AGGREGATES LEVY SUSTAINABILITY FUND
MARINE AGGREGATES AND THE HISTORIC ENVIRONMENT

ENGLAND'S SHIPPING

Progress Report on Recording and Mapping

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SUMMARY

The intention of this report is to provide English Heritage with an update on the work that has so far been undertaken, the methodology employed, the problems encountered and solutions applied to them, and the processes planned for the next stages of the 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;
- an assessment of the progress made in mapping the shipping routes in GIS;
- an assessment of the progress made in populating the database;
- a report on the progress made to link the database to the GIS;
- recommendations regarding the next stages to be taken in the project.

The design of the database has been finalised. Changes will be required following the linking of the database to the GIS, to correct minor problems. Queries will be set up within the database structure when the database has been populated with a more substantial dataset.

A network of shipping routes has been drawn in AutoCAD, to be used in presenting the results of the database queries in GIS. The positioning of the routes was decided using historic evidence for sailing directions, shallow contour lines and a 5km buffer from the high water line.

The shipping routes have been given a 5km buffer zone to account for variability in traffic routes and the need for vessels to tack when travelling into prevailing winds.

The routes network, relevant coastlines and contour data, port locations and hazard overlays have been converted to themes and incorporated into a GIS.

The GIS has now been linked to the database and a query has successfully been applied to the dataset contained within it. The system is currently being tested using the case study data previously collated, to identify and correct problems in the system's structure.

Population of the database will resume once the necessary amendments have been made and feedback has been received from EH on this report.

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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' to indicate the archaeological potential or areas of the English seabed by way of a digital atlas of historic shipping patterns. The assessment will be based entirely on evidence drawn from historic archives. The project is being funded by the Aggregate Levy Sustainability Fund, distributed by English Heritage.

1.2. This document comprises a report of the progress made on both the recording and mapping phases of the England's Shipping project, as requested by EH at the monitoring meeting on the 29th July 2003. This report relates to the revised milestone M6.

2. BACKGROUND

2.1. The project was proposed to complement 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 RCHME/English Heritage and completed in November 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 historic charts; and gross numbers of casualties (recorded shipping losses). These sets of information were intended to complement the record of located wreck sites and anomalies contained in the NMR and some SMRs in order to arrive at a fuller picture of the likely maritime archaeological potential of the seabed.

2.2. 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 the period post c. 1730 when the recording of losses, and hydrographic surveying, became commonplace.

2.3. It was noted that other data is available that can temper these biases and thus provide a fuller 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.

2.4. 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. As an ALSF funded project the primary aim of the England's Shipping project 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;
- generating guidance on best practice;
- providing comparable data on the effectiveness of different investigative techniques;
- identifying and give effect to avenues for archiving and disseminating results.

3.2. The general intention of the project 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 records to map the intensity and other characteristics of pre-1730 shipping. The results will be 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, other than hazards/destinations, casualties and wrecks, as is available from archives preceding the 1730s, and presenting it in the form of a digital atlas of England's Shipping. The archival data gathered will be mapped in a GIS format to present the filtered results of queries on shipping traffic density. The data collated will be readily assimilated with hazards/destinations, casualties and wrecks data in the course of preparing Environmental Statements for marine aggregate licences. It is anticipated that the content of the digital atlas will be made available to users via the NMR.

4. OBJECTIVES AND RESULTS

Year 1

4.1. 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.

4.2. 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 onto it. The database was then to be 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.

4.3. The source appraisal was completed within the allocated time and the results were presented in a report to English Heritage in January 2003. The sources were assessed in terms of the volume of data, its relevance to the requirements of the project, its accessibility and 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.

Year 2

4.4. 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.

4.5. The targets so far achieved for the second year of the project are as follows:

- a review of the methodology has been undertaken;
- a revised methodology has been set up for mapping the data;
- a network of shipping routes has been drawn using AutoCAD software;
- the routes have been transferred to GIS and defined within the database;
- a steering group has been put together and the membership has been agreed;
- an update of the webpage has been produced and will be put online.

4.6. The methodology behind these developments is described later in this document.

5. MILESTONES

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

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

6. METHODOLOGY REVIEW

6.1. A review was undertaken of each aspect of the project to evaluate the methods used in Year 1. The review showed that much of the work undertaken during Year 1 required only minor methodological changes. 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 are currently being applied to the recording system, methodology and use of sources.

Source Appraisal

6.2. The source appraisal was successful but will require some flexibility as the availability of sources may vary when further case studies are researched. Due to the huge range of material available, the analysis was obliged to be somewhat selective.

As a result, the appraisal of sources should be considered to be an ongoing process throughout the gathering of data and population of the database.

6.3. The variety of sources is also likely to expand beyond those assessed during the appraisal, due to the large extent of documentation available. Further digital archives, such as the Gloucester Port Books Database and the Slave Trade Database, are due to be added to the database, subject to copyright considerations, when data gathering is resumed.

Database

6.4. The process of linking the database to the GIS necessitated alterations beyond those discussed during Year 1.

6.5. The database has been populated using the Port of Southampton as a case study. Data has been gathered based on the results of the source appraisal undertaken in Year 1 of the project. Further case studies will be documented and entered into the system once the database and GIS have been linked and quality tested. This approach will ensure that any methodological problems can be identified and resolved before the database is heavily populated in order to minimise further problems if any major changes to the database structure are required.

6.6. The structure of the database will require further development 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 will be divided into four categories; complete vessel routes, complete fleet routes, incomplete vessel routes and incomplete fleet routes. They will then presented be separately in GIS, to avoid distortion of the detailed information.

6.7. Additional tables have been added to the structure (see Appendix 1) to build the required relationships between the GIS application and the data held in the database. These tables and their purpose are discussed in greater detail below.

Mapping

6.8. 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.

6.9. The main problems identified were in the methods used to represent the buffered areas around individual shipping routes and how the routes were represented. The original idea was to produce a grid of polygonised triangles to be draped over the shipping routes, which were drawn independently of each other. The buffer zones were then to be created by highlighting the polygons through which a route travelled. This approach however produced problems by creating buffers of variable width. The network of routes also threatened to become overpopulated by individual routes. As a result, the buffers would have proved more difficult to query and required large amounts of computer memory. The problem was solved by using GIS software to

produce evenly distributed buffer zones around a web of line sections which, when added together, defined a route. This method was considered to provide a more scientific approach and results, which could be considered more reliable in the long-term as the population of the database increased.

6.10. The separation of data within the database was initiated following attempts to link the database to the GIS software. The incomplete voyage records could not be mapped in the same theme as the complete route data because the partial recording of routes would have created imbalances in the representations of traffic density. Although the voyage information was incomplete, the journey itself would have been completed. The approach chosen as a solution to this problem is described in detail below.

7. METHODOLOGY

7.1. The methodology of the project was first discussed in the early part of Year 1. It was agreed 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 subtract areas of surrounding hazards from the buffer zone produced around each shipping route.

7.2. 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.

Database

Database Structure

7.3. The methodology for the database was described in detail in the Year 1 report. The database was designed whilst taking into consideration the project requirements. The database, which records individual shipping movements by English and foreign vessels to, from and around the coast of England, was designed using Access 97. It has associated word lists and methodology spreadsheets to support the entry of data. The system was required 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 with their system. Indications are that it is acceptable but formal confirmation is still expected.

7.4. The database's requirements also had to relate to the needs of the end users and therefore had to be tailored both to the needs of those required to compile environmental assessments and to the professional and amateur users of the NMR. The database was therefore designed to enable queries to be built relating to traffic density, documentary sources available, period, cargo, shipping losses, and quality of journey records.

7.5. Additional tables have been added to the database to create the structure required to link the query results to the GIS to produce colour coded buffers which represent

traffic density. For this purpose, each section of buffer zone for the shipping routes network had to be given an ID number. Individual shipping routes can then be defined by collating the ID numbers for each of the buffer segments of which they are composed. This information is now held in a series of tables within the database. 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 is currently being completed which contains ID numbers representing the individual buffer sections which make up each shipping route. As the system is designed for long-term use and the database is to be extensively populated, every conceivable route between two locations within the network must be defined in this way. It is envisaged that this process will take between 15 and 20 working days.

7.6. A relational diagram for the amended database is presented in Appendix 1.

Database population

7.7. Due to the enormous quantity of data available, a case study approach based upon locations and themes has been settled upon. Recording for the first two case studies, Southampton (location) and the English Navy (theme) has been undertaken. Work on the former has taken place using secondary sources copied at Southampton Central Library Maritime Collection and for the latter using primary documentation copied at the Public Records Office (PRO) and secondary already available at Wessex Archaeology. Due to the difficulty of accessing, reading and translating original pre-1730 documents, secondary sources (such as Port Book transcripts) have been relied upon. In due course consideration will have to be given towards the use of the very substantial quantity of information that exists only in primary document form. The quantity of data recorded per shipping movement can be considerable, particularly in respect of Port Book records. Reservations about the resulting slow speed of recording have been expressed. EH have confirmed that they nevertheless wish the maximum amount of detail to be recorded.

7.8. The design of the database is substantially complete. However, the creation of the structure relating the database to the GIS package has flagged up a few problems with the pilot data. The availability of information preceding 1730 is substantial, although collation of records from historic archives has proved to be a slow process. Many of the entries do not have both origin and destination ports listed within the data collected because the data was often not available from the sources.

7.9. The initial population of the database, using data from Southampton and its outports flagged up two significant problems with the archival evidence available. In the first instance, the data gathered shows a strong bias towards records which do not describe specific origins and destinations for the routes. The second problem is that many records describe the journeys of fleets of ships, but do not specify the number of vessels accounted for.

7.10. Although a great deal of information is available from historic archives regarding shipping traffic, the descriptions of the routes themselves often remain vague. The data gathered is required to have a specific start and finish and the number of vessels must be quantified in order to map the route confidently, using the network of routes designed in AutoCAD. The solution to both problems involves adapting the database and the GIS to allow the data to be separated into sub-groups. The separate datasets can then be queried separately.

7.11. The problem of incomplete route descriptions was identified when individual shipping routes needed to be defined geospatially within the database. In order to map

a complete route, both the origin and destination must be identified as a specific geo-referenced point. Many of the entries travelled to or from locations such as “Devon and Cornwall”, “the Netherlands”, “the South Coast”, or “the Outer Hebrides”. These locations are not specific enough to produce a route without reducing the accuracy of the data. As it will therefore not be possible to use this type of data in the same GIS format as the complete records, it would have to be separated from the complete route data within the database and queried separately in order to maintain quality assurance on the results. It has been suggested that locations described as “off Plymouth” or “off Beachy Head” should be geo-referenced to the same location as “Plymouth” and “Beachy Head”, without substantially reducing the accuracy of the data, as these entries would generally refer to a vessel anchoring just outside of that location.

7.12. The problem of undefined fleets of vessels was identified following the viewing of the query results from the case study data when the database was linked to the GIS. Descriptions of fleets of ships often do not contain information on vessel numbers. The vessel numbers for these records have been defined as “unknown” (U) in the database. As a result, the buffers for these records are drawn but are invisible in the GIS query results. The lack of a number representing the size of the fleet means that these records can not be presented alongside complete records. It would however be possible to create two more separate themes to contain the traffic density for fleets rather than vessels, where each route represented the voyage of one fleet. The problem of having complete and incomplete descriptions of routes would require further separation of the data as described above for the individual vessels. Further discussion will be required with the Systems Development Officer to ascertain how these variations can be incorporated into the database.

7.13. Therefore data collected that can only be partially mapped and data for which vessel numbers have not been defined will need to be presented in separate themes in GIS format to avoid creating biases in the query results. Queries could then be run on either datasets, and by using the Spatial Analyst add-on in ArcGIS 8 the end user would also be able to query the combined data sets if required. Although the division of data into separate groups will reduce the impact of query results in the short term because the size of the datasets will be reduced, this approach will ensure that the quality of results will be maintained in the long-term. The query results will improve as the number of entries into the database increases for each of the four datasets.

7.14. 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.

7.15. Some minor adjustments are required to the database structure to reduce the possibility of data being entered in different orders. It was noted that due to the presence of dropdown boxes for the origin, departure point, and destination point, the order in which the data was presented varied between records. The variation in the order of this data would make it very difficult for the computer to query the fields. The structure will therefore be amended to reduce the possibility of changing the order of data. It was also noted that the location where a vessel was constructed was not directly relevant to data and the field should therefore not have been stored in the same location as the journey departure and destination data, under the “Journey” theme of the database. It is likely that this data will also be stored under another theme in the database. If this is not the case, the data will need to be moved in order

to apply queries to it. It will then be possible to query the data separately from the other journey records.

7.16. The advantage of having taken the case study approach is that we have been able to identify and find a solution to these problems while the dataset was small enough to allow the structure of the database to be changed without causing additional difficulties. Adapting the database structure to allow different qualities of data to be assessed individually requires complex restructuring of the relationships between the database tables. The restructuring will need to be completed and the database comprehensively tested before it can be populated with further case studies.

7.17. A protocol still needs to be devised to avoid double entry of data by identifying when a voyage is being recorded more than once. This 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.

Mapping

7.18. Mapping is being conducted using a combination of AutoCAD software for drawing and GIS software for buffering, visualisation and querying.

AutoCAD

7.19. The majority of the data to be 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.

7.20. 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 a incremental approach in the production of layers compatible with 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
- 5km from High Water
- Modern and Historic Nautical Charts

Digitising

7.21. Problems were identified when digitising certain data manually. The shipping routes were drawn without too many problems but the digitising of the -5m contour line was found to lack accuracy because charts of varying scales produced discrepancies between the level of detail on the charts and a slight offset between the lines when laid over each other (Fig 1). The offset can be corrected by repeating the geo-referencing of the scanned charts. However, in order to accurately digitise the –5m contour line around the whole of he UK, it would be necessary to use a full set of

charts at a scale of at least 1:150 000. The problem would have had less impact if the polygons were due to be buffered.

7.22. 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 essential marine data in formats ready for immediate use within GIS.

7.23. Metoc are also providing a quote on search results of UKHO data for pre-1730 wrecksites which were recorded on historic charts.

Shipping Routes

7.24. The primary purpose of using AutoCAD was to draw a network of shipping routes that could be defined numerically within the database and related to specific routes. Documentary sources, with the possible exception of some RN logs, do not define routes with sufficient certainty to be able to map them precisely. Therefore the route mapping process has to determine what the most likely route between two named locations is.

Method 1

7.25. Documentary sources, with the possible exception of some RN logs, did not describe routes in sufficient detail to be able to map them precisely. Therefore the route mapping process has to determine the most likely route between two named locations. In order to do this it was anticipated that several different sources of information would be used in an incremental layered approach to drawing the routes, as follows:

7.26. The first layer consisted of the most direct route between named locations, staying 5km offshore of mean HW, except where exit from the departure location and entry to the destination location were made. An angle of approach no more acute than 45 degrees to the coast was allowed. This route was intended to have the 'highest' level of reliability in the sense that it allowed for the fewest subjective assumptions and interpretations. However, it had the 'lowest' information in the sense that it did not incorporate any information likely to make it a more accurate reflection of route choice, such as the presence or absence of sandbanks.

7.27. A second layer, applied the -5m seabed contour line to the route choice. The routes would then be redrawn to skirt outside this contour.

7.28. A third layer, applying historic charts as an additional source of information, would again require the routes to be redrawn.

7.29. A fourth layer, applying another source, based on records of historic sailing directions, would then be added, again redrawing the routes. With four layers of information determining routes, this layer would have a high level of route information but a potentially lower level of confidence.

7.30. It was intended that this system of layers should remain flexible, to enable further/alternative refinement of route choices to be added. The overlays were also designed to provide support in the designing of an archetypal shipping route network.

7.31. Initially, the routes were drawn manually as a line representing individual routes travelling between geo-referenced named locations (Fig 2). Although the correct

parameters were chosen to define the routes, a large number of lines were being repeated to represent different vessels travelling the same routes. The approach of redrawing all of the lines each time a different parameter was accounted for also required a great deal of additional work. Although the routes drawn were based only on the Southampton area as a case study, the multitude of routes rapidly gave the theme a cluttered appearance. It became clear that the repetition of lines over regularly used sections of route was producing a crowded image although only a select number of routes had been drawn.

Method 2

7.32. In the second approach, the same layers of hazards were to be taken into account when drawing the routes, but the lines were not repeatedly redrawn.

7.33. The problems involved in reproducing a network of shipping routes, which were identified during the first approach, were solved by drawing a web of routes made up of single lines segments (Fig 3). By choosing this approach each route would then be defined by a series of ID numbers reflecting each individual line used to make up the route.

7.34. The problems involved in deciding where to draw the lines, which made up the routes identified in the initial approach, were dealt with whilst drawing only a single layer of routes by switching hazard layers on in the background during the drawing of the network. The parameter layers could then be observed either independently or in combination in order to adjust the position of each section of route. The layers used to guide the drawing of the routes included shallow contour lines, a 5km buffer offshore for long distance travel around the coastline, and historic evidence for sailing directions. Prevailing wind directions were accounted for by creating a 5km buffer zone, wide enough to account for vessels tacking into the wind. The GIS and database were structured to allow changes to be made to the position of the route segments later in the project if further historic evidence was identified which required routes to be adjusted.

7.35. The lines had to provide a logical reflection of where vessels were likely to travel. To produce a realistic reflection of the routes chosen by historic seafarers, two shipping highways were produced (Fig 4). The inner highway applies to short distance journeys along the coastline. A vessel travelling to the next harbour along the coast would not be expected to travel as far offshore as a vessel intending to travel abroad or to a location further along the coast. Therefore, the inner highway was drawn, avoiding the -5m contour line as far as possible, but remaining inshore. Vessels travelling further would be expected to travel to the outer highway which was drawn at least 5km from the coastline. Approaching routes and departing routes linked to both the inner and outer highways were then added to the network to draw shipping routes heading in either direction along the coastline (Fig 4). If the approach to a harbour was required to cross a wide section of shallow contours, the approaching routes were merged into a single approaching route, which was drawn perpendicular to the coastline, where possible, to minimise the distance of travel through hazardous conditions (Fig 5).

7.36. Although buffer zones were being drawn to reflect the variation in routes taken, the lines had to be drawn whilst avoiding hazards such as shallow water contours as much as possible. Drawing a line too close to an object in a hazards overlay meant that when the hazards were removed from the buffer zones using Spatial Analyst, a larger section of the polygon would be unnecessarily removed. The lines were

therefore drawn with the themes reflecting the -5m contour line switched on in order to avoid initial loss of large sections of the buffers.

7.37. The use of the -5m contours was particularly useful in the drawing of routes for the approach to the Thames estuary, which is heavily populated with sandbanks. In order to account for the mobility of the sandbanks, the lines were, as far as possible, adapted to avoid 5m contours from both modern and historic charts. The observation of both modern and historic records allowed the most likely routes into the Thames to be identified.

7.38. Information currently held on sailing directions is very limited. Accounts of sailing directions are in some cases available from archival records. These accounts contained descriptions of hazards to be avoided, and in some cases, charts illustrating traffic routes. The records collated so far have been taken into account during the design of the routes network. These records are however difficult to map accurately as much of the information is contained within vague textual descriptions. The charts drawn to illustrate sailing directions are also often inaccurate and difficult to geo-reference. Further work will have to be undertaken to geo-reference historic illustrations and extract information from both charts and textual descriptions of sailing direction as further records are identified. The routes network will therefore need to be adjusted accordingly.

7.39. It would also be useful to find historic information to support the routes showing the approaches into hazardous estuarine environments such as the Thames Estuary, The Wash and the Severn Estuary. The querying between themes using Spatial Analyst will remove any additional hazard areas once the routes have been defined.

7.40. Once the lines had been drawn, time had to be spent ensuring that each section of route was represented by a single line, and that no lines had been duplicated underneath one another. Each line had to connect to the next line by snapping onto it. The lines connecting to port locations also had to be snapped onto the adjoining node. Once the network had been comprehensively quality assured, the layer was converted to a shapefile so that it could be converted to a theme in ArcView GIS 3.2 or ArcGIS 8.3. Each route then had to be defined by an ID number within the database to relate it to the corresponding routes described in the database entries.

7.41. An image of the complete network of shipping routes appears in Fig 13. The lines are colour coded to show the inner highway, outer highway, approaches from both directions along the coastline, and the merging of approaching routes as they enter shallow waters.

GIS

Buffer Zones

7.42. Experimental work was undertaken to find a method for producing buffer zones to represent areas of higher archaeological potential surrounding the shipping routes. The buffer zones were designed to represent the routes vessels were most likely to take when travelling between two ports. They also had to be large enough to account for variations between journeys, whether they were made intentionally on the part of seafarers, or caused by environmental conditions or human error.

7.43. The initial approach was for the routes to be superimposed on a regular geometric grid produced in Autodesk Map 3, covering the whole of the UK and adjacent seas,

using a scale no more coarse than 500m square. The GIS system would then be required to record all of the grid shapes over which the line travels and use them to identify a route polygon representing a buffer zone (Fig 6).

7.44. This approach however produced buffered areas which were not equidistant from the line on either sides of the route drawn. The polygons could therefore not be considered to provide a standardised method for the representation of the likely routes taken. If a route passed through the edge of a polygon, a whole additional area would be added to the buffer to one side of the line, whilst only a corner of the polygon would populate the buffer on the other side of the line (Fig 6). The variability in the shape of buffer zones made it an unreliable solution for the representation of potential for shipping traffic.

7.45. The problem of buffering the shipping routes was solved by using the buffered drawing facility in ArcView GIS 3.2 to produce the polygons for each individual section of route. The zones are 5km wide to take into account tacking, vessels being blow off course, and an extensive range of different lines for vessels to travel along.

7.46. Considerable discussion has taken place with regard to methodology and software for the mapping part of the project. A later edition of the ArcView software, such as ArcGIS 8.3, will be used to visualise the data and set up the queries. ESRI are also producing Spatial Analyst, which will enable the queries to be set up between themes. Crucial to the development of the GIS is the mapping of routes in AutoCAD between named locations in the database. It was decided following the Year 1 Review to adopt a more systematic approach for the representation of buffered shipping routes.

7.47. Buffer zones around the shipping routes were produced using ArcView GIS 3.2. The routes were given a 5km wide buffer (Fig 7), which was agreed by Wessex Archaeology staff and English Heritage to be a fair reflection of the variability in routes chosen by vessels.

7.48. An image of the complete network of buffer zones is available in Fig 14.

7.49. The line segments for both the routes layer and the buffers had to be given ID numbers which could be referred to in the database when the shipping routes were being defined numerically. Both files were opened in Excel in order to give each line an ID number. However, when the attributes table of the two themes were observed in ArcView GIS 3.2, the ID numbers given to a specific line were completely different between the two themes.

7.50. The ID numbers needed to be related, either by creating a link line by line, or by finding a method for converting the routes theme to match the numbers in the buffers theme. A solution was reached by producing a buffer of the routes which was as narrow as possible so that it almost represented the lines themselves.

7.51. The narrowest buffer available was still 64 meters wide but the individual line numbers matched those of the 5km buffer zone. The resulting image remains similar although it was noted that when the user zoomed away from the narrow buffer zone, some of the lines automatically disappeared (Fig 8). This effect was not seen with the polyline routes theme, which was made up of narrower lines. This phenomenon may not occur when the data is visualised in a more advanced version of the GIS package such as ArcGIS 8.3. It could also be due to the size of the graphics card on the computer used to undertake the work.. This problem would not have an immediate impact on the memory requirements of the end user unless the routes needed to be available without their buffer zones. If the problem persists and is not related to the

graphics card, a table will have to be produced relating the buffer ID numbers to those of the component lines of the shipping routes and incorporated into the database.

Buffer ends

7.52. The buffers created by ArcView GIS 3.2 are equidistant from every point on the line therefore, the buffer extends beyond either end of the line by an additional 2.5 km. The points at which a group of lines connect therefore represent an area where the buffers overlay each other. A case study set of buffers was selected to study the behaviour of the intersecting sections of the polygons. The overlaying of different coloured buffers creates intersections of undefined colour which will be difficult to relate to visually (Fig 9), and would not be defined numerically. Using different shades of the same colours will make the intersections difficult to discern when large numbers of routes meet at one point (Fig 10). The colour scaling required to illustrate the results of queries will have to be carefully assessed to ensure the results remain clear as the datasets expand. Spatial Analyst should however help resolve this problem as it will contain extensive pre-determined colour scales.

7.53. It is currently unclear how the buffer ends are going to behave when the density scales for traffic are applied, using Spatial Analyst. There is a possibility that the intersections will appear as areas of heightened traffic density. Currently, within a single shipping voyage, every time two buffer segments intersect, the Autodesk Raster Design 3 counts those areas as containing the sum of vessels contained within each buffer segment. Once the routes have all been defined, the buffered routes, currently made up of segments, will have to be redesigned as seamless single buffers (Fig 11). The intersection between different routes will then provide an accurate representation of areas of higher traffic density (Fig 12A).

7.54. In order to ensure that the result of a query is clearly illustrated, the intersecting areas between different buffers need to be defined in a separate colour. There is a large number of intersecting zones in the buffer network. The results are therefore unclear if the buffers are made transparent in order to visualise these areas (Fig 12B). The colours produced within the intersections are thus not defined numerically. The application of Spatial Analyst should provide the facility for the intersections to be represented as independent polygons, allowing them to follow the same numerically quantified colour schema as the major buffer sections.

8. OUTREACH

Website

8.1. 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 regularly updated to reflect progress. Links will be made available to EH/BMAPA websites as required.

8.2. The webpages for the England's Shipping Project will be launched on the Wessex Archaeology website, where they will be located alongside the other ALSF project webpages, once their contents have been agreed by English Heritage. The pages are scheduled to go online at the end of September 2003. In order to reach a wider audience, the project has been given a general introduction which describes the

concepts of the project in basic terms, as well as a technical section containing an introduction, and separate sections for the project design, Source Appraisal, and the application to GIS.

Public Lectures

8.3. Three seminars will be held in the course of the project for an invited audience drawn from industry, regulators (including curators), contractors and the research community. The seminars will provide a forum for presenting and discussing interim results of the project.

8.4. An additional series of presentations are due to be made at Conferences, and to interested parties such as members of the NAS, the Centre for Maritime Archaeology, the IFA and the London Geological Society. Information panels will also be set up at Dive 2003 and the London Dive Show.

8.5. Each seminar will comprise presentations by project staff and Steering Group members, plus extensive discussion periods to enable feedback from seminar participants. Suitable hosts have been identified (e.g. local societies, industry bodies, local societies) and details confirmed for some of the events. Each lecture will set out the context of the project and results to date.

8.6. A draft timetable for outreach, shown below (table 1), was produced and sent to English Heritage. As a number of these events have yet to be finalised, some of the events may be subject to change. Any changes will be fed back to English Heritage.

8.7. Wessex Archaeology will seek to make the digital atlas available to SMRs with interests in the case study areas concerned.

Table 1: Outreach Timetable for Wessex Archaeology ALSF Projects

Type/ relation to PD	Date	Description of Outreach	Organisation	Venue
Public Lecture	8/9/03	Conference presentation entitled: *Aggregate Dredging and the development of developer-led marine archaeology*	British Association for the Advancement of Science (BA) – Festival of Science 2003	University of Salford
Seminar	11/9/03	Seminar Day: Aggregates Levy Projects. Either presentation or display panels possible	EH & Institute of Archaeology, London	Museum of London
Public Lecture	1st 2nd Nov 03	Land and Sea: Integrated Archaeologies. Possible presentation and or display of information panels.	Centre for Maritime Archaeology	University of Southampt on,
Public Lecture	8/11/03	Presentation at NAS Conference or display information panels about the projects.	NAS Portsmouth	TBA
Public	15/11/03	Conference presentation	The Severn Estuary	

Lecture		entitled : *Investigating Marine Aggregates: interim results from four ALSF projects*	Levels Research Committee	
Public Lecture	15th 16th Nov 03	Dive Show: Dive 2003. Display infornation boards about current status of projects		NEC - Birmingham
Relates to **Seminar 2** in PDs	27/11/03	Seminar on ALSF projects. Title yet to be decided.	London Geological Society	London
Public Lecture	7/2/2004	SW Shipwreck Conference. Possible presentation and or Information panels display	NAS SW	Plymouth
Public Lecture	27th 28th March 2004	Dive Show: London International Dive Show. Display boards		London
Seminar	TBA	Possible further seminar relating to that held earlier this year: "Integrating Terrestrial and Marine Aggregate-Related Archaeology: A Workshop"	School of Geography and Archaeology	University of Exeter
Would relate to **Seminar 3** in PDs	TBA	Possible 3rd Seminar Day: Aggregates Levy Sustainability Fund-sponsored Aggregates Archaeology Frameworks (AAF) workshop		TBA
Would relate to **Seminar 4** in PDs	April 2004	IFA Conference. Whole Day Session possibly entitled "Archaeology and Marine Aggregates: methods and records"	IFA	TBA
Seminar	25/3/04	Launch of Publications for ASLF Projects – cheese & wine – speakers etc. invited audience including Steering Group	Wessex Archaeology	EH?

9. CONCLUSIONS

9.1. The targets so far achieved for the second year of the project are as follows:

- a review of the methodology has been undertaken;
- a revised methodology has been set up for mapping the data;
- a network of shipping routes has been drawn using AutoCAD software;
- the routes have been transferred to GIS and defined within the database;
- a steering group has been put together and the membership has been agreed;
- an update of the webpage has been produced and is due to go online in September 2003.

9.2. Following the review at the end of Year 1 and the experiences gained by concentrating on the methodology for mapping the shipping routes and relating the database to the shipping routes network in GIS, a number of substantive changes have been made to the methodology of the project.

9.3. The method for constructing buffer zones around the shipping routes has been changes from a polygonised grid approach to using automatic buffer drawing facilities in ArcGIS.

9.4. The approach for representing the shipping routes network in AutoCAD has been changes from using a line per route to creating a web, made up of single lines, which can be combined to define a route.

9.5. The structure of the database has been amended to separate the data in relation to the detail with which journeys were recorded. The data will be presented in two different themes which can be queried separately or combined if required.

10. RECOMMENDATIONS

10.1. The majority of mapping work has now been completed. A system has been agreed and amendments to the database and GIS to accommodate the required changes are already under way.

10.2. The table used to link the incomplete routes data to a new theme containing an identical network of routes will need to be constructed and related to the database. The database will then have to be restructured to adapt to the new approach. The new database structure will then have to be tested to ensure that it is fully functional before the database is further populated and queries can be attempted on a larger scale. Once the structure of the database has been agreed, the work involved in linking the shipping routes network to the database will then be applied beyond the case study, to the whole network.

10.3. The installation of ArcGIS 8.3 and Spatial Analyst will enable further experience to be gained in setting up queries on the data currently held in the database.

10.4. Work will then focus on populating the database. The quantity of source material to be gathered is considerable. Archival research will focus on gathering records of complete journeys, as far as possible, to improve the quality of query results and reduce time spent manually imputing partial routes later in the project. The gathering of archival data will help anticipate the queries required to be built into the GIS to produce the final version of the Atlas of England's Shipping.