shell or stone) colonised more extensively than small as they are more stable and less susceptible to smothering by mobile sand. From general observation of the area around the Nab experimental site it would be worthwhile returning the large stones remaining after sorting the marine aggregates.

Shell undoubtedly forms an important component of undisturbed natural seabed, with typically 30% coverage of the surface area on mixed sand and gravel seabeds. Whilst there is an overlap between the species of algae and fauna colonizing both stones and shells there are significant differences, with numerous species (37% in Poole Bay) selecting shells as a substratum. Thus the shells contribute to the biodiversity of the seabed. The reasons for this include the fact that the shells are made of calcium carbonate as opposed to silica of the stones; are biogenic, actively sought during settlement of many larval species; provide both smooth and rough surfaces; and are more complex in shape. Whilst crushed whelk shell was not considered to be a successful colonization substratum due to its' mobility, the remaining spires of the shells provided ideal habitat for the local hermit crab population. Scallop shell proved to be very successful at promoting fast colonization being settled after only 7months by 70% of the species found on dredged aggregate after >5years recolonisation. As importantly, within 7 months 14 species were found on the scallop

shell that were not found on the aggregate after >5years. Further studies are required to track the progress of the shell deployment colonisation.

The application rate for the shell deployment experiment was in the order of 1kg m², which equates to 1000 t km². Annually the UK shell processing industry produces some 25,000 t by-product (Archer et al., 2005), sufficient to make shell enhancement of end of life aggregate extraction areas a realistic option.

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Title: MAL004 Use of shell to speed recovery of dredged aggregate seabed

Contractor: University of Southampton

Contact: Dr Ken Collins

Telephone: 02380 596010

E-mail: kjc@noc.soton.ac.uk

Full Report Site:
www.noc.soton.ac.uk



Gravel-seeding – A suitable technique for restoration of the seabed following marine aggregate dredging?

INTRODUCTION

Remediation and restoration of offshore marine habitats is a relatively new concept with attempts in European regions largely being instigated by requirements of various strategic directives including Article 2 of the Habitats Directive (1992), the EC Water Framework Directive (2000), Article 2 of the OSPAR Convention (1992) and the developing European Marine Strategy Directive. A field experiment to establish the practicality of various options for rehabilitating the seabed on the cessation of dredging has been successfully set-up. The purpose of this experiment is to investigate the practicality and effectiveness of gravel seeding as a potential restorative method which could be applied at marine aggregate extraction sites following cessation of dredging. Zone 2, within Area 408 (offshore Humber) was chosen as the experimental site as there is some evidence for persistence of sand which may have resulted from screening operations at this site.

BASELINE SURVEY (MAY/JUNE 2005)

The baseline survey conducted in May/June 2005, prior to the gravel seeding treatment, involved collection of ten replicate 0.1m² Hamon grab samples from each of the treatment, control and reference boxes (Figure 1). The positions of these boxes was determined with reference to historic acoustic, underwater TV and Electronic Monitoring System (EMS) datasets in order to ensure consistency between treatment and control boxes. Additional acoustic and video surveys were carried out at this time to provide a comprehensive baseline dataset prior to the experimental procedure being applied (Figure 2).



Figure 1: Area 408 showing treatment, control and reference boxes.

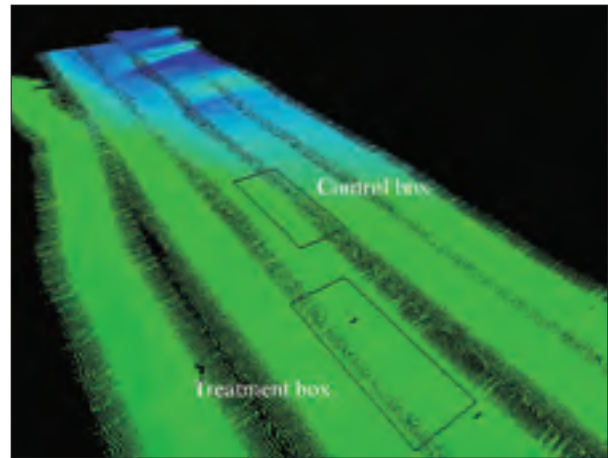


Figure 2: Multibeam bathymetry showing 'treatment' and 'control' boxes prior to gravel seeding.

GRAVEL SEEDING

The gravel seeding operation took place from the 19th to 21st July 2005 using the Hanson owned aggregate dredging vessel Arco Axe, a 98m, 3498 tonne, trailer suction hopper dredger. In total, two 4000 tonne cargoes were dredged from within an active zone of Area 408 and deposited with the 'treatment' box. Both cargoes were screened heavily in order to maximise the gravel content.

The dredging process took between 8-9 hours and was followed by approximately 4 ½ hours of draining or 'de-watering' prior to discharge. The majority of both cargoes were discharged using the same process as that employed during normal offloading operations in port. This process is known as 'dry' discharge. On the Arco Axe this involved moving material up a ramp and into a large hopper at the stern of the vessel using two large buckets, which are pulled across the surface of the cargo by large steel cables (Figure 3a). Once in the hopper, material was fed out over the stern of the vessel via a series of two conveyer belts (Figure 3b). When discharging to a dredge wharf the last conveyer is rotated through 90°. As the vessel offloads its cargo it effectively loses ballast, and, as a result of the poor weather conditions encountered at the time, a decision was made to switch to a 'wet' discharge for remainder of both cargoes (approximately 800 tonnes). In this process, which is usually reserved for 'emergency dumping' of a cargo, the dredge pipe is submerged slightly and water pumped into the hold. At the same time six doors are opened in the bottom of the hull and any material flows out (Figure 3c).

In the planning of this process it was envisaged that the vessel would discharge, using the 'dry' method whilst running along a series of 24 parallel 'discharge' lines within the 'treatment' box to given an even 20cm deposit. However, the weather conditions prevented the vessel from holding such a course and so an alternative approach was used whereby the vessel discharged whilst moving through the box under influence of wind, tide and vessel power. Using the vessel track, offset to the discharge point, and displayed on the ships plotter, the vessel attempted to produce as even a coverage as possible.



Figure 3: a) buckets moving material into hopper at the stern of the vessel during 'dry' discharge. b) material being deposited over the stern of the vessel during 'dry' discharge. c) flooding of the cargo hold following opening of hold doors during 'wet' discharge of remaining cargo.

MONITORING

Following the gravel seeding treatment, the site was immediately surveyed as part of the first round of monitoring. This similarly involved the collection of ten replicate 0.1 m² Hamon grab samples from each of the treatment, control and reference boxes along with acoustic and video surveys. Alterations in bathymetry and substrata within the treatment box were investigated through comparisons of Hamon grab sample photographs (Figure 4), acoustic images (Figure 5) and video footage obtained prior to and following application of the gravel treatment. This experiment has established that it is feasible to undertake remedial

action at offshore extraction sites. Furthermore, initial findings suggest that the gravel seeding operation was effective in restoring the sediment composition of the treatment area. Indeed, all techniques provided evidence of an increase in gravel content of the substrata following application of the gravel seeding procedure. Further monitoring will be undertaken during 2006 and 2007 to establish whether gravel seeding has the potential to enhance the rate (and nature) of recolonization in dis-used extraction areas.

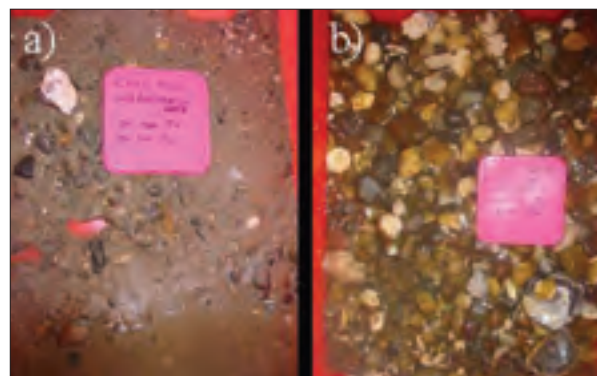


Figure 4: Photographs of Hamon grab samples collected within the treatment box prior to (a) and following application of the gravel seeding treatment (b).

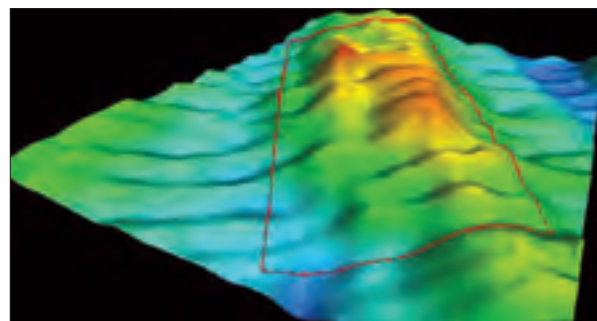


Figure 5: Difference plot using pre and post-treatment Multibeam data. This confirms that the majority of the dredged material was deposited within the treatment box.

Title: A strategic evaluation of the impacts of aggregate extraction on marine fauna (AE0916)

Contractor: Cefas, Burnham Laboratory

Contact: Keith Cooper

Telephone: 01621 787200

E-mail: keith.cooper@cefas.co.uk

Full Report Site:
[http://www2.defra.gov.uk/research/
project_data/Default.asp](http://www2.defra.gov.uk/research/project_data/Default.asp)



A predictive framework for assessment of recoverability of marine benthic communities following cessation of aggregate dredging

INTRODUCTION

The rates of recovery of biodiversity and community structure in seabed deposits have been shown to be highly site-specific. To date, few generalisations can be made in advance of dredging on the time that the biological community at a particular site might take to recover following cessation of dredging (Newell, *et al.*, 1998; Cooper *et al.*, 2005). Our proposal at the outset of this project was that knowledge of the taxonomic inventory for a site, including the abundance and biomass of the component organisms, combined with data on the recruitment and growth of the organisms that characterise the community, may allow predictions of the rate of recovery of taxonomic diversity, population density and biomass at a greatly reduced cost compared with repeated surveys over time where dredging has ceased.

The current project was designed to provide information on the following features of benthic biological communities in marine sands and gravels at aggregate licence areas:-

- The key characterising taxa likely to be encountered in marine sands and gravels at a wide range of aggregate licence sites in UK waters.
- Variations in the biodiversity and other aspects of community composition in relation to locality and sediment composition.
- Information on the biological traits that are relevant to vulnerability to disturbance and subsequent recolonisation rates and restoration of biomass following cessation of aggregate dredging.
- An assessment of the extent to which key biological traits information can be used to predict potential recovery of biodiversity and biomass in individual taxa and within the communities that inhabit marine sands and gravels.

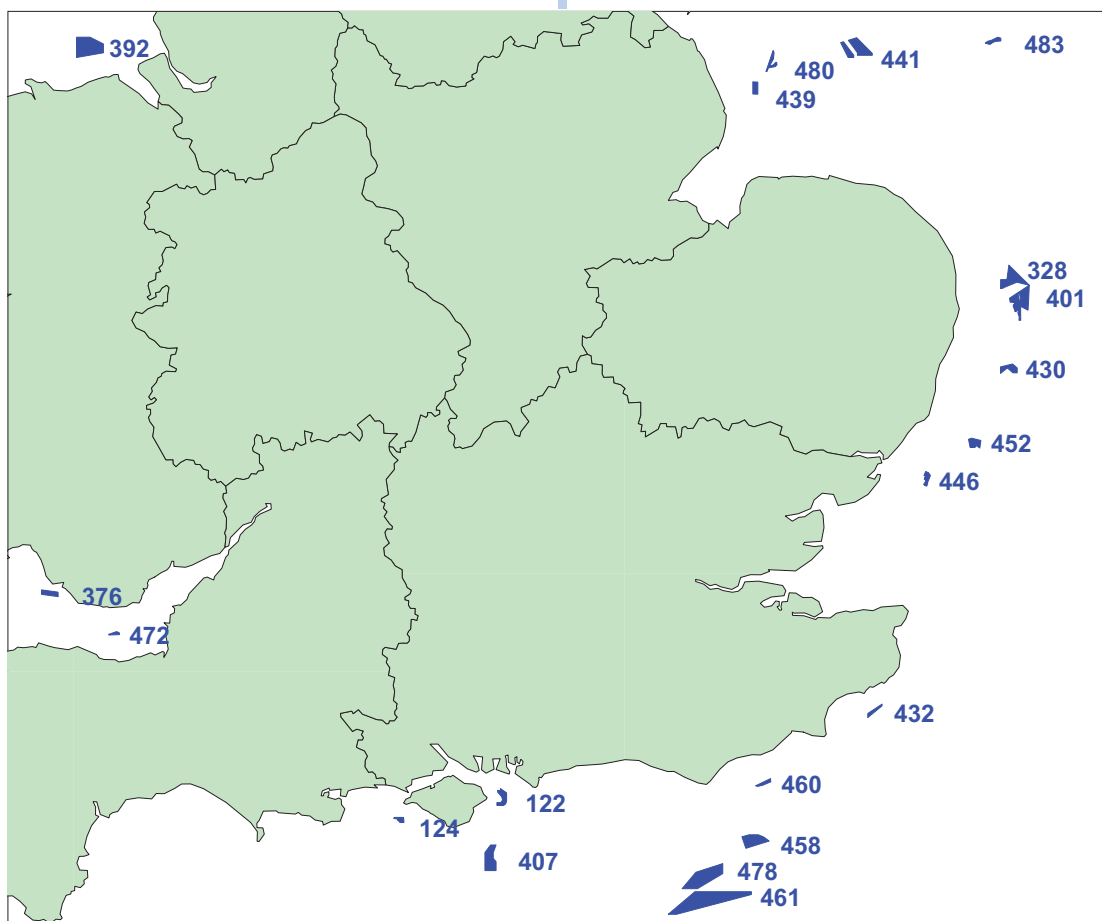


Figure 1: Map of the southern part of the United Kingdom showing aggregate licence areas chosen as study sites in an investigation into the recoverability of benthic fauna in relation to aggregate dredging. The survey was carried out in May-June 2005.

R.C. Newell¹, J.E. Robinson¹, B. Pearce¹, L.J. Seiderer¹, R.M. Warwick², P.M. Somerfield², K.R. Clarke², H. Jenkins¹, N. Beer¹, F. Burlinson¹ & K. Stacey¹

¹Marine Ecological Surveys Limited, 24A Monmouth Place, Bath, BA1 2AY

²Plymouth Marine Laboratory, West Hoe, Plymouth, PL1 3DH

ANIMAL-SEDIMENT RELATIONSHIPS

One of the problems in the use of historical data to define regional differences in community composition, and differences between the communities at individual aggregate licence areas, is that much of the information has been collected at different times of the year and by different methods. Strict comparisons between sites and over a larger regional scale are therefore complicated by potential temporal factors. We have therefore carried out a survey of 20 aggregate licence areas using identical sampling methods between May and June 2005, covering sites as far apart as the outer Humber estuary, the eastern English Channel, the Bristol Channel and Liverpool Bay. The location of the sampling areas is shown in Figure 1.

Seabed samples for analysis of the particle size composition of the deposits and the associated benthic infauna were taken with a 0.1m² Hamon grab at 10 sites in each of the 20 sample areas. Samples were also taken with a 2m beam trawl rigged with a 5mm mesh net for collection of the epifauna at 10 sites at each of the 20 survey areas. These samples were then analysed by multivariate methods to define the key characterising species in relation to deposit type and in relation to region.

The results show that there are clear regional differences in the benthic infauna of compatible deposit types based on the Folk classification. In general, the outer Humber region, the Isle of Wight and the Eastern English Channel areas were characterised by a high biodiversity, abundance and biomass of marine invertebrates compared with the other survey areas. The outer Thames, Bristol Channel and Liverpool Bay are relatively impoverished with the lowest numbers of genera and individuals, as well as the lowest biomass values (see Figure 2).

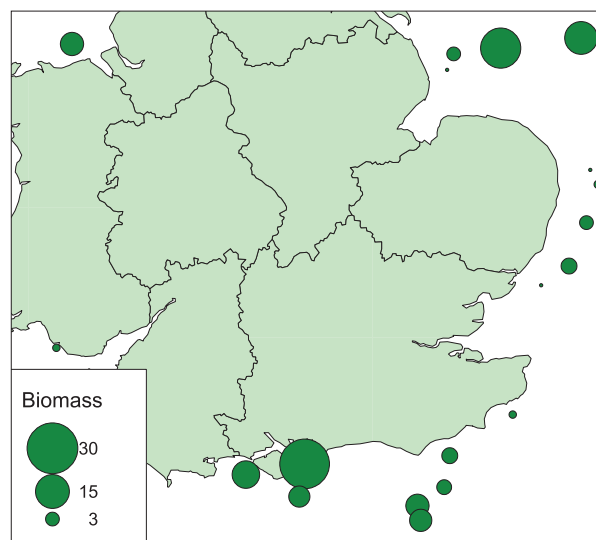


Figure 2: Map of the survey area showing the relative biomass (g wet weight) of benthic infauna in sand and gravel deposits around the UK coasts. Data based on the mean values for all taxa recorded at 10 sites in each of 20 survey areas sampled in May-June 2005.

Analysis of the samples taken within any one licence area show that there are pronounced local spatial differences in community composition. These appear to be mainly associated with differences in the complexity of the habitat, including both abiotic factors such as particle size composition and biotic factors such as the presence of epifauna. The relationship between the number of genera (**S**), the number of individuals (**N**), the species richness index (**d'**) and deposit type based on the average of samples in each deposit type are shown in Figure 3.

These histograms show that, with the exception of muddy gravel where only one sample was obtained, the extremes of the sediment scale (Gravelly cobbles and Muddy sand) show the lowest values and intermediate sediment types show the highest values. This emphasises the importance of mixed sediment types in supporting the high biodiversity that is commonly recorded from sands and gravels in UK coastal waters.

Detailed analysis of the relationship between the community composition of the benthic infauna and composition of the seabed deposits shows that the primary factor that controls biodiversity is the range of particle sizes in the deposits. The deviation of the deposits from the median particle diameter thus has a better correlation with community composition than with the median diameter itself. This suggests that the biodiversity of the benthic community in marine sands and gravels is enhanced by the wide range of habitat

Predictive framework for assessment of recoverability of marine benthic communities following cessation of aggregate dredging

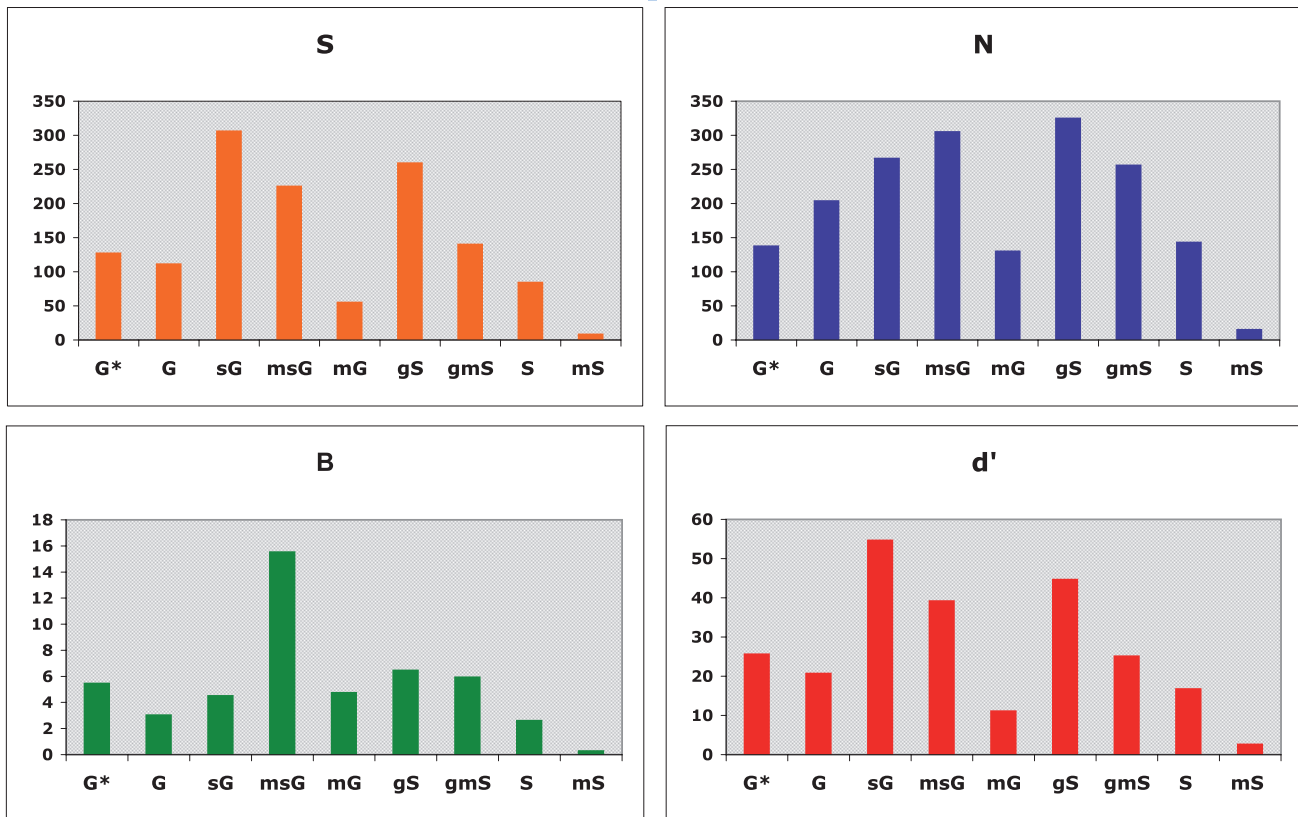


Figure 3: Histograms showing the number of taxa (S), number of individuals (N), biomass (B) and species richness (d') based on 0.1m² Hamon grab samples averaged for sediments based loosely on the Folk classification. Data compiled from pooled samples at 10 sites at each of the 20 areas sampled. Note that out of the 200 samples of sediment, the values for muddy gravel (mG) are based on one sample only, and should therefore be treated with caution. G* indicates samples that contained large cobbles.

types available in deposits that comprise coarse particles suitable for colonisation by epifauna, as well as finer deposits suitable for colonisation by a range of benthic infauna.

Despite the species diversity being strongly associated with sediment heterogeneity, the faunal assemblages were found to remain significantly related to the study area, illustrating the important influence of local conditions in shaping biological communities.

VULNERABILITY & RECOVERABILITY OF THE BENTHIC MACROFAUNA.

Material from each of the seabed samples was also used for analysis of the population structure of key characterising genera for both the benthic infauna and the mobile epibenthos. The 0.1m² Hamon grab did not provide sufficient material for analysis of population structure and growth rates of the larger, more widely distributed macrofauna. Additional samples were therefore taken in a wide variety of deposit types with an anchor-dredge. Material was collected from these

samples for information on the recruitment rates and growth rates of the benthic fauna. A total of 485 genera were identified in the grab samples taken at the study sites, and a further 51 genera from the trawl and dredge samples. Of these, 119 genera were identified as species that characterised up to 75% of the similarity of the macrofauna.

Six traits were selected as being probably the most significant ones in predicting recoverability, and for which a reasonable amount of data from both published sources and our own analyses were available. These traits are:-

- Size
- Fecundity
- Life-span
- Age at Maturity
- Larval Mode
- Mobility of Adults

Cohort analysis of some genera, measurement of growth rings in bivalves, and analysis of the relationship between body size and age were all used to provide information on the key traits identified above. Information on the biology and traits for individual genera was also compiled from an extensive literature search. One conclusion from this work is that, despite the increased emphasis on adopting an 'Ecosystem Based' approach to our understanding of the impacts of man on the marine environment, there is a surprising lack of information on the biological traits that are required to assess ecosystem function, vulnerability to disturbance by man, and the subsequent likely recovery of biodiversity and community structure.

Values for each of the six traits for the complete suite of 119 characterising species were compiled into a table that provides a score based on the 6 key traits identified as likely to be of importance in controlling both vulnerability to disturbance and recoverability following cessation of aggregate dredging in a particular area. This analysis allows some estimates of the vulnerability of individual characterising taxa to disturbance by dredging, and the likely times required for restoration of biodiversity by recolonisation. It also allows estimates of the additional time required for restoration of community structure following the growth of the colonising individuals during the life-span of the genus.

Figure 4 shows a diagram that summarises how the key traits can be summarised with appropriate scales in diagrammatic form for a particular taxonomic group.

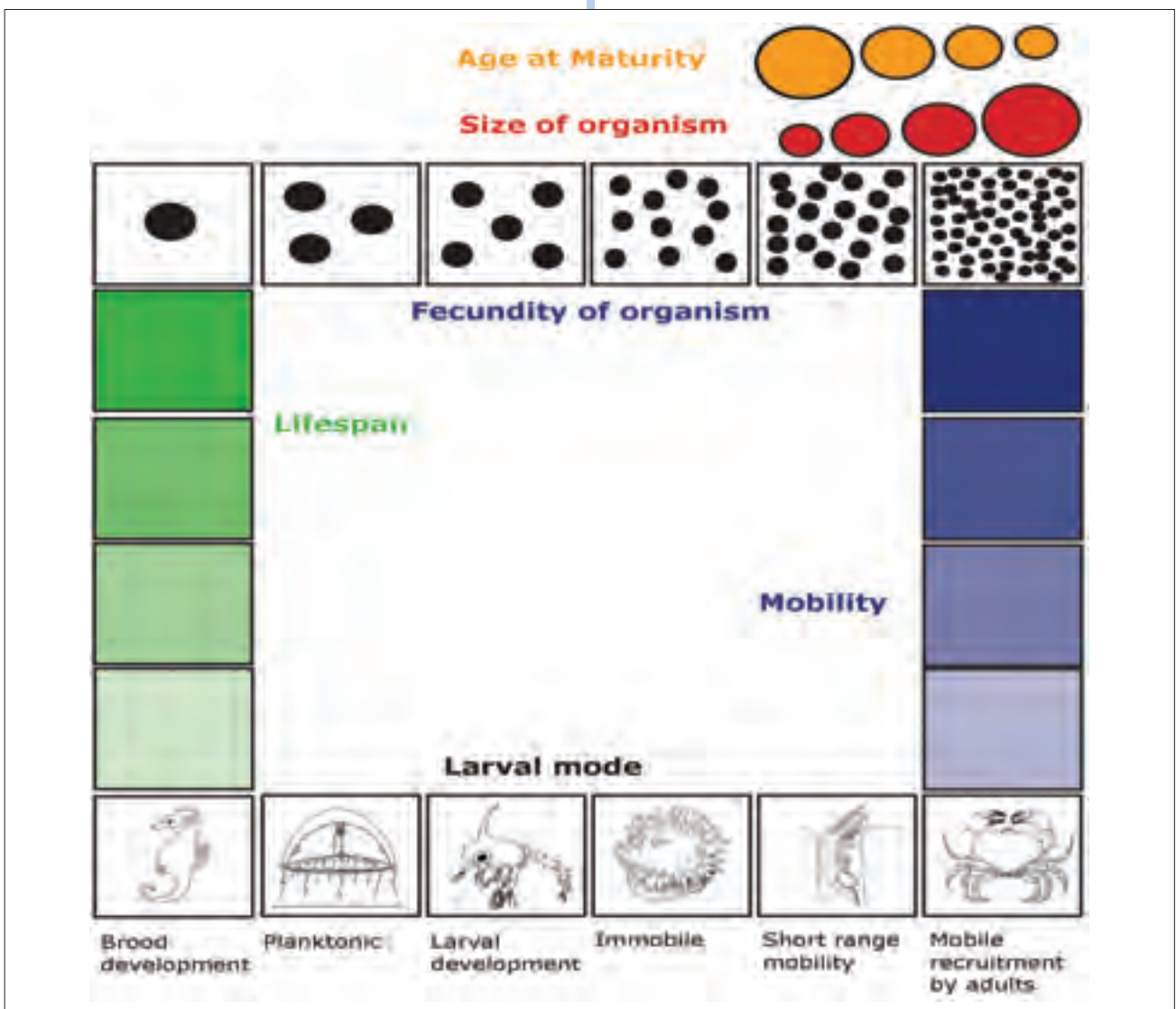


Figure 4: Schematic diagram showing how the key traits for a particular taxonomic group may be summarised to give an overview of potential vulnerability and recoverability scores.

Predictive framework for assessment of recoverability of marine benthic communities following cessation of aggregate dredging

Figure 5 shows a summary of the data for the amphipod *Leptocheirus* sp. Traits analysis for this genus showed that it has a relatively low fecundity, a medium life-span of 1-10 years, a non-planktonic larval development, limited mobility as an adult and a very small size of <1cm. This small amphipod crustacean is therefore likely to be vulnerable to impacts from dredging owing to its limited mobility, and is likely to be relatively slow in recolonisation because of the small number of offspring produced per brood.

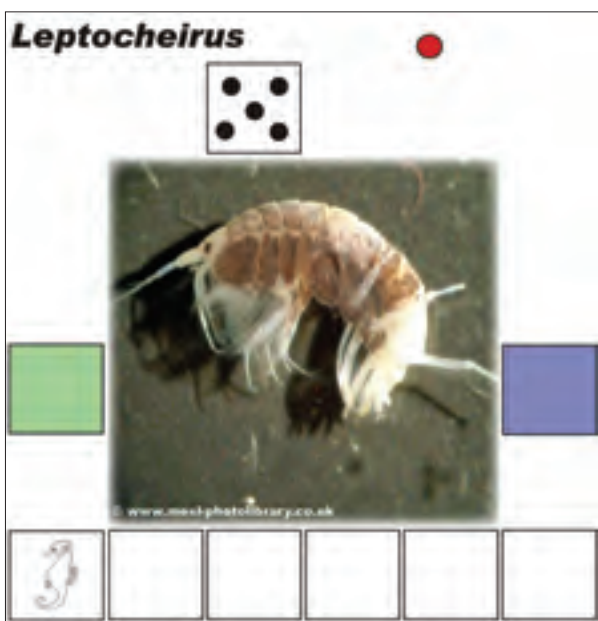


Figure 5: Summary of the vulnerability and recoverability traits for the amphipod, *Leptocheirus*.

Figure 6 shows a comparable traits summary for the hermit crab, *Pagurus* sp. In contrast to *Leptocheirus*, the hermit crab has a very high fecundity with planktotrophic larvae. The adult is moderately mobile. This genus is therefore likely to show a relatively high recoverability both as adults migrating in from undisturbed deposits and following settlement of larvae from the plankton.

It is our intention to summarise the traits in a handbook. This will include information on a wide range of macrofauna for use in assessment of the likely recolonisation and subsequent growth rates of the characterising organisms that are identified prior to dredging in any particular survey area. This may assist in improving the quality of prediction of impacts and recovery in relation to marine aggregate dredging and other infrastructure developments that have a potential impact on marine benthic communities.

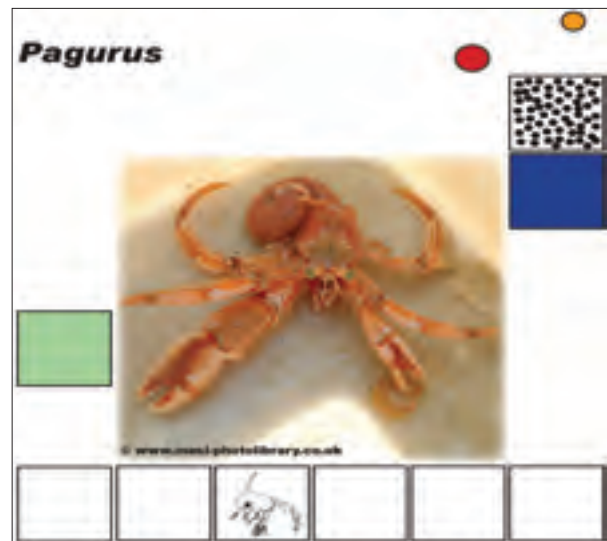


Figure 6: Summary of the vulnerability and recoverability traits for the hermit crab, *Pagurus*.

It is also possible to apply the same information to assessment of recoverability at the community level, rather than for individual component taxa. It should be stated that these estimates presuppose that the deposits after cessation of dredging remain sufficiently similar to the pre-dredge deposits to allow a succession of colonising individuals which is similar to that prior to dredging. This is normally a condition attached to a Licence for marine aggregate dredging. If there is an alteration of deposit type, then estimates for the recolonisation time for the benthic fauna will need to be added to the time required for restoration of sediment composition through natural processes of seabed sediment transport.

Analysis of the proportion of the biomass of each taxon in the 10 samples from each site for which trait information is available yields information on how much of the measured biomass at each site possesses each trait. The next step was to use the combination of these biomass values and the relationships between traits to construct a series of indices indicating the vulnerability/recoverability of the communities at each site. This gives a very large number of traits and interactions that may be of importance in controlling vulnerability and recoverability at the community level. It is also obvious from the analysis that the criteria used to indicate vulnerability and recoverability using some traits are negatively correlated with those using other traits (particularly size and fecundity).

The conclusion is that we can use biological information about genera, coupled with survey data, to construct measures indicating the vulnerability and recolonisation rates at the community level. However because of the generally weak relationships between individual traits and both vulnerability and recoverability, we cannot reduce the list of traits and their interactions very much. The only way forward in developing a predictive tool for vulnerability and recoverability at the community level will be to assess each of the measures derived from traits against real recovery data from a site at which dredging has ceased. This will then indicate which trait-based measures are actually the most closely-related to the recovery process and will assist in the development of a trait-based tool for prediction of vulnerability and recoverability at the community level.

The Citation for the Report on which this summary is based is:-

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Title: MEPF 04 02 Predictive Framework for Assessment of Recoverability of Marine Benthic Communities Following Cessation of Aggregate Dredging

Contractor: Marine Ecological Surveys Ltd

Contact: Richard Newell

Telephone: 01225 442211

E-mail: marine@seasurvey.co.uk

Full Report Site:

<http://www.seasurvey.co.uk/>

<http://www.alsf-mepf.org.uk/>



Coupling physical and ecological models: A new approach to predicting the impacts of aggregate extraction on biological recoverability

PROJECT BACKGROUND AND AIMS

Currently, no quantitative tools have been tested for their ability to predict the long-term recovery of benthic communities from dredging. Recoverability is typically inferred from conceptual models. Therefore, there is a need to develop a quantitative model to allow regulators and managers to predict the impacts that dredging operations may have on the seabed and its ecology and to estimate the time for its recovery. The aim of the project was to develop cellular grid-based models predicting the impacts on physical and biological components of the marine environment.

This project, funded through the Aggregate Levy Sustainability Fund (ALSF), was divided into several phases. The first phase of the study involved modelling sediment transport, focusing on large-scale bathymetric changes such as infilling of dredge areas using a rule-based cellular automata type model. The second phase involved developing biological models to represent the benthic ecology. The rules and source terms underpinning the biological model need to take account of the various feedback mechanisms that exist between the physical environment (hydrodynamics, sediment, bedforms) and the benthic ecology.

MODELLING APPROACH

Cellular Automata (CA) are a class of cell-based mathematical models, discrete in time and space. The evolution of each cell over time is dependent on rules governing the nature of its interactions with other neighbouring cells. The dynamics of sediment transport

are simulated by the movement of blocks, simplified as a series of iterations of the saltation process and deformational shaping by gravity, or avalanching. The saltation process is driven by the principal mechanism causing the movement, that is, wind (Aeolian transport) or currents, Schinaia *et al.* (2006). See Figure 1.

The Test Field of the model has a total dimension of 120 m x 1440 m, and is composed of uniformly distributed, sandy sediments. The dredged area forms a trench 24 m x 300 m; the lateral deposits left on either side of the trench during the dredging operations are 6 m wide x 300 m with a height 1 m above the seabed. The model assumes that screened material is deposited at the end of the trench in an area approximately 35 m wide x 80 m long. Tidal reversal is applied assuming parallel flows with a 10% asymmetry. Under these conditions, infilling of the trench is predicted to occur over 250 days, which allows for calibration of the reference time (t) to a given site condition.

A number of different scenarios were considered, altering the depth of the trench and flow velocities and considering two parallel trenches rather than one. The modelling results of one scenario are illustrated in Figure 2, which considers the evolution of a shallow dredged trench (depth less than 1 metre) with screened sediments deposited at the end of the trench. The trench becomes shallower and, although after 250 days its features are still visible, the initial seabed topography is almost recovered. The screened sediments have dispersed and migrated slightly according to the hydrodynamic flow.

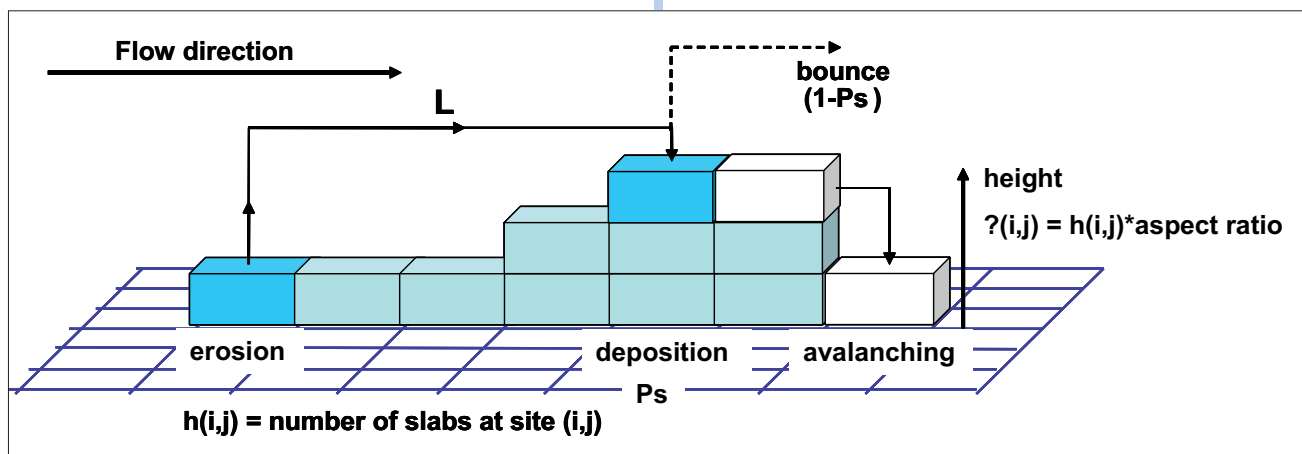


Figure 1: Schematic representation of saltation and avalanche processes simulated by the model.

N.J. Frost¹, J.M. Harris¹, J.E. Saunders¹, S.R. Bishop², S.A. Schinaia², R. R. Simons³, R.C. Newell⁴
¹ABP Marine Environmental Research, Suite B, Waterside House, Town Quay, Southampton, Hampshire, SO14 2AQ
²Mathematics Department, UCL, Gower St, London, WC1E 6BT
³Civil & Environmental Engineering Department, UCL, Gower St, London, WC1E 6BT
⁴Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY

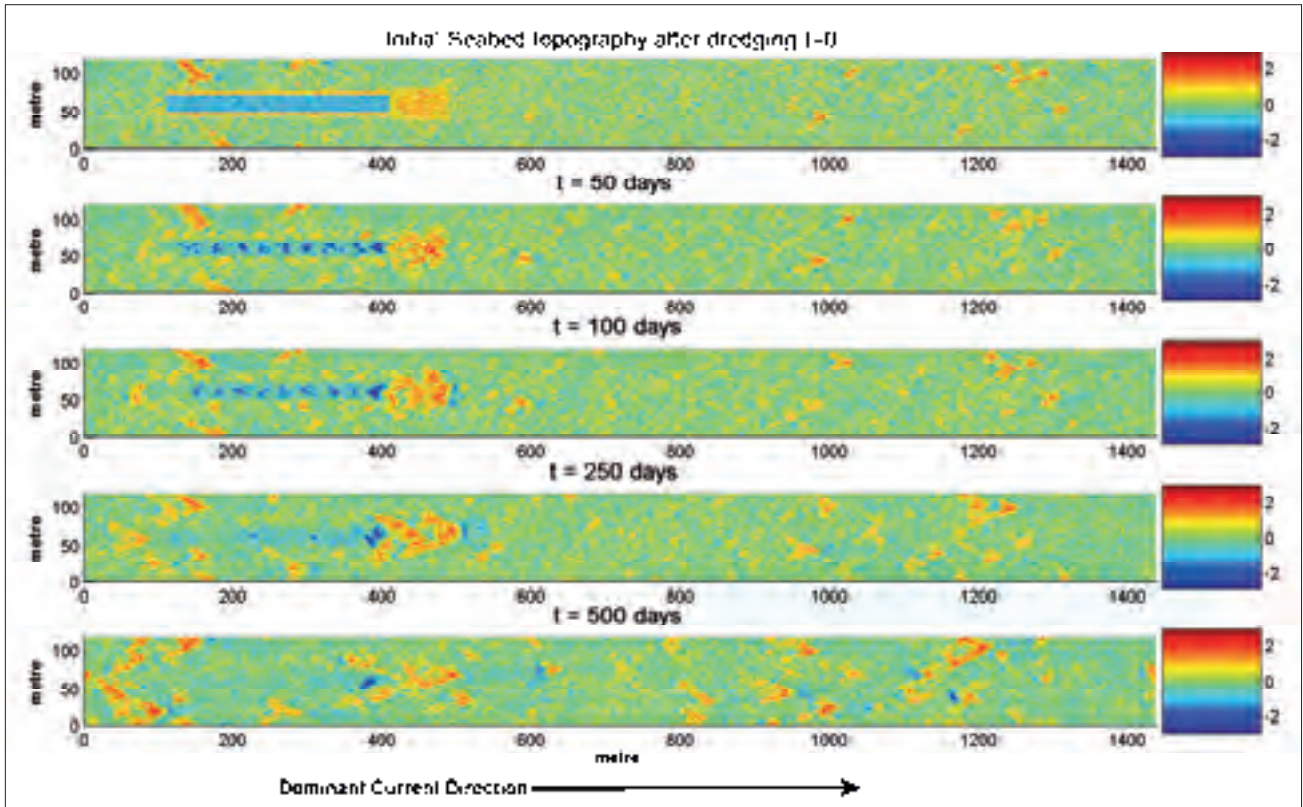


Figure 2: Simulated evolution of the bathymetry (m) and infilling of a dredging trench over 500 days and migration of screening material from the end of the trench.

MODELLING BIOLOGY

The characteristics of the biological model were determined by generating a series of simplified rules that broadly reflected the real situation, while remaining simple enough that solutions and conclusions may be validated. A model based on five species groups was selected as outlined in Table 1 below. Further variations may be possible at a later stage but it is envisaged that this structure will take into account the range of species compositions present in a number of marine sedimentary environments.

| Group | Description | Examples |
|-------|----------------|---|
| S | Scavengers | mobile fish, crustaceans and scavenging echinoderms |
| O | Opportunists | typical r-strategists such as spionid worms and capitella capitata (some barnacles may be included here too depending on their role). |
| U | Upper Benthos | other worms and small crustaceans |
| L | Lower Benthos/ | including Long-lived species that take a long time to recruit – deep bivalves and large crustaceans |
| A | Attached | highly sensitive to the effects of dredging but will recruit back quickly once the sea bed has stabilised, e.g. sponges and hydroids. |

Table 1: The five species groups included in the biological model

Coupling physical and ecological models: A new approach to predicting the impacts of aggregate extraction on biological recoverability

The general mobility, feeding and life history properties of the various species determined their grouping. This information also enabled rules to be constructed for each group, governing general biology (e.g. population size) and the group responses to:

- a) change in the local topography, either natural or anthropogenic, and involving
 - i. a reduction, e.g. dredging, or
 - ii. an increase, e.g. screening;
- b) food, both as predator and prey; and
- c) space, both occupied and empty.

The level of *change* in topography is generated by the sediment model at each time step. *Food* is derived from naturally occurring detritus, from detritus arising from the mortality of individuals during the evolution of the model and through predation of the species themselves. *Space* considers the impact of intra- and interspecific competition on the abundance of a species group within a cell.

These biological rules were then developed into a series of Boolean Logic statements with annotations and schematic diagrams set as a 'story-board' to assist in understanding the interactions. The statements can then be developed into FORTRAN code. The values of responses given in the statements are expressed as ranges to test the sensitivity of the model under different physical environments and community compositions.

All biological responses and characteristics were derived using a combination of scientific literature, discussions between experts, data collected from field studies and analysis of recoverability of species undertaken by Marine Ecological Surveys Ltd (MES).

Initial models have been run describing the change in distribution of scavengers and attached organisms in response to dredging. Figure 3 shows their distribution after 250 days. Importantly, the figure shows the ability of the biological model to enable species to respond to change, although the actual patterns maybe less meaningful at this stage, as interaction between the various species is not yet fully coupled.

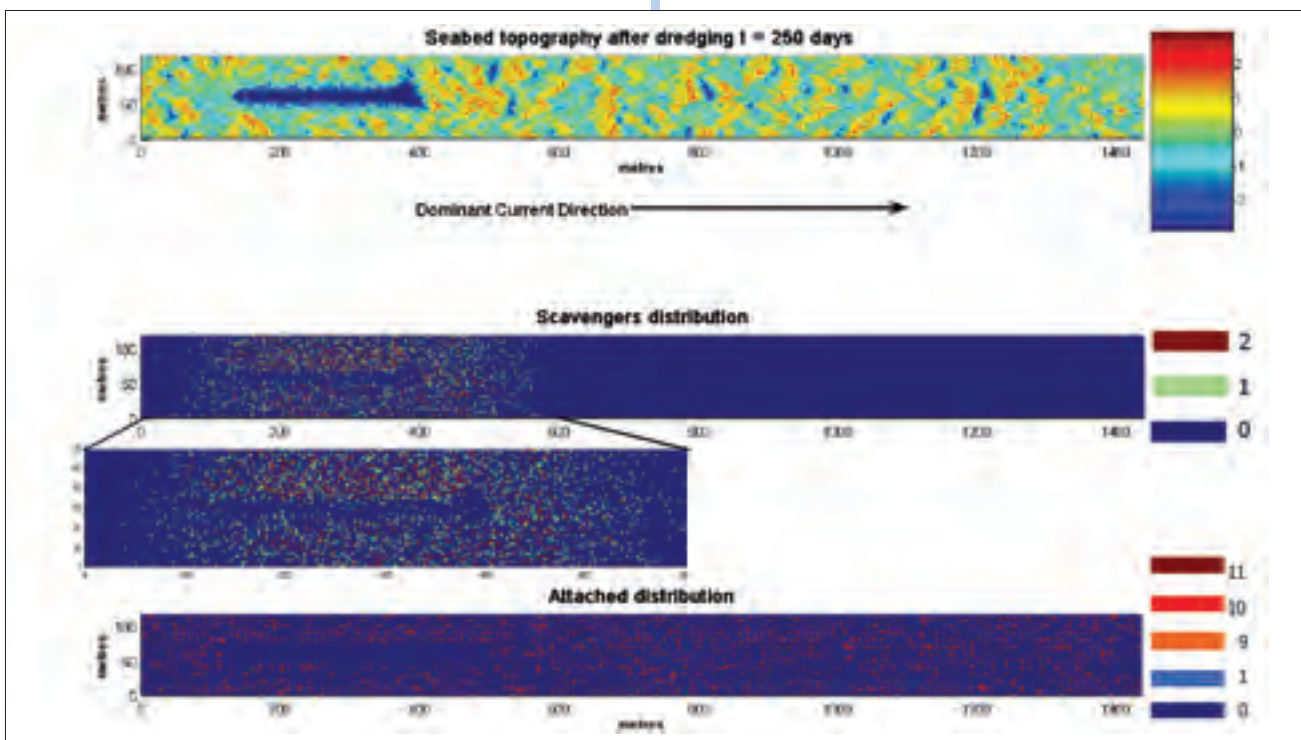


Figure 3: Distribution of Scavengers and Attached after 250 days from dredging of a deeper site.

FUTURE WORK

It is planned to undertake further development of both the physical and biological models. The immediate aims are to:

- a) further refine the physical model to reflect the range of conditions in various sedimentary environments and represent more complex hydrodynamic environments (tides and waves).
- b) develop the biological model further. This is being undertaken using an iterative approach where the degree of complexity in terms of the number of taxonomic groups and number of interactions included within the model is gradually increased. The stepwise approach will allow an assessment of the model performance throughout the development process.
- c) once completed the model will be validated using 2 case studies where monitoring has been undertaken to assess the response and recoverability of benthic organisms to extraction activities.

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Title: MEPF 04/04 Coupling physical and ecological models: A new approach to predicting the impacts of aggregate extraction on biological recoverability.

Contractor: ABP Marine Environmental Research

Contact: Natalie Frost

Telephone: 02380 711850

E-mail: nfrost@abpmer.co.uk

Full Report Site:
www.abpmer.co.uk
www.alsf-mepf.org.uk



Direct measurement of seabed stability at a marine aggregate extraction site using benthic flume technology

INTRODUCTION

Aggregate extraction can have a number of physical environmental effects on the seabed including the removal of sediment and the resident fauna (Newell *et al.* 1998), changes to the local hydrodynamic regime via localised deepening of the seabed, changes to the regional sediment transport regime through interception of sand moving over the seabed, changes to the nature and stability of sediments accompanying surface screening or the exposure of underlying strata, and increased turbidity and redistribution of fine particulates (CIRIA, 1998; Boyd *et al.*, 2002).

In spite of a considerable body of scientific research on physical processes at aggregate extraction sites, there are (to the authors' knowledge) no reported field data specifically on either sediment entrainment threshold (U_{crit}) or transport rate (q) either before or after dredging. One of the fundamental questions regarding environmental impact of dredge activities – to what

degree does the dredge operation modify the seabed stability? – therefore remains unanswered. This research project has been directed towards addressing this question.

Currently, estimates of U_{crit} and q for use in modelling schemes are obtained from existing empirical knowledge based upon grain size information and indirect observations such as bedform character (Limpenny *et al.*, 2002), or are based on historical formulae derived from laboratory flow channel studies on river sediments.

Whilst there has to date been no other choice but to adopt these approaches, now there is a new technology that can be used to measure these variables directly in the field situation. This technology is termed **benthic flume** technology. Development and use of the benthic flume technology directly addresses a stated aim within **Theme 3a** of the SAMP initiative.



Figure 1a: A wide angle shot of the flume instrument. The long yellow pods on the top of the instrument house the batteries and Arctic motor control software. The white pod directly atop the instrument is the data logger. On the outside channel facing is the housing for 3 optical backscatter turbidity sensors placed at different heights. The vertical steel unit is a height adjustable corer.



Figure 1b: Photograph of the flume partially submerged during recent field trials. A section of the lid has been removed in order to ascertain paddle movement visually. At 5 o'clock a pop up buoy with acoustic release is shackled to the instrument frame.

PROJECT OBJECTIVES

This project has been dominantly a technology development project with a stated application on and beside an aggregate extraction site, together with a considerable outreach/dissemination stage. Specifically the principal project objectives were:

Objective 1. To design, construct and field test an annular benthic flume suitable for offshore deployment.

Objective 2. To deploy the benthic flume instrument on and adjacent to an aggregate mining site (Great Yarmouth).

Objective 3. To formulate a template for the adoption of benthic flume technology and the associated experimental approach within the range of standard monitoring methods for the evaluation of dredge impact at aggregate extraction sites.

This paper provides a summary of the major technical achievements (cf. Objective 1) in terms of flume design and construction, associated sensors and data acquisition, and sediment transport rate measurement. For a complete description of the flume and the associated field programme, refer to www.partrac.com.

BENTHIC FLUME TECHNOLOGY

A variety of field-portable instruments capable of deployment in the field have been developed (see Black and Paterson, 1997, for a detailed overview). These include a shear pad, continuous and pulsed vertical jets, an erosion bell, a suction-stirring device, and a range of benthic flumes of differing designs. The flumes have been of the annular or race-way recirculating type, or straight flow-through type. Each of the flumes can be placed on the seabed, and water is then pumped or driven over the bed until erosion occurs. Flow within the flume channel is usually increased in a stepwise fashion, and most devices use fast-response sensors e.g. optical backscatter sensors, to measure the time-evolution of suspended sediment and imposed flow speed. Some flumes are equipped with a video camera to examine the sediment movement during an experiment.

VOYAGER II BENTHIC FLUME

The benthic flume comprises an annular channel based broadly on the pre-existing designs of Amos *et al.*, (1992) and Maa *et al.*, (1997). The flume was named **Voyager II** (Figures 1a & 1b). It comprises an aluminium channel 0.30m high and 0.15m wide fixed about an internal frame. It weighs approximately 150kg in air and 40kg in water. Within this channel 8 equidistantly spaced paddles are centrally fixed in order to induce a flow of water in the annulus (Figure 3). The paddles are moved around the axis of the channel by a chain-drive mounted

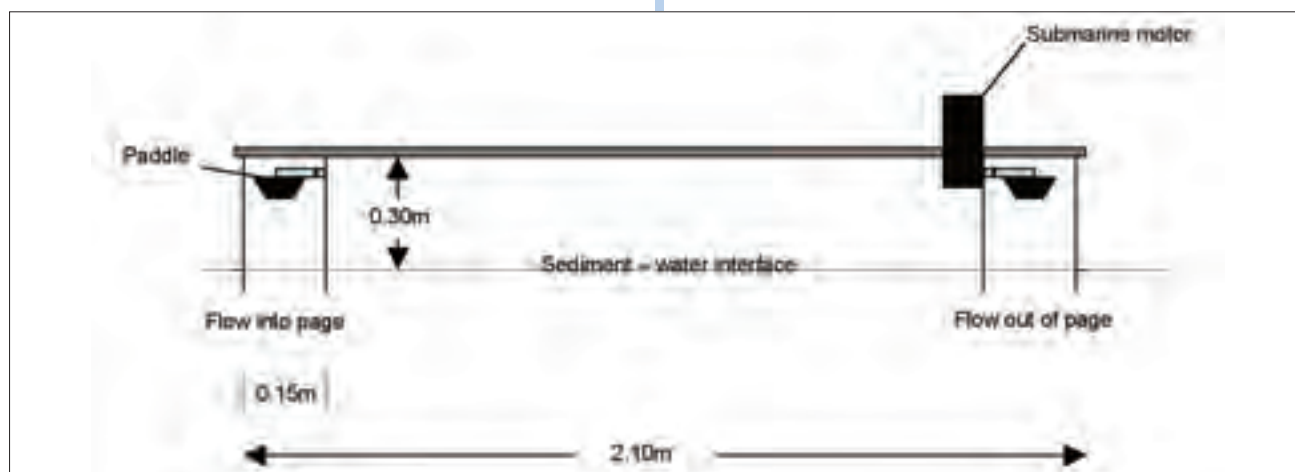


Figure 2: A schematic diagram in cross-section of the flume giving its general dimensions.

Direct measurement of seabed stability at a marine aggregate extraction site using benthic flume technology

at the top of the inner channel wall (Figure 3). A cog arrangement, which protrudes through the inner wall, is driven by a 0.6hp, 24V dc Benex submarine motor through a gearbox fixture.



Figure 3: Photograph showing one of the 8 paddles mounted within the annulus and affixed to the chain-drive.

The flume is instrumented with a variety of fast-response sensors which are used to measure the sediment transport generated by the moving paddles. Three Seapoint™ optical backscatter sensors are affixed to the outer channel wall at differing heights above the bed and these measure water turbidity within the annulus (Figure 4). Turbidity is a proxy measure for the concentration of suspended sediment in the flume water. A self-logging Nortek ADV™ flow sensor is fixed 0.15m above the nominal sediment water interface to measure flow velocity (3 components) and flow turbulence (Figure 5). In addition, using sound propagation this sensor acquires a measure of the distance from the sensor face to the bed, a method known as *altimetry*. If ripples migrate around the flume then their passage can be measured using this approach. Data from each of these sensors is logged directly to a Marine Informatics FlexiData Sublogger™ onboard programmable data logger.



Figure 4: Housing containing 3 optical turbidity sensors; note each sensor looks across the flume channel.

A bespoke onboard computer (Grund Electronics *Arctica*) can be programmed to control and measure the lid rotation frequency. The design specification for the flume was a maximum in air lid rotation rate of 1ms^{-1} , with a capacity to reverse the lid rotation direction. The software is flexible and can be configured to change the



Figure 5: Photograph of the Nortek ADV current velocity/altimeter sensor. The instrument is 'downward-looking' and acquires velocity data approximately 10cm above the bed.

lid rotation (i.e. flow speed) in a number of different ways. A series of discrete steps of a specified magnitude and duration can be applied, which constitutes the dominant historical method for measuring sediment transport. However, a smooth acceleration can also be applied to mimic the gradually changing tidal flow, and a sinusoidal (reversing) flow regime can be applied through reversal of the lid rotation direction. This mimics passage of a wave over the bed. The software also directly measures the lid rotation rate, which provides data to correlate with measured flow speeds during calibration exercises. In practise, the flume is pre-programme with the desired lid rotation, and then emplaced and left for ca. 3 hours on the seabed to operate autonomously and unattended.



Figure 6: Photograph showing the window in the inner wall and the two LED lamps. The camera [not shown] is out off the shot just to the right.

A window is located in the inner flume wall for the purposes of observing and recording the sediment motion (Figure 6). A colour JVC Everio™ long play, high memory, digital hard drive video camera within a Greenaway Marine bespoke housing is mounted within the flume frame pointing towards the window. A metal wedge at the base of the window sections the sediment upon flume deployment. Thus the upper 20mm of sediment and the lower 10cm of the water column are visible. Light is provided by 2 Seatronics SEA-LED 30W high intensity underwater LED lamps (Figure 6); switching of these and variation of the light intensity are controlled through the *Arctica* software.

The flume is also equipped with a number of ancillary fixings. These include: lifting lid sections to avoid air in the channel during deployment (see Figure 1); a warp release mechanism (to leave the flume on the seabed); a backup acoustic release; a programmable triple water sampler; lead ballast.

CONCLUSIONS

The *Voyager II* flume represents the state-of-the-art in terms of benthic flume technology. The capacity within the aggregate and marine environmental industries now exists to make extensive measurements to quantify seabed stability changes during and following aggregate extraction operations. This constitutes a highly useful capability which adds to other (e.g. biological, chemical) investigative methods that are routinely used for environmental impact assessment. Arrangements are in progress to enable the wider academic and industrial bodies, partners and agencies to use this technology with appropriate training.

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Title: SAMP 3.18 Direct measurement of seabed stability at a marine aggregate site using benthic flume technology

Contractor: Partrac Ltd

Contact: Kevin Black

Telephone: 01413 038255

E-mail: kblack@partrac.com

Full Report Site:
www.partrac.com/
<http://www.dclgaggregatefund.co.uk/themea.htm>



Modelling exclusion zones for marine aggregate dredging

INTRODUCTION

Once identified, submerged sites of actual or potential archaeological importance need to be protected from any further unnecessary damage or dispersion. Damage to artifacts may either render them unrecognizable or destroy them altogether whilst dispersion removes artifacts from their context, making interpretation more difficult and less informative. This general preservation directive aims to maximize the quantity and quality of archaeological information that can be obtained from a site by both present and future generations. In the context of marine aggregate dredging, this is achieved through the placement of protective 'exclusion zones'.

In regions of marine aggregate dredging, there are four perceived threats posed by the dredging works to any nearby artifact based sites:

1. Direct interaction with the cutting or suction head of a dredger.
2. Changes in seabed site dynamics in response to upstream modification of the flow regime and sediment input rate caused by dredging.
3. Impacts of the dredge plume on wreck site formation.
4. Changes in site dynamics of inter-tidal and sub-tidal archaeology of localities adjacent to the dredging area (including the coastal zone).

There are also many naturally occurring destructive processes of a physical (e.g. abrasion and erosion), biological (e.g. digestion) or chemical (e.g. rusting and dissolution) nature that may cause artifacts and other material to degrade with time. These processes vary in rate and severity depending upon the particular environment at the site but are, in all cases, generally reduced by burial of the wreck in the seabed sediment which tends to isolate sensitive material from any naturally occurring threats. Potential or actual threats to archeological sites by anthropological activity therefore include indirect actions which might remove sediment cover, in addition to activities that could interfere with or damage a site directly.

The risk posed by the more direct threats (1-3) is increased when dredging operations occur 'too close' to the site. In order to increase the distance of separation and thus reduce risk, it is common practice to draw an exclusion zone around the site, within which dredging is prevented. In practice, the need to protect heritage and the extent of an exclusion zone must also be balanced to some extent by the loss of available aggregate resource, imposed by the zone. Exclusion zones reducing threat (1) are of particular importance to the dredging industry as debris can also cause damage to dredging plant, contaminate the sediment load or compromise the integrity and safety of any ground tackle used.

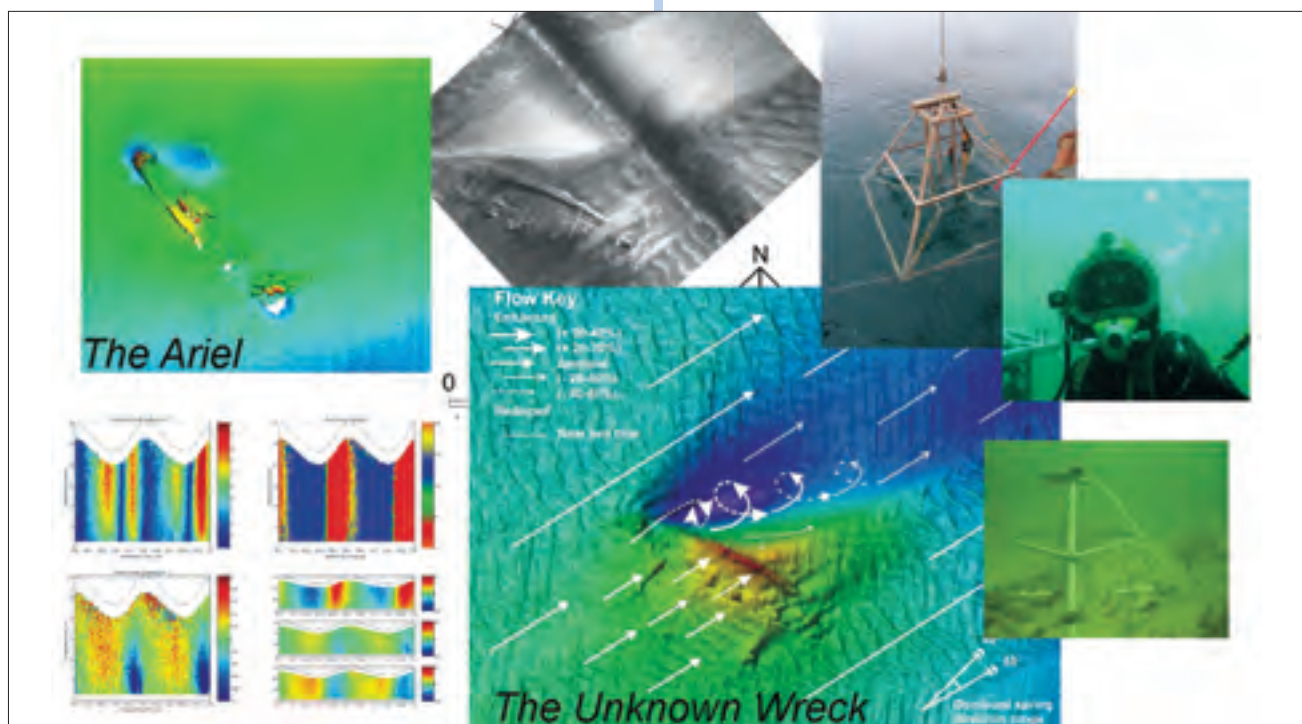


Figure 1: Flow Measurement Field Studies

In order to be effective and acceptable to all stakeholders, exclusion zones must be robust, methodical and practical in their design. In common practice, an exclusion zone is approximately circular with a radius 50-200m from the known extent of the site. The exact value is determined subjectively by trained archeologists; however, there is limited existing research upon which to base a quantitative assessment. It is the purpose of this project therefore to review and summarise any extant research and to significantly increase the amount of data and knowledge that can be applied in the design of these exclusion zones.

PROJECT AIMS

The modelling exclusion zones for marine aggregate dredging project has been investigating all of the four perceived threats posed by marine aggregate dredging activities. Through an integrated understanding of the many threats involved, the project is making recommendations to the main stakeholder groups (conservation groups and the dredging industry) regarding best practice for the design of exclusion zones. The component parts of the study also individually provide a great deal more specific and practical information that will be of actual and immediate use to managers of submerged heritage sites, the dredging industry and the wider archaeological and scientific community.

To achieve its aims and in the spirit of the ALSF, the project liaised closely with the dredging industry and other key stake holders, exchanging large and valuable data sets, information and results on a regular basis throughout the project. Certain output documents were designed to address particular and immediate interests of the industry partners during the project timeframe.

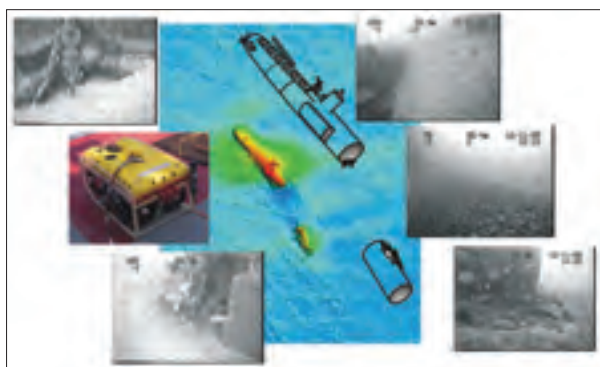


Figure 2: ROV Survey UC-65

Particular attention has been paid to understanding the processes that control rates and patterns of sediment erosion and accretion around a wreck site, as well as the

stability of these systems in response to dredging. Relationships describing similar patterns and processes around other typical two-dimensional structures (e.g. undersea pipelines, cables, wind farm/oil rig foundations, coastal defense structures, etc.) are not applicable in the case of submerged three-dimensional sites. Consequently, this project has not only generated and analysed significant quantities of new and innovative data but represents a large proportion of the publicly accessible research in the important field of flow fields and sediment dynamics around three-dimensional obstacles. In addition to shipwrecks, such three-dimensional obstacles could generically represent: partially buried pipelines/cables; some gravity based structures; anti-ship mines; and a wide variety of other undersea structures.

MAJOR INDIVIDUAL OUTPUTS OF THE PROJECT

As the tidal flow passes around and over a shipwreck on the seabed, so the flow is modified locally. The speed of the tidal flow or the level of turbulence is strongly and consistently increased in particular locations and decreased in others; the direction of the flow is also modified. Over time this produces characteristic patterns of net erosion and accretion. Accretion of sediment above the ambient bed level can be considered locally advantageous whilst scour exposes material to the threats described previously.

Concurrent investigations were conducted in the field and in the laboratory, as well as numerous desktop studies in order to characterize and quantify the patterning of flow modification and any resulting scour and accumulation. The following are a few examples of the individual studies conducted as part of the project. The output from all of the component studies were considered when making the final recommendations for exclusion zones.

FIELD STUDIES – MEASURING THE FLOW FIELD AROUND SHIPWRECKS IN THE FIELD

Two wreck study sites were carefully identified for detailed study, one in each year of the project. At each site, information was gathered about the location and orientation of the wreckage and the location of any obvious erosional or depositional features. In an unprecedented density of deployment, eight Acoustic Doppler Current Profilers (ADCPs) were precisely placed around the wrecks. Each instruments recorded observations of tidal flow, wave regime and the concentration of scatterers in the water column at 30-40 sampling points along a vertical or horizontal profile for

Modelling exclusion zones for marine aggregate dredging

30 days; profiles were recorded every 10 minutes in the first study but this was increased to every 15s for some instruments in the second. The huge quantity of data were analysed in three-dimensions to reconstruct the patterns of flow modification around the wreck. These were compared with the observed distribution of scour and accumulation at the site and with the results of the laboratory studies. The importance of these studies is that they demonstrate the link between flow, obstacle and scour at full scale in the natural environment, and secondly that they provide the necessary validation for the laboratory scale modelling (described below).

FIELD STUDIES – OBSERVING HIGH RESOLUTION CHANGES IN LOCAL MORPHOLOGY

A torpedoed World War 1 German U-boat located in the middle of the English Channel was the subject of another field study. As human diving is time-restricted at these water depths, a Remotely Operated Vehicle (ROV) was used to collect underwater video of the site on three occasions during the study. These were analysed separately to generate detailed sediment distribution maps. Comparison of the maps with additional historical footage was used to provide an estimate of naturally occurring annual and seasonal variation. The importance of this study is that it provides a particularly detailed record and baseline of naturally occurring sediment erosion and accumulation around a wreck prior to the (very recent) initial commencement of nearby dredging.

LABORATORY STUDIES – PATTERNS OF MODIFIED FLOW AROUND A ‘SHIPWRECK’

It is common practice in the field of engineering to attempt scale modelling in the laboratory if it is not possible or efficient to make similar or sufficient observations at full scale. The flow measurement field studies described above represent two (relatively similar) sizes and orientations of obstacle. By representing the wreck with a simplified model at a much smaller scale in the laboratory it was possible to make a much greater number of similar idealised measurements for other obstacle sizes and orientations. This empirical approach to characterising the flow field response has previously been the first step in other fields of scour research as the seabed response is a response to the locally modified flow interacting with it. This study increases greatly the amount of data available relating to flow around submerged three-dimensional obstacles.

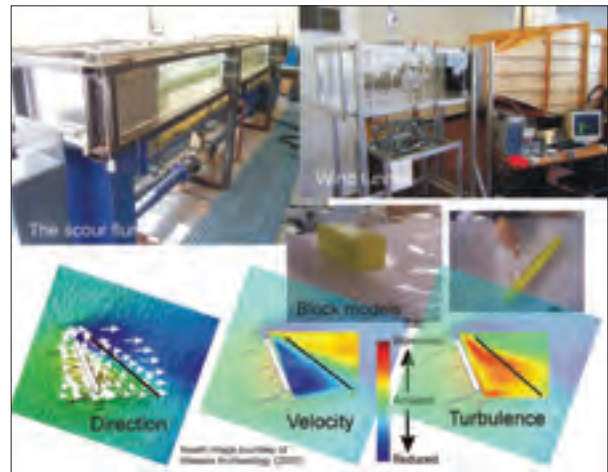


Figure 3: Experimental laboratory equipment and selected results in comparison to the Unknown Wreck study site

DESKTOP STUDIES – LITERATURE REVIEWS

Certain threats have been addressed in previous studies and every effort was made to collate and review any extant results or conclusions. Desk based literature reviews were conducted for topics including: damage caused by direct interaction with the dredge head; the impact of bed lowering on tidal regimes adjacent to and distal to aggregate dredging zones; the nature of dredge plumes; the sediments and geology of the Eastern English Channel; factors affecting scour around three-dimensional obstacles and Reynolds number effects in scale modelling.

Additional data provided by dredging industry partners allowed the project to support a Master of Science thesis dissertation and several informal sediment mobility assessments of the field study site regions. These collaborative sub-projects were hugely beneficial to both parties and reflect the best intentions of the ALSF framework.

THE COMBINED RESULTS: RECOMMENDATIONS FOR EXCLUSION ZONES

Recommendations are made by the project for the design of exclusion zones. These consider and incorporate the output from the numerous component studies, some of which are outlined above. The exclusion zone is composed of an ‘environmental buffer’ defined by the sediment dynamics of the system and a ‘dredging buffer’ defined by the operational capabilities of the dredge systems, in particular the navigational accuracy to which the dredge head can be located.

The recommended procedure considers primarily the physical extent of the wreck site as a sedimentary system, as defined by the field and laboratory studies. The environmental buffer typically forms an ellipse, aligned to the tidal axis; this is because the majority of ambient sediment transport in offshore dredging areas occurs along a parallel or sub-parallel axis. The 'upstream' separation prevents undermining of naturally stable sediment slopes leading up to the wreck whilst the 'downstream' separation encompasses regions likely to contain artifacts transported from the immediate wreck site. Recommendations for the environmental buffer are deliberately conservative to account for any differences between the predicted flow and erosional field, albeit the model calibrations in this study that we are capable of estimating to a good level of accuracy the flow and sediment dynamic regimes.

Having defined the 'environmental buffer' an additional ellipse with a fixed offset from the 'environmental buffer' is designed. This fixed distance is dependent on the demonstrable navigational accuracy of the dredge head and any operational constraints on the actual dredging process (ie the ability to follow pre-determined dredge lines). The exclusion zone boundary is determined as the sum total of these two buffers.

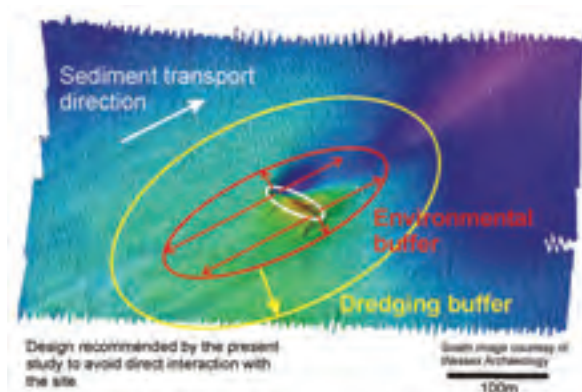


Figure 4: Exclusion Zone Design relative to the Unknown wreck site

The new exclusion zone design is more likely to form a tidally aligned ellipsoid which may prove operationally more convenient than previous circular zones and minimizes the area of aggregate resource lost. It has been identified by the present study that additional research into the impact of regional scale sediment mobility patterns would further support managers and curators of heritage in their task.

Title: 3365MAIN. Modelling Exclusion Zones For Marine Aggregate Dredging

Contractor University of Southampton

Contact: Justin Dix

Telephone: 02380 593057

E-mail: jkd@noc.soton.ac.uk

Full Report Site:

<http://www.noc.soton.ac.uk/soes/research/groups/geophysics/aggregates/Index.htm>
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

A protocol for reporting of archaeological finds at marine aggregate extraction sites

The marine aggregates industry and archaeologists have collaborated in introducing a new scheme that is helping to protect the marine historic environment whilst increasing industry's awareness of its value.

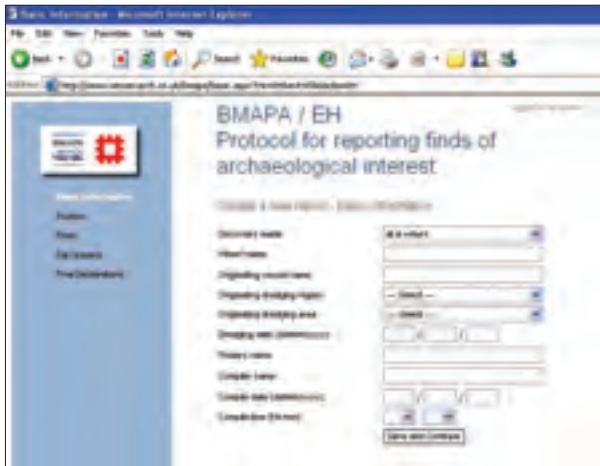


Figure 1: WWW interface for the reporting discoveries for the BMAPA/EH Protocol Implementation Service.

The BMAPA / English Heritage Protocol encompass three linked components:

- The **Protocol** – a procedure for finds to be reported to archaeologists, so that advice can be provided.
- The **Implementation Service** – a web-based system that makes it easy for reports to be made, and for each find to be properly researched.
- The **Awareness Programme** – a series of visits to aggregate wharves and vessels, providing practical advice on how to identify, record and handle archaeological finds.

The Protocol was adopted in October 2005 and has already resulted in many significant finds being reported by aggregate industry staff. These range from an entire mammoth tusk that is providing data on the landscape beneath the North Sea during the last ice age, through a possible *in situ* prehistoric site, to the remains of an early British jet fighter lost in 1956.

The Protocol is a striking example of how the ALSF is contributing directly to more sustainable aggregate dredging, resulting in tangible advances in archaeological knowledge and a broadening awareness of the marine historic environment. The Protocol is improving our knowledge of the scale and character of the marine historic environment and promotes understanding of conservation issues in the marine aggregates industry. The Protocol is already being referred to in new licence conditions as well as applying to existing licences and is included in the draft MMG2 Model Conditions.

Wessex Archaeology (WA) is currently carrying out aspects of English Heritage's (EH) role within the Protocol as part of an Implementation Service commissioned and supported by BMAPA.

The Implementation Service encompasses elements of EH's role in the Protocol that are concerned with recording and passing on information about reported finds, and limited decision-making regarding archaeological actions in respect of reports that can clearly be addressed without contention. Reports are transferred to local and national archaeological records and as such are available to subsequent marine aggregate EIAs, SEAs and REAs so that future management of the historic environment as it relates to aggregate extraction can be better informed.

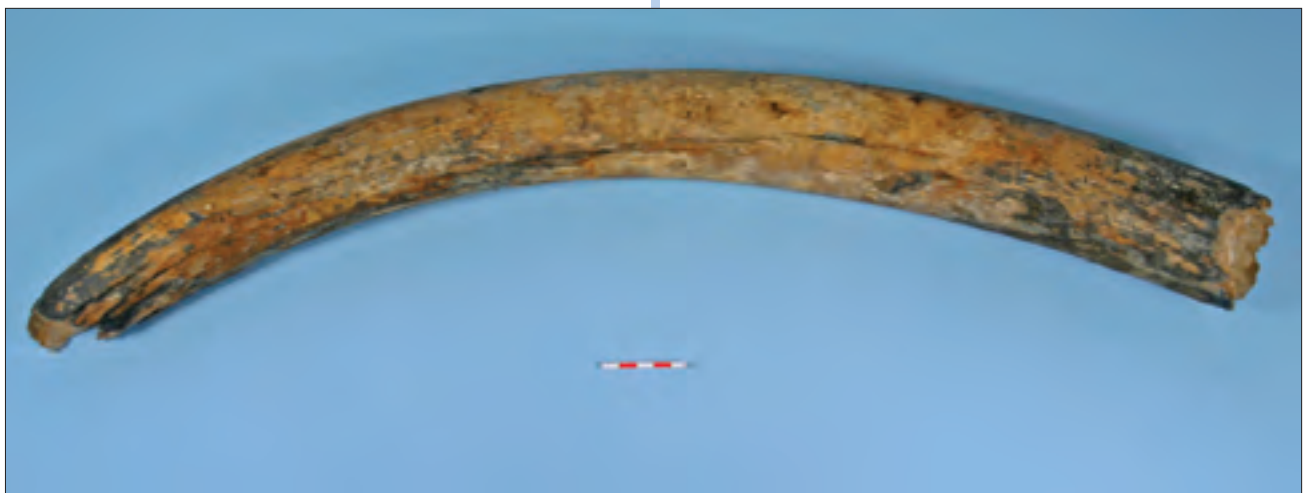


Figure 2: the mammoth tusk recovered from the East Coast off the Wash has been radio-carbon dated by English Heritage and is approximately 44,250 years old.

During 2006 WA undertook a programme of education and awareness raising to accompany the introduction of the Protocol. The Awareness Programme was funded through the Aggregates Levy Sustainability Fund (ALSF) and comprised:

- visits to BMAPA company wharves and vessels;
- visits to benthic and geophysical survey companies;
- workshops for Nominated Contacts, Site Champions and other interested parties including archaeology professionals;
- and the development of a DVD-based remote training package for BMAPA company vessels.

The Awareness programme has been a great success as evidenced by the receipt of larger numbers of reports through the Implementation Service than anticipated, the improved quality of the reports, their positional information and photography. Under the Protocol, staff report to a local 'Site Champion' on the vessel or at the wharf and the Site Champion compiles a preliminary report. The Site Champion passes the report on to the 'Nominated Contact', a single identified person within each company.

The role of the Nominated Contact within each company is to inform the Implementation Service of the find as soon as possible, and to pass on the reported details, preferably within two working days of receiving information from the Site Champion. The Nominated Contact is also required to advise other dredgers operating in the same area to keep a particular watch for finds and, if the seabed position of the find is reasonably certain, to implement a Temporary Exclusion Zone (TEZ) until archaeological advice has been obtained. TEZs may only be revoked if it can be concluded that no important wreck or other feature is present. TEZs may be formalised as a longer-term Archaeological Exclusion Zone (AEZ) if the presence of a wreck or feature is confirmed or if no conclusion can be drawn and the company does not wish to resolve the situation by further investigation.

The Implementation Service's role, on receiving the report, is to advise the Nominated Contact of the actions to be taken and will also liaise with various agencies including EH, institutions and individuals with responsibilities and interests in respect of the marine historic environment and finds from the sea, and pass details of the find on to the National Monuments Record (NMR) and appropriate local Sites and Monuments Record/Historic Environment Record (SMR/HER).



Figure 3: Victoria Cooper, Wessex Archaeology, checking for identifying maker's marks on part of an aircraft with wharfside personnel.

The Implementation Service does not cover decision-making where a higher level of curatorial involvement is required (i.e. where reports result in TEZs that are likely to warrant further investigation and/or formalisation as an AEZ).

At the core of the Implementation Service is a web-based reporting system. Nominated Contacts have secure access to web pages on which they can record details of finds reported by Site Champions and through which they can receive advice.

Each report received through the web-pages is assessed by WA staff. Contentious discoveries are forwarded promptly to EH for further curatorial assessment. Reports considered non-contentious are dealt with by WA staff (see Figure 1).

Scanned drawings, digital photographs and other files may be uploaded to the website for the purposes of interpretation. In certain circumstances WA may request that the find is made available for closer inspection but, in most cases, recovered finds are held by the companies.

Advice is sought from accredited specialists within and external to WA regarding both interpretation and any additional works required to stabilise, conserve or record recovered finds. This advice is passed to the Nominated Contacts along with guidance on resolving issues of ownership and disposing of finds.

A protocol for reporting of archaeological finds at marine aggregate extraction sites

WA is also responsible for disseminating the information reported through the Implementation Service to the NMR and local SMR/HER and other interested parties such as:

- EH Maritime Team;
- The Crown Estate;
- EH regional offices;
- Local Government Archaeological Officers;
- Portable Antiquities Scheme (PAS) Finds Liaison Officers;
- the Receiver of Wreck;
- the Ministry of Defence.

Through the web pages WA can generate a report compliant with the Monument Inventory Data Standard, a content standard for heritage data sets that sets out what sort of information should be recorded. This report can then be forwarded via email to the above parties.

Feedback is sent to the wharves and vessels in the form of an A4 poster providing an archaeological and historical context for the discovery and outlining its importance.

If permission is given by the Nominated Contact details of the finds are also made publicly available through WA's web pages.

During the first very successful year of the Implementation Service in 2005-2006 over 80 separate artefacts have been reported attesting to the success of both the Implementation Service and the Awareness Programme. A number of 'pre-Protocol' finds have also been brought to the attention of WA staff during visits to wharves as part of the ALSF funded Awareness Programme. The Implementation Service has continued into 2006/7 with additional resources being made available by BMAPA to support the success of the scheme.

A number of these discoveries have proved extremely important in their own right. For example, the identification of the Supermarine Attacker WP275; the dating of the mammoth tusk (see Figure 2) and the identification of an eroding peat layer .



Figure 4: The implementation service's spring 2007 newsletter.

All discoveries, however, will ultimately contribute to a fuller understanding of the marine historic environment and the distribution of archaeological remains on the seabed, as well as meeting best practice and discharging licence conditions and other legal obligations.

As part of the Awareness Programme visits were undertaken to 30 wharves, 3 vessels and 4 survey companies and made use of a combination of formal and informal techniques, including presentations, group discussions and one-to-one discussion as appropriate to circumstances and facilities (see Figure 3).

Specific information was provided to staff on:

- the nature of the marine historic environment;
- identifying typical marine finds;
- the responsibilities of staff under the Protocol;
- handling and storing marine finds;
- basic finds recording.

Difficulties with arranging suitable times to visit most vessels - primarily relating to tight operational schedules - and to some wharves resulted in the production of a DVD-based remote training package which was sent out to all wharves and vessels that WA was unable to visit. Three regional workshops were organised, focusing on finds recognition, handling, recording and storage. Particular emphasis was placed on the questions commonly raised by aggregate company staff. The first Workshop was held in Salisbury in April 2006, the second in York in July 2006 and the third in London in October 2006.

The workshops demonstrated the importance of finds reported from industry, and the contribution such reports are making to our understanding of the past. The workshops also provided an opportunity for discussion and the exchange of experience and views.

During the course of the Awareness Programme WA took part in a number of seminars, meetings and outreach events to introduce the Protocol to a wider audience and to illustrate the importance of the artefacts reported through the Protocol. These included:

- EH Outreach Seminar (Savile Row, London 14/02/06);
- Portable Antiquities Scheme AGM (British Museum, London 16/03/06)
- EH ALSF Seminar (Savile Row, London, 12/05/06);
- Stourhead Archaeology Extravaganza (Nautical Archaeology Society, Stourhead, Wiltshire, 03/06/06-04/06/06);
- Maritime Archaeology and Wildlife Weekend (Hampshire and Wight Trust for Maritime

Archaeology, Hurst Castle, Hampshire, 19/08/06-20/08/06) (Figure 5);

- Marine ALSF Conference (University of Southampton, 08/09/2006);

WA also submitted an article to Dredging and Port Construction magazine which has an international readership throughout all sectors of the industry. With the support of the ALSF, WA is currently piloting a newsletter to disseminate more widely details of finds reported through the Implementation Service (see figure 4).

Further details can be found at:

<http://www.wessexarch.co.uk/projects/marine/bmapa/index.html>

Title: 3645 MAIN. A Protocol for Reporting of Archaeological Finds at Marine Aggregate Extraction Sites.

Contractor: Wessex Archaeology Ltd

Contact: Euan McNeill and Antony Firth

Telephone: 01722 343403

Email: e.mcneil@wessexarch.co.uk

Full Report site:
<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE



Multiple-use, planning and management: The Overfalls area

INTRODUCTION

The Overfalls Project examines the practical issues associated with marine spatial planning at the local, site specific level and has investigated a process for sustainable site management and resource use through a strong, stakeholder led decision making process.

The project has been funded under the Marine Aggregate Levy Sustainability Fund administered by English Nature in two separate phases. Phase I of the project was completed between April 2005 and March 2006; the successful completion of Phase I led subsequently to funding being granted for Phase II of the project which was completed between April 2006 and March 2007.

BACKGROUND

The Overfalls project is focused on the Overfalls – a series of offshore sand and gravel banks approximately 12 miles south of Chichester Harbour entrance, some 10 miles to the east of the southern tip of the Isle of Wight, and within the Outer Eastern Solent (See Figure 1). These seabed features form a range of habitats for

various fish including bass, blonde rays, turbot, brill, cod and tope. The concentration of fish attracts a high density of both commercial and recreational fishing activity. More latterly, these sand and gravel banks have also been identified as potential aggregate resources and have been subject to an application to dredge under the Government View procedure.

The dredging application resulted in a unified objection from the commercial and recreational fishing sectors which led to the dredging application being put on hold. However, it was clear that there was both a lack of common understanding in terms of the importance of the area and the absence of a longer term management framework within the current legislative framework which could allow sustainable use whilst protecting the key habitat features.

AIMS AND OBJECTIVES

The Overfalls project was proposed in order to investigate these issues at the Overfalls by engaging a broad range of stakeholder groups, including fishermen, anglers, the dredging industry and nature conservation

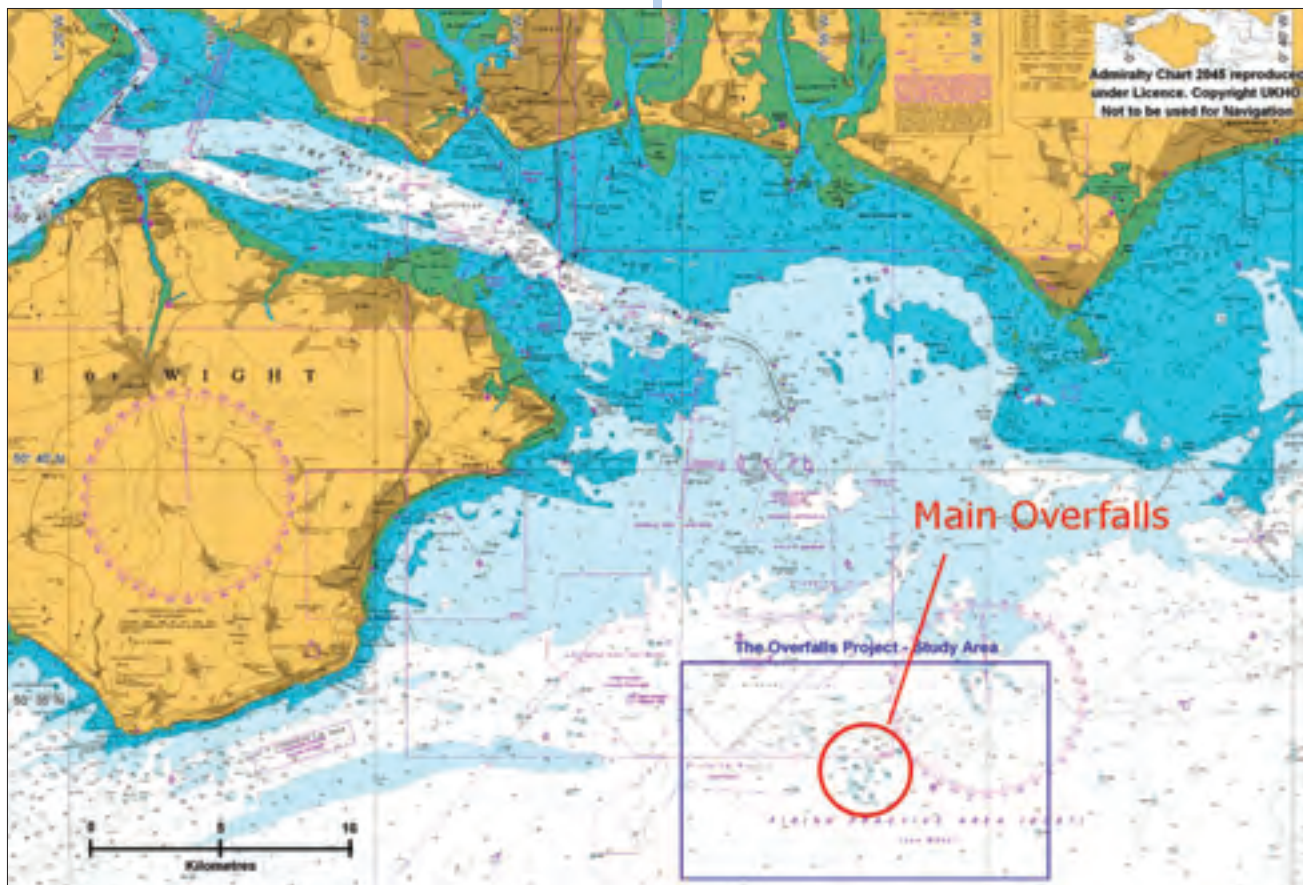


Figure 1: Location of the Overfalls project area and key Overfalls bank features

D. Tingley¹, S. Bellew² & P. Franklin³

¹CEMARE, University of Portsmouth, Burnaby Terrace, 1-8 Burnaby Road, Portsmouth, PO1 3AE

²Offshore Environmental Solutions Ltd, 54 Liss Road, Southsea, Hampshire, PO4 8AS

³Homarus Ltd, Estate Yard House, High Street, Beaulieu, Hampshire, SO42 7YB

interests. In parallel the project sought to develop a process by which similar spatial planning conflicts might be investigated and managed at other UK offshore sites.

The Overfalls project has drawn on the existing stakeholder interest, precipitated by the dredging application process, in seeking to develop a consensus led decision making process based on an agreed set of core values and objectives. Specifically, the project has:

- Developed a common understanding of the resource use and conservation value of the Overfalls features through an extensive benchmarking process
- Developed a Governance process and associated code of conduct drawing stakeholders together through a consensus based forum
- Embarked on a process of education both with stakeholders and a broader audience
- Continually sought to evaluate and improve the Overfalls Group process in learning future lessons for local marine spatial management

WORK UNDERTAKEN

The Overfalls project has been completed using a building block approach over two phases.

The first phase of the project sought to establish a baseline understanding of the Overfalls area – its key economic and resource use together with an understanding of the ecosystem, species and habitats that comprise the area. This benchmarking exercise included questionnaires which sought to evaluate use of the area, determine opinions on current and possible future conflicts at the site and survey attitudes towards site use and possible management amongst the various stakeholder groups. Alongside this, a review of the current management measures was completed looking at examples of possible statutory and voluntary options for ensuring sustainable use and adequate protection of the Overfalls features. Importantly, this benchmarking exercise closely involved a steering group made up of the various stakeholder groups and ultimately determined the desire amongst these stakeholders for the creation of a more formalised ‘Overfalls Group’ process.

Phase 2, although including some continued benchmarking and assessment work, focused on the development and working of an Overfalls Group process. This led to the establishment of an Overfalls Group with the following stakeholder Group membership:

Dredging Industry: Hanson Aggregate Marine Ltd

Charter Boat Operators: Langstone Boatmen's Association

Recreational anglers: Local club members, individual anglers & National Federation of Sea Anglers

Nature conservation: Hampshire Wildlife Trust (South East Marine Programme)

Commercial Fisheries: Sussex Sea Fisheries Committee & commercial fishermen from Langstone & Portsmouth harbours

Initially Phase 2 focused on formalising this Group process through the development of a Governance process and associated code of conduct based on a consensus process. The intention was for this process to allow future discussion and resolution of conflicts between user groups (focused initially on the aggregate dredging proposals). Latterly, Phase 2 has focused on facilitating the Group process through administering Group meetings, managing the consensus process and providing advice to the Group in discussing and developing its core objectives. In particular, the Group has developed a common strategy for lobbying for protection of the Overfalls features within a framework of sustainable resource use. Finally, Phase 2 has also looked to the future in attempting to ensure that the Group process continues beyond the project timeframe as a working example of a consensus based, stakeholder led, multi-use management forum.

KEY FINDINGS AND CONCLUSIONS

On a site specific basis, the Overfalls Project has been successful in formalising the existing stakeholder interest which resulted from the dredging application. The resulting Overfalls Group has adopted a set of common aims and objectives through which common understanding has developed. This has resulted in key conflicts being addressed through the consensus process and as a result immediate conflicts have started to be resolved. For example, the dredging industry has recognised the importance of the key areas for fishing and have submitted revised proposals accordingly. Similarly, the fishing interests have recognised the need for compromise and have worked with the dredging interests in developing acceptable proposals. Together, all of the stakeholder Groups have united in developing a lobbying approach to securing their longer term objectives of site protection and sustainable resource use. The crucial role of the stakeholders in this Group process – their willingness and enthusiasm to commit

Multiple-use, planning and management: The Overfalls area

their time and effort to a Group process has been key, the project in a sense has simply facilitated an existing situation by providing an appropriate 'playing field'.

Beyond the immediate achievements of the Overfalls Group, the project has sought to develop and evaluate a process which might equally be applied to similar local, marine areas – for example such as those that might evolve from the Marine Bill (for example marine protected areas, specific multiple-use areas identified with a marine spatial plan etc). To that end, the Project has sought to record the process undertaken at the Overfalls and to evaluate that process critically in developing lessons that might be more widely applied. For example, The Environment Council (<http://www.the-environment-council.org.uk/>), an organisation with considerable expertise in stakeholder dialogue and facilitation, has been asked by the project team to attend a number of the stakeholder meetings, to provide advice on Group facilitation and to provide an independent, critical review of the project approach and achievements.

Ultimately, it is possible to draw a number of key conclusions from the project process, looking beyond the Overfalls itself, about the involvement of local stakeholder groups in the management of the marine environment. The following figure (Figure 2) provides a simplified illustration of some of the challenges often faced in drawing together different stakeholder groups and meeting common challenges.

Figure 2 summarises, in a simplified way, what the process of multiple stakeholder dialogue and involvement can achieve through a process such as the Overfalls Group. In simple terms, an ongoing dialogue set in the context of 'common ground' can lead to a unified understanding and the ability to achieve common aims and importantly tackle often difficult conflicts and differences. Broadening horizons, developing trust and a collective approach are key words in that process.

It is not, of course, all plain sailing in such a process and Figure 2 also identifies some of the initial difficulties that can be encountered in such a process. Moving away from a single issue or sectoral position is often difficult; practical problems of time and resource commitment from individuals many of whom have 'proper jobs' can be a challenge for any Group; frustration at the time taken to develop the process or make real decisions can occur; and the actual mandate of individuals within a Group to make decisions that can affect many people may be questioned. However, such issues should not prevent stakeholders from achieving the tangible benefits that can be realised in engaging in such a process. It is to be admired that so many individuals and Groups are willing to engage so enthusiastically and intelligently - a fact that gives hope to the success of future marine management.

Ultimately, the Overfalls project and indeed the Group itself hints at a future process for engaging in the marine management process. The project team have been struck by the potential parallels between the Overfalls

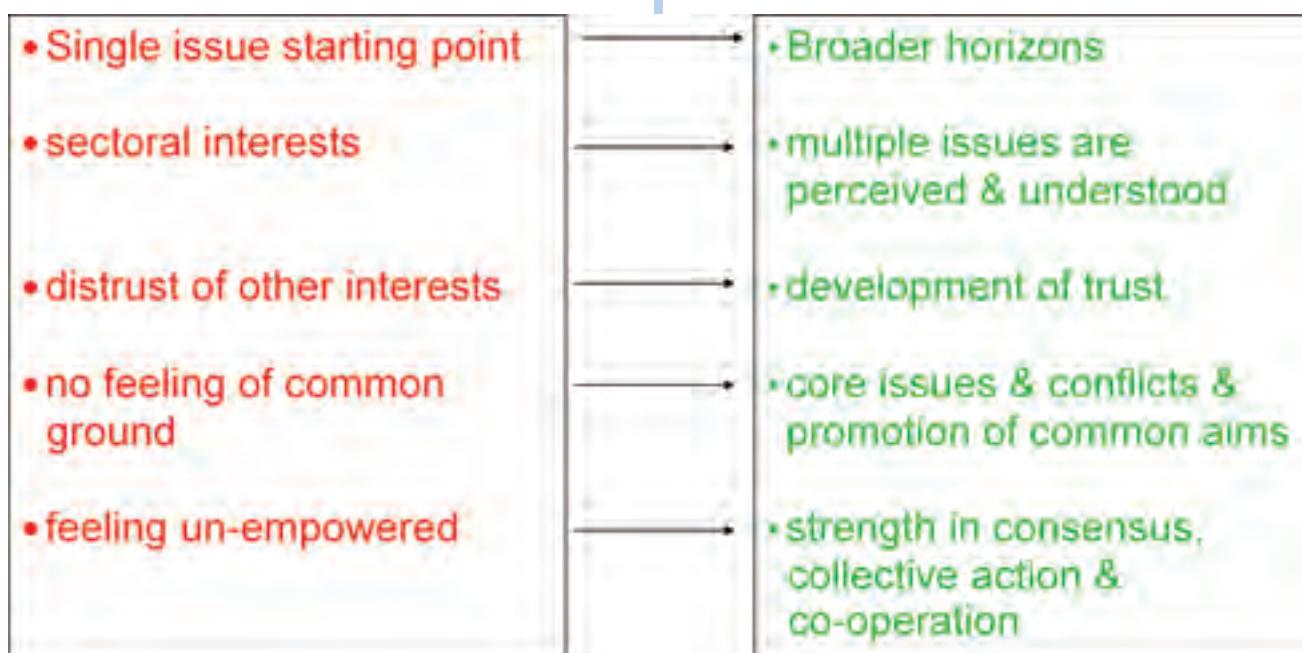


Figure 2: Examples of what can be achieved by stakeholder dialogue and co-operation

process and the achievements of some of the coastal partnerships such as, for example, the Solent Forum. We would suggest that one of the key lessons that might be taken from this project is the need to consider how such forums might be developed in a truly marine environment, for example in taking forward marine spatial planning or marine protected areas. Resource might be directed to the development of regional or local 'Partnerships for Our Seas' in ensuring that effective management is achieved. In developing such forums we would offer the following, concluding remarks based on our Overfalls experience:

- Real stakeholder involvement must accept bottom up as well as top down solutions – central Government policy must meet the aspirations, needs and knowledge of local stakeholders – local or regional partnerships might present such an opportunity
- True stakeholder engagement brings real benefits – engagement in a partnership approach can build understanding, trust and the development of common aims and objectives with real stakeholder buy-in.
- Such stakeholder partnerships allow the social and economic perspectives to be properly accounted for in marine management at a local level – looking at community effects and opportunities
- The process of stakeholder engagement and involvement can be long, frustrating and very resource-hungry – but it must be at the heart of the marine management process not on the periphery

With great thanks to the advice, enthusiasm and support provided by all of the stakeholder Groups and individuals involved in the project.

Title: MAL0012 Multiple-use, Planning and Management: The Overfalls Area – Phases I & 2

Contractor: CEMARE, University of Portsmouth

Contact: Diana Tingley

Telephone: 02392 844283

E-mail: diana.tingley@port.ac.uk

Contact: Steve Bellew, OES Ltd

Telephone: 02392 787061

E-mail: Steve.bellew@ntlworld.com

Full Report Site:
www.port.ac.uk/theoverfalls



A young girl with blonde hair tied back, wearing a dark zip-up hoodie, is seated at a desk in a classroom. She is looking down at a small, green, cylindrical object she is holding with both hands. On the desk in front of her is a worksheet with a grid and a purple pen. In the background, other students are visible, some working at their desks. The text "EDUCATION, DISSEMINATION & OUTREACH" is overlaid in large white letters across the center of the image.

EDUCATION, DISSEMINATION & OUTREACH

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Education, dissemination and outreach – Workshop overview

L. Browning

The Wildlife Trusts, The Kiln, Mather Road,
Newark, NG24 1WT

Most – if not all – of the marine ALSF projects funded to date have had an element of dissemination included in the project brief. However, a smaller number of projects have education, outreach and dissemination as a primary or major objective. This session of the conference showcased a number of these projects and promoted discussion of key themes.

The starting point for the session was a statement from the Marine ALSF Science Review (MES 2005): “...it is not so much the ‘knowledge-base’ but public perception that is limiting decision making in relation to marine aggregate dredging and this needs to be addressed as a higher priority than can be achieved through dissemination from individual projects.”

This quote highlights a pivotal role for education, dissemination and outreach in the future of marine aggregates, changing the perceptions of decision makers and stakeholders. Indeed, it suggests that we may have reached a stage at which raising stakeholder awareness may be a higher priority than further scientific research. It will be interesting to see how this view is carried forward into future ALSF spending rounds.

The session featured a variety of educational projects aimed at diverse audiences, from hands-on work with schoolchildren to web-based guidance for the industry and major stakeholders. One of the main unanswered questions was “*Who are the key stakeholders: who are these people whose perceptions are supposedly limiting decision making, and how can we reach them?*” It was suggested that it may be worthwhile to undertake stakeholder analysis to clarify this issue. This would then enable a review of ALSF projects to identify how well they are matched to the target audiences and evaluate their success.

Another concern was the need to maintain and update useful websites once project funding comes to an end. Those involved in ALSF websites offered assurances that they would seek to maintain the sites, though this shone the light on a wider issue: the need for continuity and a long-term approach in public awareness work, and the difficulty of achieving this with project funding.



Laboratory analysis of marine fauna from dredge sites
© Marine Ecological Surveys Ltd

Marine aggregates – Science, industry, stewardship and people networks

PROJECT BACKGROUND

Good stewardship of the marine environment relies heavily on knowledge. Real information concerning the sea bed in areas of potential development or use is vital for any kind of stewardship. Further, for transparent planning and management, that information should be readily available to all 'stakeholders' – from Government through to the general public.

This project builds upon the successful 3 year ALSF (England & Wales) supported collaboration between the National Museum Wales and the British Geological Survey in mapping the sea bed of the Outer Bristol Channel, an area with potential for marine aggregate extraction.

The marine education interpretation and outreach programme 'Explore the Sea Floor' established in the final year of the 'Outer Bristol Channel Marine Habitat Study' is now being developed and extended further in both England and Wales. Using the experience gained, the new project is making full use of the integrated biological-geophysical results and the wide range of outputs and activities associated with the Bristol Channel study in developing innovative interpretative techniques to enable a wide audience to access the findings.

PROJECT AIMS

The project aims to:

- Raise awareness of the marine environment and sustainable use of resources
- Use a range of resources and activities to reach wide audiences
- Raise awareness of the role of science in environmental decision making
- Build collaborative networks with other organisations
- Evaluation of the project to continue best practice

PROJECT OUTPUTS

The exhibition has toured to: National Waterfront Museum, Swansea; St Davids Visitor Centre, Pembrokeshire; National Museum Cardiff and will be at Barnstaple Museum from April – June 2007.

School workshops designed to meet National Curriculum requirements and covering a range of different aspects of the survey. Workshops are available

to both Primary and Secondary schools. Over 350 workshops have been carried out in 120 schools across Wales and South West England since the project began.



Touring 'Explore the Sea Floor' Exhibition



Interactive bilingual educational 'Explore the Sea Floor' CD-ROM (over 7500 distributed to date)

Teacher training sessions These are designed to give teachers the knowledge and confidence to include the marine environment in their teaching.



Pupils sieving sea bed sediments during a workshop

L. Murphy

National Museum Wales, Dept Biodiversity and Systematic Biology, Cathays Park, Cardiff, CF10 3NP



Public talks and activity sessions

Talks and demonstrations at conferences

Scientific report + searchable data CD-ROM

Executive report

Education and Outreach Report

Scientific and educational CD-ROM

Website dissemination via the National Museum Wales (www.museumwales.ac.uk), BGS (www.bgs.ac.uk); and *MarLIN* (www.marlin.ac.uk)

CONCLUSIONS

The project has been very popular and well received by all those who have taken part. It is estimated that over 20,000 people have directly taken part in activities to date. The project demonstrates the demand and need for such projects and how interested people are in the

marine environment and sustainability. The project also highlights how a range of organisations can work together to share ideas, resources and experiences.

The project meets ALSF objectives by:

Minimise the demand for primary aggregates:

- Raising awareness of marine aggregates and their uses

Promoting environmentally friendly aggregates extraction in the marine environment:

- Increasing understanding and awareness of biodiversity and nature conservation interests of marine sand and gravel habitats
- Exchanging information and sharing ideas with other ALSF funded projects
- Taking an integrated approach to looking at the geodiversity and biodiversity of extraction areas in a wider context

In addition, the project contributes to ALSF objectives by:

- Disseminating and publicising the findings of ALSF supported projects
- Providing information in a variety of innovative ways
- Evaluating best practice procedures in education and outreach

The project is supported by grants from the Aggregate Levy Sustainability Fund administered by the Welsh Assembly Government and Natural England, and from The Crown Estate.

Title: Marine Aggregates – Science, Industry, Stewardship and People Networks

Contractor: Amgueddfa Cymru -National Museum Wales and British Geological Survey.

Contact: Lara Murphy

Telephone: 02920 573242

E-mail: Lara.Murphy@museumwales.ac.uk

Full Report Site:
<http://www.nmgw.ac.uk/en/seafloor/>



Llywodraeth Cynulliad Cymru
Welsh Assembly Government



Marine aggregates and biodiversity: Stakeholder engagement in South East England

INTRODUCTION

South East England is one of the UK's principal locations for marine aggregate extraction, with licensed sites off the Isle of Wight and East and West Sussex. The east channel region extraction area – a relatively recently identified resource – may potentially be England's largest and most productive site, yielding up to 17 million tonnes per annum, virtually tripling previous extraction volumes.

Gravel extraction in the East Channel Region and other licensed areas in the South East could cause severe and possibly permanent reductions in biodiversity over an area of more than 200 km². At present, the conservation of offshore sand and gravel biotopes in the South East is wholly reliant on the environmental management of marine aggregate extraction and other industries, as neither Marine Protected Areas nor Biodiversity Action Planning have been actively applied in this environment.

The lack of protection for those biotopes affected by marine aggregate extraction is hindered by a lack of awareness of marine biodiversity and associated issues amongst decision makers, conservation professionals, the marine aggregate industry and the public.

In the 2005 Review of Marine ALSF Science, Richard Newell wrote:

- “Insufficient attention has been given to presenting results of aggregates-related research to a wide range of stakeholders.”
- “It is not so much the ‘knowledge-base’ but public perception that is limiting decision making in relation to marine aggregates dredging...”

AIMS AND OBJECTIVES

This project sought to address the issues associated with stakeholder awareness outlined above by engaging with various stakeholder and interest groups to raise awareness of the aggregates industry and the impacts on biodiversity. This was the third ALSF project delivered in four years by the Wildlife Trusts' South East Marine Programme. Each project has built upon the foundation of the last, utilising the networks and resources developed over the years.

Specifically, this project aimed to:

1. Establish exchange of information between stakeholders at the national, regional (SE England) and local levels regarding the impacts of marine aggregate extraction on biodiversity.

2. Engage with professionals and volunteers in the environmental field to raise awareness of the relationship between marine aggregate extraction and biodiversity and build capacity to address key issues.
3. Work with a team of partner organisations to deliver a suite of projects that:
 - work with local communities to increase awareness of the issues surrounding marine aggregates and biodiversity.
 - provide resources and services for schools, to raise awareness of these same issues
 - provide and promote opportunities for public participation in the conservation of sand and gravel biodiversity
 - gather data on habitats and species associated with the marine aggregate resource (including BAP priorities).

PROJECT ADMINISTRATION

This was a major partnership project led by Hampshire and Isle of Wight Wildlife Trust on behalf of the Wildlife Trusts' South East Marine Programme.

Project duration: 19 months (August 2005 to March 2007)

Project budget: £175,000 (88% paid through Natural England and the ALSF)

Partners (funding only)

- Natural England through Defra's Aggregate Levy Sustainability Fund
- Wildlife Trusts in the South East

Partners (funding and delivery)

- South East Marine Programme
- Hampshire and Isle of Wight Wildlife Trust
- Medina Valley Centre
- University of Southampton's National Oceanography Centre
- Arun District Council and the Nature Coast Project
- RSPCA Mallydams Wood

J. Chesworth

The Wildlife Trusts, South East Marine Programme, c/o Hampshire & Isle of Wight Wildlife Trust, Beechcroft house, Vicarage Lane, Curdridge, Hampshire SO32 2DP

PROJECT OUTPUTS

ESTABLISH EXCHANGE OF INFORMATION

In order to promote the exchange of information between stakeholders at the national, regional (SE England) and local levels regarding the impacts of marine aggregate extraction on biodiversity, several mechanisms were employed. The Memorandum of Understanding that exists between the Wildlife Trusts and BMAPA was renewed. The project was also involved with various aggregates working groups, including the Marine Aggregate Site Recovery, Restoration & Enhancement Working Group, the South Coast Aggregates Liaison meetings and the 'Overfalls Group', another ALSF funded initiative reported in this publication. The involvement with these various groups allowed the project to keep up to date with developments with the industry and provided opportunities for disseminating the outputs of our project.

To raise awareness amongst a wider audience, four Shingle Currency seminars, originally devised during our previous ALSF projects were also delivered. The Shingle Currency seminars aimed to inform stakeholders about the industry, why it exists, how it operates and how it is regulated. The seminars considered the industry's impacts on the marine environment, but focused particularly on the impacts associated with the biodiversity of sand and gravel habitats. To achieve this aim the seminars comprised of speakers from organisations representing various aspects of the extraction process including BMAPA, DCLG, Cefas, Emu Ltd and the Wildlife Trusts. The programme included a trip around a local aggregate wharf to allow the delegates to witness first hand how the industry operates (Figure 1). Over 100 delegates representing a variety of interests attended including NGO's, consultants, government agencies (NE, EA, MFA, Cefas, Defra, EH), academia and local authorities.



Figure 1: Delegates at a Shingle Currency seminar on a tour of an aggregate wharf. Photograph by K. Knapp

To disseminate the information presented during the seminars to an even wider audience, and to provide value after the project had ended, a Shingle Currency pamphlet was produced. This 20 page full colour document summarises the contents of all of the Shingle Currency presentations, collating them in to a comprehensive introduction to the aggregates industry, its regulation, the biodiversity and conservation interests of sands and gravels, how this may be compromised by the aggregates industry, and the monitoring and mitigation mechanisms adopted. The pamphlet has been sent to over 200 people who have either attended the Shingle Currency seminars in the past, or are known to have an interest in the industry. An electronic version is also available for download on the South East Marine Programme website.

Another mechanism adopted to raise awareness amongst a wider number of stakeholders was the production of a series of 'Shingle Currency' e-bulletins. These short communications summarised news and updates with issues such as the Marine Bill, the East Channel Region, ALSF projects and minerals policy and regulation developments. They were emailed to our networks that contain over 300 people representing various interests from local authorities to conservation NGO's and community group leaders.

ENGAGING WITH ENVIRONMENTAL PROFESSIONALS AND VOLUNTEERS

The outputs described above were focused on information exchange and dissemination. Engagement goes further, trying to encourage active involvement and participation. Several work packages were aimed at promoting this.

Marine Champions

Marine Champions is a programme that seeks to build a network of marine conservation advocates (mostly environmental professionals, but typically not marine specialists) within the South East, encouraging them to get actively involved. It does this by running a programme of training events and workshops, the development of the South East Marine Programme website, regular email updates and ongoing co-ordination and support.

Two Marine Champions events were held with different purposes in mind. The first event was an introductory day, aimed at people new to marine conservation and Marine Champions. It included an introduction to marine ecology session with discussion on impacts, talks on marine life in South East England and marine industries, with a focus on aggregate extraction. It also included a

Marine aggregates and biodiversity: Stakeholder engagement in South East England

session on the research vessel the Callista, which trawled over sand and gravel areas to demonstrate what the biodiversity associated with these habitats consisted of. The second Marine Champions event was more focused and concentrated on the theme of Marine Protected Areas, with talks on various types and aspects of MPA's and discussions on the advantages and disadvantages of the different approaches. To encourage active participation all Marine Champions were asked to fill out an action plan, detailing how they intended to engage in marine conservation, giving deadlines within which they were to complete their actions and listing the resources required, which the Wildlife Trust subsequently supplied where possible.

Marine Biodiversity Action Planning

As Chair of the South East Marine BAP working group, a meeting was called to discuss priorities during the project. It was decided to focus on completing and disseminating the revised Marine Biodiversity Action Guide and Marine Biodiversity Initiatives database (funded under the previous ALSF project).

During the early stages of this project the Marine Biodiversity Action Guide and the Marine Biodiversity Initiatives database were completed. The Action Guide is a regional document designed to promote local involvement in marine conservation. It stems from the Marine BAP conference organised by the South East Marine Programme in 2004, this concluded that marine BAP was best delivered at a local level but a regional overview document was required. The Action Guide provides background information on our marine environment and the activities and industries operating there. It provides details of how people can get involved, with a step by step guide and what they need to consider. It also contains a CD with a Microsoft Access database of over 100 marine conservation initiatives with contact details to enable and promote collaboration. Hard copies of the Action Guide have been sent to over 200 people who are all involved, or have an interest in, marine management, research or conservation within the South East region. An electronic version has been uploaded on to the South East Marine Programme website.

The South East Marine Programme was invited by the Marine Conservation Society to present a session at the annual Marine BAP conference, held in Liverpool in December 2006. The session was focused on education and awareness raising, this allowed an opportunity to showcase the BAP and awareness work we had carried out under our ALSF projects to an audience of over 100 people.

Marine awareness

Three education and awareness training events were successfully delivered. A partnership was established with CoastNET to deliver a joint workshop on Public Engagement in Coastal Issues. Educators from around the region discussed how best to increase awareness of the local coastal and marine environment and share best practice.

The other two workshops were aimed at our network of Marine Week event organisers. The two day residential workshops provided information on Marine Week including: resources and support available, how to organise events, ideas for activities to engage with all ages and promote conservation. There were also sessions on media, publicity and event photography, delivered by professionals on a pro-bono basis. Both workshops were fully booked and received excellent feedback, they were voted the top training events for marine awareness in the region.

As part of our work encouraging participation, the South East Marine Programme commissioned various resources to help organisers deliver their events. Leaflets, postcards, DVD's, displays, ID guides and banners were all supplied to over 15 organisations across the region to help deliver Marine Week 2006. Most of these resources contained information on the aggregates industry.

Marine Week 2006 was hugely successful. Seventeen organisations delivered over 50 events throughout the region ranging from seashore safaris to seal watching trips and large family events with educational activities (Figure 2). It is estimated over 4000 people visited these events.



Figure 2: Guided public walk of Hurst Shingle Spit, maintained using marine won gravel, as part of a Marine Week event. Photograph by A. Rothwell.

PARTNERSHIP PROJECTS

A suite of 5 projects, led by external partners, were delivered. These projects aimed to engage with sea user groups such as anglers, commercial fishermen, scuba divers, the general public and community groups.

Aggregates and the curriculum – Nature Coast Project

The project aimed to deliver marine education to the schools of West Sussex, focusing on man's impact, specifically the aggregates industry. The project utilised and developed the already existing Treasure Chest; a chest of teaching resources and activities for school children. Four additional teaching activities were designed; Oil Slick!, Coastal Defences, Managing Coastlines and Coastal Estate Agents. A sea bed model, showing the contours of the coast and sea bed with gravel extraction sites, and a very large map 2m x 4m, showing an island and surrounding sea bed, were also developed. Six teacher training days attended by 48 teachers were delivered to encourage schools to use the Treasure chest in the classroom.

Hastings gravel ranger – RSPCA Mallydams Wood

This project aimed to raise local awareness about the issues associated with dredging activities on the Hastings Shingle Bank. The project focused on engaging with local people, industry and other stakeholders in order to explore the issues, gather information, and elevate the profile of marine sand and gravel habitats and the impact of dredging on wildlife. Twenty seven events were delivered including field teaching, workshops, discussions, craft activities and power point presentations. More than 600 people from the under 5's to over 60's have participated in the events ranging from youth groups to Women's Institute groups. Excellent value has been ensured as the most keen participants have formed their own group to continue some of the activities and events initiated by the project.

Solent sharks and seabed survey – University of Southampton's National Oceanography Centre

The region to the east of the Isle of Wight, an area of extensive gravel extraction, supports a major sport shark angling fishery. The shark population is being studied in collaboration with the sport anglers and charter boat skippers. The seabed habitats in this region are also being mapped in order to help understand why this area of aggregates is particularly attractive to sharks. Approximately 250 sharks were captured and released, with 100 being tagged, and 20km of seabed video footage was filmed.

Solent and South coast mantis shrimp project – Medina Valley Centre

The mantis shrimp, *Rissoides desmaresti*, is one of two species of mantis shrimp found in UK waters. It is regarded as scarce, with most records being from the south coast of England. The main aim of this project was to learn more about the species distribution and life history and to determine more precisely its habitat requirements and association with sand and gravel substrate. Between March 2005 and February 2007, the project succeeded in obtaining data and information on 185 records of mantis shrimps, largely collected as by-catch in oyster dredges, in prawn pots and as stomach contents of gutted fish caught by anglers. Fifteen commercial fishermen and six anglers have contributed records and the general awareness of the project and the aggregates industry has noticeably increased. As a result of the data collection the species has been recorded in an additional seven 2x2' grid squares around the Isle of Wight and especially in the eastern Solent (Figure 3). It has also been identified living in intertidal habitats. Following this work the general perception is that the species is probably much more widespread than initially thought three years ago and because of its prevalence in muddy inshore sediments and in harbours may not be at risk from aggregate dredging operations. However, there remains strong anecdotal evidence for the view that offshore, the species is likely to be found at the boundary between gravels and finer muddy sediments. Disturbance of these through aggregate dredging operations may well occur.

Marine aggregates and biodiversity: Stakeholder engagement in South East England

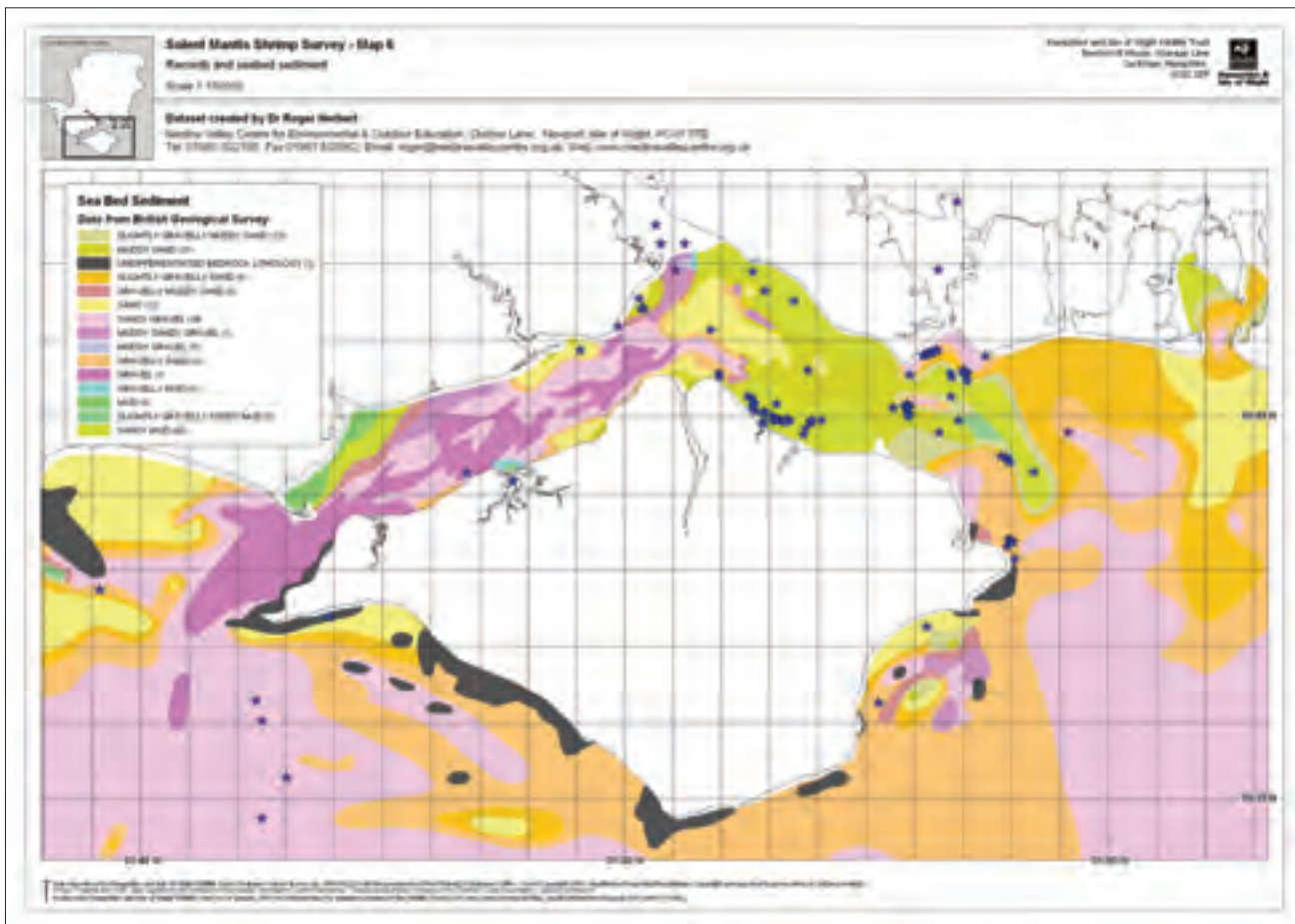


Figure 3: Chart showing known distribution of Mantis shrimps caught in the Solent in 2005-2007. Shrimps locations shown as blue stars, overlaid on BGS sediment chart.

Hampshire and Isle of Wight Seasearch – Hampshire and Isle of Wight Wildlife Trust

Seasearch is a national subtidal habitat survey programme. It aims to recruit volunteer Scuba divers, train them in basic species identification and habitat survey and organise survey dives to gather data. This project aimed to initiate a coordinated Seasearch programme across the two counties and use the trained divers to survey sand and gravel habitats and species. Five courses, attended by 30 volunteer divers, were delivered (Figure 4). Six days of survey diving were conducted, with sites chosen including areas of sand and gravel to the east of the Isle of Wight. Additionally, three more survey dives were carried out in collaboration with the mantis shrimp project in an effort to ground truth video data of mantis shrimp burrows. Data collected from these dives has been input on our Marine Recorder database and submitted to MCS and the JNCC for inclusion on their NBN Gateway, accessible to all over the internet.



Figure 4: Divers participating in a Seasearch training course. Photo L. Browning

CONCLUSIONS

'Marine aggregates and biodiversity: stakeholder engagement in South East England' was a major partnership project involving eight separate organisations in the delivery of 10 different sub-projects. It was the third ALSF project run by the South East Marine Programme in four years building upon and developing what had been delivered in the past.

The project worked to target as many stakeholder groups as possible and those engaged included the public, local decision makers and planners, the aggregates industry, conservationists, and user groups such as fishermen and scuba divers. In 19 months the project delivered 4 seminars, 5 workshops and supported over 80 externally delivered public events, engaging directly with over 4000 people. There is a general consensus amongst the people that have come in to contact with the project and its outputs that they are now more aware of both the issues surrounding the aggregates industry and its potential impacts on biodiversity and what the ALSF is trying to achieve.

The project has consolidated and extended a number of networks and groups for marine biodiversity conservation in the South East and beyond that have developed through previous ALSF projects. Excellent value has been achieved by working in collaboration with these networks and other organisations and individuals that have allowed cost sharing or in some cases working on a pro-bono basis. Many of the materials and resources purchased as part of the project will be in use for many years to come. The South East Marine Programme is committed to continuing many of the work packages in this project long after ALSF funding has finished, notably the Marine Week and Marine Champions initiatives. The Programme's participation in various aggregate related projects, meetings and groups

will continue and the knowledge and understanding of the industry and biodiversity issues gained over the years will continue to be used to inform the debate.

The South East Marine Programme is extremely grateful to Natural England and the ALSF for their support over the last 4 years. Throughout the development and delivery of this, and previous ALSF projects, staff at Natural England have been supportive and helpful. The ALSF has greatly contributed to marine conservation and raised awareness of the aggregates industry through the South East as a result of allocating money to the South East Marine Programme and its partners.

Title: Marine Aggregates and Biodiversity: Stakeholder Engagement in South East England

Contractor: Hampshire and Isle of Wight Wildlife Trust

Contact: Jolyon Chesworth

Telephone: 01489 774445

Email: JolyonC@hwt.org.uk

Full report: <http://www.southeastmarine.org.uk/>



Solent aggregates to outreach: Maritime archaeology and marine aggregates – teaching resources and presentations

PROJECT BACKGROUND

This project has been motivated by the submerged archaeological resource of the Solent and Wight sea area, which in many areas lies on or within aggregate rich seabed deposits.

The experience of the Hampshire and Wight Trust for Maritime Archaeology (HWTMA) led to a realisation of a lack of readily available presentation materials for groups, clubs and societies in addition to a particularly limited amount of education materials which deal with marine cultural heritage.

The link between aggregates and marine heritage in the Solent and Wight region is evident from the presence of dredging zones and vessels on the water, aggregate wharves around the shores and the use of aggregate in a diverse range of commercial, development and shore line recharge roles.

The ALSF has led to an increased awareness of many aspects of marine heritage related to aggregate deposits. However, there was still a need to present this data to the wider public community. The 'Aggregates to Outreach' project addressed this through a number of innovative initiatives.

PROJECT INSPIRATION AND AIMS

This project was created as a response to several needs:

- Reaction to the ALSF's need for "Projects which raise awareness of the conservation issues arising from the impact of aggregate extraction on the historic environment and communicate the huge knowledge gained from work related to aggregate extraction". To raise awareness the HWTMA have created teaching resources to communicate this information to a wide audience. These are in the form of presentations for local community groups and teaching packs for schools. The information contained within the resources is a collation of information gathered from other ALSF project results, information from the marine aggregate industry and information researched by the HWTMA of other maritime archaeological groups. The resources create an understanding of the important issues involved and show how maritime archaeologists and the marine aggregate industry are working together to establish a positive relationship in which each group's needs are valued and considered.

- The need for an increased understanding of the relationship between maritime archaeology and marine aggregate dredging. Due to the 'out of sight, out of mind' nature of both maritime archaeology and marine aggregate, many people are either unaware of the relationship or have made up their minds on it using inaccurate information.
- As a response to an increased demand for outreach and community activities and resources, this project gives local people access to information that will help them understand a very important local issue. This need has been confirmed by examples such as the shocked looks of people when told of the sheer amount of shipwrecks in this area, and their response to accurate information on the affects of marine aggregate dredging on the seabed.
- A need to develop educational resources based on this subject has been recognised due to its current absence from the national curriculum, and through the regular requests for talks from local groups that the HWTMA receives.



Figure 1: Dorset Young Archaeology Club using the Aggregates to Outreach activities

PRESENTATIONS

A slide show presentation was created to reveal the issues concerning the relationship between the marine aggregate industry and maritime archaeology. This included specific case studies where maritime archaeology was found in aggregate dredging areas, information generated by other ALSF projects, benefits generated by the relationship that maritime archaeologists obtain through access to advanced survey techniques, and the history of dredging. The presentations are compiled in a manner that is easy to understand and relies on no prior knowledge of the

R. Causer

Hampshire & Wight Trust for Maritime Archaeology, Room W1/95, National Oceanography Centre, Empress Dock, Southampton SO14 3ZH

subject. By combining local archaeology with marine aggregate dredging, people interested in either subject will be engaged.

To attract the widest audience possible, several advertising methods were used to create interest in the presentations. Letters were sent to community groups throughout Hampshire and the Isle of Wight, adverts were placed in newspapers, on websites and in magazines, and public events were held. The success of the presentations also generated further publicity as people spread the word and more groups became interested. The times and places of the presentations were tailored to each group to reduce any access problems.



Figure 2: Pupils at Da Vinci Community College using project pack

The presentations have been used to

- Communicate an important message concerning local and national issues
- Give people the understanding that these issues are relevant to their own lives
- Generate questions, discussion and feedback
- Encourage people to find out more and get involved in local heritage and industry
- Spreading the word about available resources

Forty three presentations have been provided between 27th November 2005 and 10th January 2007. These include 11 Probus Clubs, 12 Historical or Archaeological Societies, 3 Isle of Wight interest groups, 1 Disability Activity Group, 1 university of 3rd Age, 1 Environmental Education Forum, 2 Museum Groups, 1 Sailing Club, 1 Church Group, 3 other general groups, 5 Open Events at the Needles Battery, 2 Open Events at the Maritime extravaganza at Hurst Castle.

More than 2000 people have attended this presentation.

TEACHING PACKS

There is an absence of information on both maritime archaeology and the aggregate industry within the school curriculum. Although there is no curriculum chapter that specifically applies to these subjects, there are several places that it can be applied, particularly within history, geography, science, and local studies, and also within maths, English, art and IT. The teaching packs are therefore very much cross-curricular. This is in line with the multi-disciplinary nature of maritime archaeology, especially when it is linked with the marine aggregate industry. Due to the interpretive, observational and recording character of archaeology, most of the packs' activities can be used by children at many different levels. This has enabled the pack to be aimed at both Key Stages 2 and 3. The pack has been formed to allow teachers to do the whole project or select areas that they feel fit in with their own targets/subject focus.

Pack contents: Folder containing six information chapters, activities and a CD Rom, a range of real and reconstructed archaeological artefacts, and marine aggregate within a core. The contents are contained within a sturdy container with a decorative lid. They come accompanied with enough 'maritime-line's', an illustrated chronology of marine related history, for every pupil to keep and with details of how to gain best use of the resource.

The packs have been used on a loan basis. This is mainly due to the inclusion of real archaeological artefacts. This has proved to be a successful method with resources being sent through the post or delivered by hand. The length of time each group kept the pack varied greatly and this generally depended on the type of group using the pack.

Solent aggregates to outreach: Maritime archaeology and marine aggregates – teaching resources and presentations

A surprise during the project was the variety of groups using the packs. We found that it was not just school groups that were interested in using them, other groups included Museum Clubs, Young Archaeological Clubs (YAC) (Figure 1), After Schools Clubs (held on school grounds), and a Children's Services Librarian. We were also contacted by an archaeology A-level teacher who wanted to use the pack to be accompanied by a presentation. It was important that the pack could be used in a flexible manner in order to fit it into teachers' specific timetables and subject focus (Figure 2). We also found that the flexibility of the packs meant we could utilise them in group situations ourselves such as at secondary schools during cross-curricular days. The boxes were also used at primary school level where we took several classes of children out onto the beach to find archaeology and understand about marine aggregates (Figures 3 and 4).

Overall the packs have been used by 37 groups including 5 Secondary Schools, 18 Primary Schools, 2 Museum Clubs, 2 YACs, 1 Children's Services Librarian (who distributes the pack throughout the region), 6 Beach Workshops, 2 Cross-Curricular Days and 1 School Presentation. It has also been downloaded 843 times from the HWTMA website.



Figure 3: East Cowes Primary School examine pack artefacts

The use of the packs has exceeded that originally planned. This could be a result of the alternative ways in which the pack has been used; by teachers using the whole pack, by teachers using selective parts of the pack, and by non-school groups. The interest in the packs by non-school groups has been an excellent and unexpected addition to the pack use. Due to this interest future marketing of the pack will include this wider variety of groups.

DEVELOPMENT AND MONITORING

When developing this project related parties were consulted at all stages to find out the most suitable approaches and to create the most useful outcomes. During the planning stages, meetings with teachers, community groups, aggregate industry representatives and maritime archaeologists took place to ensure the resources' future success and relevance. Meetings continued throughout the process and were combined with feedback during the development period. This led to the evolution of both the teaching pack and the presentations, creating useable and interesting resources for the target audiences.

The creation of these resources in an interesting and fun manner was a good way to highlight important issues and make them appealing to the consumer. The presentations and the teaching packs were trialed prior to finalisation, during which vital feedback through use of the deliverables resulted in changes being made to both. Comments from trial presentations resulted in the message about the relationship between the aggregate industry and maritime archaeology being more closely entwined and presented through the use of local case studies.

Monitoring has continued since the final resources have been in use. This has been through the completion of feedback forms and letters. So far these have been very positive and constructive comments will be used during any follow up stages of this project.

KEY TO THE PROJECTS SUCCESS

- **Accessibility:** By bringing the resource to the audience, both the teaching pack and the presentations were made accessible to everyone. This audience was increased as the packs and the presentations were available free of charge.
- **Real artefacts and real case studies:** It is rare that school pupils have access to or can handle real artefacts. These artefacts act as a teaching aid and make lessons fun. The use of case studies enforces the message in both the presentations and teaching packs.
- **Learning from a local perspective:** The local focus of this project helps verify the message delivered by the resources. When people can witness or imagine something happening in their own locality, the message is strengthened through a greater understanding generated by issues that may affect people personally.

- Importance of flexibility: The pack is set up to be used by teachers in a flexible manner. Teachers from several different subject areas teaching pupils of different ages can easily utilise the pack, as can educators from a non-school environment. The pack can be used as a whole, or different areas can be selected. Much of the success of the presentations can also be owed to flexibility. The approach taken was to accommodate any group by taking the talks to the groups and holding them at times that were most suitable to them. The length and content would also be adapted depending on the audience.



Figure 4: East Cowes Primary School using pack artefacts during a beach workshop

PROJECT SUSTAINABILITY AND POSSIBLE EXTENSION

The resources are now complete. Usage of both the teaching pack and the presentation is easily sustainable, with the only limiting factors being postage costs and keeping information up-to-date. We hope to extend the teaching pack element of the project by using the same format in other marine aggregate dredging areas around the UK. This will use the Solent based pack as a prototype that will be developed with the use of local case studies relevant to each area.

Title: 3963MAIN. Solent aggregates to outreach: Presentation and teaching pack

Contractor: Hampshire and Wight Trust for Maritime Archaeology

Contact: Rebecca Causer

Telephone: 02380 237300

E-mail: Rebecca.causer@hwtma.org.uk

Full Report Site:

<http://www.hwtma.org.uk/education/aggtoout/index.htm>

<http://ads.ahds.ac.uk/project/alsf/>



ENGLISH HERITAGE

Mineral wealth – Seabed health at Explorocean

INTRODUCTION

Mineral Wealth – Seabed Health promotes the public understanding of marine aggregate extraction and seabed organisms. It is a joint project between the Marine Biological Association (MBA), the National Marine Aquarium and Cefas (The Centre for Environment, Fisheries and Aquaculture Science). The two year project started in June 2005.

The project has brought together and interpreted information collected as part of surveys related to aggregate extraction. This information was made available from industry and Cefas databases, covering the majority of the coast of the UK where aggregate extraction occurs. These data have been made accessible via a series of routes: mainly a website, dissemination at the National Marine Aquarium and an interactive CD-ROM as a resource for schools and the general public.

The programme also benefited from the support of a steering group composed of representatives from: Natural England, the British Marine Aggregates Producers Association (BMAPA), The Crown Estate, The National Museum Wales, Hele's School, Plympton and all project partners and contractors.



*A small cuttlefish, captured during a survey of the English Channel.
Image: Hilmar Hinz*

PROJECT AIMS AND OBJECTIVES

The main aims of the project have been:

- to continue to bring together and interpret information collected as part of surveys related to areas subjected to aggregate extraction in UK waters
- to use this information with other materials to produce an interactive learning and training experience.

Dissemination of un-biased information about the biodiversity of sand and gravel habitats and information about the aggregates industry has been undertaken. The objective of such work has been to provide the public with information that can form the basis of informed debate about marine aggregate dredging.

DATA AND RESOURCE COLLATION

Survey data have been collected and interpreted to provide the public with information about what species are found in the majority of the areas surveyed in relation to aggregate extraction in the UK. The information collected has been made available through the website and linked to basic reviews for the species recorded.

Biological survey data have been obtained and entered into Marine Recorder for 20 surveys. This has included a total of 900 individual survey events and 20,000 species records. Data were obtained from the aggregates industry and Cefas. Much of the data were only available in paper format, but have now been converted into electronic format and have been archived under the DASSH (Data Archive for Seabed Species and Habitats) program. The data entry process involved data validation and verification procedures, which were strictly followed to ensure the accuracy and reliability of the information archived and displayed. The data are fully searchable through the *MarLIN* website and a special interactive search tool has been developed to allow the species lists generated from the data to be accessed easily. The data will be passed on to the NBN (National Biodiversity Network) and maintained and archived in the long term by DASSH. DASSH will safeguard marine benthic survey data (past and future) and make those data available as a national information resource to support marine science and better stewardship of the marine environment.

Continued support of DASSH and the digitisation of aggregate industry-related biological survey data is essential, to ensure that this valuable information remains accessible for everyone, including those who are able to use the data to support management decisions.

J. Sewell

The Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon, PL1 2PB



*Brittlestars on a gravel sea bed. An example of the beautiful sea bed survey images provided by Cefas.
Image: Cefas*

Images and video footage from surveys have also been obtained through collaboration with Cefas, BMAPA and private image donations. This information has been archived, used in educational resources and made available through the website. This visual information has been a valuable resource to display the presence of species and habitats encountered around our coasts and to educate a wide range of audiences (i.e. general public, schools, teachers) about the biodiversity present in our marine habitats.

EDUCATIONAL RESOURCES

The key educational outputs developed for the project have been:

- An interactive CD ROM, developed by STEP (Science Training & Education Partnership). The CD includes resources for teachers and students. The resource includes a decision based exercise, which has been developed to complement decision making elements of the National Curriculum and has been developed with teachers and learning professionals to ensure that it is as useful as possible to teachers and students. The user works aboard a virtual survey vessel and is required to examine data to assess whether or not dredging should be allowed at a selection of sites. More than 500 CDs have already been distributed to teachers during education conferences and by post in early 2007. Over a hundred orders have also been received by teachers and learning professionals requesting the CD.

Mineral wealth – Seabed health at Explorocean



The interactive Mineral Wealth – Seabed Health CDROM, produced by STEP.
Image Credit: Science Training Education Partnership

- The Sea Games display at the National Marine Aquarium's Explorocean gallery is an 'arcade' of interactive games, activities, information and 3D models. The display has been developed by Hartnell Creative Communication Ltd and includes games adapted from traditional arcade attractions and real survey and dredging artefacts, kindly donated by the aggregates industry and Cefas. The display is expected to appeal to a range of people and entertain and inform visitors for years to come.
- The project website includes information and resources about sand and gravel habitats and species. It also includes information about the aggregates industry and how aggregates are used. A mapping tool has also been developed for the site and gives information about relevant seabed surveys and the species which have been found. The website, hosted on the MarLIN server will be maintained for the foreseeable future by the Marine Biological Association, with new species added to the pages regularly.



Screenshots from a selection of interactive games in place at the 'Seagames' exhibit in the National Marine Aquarium's Explorocean gallery.
Images: Hartnell Creative Communication Ltd

All educational resources have been developed in association with learning professionals, marine scientists and industry experts.

Additional Dissemination Venues:

The project has been extremely active in disseminating their outcomes in a wide range of venues. Some examples are as follows:

- Marbef Newsletter, Autumn 2006
- Promotion through *MarLIN* and MBA newsletters, distributed to MBA members and members of the marine biology and conservation community
- Platform presentation at the MALSF conference 2006 in Southampton
- Stall and poster presentation at the ASE (Association of Science Educators) annual conference in Birmingham (Jan 2007). This was shared with the National Museum Wales' ALSF funded 'Explore the Seafloor' project
- Poster display at the Devon and Cornwall regional ASE conference, Kingsbridge (March 2007)

Future development of this programme:

Further funding to continue with the dissemination strategies of this current programme is being explored. The availability of extra resources will help to create continued awareness of the effects of aggregate extraction and the marine life encountered in these habitats. Collaborations are also being sought with other ALSF projects to allow resources developed with ALSF funding to be shared and used to reach an even wider audience.

ACKNOWLEDGEMENTS

The project partners would like to thank the following people and organisations for their valued support, without which the project would not have been possible.

Mark Russell (BMAPA), Julian and Philippa Priddle (STEP), William Drake (The Crown Estate), Lindsay Ward (Hele's School), Natural England (formerly English Nature's Maritime Team), Lara Murphy (National Museum Wales), Hilmar Hinz (MBA), Prof Paul Leonard (Defra).

Data providers –

Dr Hubert Rees, Keith Cooper and Dr Sian Boyd (Cefas)

Andrew Bellamy – United Marine Dredging Ltd

Graham Singleton – CEMEX

Ian Taylor – Westminster Gravels Ltd

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Title: MAL0007 Mineral Wealth – Seabed Health at Explorocean

Contractor: The Marine Biological Association

Contact: Jack Sewell

Telephone: 01752 633336

Email: jase@mba.ac.uk

Full Report Site:
<http://www.mineralwealth-seabedhealth.org>



Marine ALSF GIS

PROJECT OVERVIEW

In September 2004 Cefas awarded the MEPF 04/07 Marine ALSF GIS project to a team comprising of ABP Marine Environmental Research Ltd (ABPmer) and the GeoData Institute. The purpose of the project is to ensure that marine aggregate research provides maximum benefit and addresses policy needs through an improvement in 'knowledge management'.

The project provides access to past and current marine aggregate research through a website (www.MarineALSF.org.uk) which holds a live register of research studies structured as a spatial database and, where available, supplies direct links to research outputs. The research in the system may be directly related to marine aggregates or associated to another sectoral interest, it may offer a UK context or be developed from an relevant overseas study. The

database is designed to recognise planned, current and past activities with associated funding bodies and research institutes. The use of Geographic Information Systems (GIS) is included to provide a means of assisting search facilities and determining geographic areas which may be research rich or poor. The project also provides a valuable tool for disseminating information from other ALSF funded research programmes.

It is understood that many web-based facilities exist which host or sell spatial data (commonly in GIS format) to define a multitude of marine environmental parameters. It is not intended for the Marine ALSF GIS to replicate or compete with these data delivery sites. The main driver for the present project is to deliver a spatial metadatabase providing information about contemporary research studies related to marine aggregates.

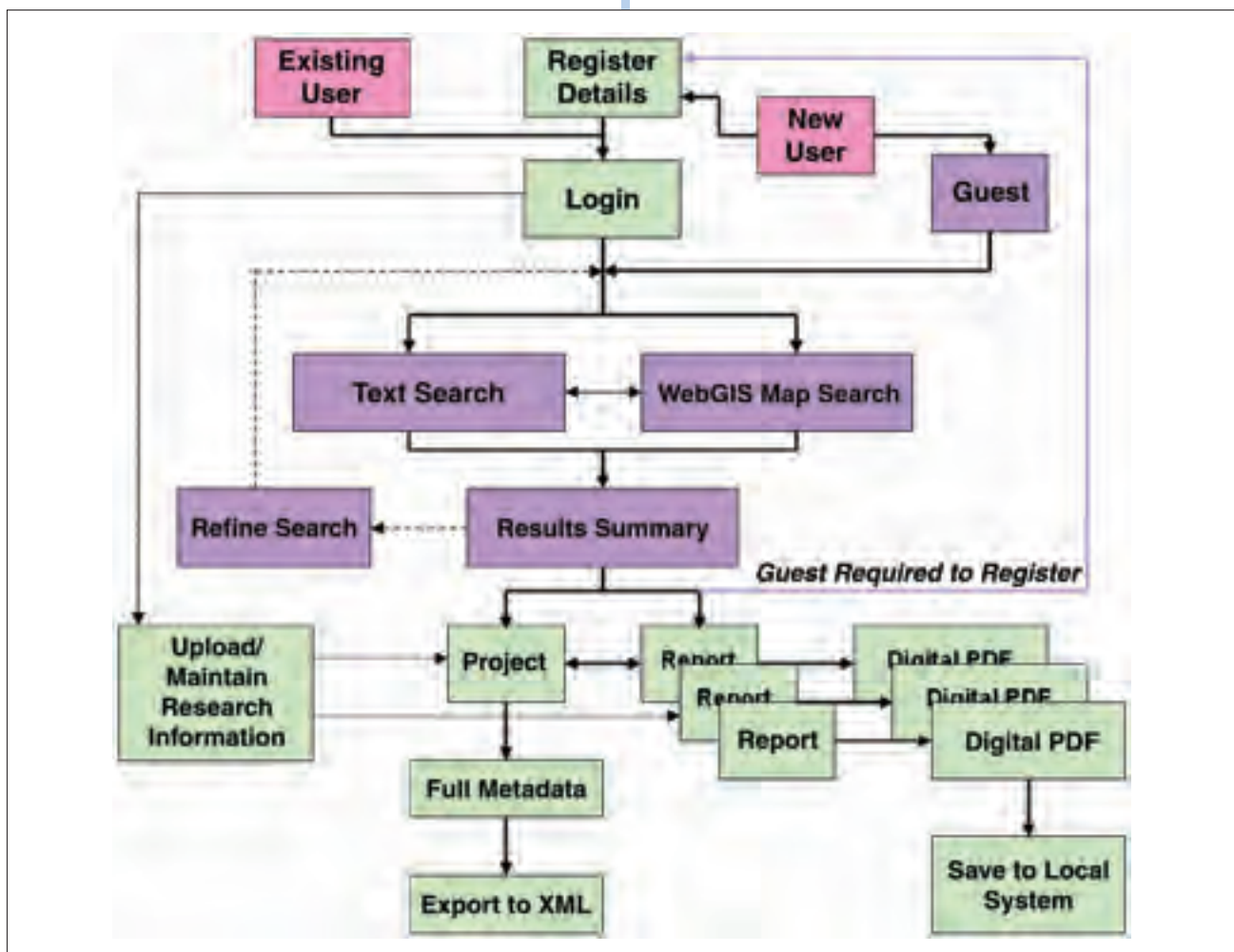


Figure 1: Retrieval of information from the Marine ALSF GIS Database

SYSTEM DEVELOPMENT

A user specification study was undertaken at the start of the project during which a range of potential user groups were consulted about the functionality of the proposed system. The outputs from this activity were used to create a technical specification for the system development. Further detail about these activities can be found in specialist reports that are available from the publications page of the project website. The technical specification was used to guide the project developments that include a metadatabase which has been populated with aggregate research project metadata collated from industry, regulators and other consultancy sources. The website combines text searches with information from the webGIS to support the searching and retrieval of marine aggregate research project metadata and associated reports, as demonstrated in Figure 1. It also provides functionality for the remote update of new project metadata and associated deliverables by registered users. The website was launched in March 2007.

The entire system has been developed using open source tools, and the spatially enabled DataBase Management System (DBMS) has been developed using the PostgreSQL database incorporating functionality from the PostGIS extension. The manipulation and display of spatial data in the webGIS map window has been implemented using the MapServer GIS component library. This also integrates a collection of other open source software libraries for manipulating and transforming a wide range of spatial data types. The MapScript scripting extension has been implemented to enable the use of MapServer within the PHP scripting language. All of these development tools conform to the standards published by the Open GIS Consortium (OGC) and ensure that there will be no cost for software packages, server or client licences, support or upgrades for the final system.

The web application and server are also designed using open source tools. The main web interface is constructed using open source PHP web scripting language and implemented using HTML and style sheet standards. The Apache web server is used to execute the web application and deliver web page output to users. This means that no special client-side technologies will be required to view information at the browser end and the whole system is fully portable between computer hardware of different organisations.

INPUTS

The ALSF GIS study has sourced information from completed research projects and captured details into a structured database. This information is stored as metadata including an abstract, contacts, history and spatial extent for each project record. Where available, the digital project deliverable report has also been obtained and made accessible as a digital pdf document, website reference, or library location. Summary information about these reports is stored as a bibliographic record and is linked to a 'parent' project record in the system. Each individual research project record may have zero to many report references yet each report record only has one mandatory 'parent' project record.

All relevant aggregate projects have been considered, however, the database is focused on research from within UK waters completed since the year 2000. This has helped to maximise the availability of relevant project metadata and digital deliverables held within the system. Information from current marine aggregate projects has also been entered into the database. This project information conforms to the UK GGeo-spatial Metadata INteroperability Initiative (GEMINI) specification that has been adopted to standardise the metadata stored within the database.

OUTPUTS

The primary project deliverable is a customised website (www.MarineALSF.org.uk) providing the tools to search and retrieve aggregate project metadata. Initially the website content provided general marine ALSF GIS project information, as well as a user forum, and this has developed into a data catalogue of research studies as the project progressed. The research project information is accessed through a helpful front-end, including an intuitive search facility with provision for standard bibliographic keywords (title, abstract, date, project leader, project distributor) and an option for visual 'by map location' data queries. Direct links to digital project reports are also provided for user download where available.

The visual search facility is presented using a web-enabled Geographic Information System (webGIS), as demonstrated in Figure 2. This includes several key base-mapping layers (aggregate licence blocks, coastline, general sea areas, bathymetry, coastal places) to enable users to search and place results in a spatial context. This helps to rapidly identify areas that are rich/poor in research from particular topics or themes. Interactive text help is also implemented to guide new users through the functionality of the system. Initial

Marine ALSF GIS

searches can be undertaken without registering on the website however, users are required to register and log-on to the system prior to receiving any detailed metadata or PDF reports (Figure 3) thus enabling the monitoring of both user groups and downloads from the database.



Figure 2: The web-geographical information system interface



Figure 3: Example of detailed information available from the system

Registered users are also able to add references about their current research projects into the database by completing online metadata forms, which will only require limited checking by a nominated administrator before being included in the live system. Further functionality facilitates the upload of user project reports into the system to accompany their project metadata records. This enables the dissemination of project information to a wider community and also ensures that the database will remain as a contemporary resource after the project has been completed. It is also anticipated that this functionality will provide a valuable tool for disseminating information from other current, and potential future, ALSF funded research programmes.

END USERS

The primary project deliverable is aimed at improving the management of information and digital documents rather than advancing our scientific/technical understanding of marine aggregates. A summary of potential users and associated benefits are presented in Table 1. The database provides an additional support vehicle to assist wider dissemination from other ALSF and non-ALSF funded research with the overall benefit of improved take up of all the research.

TABLE 1: POTENTIAL USERS OF THE MARINE ALSF GIS DATABASE

| | |
|---------------------------|--|
| Defra | <ul style="list-style-type: none"> • Improve co-ordination of sectoral funding. • Maximise benefits of available funds by targeting research to priorities. • Supporting policy requirements. • Achieving Public Access to Environmental Information (Environmental Information Regulations) and Freedom of Information. |
| OTHER FUNDERS | <ul style="list-style-type: none"> • Maximise benefits of available funds by targeting research to priority themes and spatial locations. • Identifying other research programmes and researchers to help avoid duplication of effort. |
| MARINE AGGREGATE INDUSTRY | <ul style="list-style-type: none"> • More readily identify available research to improve their own scientific / technical understanding. • Improve linkages to other sectors. • Improve access to information for prospecting and associated activities. • Provide a primary location for information from ALSF and other aggregate research programmes. |
| RESEARCHERS | <ul style="list-style-type: none"> • More readily identify available research to improve their own scientific / technical understanding. • Become more identifiable as contributors to research. • Improve linkages within the wider research community. • Identify potential funding bodies. • Respond better to research calls. |
| REGULATORS | <ul style="list-style-type: none"> • Identify status of present knowledge. |

Title: MEPF 04/07. Marine ALSF
Geographical Information System

Contractor: ABP Marine Environmental Research
Ltd. & GeoData Institute

Contact: Jamie Moore

Telephone: 02380 711840

Email: jmoore@abpmer.co.uk

Full Report Site:
<http://www.marinealsf.org.uk/>
<http://www.alsf-mepf.org.uk/>



Development of an open access website to collate and disseminate good practice and information on marine aggregate dredging

INTRODUCTION

The aim of this ALSF project was to develop a high-quality, open-access web site to inform members of the public about aggregate extraction in the marine environment. The website that has been developed contains comprehensive, up-to-date information on measures that can be applied to mitigate the environmental effects of marine aggregate extraction. These include compulsory regulations, standard measures routinely adopted by the industry and emerging good practice procedures.

Once accessible in the public domain, the Goodmarine.com website will provide a significant information resource similar to Goodquarry.com, which successfully disseminates environmental good practice for terrestrial aggregate extraction.

DELIVERY ORGANISATIONS

The project has been developed under the Sustainable Land-Won and Marine Dredged Aggregates Minerals Programme (SAMP), funded through Defra's ALSF, with administrative assistance from the Mineral Industry Research Organisation (MIRO). Delivery Partners working on the project are based at the University of Leeds, the Centre for Environment, Fisheries and Aquaculture Science (Cefas) and Royal Haskoning. There has also been input from a wider Steering Group set up to participate in the delivery and quality assurance of the project. In addition to the Delivery Partners, the Steering Group has comprised of representatives from the following organisations: Department for Communities and Local Government (DCLG), Department for Environment, Food and Rural Affairs (Defra), English Heritage, ABP (Marine Environmental Research Ltd.) and the British Marine Aggregate Producers Association (BMAPA).

PROJECT OBJECTIVES

The objectives for this project were to develop an open-access website to collate and disseminate good practice and information on marine aggregate dredging. The website was designed to provide an overview of the marine aggregates industry, and to consider the environmental implications of its extraction activities. The website aimed to gather together examples of existing and emerging techniques and technologies used by the industry to minimise potential environmental impacts. It is hoped the website will

become the entry point or portal for anyone wishing to find out about mitigating the effects of marine aggregate extraction.

The original thematic research priority for this project was to collate and disseminate information 'for a wide range of stakeholders'. The website was intended to serve operators, regulators, conservation organisations and members of the public wishing to be better informed about the issues, by becoming a portal or "one-stop shop" for information. Following the initial project application, the Delivery Partners were encouraged to amend the objectives of their original proposal to provide best available information suitable for "a wider 'lay-person' audience". The website material has therefore been developed in a style and form which is understandable to a lay-person audience, and includes explanations, summaries and illustrative features where appropriate. However, the web site is still expected to be of benefit to the industry, and provides links to more technical information where it is accessible elsewhere.

The need for an open-access information resource on marine aggregate extraction (similar to Goodquarry.com) was highlighted when a request for permission to use a recreational diver's photograph produced this response:

"As a diver who is concerned about the welfare of the marine environment I am instinctively against marine based dredging and mineral extraction. However as a realist I understand that the practice is not likely to stop in the near future and therefore education and information are the best way of minimising the impact on the environment. I have looked at your existing land based quarry advice site (www.goodquarry.com) and can see that your aim is to promote best environmental practice. We are therefore happy to allow you to freely use any of our underwater photos on your new site."

One of the original objectives was to build on, and link to, existing and emerging marine aggregates websites. The University of Leeds has worked hard to collaborate with another website provider (ABP Marine Environmental Research Ltd.) who have been represented on the Steering Group Committee throughout the project. Information resources have been shared between the Delivery Partners and appropriate links made between the two websites. Links have also been provided to the websites of other Marine ALSF-funded projects.

WEBSITE DEVELOPMENT

Data Collation

Cefas and Royal Haskoning have assisted the University of Leeds to facilitate the collation of material from a comprehensive list of existing publications and reports. The Project Partners have liaised with BMAPA to determine current operational good practice. Other organisations represented on the steering group have been involved in the collation and editing of website material. Efforts have been made to monitor and review emerging publications and reports to ensure that the website contains up-to-date and relevant information.

Website Structure and Content

The 'Home Page' (Image 1) provides an introduction to the website, and access to the 11 main sections via the left hand navigation bar. The four introductory sections provide an overview of the marine aggregates industry, the nature and location of aggregate resources, the dredging process and operations, and the strict regulations that control extraction activities.

Having provided a background to the industry, the majority of the website is then dedicated to considering the implications of marine aggregate extraction on a range of environmental receptors and other sea users. Each of the sections includes detailed descriptions of the baseline data requirements, potential environmental impacts to be assessed, and the good practice mitigation and monitoring measures relevant to that



Image 1: Website Home Page

Development of an open access website to collate and disseminate good practice and information on marine aggregate dredging

specific receptor. An up-to-date summary of current research in relation to cumulative impacts and recovery and rehabilitation is also provided.

Additional Features

There are a number of additional features included within the website which help to make a more interesting, interactive and engaging information resource. High quality graphics, interactive animations, diagrams, photos and video clips have been used throughout the resource to help illustrate concepts and ideas introduced within the text.

Case studies have been included wherever relevant to illustrate the use of good practice mitigation and monitoring. Glossary definitions are provided for all scientific terms and abbreviations to avoid any confusion to the 'lay-reader' and to reduce unnecessary repetition. Links are made to the 'References' page throughout the text, where the full citation of the referenced document can be found. The reader is redirected to the Full Text Document if it is publicly available, via a link to the appropriate page within the ABP(Mer) Marine ALSF Database Project. Links to a variety of relevant organisations are provided throughout the text, as well as on a dedicated 'Links' Page. Once 'live', it will be possible for the Project Partners to monitor usage and opinion of the site through a website statistics package and a 'Feedback' form.

FURTHER WORK

Addressing Concerns

A formal independent review of the content of the website was undertaken in December 2006. With assistance from Steering Group organisations, the Project Partners have worked to address the concerns raised within the review.

The re-drafted material will go through the final reviewing process in March 2007, and any further editing will be incorporated to ensure endorsement from the Steering Group.

Website Launch

It is anticipated that the Goodmarine.com website will be launched in May 2007. The website launch will be widely publicised amongst the marine sector, with regulators, consultants, scientists, marine aggregate dredging companies, universities, conservation bodies and other offshore industries to be made aware of the existence of the website.

Incorporation of New Material

Although no contractual commitment exists, the University of Leeds aims to maintain the website and keep the information as accurate and up-to-date as possible after the project's closure. New and emerging research work providing information on new technologies or techniques will be monitored and incorporated.

Future Funding

The security of further funding would ensure that significant time and resources could be used to keep the website as current and up-to-date as possible.

CONCLUSIONS

The development of Goodmarine.com has successfully contributed to the aims and objectives of the Marine ALSF, particularly to Theme D: Co-ordination, Dissemination and Outreach.

This web resource disseminates comprehensive information on marine aggregate extraction in a format easily accessible to the interested public. A non-technical summary of the latest research projects can be found in a single location. The well-structured sections provide easy navigation through the information, and the illustrations and video clips provide visual representations of some of the more complicated concepts. A wide audience can now gain free access to up-to-date information on marine aggregate extraction related research.

Title: SAMP 3.A7 Development of an Open Access Website to Collate and Disseminate Good Practice and Information on Marine Aggregate Dredging.

Contractor: University of Leeds

Contact: Toby White

Telephone: 01133 432784

E-mail: T.J.White@Leeds.ac.uk

Full Report Site:

<http://www.goodmarine.com/>

<http://www.dclgaggregatefund.co.uk/themea.htm>



Underwater safari

INTRODUCTION

Medina Valley Centre (MVC) consider that high quality underwater video offers considerable scope as a field teaching aid for showing students and members of the wider public the diverse nature of the underwater environment. In partnership with Emu Ltd. and the Sussex Sea Fisheries Committee, the project developed a capability to incorporate underwater video as a tool for use in environmental field trips, with sustainable marine development in the context of the aggregates industry providing the focus.

The aim was:

To demonstrate and evaluate the contribution of underwater video as a teaching aid in the field.

OBJECTIVES

Within the overall aim, several objectives had to be met, reflecting the requirements for funding from the ALSF.

- The development of a teaching package which uses marine aggregate extraction as a focus for explaining sustainable development, incorporating the use of UW video.
- The development of the capability to project real-time seabed images onto a large screen on a vessel as a teaching aid.
- A comparative trial of both underwater video and ROV for use as field-study teaching aid.
- Demonstration that data acquisition using underwater video can be captured in a field-study context for subsequent uploading and analysis in GIS.
- Evaluation of the Underwater Safari concept by the schoolchildren themselves, by the teachers and by representatives from the conservation agencies and the aggregates industry.

METHOD

Real-time projection

The principal challenge was to identify a means of projecting real-time underwater images onto a large screen that could be viewed comfortably from all seats on the vessel. Furthermore, the design had to be developed with a preferred vessel in mind which is routinely used by MVC for field study trips. This is an open vessel with bench seating to a capacity of 50. (Plate 1).



Plate 1

Several options were considered including possible use of an LCD. However, we opted for a digital projector with a very high power luminescence projecting onto a fabricated white screen. Shielding of the screen from direct sunlight using a large black-out canopy allowed a good image quality to be achieved - even in bright ambient conditions.

Educational material

A specially designed laminated species-identification sheet was developed for the students, by MVC together with a recording sheet to note the species seen and record other aspects of each survey site such as seabed type, depth and position.

Samples of different grades of sand / gravel, donated by Kendall Bros. (Portsmouth) Ltd. were put into a display rack in order to demonstrate how variations in sediment grades create different interstitial spaces on the seabed.

Finally a presentation was prepared by MVC using information provided by both Emu Ltd. and the British Marine Aggregates Producers' Association (BMAPA).

TRIAL

A Trial to test the equipment and reconnoitre suitable sites for the Safari was undertaken on the 15th & 16th March 2006. Following successful equipment checks alongside on 15th March, a number of sites were reconnoitred the following day for potential field-study sites. Deployments of the drop-down video and a Video Ray Scout ROV (Plate 2) (kindly loaned by Sussex Sea Fisheries Committee) were made in the Yar Estuary and off Norton Spit immediately outside of Yarmouth Harbour. There was a cold onshore NE wind (F4-5) which created less than ideal conditions!

R. Herbert¹ & R. Drabble²

¹ Medina Valley Centre, Dodnor Lane, Newport, Isle of Wight, PO30 5TE

² EMU Ltd, 1 Mill Court, The Sawmills, Durley, Southampton, Hampshire, SO32 2EJ

Initial evaluation of trials

Projection of a high quality image onto a large screen for use in a field study context was largely achieved, even in reasonably bright sunlight (Plate 3). Glare on the painted matt-white screen was subsequently removed by covering the screen with a white, nylon shower curtain.

Due to technical problems with the smaller underwater video camera belonging to Emu Ltd., a larger camera system with deep water heavy-duty cable had to be

mobilised and brought on to the vessel. This made deployment difficult and working deck area was reduced.

Cameras were deployed at two locations in the Yar estuary where previous subtidal survey work had revealed the presence of a diverse marine fauna. These locations were Kings Manor pontoon (courtesy of Mr & Mrs Sheldon) and Yar Boatyard pontoons. Deployment was at High Water during spring tides. The vessel was tied up alongside the pontoons at both locations while deployment was undertaken.



Plate 2

Underwater safari

A third location was visited immediately west of the harbour entrance close-in at Norton Spit. The hope here was to locate a previously known eel grass bed (*Zostera marina*)

The ROV performed remarkably well at both sites in the Yar Estuary and revealed the presence of interesting benthic assemblages, including sponges (*Suberites massa*), anemones (*Urticina felina*) and red algae. Eggs of the green paddle worm *Eulalia viridis* were also seen.

A limitation of the Chalco drop-down video was inability for fine spatial adjustment. To move the video camera it has to be raised off the seabed and then lowered again. However the close-up capability was very good, enabling excellent viewing of burrowing shore crab (*Carcinus maenas*).

At Norton Spit, the vessel anchored about 50m off the beach, well below Low Water Spring Tide mark. The Eel grass bed (*Zostera marina*) was immediately located and

very good views were obtained using both UW video systems. The seabed was mainly sand with some surface gravel. Species seen included the anemone *Anemonia viridis*, which was frequent.

A fourth site, Hamstead Ledge, was visited but tidal and wind conditions made it impractical to deploy the video systems. The site is different, being primarily rock and had the potential for interesting underwater scenery.

THE UW SAFARI – PROOF OF CONCEPT

An Underwater Safari was arranged for 11am on Wednesday 22nd March 2006. Seventeen visitors arrived including 9 'A' level Biology students from Cowes High School on the Isle of Wight. Other guests included representatives from the marine aggregate industry, English Nature, Kent Wildlife Trust, Isle of



Plate 3

Wight Council Countryside Section and the Isle of Wight Economic Partnership. With boat crew and operatives, 24 personnel were present.

Due to the cold conditions, the initial presentation took place in the nearby Wheatsheaf Inn. The programme for the day was explained and a short PowerPoint presentation given to place the day in a context of sustainable development with a particular focus on the marine aggregates industry. The need for accurate ecological information on the seabed and the importance of increasing awareness of the marine environment was emphasised. Hence, the opportunity provided by the Underwater Safari.

Weather was dry and bright, but with cold NE veering E wind, F4. Unfortunately, due to operational failure of the Yar swing bridge on Monday 20th the upper estuary sites which we had reconnoitred the week previously were not accessible. It was therefore decided to focus on the Eel grass bed at Norton Spit and find a site in the harbour. The vessel left the quayside at Yarmouth at approximately 12.00.

Two sites off Norton Spit were surveyed using both the VideoRay ROV and Emu Chalco hyperdigital 18:1 zoom video, which due to servicing had not been available during the earlier trial. This latter system does not require heavy duty cable so there was much more deck area and room on the vessel for the Safari.

Full use was made of the ID sheets handed to the students with interpretation of the underwater ecology being provided by Roger Herbert and Claire Dalglish from EMU Ltd.

Problems were encountered with both the ROV and Chalco Underwater Video system. The ROV performed well and gave good clear images of the Eel grass bed, however due either to wave turbulence or inshore tidal currents, it was difficult to keep it stable for any length of time. Usefully, some semi-quantitative data on the shoot-density of the eel grass bed was obtained by calibrating the maximum field of view of the camera. The Chalco video system appeared to be dragged by the current each time it was deployed, reflecting its unsuitability for use in static conditions. A second deployment closer to the harbour wall also gave good clear images of kelp (*Laminaria* sp.) and Japanese seaweed *Sargassum muticum*.

The final deployment was made in the harbour. The vessel was moored up against a pontoon and both systems were deployed. Of particular interest were excellent close-up views of paddle worms *Eulalia viridis*, again with the ROV. This location within a muddy

substrate provided a useful contrast with the sandy substrate of the Eel grass bed. A Van Veen hand-grab, borrowed from Bournemouth University was deployed to attempt to obtain a sample of the worms. However although the grab worked well we did not collect any worms, although there was other interest in the sediments.

While the vessel was returning to her berth on the quayside, recorded subtidal video footage showing a wide range of other habitats was played on the screen which was particularly well received. The vessel returned to the quayside; the overall Safari duration being about 90 minutes. Visitors and students returned to the Wheatsheaf for debriefing and evaluation.

OVERALL EVALUATION

From the feedback forms received from the 9 students, 8 were extremely positive about the experience. The only negative comments were from a student believed to be suffering from mild sea-sickness, a problem that needs to be addressed more seriously with longer boat trips of this nature where people are asked to watch a screen.

Appendix 1 summarises the results of the evaluation. It is apparent that the students and visitors really enjoyed the experience and found the opportunity contributed greatly to their knowledge of the local underwater marine environment. There was also positive feedback on the extent to which the event contributed to their appreciation and understanding of the marine aggregates industry and challenges for sustainable exploitation of the seabed resources.

Overall, compared to the other systems, the VideoRay ROV performed consistently well, although it is likely to be limited to relative sheltered and shallow water. The other advantage of this system is that it is relatively simple to deploy from a pleasure cruise vessel with minimal additional equipment: this can be accommodated in a small suitcase. This equipment gave excellent clear images, which were easy to interpret. A slightly heavier camera may be more suitable for these waters.

Of particular interest is the dual Survey/Safari capability of UW video. It was generally considered that Safari goers would be interested in using the opportunity to generate scientific information, in addition to enjoying and learning about the underwater environment. It is relatively easy to overlay GPS data on to the digital video output. This also provides an interesting interface between the general public and the scientific community.

Underwater safari

CONCLUSIONS

- The principle objective of demonstrating the feasibility of using in-situ underwater video footage to help promote awareness of marine biodiversity in the field was achieved. (Plate 3).
- The UW Safari concept worked well alongside consideration of marine aggregates in the context of sustainable development.
- The Video Ray ROV performed well although the model used was slightly underpowered for operating in any noticeable current.
- The objective of data acquisition in parallel with field-study was achieved. Images, with GPS overlay, were recorded onto mini DV and each deployment was logged professionally. This demonstrates the feasibility of a largely unexplored opportunity to capture valuable scientific data in conjunction with field study programmes making optimum use of resources for the benefit of the wider community.
- Positive feedback was received from students / visitors and provided a basis for planning a further series of UW Safaris in July 2006.

POST SCRIPT

In July 2006 a further 3 schools participated in UW Safari led by MVC over 2 days, supported by Leader+ via the IOW Economic Partnership. Valuable lessons learnt from the proof of concept trial were applied, in particular:

- Use of a more powerful Video Ray ROV as the equipment of choice.
- Combining sampling using plankton nets and hand-held Van Veen grabs to view organisms from the video sites. (Plate 4).
- The benefits of a pre-planned programme which can maximise participation, once resources are mobilised.



Plate 4

A DVD of these Safaris has been produced, consisting of 21 short video clips with an accompanying guide. This important local resource on the Medina and West Yar estuary has been deposited in the Isle of Wight County Records Centre and Teachers Resource.

An indirect output from the follow-on safaris in July has been media coverage by the press and Meridian TV which has generated additional interest in the concept suggesting the scope for a more strategic approach.

APPENDIX 1

Underwater Safari 21st March 2006
Evaluation Results

Total number of responses = 11. There were 9 'A' level students and 2 adult

1. How much did you enjoy the experience? (5 = Very Enjoyable)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| 1 | | 1 | 6 | 3 |

3. Did you find the day well organised? (5 = Very well organised)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| | | | 4 | 6 |

4. Was the duration of the trip Too Long (1), Too Short (2), About Right (3)

| | | |
|---|---|----|
| 1 | 2 | 3 |
| | | 11 |

5. Was the quality of the projected image satisfactory? (5 = Excellent)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| | | 2 | 6 | 3 |

6. To what extent do you feel the Safari has helped you understand more about marine biodiversity and marine ecology? (5 = have learned much)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| | 1 | 3 | 4 | 3 |

7. To what extent do you feel the Underwater Safari has helped you learn more about the Marine Aggregates Industry (5 = have learned much)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| | 1 | 2 | 4 | 4 |

8. Do you feel there is high potential for Underwater Safaris for the general public? (5 = Very High Potential)

| | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| | 1 | | 4 | 5 |

9. What would you be prepared to pay for a 1hr Underwater Safari cruise.

| | | | |
|-----|-------|-------|--------|
| <£5 | £5-10 | £5-10 | £10-15 |
| 2 | 6 | 1 | 2* |

*The 2 adults on board.

Appendix 1

ACKNOWLEDGEMENTS

Richard Kendall of Kendall Bros. (Portsmouth) Ltd.

Peter Lemonius, owner / skipper of Needles Pleasure Cruises

Mr. and Mrs. Sheldon

Tim Dapling of Sussex Sea Fisheries Committee for loan of ROV and operator, Sean Blake.

Title: MAL0024 Underwater Safari

Contractor: Medina Valley Centre

Contact: Dr. Roger Herbert

Telephone: 01983 522195

E-mail: roger@medinavalleycentre.org.uk

Contact: Ray Drabble

Telephone: 01489 860070

E-mail: ray.drabble@emulimited.com

Full Report Site:

<http://www.emulimited.com>



Glossary of terms

Note that this glossary is more comprehensive than the proceedings of the 2006 Marine ALSF Conference might require. It does however cover a number of terms which appear in linked documents.

A

| | |
|---------------------------|--|
| Accretion | – process of sediment build-up |
| Acoustic backscatter | – a method of detecting discontinuities in the water, often used for current and turbidity measurements |
| Active dredge zone | – area within a licence area that is dredged |
| Aggradation | – reworking of the sediment by waves and currents |
| Aggregate | – the collective term for sand, gravel and crushed rock. They can be compacted to firmly fill a space and are often bound together with cement (to make concrete) or bitumen (for road surfacing) |
| Amphipod crustacean | – a group of small crustaceans eg., ‘sand hoppers’ |
| Annelida | – worms |
| Anthropogenic | – effects of man |
| Appraisal | – A rapid reconnaissance of a site and records to establish whether a mineral extraction or other development proposal has potential requiring further investigation |
| Archaeological Contractor | – Archaeological organisation commissioned to carry out archaeological assessments, evaluations, excavations and other required mitigation works |
| Archaeological Curator | – A person or organisation with a statutory responsibility for the management and conservation of archaeological sites and archaeological evidence generally for a specific area. It includes national bodies such as English Heritage |
| Archaeology | – the study of historic and prehistoric communities |
| Artefacts | – objects of archaeological interest, often stone tools or other man-made objects |
| Ascidians | – generally soft-bodied animals sometimes forming colonies attached to stones and rocks – sea squirts |
| Attenuation | – Term used to describe the decrease in noise level. It is the opposite of amplification. |

B

| | |
|-------------------|---|
| Barnacles | – small crustaceans encased in a calcareous shell, usually attached to shells and rocks on the seabed |
| Barrier islands | – offshore sandbanks that may, or may not be exposed at low tide and which protect a coast from prevailing wave action |
| Baseline | – the conditions existing before the commencement of mineral operations. This may not be the “natural” state, as there may be other impacts already operating |
| Baseline survey | – a survey of environmental resources carried out prior to a development |
| Bathymetry | – the topography of the seabed |
| Beach draw down | – removal of deposits from a beach by seabed transport |
| Beach recharge | – placement of aggregates on beaches to replace that lost by erosion (beach nourishment) or to protect coastal resources |
| Bedform | – sand sheets, ribbons and sand waves on the seabed |
| Bedload transport | – the transport of sediments along the seabed |

| | |
|----------------------------|---|
| Benthic boundary layer | – a zone at the seabed where sediment transport occurs |
| Benthic ecology | – the nature and distribution of organisms on the seabed |
| Benthic fauna | – animals that live on the seabed |
| Biodiversity | – the range of species that comprise a particular community or habitat |
| Biodiversity Action Plan | – This is a range of 59 broad activities for conservation work which were agreed at the UK Biodiversity Convention in 1993, held in response to the Rio summit in 1992, which called for the creation and enforcement of national strategies and action plans to conserve, protect and enhance biological diversity. www.ukbap.org.uk |
| Biogenic reefs/concretions | – aggregates of species that together form a hard substrate |
| Biomass | – the mass of organisms in a community |
| Biotope | – a distinctive community of interdependent organisms that characterise a particular habitat type. |
| Boundary layer currents | – currents at the sediment-water interface |
| Bronze Age | – in Britain the period approximately between 2000-700BC. Equated with the introduction of copper metallurgy. |
| Bryozoa | – mainly colonial animals that can form encrusting growths or leaf-like colonies attached to rocks and stones on the seabed |

C

| | |
|-----------------------|---|
| Catchment Area | – a land area where precipitation runs off into streams, rivers, lakes, and reservoirs. It is a land feature that can be identified by tracing a line along the highest elevations between two areas on a map, often a ridge. Large drainage basins, like the area that drains into the River Severn contain thousands of smaller drainage basins |
| Cetaceans | – whales and dolphins |
| Chart Datum | – a reference point to which water depths are referred |
| Chronology | – the relative timing of events |
| Coastal Impact Study | – a comprehensive study of all aspects of a project on the coastal morphology, bathymetry and coastal processes |
| Coastal squeeze | – narrowing of the upper shore from a combination of sea defences and rising sea level |
| Community composition | – the relative species variety, population density and biomass |
| Compensation | – the measures taken to offset or compensate for residual adverse effects that cannot be mitigated, or for which mitigation cannot entirely eliminate adverse effects |
| ‘Conditions’ | – constraints or requirements imposed on a licence as part of the consent for aggregate dredging |
| Conservation status | – an assessment of the significance of an area for wildlife resources and habitats protected under conservation law |
| Consultees | – those consulted as part of the Environmental Impact Assessment process |
| Crown Estate | – the Body responsible for the commercial management of the seabed that is under the jurisdiction of the Crown |
| Crustacea | – shellfish such as crabs, lobsters and prawns |
| Cumulative effects | – the sum of effects from adjacent activities such as dredging and fishing, including spoils and waste disposal |

Glossary of terms

Cut depth – the depth of individual passes by the draghead during dredging for aggregates

D

Deepseas – areas of seabed where the depth greatly exceeds that in the surrounding waters

Defra – Department for Environment, Food and Rural Affairs. This is a government department whose aim is sustainable development. www.defra.gov.uk

Demersal fish – fish that live on the seabed

Dendrogram – a method of showing the similarity between samples

Density current jet – a fast moving dense plume of suspended solids descending to the seabed from dredger reject chute discharge

Dependent species – species that depend on the presence of other species for their occurrence in a particular habitat

Designated habitats – habitats protected under Directive 92/43/EEC The Habitats Directive and Directive 74/409/EC the Birds Directive

Designated species – species protected under Directive 92/43/EEC The Habitats Directive and Directive 74/409/EC the Birds Directive

Development Control – the procedures that operate to ensure that the decision about whether to permit a particular mineral application is made in the appropriate way

Development Plan – a set of documents (text and maps) which contain the regional planning body and local planning authority policies and proposals for development, including minerals (Regional Spatial Strategies and Development Plan Documents)

Dispersion – the movement of suspended matter away from the source of the emissions

Doggerland – habitable area on the North Sea plain prior to transgression by the sea

Dominance – a method of expressing the relative contribution of different species to the population density of a community

Draghead – dredging gear at the seabed, often with a centrifugal pump

Dredge pipe – the pipe through which aggregates are sucked from the seabed into the hopper of the dredger

Dredge pit – depression in the seabed associated with static dredging

Dredging area – the area actually dredged as opposed to that Licenced

Dredging footprint – the area of seabed that is affected by dredging

Dredging intensity – the amount of material dredged from the seabed

Dredging lane – a narrow strip of seabed chosen for dredging within the dredging area

Duration of Impact – the time over which an impact occurs – used as a component of risk assessment for environmental resources

E

Ebb dominance – the ebb tide is stronger than the flood tide in moving sediment

Echinodermata – organisms such as starfish, sea urchins and sea cucumbers

Ecological Quality Objective – objectives set to define environmental quality (EcoQO)

Elasmobranch fish – cartilaginous fish such as skates, rays and sharks

| | |
|--------------------------|---|
| Environmental Assessment | – the process of assessing impacts on environmental resources |
| Environmental Statement | – A comprehensive review of the proposed project, environmental resources, potential impacts and mitigation measures required as part of the Licence Application process |
| Epibenthic | – animals or plants that live on the surface of the seabed |
| Epifauna/epibiota | – animals that live on the surface of the seabed |
| Equilibrium communities | – complex communities with a slow rate of growth and reproduction (' <i>k</i> -strategists') that are often controlled by complex biological interactions |
| Erosion zone | – area of seabed where the surface sediments are coarse, fine sediments having been winnowed out |
| Evaluation | – A limited programme of non-intrusive and/or intrusive fieldwork designed to ascertain the presence or absence, nature and character of the environmental resources of a specific site or area |
| Exclusion | – prevention of use of an area by other vessels |
| Extent of Impact | – the spatial area of environment over which impacts extend– used as a component of risk assessment for environmental resources |
| Extraction rate | – the mass of marine aggregates removed from the seabed per unit time |

F

| | |
|------------------------|---|
| Fauna | – animals – both invertebrates and vertebrates |
| Fin fish | – a general term to distinguish 'fish' from 'shellfish' |
| Fines | – small particles such as sand and silt |
| Fisheries Associations | – associations that represent the interests of regional fisheries |
| Fisheries catch | – the weight (or value) of exploitable fish caught |
| Fisheries resources | – all aspects of the nature and abundance of exploitable fish and shellfish |
| Flatfish | – demersal fish such as plaice, sole and flounder |
| Flood dominance | – the flood tide is stronger than the ebb tide in moving sediments |
| Floodplain | – a strip of relatively flat and normally dry land alongside a stream, river, or lake that is covered by water during a flood |
| Food web | – a term used to describe the food relationships between members of a community |
| Frequency range (Hz) | – the wavelength of sound – measured in Hertz (Hz) |

G

| | |
|---------------------|--|
| Geodatabase | – A collection of geographic datasets for use by ArcGIS. There are various types of geographic datasets, including feature classes, attribute tables, raster datasets, network datasets, topologies, and many others |
| Geophysical anomaly | – an abrupt change in the geophysical features of the seabed, potentially associated with wrecks and archaeological sites |
| Geophysics | – the study of the physics of the earth. Geophysical survey techniques use physical properties themselves (e.g. magnetism) or apply properties to see how the earth affects them (e.g. radar), to determine something about the earth structure. |
| Glacial outwash | – deposits of material washed out from glaciers |



Glossary of terms

| | |
|--------------|--|
| Glaciation | – the presence of glaciers |
| Granulometry | – the particle size composition of deposits |
| Groynes | – breakwaters used to reduce the rate of transport of beach deposits |

H

| | |
|-------------------------------------|---|
| Habitat | – the summed physical and biological features of an area that distinguish it |
| Hamon grab | – a type of grab used for sampling of seabed deposits |
| Handaxe | – stone age tool |
| Haul-out site | – a site where seals come onto the shore or sandbanks |
| Heritage | – historic or cultural associations |
| Historic environment | – English Heritage understands that the historic environment is what generations of people have made of the places in which they live. It is all around us and we are all the trustees of the inheritance. The historic environment includes both the natural and human-made environments (often overlapping) and heritage above– and below-ground, as well as under the sea, that has cultural value and significance worthy of sustainable management and conservation |
| Historic Landscape Characterisation | – Historic Landscape Characterisation helps to manage change in the historic environment by tracing the imprint of history. Piecing together information from historical and modern maps, from aerial photos, and from the wealth of data that we already have about archaeology, buildings and their environment, it builds up area-based pictures of how places in town and country have developed over time. It shows how the past exists within today's world. (Source: http://www.english-heritage.org.uk/) |
| Holocene | – It is the present, the period of geological time since the last glaciation; the post–Pleistocene geological epoch of the Quaternary period beginning about 10,000 years ago; it is the recent or Post-glacial period |
| Hopper | – the main hold of the vessel into which the aggregate is loaded |
| Hydrodynamic processes | – processes associated with waves, tides and currents |
| Hydroids | – small plant-like colonies of polyps that live attached to stones and shells on the seabed |

I

| | |
|-------------------------|--|
| Infauna | – animals that live within the deposits on the seabed |
| <i>In situ</i> material | – material in an undisturbed condition on the seabed |
| Intensity of sound | – measured in decibels (Db) |
| Interglacial | – the warm periods between cold (glacial) interludes |
| 'Interim Procedures' | – temporary arrangements in place that control the approval and issue of licences for aggregate dredging |
| Intertidal mudflats | – areas of seabed that are alternately covered and uncovered by the tide and which comprise sands and muds |
| Intolerance | – a measure of the ability of an organism to tolerate environmental stress |
| Invertebrates | – animals without backbones – worms, molluscs etc. |

Iron Age – in Britain the period approximately between 700BC and the Roman conquest. Equated with the introduction of iron technology.

J

Joint Nature Conservation Committee (JNCC) – The Joint Nature Conservation Committee is the UK Government's wildlife adviser, undertaking national and international conservation work on behalf of the three country nature conservation agencies Natural England, Scottish Natural Heritage and the Countryside Council for Wales. www.jncc.gov.uk

Juveniles – the young post-larval stages of animals

K

Key faunal species – animal components considered to be of importance in defining the community

Knots – a speed of one nautical mile (nM) per hour

L

Landings data – reported fish landed at ports

Larvae – stages that hatch from eggs

Licence Area – area of seabed licenced by the Crown Estate for aggregate dredging

Littoral drift – the net movement of material along the shore under the influence of prevailing waves and currents

Loading time – the time taken for a dredger to load a cargo (approx 5-6h)

Lower Palaeolithic – early prehistoric period ('old stone age')

M

Macrofauna – larger animals generally defined as those retained on a 1mm mesh sieve

Magnetometer – also known as a fluxgate gradiometer. A remote sensing instrument capable of identifying sub-surface archaeological features by measuring the difference in their magnetic properties against the surrounding soils

Mammals – warm-blooded animals with hair eg., seals, whales, otters

Managed retreat – areas where the sea is allowed to inundate sites formerly protected by sea defences

Marine Aggregates – sand and gravel deposits on the seabed

Marine Protected Areas – areas designated under the 1998 OSPAR Annex V on the Protection & Conservation of the Ecosystems & Biodiversity of the Maritime Area

Maritime sites – sites of historic wrecks or maritime features of historic and archaeological interest

Mesolithic – It comprises the period between 10,000 to 5,000 years ago and it can be identified with the presence of anatomically modern humans (*Homo sapiens sapiens*)

Mineral Industry Sustainable Technology (MIST) – The Mineral Industry Sustainable Technology programme aims to deliver environmental benefit through development and demonstration of new technologies and approaches. It funds projects with money from the Aggregates Levy Sustainability Fund and is administrated by MIRO.

Mitigation – measures to reduce or eliminate impacts

Glossary of terms

| | |
|--------------------------|--|
| Mollusca | – a large group of animals including snails, bivalves and squid |
| Monitoring | – steps taken to measure process or impacts predicted in the Environmental Impact Assessment |
| Monitoring target | – the target against which the results of monitoring is to be assessed |
| Morphology of Plume | – the size and shape of a plume of sediment adjacent to an operating dredger |
| Multidimensional Scaling | – a method of ordination (MDS) that shows the similarity of groups of samples |
| Multiple Licence Areas | – groups of Licence Areas that are close to one another |
| Multi-variate analysis | – a statistical method to compare samples using many features in combination |

N

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| National Monuments Record (NMR) | – The NMR is the public archive of English Heritage. Over 10 million historic and aerial photographs, architectural and archaeological reports, plans and other items related to the historic environment of England are held in this archive. The NMR is also responsible for the development and management of the national historic environment databases of buildings and sites in England and its territorial waters (for further details see http://www.english-heritage.org.uk/server/show/conWebDoc.4609) |
| Natura 2000 | – a European network of SACs, SPAs and other protected sites |
| Nautical miles (Nm) | – a distance corresponding with 1 minute of arc on a meridian |
| Neap tide | – the minimum amplitude of the tide (each 14 days between the full and new moon) |
| Neolithic | – later stone age period ('new stone age') |
| Net transport | – the residual movement of sediment after its oscillatory movement on tidal currents, or under the influence of waves |
| Noise | – defined as unwanted sound and is usually measured in decibels (dB) |
| Nursery ground | – and area of importance for juvenile fish |

O

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| Occupancy | – the time spent in a particular area by a dredger |
| Office of the Deputy Prime Minister (ODPM) | – Office of the Deputy Prime Minister. This is the UK government office responsible for policy on housing, planning, devolution, regional and local government and the fire service. It also takes responsibility for the Social Exclusion Unit, the Neighbourhood Renewal Unit and the Government Offices for the Regions. It has now been renamed Communities and Local Government (CLG) |
| Opportunistic species | – small fast-growing organisms with a high rate of growth and reproduction ('r-strategists') that rapidly recolonise deposits |
| Optically Stimulated Luminescence (OSL) | – Method of luminescence dating in which the time-dependent energy stored in sediments or archaeological specimens is released by the application of laser light |
| OSPAR Convention | – the Oslo & Paris Convention controlling the discharge of material at sea and conservation of offshore marine resources |
| Overburden | – deposits (often sand) deposited on top of local sediments |
| Overfalls | – areas of rough water where eaves are generated by sudden changes in seabed topography, such as sandbanks and deeps. |

P

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| Palaeo-beach | – a beach laid down in prehistoric times |
| Palaeolithic | – The term Palaeolithic is used to describe the earliest period of tool making by humans. Humanly-flaked stones dating to more than two million years ago have been found in East Africa. The earliest known Palaeolithic sites in Britain are about half a million years old. The end of the Palaeolithic occurred when glacial ice finally retreated from Northern Europe (about 10,000 years ago) |
| Palaeo-topography | – topography of the land surface in prehistoric times |
| Palaeo-river valley | – a prehistoric river valley |
| Passive phase | – the period of dispersion and plume decay that occurs 2-3h after initial discharge |
| Pelagic fish | – fish that live in mid-water |
| Phocidae | – the family to which seals belong |
| Plankton | – animals and plants that drift in the water column |
| Plume | – the visible material settling to the seabed following discharge from a dredger |
| Plume morphology | – the shape and configuration of dispersing sediment plumes associated with dredging |
| Polychaeta | – a group of marine worms with numerous bristle-like chaetae |
| Population density | – the numbers of organisms in a community |
| Predation | – use of food species (prey) by predators such as fish and seals |
| Predation pressure | – the extent to which food resources are depleted by animals that prey on them |
| Prehistoric | – a catch-all term for the pre-Roman periods |
| Primary production | – fixing the energy of sunlight into carbon by plants |
| Production tonnage | – the mass of marine aggregate removed from the seabed |
| Production zones | – Company-specified dredging areas within the Licence Area |
| Productivity | – the yield per unit area. In the case of Fisheries this is often expressed as the value per km ² per year |

Q

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| Quantitative | – this refers to something that can be measured in a precise way to give a definite result. This contrasts with qualitative, which is usually a more subjective assessment of the amount of something |
| Quaternary | – The Quaternary is a subdivision of geological time (the Quaternary Period) which covers the last 2 million years up to the present day. The exact duration is a matter of debate with estimates of the onset of the Quaternary Period placed at between 1.8 million years and 2.6 million years by different authors. The Quaternary can be subdivided into two epochs: the Pleistocene (2 million years to 10,000 years ago) and the Holocene (10,000 years ago to the present day). The initial occupation and subsequent settlement of Britain and north-west Europe has taken place against the backdrop of the Quaternary period, characterised by the onset and recurrence of a series of glacial-interglacial cycles as well as the period during which much of hominid evolution took place |
| Quaternary deposits | – a geological term for deposits laid down in the Eocene, Oligocene, Miocene and Pleiocene periods |



Glossary of terms

R

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| Radiocarbon Dating | – Also called Carbon-14 dating, which is an absolute dating method based on the radioactive decay of Carbon-14 contained in organic materials. Carbon-14 dating is a method that measures the amount of radioactive carbon contained in a sample of organic material. All living organisms absorb a form of carbon dioxide that contains Carbon 14. When the organism dies, the radioactive carbon beams to change back to its original structure. Carbon-14 dating measures this rate of change |
| Recolonisation | – the re-establishment of marine communities by organisms |
| Recoverability | – an assessment of the ability of a community to recolonise |
| Reef assemblage | – a group of organisms that are interdependent and which are either attached to a rocky substrate or form one by accretion. |
| Regional transport pathway | – a pathway of regional significance in the movement of sediments |
| Rehabilitation | – the recovery and restoration of seabed sediments, topography and biological communities |
| Reject chute | – chutes attached to screening towers through which material rejected during the sorting process is returned to the seabed |
| Replacement tonnage | – aggregates that are intended to replace those dredged at another site |
| Risk assessment | – a process of assigning 'risk' to resources |
| Roman | – the period of Roman influence and occupation of Britain between AD43 and c.AD450. The term Romano-British is often employed in reference to the contemporary native population |
| Rough ground | – areas of seabed where there are boulders or biogenic reefs |
| Routeing pattern | – the distribution and frequency of use of shipping |
| Ross worm | – common name of <i>Sabellaria spinulosa</i> , a species that forms biogenic reefs by accretion that in turn support a range of dependent species |

S

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| Sand waves | – seabed 'sand dunes' that may be static or move under the influence of waves and tides |
| Saturated slurry | – the mix of aggregate and water that is pumped from the seabed to the screening towers |
| 'Scoping' Document | – survey of issues of legitimate concern to be taken into account in the Environmental Impact Assessment |
| Screening | – adjustment of gravel content with mesh screens |
| Screening towers | – on-board towers that house the screening and reject chutes |
| Seabirds | – birds that spend a significant proportion of their time at sea |
| Sediment processes | – processes that affect the movement of sediments |
| Sediment sink | – a site where there is a net accumulation of sediment |
| Sediment transport | – movement of sediment in the water column or on seabed |
| Seismic data | – data derived from seismic surveys of the seabed |
| Sensitivity | – a measure of response of organisms and habitats to impacts based on the intolerance and recoverability. |

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| Serpulid worms | – worms that live in a calcareous tube attached to stones and shells |
| Shellfish | – a general term to include molluscs (whelks, scallops, mussels, cockles etc) and crustaceans (crab, lobster, shrimps) |
| Side scan sonar | – a remote-sensing method of identifying seabed features |
| Significance of Impact | – assessment of risk based on the scale and duration of environmental impacts |
| Similarity analysis | – analysis of the similarity of samples |
| Site-specific issues | – issues that relate to a particular licence application Area |
| Spatial variability | – variations in space |
| Spawning habitat | – areas or communities selected for release of eggs |
| SACs | – Special Areas of Conservation (Habitats Directive) |
| SPAs | – Special Protection Areas (Habitats Directive) |
| Spillways | – openings through which displaced seawater is discharged when the hopper is almost full |
| Spring tide | – the maximum amplitude of the tide each 14 days (corresponding with the new and full moon) |
| Static dredger | – dredging by a stationary vessel |
| Static gear | – fishing gear deployed at fixed sites on the seabed eg., trammel nets and pots |
| Storm surge | – a major rise in sea level above the predicted range due to episodic events such as low pressure and high winds |
| Strategic Environmental Assessment (SEA) | – Strategic Environmental Assessment assesses the environmental impact of plans and programmes prepared by public bodies. |
| Substrate | – the type of material on the seabed |
| Sustainable Development | – a key objective of sustainable development is the need to secure an adequate supply of minerals to meet economic needs, whilst minimising the potential adverse effects of mineral extraction on the environment. |
| Sustainability Plan | – a corporate plan designed to maximise efficient use of seabed resources, minimise waste and environmental impacts, and to maximise recovery of seabed resources |

T

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| Taxon/taxa | – a distinct category of organism such as species, genus or family |
| Temporal variability | – variations with time |
| Terms of Reference | – the range of issues addressed in the Environmental Statement |
| Tidal range | – the amplitude of the tides in a particular area |
| Tidal stream atlas | – a chart of an area showing the strength of tidal currents at different stages of the tide. |
| Tidal streamlines | – movement of sediments on tidal currents |
| Trailer dredging | – dredging underway. The draghead is trailed along the seabed |
| Trammel netting | – static nets placed on the seabed |
| Transgression | – warmer periods when the sea level rose and covered parts of the land |
| Trawl | – a method of fishing using a towed net (trawl) |

Glossary of terms

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| Trawlers | – vessels engaged mainly in fishing by trawl (beam or otter trawl) |
| Trophic level | – a step in the food web from one level to another |
| Trophic models | – estimates of the flow of material (or energy) from one level in the food web to another |
| Turbidity | – reduction in light penetration due to suspended solids |

V

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| Vertebrates | – animals with backbones – fish, birds and mammals |
| Vibrocore | – a core sample taken of seabed sediments with a long tube attached to a vibrating motor – generally used for seabed sampling at depth for sediment analysis |

W

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| Wave refraction | – modification of the angle of waves by seabed features |
| Wave rose | – a method of showing the size and direction of waves based on the frequency of occurrence in different quadrants of the compass. |
| Winnowing | – removal of fine material from coarse ones by winds or currents |
| Worked-out Area | – a Licence Area from which economic aggregate resources have been dredged. |

Z

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| Zoning | – sub-areas within the Licence Area that are worked to minimise area of the seabed that is worked at any one time |
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Appendices

Table 1: Table summarising the complete list of marine projects funded through the ALSF since 2002

| TABLE 1A: DELIVERY PARTNER: NATURAL ENGLAND | | | |
|--|---|--|-------------------|
| Code | Title | Contractor | Amount |
| | Marine Aggregates and Biodiversity in both 2 and 3 dimensional Context | EMU Ltd | £224,013 |
| | Conservation of Marine Sand and Gravel Biotopes in South East England | Hampshire & Isle of Wight Wildlife Trust | £173,190 |
| | South Coast Skates & Rays: Assessing the Impact of Aggregates Extraction | The Shark Trust | £13,240 |
| 2005/500 | Marine Biodiversity and Aggregate Dredging in both 2 and 3 dimensional Context | EMU Ltd | £112,878 |
| MAL0002 | Sand Banks and Offshore River Channels: Examples of Geodiversity for Aggregate Industry Sites | Dr Chris Evans | £23,020 |
| MAL0004 | Use of Shell to Speed Recovery of Dredged Aggregate Sites | University of Southampton | £48,450 |
| MAL0007 | Marine Wealth-Seabed Health (atExplorOcean) | Marine Biological Association | £137,725 |
| MAL0008 | Best Methods for Identifying and Evaluating Biogenic and Cobble Reef | Joint Nature Conservation Committee (JNCC) | £318,696 |
| MAL0012 | Development of a Multi-use Marine Reserve - The Overfalls Area | University of Portsmouth | £57,936 |
| MAL0020 | The Seabed & Inshore Fishing Activities: Assessment & Relationship | Sussex Sea Fisheries Committee | £57,850 |
| MAL0018 | Marine Aggregates & Biodiversity: Stakeholder Engagement in the South East | Hampshire & Isle of Wight Wildlife Trust | £154,337 |
| MAL0022 | An Environmental Context to Effects of Marine Aggregate Dredging | Marine Biological Association | £108,759 |
| MAL 0024 | Underwater Safari | Medina Valley Centre for Outdoor Education | £13,466 |
| MAL 0026 | Marine Aggregates: Science, Industry, Stewardship and People Network | National Museum of Wales | £20,000 |
| MAL 0027 | Recoverability of Sabellaria spinulosa following marine aggregate extraction | Marine Ecological Surveys Ltd | £62,000 |
| TOTAL | | | £1,525,560 |

Appendices

TABLE 1B: DELIVERY PARTNER: CENTRE FOR THE ENVIRONMENT, FISHERIES & AQUACULTURE SCIENCE (CEFAS)

| Code | Title | Contractor | Amount |
|--------------|--|---|-------------------|
| MEPF 04/00 | Assessment of the Rehabilitation of the Seabed following Marine Aggregate Dredging | Centre for Environment Fisheries & Aquaculture Science (CEFAS) | £202,700 |
| MEPF 04/01 | Eastern English Channel Large-Scale Seabed Habitat Map | British Geological Survey (BGS) | £1,052,694 |
| MEPF 04/02 | Predictive Framework for Assessment of Recoverability of Marine Benthic Communities following Cessation of Aggregate Dredging | Marine Ecological Surveys Ltd (MESL) | £416,152 |
| MEPF 04/03 | Marine Aggregate Extraction Risk Assessment Framework | HR Wallingford | £180,000 |
| MEPF 04/04 | Coupling Physical and Ecological Models: A New Approach to Predicting the Impacts of Aggregate Extraction on Biological Recoverability | Associated British Ports Marine Environmental Research (ABPmer) | £200,000 |
| MEPF 04/05 | Marine ALSF Science Co-ordinator | Marine Ecological Surveys Ltd | £150,000 |
| MEPF 04/06 | Marine ALSF Annual Conference 2005 | Coastal Management for Sustainability (CMS) | £13,000 |
| MEPF 04/07 | Marine ALSF Offshore Geographical Information System | ABPmer | £165,633 |
| MEPF 05/01 | Marine ALSF Conference 2006 | CMS | £43,400 |
| TOTAL | | | £2,423,579 |

TABLE 1C: DELIVERY PARTNER: MINERALS INDUSTRY RESEARCH ORGANISATION (MIRO) ON BEHALF OF THE DCLG

| Code | Title | Contractor | Amount |
|-----------------|---|--------------------------------|-------------------|
| SAMP 1.001 | Seabed Characterisation and the Effects of Soil Structure on Benthic Recolonisation | Andrews Survey | £185,000 |
| SAMP 1.022 | Impacts of Overboard Screening on Seabed and Associated Benthic Biological Community Structure in Relation to Marine Aggregate Extraction | Marine Ecological Surveys Ltd | £393,420 |
| SAMP 1.031 | Best Practice Guide to Assessing the Impacts of Aggregate Dredging | Posford Haskoning Ltd | £156,830 |
| SAMP 1.042 | Seabed Prehistory: Gauging the Effects of Marine Aggregate Dredging | Wessex Archaeology | £219,480 |
| SAMP 1.044 | Outer Bristol Channel Marine Habitat Study (Round 1) | British Geological Survey | £201,814 |
| MIST MA/3/1/003 | Towards Establishing a Tool to Provide Baseline Data on Fisheries within Sussex Sea Fisheries District | Sussex Sea Fisheries Committee | £6,991 |
| MIST MA/3/1/005 | Towards Developing Best Practice for Sussex Sea Fisheries in the Acquisition of Data for Marine Resource Management | Sussex Sea Fisheries Committee | £3,981 |
| SAMP 2.06 | Outer Bristol Channel Marine Habitat Study: Geographical and Video Surveys | British Geological Survey | £78,864 |
| SAMP 2.24 | Dredging Lane Management – CFD Simulations | CEFAS | £96,054 |
| SAMP 2.25 | Building GIS and Environmental Data Management Capability of the Sea Fisheries Committees | CEFAS | £35,366 |
| SAMP 2.43 | Seabed Prehistory 2: Archaeology and Marine Aggregates in the North Sea and English Channel | Wessex Archaeology | £482,517 |
| SAMP 3.1.07 | Development of an Open Access Website to Collate and Disseminate Information on Environmental Good Practice for Marine Aggregate Dredging | Leeds University | £142,469 |
| SAMP 3.1.08 | Direct Measurements of Seabed Stability at a Marine Aggregate Site using Benthic Flume Technology | Partrac Ltd | £118,125 |
| TOTAL | | | £2,120,911 |

Appendices

| TABLE 1D: DELIVERY PARTNER ENGLISH HERITAGE | | | |
|--|--|--|---------------|
| Code | Title | Contractor | Amount |
| | Greater Thames Survey of Mineral Extraction Sites | Essex County Council | £115,012 |
| | Multi-beam Sonar on Wrecks | Wessex Archaeology | £11,012 |
| | Submerged Palaeo-Arun and Solent Rivers: Reconstruction of Prehistoric Landscapes Pt 1 & 2 | Imperial College London | £121,629 |
| | Palaeolithic Archaeology of the Sussex/ Hampshire Coastal Corridor | University of Wales Lampeter | £94,525 |
| | Wrecks on the Seabed: Assessment Evaluation and Recording | Wessex Archaeology | £92,090 |
| | England's Shipping | Wessex Archaeology | £31,710 |
| | Artefacts from the Sea | Wessex Archaeology | £32,897 |
| | High Resolution Sonar for the Archaeological Investigation of Marine Aggregate Deposits | Southampton University | £20,000 |
| | A Re-assessment of the Archaeological Potential of Continental shelves | Southampton University | £21,156 |
| | A Re-assessment of the Archaeological Potential of Continental shelves | Southampton University | £14,300 |
| | Beach Replenishment and Derived Archaeological Material | Museum of London Archaeology Service | £20,000 |
| | Solent Aggregates to Outreach | Hampshire & Wight Trust for Maritime Archaeology | £50,000 |
| | Enhancing Our Understanding: Navigational Hazards | Bournemouth University | £100,000 |
| | Modelling Exclusion Zones for Marine Aggregate Dredging | University of Southampton | £234,000 |
| | Modelling Exclusion Zones for Marine Aggregate Dredging (Variation Grant) | University of Southampton | £85,100 |
| | Marine Historic Landscape Characterisation (HLC) Pilot: Liverpool Bay | Wessex Archaeology | £144,000 |
| | Marine Historic Landscape Characterisation (HLC) Pilot: Solent & Isle of Wight | Hampshire & Wight Trust for Maritime Archaeology | £67,400 |
| | Marine Historic Landscape Characterisation (HLC) Pilot: Scarborough to Hartlepool | Cornwall County Council | £74,500 |
| | Marine Historic Landscape Characterisation (HLC) Pilot: Southwold to Clacton | Oxford Archaeology | £69,400 |
| | Marine Historic Landscape Characterisation (HLC): Pilot: Withernsea to Skegness | Museum of London Archaeological Service | £69,400 |
| | Severn Maritime Assessment | Museum of London Archaeology Service | £25,000 |
| | Seabed Prehistory Round 2 | Wessex Archaeology | £299,000 |

Continued

TABLE 1D: DELIVERY PARTNER ENGLISH HERITAGE (continued)

| Code | Title | Contractor | Amount |
|--------------|--|--|-------------------|
| | Wrecks on the Seabed (Round 2) Happisburgh (Variation) | Wessex Archaeology | £37,800 |
| | Wrecks on the Seabed Round 2 | Wessex Archaeology | £557,000 |
| | Innovative Approaches to Rapid Archaeological Site Surveying & Evaluation in the Maritime Environment Transition Zones | University of St Andrews | £204,000 |
| | Innovative Approaches to Rapid Archaeological Site Surveying & Evaluation in the Maritime Environment Transition Zones (Variation Grant) | University of St Andrews | £13,700 |
| | On the Importance of Shipwrecks | Wessex Archaeology | £30,000 |
| | Enhancing our Understanding: Shipwreck Importance | Bournemouth University | £100,000 |
| | 3D Seismics as a Source for Mitigation Mapping of the late Pleistocene and Holocene Depositional Systems and Palaeogeography of the Southern North Sea | University of Birmingham | £176,532 |
| | 3D Seismics as a Source for Mitigation Mapping of the late Pleistocene and Holocene Depositional Systems and Palaeogeography of the Southern North Sea (Variation Grant) | University of Birmingham | £35,300 |
| | Archaeology Within Marine Aggregate Environmental Statements | Hampshire & Wight Trust for Maritime Archaeology | £16,300 |
| TOTAL | | | £2,962,763 |

TABLE 1E: DELIVERY PARTNER: ENGLISH HERITAGE AND BRITISH MARINE AGGREGATES PRODUCERS ASSOCIATION (BMAPA)

| Code | Title | Contractor | Amount |
|--------------|---|--------------------|----------------|
| BMAPA/EH | Protocol for Reporting Finds of Archaeological Significance | Wessex Archaeology | £8,500 |
| BMAPA/EH | Protocol Awareness Programme | Wessex Archaeology | £54,000 |
| TOTAL | | | £62,500 |

Total from all Delivery Partners**£9,095,313**

Summary of non-ALSF investment in aggregate research

The ALSF has provided a major source of research funding for marine aggregate research in recent years. However significant funding has also been directed towards dredging-related research through the Living Land & Seas Directorate of the Department for Environment, Food & Rural Affairs (Defra) Marine Environment Division. Many additional projects have an indirect relevance to the management of dredging activities in UK coastal waters. A summary of projects that have a direct or indirect bearing on dredging activities that have been funded through the Defra Marine Environment Division Research & Development (R&D) programme since 1997 is given in Appendix Tables 2a & 2b.

This shows that over the past 10 years, approximately £8.5 million has been spent through Defra R&D funding on projects that are directly related to marine aggregate dredging, and a further sum of at least £5.4 million on projects that are indirectly related to aggregate dredging issues. That is, a considerable sum of around £14m has been spent on dredging-related research from Government sources over and above the £9 million allocated from the ALSF. Of this, £11.4 million was in support of projects carried out by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS), with smaller sums to other organisations including over £600,000 to the Marine Biological Association and around £530,000 to HR Wallingford.

It is of some interest that in the 5 years from 1997 prior to initiation of the ALSF, a sum of about £.8 million was spent through Defra R&D funds on projects directly related to marine aggregate dredging. In the period from 2002-2007, this was reduced to £2 million; that is, the main focus of aggregate-related research switched in 2002 from Defra R&D expenditure to the ALSF.

Our best estimate of the total sum available to support marine aggregate research in the UK from both Defra R&D sources and through the ALSF in the period 2002-2007 is therefore a relatively large sum of at least £11.1 million or about £2.2m per year over the past 5 years.

Appendices

Table 2a: Table summarising the Defra R&D Expenditure on projects directly related to marine aggregates since 1997

| PROJECTS DIRECTLY RELATED TO MARINE AGGREGATES | | | | | |
|--|------------|------------|------------|--|----------------------------|
| Project Code | Start Date | End Date | Cost | Title | Contractor |
| AE0261 | 04.01.2002 | 04.01.2006 | £523,263 | Development of Indicators of environmental quality relating to dredging and disposal in the marine environment | CEFAS |
| ME1105 | 30.09.2005 | 29.11.2005 | £17,000 | Preparation of Regulatory Impact Assessment (RIA) on proposals for the reform of the marine and coastal development control system | Risk & Policy analysts Ltd |
| ME1102 | 01.04.2006 | 30.03.2009 | £500,000 | Broadscale mapping of hard substrates in the central English Channel: providing an evidence base to support regional management of aggregate resources and the designation of SACs relating to Annex 1 reef habitats | CEFAS |
| AE0908 | 01.04.1998 | 01.04.2001 | £1,407,850 | Mapping of Gravel Biotopes and an Examination of the Factors Controlling the Distribution, Type and Diversity of their Biological Communities | CEFAS |
| AE0904 | 01.08.1997 | 31.03.2001 | £500,000 | Beneficial uses of dredged material | CEFAS |
| AE0911 | 01.04.1999 | 31.10.1999 | £5,875 | Scoping the assessment of sediment plumes arising from dredging | CEFAS |
| ME1203 | 12.03.2007 | 31.03.2008 | £15,000 | Designing a generic approach to regional environmental assessments (REAs) for the marine aggregate Industry | HR Wallingford |
| AE0916 | 01.04.2003 | 01.04.2008 | £1,303,523 | A Strategic Evaluation of the impacts of marine aggregate extraction on marine fauna | CEFAS |
| AE0253 | 01.04.2000 | 31.03.2002 | £80,181 | A Procedure to assess the effects of dredging on commercial fisheries | CEFAS |
| ME1202 | 04.01.2000 | 04.03.2004 | £80,000 | Assessment of the rehabilitation of the seabed following Marine Aggregates Dredging | CEFAS |
| AE0903 | 01.01.1998 | 01.01.2002 | £674,628 | Cumulative Environmental Impacts of Marine Aggregate Extraction | CEFAS |
| AE0910 | 01.04.1998 | 01.04.2002 | £699,885 | A Computer Modelling Tool for Predicting the Dispersion of Sediment Plumes from Aggregate Dredging Activities | CEFAS |
| AE0914 | 01.04.2000 | 01.04.2003 | £50,955 | Preliminary Investigation of the Sensitivity of Fish to Sound Generated by Aggregate Dredging and Marine Construction | CEFAS |
| AE0915 | 01.04.2000 | 01.04.2004 | £527,087 | Rehabilitation of the seabed following marine aggregate extraction | CEFAS |
| AE1224 | 01.04.2001 | 01.04.2005 | £961,554 | The Ecosystem consequences of seabed disturbance | CEFAS |

Continued

Appendices

| PROJECTS DIRECTLY RELATED TO MARINE AGGREGATES (continued) | | | | | |
|--|------------|-------------------|----------|--|------------|
| Project Code | Start Date | End Date | Cost | Title | Contractor |
| AE1033 | 01.04.2001 | 01.04.2005 | £976,391 | The role of seabed mapping techniques in environmental monitoring | CEFAS |
| ME4116 | 18.11.2005 | 31.03.2006 | £175,402 | Seabed Mapping in the Eastern English Channel - Optimising conditions to meet disparate policy needs | CEFAS |
| Total | | £8,498,594 | | | |

Table 2b: Table summarising the Defra R&D Expenditure on projects indirectly related to marine aggregates since 1997*

| PROJECTS INDIRECTLY RELATED TO MARINE AGGREGATES | | | | | |
|--|------------|------------|------------|--|----------------------------|
| Project Code | Start Date | End Date | Cost | Title | Contractor |
| ME1407 | 01.12.2004 | 30.11.2005 | £207,000 | A Pilot Study on Marine Spatial Planning | ABPmer |
| ME1414 | 31.10.2006 | 31.03.2007 | £13,000 | Implementation of EIA and Habitats Directive requirements for licencing marine works | Risk & Policy analysts Ltd |
| ME1415 | 17.07.2006 | 30.11.2006 | £139,000 | Determining the Costs and benefits of current and potential new marine arrangements | Risk & Policy analysts Ltd |
| AE1148 | 01.09.2003 | 01.03.2010 | £1,528,859 | Integrated Science for Integrated Management - Developing the capacity for Adaptive Ecosystem Management | CEFAS |
| ME1103 | 18.01.2005 | 31.01.2006 | £123,000 | Investigation of the potential range of socio-economic impacts on the fishing industry from offshore developments | CEFAS |
| AE0262 | 01.01.2003 | 30.11.2005 | £84,245 | Development of generic guidance for sediment transport monitoring programmes in response to construction of offshore windfarms | CEFAS |
| AE0257 | 01.04.2000 | 30.09.2005 | £368,096 | Background levels and the anthropogenic component of naturally occurring elements in marine sediments subject to dredging | CEFAS |
| AE0260 | 01.12.2002 | 01.12.2006 | £531,379 | Large scale use of muddy dredged material for sustainable flood defence and habitat management | HR Wallingford |

Continued

* This list contains projects considered to be relevant to marine aggregate dredging, but many other projects loosely connected with dredging have been funded through Defra R&D

PROJECTS INDIRECTLY RELATED TO MARINE AGGREGATES

| Project Code | Start Date | End Date | Cost | Title | Contractor |
|--------------|------------|-------------------|----------|--|---------------------|
| ME4108 | 19.09.2003 | 19.11.2004 | £63,800 | State of the Seas Assessment - 2: Marine Nature Conservation & Biodiversity Input | JNCC |
| ME4111 | 01.04.2004 | 01.10.2004 | £35,000 | State of the Seas Assessment - 3: Marine Nature Conservation & Biodiversity Input | JEP |
| ME4112 | 01.04.2004 | 01.04.2006 | £50,000 | Support for the National Marine Monitoring Programme Database | Environment Agency |
| AE1041 | 01.07.2003 | 01.07.2008 | £393,283 | Marine and Coastal Data Network | CEFAS |
| ME3102 | 15.09.2000 | 04.03.2004 | £184,000 | Rapid Assessment of Marine Biodiversity (RAMBLERS) | Plymouth Marine Lab |
| ME3105 | 01.03.2002 | 30.06.2005 | £270,000 | Marine Environmental Change Network | MBA |
| ME3109 | 01.10.2004 | 30.09.2009 | £334,000 | AMBLE (Assessment of Marine Biodiversity Linked to Ecosystems) | Plymouth Marine Lab |
| ME3111 | 01.10.2005 | 31.03.2010 | £242,000 | DASSH - Data Archive for Seabed Species and Habitats | MBA |
| ME3112 | 01.07.2005 | 31.03.2009 | £423,000 | Benthic state and change in UK marine waters, Phase II: The English Channel and Celtic Sea | CEFAS |
| ME3115 | 01.07.2005 | 31.03.2007 | £184,000 | Marine Environmental Change Network (ME3105 cont.) | MBA |
| ME3107 | 05.11.2001 | 01.11.2004 | £250,000 | MarLIN | MBA |
| Total | | £5,423,662 | | | |

Details of projects funded under the Marine ALSF 2002 – 2007

ALSF delivery partner – Natural England

The following projects were funded through the ALSF Partnership Grants Scheme of Natural England. The ALSF Marine grants scheme was initiated by Natural England in April 2004, providing grants specifically for projects addressing the impacts of aggregate extraction in the marine environment.

Details of the ALSF Partnership Grant Scheme can be obtained from:

<http://www.english-nature.org.uk/about/alsf.htm> or by e-mail to alsfgrants@naturalengland.org.uk

MARINE AGGREGATES AND BIODIVERSITY IN BOTH A 2 AND 3 DIMENSIONAL CONTEXT

Contractor: EMU Ltd

Grant: £224,013

Timescale: MALSF Round 2, completed March 2005

Contact: Dr. Nigel Thomas, EMU Ltd, 1, Mill Court, The Sawmills, Durley, Hampshire, SO32 2EJ

Tel: 01489 860070

E-mail: Nigel.Thomas@emulimited.com

<http://www.emulimited.com/>

Additional project information is available at:

<http://www.biodiversityingravels.org.uk/>

The full report is available upon request to EMU Ltd

CONSERVATION OF MARINE SAND AND GRAVEL BIOTOPES IN SOUTH EAST ENGLAND

Contractor: Hampshire and Isle of Wight Wildlife Trust

Grant: £173,190

Timescale: MALSF Round 2, completed March 2005

Contact: Lisa Browning, The Wildlife Trusts, The Kiln, Mather Road, Newark, NG24 1WT

Tel: 01489 774436

E-mail: lbrowning@wildlifetrusts.org

<http://www.hwt.org.uk/>

Additional project information is available at:

<http://www.southeastmarine.org.uk/frameset2.htm>

SOUTH COAST SKATES AND RAYS: ASSESSING THE IMPACT OF AGGREGATES EXTRACTION

Contractor: The Shark Trust

Grant: £13,240

Timescale: MALSF Round 2, completed March 2005

Contact: Ms Ali Hood, The Shark Trust, National Marine Aquarium, Rope Walk, Coxside, Plymouth, PL4 0LF

Tel: 01752 672008

www.sharktrust.org

Additional project information is available at:

http://www.sharktrust.org/view_folder.asp?folderid=6197&depth=2&rootid=6160&level2id=6197&level1=&level2=6197&toptab=2

2005/500: MARINE BIODIVERSITY AND AGGREGATE DREDGING IN BOTH A 2 AND 3 DIMENSIONAL CONTEXT

Contractor: EMU Ltd

Grant: £112,878

Timescale: MALSF Round 2, July 2005 – March 2006

Contact: Dr. Nigel Thomas, EMU Ltd, 1, Mill Court, The Sawmills, Durley, Hampshire, SO32 2EJ

Tel: 01489 860070

E-mail: Nigel.Thomas@emulimited.com

<http://www.emulimited.com/>

Additional project information is available at:

<http://www.biodiversityingravels.org.uk/>

The full report is available upon request to EMU Ltd

MAL0002: SAND BANKS AND OFFSHORE RIVER CHANNELS: EXAMPLES OF GEODIVERSITY FROM AGGREGATE INDUSTRY SITES

Contractor: Christopher Davis Rhys Evans

Grant: £23,020

Timescale: MALSF Round 2, June 2005 – March 2006

Contact: Christopher David Rhys Evans, Independent consultant, Bryneos, Llangoedmor, Cardigan, Ceredigion, SA43 2LB

E-mail: bryneos@btinternet.com

A final report was issued in March 2006, Details can be obtained from:

alsfgrants@naturalengland.org.uk

MAL0004: USE OF SHELL TO SPEED RECOVERY OF DREDGED AGGREGATE SEABED

Contractor: University of Southampton

Grant: £48,450

Timescale: MALSF Round 2, July 2005 – March 2006

Contact: Dr Ken Collins, School of Ocean and Earth Science, University of Southampton, National Oceanography Centre, Southampton, SO14 3ZH

Tel: 02380 596010

E-mail: k.j.Collins@soton.ac.uk

A final report was issued in March 2007, Details can be obtained from:

alsfgrants@naturalengland.org.uk

MAL0007: MARINE WEALTH – SEABED HEALTH (AT EXPLOROCEAN)

Contractor: Marine Biological Association

Grant: £137,725

Timescale: MALSf Round 2, April 2005 – March 2007

Contact: Jack Sewell, Mineral Wealth Seabed Health Project Coordinator, The Marine Biological Association, The Laboratory, Citadel Hill, Plymouth, Devon, PL1 2PB
Tel: 01752 633336

E-mail: jase@mba.ac.uk

Additional project information is available at:
<http://www.mineralwealth-seabedhealth.org/>

MAL0008: BEST METHODS FOR IDENTIFYING AND EVALUATING BIOGENIC AND COBBLEY REEF

Contractor: Joint Nature Conservation Committee

Grant: £318,696

Timescale: MALSf Round 2, May 2005 – March 2007

Contact: David Limpenny, CEFAS Burnham Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA

Tel: 01621 787240

E-mail: david.limpenny@cefas.co.uk

Additional project information and a final report are available at:
<http://www.jncc.gov.uk>

MAL0012: DEVELOPMENT OF A MULTI-USE MARINE RESERVE: THE OVERFALLS AREA

Contractor: University of Portsmouth Higher Education Corporation

Grant: £57,936

Timescale: MALSf Round 2, April 2005 – March 2006

Contact: Diana Tingley, CEMARE, University of Portsmouth, Burnaby Terrace, 1-8 Burnaby Road, Portsmouth, PO1 3AE

Tel: 02392 844283

E-mail: Diana.tingley@port.ac.uk

Additional project information and a final report are available at:
<http://www.port.ac.uk/special/theoverfalls/?sfgdata=4>

MAL0020: THE SEABED AND INSHORE FISHING ACTIVITIES: ASSESSMENT AND RELATIONSHIP

Contractor: Sussex Sea Fisheries District Committee

Grant: £57,850

Timescale: MALSf Round 2, August 2005 – March 2007

Contact: Tim Dapling, Sussex Sea Fisheries Committee, Unit 6, Highdown House, Shoreham Airport, Shoreham-by-Sea, West Sussex, BN43 5PB

Tel: 01273 454407

E-mail: dapling@sussex-sfc.gov.uk

Additional project information and a final report are available at:
<http://www.sussex-sfc.gov.uk/malsf.htm>

MAL0018: MARINE AGGREGATES AND BIODIVERSITY: STAKEHOLDER ENGAGEMENT IN THE SOUTH-EAST

Contractor: Hampshire and Isle of Wight Wildlife Trust

Grant: £154,337

Timescale: MALSf Round 2, August 2005 – March 2007

Contact: Lisa Browning, The Wildlife Trusts, The Kiln, Mather Road, Newark, NG24 1WT

Tel: 01489 774436

E-mail: lbrowning@wildlifetrusts.org

<http://www.hwt.org.uk/>

Additional project information and a final report are available at:
<http://www.southeastmarine.org.uk/frameset2.htm>

MAL0022: AN ENVIRONMENTAL CONTEXT TO THE EFFECTS OF MARINE AGGREGATE DREDGING

Contractor: Marine Biological Association

Grant: £108,759

Timescale: MALSf Round 2, August 2005 – March 2007

Contact: Dr Stuart Jenkins, School of Ocean Sciences, Westbury Mount, University of Wales, Bangor, Menai Bridge, Anglesey, LL59 5AB

Tel: 01248 382896

E-mail: s.jenkins@bangor.ac.uk

Additional project information and a final report are available at:
<http://www.mba.ac.uk/ALSf/>

MAL0024: UNDERWATER SAFARI

Contractor: Medina Valley Centre for Outdoor Education

Grant: £13,466

Timescale: MALSf Round 2, February 2005 - March 2006

Contact: Dr Roger Herbert, Medina Valley Centre for Outdoor Education, Dodnor Lane, Newport, Isle of Wight, PO30 5TE

Tel: 01983 522195

E-mail: roger@medinavalleycentre.org.uk

ALSF delivery partner – Natural England

MAL0026: MARINE AGGREGATES: SCIENCE, INDUSTRY, STEWARDSHIP AND PEOPLE NETWORK

Contractor: The National Museum Wales

Grant: £20,000 (33.55% of the project total)

Timescale: MALSF Round 2, July 2006 - March 2007

Contact: Dr Andrew Mackie. The National Museum Wales, National Museum Cardiff, Cathays Park, Cardiff, CF10 3NP

Tel: 02920 397951

E-mail: andrew.mackie@museumwales.ac.uk

MAL0027: RECOVERABILITY OF *SABELLARIA SPINULOSA* FOLLOWING MARINE AGGREGATE EXTRACTION

Contractor: Marine Ecological Surveys Ltd

Grant: £62,000 (14% of the project total, additional funds were from the Crown Estate & BMAPA)

Timescale: MALSF Round 2, Jul 2006 - March 2007

Contact: Miss Bryony Pearce, Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY

Tel: 01225 442211

E-mail: bryony@seasurvey.co.uk

Additional project information and a final report are available at:

<http://www.seasurvey.co.uk/>

ALSF delivery partner – Cefas

The following projects were funded through the Marine Environmental Protection Fund (MEPF) administered by Cefas. The MEPF was initiated in 2004, providing grants specifically for projects addressing the second theme of the ALSF:

Promoting environmentally friendly aggregates extraction in the marine environment.

Details of the MEPF grants scheme, and additional project specific information including final reports can be obtained from:

<http://www.alsf-mepf.org.uk/>

MEPF 04/00: ASSESSMENT OF THE REHABILITATION OF THE SEABED FOLLOWING MARINE AGGREGATE DREDGING

Contractor: Cefas

Grant: £202,700

Timescale: MALSF Round 2, completed March 2005

Contact: Keith Cooper, Cefas Burnham Laboratory, Remembrance Avenue, Burnham-on-Crouch, Essex, CM0 8HA

Tel: 01621 787238 Fax: 01621 784989

E-mail: keith.cooper@cefass.co.uk

Reference: Cooper, K.M., Eggleton, J.D., Vize, K., Vanstaen, K., Boyd, S.E., Ware, S., Morris, C.D., Curtis, M., Limpenny, D.S. & Meadows, W.J. 2005. Assessment of the re-habilitation of the seabed following marine aggregate dredging – part II. Sci. Ser. Tech. Rep., CEFAS Lowestoft, 130: 81pp.

Additional project information and a final report are available at:

http://www.alsf-mepf.org.uk/projects/projects_db.asp

MEPF 04/01: THE EASTERN ENGLISH CHANNEL LARGE-SCALE SEABED HABITAT MAP

Contractor: British Geological Survey

Grant: £ 1,052,694

Timescale: MALSF Round 2, 2004 - 2007

Contact: Ceri James, British Geological Survey, Kingsley Dunham Centre, Nicker Hill, Keyworth, Nottingham, NG12 5GG

Tel: 01159 363467

E-mail: jwjcj@bgs.ac.uk

Additional project information and a final report are available at:

http://www.alsf-mepf.org.uk/projects/projects_db.asp

<http://www.bgs.ac.uk/eecmhm>

MEPF 04/02: A PREDICTIVE FRAMEWORK FOR THE ASSESSMENT OF RECOVERABILITY OF MARINE BENTHIC COMMUNITIES FOLLOWING CESSATION OF AGGREGATE DREDGING

Contractor: Marine Ecological Surveys Limited

Grant: £416,152

Timescale: MALSF Round 2, 2004 - 2007

Contact: Dr Richard Newell, Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY

Tel: 01225 442211

E-mail: Richard@seasurvey.co.uk

Additional project information and a final report are available at:

http://www.alsf-mepf.org.uk/projects/projects_db.asp?fset=0

<http://www.seasurvey.co.uk>

MEPF 04/03: MARINE AGGREGATE EXTRACTION RISK ASSESSMENT FRAMEWORK (MARA)

Contractor: HR Wallingford Ltd

Grant: £180,000

Timescale: MALSF Round 2, 2004 - 2007

Contact: Paul Sayers, Group Manager, HR Wallingford Ltd, Howbery Park, Wallingford, OX10 8BA

Tel: 01491 822344 Fax: 01491 835311

E-mail: pbs@hrwallingford.co.uk

Additional project information and a final report are available at:

http://www.alsf-mepf.org.uk/projects/projects_db.asp?fset=10

http://www.mara-framework.org.uk/Home_Page.htm

MEPF 04/04: COUPLING PHYSICAL AND ECOLOGICAL MODELS: A NEW APPROACH TO PREDICTING THE IMPACTS OF AGGREGATE EXTRACTION ON BIOLOGICAL RECOVERABILITY

Contractor: ABP Marine Environmental Research Ltd

Grant: £200,000

Timescale: MALSF Round 2, 2004 - 2007

Contact: Natalie Frost, ABP Marine Environmental Research, Suite B, Waterside House, Town Quay, Southampton, Hampshire, SO14 2AQ

Tel: 02380 338100 Fax: 02380 338040

E-mail: nfrost@abpmer.co.uk

Additional project information and a final report are available at:

<http://www.abpmer.co.uk/>

http://www.alsf-mepf.org.uk/projects/projects_db.asp?fset=20

ALSF delivery partner – Cefas

MEPF 04/05: MARINE ALSF SCIENCE CO-ORDINATOR

Contractor: Marine Ecological Surveys Limited
Grant: £150,000
Timescale: MALSF Round 2, 2004 - 2007
Contact: Dr Richard Newell, Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY
Tel: 01225 442211
E-mail: richard@seasurvey.co.uk

Additional project information is available at:
<http://www.seasurvey.co.uk/>
http://www.alsf-mepf.org.uk/projects/projects_db.asp?ofset=20

MEPF 04/06: MARINE ALSF ANNUAL CONFERENCE 2005

Contractor: CMS - Coastal Management for Sustainability
Grant: £13,000
Contact: Bob Earll, CMS Limited, Candle Cottage, Kempley, Gloucestershire, GL18 2BU
Tel: 01531 890415
E-mail: bob.earll@coastms.co.uk

The conference program, participant responses and speaker presentations are available at:
<http://www.coastms.co.uk/index.html>

MEPF 04/07: MARINE AGGREGATE LEVY SUSTAINABILITY FUND (ALSF) OFFSHORE GEOGRAPHICAL INFORMATION SYSTEM

Contractor: ABP Marine Environmental Research Limited
Grant: £165,633
Timescale: MALSF Round 2, 2004 - 2007
Contact: Jamie Moore, ABP Marine Environmental Research, Suite B, Waterside House, Town Quay, Southampton, Hampshire, SO14 2AQ
Tel: 02380 338100 Fax: 02380 338040
E-mail: jmoore@abpmer.co.uk

Additional project information and a final report are available at:
<http://www.marinealsf.org.uk/>
http://www.alsf-mepf.org.uk/projects/projects_db.asp?ofset=30

MEPF 05/01: MARINE ALSF ANNUAL CONFERENCE 2006

Contractor: CMS - Coastal Management for Sustainability
Grant: £43,000
Contact: Bob Earll, CMS Limited, Candle Cottage, Kempley, Gloucestershire, GL18 2BU
Tel: 01531 890415
E-mail: bob.earll@coastms.co.uk

The conference program, participant responses and speaker presentations are available at:
<http://www.coastms.co.uk/index.html>

ALSF delivery partner – MIRO

The following projects were funded through the Sustainable Land Won and Marine Dredged Aggregate Minerals Programme (SAMP) managed by the Mineral Industry Research Organisation (MIRO) on behalf of the Department for Communities & Local Government (CLG); formerly the Office of the Deputy Prime Minister. Some projects were funded through the Mineral Industry Sustainable Technology Programme (MIST) also administered by MIRO.

Both SAMP and MIST were initiated in 2002, providing grants specifically for projects addressing the second objective of the ALSF:

Promoting environmentally friendly aggregate extraction in the Marine environment.

Details of the SAMP grants scheme, and additional project specific information including final reports can be obtained from:

<http://www.dclgaggregatefund.co.uk/>

Details of the MIST grants scheme, and additional project specific information including final reports can be obtained from:

<http://www.mi-st.org.uk/>

SAMP 1.001: SEABED CHARACTERISATION AND THE EFFECTS OF SOIL STRUCTURE ON BENTHOS AND ON BENTHOS RECOLONISATION CAUSED BY THE IMPACT OF MARINE AGGREGATE DREDGING

Contractor: Andrews Survey

Grant: £185,000

Timescale: MALSF Round 1, project completed 2004

Contact: Roy Jarman, Andrews Survey, Salmon Road, Great Yarmouth, Norfolk, NR30 3QS

Tel: 01493 332111

E-mail: royjarman@andrews.co.uk

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

SAMP 1.022: IMPACTS OF OVERBOARD SCREENING ON SEABED AND ASSOCIATED BENTHIC BIOLOGICAL COMMUNITY STRUCTURE IN RELATION TO MARINE AGGREGATE EXTRACTION

Contractor: Marine Ecological Surveys Ltd

Grant: £393,420

Timescale: MALSF Round 1, project completed 2004

Contact: Dr Richard Newell Marine Ecological Surveys Ltd, 24a Monmouth Place, Bath, BA1 2AY

Tel: 01225 442211

E-mail: richard@seasurvey.co.uk

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

<http://www.seasurvey.co.uk>

SAMP 1.031: BEST PRACTICE GUIDE TO ASSESSING THE IMPACTS OF AGGREGATES DREDGING

Contractor: Royal Haskoning Ltd.

Grant: £156,830

Timescale: MALSF Round 1, project completed 2004

Contact: Ms Sian John, Royal Haskoning Ltd, Rightwell House, Bretton, Peterborough, PE3 8DW

Tel: 01733 334455

E-mail: s.john@royalhaskoning.com

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

SAMP 1.042: SEABED PREHISTORY: GAUGING THE EFFECTS OF MARINE AGGREGATES DREDGING

Contractor: Wessex Archaeology

Grant: £219,480

Timescale: MALSF Round 1, project completed 2004

Contact: Stuart Leather, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: S.leather@wessexarch.co.uk

Additional project information and a final report are available at:

http://www.wessexarch.co.uk/projects/marine/alsf/seabed_prehistory/index.html

<http://www.dclgaggregatefund.co.uk/themea.htm>

<http://ads.ahds.ac.uk/project/alsf/>

ALSF delivery partner – MIRO

SAMP 1.044: OUTER BRISTOL CHANNEL MARINE HABITAT STUDY (ROUND 1)

Contractor: British Geological Survey

Grant: £201,814

Timescale: MALSF Round 1, project completed 2004

Contact: Ceri James, British Geological Survey, Kingsley Dunham Centre, Nicker Hill, Keyworth, Nottingham, NG12 5GG

Tel: 01159 363467

E-mail: jwcj@bgs.ac.uk

Additional project information and a final report are available at:

<http://www.dclgaggregategfund.co.uk/themea.htm>

<http://www.bgs.ac.uk>

MIST MA/1/1/003: TOWARDS ESTABLISHING A TOOL TO PROVIDE BASELINE DATA ON FISHERIES WITHIN SUSSEX FISHERIES DISTRICT

Contractor: Sussex Sea Fisheries Committee

Grant: £6,991 (from MIST) of total £7,962.50

Status: MALSF Round 1, project completed 2004

Contact: Robert Clark, Sussex Sea Fisheries District Committee, Unit 6, Highdown House, Shoreham Airport, Shoreham-by-Sea, West Sussex, BN43 5PB

Tel: 01273 454407

E-mail: rclark@sussex-sfc.gov.uk

Additional project information and a final report are available at:

http://www.mi-st.org.uk/section_a.htm

MIST MA/3/1/005: TOWARDS DEVELOPING BEST PRACTICE FOR SUSSEX SEA FISHERIES IN THE ACQUISITION OF DATA FOR MARINE RESOURCE MANAGEMENT

Contractor: Sussex Sea Fisheries District Committee

Grant: £3,981 (from MIST) of total £13,982

Status: MALSF Round 1, project completed 2004

Contact: Robert Clark, Sussex Sea Fisheries District Committee, Unit 6, Highdown House, Shoreham Airport, Shoreham-by-Sea, West Sussex, BN43 5PB

Tel: 01273 454407

E-mail: rclark@sussex-sfc.gov.uk

Additional project information and a final report are available at:

http://www.mi-st.org.uk/section_a.htm

SAMP2.06: OUTER BRISTOL CHANNEL MARINE HABITAT STUDY – GEOPHYSICAL AND VIDEO SURVEYS

Contractor: British Geological Survey

Grant: £78,864

Timescale: MALSF Round 2, October 2004 – March 2006

Contact: Ceri James, British Geological Survey, Kingsley Dunham Centre, Nicker Hill, Keyworth, Nottingham, NG12 5GG

Tel: 01159 363467

E-mail: jwcj@bgs.ac.uk

Additional project information and a final report are available at:

<http://www.dclgaggregategfund.co.uk/themea.htm>

<http://www.bgs.ac.uk>

SAMP2.24: DREDGING LANE MANAGEMENT – CFD SIMULATIONS

Contractor: CEFAS

Grant: £96,054

Timescale: MALSF Round 2, October 2004 – March 2006

Contact: John Rees, Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT

Tel: 01502 524383

E-mail: jon.rees@cefass.co.uk

Additional project information and a final report are available at:

<http://www.dclgaggregategfund.co.uk/themea.htm>

SAMP2.25: BUILDING GIS AND ENVIRONMENTAL DATA MANAGEMENT CAPABILITIES OF THE SEA FISHERIES COMMITTEES

Contractor: CEFAS

Grant: £35,366

Timescale: MALSF Round 2, October 2004 – August 2005

Contact: Paul Eastwood, Cefas Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk, NR33 0HT

Tel: 01502 524536

E-mail: paul.eastwood@cefass.co.uk

Additional project information and a final report are available at:

<http://www.dclgaggregategfund.co.uk/themea.htm>

**SAMP2.43: SEABED PREHISTORY 2:
ARCHAEOLOGY AND MARINE AGGREGATES IN THE
NORTH SEA AND ENGLISH CHANNEL**

Contractor: Wessex Archaeology

Grant: £482,517

Timescale: MALSF Round 2, October 2004 – March 2007

Contact: Stuart Leather, Wessex Archaeology Ltd,
Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: s.leather@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

http://www.wessexarch.co.uk/projects/marine/alsf/seabed_prehistory/index.html

**SAMP3.1.07: DEVELOPMENT OF AN OPEN ACCESS
WEBSITE TO COLLATE INFORMATION AND
DISSEMINATE GOOD ENVIRONMENTAL PRACTICE
FOR MARINE AGGREGATE DREDGING**

Contractor: Leeds University

Grant: £142,469

Timescale: MALSF Round 2, September 2005 – February 2007

Contact: Toby White, School of Process, Environmental and Materials Engineering, University of Leeds, Leeds, LS2 9JT

Tel: 01133 432784

E-mail: t.j.white@leeds.ac.uk

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

<http://www.goodmarine.com/>

**SAMP3.1.08: DIRECT MEASUREMENT OF SEABED
STABILITY AT A MARINE AGGREGATE EXTRACTION
SITE USING BENTHIC FLUME TECHNOLOGY**

Contractor: Partrac Ltd

Grant: £118,125

Timescale: MALSF Round 2, September 2005 – February 2007

Contact: Dr Kevin Black, Partrac Ltd, 141 St. James Road, Glasgow, G4 0LT

Tel: 01413 548855

E-mail: kblack@partrac.com

Additional project information and a final report are available at:

<http://www.dclgaggregatefund.co.uk/themea.htm>

http://www.partrac.co.uk/content/04_projects_sediment_stability.php

ALSF delivery partner – English Heritage

The following projects were funded through English Heritage, from 2002 onwards, under the second ALSF objective:

Promoting environmentally friendly aggregate extraction in the marine environment.

Details of all projects funded by EH through the ALSF scheme can be obtained from:

[http://www.english-](http://www.english-heritage.org.uk/server/show/nav.1315)

[heritage.org.uk/server/show/nav.1315](http://www.english-heritage.org.uk/server/show/nav.1315)

[http://hec.english-](http://hec.english-heritage.org.uk/admisremote/ALSFOOnline/HOME.ASP)

[heritage.org.uk/admisremote/ALSFOOnline/HOME.ASP](http://hec.english-heritage.org.uk/admisremote/ALSFOOnline/HOME.ASP)

<http://ads.ahds.ac.uk/project/alsf/>

GREATER THAMES SURVEY OF MINERAL EXTRACTION SITES

Contractor: Essex County Council

Grant: £115,012

Timescale: MALSF Round 1, 2002 - 2003

Contact: <http://www.essexcc.gov.uk/>

Additional project information is available at:

<http://ads.ahds.ac.uk/project/alsf/>

MULTI-BEAM SONAR ON WRECKS

Contractor: Wessex Archaeology

Grant: £11,012

Timescale: MALSF Round 1, 2002 - 2003

Contact: Stuart Leather, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: s.leather@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

Marine ALSF Project Reports are available on disc from Wessex Archaeology.

Additional project information and a final report are available at:

http://www.wessexarch.co.uk/projects/marine/alsf/alsf_info.html

<http://www.wessexarch.co.uk/projects.asp>

<http://ads.ahds.ac.uk/project/alsf/>

SUBMERGED PALAEO ARUN AND SOLENT RIVERS: RECONSTRUCTION OF PREHISTORIC LANDSCAPES PT 1 & 2

Contractor: Imperial College

Grant: £121,629

Timescale: MALSF Round 1, 2002 - 2003

Contact: Dr. Sanjeev Gupta & Dr. Jenny Collier, Department of Earth Science & Engineering, Imperial College, Exhibition Road, London SW7 2AZ

Tel: 02075 946527/ 02075 946443 Fax: 02075 947444

E-mail: s.gupta@ic.ac.uk, jenny.collier@ic.ac.uk

Additional project information and a final report are available at:

<http://www3.imperial.ac.uk/>

<http://ads.ahds.ac.uk/project/alsf/>

PALEOLITHIC ARCHAEOLOGY OF THE SUSSEX/HAMPSHIRE COASTAL CORRIDOR

Contractor: University of Wales, Lampeter

Grant: £94,525

Timescale: MALSF Round 1, 2002 - 2003

Contact: Martin Bates, Dept of Archaeology, University of Wales, Lampeter, Ceredigion, Wales, SA48 7ED

Tel: 01570 423423

E-mail: m.bates@lamp.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

WRECKS ON THE SEABED: ASSESSMENT, EVALUATION & RECORDING

Contractor: Wessex Archaeology

Grant: £92,090

Timescale: MALSF Round 1, July 2002 - March 2004

Contact: Stuart Leather, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: s.leather@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

http://www.wessexarch.co.uk/projects/marine/alsf/wrecks_seabed/seabed.html

ENGLAND'S SHIPPING

Contractor: Wessex Archaeology
Grant: £31,710
Timescale: MALSF Round 1, 2002 - 2003
Contact: Stuart Leather, Wessex Archaeology Ltd,
Portway House, Old Sarum Park, Salisbury, SP4 6EB
Tel: 01722 326867
Email: s.leather@wessexarch.co.uk
<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
http://www.wessexarch.co.uk/projects/marine/alsf/englands_shipping/index.html

ARTEFACTS FROM THE SEA

Contractor: Wessex Archaeology
Grant: £32,897
Timescale: MALSF Round 1, October 2002 - March 2004
Contact: Stuart Leather, Wessex Archaeology Ltd,
Portway House, Old Sarum Park, Salisbury, SP4 6EB
Tel: 01722 326867
Email: s.leather@wessexarch.co.uk
<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
http://www.wessexarch.co.uk/projects/marine/alsf/artefacts_sea/artefacts_sea.html

HIGH RESOLUTION SONAR FOR THE ARCHAEOLOGICAL INVESTIGATION OF MARINE AGGREGATE DEPOSITS

Contractor: Southampton University
Grant: £20,000
Timescale: MALSF Round 1, 2002 - 2003
Contact: Dr. Justin Dix, School of Ocean and Earth
Science, National Oceanography Centre, European Way,
Southampton, SO14 3ZH
Tel: 02380 597817
E-mail: j.k.dix@soton.ac.uk

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.arch.soton.ac.uk/Research/Aggregates//index.htm>

A REASSESSMENT OF THE ARCHAEOLOGICAL POTENTIAL OF CONTINENTAL SHELVES

Contractor: Southampton University
Grant: £21,156
Timescale: MALSF Round 1, 2002 - 2004
Contact: Dr. Justin Dix, School of Ocean and Earth
Science, National Oceanography Centre, European Way,
Southampton, SO14 3ZH
Tel: 02380 597817
E-mail: j.k.dix@soton.ac.uk

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.arch.soton.ac.uk/Research/Aggregates//index.htm>

RE-ASSESSMENT OF THE ARCHAEOLOGICAL POTENTIAL OF CONTINENTAL SHELVES

Contractor: University of Southampton
Grant: £14,300
Timescale: MALSF Round 2, 2004 - 2007
Contact: Dr. Justin Dix, School of Ocean and Earth
Science, National Oceanography Centre, European Way,
Southampton, SO14 3ZH
Tel: 02380 597817
E-mail: j.k.dix@soton.ac.uk

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.arch.soton.ac.uk/Research/Aggregates//index.htm>

BEACH REPLENISHMENT AND DERIVED ARCHAEOLOGICAL MATERIAL

Contractor: Museum of London Archaeology Service
Grant: £20,000
Timescale: MALSF Round 2, 2004 - 2007
Contact: Dick Malt, Project Manager, Museum of
London Archaeology Service, Mortimer Wheeler House,
46 Eagle Wharf Road, London, N1 7ED
Tel: 0207 4102200
E-mail: dickm@molas.org.uk
<http://www.molas.org.uk>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>

ALSF delivery partner – English Heritage

SOLENT AGGREGATES TO OUTREACH

Contractor: Hampshire & Wight Trust for Maritime Archaeology

Grant: £50,000

Timescale: MALSF Round 2, completed March 2007

Contact: Julie Satchell, Archaeological Officer, Hampshire and Wight Trust for Maritime Archaeology, Room W1/95, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH

Tel: 02380 237300

Email: Julie.satchell@hwtma.org.uk

<http://www.hwtma.org.uk/>

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.hwtma.org.uk/education/aggtout/index.htm>

ENHANCING OUR UNDERSTANDING: NAVIGATIONAL HAZARDS

Contractor: Bournemouth University

Grant: £100,000

Timescale: MALSF Round 2, April 2004 - March 2007

Contact: David Parham, Bournemouth University, Talbot Campus, Fern Barrow, Poole, Dorset, BH12 5BB

Tel: 01202 965452

E-mail: dparham@bournemouth.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

MODELLING EXCLUSION ZONES FOR MARINE AGGREGATE DREDGING

Contractor: University of Southampton

Grant: £234,000

Timescale: MALSF Round 2, February 2005 - February 2007

Contact: Dr. Justin Dix, School of Ocean and Earth Science, National Oceanography Centre, European Way, Southampton, SO14 3ZH

Tel: 02380 597817

E-mail: j.k.dix@soton.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.noc.soton.ac.uk/soes/research/groups/geophysics/aggregates/Index.htm>

MODELLING EXCLUSION ZONES FOR MARINE AGGREGATE DREDGING (VARIATION GRANT)

Contractor: University of Southampton

Grant: £85,100

Timescale: MALSF Round 2, 2004 - 2007

Contact: Dr. Justin Dix, School of Ocean and Earth Science, National Oceanography Centre, European Way, Southampton, SO14 3ZH

Tel: 02380 597817

E-mail: j.k.dix@soton.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.noc.soton.ac.uk/soes/research/groups/geophysics/aggregates/Index.htm>

MARINE HISTORIC LANDSCAPE CHARACTERISATION (HLC) PILOT: LIVERPOOL BAY

Contractor: Wessex Archaeology

Grant: £144,000

Timescale: MALSF Round 2, October 2004 - February 2006

Contact: Deanna Groom, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 343433

E-mail: d.groom@wessexarch.co.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.english-heritage.org.uk/server/show/conWebDoc.4447>

<http://www.wessexarch.co.uk/projects/marine/eh/seascape/>

MARINE HISTORIC LANDSCAPE CHARACTERISATION PILOT: SOLENT AND ISLE OF WIGHT

Contractor: Hampshire and Wight Trust for Maritime Archaeology

Grant: £67,400

Timescale: MALSF Round 2, completed March 2007

Contact: Julie Satchell, Archaeological Officer, Hampshire and Wight Trust for Maritime Archaeology, Room W1/95, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH

Tel: 02380 237300

E-mail: julie.satchell@hwtma.org.uk;

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.hwtma.org.uk/publications/download.htm>

<http://www.english-heritage.org.uk/server/show/conWebDoc.4447>

**MARINE HISTORIC LANDSCAPE
CHARACTERISATION PILOT: SCARBOROUGH TO
HARTLEPOOL**

Contractor: Cornwall County Council
Grant: £74,500
Timescale: MALSF Round 2, completed March 2007
Contact: Charlie Johns, Senior Archaeologist, Historic Environment Service, Environment and Heritage, Cornwall County Council, Kennall Building, Old County Hall, Station Road, Truro, Cornwall, TR1 3AY
Tel: 01872 323603
E-mail: chjohns@cornwall.gov.uk
<http://www.cornwall.gov.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.english-heritage.org.uk/server/show/conWebDoc.4447>

**MARINE HISTORIC LANDSCAPE
CHARACTERISATION PILOT: SOUTHWOLD TO
CLACTON**

Contractor: Oxford Archaeology
Grant: £69,400
Timescale: MALSF Round 2, completed March 2007
Contact: Ianto Wain, Head of Heritage Management Services, Oxford Archaeology, Janus House, Osney Mead, Oxford, OX2 0ES
Tel: 01865 263800
E-mail: i.wain@oxfordarch.co.uk
<http://www.oxfordarch.co.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.english-heritage.org.uk/server/show/conWebDoc.4447>

**MARINE HISTORIC LANDSCAPE
CHARACTERISATION PILOT: WITHERNSEA TO
SKEGNESS**

Contractor: Museum of London Archaeological Service
Grant: £69,400
Timescale: MALSF Round 2, completed March 2007
Contact: Dick Malt, Museum of London Archaeology Service, Mortimer Wheeler House, 46 Eagle Wharf Road, London, N1 7ED
Tel: 0207 4102200
E-mail: dickm@molas.org.uk
<http://www.molas.org.uk>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
<http://www.english-heritage.org.uk/server/show/conWebDoc.4447>

SEVERN MARITIME ASSESSMENT

Contractor: Museum of London Archaeology Service
Grant: £25,000
Timescale: MALSF Round 2, February 2005 - March 2007
Contact: Dick Malt, Museum of London Archaeology Service, Mortimer Wheeler House, 46 Eagle Wharf Road, London, N1 7ED
Tel: 0207 4102200
E-mail: dickm@molas.org.uk
<http://www.molas.org.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>

SEABED PREHISTORY ROUND 2

Contractor: Wessex Archaeology
Grant: £299,000
Timescale: MALSF Round 2, April 2004 - February 2007
Contact: Stuart Leather, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB
Tel: 01722 326867
E-mail: s.leather@wessexarch.co.uk
<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:
<http://ads.ahds.ac.uk/project/alsf/>
http://www.wessexarch.co.uk/projects/marine/alsf/wrecks_seabed/round2/round2.html
This project complements the MIRO funded Seabed Prehistory Round 2: Archaeology and Marine Aggregates in the North Sea and English Channel project.
See:
Seabed Prehistory Round 2: Grab Sampling Survey. Wessex Archaeology February 2006. Ref 57421. 53pp
Seabed Prehistory Round 2: Geophysics Survey Great Yarmouth. Wessex Archaeology March 2006. Ref. 57421. 23pp.

Additional project information is available at:
http://www.wessexarch.co.uk/projects/marine/alsf/seabed_prehistory/

ALSF delivery partner – English Heritage

WRECKS ON THE SEABED ROUND 2- HAPPISBURGH (VARIATION)

Contractor: Wessex Archaeology

Grant: £37,800

Timescale: MALSF Round 2, April 2004 - October 2006

Contact: Anthony Firth, Wessex Archaeology Ltd,
Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: a.firth@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

http://www.wessexarch.co.uk/projects/marine/alsf/wrecks_seabed/

WRECKS ON THE SEABED ROUND 2

Contractor: Wessex Archaeology

Grant: £557,000

Timescale: MALSF Round 2, completed October 2006

Contact: John Gribble, Project Manager, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: j.gribble@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

See: Wrecks on the Seabed Round 2. Assessment, Evaluation & Recording: Geophysical Surveys. Wessex Archaeology. Ref 57452.01. 93pp.

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

http://www.wessexarch.co.uk/projects/marine/alsf/wrecks_seabed/

INNOVATIVE APPROACHES TO RAPID ARCHAEOLOGICAL SITE SURVEYING AND EVALUATION IN THE MARITIME ENVIRONMENT TRANSITIONAL ZONES

Contractor: University of St Andrews

Grant: £204,000

Timescale: MALSF Round 2, April 2004 - late 2006

Contact: Dr. Richard Bates, University of St. Andrews,
School of Geography and Geosciences, St. Andrews,
Fife, KY16 9AL

Tel: 01334 463997

E-mail: crb@st-andrews.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.st-andrews.ac.uk/~wrecks/>

INNOVATIVE APPROACHES TO RAPID ARCHAEOLOGICAL SITE SURVEYING AND EVALUATION IN THE MARITIME ENVIRONMENT TRANSITIONAL ZONES (VARIATION GRANT)

Contractor: University of St Andrews

Grant: £13,700

Timescale: MALSF Round 2, April 2004 - late 2006

Contact: Dr. Richard Bates, University of St. Andrews,
School of Geography and Geosciences, St. Andrews,
Fife, KY16 9AL

Tel: 01334 463997

E-mail: crb@st-andrews.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.st-andrews.ac.uk/~wrecks/>

ON THE IMPORTANCE OF SHIPWRECKS

Contractor: Wessex Archaeology

Grant: £30,000

Timescale: MALSF Round 2, completed 2006

Contact: Anthony Firth, Project Manager, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 343443

E-mail: a.firth@wessexarch.co.uk

<http://www.wessexarch.co.uk/>

This work is reported as follows:

Marine Aggregates & the Historic Environment: The Importance of Shipwrecks Vol 1. Final Report. Wessex Archaeology Ref. 58591.02A. 75pp.

Marine Aggregates & the Historic Environment: The Importance of Shipwrecks Vol.2. Appendices. Wessex Archaeology Ref. 58591.02B 75pp.

Marine Aggregates & the Historic Environment: The Importance of Shipwrecks. Applying the Framework. Wessex Archaeology Ref. 58591.03. 47pp.

Marine Aggregates & the Historic Environment: The Importance of Shipwrecks. Using the Database. Wessex Archaeology Ref. 58591.04. 17pp.

Reports on this work are available as electronic versions on CD from Wessex Archaeology.

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

ENHANCING OUR UNDERSTANDING: SHIPWRECK IMPORTANCE

Contractor: Bournemouth University

Grant: £100,000

Timescale: MALSF Round 2, completed March 2007

Contact: David Parham, School of Conservation Science, Bournemouth University, Talbot Campus, Fern Barrow, Poole, Dorset, United Kingdom, BH12 5BB

Tel: 01202 965452

E-mail: dparham@bournemouth.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.bournemouth.ac.uk/conservation/>

3D SEISMICS AS A SOURCE FOR MITIGATION MAPPING OF THE LATE PLEISTOCENE AND HOLOCENE DEPOSITIONAL SYSTEMS AND PALAEOGEOGRAPHY OF THE SOUTHERN NORTH SEA

Contractor: University of Birmingham

Grant: £176,532

Timescale: MALSF Round 2, April 2005 – March 2007

Contact: Professor Vincent Gaffney, Institute for Archaeology and Antiquity, University of Birmingham, Edgbaston, B15 2TT

E-mail: v.l.gaffney@bham.ac.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

http://www.iaa.bham.ac.uk/research/fieldwork_research_themes/projects/North_Sea_Palaeolandscapes/index.htm

ARCHAEOLOGY WITHIN MARINE AGGREGATE ENVIRONMENTAL STATEMENTS

Contractor: Hampshire & Wight Trust for Maritime Archaeology

Grant: £16,300

Timescale: MALSF Round 2, completed November 2006

Contact: Julie Satchell, Archaeological Officer, Hampshire and Wight Trust for Maritime Archaeology, Room W1/95, National Oceanography Centre, Empress Dock, Southampton, SO14 3ZH

Tel: 02380 237300

E-mail: julie.satchel@hwtma.org.uk

<http://www.hwtma.org.uk/>

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.hwtma.org.uk/techniques/esreview.htm>

JOINT FUNDED PROJECTS BETWEEN ENGLISH HERITAGE & THE BRITISH MARINE AGGREGATE PRODUCERS ASSOCIATION (BMAPA)

BMAPA/EH PROTOCOL FOR REPORTING FINDS OF ARCHAEOLOGICAL SIGNIFICANCE

Contractor: Wessex Archaeology

Grant: £8,500

Timescale: MALSF Round 2, 2004 - 2007

Contact: Antony Firth, Coastal & Marine Section, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: a.firth@wessexarch.co.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.wessexarch.co.uk/projects/marine/bmapa/index.html>

BMAPA/EH PROTOCOL AWARENESS PROGRAMME

Contractor: Wessex Archaeology

Grant: £54,000

Timescale: MALSF Round 2, 2004 - 2007

Contact: Antony Firth, Coastal & Marine Section, Wessex Archaeology Ltd, Portway House, Old Sarum Park, Salisbury, SP4 6EB

Tel: 01722 326867

E-mail: a.firth@wessexarch.co.uk

Additional project information and a final report are available at:

<http://ads.ahds.ac.uk/project/alsf/>

<http://www.wessexarch.co.uk/projects/marine/bmapa/protocol-awareness.html>

Edited by

R.C. Newell D.Sc(Lond.)^{1,2}

&

D.J. Garner M.Sc²



¹ Marine ALSF Science Co-ordinator

² Marine Ecological Surveys Limited
24A Monmouth Place, Bath BA1 2AY