

**AGGREGATES LEVY SUSTAINABILITY FUND
MARINE AGGREGATES AND THE HISTORIC ENVIRONMENT**

ENGLAND'S SHIPPING

Year 2 Report

Prepared for:

English Heritage

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SUMMARY

The intention of this document is to provide a detailed report to English Heritage on the activities of the project during Year 2 and also to bring to a conclusion the entire project.

The report includes the following:

- a description of the results of the Review undertaken at the end of Year 1;
- a report of changes made to the methodology, following the Review and progress during Year 2;
- a report on the developments in the mapping of data for England's Shipping;
- a summary of the degree of population of the database;
- a summary of the results of the project;
- recommendations regarding further stages that might follow in future projects.

The construction of the Geographical Information System (GIS) and the design of the MS Access database has been completed according to the original Project Design. The GIS has been constructed to represent records of individual ship voyages spatially, along with an extensive series of additional point data relating to known wrecks, casualties, battle sites and anchorages, all of which are of benefit in attempting to gauge potential and to place wreck sites in context.

All datasets have been drawn from historical data contained in documentary sources pertaining to pre-1730 shipping activity in England. The results generated from the GIS allow a new assessment of the evidence for maritime activity for periods that are poorly represented in currently available sources. Such assessments will complement the existing approach for producing assessments of archaeological potential for the purposes of environmental assessments.

A network of shipping routes has been created which produces artificial representations of shipping voyages between historical ports and enables the representation of the density of records available in the database for a particular ship route. This approach enables the spatial characterisation of shipping between ports and increases access to the information available for the contextualisation of known wrecks. The querying of traffic data for ports by period provides a basis for assessing the commercial and naval importance of a port and thus improves the scope for inferences about the density of traffic travelling through port approaches.

The assessment of sources for pre-1730 shipping movements showed the records to have a significant lack of data relating to shipping routes that could be mapped spatially. In order to improve the representation of the nature and quantity of shipping in English Waters, it was necessary to seek further and alternative methods of mapping data in order to complement the interpretation of shipping routes.

Events such as battles and casualties have been mapped as points using different techniques to manage the uncertainty identified during the source appraisal, which arises from inaccurate recording in historical archives.

During the course of the project the development of a methodology had to take precedence over the population of the database in order to produce an efficient system. Once the methodologies have been discussed in detail and any required improvements have been made, further population of the database will provide a more comprehensive basis on which to pursue detailed discussions of the potential character, quantity and importance of historical shipping within an area of seabed.

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1. INTRODUCTION

- 1.1. Wessex Archaeology has been commissioned by English Heritage to undertake a desk-based project entitled 'England's Shipping' with the principal aim of improving assessments of archaeological potential in English waters. This has been addressed by creating a digital atlas of shipping movements based on historical data from a range of documentary sources about shipping movements in England from the period before 1730. The project is being funded by that part of the Aggregate Levy Sustainability Fund distributed by English Heritage.
- 1.2. Much of this project has been related to the design and creation of a system (i.e. database and linked GIS) to allow the process of presenting early sources. The project serves to highlight the weaknesses of the current reliance on existing NMR and UKHO data to draw inferences about maritime archaeological potential in areas proposed for aggregate extraction. The results of the project provide data that should be interpreted in conjunction with other datasets that, combined, will better inform the assessment of maritime archaeological potential and its importance.
- 1.3. This document comprises a report of the progress during the second year of the project. This report relates to the revised milestone M8.

2. BACKGROUND

- 2.1. The character of England's Shipping is reflected in the movement of traffic around the coastline and the location of known wrecks on the seabed. It is also reflected in the commercial importance of ports, Naval conflict, and casualty events that did not lead to wrecking.
- 2.2. Only a fraction of the events, that took place at sea, have been recorded in detail in existing records. In order to gain a clearer understanding of the quantity and character of shipping, and the resulting trends in the presence of maritime sites on the seabed, it is necessary to observe combinations of various sources of data in order to build a picture.
- 2.3. This project complements a previous research project undertaken by Wessex Archaeology, entitled "Marine Aggregate Dredging and the Historic Environment: Characterisation Maps" (Project Ref.: 49047). The project was carried out on behalf of British Marine Aggregate Producers Association (BMAPA) and English Heritage and was completed in November 2001(Wessex Archaeology, 2001). It sought to characterise the southern North Sea and eastern English Channel for their maritime

archaeological potential by collating information on hazards and destinations recorded on historical charts, and gross numbers of casualties (recorded shipping losses) held by the NMR. These sets of information were intended to complement the record of known and located wreck sites and anomalies contained in the National Monuments Record (NMR) in order to arrive at a more informed assessment of the maritime archaeological potential of the seabed in these areas.

- 2.4. It was recognised that the overview obtained from overlaying these three types of information – hazards/destinations, casualties and wrecks – is still heavily biased towards upstanding (more recent) wrecks and to the period post c. 1730 when the recording of losses, and hydrographic surveying, became commonplace.
- 2.5. It was noted that other data is available that can temper these biases and thus provide a better appreciation of maritime archaeological potential. This data takes the form of documentary sources relating to volumes and types of shipping extending back through the Post-Medieval to the Medieval and even Early Medieval periods.
- 2.6. This data is not however readily incorporated into Environmental Statements for marine aggregate licences to a level that might reasonably be expected for desk-based assessment, due to the timescales or resourcing requirements involved in tackling these sources.

3. PROJECT AIM

- 3.1. England's Shipping is one of four projects being undertaken by Wessex Archaeology with the support of the Aggregate Levy Sustainability Fund. The overall intention of the four projects is to improve the conservation, understanding and wider appreciation of the marine historic environment affected by aggregate dredging by:
 - improving basic understanding of the marine historic environment;
 - increasing awareness and expertise in respect of the marine historic environment among aggregate companies, their staff, archaeological curators and archaeological contractors;
 - engaging the wider public in the marine historic environment and its importance to the history of England;
 - enhancing national and local archaeological records;
 - enhancing ability to assess archaeological potential;
 - providing comparable data on the effectiveness of different investigative techniques;
 - identifying and giving effect to avenues for archiving and disseminating results.
- 3.2. The specific aim of England's Shipping is to collate documentary information about shipping patterns in a readily accessible format to facilitate the assessment of maritime archaeological potential in the course of preparing Environmental Statements to accompany marine aggregate licence applications.
- 3.3. The project is using primary and secondary documentary sources to map the intensity and other characteristics of pre-1730 shipping. The results are presented in a manner that will assist seabed developers, their archaeological advisors and heritage curators to better predict the potential for the presence of submerged cultural resources that

relate to vessel movements in areas of the seabed around the English coast being considered for development.

- 3.4. The England's Shipping project is therefore concerned with taking such data, as is available in the archives for the period prior to 1730, and presenting it in the form of a digital atlas of England's Shipping. The archival data gathered is mapped using Geographical Information System (GIS) software in order to present the filtered results of queries on shipping traffic density. In order to test and validate the methodologies used and the data collated, the records were assimilated with hazards/destinations, casualties and wrecks data from the BMAPA project (Project Ref.: 49047) and from other data gathered during the course of the project. It is anticipated that the content of the digital atlas will be made available to users via the NMR.

4. OBJECTIVES AND ACHIEVEMENTS

4.1. Year 1

4.1.1. The objectives of Year 1 were:

- to establish a system for recording and mapping England's shipping that is compatible with current data standards;
- to develop and trial a methodology for incorporating details of England's shipping into the recording and mapping system;
- to obtain and appraise examples of secondary and primary sources;
- to generate records of England's shipping.

4.1.2. The objectives set out for the first year of the project were successfully achieved (England's Shipping Year One Report 51552.02). A database was designed, along with a process for recording the data. The database was then linked to a GIS package in order to present the data in a geospatial format. The database was designed and populated with the first case study of data relating to shipping traffic for Southampton and its outports.

4.1.3. An initial source appraisal was completed and the results were presented in a report to English Heritage in January 2003 (Ref: 51552.01). The sources were assessed in terms of the volume of data, their relevance to the requirements of the project, their accessibility and their speed of use. The sources identified as being most useful were the Port Books, early Customer records, Board of Trade Shipping Returns, Royal Navy Masters' Logs, Abstracts of Ships Journals and other Logs.

4.2. Year 2

4.2.1. The objectives of Year 2 are as follows:

- to review the recording and mapping system, and methodology;
- to generate records of England's shipping;
- to initiate and maintain a dialogue with industry, regulators and contractors regarding England's shipping and its implications for maritime archaeological potential;
- to support the development of skills and experience in the archaeological profession;

- to engage in academic debate nationally and internationally regarding England's shipping;
- to inform the public of the importance of England's shipping.

4.2.2. The targets achieved for the second year of the project are as follows:

- a review of the methodology has been undertaken;
- a revised methodology was set up for mapping the data, which was adapted to the needs of the project and limitations of the sources;
- a system for visualising vessel journeys in a GIS has been developed.
- a series of event datasets have been mapped to complement the routes and increase the amount of information from historical archives, other than routes, which can be mapped.
- a steering group has been put together and met at Wessex Archaeology Offices on the 27th October 2003 and on the 19th February 2004.
- Presentations have been made to academic and public audiences and a further outreach programme has been agreed. The web pages for the project have been updated and put online.

4.2.3. The methodology applied in the project is described later in this document.

4.2.4. A publication based on the development and initial results of the project has been prepared. This is aimed at a general readership and illustrated with examples of England's Shipping.

5. MILESTONES

5.1. The revised project milestones are listed in the table below:

Year	Original Milestone/ task	Original Date	Revised Date	Revised Milestone/ task	Achieved
1	M1 Initiate Project	25/11/02		As before	√
1	M2 Sources appraised	31/01/03		As before	√
	M3 Submit draft Y1 report	28/03/03		As before	√
1	Prepare Y1 records for transfer	26/03/03	11/08/03	Letter to David Graty initiating process of transfer in addition to preparing records for transfer	√
2	M5 Commence Y2 tasks	28/04/03		As before	√
2	M6 – Update on Mapping	17/10/03	01/09/03	M6 - Progress report on Recording and Mapping	√
2	M7 – Confirm External Costs and Programme for publication	31/10/03	19/12/03	M7 – Confirm External Costs and Programme for publication	√
2	M8 – Submit draft Year 2 report	27/02/04	30/01/04	M8- Submit draft Year 2 report – Submitted (this report)	√
2	M9 – Submit Final Year 2 report	19/03/04	27/02/04	M9 – Submit Final Year 2 report	
2	M10 Launch	25/03/04		As Before	

Table 1: England's Shipping Project milestones

6. SUMMARY OF METHODOLOGICAL REVIEW

6.1. Introduction

6.1.1. A review was undertaken at the end of Year 1 of the project to evaluate the methods initially developed. The review showed that much of the work undertaken during Year 1 required only minor methodological changes to the database structure. The majority of revisions made to work undertaken in Year 1 were as a result of a decision in year 2 to change the presentation of the data in the Geographic Information System (GIS). Revisions resulting from the review have been applied to the recording system, methodology and use of sources.

6.2. Source Appraisal

6.2.1. The source appraisal was successful but required some flexibility to deal with the variable availability of certain primary sources. The analysis was forced to be selective due to the huge range of material available and, because of the extent and variation within the sources, the appraisal has become an ongoing process throughout the gathering of data and populating the database during the project.

6.3. Database structure

6.3.1. The review of the database did not require the core structure to be subjected to any major changes. Minor alterations included the separation of complete and incomplete routes simply by adding a field to the routes table to indicate the status of the route. Additional changes were later identified during the development of a methodology for mapping historical data. They are discussed in detail below.

6.3.2. Additional tables were added to the structure (see Appendix 1) as a temporary measure ahead of the acquisition of ArcGIS 8.3 and Spatial Analyst, to build the required relationships between the GIS application and the data held in the database. These tables were to be replaced by relationships between the tables of the database, built within the GIS, using the new software.

6.4. Mapping

6.4.1. The mapping methodology, which had been discussed during Year 1 but had not been substantially implemented, was the only area requiring a major review. The gathering of themes representing contour lines, hazards and sailing limits was successful using AutoCAD software. The software enabled data to be digitised quickly and easily from scanned images of charts and superimposed.

6.4.2. The review of the methodology for mapping the data concluded that the routes were best represented by a network of buffered routes created using the GIS buffering tool, rather than a grid of polygonised triangles as originally proposed. In addition, the mapping of the polylines in AutoCAD, on which the network was originally based was changed from a single line per individual route to a series of line segments which made up the network. Each route would then be made up of a series of line segments before being buffered.

- 6.4.3. The Progress Report on Recording and Mapping (51552.03) noted the need for the structure of the database to be further developed to allow the incorporation of datasets containing descriptions of partially complete journeys and fleets of unspecified numbers of vessels. Much of the data so far gathered contains non-specific information on the exact departure and arrival locations of the journeys recorded. This has created difficulties in mapping the partially documented routes. By amending the database, the data can now be divided into four categories; complete vessel routes, complete fleet routes, incomplete vessel routes and incomplete fleet routes. They are then presented separately in GIS to avoid distortion of the detailed information.

7. METHODOLOGY

7.1. Introduction

- 7.1.1. Following the methodological review and the production of the Progress Report on Recording and Mapping (51552.03), extensive progress was made in the development of a methodology for mapping historical data. Further changes to the system's structure were made as the project developed, beyond those identified during the review.
- 7.1.2. The methodology of the project was first discussed in the early part of Year 1. It was agreed at the outset of the project that a database, produced using Microsoft Access, would be populated primarily by data gathered from sources identified as useful and cost effective during the source appraisal. The data contained in the database would then be linked to a GIS package to enable the data to be presented geospatially and queried. The use of GIS allows different sets of mapped data contained within separate themes to be overlaid. The data can then be queried to extract trends from the patterns within the data and subtract areas of surrounding hazards from the buffer zone produced around each shipping route or event.
- 7.1.3. It was proposed that the project focus initially on a series of case study areas, based on the availability of shipping-related sources and on their proximity to aggregate dredging areas. The case study areas were confirmed in the source appraisal, following their proposal and subsequent discussions with English Heritage. The case-study areas were later adapted in relation to the GIS data available for validating the methodologies and the availability of ship voyage data that could actually be mapped.

7.2. Database

Database Development

- 7.2.1. The structure of the database was designed whilst taking into consideration the project requirements. The database initially developed during year 1 and described in detail in the Year 1 report (51552.02), originally recorded individual shipping movements by English and foreign vessels off the coast of England, and casualty events. The database was designed using Microsoft Access 97. The system was designed to be MIDAS/INSCRIPTION compatible. The design of the system also had to comply with other systems used for recording shipping data within the maritime section of the NMR. The structure of the database was submitted to David Graty at the NMR in Swindon for official confirmation that the system was compatible. A visit by Mr Graty in November 2003 to Wessex Archaeology offices confirmed that no major problems relating to the structure of the database, or more importantly the transfer of data to the NMR, were apparent. Following Mr Graty's visit test data from the

project database has been passed to the NMR for comment ahead of the full transfer of data expected to take place in March 2004.

- 7.2.2. The initial population of the database concentrated on gathering records for individual journeys and casualty events preceding 1730. The quantity of data available that could be mapped in this way (i.e. information about the point of departure and the destination) was less than expected, making it difficult to focus on the case study areas initially suggested for the gathering of route data. During this initial phase of data assimilation further categories of data were identified from secondary sources, which provided additional means of assessing shipping activity, including for example battle events and information on ports. The switchboard for the database was reorganised at this time to accommodate changes to the structure of the forms that would enable further battle data to be entered (Fig 1, Plate A). Further information on ports is currently contained within the data on journeys and can be extracted through database queries. The development of a separate form for recording additional data on ports would aid the collation of port data in greater detail.
- 7.2.3. Although casualty data was available from the NMR, a greater emphasis needed to be put on pre-1730 records and the descriptions of losses related to recorded voyages needed to be described in the database. The greater emphasis given to identifying casualty and battle events from various sources and plotting their location in the GIS was considered important since it reflects at least in part a maritime historical perspective when trying to characterise shipping activity around the coast of England. A high frequency of casualties in any part of the sea may indicate high levels of shipping activity. Similarly with a battle event, there are casualties and losses attributed to that event.
- 7.2.4. The mapping of naval vessel routes was more difficult than initially anticipated. Naval logbooks contained few descriptions of voyages between ports. Naval fleets tended to travel between known anchorages, making the data difficult to map using the routes network initially designed for the GIS. The adaptation of the route network to accommodate naval movements between known anchorages was too time-consuming to initiate within the timeframe of the project although data on anchorage locations has been mapped. Naval battles were however described in great detail in secondary sources and it was possible to gather extensive information relating to battles.
- 7.2.5. The entry fields for battles and journeys were initially recorded within a single form. As the quantity of data recorded for battles increased, it was decided that the fields should be separated into an independent form within the database. The database was adapted to record battle data in greater detail. The new form was created, allowing the entry of information about the nations at war, the commanders of the fleets involved, the starting number of vessels and guns, the vessel and human casualties, battle dates and related fleets to be recorded in more detail (Fig 1, Plate B).
- 7.2.6. The gathering of casualty data independently from the NMR was initiated to increase the data available pre-1730 for the purpose of the project (Fig 1, Plate D). It also provided a basis for comparing data collected with the datasets normally available from UKHO and NMR. The data was gathered and mapped using loose co-ordinates provided or named locations. The points were given 5km buffers to reflect the uncertainty of data. The data was gathered from a variety of secondary sources including shipwreck indexes, and individual descriptions of events published.
- 7.2.7. A relational diagram for the amended database is presented in Appendix 1.

Database population

- 7.2.8. Data was gathered from Southampton University Library, Southampton City Library and Portsmouth City Library, to further populate the database. Due to the difficulty of accessing, reading and translating original pre-1730 documents, secondary sources have largely been relied upon as the main sources of data. The gathering of extensive primary data would be a very slow and time consuming task (fig 2, Plate B&C). The gathering of primary source data during the project concentrated on transcribed records (Fig 2, Plate A). Further population of the database using primary data would require a lot of time to be allocated to the interpretation of primary sources.
- 7.2.9. The problem of data relating to incomplete routes (data that referred to a departure point but did not mention a destination) described in the Progress Report on Recording and Mapping (51552.03) was not solved within the limits of the current project. The mapping of incomplete routes would have required extensive developments to both the GIS and database. It would also have required each route to be given individual treatment when mapped to avoid data misrepresentation. It was therefore decided that it would be of more benefit to the project to concentrate on gathering data pertaining to complete routes for the GIS with additional data for battles and casualties. However data recorded earlier in the project representing incomplete routes can be still be represented within the queries applied to ports and from database queries.
- 7.2.10. Locations described as ‘off Plymouth’ or ‘off Beachy Head’ have, at the present time, been geo-referenced to the same location as ‘Plymouth’ and ‘Beachy Head’. Data has been recorded in such a way that this can be altered retrospectively should clarification be necessary. It was felt that the accuracy of the data suffered no great loss, as these entries generally referred to a vessel anchoring just outside of that location.
- 7.2.11. The Progress Report on Recording and Mapping (51552.03) highlighted the problem of mapping the journey of fleets of vessels of undefined size. The primary purpose behind mapping route information is to reflect the number of records available in the database rather than traffic density recorded within the database. The combination of single vessels and fleets in the same table therefore has no misleading effect on the results of the queries. ArcGIS 8.3 does have the ability to query individual vessel journeys and fleets independently of each other using relational queries.
- 7.2.12. The separation of data into distinct categories containing specifically recorded routes and incompletely described routes would also allow the user to observe trends in the quality of recording of journeys. For example, it may become clear that certain vessel types or vessels from a particular period or trade may have taken particular care in recording their shipping routes. These queries would only be available if the data had been separated into two levels of quality. The assessment of the quality of historical records by querying the data based on the sources could provide a useful insight into the use of pre-1730 data in the assessment of archaeological potential, providing insight into the strengths and weaknesses of different data groups.
- 7.2.13. A protocol has been devised to avoid double entry of data by identifying when a voyage is being recorded more than once. A duplicate record query has been set up within the database to enable individuals to check for duplications of the records entered (Fig 1, Plate C). Duplication may be due to the same source being accidentally recorded twice or may be as a result of the same voyage being referred to in two or more sources.

7.2.14. The majority of the data mapped was drawn using an AutoCAD package, Autodesk Raster Design 3, on Autodesk Map 6. The package is generally better adapted to drawing and digitising work than ArcView GIS 3.2. It allowed the hazards and shipping routes to be drawn and edited more rapidly whilst enabling the overlaying of themes for the purpose of visualisation and digitising. The network of shipping routes had to be designed whilst taking into account natural hazards.

7.3. Mapping

7.3.1. The mapping methodology was discussed during Year 1 but had not been substantially implemented during Year 2. This was the only area requiring significant modification to the methodology. Mapping was initially conducted using a combination of AutoCAD software for drawing and GIS software for buffering, visualisation and querying. The details of the initial mapping methodologies are described in detail in the Progress Report on Recording and Mapping (51552.03). The gathering of themes representing contour lines, hazards and sailing limits was achieved successfully using AutoCAD software. The software enabled data to be digitised quickly and easily from scanned images of charts and superimposed.

7.3.2. AutoCAD was used to produce a series of overlays containing shipping routes, modern high water and low water contours, and a modern 5m contour to allow for an incremental approach in the production of layers compatible with the GIS. The layers used as aids in drawing routes were as follows:

- Port Locations
- Port Locations Labels
- UK High Water and Low Water marks provided by Ordnance Survey
- Modern 5m contours
- 5km from High Water
- Modern and Historical Charts

7.3.3. The project was set up using the OSGB36 datum and British National Grid projection and the different co-ordinate formats for all the data, including the casualties and ports, had to be translated into this in order that it could be mapped in the GIS.

7.3.4. During the development of the GIS, a method for mapping the data had to be agreed. Many different types of data capable of being mapped were identified within the historical archives. The data described both individual voyages and specific events such as battles, casualty events and shipwreck events that could be mapped as routes, points or areas on a map. The method chosen for presenting ship's voyages was agreed during Year 1 of the project. The aim was to map the routes taken by ships travelling around the coast as a line between ports. The lines were buffered to give an indication that the ship route represented more than one possible line of travel. The method for buffering the routes was reassessed during Year 2 as described in the Progress Report on Recording and Mapping (51552.03). This approach could however only be applied to commercial shipping that tended to travel between ports and was recorded by port administration. Little evidence is available for naval voyages or small scale shipping from administrative records pre-1730. The mapping of point data was given further priority during Year 2 due to concerns regarding the biases caused by representation of the ship routes alone.

7.3.5. Due to the enormous quantity of data available, a case study approach was originally applied to the project. During the development of the GIS in Year 2, the study areas were changed to highlight the capabilities of the database and to adapt to the

availability of GIS data which was used to validate the datasets. Although the gathering of route data initially focused on the Solent and Severn Estuary, it was difficult to gather data solely relating to case-study areas due to the scarcity of data capable of being mapped. The GIS data available for comparing the results to was mainly available for the East Coast. The data available for this area included displayed information on vessel traffic journeys, battle and casualty locations recorded in the England's Shipping database, offshore hazards, anchorages, wrecksites and aggregate extraction areas. The study areas were reassessed and now focus on the Solent and the East Coast of England from Norfolk to the South Kent coast.

7.4. Ship Routes

- 7.4.1. The original aim of the project was to design a network of shipping routes, which could be used to visualise the data on shipping movements recorded in the database. The design of a network of routes is a task that has been attempted in the past in order to improve the representation of traffic density around UK waters. To achieve this would however require the collation of datasets that gave a true representation of the balance between the different types of shipping traffic throughout history. Due to the biases in historical records that are evident, this cannot realistically be achieved. The design of a network of ship routes does however have other uses, which improve the assessment of archaeology on the seabed.
- 7.4.2. Certain advantages exist by the portrayal of routes as “obviously artificial”. It is clear that this project will never achieve with any real confidence the definition of all possible actual routes followed by vessels. In this case it is better to make sure that the route system described in this report and setup in the GIS remains clearly artificial and as such will provoke care in the interpretation of the data it provides when used subsequently.
- 7.4.3. The primary purpose of the network is to contextualise the data currently available on wreck sites. By providing a database containing information on the nature of traffic in UK waters and being able to visualise it spatially via an artificial network of ship routes, it is possible to query the database for patterns of information relevant to the wrecksite recorded within a study area. For instance, if the UKHO data collected for an environmental assessment contained a wreck known to have carried wool, it would be possible to view the trade routes for that cargo, the related records available and the importance of that trade for ports at that time. This could be used to characterise the role of the vessel in England's shipping during that period.
- 7.4.4. In addition to providing contextual information on known archaeological features within an area, the ability of GIS to represent density data enables the ship routes to be queried to represent the density of records for any given route.
- 7.4.5. In order to produce a network of ship routes which could give an artificial representation of shipping, using colour coded buffers to represent record density, it was necessary to draw the routes in AutoCAD (Fig 3, Plate A). In order to transfer the data to a GIS, each line segment which made up a route had to be given an ID number. The definition of the GIS route network from port to port using the different ID numbers was completed and buffered using a five kilometres buffer (Fig 3, Plate B).
- 7.4.6. In order to represent the shipping routes described in the database, each individual route of travel has to be defined numerically within the database. A table was completed, to contain ID numbers representing the individual buffer sections which

make up each shipping route. This process was done for all of the routes within the database that could be mapped. The mapping of every route between any two ports in UK Waters was not possible within the time limits of the project. Some routes were added as they became required in the course of populating the database. Once the routes had been defined by a series of buffer ID numbers, they had to be redefined as single buffers. This was a necessary part of building the routes network. The overlapping areas of buffers within a single route would have created faulty values when queried for record density as the overlaps would have been valued as the sum of the two buffers. Although the route reflected a single voyage, each intersection would receive a value of two. The further offshore the routes extended, the more likely they were to misrepresent the possible routes taken by ships. Once constructed, the network was then cut by a fifty kilometre buffer from the coast in order to limit the uncertainty of mapping offshore routes. (Fig 3, Plate C).

- 7.4.7. The process for redefining each route as a single buffer was lengthy but provided an opportunity for quality testing the routes defined. The table containing the buffer IDs in the database was related to the layer of buffers in the GIS, via the ID number. Each individual route then had to be queried out in the database table and related to the routes in order to highlight all of the buffers within that route (Fig 4, Plate A). The highlighted buffers were then saved as a separate layer. The geo-processing wizard then provided a tool to dissolve the buffers into a single polygon (Fig 4, Plate B). Once a series of routes had been separated in this way, they could be merged into a single layer (Fig 4, Plate C), where the attributes for departure, destination and the new route ID number had to be added to the table. This method ensured that only the intersections between two separate routes would reflect increased record density. The individual routes were thus redefined, within the same table in the database, by a single ID number in order to produce accurate representations of the intersections between these routes (Fig 4, Plate D).
- 7.4.8. In order to enable the routes to be queried by record density, the database query had to be relational. The required information relating total numbers of records to each artificial route was contained in more than one table. The ability to undertake relational queries in the database from the GIS is a task which is not supported by ArcView GIS 3.2. It has to be undertaken using ArcGIS 8.3. In order to relate the record densities to the GIS, the table containing the list of routes recorded and the journey IDs had to be joined to the table in the database containing the route IDs. The resulting table could then be queried and related in turn to the layer of route buffers. The layer properties then had to be changed to allow the routes to represent the different counts of journey. The intersections were not however evident from the results. GIS software tends to overlay objects within a layer, with the most recently drawn object overlapping the older objects. In order to obtain the values of the intersections, the layer had to be rasterised. There is currently no other way known for doing this. (Fig 5). A map showing the results of the recorded voyages in a raster format are shown in Appendix 2.
- 7.4.9. The methodology developed to represent shipping traffic contains a majority of records pertaining to commercial and transport records. Extensive documentation is available containing records of cargoes entering and leaving ports, the taxes paid and the quantities transported. Naval movements are not often recorded in port books as they did not carry taxable cargoes. Naval records tend to describe movements between anchorages rather than ports. It was therefore not straightforward to contain the movements of naval fleets and vessels within the system. However this would be possible simply by considering anchorages as quasi-ports. New routes would have to be added to the network and journeys between ports and anchorages would have to be defined individually. Data is currently being gathered on the location of safe

anchorage, which were used throughout history. There may therefore be future opportunities to develop a method for representing the records for naval shipping within the GIS at a later date. Currently the recording of naval data is focused on the mapping of battles and the querying of Navy casualty sites. No data was available on fishing industries, non-commercial transport and private vessel use before 1730 as few administrative records contained information relevant to this traffic.

7.5. Point Data

- 7.5.1. In addition to using the ship routes model and supporting data in the database to show the character of England's shipping, the routes can also be queried with other data available. Such data relates to battles, anchorages, ports and casualty sites and would improve the mapping of data drawn from historical records for which locations have not been specified. The data also allows the observation of hotspots for different types of event in seas around the UK.

Events

Battles

- 7.5.2. The location of battle sites were assessed (Fig 6, Plate A & B) and plotted (Fig 6, Plate C & D) during the project to help identify 'hotspots' in shipping activity and to characterise some of the naval activity recorded in historical archives. Historically Britain was one of the most powerful maritime nations. Until the 16th century and the development of firearms, fleets in battle had to fight at close quarters (National Maritime Museum, Seapower Gallery). The use of fireships was commonplace in naval warfare during the Medieval and Early Post-Medieval periods. The potential for archaeology is therefore based primarily on the loss of vessels or debris during battles. In many cases, vessels were however taken as prizes rather than sunk, as ships were a valuable resource.
- 7.5.3. Many of the maritime battles that occurred around the United Kingdom were concentrated in the English Channel and along the East Coast. Control of the English Channel was an important factor in the economic activity of the country because it allowed control of incoming trade from the Mediterranean and the Caribbean (Lambert 2000). The English, Dutch, French, Spanish and Flemish fleets periodically went to war from the 15th century. Records of these wars and battles were recorded in the journals or letter books of the officials involved.
- 7.5.4. The data used to plot the battle locations came predominantly from secondary sources, which included library and online resources. In some cases, authors provided diagrams and maps, giving approximate positions of battles (Fig 6, Plate A). These however had to be compared to other sources to assess their level of accuracy. Research was also undertaken into primary sources and historical charts to improve the positioning of the battle locations. The battle was plotted as a point interpreted from the text. The points were plotted in the GIS, based on references to direction of travel, line of attack and distances from coast references.
- 7.5.5. Battle sites rarely had accurately recorded locations but were based on sightings along the coast. Battles were not static but occurred sometimes over large areas and were made up of separate assaults. Battles were often plotted as a series of points to reflect the individual assaults rather than trying to define the limits of an area. In addition, to overcome the uncertainty of mapping the points, they were given a 15-km buffer. When the distance of the battle from the shore could not be determined from the text, points were plotted 15 kilometres offshore from the location described in the sources.

- 7.5.6. Discrepancies were often apparent between secondary sources in the locations and dates of battles. For each battle, several sources were studied and the points were plotted based on locations that coincided in more than three sources. Furthermore, to try and qualify the battle locations, they were checked against primary data such as the positions of the English and Spanish fleets on the Robert Adams chart from 1590. Advice was also sought from a maritime naval historian working on a similar project.
- 7.5.7. The quality of data could be improved by looking at Navy logs using the vessel names, event dates and the commanders involved, for vessels involved in battles, to extract more precise descriptions of battle locations.

Casualties

- 7.5.8. Casualties are events that caused the loss or damage of a vessel but not necessarily its wrecking. The data includes vessels that are taken as prizes during battles, and vessels burnt, grounded or cast away. The combination of casualty, wreck and battle data could be used to help identify areas with a higher frequency of events, thereby suggesting higher-shipping activity. Casualty data was gathered because although data was available from the NMR, only a small percentage of the data applied to pre-1730 data. In order to provide a basis for comparing the datasets for the project, it was necessary to gather additional data with a greater focus on pre-1730 events.
- 7.5.9. Data was extracted from secondary sources such as the *'Shipwreck Index of the British Isles'* (Larn, & Larn, 1998), *'Safeguard of the Seas'* (Rodger, 1997), and *'British Warship Losses in the Age of Sail'* (Lambert 2000). Co-ordinates were obtained for most of the secondary data. However they tended to be vague, inferred from historic descriptions rather than based on archaeological evidence. To account for these inaccuracies, the points were given 5 kilometre buffers.
- 7.5.10. Initially the positional data was in Latitude and Longitude format with an OSGB36 projection, so they were all converted to OSGB36 National Grid Easting and Northing prior to being incorporated into the GIS project for querying against other casualty data. The quality of the co-ordinate data varied even within one source so a qualifier was incorporated into the database to state the accuracy of that position.

Locations

Anchorage

- 7.5.11. Anchorages are areas often located along a coastline within bays or areas sheltered from predominant winds, strong currents and turbulent waters, which are known and regularly re-used by vessels for safe anchoring and sheltering from bad weather.
- 7.5.12. According to Navy logs, anchorages were more commonly used for mooring Navy fleets than ports, during military patrols. Historic records show that Naval fleets spent the majority of time travelling along coastlines, between anchorages to defend their country or prepare an attack on an opponent's country or fleet. Few records contain descriptions of naval voyages travelling directly between two ports unless they needed supplies or repairs to the vessels. Anchorages were also commonly used by other shipping traffic such as fishing vessels, commercial trade vessels, privateers and private vessels for shelter or safe moorings.
- 7.5.13. Historical records of anchorages were gathered during the BMAPA project. A comparison of the data with modern anchorages provided by Metoc plc showed a strong correlation between the two datasets, suggesting that the locations of safe anchorages today are much the same as they were during the Medieval and later

periods (Fig 7). Further descriptions of anchorage locations may be drawn from historical primary sources.

- 7.5.2.4. Anchorages were mapped because they would have been repeatedly occupied by vessels, sometimes during storms, and therefore could potentially be areas where archaeological potential may be higher. Regular occupation of these areas would increase the likelihood of finding vessels that had sunk in bad weather despite seeking shelter, and debris discarded or dropped from ships.
- 7.5.14. Historical charts were studied to ascertain whether anchorages were mapped before 1730 (Fig 8). Charts of the Solent showed anchorage symbols as far back as the 1400s. For this project, the data for historical anchorages was studied to assess the possibility of mapping the anchorage locations for recorded naval movements.
- 7.5.15. Although modern anchorages are mapped on hydrographic charts, and are sometimes described in greater detail in nautical almanacs, they are in many cases represented by a single symbol, giving no indication of the safe limits of the areas. They therefore needed to be mapped as buffer zones around these points in order to give a representation of the areas of safety. The anchorage points were given a 1 km buffer. Research into historic evidence for anchorages revealed that sources were available for the 17th century pilot books. However, the amount of work required to gather the data would be time-consuming and require further developments to the project parameters. For the purpose of this project, anchorage data has therefore been mapped from modern sources, on the basis that many of the safe havens within the cast-study areas would have remained the same.

Ports

- 7.5.16. The names of historic ports in the UK were provided by the National Monuments Records (Fig 9). The list contained ports for which a history of maritime activity had been recorded. Co-ordinates were generated through the Ordnance Survey mapping facilities on the Internet.
- 7.5.17. These points not only provided reference points for other features, they could also be queried for record density. The records which did not have a departure and destination and were therefore not reflected in the route queries recorded could be queried through the ports as either incoming or outgoing traffic. The representation of port size gave a more accurate representation of the activity within a port and could be used to support or contradict the record density queries to identify gaps in the data. With further population of the database and the recording of data summarising the importance of port activities, the querying of data recorded could provide a more balanced representation of the density of traffic travelling along a port approach, which could highlight areas of heightened maritime activity inshore.

Additional Datasets

Metoc plc SeaZone products

- 7.5.18. Additional datasets were imported to provide a structured background to the analysis of historic data. In order to ensure that the data for the contour lines and coastline were of an officially recognised standard, the data was purchased from Metoc plc. Metoc recently launched a project called SeaZone; a partnership initiative with the commercial arm UK Hydrographic Office (known as Admiralty Holdings), that provides fast and easy access to marine data in a GIS format. The data for wrecksites contained in the UKHO wrecks database, were also bought in a GIS format from

Metoc, along with data for licensed dredging areas, anchorages and dangerous currents (Fig 10, Plate A).

- 7.5.19. The standards for mapping data vary from one organisation to the next due to discrepancies in the co-ordinate systems used by different mapping organisations. Within the UK alone, mapping and charting organisations such as Ordnance Survey, the British Geological Survey and the UK Hydrographic Office, provide land maps, nautical charts and geological maps using different mapping co-ordinate systems. The data was mapped using the Ordnance Survey datum, OSGB36, in accordance with predominant co-ordinate system used in archaeology. The data provided by Metoc was displayed in OSGB36 in order to maintain this standard.

BMAPA

- 7.5.20. GIS datasets from the project “Aggregate Dredging and the Historic Environment”, undertaken for the British Marine Aggregate Producers Association (BMAPA) were also used to compare the data and methods employed during the project. These datasets included aggregated casualty data from the National Monuments Records office, historical anchorages and hazards which had been digitised from historic charts (Fig 10, Plate B). The NMR data was plotted as a series of named locations to which events described in archives had been related. The data was not however limited to records before 1730.
- 7.5.21. The Casualty data made available for the BMAPA project by the NMR was divided between time periods. It was therefore difficult to identify the dataset relevant to pre-1730 shipping. Further enquiries had to be made to get the figure of records available for the point data case-study area.

8. RESULTS

8.1. Introduction

- 8.1.1. The results of the project comprise both methodological results from the development of the system and statistical results that are based purely on output from the current system and the data within it.

8.2. Methodological Results

- 8.2.1. A methodology has been produced which enables pre-1730 data on shipping movements around the English coastline to be gathered from historical records, stored, queried and exhibited spatially so that the data can be used in the assessment of archaeological potential. This will provide opportunity to reduce the bias in archaeological data currently used in maritime archaeological assessments for the purposes of Environmental Statements.
- 8.2.2. The methodological results comprise the successful creation of a system able to support all types archival information pertaining to England’s shipping. The flexibility of the querying facilities enables the extraction of data in a way that improves the characterisation of England’s shipping both pre-1730 and, due to the previous lack of data for these periods, also improves access to data as a whole.
- 8.2.3. The routes network has a number of different uses, which, when combined with current data available from UKHO and the NMR, can improve the quality of archaeological assessment applied to any given area.

- 8.2.4. The first feature of the system is its ability to search for information matching characteristics identified on wreck data located within the study area. The ability to search for other similar vessels, transport of similar cargoes, patterns of shipping of the same nationality, etc, enable the user to make a more informed assessment of the archaeological value of the wrecks identified on the seabed.
- 8.2.5. Another feature is the user's ability to extract information on the character of shipping (and predominant trade) travelling through an area. The database contains large quantities of data on vessel types and characteristics, traded goods, people such as masters, merchants and owners.
- 8.2.6. A further feature is the ability to reflect record density, providing a quick and easy resource for assessing how much data has been recorded for a port or route and which sources contain it.
- 8.2.7. Further information gathered on the quantities of cargoes transported to and from ports is available from archival sources although only a small quantity of data contains information on both departure and destination locations. Further gathering of this data would provide a clearer reflection of the importance of ports between different periods. The use of this data in combination with the routes data may provide further insight into the likely density of traffic between two ports, based on their commercial or military importance.
- 8.2.8. Although the routes network can provide a reflection of the record density for routes between ports, the dataset currently gathered is too small to make any assumptions regarding the density of traffic through areas of sea. The quantity of trade remains inaccessible; however, the development of the database to incorporate further data on cargoes arriving and departing would provide further insight into the quantity of traffic travelling to and from a port.

8.3. Analytical Results

Contents of the Database

- 8.3.1. Much of the effort involved during the project has been directed at the design and building of a structure to enable information about the ship movements to be collated from the various sources, queried and then displayed in a GIS system, in the form of a 'digital atlas'.
- 8.3.2. At this stage the data collected is not as comprehensive as it might be and plenty of scope exists for additional data to be added to further populate the database.
- 8.3.3. The data collated so far does however already allow a better approach to be made to the assessment of archaeological potential and certainly provides a context for existing sites.
- 8.3.4. A clear way of demonstrating the value of England's Shipping is by presenting a number of case studies that relate to archaeological assessments previously undertaken for the purposes of environmental assessment ahead of aggregate dredging activity off the south coast of England. The assessments made comments about the potential for submerged archaeology and these comments are reviewed below in the light of additional data now available within the England's Shipping database.

8.3.5. A summary of the data collected for England's Shipping appears below:

Shipping voyages	(Total 1294)
Single vessels	855
Groups of vessels	149
Fleets	290
(Total number of ships)	(3925)

Voyages Recorded as a result of:	
Trade	441
Trade convoy	25
War	267
Naval patrol	53
Naval passage	137
Blockade	17
Supply	26
Privateering/Piracy	17
Settlement	6
Raid	16
Other	4
Unknown	239

Ports	493
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Events	
Mapped battle sites	34
Total Pre-1730 recorded casualties	569
Mapped casualty locations	296
Vessels that have been lost as a result of battle	513
Overall number of vessels recorded with cargo	1084
Single vessels with cargo	1052
Fleets with cargo	27
Groups of vessels with cargo	5

Sources	307
Primary Sources	246
Secondary Sources	53
Online Sources	8

Table 2 : Contents of the database

8.3.6. The number of records relating to routes and ports were assessed in the GIS and the datasets were compared to highlight the difference between the number of records capable of being mapped and those only accessible through the querying of ports. The data was divided by century to give an indication of the ports for which more data was available from one century to the next (Fig 12).

8.3.7. Before the 15th century, Southampton and Hull were the most recorded ports, while the majority of trade for that period was recorded between the Solent and the

Mediterranean (Fig 12, Plate a & B). From 1500 to 1599, very little data was recorded. Portsmouth was the port most recorded and was also shown to have trade relations with the Mediterranean (Fig 12, Plate C & D). From 1600-1699, Southampton, Plymouth and Bristol were recorded as popular trading ports. The routes analysis showed the majority of complete records to have been recorded between ports on the East Coast (Fig 12, Plates E & F). From 1700 to 1799, the results were fragmented with few ports showing high numbers of records (Fig 12, Plate G & H). This is likely to be because the focus of the project was limited to pre-1730 shipping, thus limiting the number of records entered for this period. All of these results are biased to some extent by the sources used to populate the database. However, although the majority of records were incomplete, there remains a noticeable correlation between the results of the number of movements shown using the routes network and the records of both complete and incomplete journeys shown by the port queries.

- 8.3.8. All of the datasets collated were overlaid with the current licensed dredging areas to evaluate the areas most affected by the wreck data, and the battle data and routes network mapped during the project (Fig 12). The dredging areas off the East Anglian and Norfolk coast were most affected by the wreck data hotspots and the battle locations mapped during the project. The routes network intersected with some of the dredging areas, though this currently bears no significance in terms of the potential for archaeology, related to traffic density. The dredging areas on the south coast were mostly located near the entrance to the Solent, which is heavily populated with ports and their approaches. These areas are therefore heavily intersected by the artificial network of ship routes. The dredging areas least affected by the additional data collated and mapped are the areas off the approaches to the Humber estuary, although Hull was shown to have been an active port during the Early Medieval Period, pre-15th century. Further population of the database may show that Hull and its surrounding ports exhibited a level of activity which would affect the potential for archaeology for those areas.

Demonstrating the value of England's Shipping data

- 8.3.9. In order to illustrate the application of the England's Shipping GIS and demonstrate how the additional information made available will allow a better assessment of archaeological potential, assessments for two dredging areas off the south coast of England previously undertaken by Wessex Archaeology were revisited as case-studies. Both of the original assessments relied on existing wreck data from the UKHO and the NMR on which to base the assessment of maritime archaeological potential.
- 8.3.10. England's Shipping allowed an analysis of the number of recorded ships entering and leaving nearby ports to provide direct evidence of shipping activity in the immediate vicinity of the dredging areas and the network of ship routes was used to contextualise the pre-1730 wrecks in terms of the character of historical shipping.

8.4. Case-Study 1: Aggregate Extraction Area 407 - St Catherine's, Isle of Wight.

Introduction

- 8.4.1. The first case-study area chosen was located to the South East of the Isle of Wight. An Environmental Assessment was undertaken in 1998 to assess the potential for archaeology within the proposed dredging area (Wessex Archaeology, 1998).

Original assessment - submitted in August 1998

- 8.4.2. The results of the assessment highlighted one known site within the area itself, the wreck of a 3000-ton merchant ship built in 1903 and torpedoed in 1917. A second wreck of interest, the submarine *Swordfish*, was located off St Catherine's Point but her exact position had been kept secret.
- 8.4.3. The discussion of potential for archaeology remained tentative in the assessment, based primarily on the listing of known wreck sites and casualty sites recorded by the NMR. Paragraph 2.4.7 noted that, "*An analysis of the dates of loss of the known casualties shows a strong bias to recent, predominantly Post-Medieval and Modern periods.*" This bias was attributed to the systematic recording of casualties during the period since 1700 and the focus on identification of metal wrecks.
- 8.4.4. The wreck and casualty data recorded during the original assessment contained 273 records of which 17 were pre-1730. Eleven sites were NMR casualty sites, none were taken from UKHO records and the remaining records were drawn from the records of the Archaeological Diving Unit (ADU) and from Pritchard and MacDonald (1991).
- 8.4.5. The summary suggested that the archaeological potential for the area comprised, "*a series of known wrecks, only some of which had been identified; a number of documented losses which may lie within Area 407; unknown and undocumented wrecks dating back to the Iron Age or earlier; and stray finds of shipborne debris from various periods.*" The majority of information available related to modern shipping.

Revised assessment - with the benefit of England's Shipping Data to date

- 8.4.6. The analysis of the data available for the area, using the records in the England's Shipping database, provided considerable additional data, particularly with respect of pre-1730 shipping for which little archaeological evidence is currently available.
- 8.4.7. A comparison of the records with the data collated for pre-1730 casualties showed a significant improvement in the data available. No additional points were identified within the area but a larger number of casualties pre-1730 were recorded in the vicinity (Fig 13, Plates A and B). A further four UKHO wreck sites were recorded which had been listed in the original report under other sources.
- 8.4.8. The data recorded in the database contained additional information on the nature of shipping and trends in trade relations which can help indicate the value of wrecks as representatives of the nature of shipping in that area, ie helping to ascertain archaeological importance.
- 8.4.9. The complete traffic data recorded travelling through or near the study area focused on long distance commercial traffic, travelling from Southampton to other parts of the UK coast or down towards the Mediterranean. Two of the sites recorded in the Environmental Assessment were Spanish merchant vessels. The presence of these sites was reflected in the numerous records of trade between Southampton and the Mediterranean recorded during the pre-15th century. Trade was recorded between

Southampton and Spanish ports such as Santander, San Sebastian, Majorca and Castile during the 14th and 15th centuries. During this period, Southampton was a major exporter of wool to the Mediterranean in return for wine (Platt 1973).

8.4.10. An evaluation of the traffic recorded as entering or leaving the ports within the local area was undertaken. The main ports of interest were Southampton, Portsmouth, Poole, Yarmouth, Lymington, Calshot, Waterford, Milford and Chichester (Tables 3 & 4). The results were highest for Southampton and Portsmouth and showed that high levels of shipping traffic were recorded entering and leaving the Port of Southampton before the 15th century. The level of traffic recorded leaving Southampton was much higher (97%) than the number of vessels recorded entering the port (89.5%) during this period (Fig 14, Plates A and B).

Ports IN

Location	Easting	Northing	PRE15	15_16	16_17	17_18	POST_18	TOTAL
Poole	401110	90272	6					6
Portsmouth	463420	99810	7		59	4		70
Southampton	442020	111010	69	3	4			77
Yarmouth	435445	89660	3					3
Calshot	447480	101510	1					1
Lymington, Hampshire	432770	95600	1					1
Chichester	486500	104500		36				36
Waterford	433410	94890	1					1
Milford	429600	91000			2	2		4

Ports OUT

Location	Easting	Northing	PRE15	15_16	16_17	17_18	POST_18	TOTAL
Poole	401110	90272	5					5
Portsmouth	463420	99810	3		133			136
Southampton	442020	111010	443	5	7			456
Yarmouth	435445	89660	1		1			2
Calshot	447480	101510	1					1
Lymington, Hampshire	432770	95600	1					1
Chichester	486500	104500		36				36
Milford	429600	91000			3	1		4

Tables 3 & 4: Numbers of records contained in the database entering and leaving ports discussed in case-study 1

8.4.11. Portsmouth was recorded as being a popular trading port during the 16th century (84% of incoming traffic and 98% of outgoing traffic) although no complete routes have been recorded in the database and are therefore not reflected in the journeys recorded in the routes model.

8.4.12. The potential for wrecks was discussed in the Environmental Assessment of the area. It suggests that shipping traffic was likely to have travelled through the study area from the Iron Age onwards and that some vessels may have foundered within Area 407. The additional data in the England's Shipping database supports this. The high number of archival records gathered for shipping movements for Southampton and Portsmouth shows that the ports were important maritime trading centres from the Medieval Period. Secondary sources supported the importance of these ports through later centuries. Further population of the database will reduce the biases in results currently seen, reducing the need to refer to secondary sources.

8.4.13. Although none of the routes defined travelled through the dredging area, they are designed to give a representation of the maritime activity in the area. Despite the limited population of the database, it is clear that the Solent area was an important area of maritime commercial and military activity before the 18th century, suggesting higher potential for archaeological debris in the area.

Name of Battle	War	Date	Casualties	comments
Battle of Beachy Head	War of the English Succession 1689-97	30 June 1690	6 English ships were destroyed, including one that was burnt and five that were sunk.	discrepancy in dates
Battle of La Hogue 1	War of the English Succession 1689-97	29 May - 3 June 1692	Three vessels including Tourville's flagship which anchored in the harbour of Cherbourg. vessels were burnt and sunk	discrepancy in dates
Battle of La Hogue 2	War of the English Succession 1689-97	29 May - 3 June 1692	Three French vessels including the flagship were sunk	discrepancy in dates
Battle of La Hogue 3	War of the English Succession 1689-97	29 May - 3 June 1692		discrepancy in dates
Battle of La Hogue 4	War of the English Succession 1689-97	29 May - 3 June 1692		discrepancy in dates
Off Dunnose Head	Spanish Armada	25 July 1588		
Off Portland Bill	Spanish Armada	23 July 1588		
Battle of Portland / Three days battle	First Anglo-Dutch War	18-20 February 1653	Dutch losses included 11 warships and 30 merchantmen. Nearly 2000 crew were killed.	discrepancy in dates

Table 5: Battles discussed in case-study 1

8.4.14. The Environmental Assessment undertaken for Area 407 listed stray finds of shipborne debris as part of the potential archaeology suggested for the area. The collation of information on battle sites and the characterisation of shipping activity helps specify the sources of potential debris in greater detail. The location of three battle sites in the vicinity of the area and the extensive area over which naval conflict often took place, increases the likelihood of battle related debris such as ordnance, and in some cases, ship remains to be found. Further information on casualty events, which has to be drawn from archival records, and a better understanding of the character of historic shipping in the area will also inevitably improve the characterisation of the potential related debris to be found on the seabed.

8.4.15. The GIS showed that the Southern English Channel was a regular naval battlefield from the Medieval period. Nine different battle locations were mapped within a hundred kilometre radius of Dunnose Head, on the Isle of Wight (Table 5). The war of English Succession was fought across the Mid-Channel area. The battle of La Hogue was fought in May 1692 off the French coast, to the south of the study-area. On the 30 June, the navies fought again at the Battle of Beachy Head, to the East of the study-area. It is likely that the fleets would have either been active over the study area at some point during the conflict. The second engagement of the Spanish Armada took place off Portland Bill, while the third battle was fought off Dunnose Head, Isle of Wight. The estimated location of the battle was located within 90 kilometres of the study area. Both battles were fought over a period of three days. The only recorded casualty was the *Santa Anna*, grounded outside Le Havre. During the Spanish Armada expedition, over 20 vessels were lost in the Channel. The grounding of a vessel of Le Havre during the Battle off Dunnose Head shows that the area over which the battles were fought was extensive and could potentially had an impact on the archaeological

potential of study area 407. No vessels were recorded as lost within the study area (Fig 15).

- 8.4.16. The results for the ports within the study area show that Winchelsea had the highest frequency of shipping traffic pre-15th century, of which there were more recorded inward journeys than outward journeys in the same period. The only record for which there is data available post the 15th century is Dungeness that had records for outward traffic only in the 17th century. It is therefore very likely that the activity of the nearby ports and the shipping traffic would have contributed to the archaeological record within the study areas.

8.5. Case-Study 2: Hastings Shingle Bank

Introduction

- 8.5.1. The second case-study area chosen was located to the south east of Hastings, on Hastings Shingle Bank. An Environmental Assessment for this proposal was initially undertaken in April 2000 to assess the potential for archaeology within the suggested dredging area. The high number of reported obstructions in and around the area led to a survey of the area in October 2001 using side-scan sonar. In January 2003, a diver inspection was undertaken to assess the nature of some of the anomalies identified by the survey.

Original Assessment – submitted April 2000

- 8.5.2. The results of the assessment highlighted one known and located wreck site within the extraction area itself and seventeen further wrecks were recorded within the inner and outer study areas (Wessex Archaeology 2000). All of the known and located wrecks were dated to the mid 19th century and later and generally of steel construction. Another wreck of known location was identified within the extraction area, along with a further eighteen wrecks for which the location was not confirmed. High numbers of obstructions were reported by fishermen for this area. The reason for the high numbers of wrecks and obstructions can be partly attributed to naval warfare activities within the channel during the first and second World Wars.
- 8.5.3. The summary of the assessment suggested that the potential comprised:
- six wrecks and obstructions within the proposed extraction zone, along with three reported casualties;
 - a further seven wrecks and obstructions in the Inner Marine Study Area, two of which were within 100m of the proposed extraction area;
 - eighty-nine wrecks obstructions and casualties in the Outer Marine Study Area;
 - possible unknown and undocumented wrecks from various periods dating back to the Iron Age or earlier, and;
 - possible stray finds of ship-borne debris from various periods.
- 8.5.4. A series of mitigating measures were proposed along with the suggestion that existing geophysical data for the area should be scanned to identify other features that may be of archaeological interest.

Geophysical Survey Analysis– October 2001

- 8.5.5. Following a later revision of the proposed extraction area, a second report was produced to assess the survey data available and revise where necessary the mitigating measures proposed in the desk-based assessment (Wessex Archaeology 2001).
- 8.5.6. The data from three geophysical surveys was made available to Wessex Archaeology. Further high-resolution side-scan surveys were then undertaken for targets highlighted during their assessment.

Archaeological Diving Inspection – January 2003

- 8.5.7. A diving inspection was undertaken on seven of the anomalies identified during the analysis of survey data. The diving was undertaken in order to ground-truth and interpret the anomalies that were seen, and produce an interpretation of their archaeological value. Five objects were located and assessed during the inspection. All of the archaeological evidence found dated to the late 20th century (Wessex Archaeology 2003).

Revised assessment - with the benefit of England's Shipping Data to date

- 8.5.8. The analysis of the data available for the area, using the records in the England's Shipping database, provided considerable additional data pertaining to the periods pre-1730. None of the wrecks recorded in previous assessments were dated before the mid-19th century (Fig 16).
- 8.5.9. An assessment of the route network showed no complete routes recorded in or out of Winchelsea, Dungeness and Hastings although port traffic were reflected in the assessment of records for incoming and outgoing traffic. Traffic was recorded passing through the area. Twenty vessels travelling between Southampton and Sandwich were recorded during the pre-15th century period. The artificial ship route intersected significantly with the proposed extraction area. Though not a true representation of the routes taken by historical shipping, the route drawn does provide a representation of the routes taken that is based on the avoidance of hazardous seabed areas. The dredging area lies within a distance from the coast that suggests that it would have been regularly crossed by coastal shipping traffic. The number of wrecks recorded in the study areas supports this suggestion. Although only modern wrecks were identified during the desk-based assessment, traffic in the southern channel was likely to have been extensive at least from the early Medieval period.
- 8.5.10. An assessment of the traffic recorded for ports within the area was undertaken. The ports with the highest records of traffic data were Winchelsea, Dungeness and Hastings. Other locations outside of the case study area including the Downs, Dover and Sandwich also reflected traffic records. The results from these port locations have been summarised in tables 6 & 7.
- 8.5.11. Winchelsea had the highest frequency of shipping traffic pre-15th century and there were also more recorded inward journeys than outward journeys in that time. The only record for which there is data available after the 15th century is Dungeness - for which the project only had records for outward bound traffic in the 17th century. An assessment of the ports outside of the case study area was undertaken because of the route running through the study area. The assessment showed that the Downs, Sandwich and Dover also contained recorded traffic data despite not having complete routes to these ports (Fig. 17). Sandwich and Dover also contained recorded traffic data. Sandwich had the highest frequency of activity in pre 15th century with journeys into the port, while very few were recorded out of the port on an outward journey.

Between the 16th and 17th centuries the Downs recorded the highest frequency of outward journeys. This might suggest that the Downs were probably used more as an anchorage in the later periods.

Ports IN within the Case study areas

Location	Easting	Northing	Notes	PRE15	15_16	16_17	17_18	POST_18	Total
Winchelsea	590500	117500		9					9
Hastings	582490	109326		1					1
Hastings	582640	109210	East Sussex	1					1
Downs	642175	152187		0	0	2	3	0	5
Sandwich	632975	158300		20	0	0	0	0	20
Dover	632100	141200		2	0	2	0	0	4

Ports OUT within the Case study areas

Location	Easting	Northing	Notes	PRE15	15_16	16_17	17_18	POST_18	Total
Winchelsea	590500	117500		5					5
Dungeness	609300	116740				6			6
Hastings	582490	109326		1					1
Hastings	582640	109210	East Sussex	1					1
Downs	642175	152187		0	0	52	4	0	56
Sandwich	632975	158300		4	0	0	0	0	4
Dover	632100	141200		0	0	3	0	0	3

Tables 6 & 7: Numbers of records contained in the database entering and leaving ports discussed in case-study 2.

8.5.12. The battle data collected for the surrounding area showed the study area to be located between three battle locations (Fig 18) The Battle of Winchelsea would have occurred to the West the study area, while the Battle of Beachy Head and Dungeness occurred to the East of the study area. In an evaluation of other battle locations in relation to the case study area, more battles were identified around the Downs and off the East Coast Kent and these included some of the major engagements of the Anglo-Dutch wars of which there are recorded losses on both sides. A further nine battles took place further East of the study area. These have been summarised in table 8.

8.5.13. The frequency of the battles in close proximity to the study area is more than likely to have affected the archaeological potential within the study area. This is due to the fact that the major engagements often resulted in voyages of a large number of vessels (up to a hundred vessels on each side) in a fleet to and from the naval battle sites. Also during battle, vessels are damaged or sunk altogether, adding to the archaeological record. Some of the losses that occurred with this region included fireships, which were frequently used during naval battles in the Anglo-Dutch wars, and warships.

	Name of Battle	War	Date	Casualties	Comment
1	Battle of Winchelsea	100 Years' War	29/8/1350	English losses included one vessel that was sunk and the Spanish lost twenty vessels that were all taken as prizes.	Discrepancy in dates
2	Battle of Beachy Head	War of the English Succession	10/7/1690	6 English ships were destroyed, including one that	Discrepancy in dates

				was burnt and five that were sunk.	
3	Battle of Dungeness	First Anglo-Dutch War	10/12/1652	English losses included three that were sunk, one that sustained damage (TRIUMPH, who mast was shot away) and two that were taken as prizes (GARLAND and BONAVENTURE). The Dutch losses included 1 vessel that was sunk.	Discrepancy in dates
4	Spanish Armada, off Calais	Spanish Armada	6/8/1588	The Spanish were anchored off Calais when English fireships were sent in, this resulted in panic but the Spanish fleet lost no ships.	Discrepancy in dates
5	Spanish Armada, off Gravelines, France	Spanish Armada	8/8/1588	4 Spanish vessels were sunk during final engagement between the English and Spanish fleets.	Discrepancy in dates
6	Battle of the Downs	The Franco-Spanish War	11/10/1639	Sources record the Spanish as being annihilated, over 7000 people were killed but there are no precise numbers of the vessels lost.	Discrepancy in dates
7	Battle of Goodwin Sands/Battle of Dover	First Anglo-Dutch War	29/5/1652	2 English vessels were lost at this opening engagement of the First Anglo-Dutch war.	Discrepancy in dates
8	Four Days' Battle	Second Anglo-Dutch War	11/6/1666 to 14/6/1666	17 English vessels were lost compared to the Dutch 6 vessels. Also 8000 English naval soldiers were killed compared to the Dutch 2000 soldiers.	Discrepancy in dates
9	St. James Day Battle	Second Anglo-Dutch War	4/8/1666 to 5/8/1666	One English vessel was sunk and 20 Dutch vessels were lost. Also The 4000 crew were killed and 3000 were wounded.	Discrepancy in dates
10	Battle off Sandwich/Battle of Dover	100 Years' War	24/8/1217	65 French vessels were taken as prizes.	Discrepancy in dates
11	The Dutch in Chatham	Second Anglo-Dutch War	19/6/1667 to 23/6/1667	No exact record of the number of losses, however several vessels were sunk to act as a blockade to the Dutch encroaching up the estuary of the Thames.	Discrepancy in dates
12	Response to the attack by the Dutch in the Medway	First Anglo-Dutch War	23/7/1667 to 26/7/1667	No record of the number of vessels lost, although the English fireships sent into action were unsuccessful.	Discrepancy in dates
13	Battle of Kentish Knock	First Anglo-Dutch War	8/10/1652	Three Dutch Ships were sunk.	Discrepancy in dates

Table 8: Battles discussed in case-study 2

8.5.14. Recorded battles are known to have occurred in the case study region, thereby increasing the likelihood of archaeological material on the seabed due to the damage and loss of vessels during battle. The data from the England's Shipping project has also highlighted the traffic frequency of ports within and outside of the case study areas and showed that Winchelsea had the highest frequency of vessels in and out of the port pre15th century but declined after that date. Similarly Sandwich possessed

the highest frequency of inward journey pre 15th century but again declined post this period and moved towards the Downs.

- 8.5.15. The combination of data for battles and shipping traffic for the Hastings Shingle Bank suggests that the levels of maritime activity around the ports in the area and along the coast were much higher than was previously reflected in the original reports. Although no known evidence for archaeological sites was identified for pre 1800 shipping in the area, the potential for unknown archaeology from earlier periods in the study area is high. The number of obstructions recorded by fishermen was also high in the study area. Those posing a possible hazard or of likely archaeological significance were investigated visually. However, numerous other objects located by fishermen were not identified in the side-scan data assessed in 2001. It is possible for some of these anomalies to have been related to earlier shipping and later reburied due to sediment movement.

8.6. England's Shipping and the Development of Archaeological Assessments

- 8.6.1. The primary application of the data gathered for England's Shipping is to overcome the bias towards the analysis of post-1700 shipping currently seen in Environmental Assessments.
- 8.6.2. The assessments of archaeological potential for shipping-related archaeology are currently based on the records provided by the NMR and UKHO databases. The information gathered from historical archives on battles, traffic between ports, and pre-1730 casualties provides a new basis for discussing the potential for archaeology that is not reflected in the current archaeological record. The data collated for the project focuses on a period for which little data was previously available, enabling the user to be better informed about events relating to earlier shipping activity.
- 8.6.3. By providing contextual information on the traffic and therefore on the wrecks identified, it allows users to establish what might constitute atypical vessels from those associated with more general shipping travelling through the area and which characterise shipping during their period.
- 8.6.4. A better understanding of the character and quantity of historical shipping will lead to a better understanding of the potential for archaeology. The route data provides a useful tool for representing maritime relationships between ports. The analysis of the port data will in time provide a better representation of traffic density for the seabed on the approaches to ports.
- 8.6.5. The network of routes drawn to provide a structure for recording ships voyages geospatially was not designed to give an accurate reflection of where vessels travelled historically. The network represents a tool for use primarily in representing relationships between ports and reflecting the quantities of records contained within the database. The routes network was given a limit of 50 kilometres from the UK coastline.
- 8.6.6. Over 90% of the data recorded in the database contain incomplete information on the routes travelled by vessels. In most cases, the destination was recorded because vessels were registered in port books on arrival. However, the lack of information on the departure point of these vessels made it impossible for the journeys to be represented using the ship routes model. Querying the ports for density of records for traffic entering and leaving ports only requires either a departure or destination point. The results of the queries applied to the port data, represented by graded points,

therefore give a better representation of the traffic density recorded in the database than the representation of shipping using routes. The ship routes network is however a necessary tool when representing the transport of cargoes and the relationship between ports.

- 8.6.7. The data provided in the database enables the researcher to increase the quality of discussion of the potential for pre-1730 shipping-related archaeology on the seabed for un-located events, unknown events and debris from events.

9. DATA ACCESSIBILITY

- 9.1. Access to the data in the database initially required an understanding of MS Access software in order to design queries to extract data required during environmental assessments. In order to make the data more accessible to the user, a series of query forms were designed to enable direct access to records. The information most required to complement data currently available for environmental assessments are the location of records on individual vessels relating to journeys, ports, battles and casualties, the proximity of battle sites, the trends in journey types (trade, warfare, exploration etc.) in relation to nationality and the movement of cargo types by period. Three query forms have been created in order to extract information on voyages, ports, battles and casualties (Fig 19).
- 9.2. The query table for voyages allows the extraction of data by vessel name, vessel type, nationality, journey type, departure and destination locations, period or date. The data can also be queried using a combination of these fields. The resulting data is presented in a table where each record has a link to view the complete data form. Data can be extracted for representation as graded point sizes for port locations by selecting either departure data, destination data or the total vessels travelling to and from port. To represent voyages as routes, both departure and destination must be defined. The traffic recorded can also be queried through ports to extract information on vessel types, nationality, period, propulsion and traffic relating to battles.
- 9.3. Searches for casualty records can be undertaken for individual vessel names, propulsion method, vessel type, nationality, manner of loss and period. To access the complete record for the event, the voyage record must be viewed in association with the casualty query result.
- 9.4. The records for battle sites can be queried using the battles query form. The results of queries by individual war, battle name, location description, nationalities involved and filtering by period are presented both in a tabular format and spatially. In ArcView GIS 3.2 the results are available as shapefiles. Development of a query pop-up form will allow the results to be automatically presented in the GIS whilst allowing the data from the database to be viewed.
- 9.5. The database has been queried to extract the filtered datasets listed above to demonstrate the ability of the system. The results of the queries can not be considered to provide a basis on which to make statements on the character of England's Shipping as they are based on a sample dataset and therefore contain biases. The current results have been saved as individual shapefiles in the GIS and the resulting screen captures have been made available within the image gallery provided on the project CD-ROM.

- 9.6. The development of a user interface for the GIS will enable the queries to be made directly from the GIS, making the data more accessible in its spatial format to the end user. This can be done by creating a simple query pop-up box in the GIS which enables the user to request data containing specific attributes. The results can then be illustrated directly in the GIS along with the related data from the database. This work is currently in progress.
- 9.7. The querying of cargo data is achievable to a degree within the remit of the project. Trial queries have been created to illustrate the potential of the system. However, extensive querying of data based on cargo is currently outside of the capability of the current software and further development of the system would be required to enable it to cope with the numerous cargo types contained in the NMR's MIDAS compliant word list.
- 9.8. The final product of the GIS and related database has been designed to remain as user-friendly as possible, to reduce the requirement of users to have previous technical experience in the use of GIS and database software. The final versions of both the database and GIS will contain individual user interfaces for accessing filtered data, along with guidance on the extraction of data and the entering of further data into the system.

10. OUTREACH

10.1. Website

- 10.1.1. Information about the project was required to be disseminated to the wider public through project web pages attached to Wessex Archaeology's website. A brief overview of the project was provided for the website during Year 1. The project has now been presented in more detail and will be further updated to reflect the results of the project. Links will be made available to EH/BMAPA websites as required.

10.2. Seminars

- 10.2.1. A seminar was held in November 2003 to present the four ALSF projects, run by Wessex Archaeology, to postgraduate students in Maritime Archaeology from the University of Southampton.
- 10.2.2. A further seminar has been scheduled to take place at the Annual Conference for the Institute of Field Archaeologist in April. This will provide the opportunity for open discussion of the project with a wide audience of archaeologists and GIS specialists.

11. CONCLUSIONS

- 11.1. Statements about archaeological potential written during Environmental Assessments are currently undertaken in two parts. First, they contain a discussion of the potential for submerged prehistoric landscapes, based on the analysis of known coastal settlements in combination with geological and topographic data, and estimated changes in sea-level. The second part encompasses a discussion of the potential for wrecks and artefact scatters, based on the study of known wrecksites recorded in the database at the UK Hydrographic Office, of casualties recorded by the National Monument Records office, and in some cases, additional secondary source data.

- 11.2. Both the records at the UKHO and the NMR however reflect a bias towards post-1700 records, which is normally attributed to the development of systematic recording of casualties after 1700 and the technological and administrative progress made in hydrographic surveying. In order to reduce this bias, further assessment of pre-1700 evidence for shipping must be undertaken. Little archaeological information is currently available on maritime archaeology before the early 18th century. However, extensive administrative records were kept from as early on as the 12th century. A source appraisal showed that large amounts of information from primary and secondary sources are available but that the data is often slow to interpret, often incomplete, and difficult to map.
- 11.3. The development of the database has provided a basis for collating this information into an accessible format, making it easier to draw information period by period. The reliability of the data will depend inevitably on the quality and quantity of data entered. By combining the information available from the NMR and encouraging the public to produce additional information, structured within a form designed from the database, any further data collated will improve the quality of results.
- 11.4. The use of England's Shipping will provide a more balanced representation of the quantity and character of archaeological potential by enabling the discussion of the potential for wrecks as far back as the early Medieval period. The data contained in the database also provides a representation of the character of shipping in an area, which allows the wreck and casualty data provided by the UKHO and NMR to be put into context. This will improve the assessment of the importance of known archaeology on the seabed.
- 11.5. The development of a GIS has shown produced a system for visualising many different forms of data whilst taking into account the uncertainty of the data positioning. The data currently held in the database provides the basis for making a better assessment of the character of shipping for periods which are not well reflected in the UKHO and NMR datasets.
- 11.6. A system was successfully developed to contain the numerous types of information available on historical shipping and allow the extraction of queried data. It was also possible to highlight trends within the datasets. An assessment of the quality of the data recorded showed that the datasets collated reflect the results of similar queries applied to more modern maritime archaeology. Although the datasets collated in the database were substantially smaller than the UKHO and NMR datasets, further population of the database would allow more reliable comparisons to be made.
- 11.7. During the course of the study, the majority of efforts were focused on developing a system for containing the archival data in a database and building a GIS to reproduce the results spatially. It was clear that it would not be possible to produce a representation of traffic density, therefore making it difficult to produce general statements on the character and nature of England's Shipping. Further population of the database will help provide a clearer representation of traffic density by querying the ports for records of incoming and outgoing traffic.
- 11.8. The application of the data gathered to case-study dredging areas via the GIS, has demonstrated that the system provides information which complements the data from the UKHO and NMR and works towards reducing the bias in information used during Environmental Assessments.
- 11.9. England's Shipping as a project represents the initial efforts towards producing a system, which can be easily managed to contain and identify trends in data on

England's Shipping. The system produced provides a structure for containing and presenting data which can be developed and improved by undertaking further research to improve the accuracy of the data's representation. The system would also be improved by gathering and validating further data types which when studied in conjunction with wrecks, battles, casualties, ports and hazards, could provide valuable information to improve the characterisation of England's Shipping, particularly for periods preceding 1730.

12. FURTHER RESEARCH

12.1. The mapping of the current GIS has been developed to allow data to be queried on two levels. The first method of querying was part of the initial objective of the project. The network of routes was designed to give a representation of the density of traffic recorded along any particular route. By designing the network in this way, it enables the increase in record density at the intersections between routes to be represented. Further research would have to be undertaken to create a system that automatically updated with further population of the database. The results can currently only be represented as a vector layer which does not show the values of the intersections between polygons but has extensive attribute data attached to it, or a raster layer which show the true values of route segments but for which the attributes have been lost.

12.2. The second method of querying, one that is a fundamental part of any GIS is the ability to pull out to specific sets of data by requesting all objects matching a same set of criteria. In this way, it is possible to identify simple trends within the data. The analysis of shipping recorded in the database can be undertaken for both ship routes and ports to extract specific trends.

12.3. The types of queries possible are as follows:

Total Shipping Records	Cargo routes per century
Traffic by century	Cargoes to and from ports
Traffic relationships between ports	Total Shipping Movements
Queries by area	Shipping movements by century
Casualty types by century	Relationships between battles and casualties
Battle sites by century	

12.4. Queries have been run to test the system, illustrate its capabilities and assess the data for the case-studies described above. Once the relational queries have been built from the GIS to the database, it will be possible for the user to access the results through a simple pop-up query form. To enable the results of a query picked from the pop-up form to be viewed, the relationships between tables and the attributes required need to be pre-defined using MS Visual Basic for Applications (VBA) programming language. It is likely that the structure for all query types available via the interface will need to be predefined in VBA and programmed into the GIS.

12.5. It would also be necessary to identify areas causing variations in sailing approaches due to technology. The approach to a port may be different depending on the size of the vessel and method of propulsion. The division of data between types of propulsion would help further qualify the routes network and improve the characterising of the trends in behaviour of different vessel types.

- 12.6. The mapping of naval activities was limited because many available records describe the fleets as travelling between anchorages rather than ports. Historically mapped anchorages were compared to modern anchorages to show a correlation between their locations. The mapping of routes between anchorages would be possible, using the routes network designed for England's Shipping, enabling the visualisation of naval movements, but could not be achieved due to the time constraints of the project. Further research would be necessary to develop a method for mapping the location points, based on a combination of historical and modern evidence. Further research into historical charts would provide a more accurate picture of which anchorages were used during different historic periods.
- 12.7. The creation of the England's Shipping GIS has highlighted the value of collating information not only from historical records relating to shipping, but also information pertaining to the environment, and the activities of ports. The development of these datasets can only improve our insight into the character of shipping over past centuries.
- 12.8. Further population of the database will improve the representation of shipping traffic through the querying of ports. It will also increase the likelihood of extracting further information on wreck sites of particular interest. Increasing the number of records for individual voyages would also improve the validity of the routes network design and the quality of query results.
- 12.9. The defining of ship routes will have to be a continuing process. The system in place is designed to allow continuous development of the route network as new port relationships are entered into the database.
- 12.10. By buffering individual routes, the network encompassed approaches to the majority of anchorages as well as ports. It would be of benefit to the project to suggest that the network be adapted in future to incorporate the approaches to any anchorages which are not yet plotted. Research into the routes employed by naval fleets showed that they tended to travel between anchorages rather than ports. It would therefore be possible to plot their journeys between anchorages using the network. This would however require further work to be undertaken to compare modern anchorages to those recorded historically in order to validate the use of anchorages currently mapped by the UKHO.
- 12.11. The opportunities for developing this system into a methodology for helping discuss and predict archaeological potential are extensive. It is however suggested from the results of the study that the structure already developed is reliable, accessible and flexible enough to provide a basis on which to build.

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APPENDIX 1: DATABASE RELATIONSHIP DIAGRAM