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GEOGRAPHICAL INFORMATION SYSTEMS APPLIED TO MARITIME ARCHAEOLOGY, WITH SPECIFIC REFERENCE TO THE TABLE BAY PROJECT*

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ABSTRACT

Geographical Informations Systems or GIS are valuable tools for the recording, management and analyses of data. Although their worth has been proven extensively in such fields as town planning, natural and cultural resource management, relatively few contributions have been made to archaeology to date, and even less so to the specialisation of maritime archaeology (Kvamme 1989; Wansleeben, 1988; Allen, Green & Zubrow 1990; Allen, Gardiner, Fontana & Pearson 1993; Murphy 1993). This article describes the design of a specific GIS database for the Maritime Archaeological Project of Table Bay (MAP), as designed in the mid-1990s, which will be further developed in the future. Very recent developments, such as the introduction of the World Geodetic System (WGS 84) and multi-beam sounding techniques for underwater surveys in South Africa will further enhance this project.

INTRODUCTION

Since 1989, the second author of this article has been focusing on the maritime history and archaeology of the greater Table Bay area. Historically, this bay has seen intense shipping traffic since the seventeenth century due to its geographical position, roughly halfway between Europe and Asia. Because of its importance as a place of refuge and port-of-call for vessels in the southern oceans, as well as being a major repository for historical shipwrecks originating from many different nations, a detailed study of Table Bay and its archaeological poten-tial can contribute considerably to international maritime studies (Breitenmoser 1991; McLachlan 1991; Durden 1992; Werz 1992a; 1993c:237-238; Werz & Martin 1994:3-7; Sharfman 1998; Werz 1999:67; Mavrodinov 1999).

The Maritime Archaeology Project focusing on Table Bay is complex and multi-faceted and attempts to answer a variety of research questions. As a result of this holistic approach, which includes contributions from archaeologists, hydrographers, oceanographers, surveyors and geologists, the objectives of the Maritime Archaeological Project (MAP) have been formulated as follows:

a. to study the geographical, oceanographical, geological and meteorological characteristics of the Table Bay area and any changes which might have occurred in the course of time;

b. to provide an inventory and explain shipping movements and trends based on documentary evidence until 1900;

c. to itemise the archaeological potential of Table Bay, with an emphasis on shipwrecks and harbour constructions; and

d. to undertake detailed surveys of specific archaeological sites situated in the bay and on its shores;

e. to collate and integrate data obtained via the above-mentioned approaches in order to explain the formation and deposition of identified archaeological sites (Werz & Martin 1994:3-4; Werz, 1999: 67).

It was appreciated in the planning of the project that a Geographical Information System (GIS) would be a valuable tool for the record, management and analysis of the variety of data collected by different researchers. This system was developed by surveyors who are also involved in archaeological fieldwork for defining the positions of located sites and associated artefacts, as well as providing survey control based on the national grid system so that the position of each artefact may be defined by a three-dimensional coordinate (Breitenmoser 1991). In this context, such a coordinate is a key element from which the GIS is developed.

Although the project is still being developed further, enough experiences have already been gained to be able to provide this interim report on progress made thus far.

BASIC CONCEPT OF A GEOGRAPHICAL INFORMATION SYSTEM

Surveying essentially deals with determining positions in space. Within the context of archaeological work, surveying techniques are used to visualize the object of survey, usually a part of the earth's surface, and artefacts or features contained therein. Measurements taken from the survey control to these items can assist in indicating their spatial relationships and the results are normally depicted on a traditional paper map or plan. However, such maps have three major limitations:

1. the physical extent of the paper restricts the amount of detail that can be shown;
2. the scale of the map is predetermined by the maker and the user can only 'zoom' into an area by consulting another map drawn at a larger scale; and
3. there is much non-spatial information recordable in tabular form which can not be depicted on a map.

During the last three decades, these shortcomings were partly counteracted by developing computer technology which allowed for the creation of statistical packages and spreadsheets, and to facilitate computer-assisted draughting (CAD), being both graphical and spatial but with a limited application. A Geographical Information System is the amalgamation of the two, allowing statistical data to be linked to a spatial identity. This facilitates enquiry concerning spatial relationships and helps towards sensible decision making. A GIS is not simply a map producer, but more of an analysis tool. The basic questions expected to be asked of a GIS include those of the following:

- location (What is at...?)
- condition (Where is it?)
- trends (What has changed since...?)
- patterns (What spatial patterns exist?)
- modelling (What if...?)

Planning the database and anticipating the type of enquiry are all-important elements when designing a GIS and cognizance must be taken of the real world which consists of many elements or layers of related data, e.g. relief, rivers, roads, soils, etc. In this article, such layers are called 'coverages'. Different data sets which are entered into the system must be linked so that they match (*e.g.* rivers should flow under road bridges); a hierarchical structure can be recognised (*e.g.* roads may be classified as motorways, secondary roads, tracks, *etc*); and a tolerance must be adopted to accommodate different levels of accuracy of the original measurement at time of survey. In short, space and the position of features within this space are the common factors for which a coordinate system on the earth's surface is required and this must be understood by the computer after transformation to its built-in coordinate system. Then the concepts of coverages in graphics and overlays for analysis may be pursued.

There are three basic elements in the graphics of a GIS: points, arcs and polygons. To illustrate these, two polygons (I and II) are shown in Figure 1, having arc elements (A to E) where each arc has points as terminals (21 to 24).

The non-spatial tabulated data may be called up by identifying that element to which the data refers, e.g. what is the traffic density and when was the last date of repair of the road depicted as arc A ? The more sophisticated GIS packages allow for the overlay of tables as well as the graphic coverages, where the principles of Boolean logic apply, so that new tables may be automatically constructed for those identities formed by intersection or union. Diagrammatically, these identities are shown in Figure 2.

The above is a very brief description of the principles of a GIS which can be used by anyone who works in a spatial environment, an archaeologist being one. The second author, being a maritime archaeologist, took advantage of GIS in 1990 to enhance his study. The software package obtained was ARC/INFO and terminology used in this paper will be with reference to this system (ESRI, 1990).

DESIGN OF THE GIS DATABASE FOR TABLE BAY

Table Bay, which has an approximate surface area of 20 square miles, is the repository of more than 350 shipwrecks and also contains the remains of harbour works and anchorage debris (Werz 1999:67, 70-76). Given this potential, it is likely that more archaeological work will be undertaken during the next few years. Therefore, in anticipation of this, the GIS should facilitate uniformity in the database covering wrecks and other maritime sites, simplicity in file and directory management and accessibility of any area in the bay, thus avoiding a multiplicity of such systems. Also, although the major users will be maritime archaeologists, much more useful data can be incorporated by using GIS so that geologists, oceanographers, biologists and others can benefit. Thus, in addition to an inventory of shipwrecks and artefacts, the database has been designed to offer a statistical analysis technique for surface-, intermediate- and bottom-currents, as well as presenting wind data, sediment distribution and an analysis of the bathymetry using digital elevation modelling. It is expected that by planning the GIS for Table Bay with these possible applications in mind, one of the most obvious pitfalls of many in their early working with GIS, namely to rush into the storage of data without proper planning, has been avoided.

When designing the above-mentioned components for a database, the underlying goals were to maintain consistency, reduce redundancy and maintain user- flexibility,

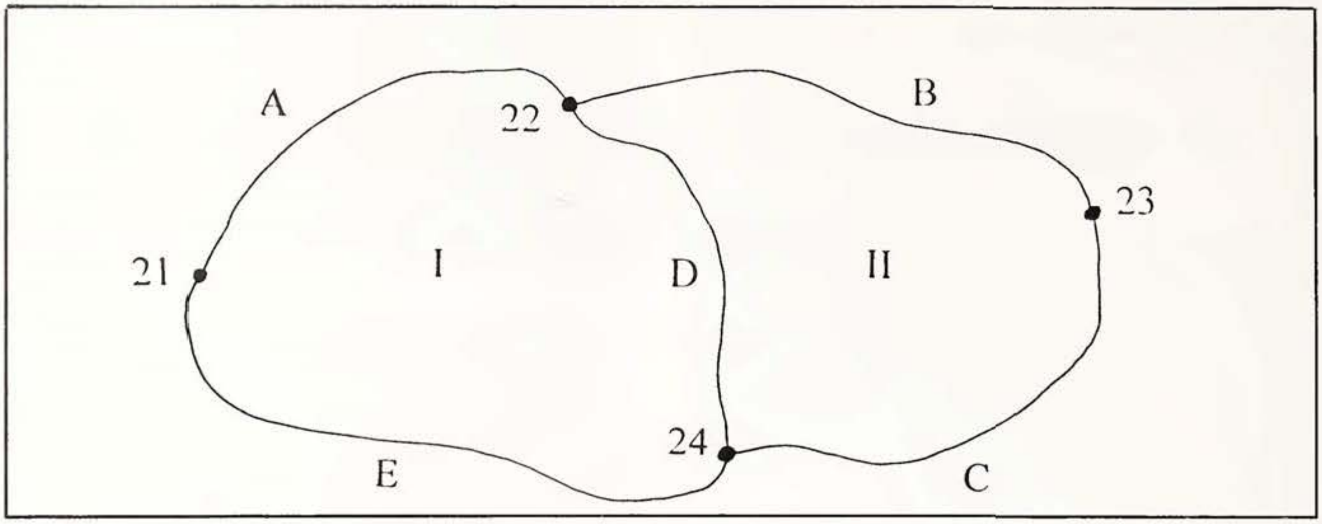


Fig. 1. The three basic graphic elements of a GIS : points (nodes), arcs (lines) and polygons.

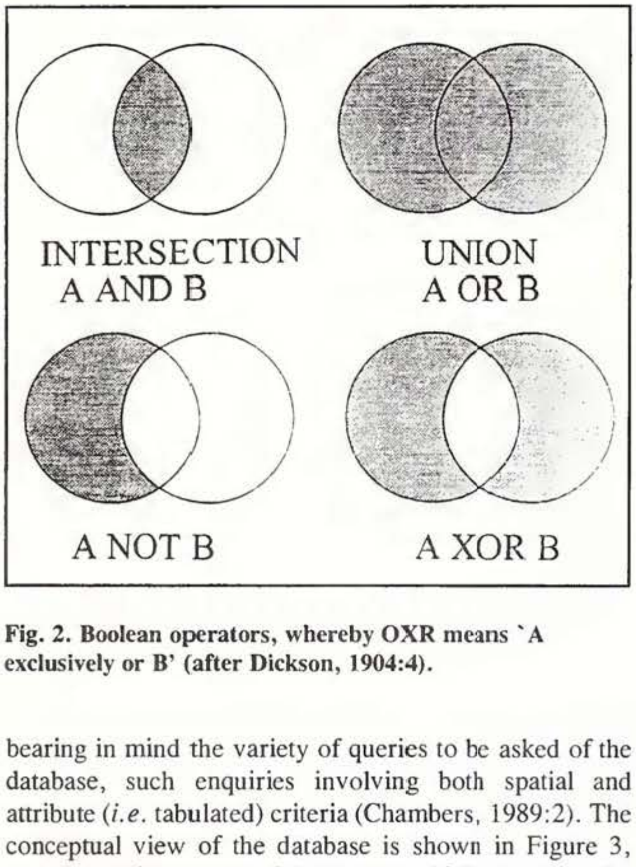


Fig. 2. Boolean operators, whereby OXR means `A exclusively or B' (after Dickson, 1904:4).

bearing in mind the variety of queries to be asked of the database, such enquiries involving both spatial and attribute (*i.e.* tabulated) criteria (Chambers, 1989:2). The conceptual view of the database is shown in Figure 3, where certain groups of coverages which comprise the base map, the environment and shipwrecks are depicted. Also shown are the forms of the spatial entities, *i.e.* whether points, lines (*i.e.* arcs) or polygons, which are the basic elements of any GIS. Individual coverages of the GIS for Table Bay will be described in more detail hereafter.

The base map has three coverages, the first being geodetic control. This coverage was created by entering the coordinates of trigonometrical beacons and other physical survey control points on land. These coordinates were provided by the South African national survey authority. On the graphics screen, these are symbolised by a triangle with an identity number alongside. An example of this, representing trigonometrical control beacon 265, can be seen in Figure 4. When queried, the numerical values of the coordinates to one or two decimal places can be displayed on the screen in tabulated form. These represent the non-spatial attributes of these point entities.

The geodetic grid lines form the second coverage. These may be depicted as complete lines (Fig. 4) or suppressed and replaced by intersection crosses only (Fig. 5). In both instances, the values at the chosen interval are displayed around the perimeter of the map.

The third coverage of the base map, topography, shows the coastline and detail of some features on land. In most cases these are arc entities, but where arcs fully enclose an area, such as the coastline of an island or the outline of a building, then these become polygon entities. This coverage was created by digitizing the detail shown on existing maps and charts.

The coverages of the environment database are included in order to enable archaeologists to analyse those factors which possibly influenced archaeological site formation and deposition, and to anticipate the dispersal of associated artefacts. To date, four such coverages have been incorporated or planned in the GIS, prevailing winds and the bathymetry being the most substantial. A coverage for current data has been established while that for sediment deposits has yet to be included. Where created, these have feature attribute tables attached.

Wind data were provided by the Electricity Supply Commission (ESCOM) for the six-year period 1985-90. These were categorized into ten groups of wind velocities. For the GIS and the production of wind roses, these were generalized into three categories: less than 4 m per second, 4 to 8 m per second and more than 8 m per second. The ARC/INFO software has a 'simple macro language' and a program using this was written for construction of the wind roses (Fig. 6).

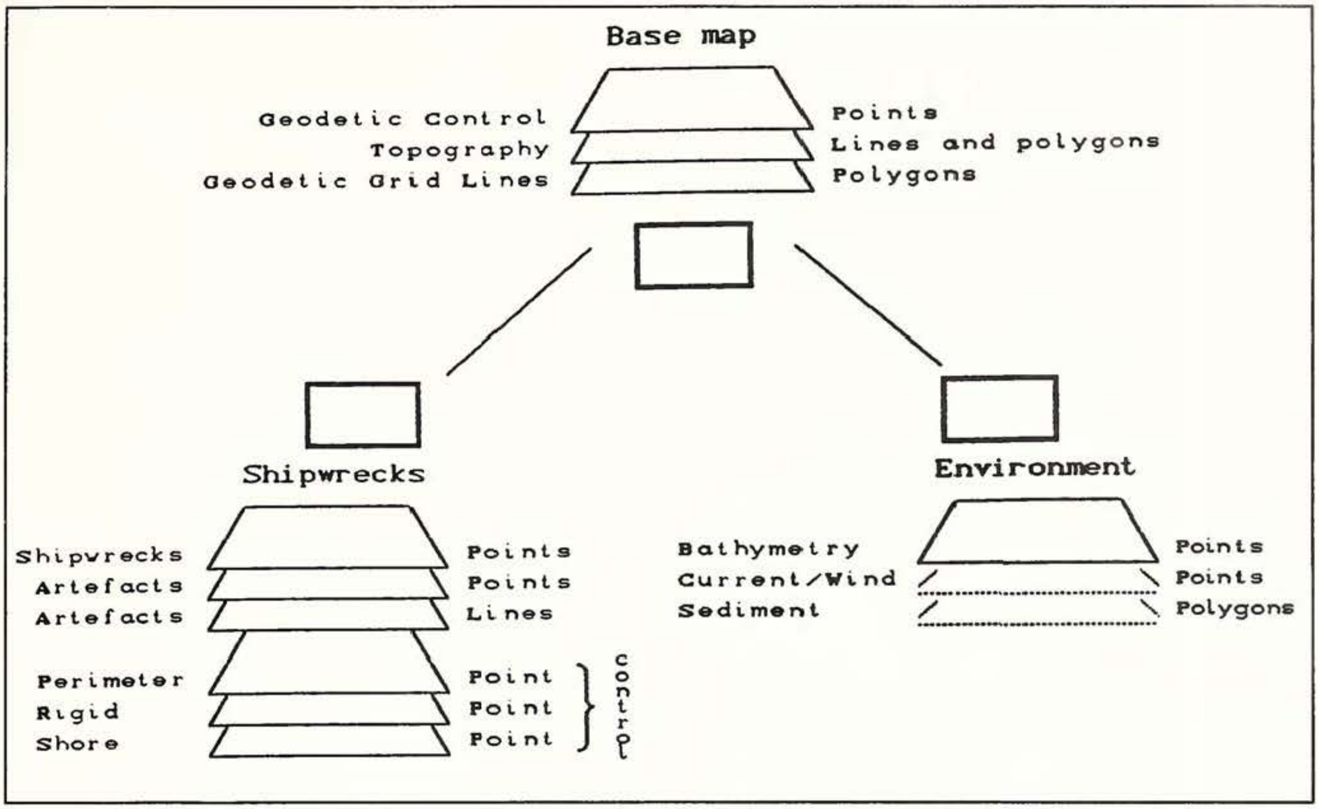


Fig. 3. Conceptual view of the database for wrecks (after Chambers, 1989).

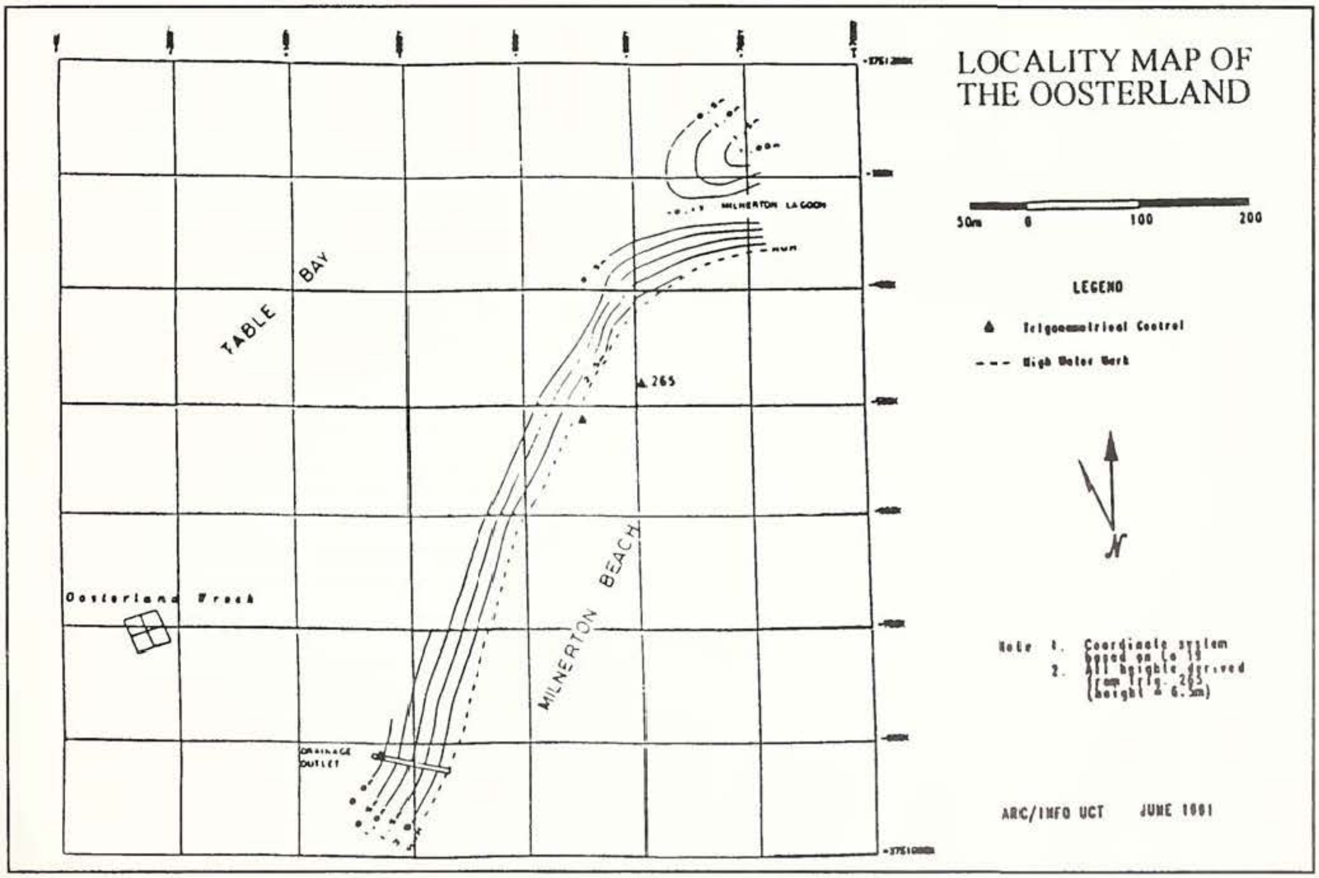


Fig. 4. Locality map of the *Oosterland* (Breitenmoser, 1991: appendix G).

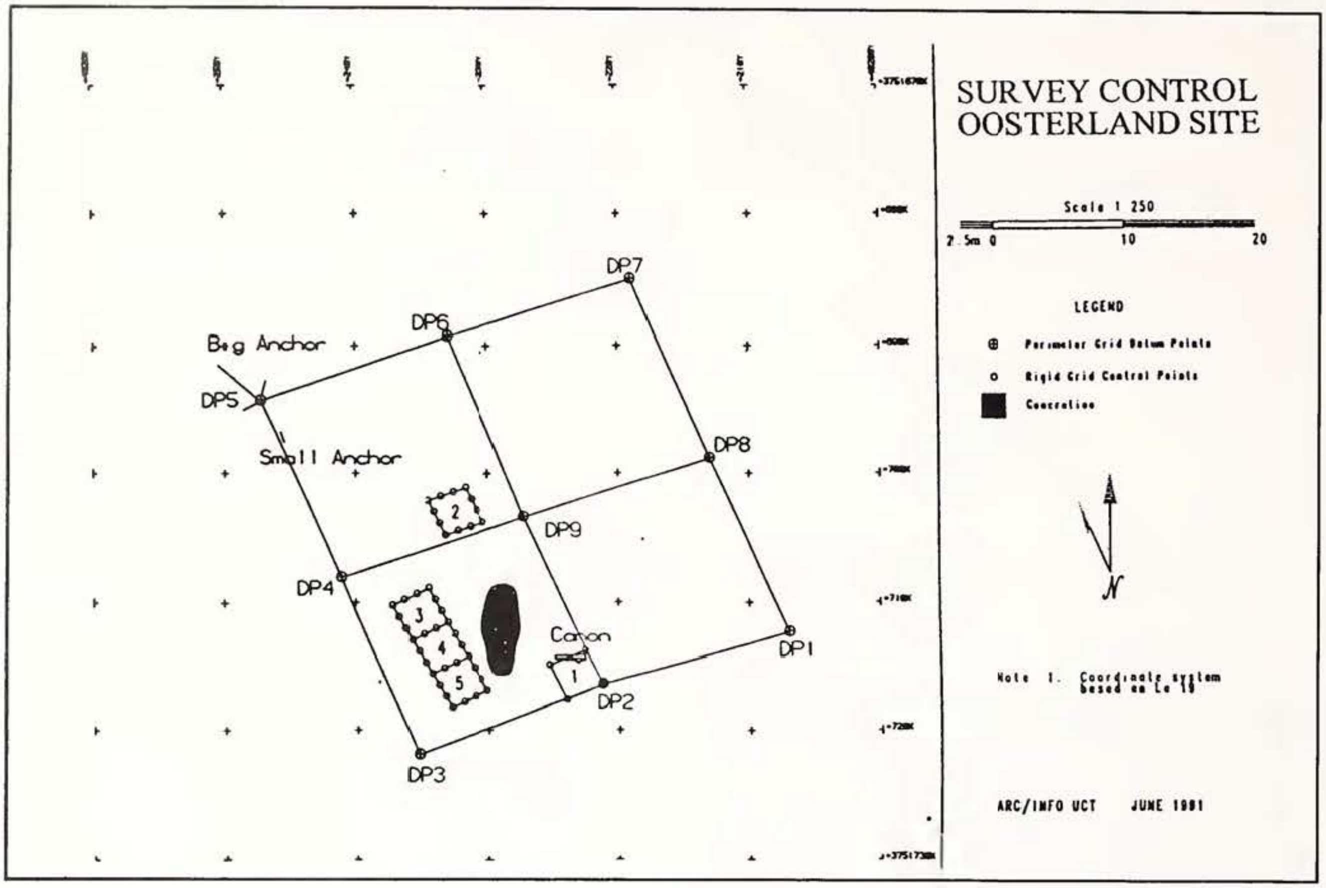


Fig. 5. The *Oosterland* wrecksite, showing the nine perimeter control points and the rigid grids (Breitenmoser, 1991: appendix G).

A navigational chart, published by the Hydrographer, South African Navy, contains bathymetric data which are only a selection of previously acquired survey data. The latter are recorded on a 'fair chart' which may show thousands of soundings, these being of great interest to those more concerned with the details of the relief of the seabed than the navigator. This is especially the case in maritime archaeological research whereby attention is often paid to those areas which show submerged obstacles, indicating possible wreck sites, or areas with a more rugged bathymetry, where the wide dispersal of wrecks and associated artefacts is less likely. Many of these fair charts were produced from surveys using sextant fixes and lead-line soundings, others from electromagnetic position fixing and echo-sounding of more recent decades, but all are recorded on paper. The Hydrographer has a massive programme to convert this traditional record of bathymetric data to digital form which would be acceptable in a GIS. Unfortunately, fair charts of Table Bay have not yet been converted and for the Maritime Archaeological Project, the digitizing was carried out by ourselves for a small area around Robben Island which was the subject of a detailed investigation during 1991-1992, called `Operation Sea Eagle' (Werz 1993b; Werz 1994; Werz 1999:88-103). The coverage for bathymetry was created and 4000 soundings were digitized from fair charts provided by the Hydrographer, which provided the graphical element of the coverage. The values of the soundings were then entered in a Point Attribute Table, `BATH.PAT'. Considering that the area so converted extended just one nautical mile around Robben Island and took sixteen hours to complete, this laborious exercise was not continued for the rest of Table Bay. This must await the availability of digital bathymetry from the Hydrographic Office which, with the introduction of multi-beam sounding techniques, may be realized fairly soon. However, the digital elevation model for that one-mile zone was then used to draw a bathymetric contour map with a two-metre interval and to draw three-dimensional perspective views of the seabed around Robben Island (Fig. 7). The ARC/INFO package SEM was used for these drawings, because it can accommodate input through a coverage and/or ASCII files, where boundaries of the model such as the shoreline are defined by coordinates contained in a `structure line file' (SEM, 1990).

Data for the current coverage were obtained from an oceanographic investigation carried out in 1971 (Van Ieperen, 1971). Of the raw data from 41 stations, that for five were selected and entered in a database file 'CURRENT.DAT'. No further work has been done on this, but what has been done illustrates that a question such as the following can be answered:

> What is the frequency that sub-surface currents between directions 120 and 180 degrees and velocity

1 m per second or greater coincide with surface currents of the same direction and velocity?

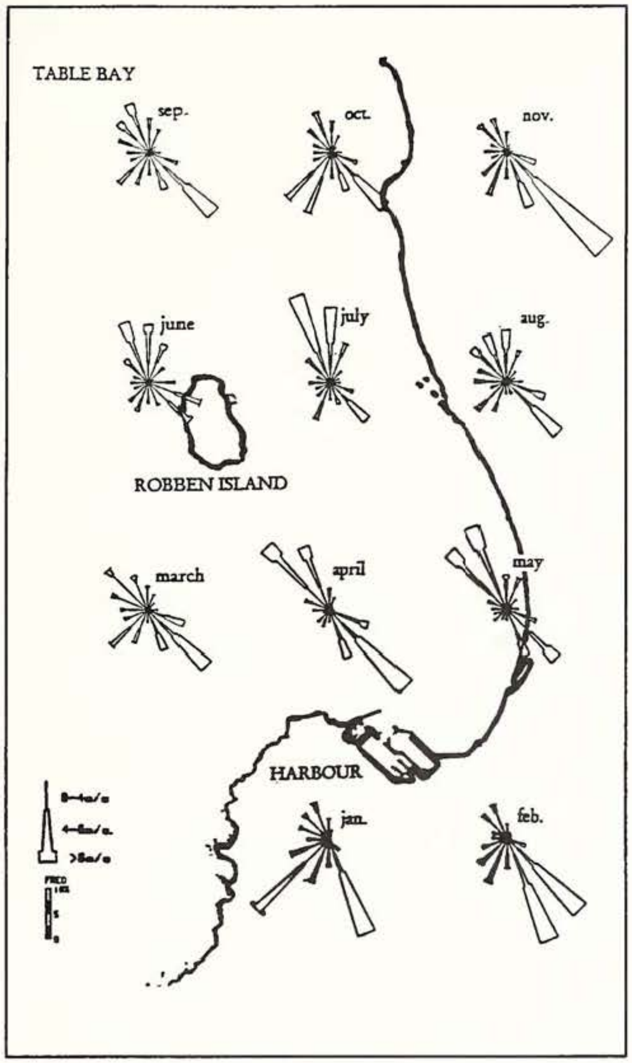


Fig. 6. Table Bay, the area of the GIS project, showing monthly wind roses.

The coverage for sediment deposits has not yet been attempted, except that the source of data depicted graphically has been identified (Woodborne, 1982). This still needs to be digitized and transformed to the GIS format.

The database for shipwrecks has been designed to accommodate those sites which have been already identified, either from artefacts or from documentary evidence or a combination of both, as well as those which will be discovered in the future. Figure 8 shows the 21 sites which were identified during 'Operation Sea Eagle', in which various government departments and the South African Navy participated. This project aimed at assessing the underwater cultural resource within the area of one nautical mile around Robben Island, which hitherto had been declared a restricted zone for shipping and fishing activities. This project has since assisted in the formulation of a plan for the future management of the island, which has played a significant role in the history of South Africa (Werz 1993b; Werz 1994; Werz 1999:88-103). The field work done by surveyors consisted of fixing the positions of wrecks discovered by divers, each wreck thus having an x- and y-coordinate.

As with the geodetic control coverage, the geographical location defined by the coordinate is the link between the graphical record and the non-spatial information. Thus, the map of Table Bay has a graphical coverage showing wreck sites. The coverage is named 'SHIP' and Figure 8 is a part of that coverage. Each site is regarded as a point entity, having an identity number, 'ID', with a unique coordinate, and via this link the non-spatial information can be called up in the form of a Point Attribute Table,

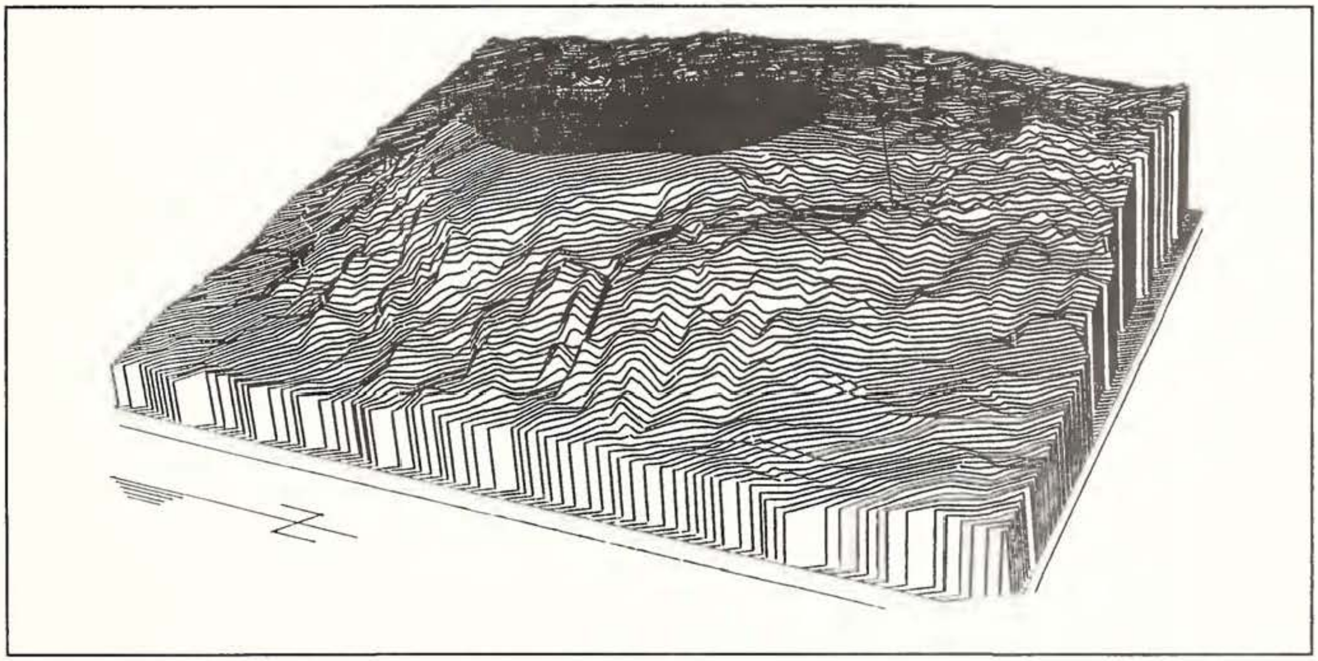


Fig. 7. The seabed within one nautical mile of Robben Island. A perspective view from west-south-west. The island measures approximately 3.5 by 2.0 km.

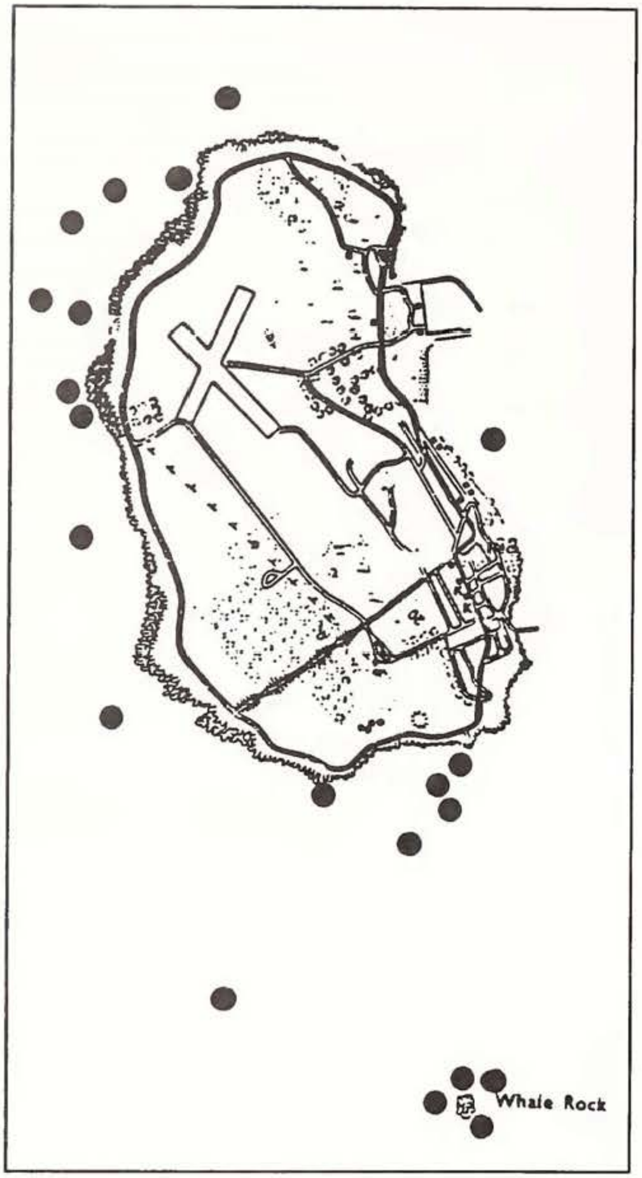


Fig. 8 Shipwreck locations off Robben Island as located during 'Operation Sea Eagle' (after Werz, 1993b).

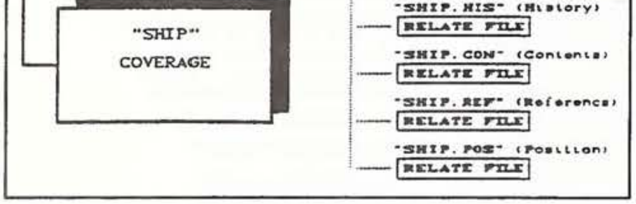
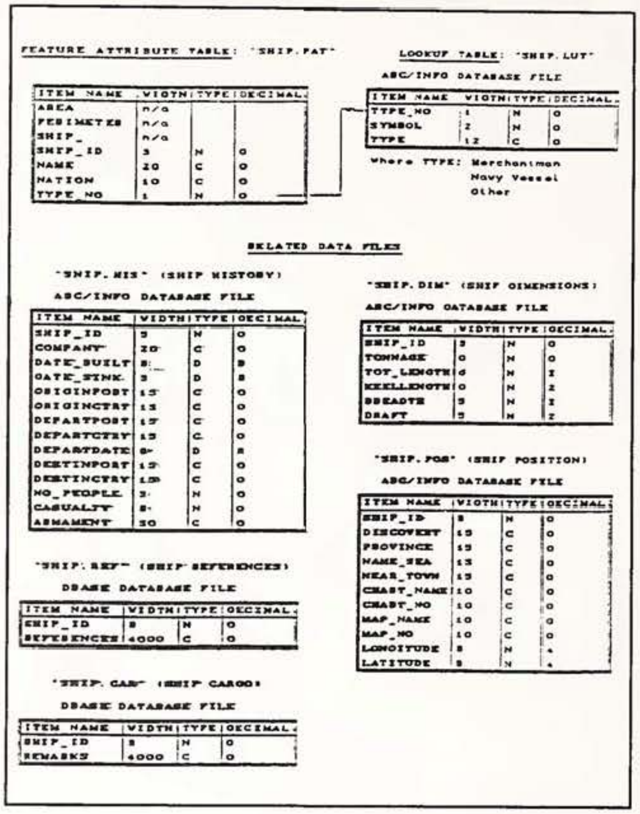


Fig. 9. The shipwreck database (Breitenmoser, 1991: 36).



FEATURE ATTRIBUTE TABLE: "SHIP.PAT"

ITEM NAME	WIDTH	TYPE	DECIMAL
AREA	n/a		
PERIMETER	n/a		
SHIP_	n/a		
SHIP_ID	3	N	0
NAME	20	C	0
NATION	10	C	0
TYPE_NO	1	N	0

LOOKUP TABLE: "SHIP.LUT"

ABC/INFO DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
TYPE_NO	1	N	0
SYMBOL	2	N	0
TYPE	12	C	0

Where TYPE: Merchantman
Navy Vessel
Other

RELATED DATA FILES

"SHIP.HIS" (SHIP HISTORY)

ABC/INFO DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
SHIP_ID	5	N	0
COMPANY	20	C	0
DATE_BUILT	8	D	8
DATE_SINK	8	D	8
ORIGINPORT	15	C	0
ORIGINCTRY	15	C	0
DEPARTPORT	15	C	0
DEPARTCTRY	15	C	0
DEPARTDATE	8	D	8
DESTINPORT	15	C	0
DESTINCTRY	15	C	0
NO_PEOPLE	3	N	0
CASUALTY	5	N	0
ARMAMENT	30	C	0

"SHIP.DIM" (SHIP DIMENSIONS)

ABC/INFO DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
SHIP_ID	3	N	0
TONNAGE	6	N	0
TOT_LENGTH	6	N	1
KEELLENGTH	6	N	2
BREADTH	5	N	1
DRAFT	5	N	2

"SHIP.REF" (SHIP REFERENCES)

DBASE DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
SHIP_ID	8	N	0
REFERENCES	4000	C	0

"SHIP.POS" (SHIP POSITION)

ABC/INFO DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
SHIP_ID	8	N	0
DISCOVERY	15	C	0
PROVINCE	15	C	0
NAME_SEA	15	C	0
NEAR_TOWN	15	C	0
CHART_NAME	10	C	0
CHART_NO	10	C	0
MAP_NAME	10	C	0
MAP_NO	10	C	0
LONGITUDE	8	N	4
LATITUDE	8	N	4

"SHIP.CAR" (SHIP CARGO)

DBASE DATABASE FILE

ITEM NAME	WIDTH	TYPE	DECIMAL
SHIP_ID	8	N	0
REMARKS	4000	C	0

Fig. 10. Structure of the Point Attribute Table 'SHIP' and related data files (Breitenmoser, 1991: appendix E).

named `SHIP.PAT'. With the PAT depicted on the screen, the ID of the wreck can be selected and a related file, *e.g.* the dimensions of the ship or its history, can be called up. All non-spatial data, such as that collected from documentary evidence, must be linked in this manner and this allows related data files to be combined. Figures 9 and 10 show the structure of SHIP.PAT and related data files respectively.

Returning to Figure 3, we have described the first coverage of the database for shipwrecks.Two other coverages are included for artefacts discovered, whether they are point entities, *e.g.* cannon balls, or line (*i.e.* arc) entities *e.g.* ship's timbers. In the same diagram, there are three more coverages for perimeter grid, rigid grid and shore control.These and the two artefact coverages, points or lines, are used once detailed investigation and excavation of a particular site has commenced. To date, only one wreck has been so studied and this project is described below.

THE *OOSTERLAND* GIS

Archaeological sites are unique and require particular survey solutions according to the conditions prevailing, bearing in mind that the end product of the survey measurements is the record of position. This also applies to the *Oosterland* project. The shipwreck of the *Oosterland,* a Dutch East India Company vessel which foundered on 24 May 1697 while lying at anchor in Table Bay, was discovered in December 1988 by local divers M. Barchard, C. Byrnes and G. Raynor. Since 1990, this wrecksite has been the subject of a maritime archaeological excavation as part of the MAP of Table Bay (Werz 1989; Werz 1990; Werz 1992b; Werz 1992c; Werz 1993a; Werz 1999: 104-133).

Table 1. Comparison of precision coordinates obtained from underwater trilateration and theodolite intersections (Breitenmoser, 1991: 12).

Underwater Control (Perimeter) Points	Precision resulting from underwater trilateration		Precision resulting from shore stations	
	Standard deviation in metres			
	Sx	Sy	Sx	Sv
SE (DP1)	0.06	0.06	0.33	0.58
S (DP2)	0.05	0.04	0.54	1.06
SW (DP3)	0.05	0.04	0.25	0.52
W (DP4)	0.04	0.04	0.27	0.54
NW (DP5)	0.06	0.06	0.31	0.61
N (DP6)	0.04	0.05	0.52	0.90
NE (DP7)	0.06	0.06	0.21	0.37
E (DP8)	0.04	0.05	0.22	0.39
C (DP9)	0.03	0.03	0.21	0.40

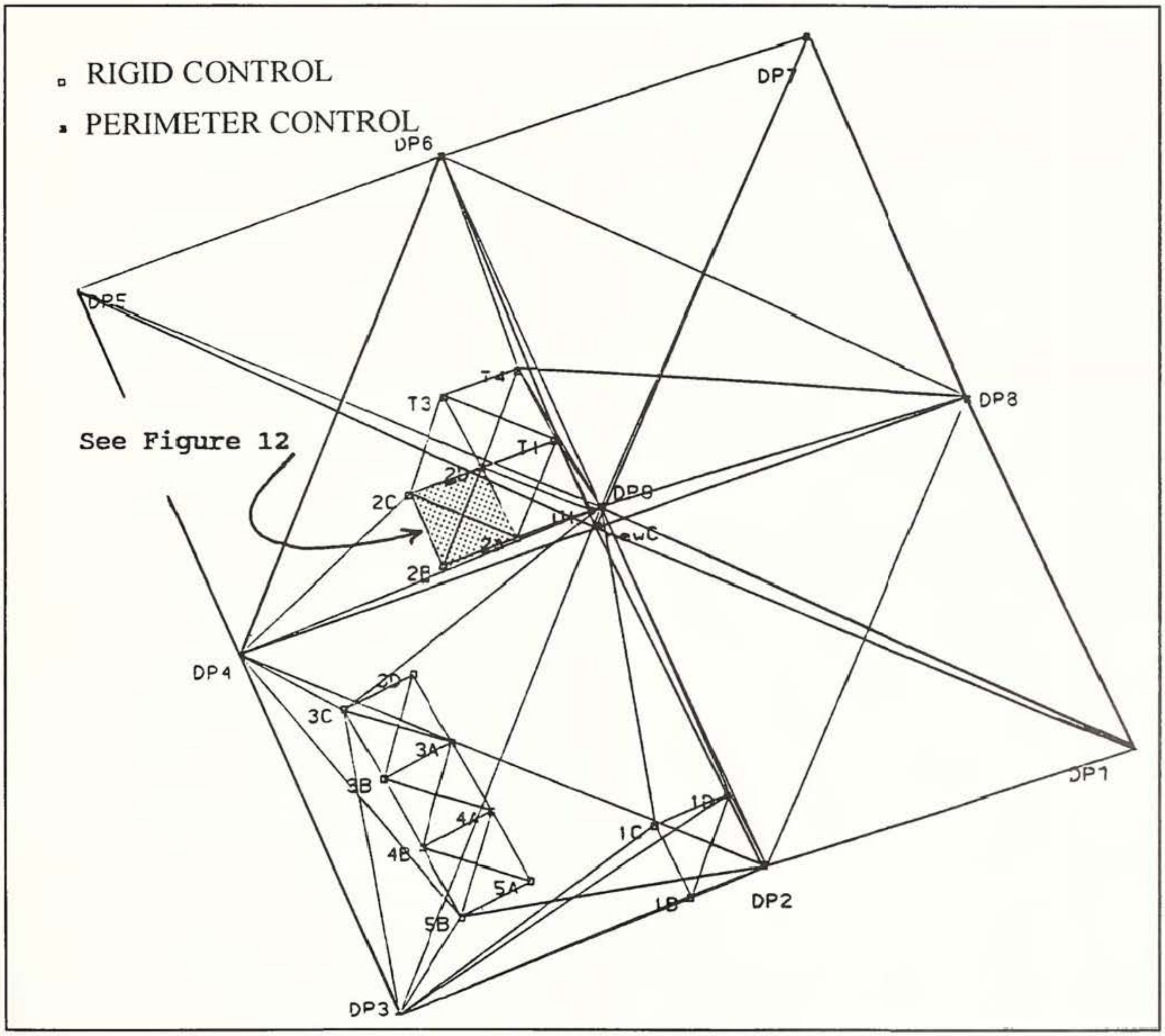


Fig. 11. The underwater control network, as adjusted (Breitenmoser, 1991: 15).

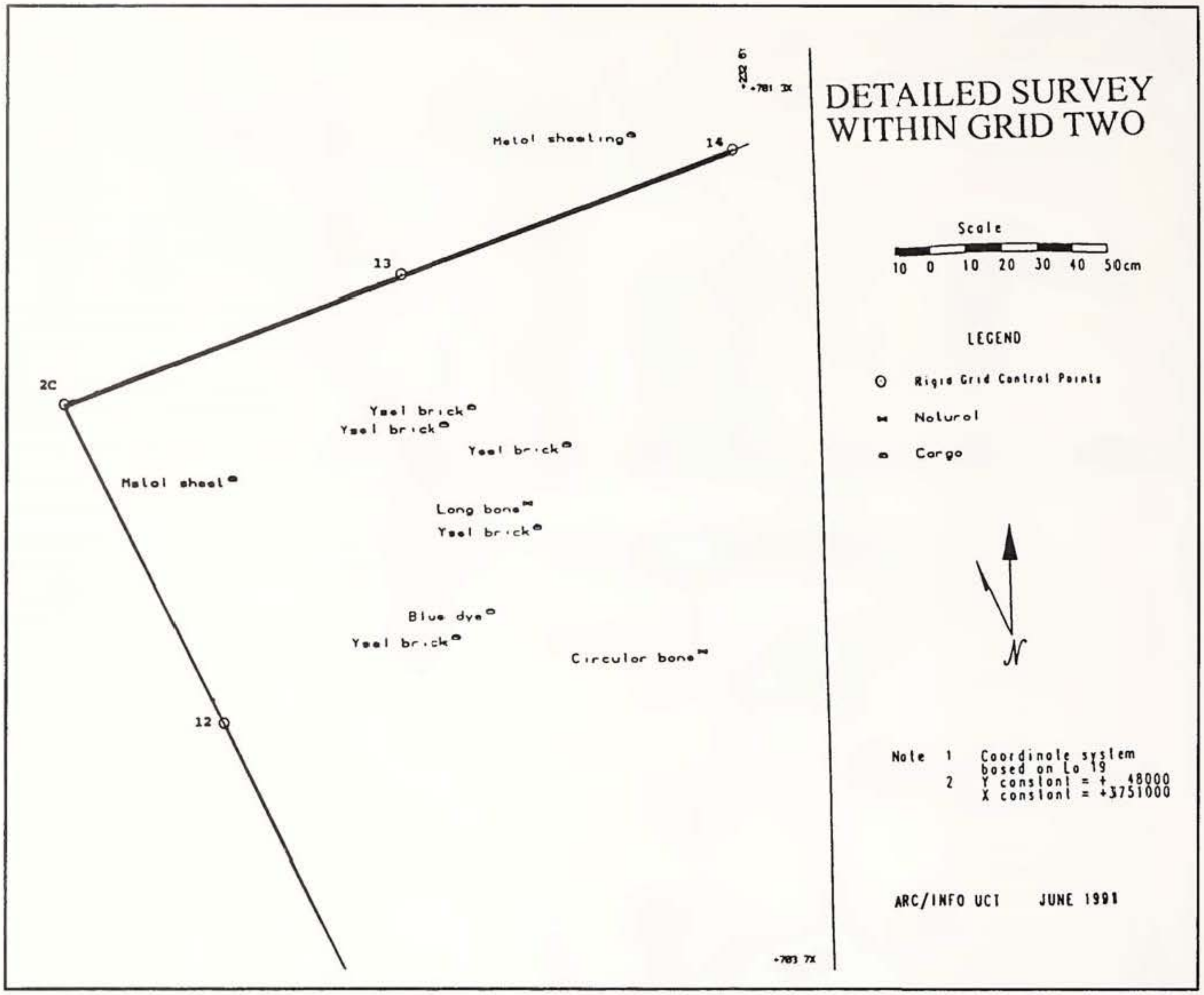
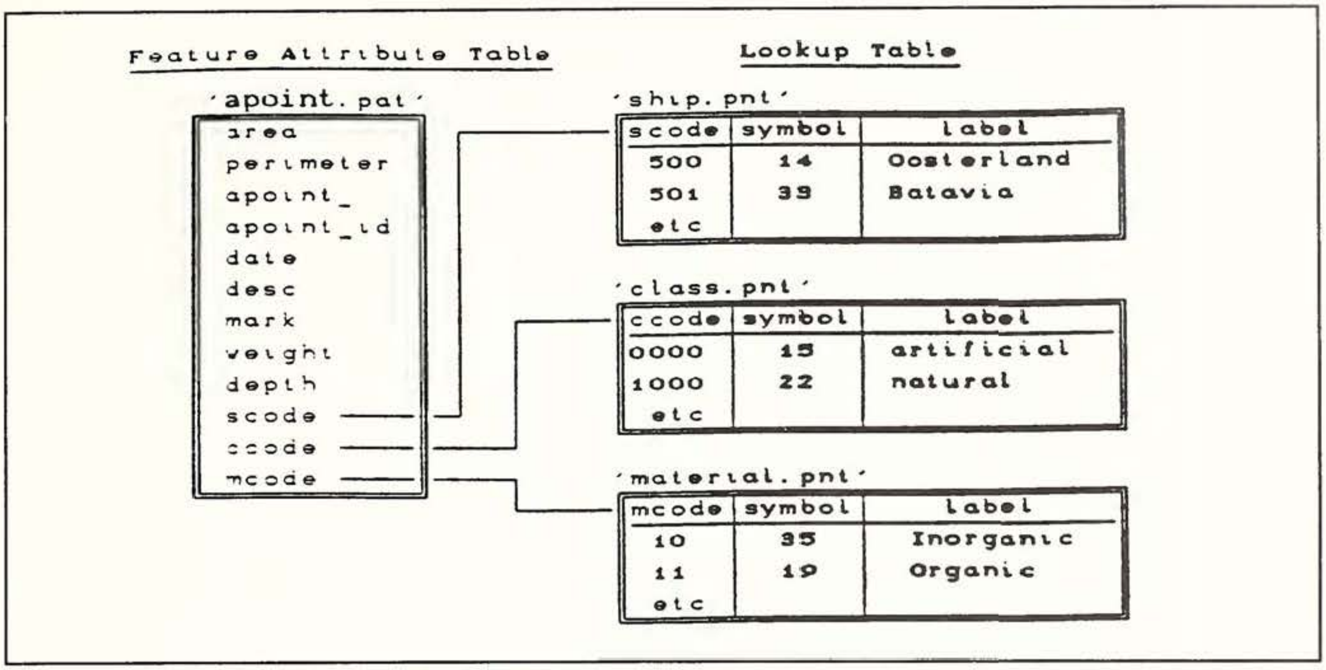


Fig. 12. A part of rigid grid 2, showing markers at 1 m intervals from which three direct tape measurements are taken to each artefact.

The requirements of the *Oosterland* GIS are: to record the location of the wreck, which is already provided by the Table Bay GIS as described earlier; to map the positions of artefacts for the study of their spatial relationships, for example, the arrangement on site of items of cargo; and to establish a database for artefacts to ease access for enquiry into their attributes. In the design of the database, queries expected from archaeologists are assumed and the need for maintenance and up-dating as more artefacts are recovered is taken into account. Also, from the ARC/INFO coverages it must be possible to produce cartographic layers in proper registration for subsequent hard copy output, which is facilitated by the national geodetic coordinate system on which the surveying is based. It is appropriate here to describe briefly the methods by which the survey is done, although this has been reported on in detail elsewhere (Werz, 1993a: 35-39; Werz & Martin, 1994; Werz 1999: 122-125).

The *Oosterland* site is situated only 250 m from the high-water mark in the breaker zone. The known extent of the site at present is approximately 30 by 30 m but could well become greater as excavation progresses. This area is demarcated on the seabed by nine Perimeter Datum Points or PDP's, approximately 15 m apart in the form of a grid and orientated to the magnetic north. Within this perimeter grid, rigid grids measuring 3 by 3 m are assembled around those areas earmarked for excavation. Each side of a rigid grid is marked at 1 m intervals and, once exposed, the position of artefacts is determined by direct tape measurements from the markers to the artefacts. Thus the sequence of survey is as follows:

1. establishing shore control based on the position of triangulation pillar 265 (Fig. 4);
2. determining the positions of the Perimeter Datum Points (PDP's) from the shore control by means of a theodolite survey to buoys which are attached to the PDP's (Table 1);
3. determining the positions of the rigid grids from the PDP's and hence the positions of the grid markers by direct tape measurements (Fig. 11); and,



'apoint.pat'

area
perimeter
apoint_
apoint_id
date
desc
mark
weight
depth
scode
ccode
mcode

'ship.pnt'

scode	symbol	label
500	14	Oosterland
501	33	Batavia
etc		

'class.pnt'

ccode	symbol	label
0000	15	artificial
1000	22	natural
etc		

'material.pnt'

mcode	symbol	label
10	35	Inorganic
11	19	Organic
etc		

Fig. 13. Conceptual view of the database for artefacts (Breitenmoser, 1991: 31).

4. determining the positions of artefacts from the markers by direct tape measurements (Fig. 12).

By this procedure, all points (*i.e.* those on shore, the PDP's, the markers and artefacts) are provided with x and y coordinates.

Concerning the GIS, two separate coverages for artefacts were created: one for artefacts represented by point features, *e.g.* ceramics, instruments, ornaments, *etc.* and one for artefacts represented by arc features, *e.g.* cannons and large timbers. Artefacts may be represented upon a conventional map by a symbol having certain characteristics, *e.g.* colour, pattern, font and size. In ARC/INFO, the same characteristics can be stored in a 'markerset file' and artefacts are linked to these. Figure 13 illustrates the design of a 'Feature Attribute Table', in this case a 'Point Attribute Table' (PAT) with associated 'Lookup Tables', which identify the code number for a particular symbol according to the ship's name, the class and the material of which a specific artefact was made. A Feature Attribute Table maybe constituted as a Point Attribute Table, an Arc (*i.e.* line) Attribute Table or a Polygon Attribute Table according to the nature of the artefact. Examples of a Point Attribute Table and an Arc Attribute Table, from the *Oosterland* GIS, are shown in Tables 2 and 3 respectively.

At the beginning of this paper it was explained that the three basic graphic elements of a GIS are points, arcs and polygons. In the GIS for Table Bay, very few polygons were used, the only examples being the shoreline of Robben Island, the occasional building, and at a later stage the geology once that has been digitised. In this context, a polygon is defined as being a closed perimeter consisting of arcs. When a Polygon Attribute Table (PAT) is created, the first two attributes listed for a polygon are area and length of perimeter, followed by other attributes according to the design. Such a table is not illustrated here, but the reader should refer to Table 2 which is a Point Attribute Table. This is also called a PAT, because what is a point but a polygon with no area or measurable perimeter ! This explains why the first two items listed in Table 2 are strings of zeros. Thus, this part of the software can accommodate both points and polygons.

When a file is created in the tabular, non-graphical section of a GIS, its structure must first be designed by listing those items which will be entered once the data have been collected. Referring again to Table 2, which shows the structure of the table and its output, the first item is 'area' and the size of the area is listed from the first column of the output table. The type of entry is numeric (N) and six decimal places are allowed for. The next item is 'perimeter'. This starts on the 14th column and is treated similarly. Item 'APOINT' is an identification number entered automatically by the computer in the order that the data are entered and cannot be changed by the operator. 'APOINT-ID' is the identification number given by the archaeologist and need not be sequential. For both 'APOINT-ID' and 'APOINT', a width of 11 spaces is provided of numerical type with no decimal places. Then follows the name, in character type with five spaces provided and enclosed in quotation marks, date of excavation and a written description as given by the archaeologist, in character type and also in quotation marks. The following two items provide for the record of artefact weight and depth below the water surface. In this specific example, no artefact weight was recorded and a nominal water depth of 5 m was maintained. The last three items, 'SCODE', 'CCODE' and 'MCODE', are those described earlier with reference to symbols used as shown in Figure 13.

Table 2. Extract from an artefact Point Attribute Table (PAT), with the parameters given at the top (Breitenmoser, 1991: appendix E).

Point Attribute Table (PAT)   Table structure

```
COVERAGE: APOINT

ATTRIBUTE PARAMETERS:

COLUMN   ITEM NAME      WIDTH   TYPE   N.DEC
     1   AREA              13      N       6
    14   PERIMETER         13      N       6
    27   APOINT_           11      N       0
    38   APOINT_ID         11      N       0
    49   NAME               5      C       0
    54   DATE               8      D       0
    62   DESC              30      C       0
    92   WEIGHT             5      N       2
    97   DEPTH              6      N       2
   103   SCODE              3      N       0
   106   CCODE              5      N       0
   111   MCODE              2      N       0
```

Table output

```
COVERAGE: APOINT

FEATURE: POINTS

REMARKS: SMALL ARTEFACTS REPRESENTED BY POINTS

SOURCE: E BREITENMOSER

DATE: 17/10/1991


0.0000000E+00,0.0000000E+00,1,4,’CBL’,19910404,’Centre Basket Lid’,0.00,5.00,500,1000,11
0.0000000E+00,0.0000000E+00,2,5,’V1’,19910326,’Min B&W Vase’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,3,6,’DOG2’,19910326,’Dog’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,4,7,’BWVL3’,19910326,’B&W Vase + Lid’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,5,8,’BL1’,19910330,’Budhist Lion’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,6,9,’VOC’,19910330,’V.O.C. Spoon’,0.00,5.00,500,5000,16
0.0000000E+00,0.0000000E+00,7,10,’O4/15’,19910119,’Various Armaments’,0.00,5.00,500,6000,21
0.0000000E+00,0.0000000E+00,8,11,’O-18’,19910127,’Concretion’,0.00,5.00,500,11000,21
0.0000000E+00,0.0000000E+00,9,12,’2-?’,19910127,’Sheat’,0.00,5.00,500,11000,33
0.0000000E+00,0.0000000E+00,10,13,’2-5/8’,19910127,’Metal Sheating’,0.00,5.00,500,9000,13
0.0000000E+00,0.0000000E+00,11,14,’2-7’,19910203,’Long Bone’,0.00,5.00,500,1000,11
0.0000000E+00,0.0000000E+00,12,15,’2-8’,19910203,’Circular Bone’,0.00,5.00,500,1000,11
0.0000000E+00,0.0000000E+00,13,16,’2-9’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,14,17,’2-10’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,15,18,’2-11’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,16,19,’2-12’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,17,20,’2-13’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,18,21,’2-14’,19910203,’Ysel Brick’,0.00,5.00,500,9000,30
0.0000000E+00,0.0000000E+00,19,22,’WV1’,19910212,’White Vase’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,20,23,’BJ5’,19910212,’Bellarmine Jug’,0.00,5.00,500,0,30
0.0000000E+00,0.0000000E+00,21,24,’EG3’,19910221,’Eagle’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,22,25,’BJ7’,19910221,’Bellarmine Jug’,0.00,5.00,500,0,30
0.0000000E+00,0.0000000E+00,23,26,’LS1’,19910223,’Leatbar Shoe’,0.00,5.00,500,10000,24
0.0000000E+00,0.0000000E+00,24,27,’BWV4’,19910308,’B&W Vase’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,25,29,’BWV’,19910309,’B&W Vase’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,26,30,’BC1’,19910312,’Brass Candle’,0.00,5.00,500,5000,18
0.0000000E+00,0.0000000E+00,27,31,’BWL2’,19910312,’B&W Lid’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,28,32,’Log3’,19910312,’Log’,0.00,5.00,500,1000,11
0.0000000E+00,0.0000000E+00,29,33,’CC4’,19910312,’Concretion’,0.00,5.00,500,11000,21
0.0000000E+00,0.0000000E+00,30,34,’WBL1’,19910314,’White Budhist Lion’,0.00,5.00,500,0,29
0.0000000E+00,0.0000000E+00,31,35,’BUD2’,19910314,’Budha’,0.00,5.00,500,0,29
```

Table 3. Extract from an artefact Arc Attribute Table (AAT), with the parameters given at the top (Breitenmoser, 1991: appendix E).

```
          Arc Attribute Table (AAT)               Table structure

               COVERAGE: ALINE

               SPECIFICATIONS OF ITEMS:

               COLUMN    ITEM NAME      WIDTH   TYPE   N.DEC
                    1    FNODE_            11     N       0
                   12    TNODE_            11     N       0
                   23    LPOLY_            11     N       0
                   34    RPOLY_            11     N       0
                   45    LENGTH            13     N       6
                   58    ALINE_            11     N       0
                   69    ALINE_ID          11     N       0
                   80    NAME               5     C       0
                   85    DATE               8     D       0
                   93    DESC              30     C       0
                  123    WEIGHT             7     N       2
                  130    DEPTH              6     N       2
                  136    SCODE              3     N       0
                  139    CCODE              5     N       0
                  144    MCODE              2     N       0


                                                          Table output
COVERAGE: ALINE

FEATURE: LINES

REMARKS: LARGE ARTEFACTS REPRESENTED BY LINES

SOURCE: E BREITENMOSER

DATE: 17/10/1991


2,1,1,4,0.1316326E+01,1,3,'T1a',19910317,'Timber',0.00,-5.00,500,1000,11
4,2,3,5,0.2066022E+00,2,3,'',0,'',0.00,-5.00,500,1000,11
4,2,1,3,0.8224468E+00,3,1,'T2TAG',19910316,'Timber',0.00,-5.00,500,1000,11
1,5,1,4,0.1383841E+01,4,3,'',0,'',0.00,-5.00,500,1000,11
2,5,4,5,0.2297725E+00,5,1,'',0,'',0.00,-5.00,500,1000,11
6,4,7,5,0.1961700E+00,6,1,'',0,'',0.00,-5.00,500,1000,11
5,6,8,5,0.2208640E+00,7,3,'',0,'',0.00,-5.00,500,1000,11
6,4,1,7,0.1482318E+01,8,3,'',0,'',0.00,-5.00,500,1000,11
3,7,1,6,0.9988473E+00,9,2,'T3tag',19910316,'Timber',0.00,-5.00,500,1000,11
7,8,9,6,0.3585649E+00,10,6,'MC1',19910404,'Concretion',0.00,-5.00,500,11000,21
8,3,1,6,0.1506683E+01,11,2,'',0,'',0.00,-5.00,500,1000,11
5,9,1,8,0.1435896E+01,12,1,'',0,'',0.00,-5.00,500,1000,11
9,6,1,8,0.1740653E+01,13,1,'',0,'',0.00,-5.00,500,1000,11
7,8,2,9,0.1537916E+01,14,2,'',0,'',0.00,-5.00,500,1000,11
11,11,1,11,0.5998204E+01,15,5,'P1',19910113,'Canon',0.00,-5.00,500,6000,18
8,12,2,1,0.4384624E+01,16,6,'',0,'',0.00,-5.00,500,11000,21
12,7,2,1,0.1157216E+02,17,6,'',0,'',0.00,-5.00,500,11000,21
10,10,1,10,0.1010756E+02,18,4,'T2a',19910317,'Timber',0.00,-5.00,500,1000,11
```

Table 3 is an Arc Attribute Table (AAT) of similar design and it is sufficient here to describe the differences between AAT and PAT only. An arc has terminals known as the 'From-node' ('FNODE') and the 'To-node' ('TNODE') and these are the first two items listed. The IDs of these taken from the PAT are given. As arcs contribute towards the definition of polygons, a polygon will be created on the left and another on the right, which can be visualized on the computer screen, as one proceeds from FNODE to TNODE. These are the next two items listed as 'LPOLY' and 'RPOLY', followed by 'LENGTH'. The other items are the same as those described for the PAT.

The archaeologist and the surveyor

Multi-disciplinary cooperation is the hallmark of projects such as the MAP for Table Bay. In those fields where he becomes involved, the role of the surveyor is : to record position; to monitor movement; and to store and manage the data. Due to its versatile application, a Geographical Information System seems to be the most appropriate tool for the filing and interpretation of information retrieved from archaeological sites. In the context of GIS, the following stages should be thoughtfully planned:

1. collection (by archaeologists and divers);
2. storage (by surveyors and archaeologists);
3. retrieval (by archaeologists and surveyors); and
4. analysis (by archaeologists).

The establishment of a GIS is not an end in itself but is the means towards better data management. All participants in a project such as the one described in the above should be aware of the guiding principles of good data management at each stage of the project and the value of different contributions that participants can provide. Very recent developments, such as the introduction of the World Geodetic System (WGS 84) and multi-beam sounding techniques for underwater surveys in South Africa will further enhance this project.

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