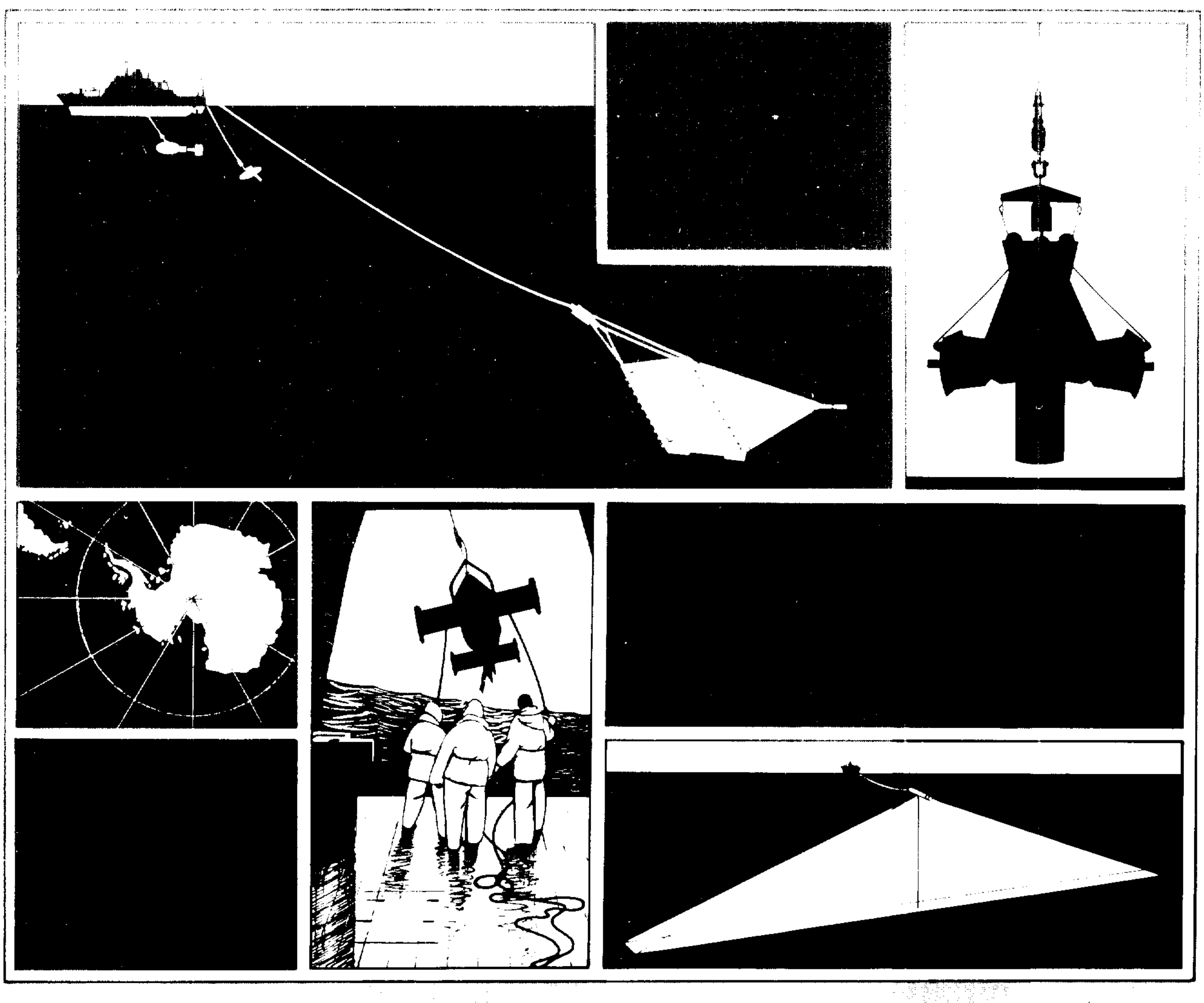
Institute of
Oceanographic Sciences
Deacon Laboratory

European marine atlases: current trends and future directions

G J Robinson & D T Pugh

Report No 283 1991



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Editors

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1991

DOCUMENT DATA SHEET

AUTHOR

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PUBLICATION DATE 1991

TITLE

European marine atlases: current trends and future directions.

REFERENCE

Institute of Oceanographic Sciences Deacon Laboratory, Report, No. 283, 77pp.

ABSTRACT

This publication contains the proceedings of a workshop held at Reading University, England in April 1990. The aim of the workshop was to bring together European marine scientists and other specialists in order to discuss ways of presenting more effectively the increasing volumes of information. available to marine science, particularly through the establishment of a European marine atlas. The financial, administrative and technical issues involved in such a programme are summarised.

KEYWORDS

ATLASES
COMPUTER GRAPHICS
CONFERENCE
GEOGRAPHICAL INFORMATION SYSTEMS
INFORMATION TECHNOLOGY

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PRICE £21.00

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FOREWORD

Scientists and government experts who advised the CEC (Commission of the European Communities) on the contents of the MAST (Marine Sciences and Technology) programme, eventually adopted in 1989, insisted from the start on the need for better cooperation and coordination of European researchers. A similar plea had been made in 1986 within the European Parliament. From this concern arose the so-called Supporting Initiatives of the programme. The first of these addresses the requirement for Community action in the field of ocean data and information exchange.

I am pleased to acknowledge the role of NERC in promoting pioneer work on important aspects of this highly critical issue. A definition study on an atlas-based marine information system for European seas, commissioned by the CEC, was carried out by NERC's IOS Deacon Laboratory in 1988. Some of the main conclusions of the study can be summarised as follows:

1. There is a clear need for evolution towards a common European system of preparing and disseminating information on European Seas. A future 'atlas' should consist of a common database of higher level products.

2. The marine atlas system should be seen as an on-going, rather than an ad-hoc activity.

3. One product of the system should be database software capable of running on personal computers.

The study was subsequently expanded in 1990, also with CEC funding, to confirm the need for a European atlas, what form it might take and how it might be implemented. As explained in the subsequent introduction to these proceedings, a workshop was organised at Reading University, England with these objectives in mind.

The Commission is interested in the follow-up of this activity and would be ready to consider possible ways to move forward.

Dr. J. Boissonnas
MAST Programme
Directorate E
Directorate-General XII
CEC

INTRODUCTION

Marine Scientists are inundated with information. Our new-found ability to make and record vast oceans of data from ships at sea is matched by the increased computer power which is necessary for data processing and analysis. However, our ability to absorb this information, to fit it into our existing patterns of knowledge, and to use it to generate new ideas and knowledge, is often limited. We cannot absorb all the information which is available to us. Inevitably we must pay increasing attention to developing ways of making synthesis of information available in a standard format and of manipulating them.

Within the MAST programme of the CEC, a Europe-wide approach to presenting marine information in the form of digital maps and atlases is being developed. Computerised methods of manipulating existing and future maps will allow individual scientists to think creatively and to test "what if" hypotheses. Working together to prepare common ways of presenting and thinking about marine data is a powerful stimulus for further collaboration.

As part of this development, The Institute of Oceanographic Sciences Deacon Laboratory and the NERC Unit for Thematic Information Systems, together with the Serviços Geologicos de Portugal (Dr. J H Montiero) organised a two-day workshop at the University of Reading in the UK from 4-6th April 1990. A small number of participants, all active marine scientists/cartographers interested in computer presentation of information, were invited to present a paper summarising activities in their country. In addition two scientists involved in similar activities in the USA attended and made presentations of their work. Facilities were also made available for practical demonstrations.

Participants at the workshop considered the best way to develop a full European marine atlas. Their recommendations are included as an Appendix to this report. There was general agreement that a 2-3 year pilot study to develop standard techniques and to apply them to selected representative areas should be the next step.

This report presents the papers by the individual scientists, which form the background against which future developments will proceed.

Gary Robinson / David Pugh

UNEP/MAP: ON-MAP PRESENTATION ACTIVITIES

Adnan Aksel

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The Mediterranean Action Plan (MAP)

Geographical coverage of MAP is the Mediterranean Sea proper, between the Straits of Gibraltar and the Straits of the Dardanelles.

MEDU co-ordinates the work of four centres ("Regional Activity Centres, RACs") around the Mediterranean. These RACs are entrusted with the technical implementation of some of the MAP components listed below:

- Regional Marine Pollution Emergency Response Centre for the Mediterranean Sea (formerly ROCC/RAC, Manoel Island-Malta).
- Priority Actions Programme (PAP/RAC, in Split-Yugoslavia).
- Blue Plan (BP/RAC, Sophia Antipolis-France).
- Specially Protected Areas (SPA/RAC, Tunis-Tunisia).

MAP was initially financed by UNEP and other co-operating UN agencies. Now, however, following the creation of the Mediterranean Trust Fund (MTF) in 1979 by the Contracting Parties, over 95% of the funds come from the Mediterranean countries. MTF plus the financial contribution of UNEP and other UN co-operating agencies, and finally the host country contributions sum up to a figure of over $US 5 million annually, which is administered by UNEP.

Map Data Processing

Data processing activities were initially carried out by utilizing the International Computer Centre (ICC) facilities, before the MEDU office was transferred from Geneva to its permanent headquarters in Athens.

In 1985, an increased demand for digital mapping resulted in MEDU's acquisition of a Tektronix graphics processing microcomputer (4170) and related peripherals. (Its utilization for MEDU mapping activities will be explained later).

In the last quarter of 1986, MEDU made a further purchase of a small number of IBM PC-XT/AT compatibles, and thus entered into the PC-technology. A similar approach was also initiated for RACs in 1988. Currently, MEDU, having transferred all applications from the WANG minicomputer to PCs, is equipped with nearly 20 PC-XT/AT/386 machines and a variety of other hardware.

Computer operations at MEDU fall into four groups:

- Data processing applications (processing of MED POL pollution data, others).
- Word processing (bi-lingual document preparation, conversions).
- Communications (E-Mail, other network usage, telex automation, *etc.*).
- Graphics processing (presentation graphics, mapping, GIS applications).

All computer-related applications are under the supervision of a computer-operations officer, assisted by a data processing assistant. Most RACs are also supported by a computer person who co-operates with the MEDU computer officer.

Map Data Inventories

MAP is rich in data inventories on the Mediterranean region. Large data sets exist for the following:

MED POL Data

Being one of the major components of MAP, MED POL covers pollution monitoring and research activities (research grants, fellowships, training, equipment support to Mediterranean laboratories) along with the preparation of various pollution assessment documents. Annually signed monitoring agreements (specifically mainly PARAMETER, FREQUENCY OF MEASUREMENT, LOCATION, and MEASURING BODY) are followed by data submission in the form of reports from the countries. Most of the data received is on microbiological parameters, heavy metals, hydrocarbons, nutrients, and effluents. Recently, an initiative has been made to distribute the digital formats to countries, to speed up the overall cycle of the data.

Blue Plan Data

Blue Plan has been collecting various socio-economic, and environmental data on the Mediterranean region for building trend and alternative scenarios. Most of the data is on a national level, with very little on coastal regions. These data (consisting mainly of a uniform structure of CRITERION, DATA SOURCE, LOCATION, YEAR, VALUE, UNIT and REMARK) have recently been transferred to MEDU on PC-medium.

RACs' Generated Data

Data coming from the RACs also form a set. Some examples are Mediterranean ports, specially protected areas, historical sites, sea accidents, and coastal cities.

Data Compiled at MEDU

Almost any acquired data (on the Mediterranean region) is kept at MEDU, under appropriate categories. These are unique tools for the management during decision-making processes.

The above data sets have geographical co-ordinates associated with them. MEDU considers any data set without co-ordinates as incomplete.

On-Map Presentation Activities

MONA

The MONA mapping application was created by MEDU in the summer of 1986. Its starting point was the acquisition of over 120,000 points of digital geographical co-ordinates of the Mediterranean coastline (in addition to islands, and some major lakes/rivers) in vector form. Data was received from GEMS/GRID (Global Environment Monitoring System/Global Resource Information Database, affiliated with UNEP).

This data was a subset of the World Database US State Department, and was transferred to the WANG minicomputer where other applications were residing.

Shortly afterwards, a flat-file management system enabling query to this geographical data was established. Through queries with MONA, one is able to retrieve the coastline (and also islands, rivers, lakes, all being user selectable) co-ordinates of a user-defined rectangular area within the

Mediterranean region. The user is further prompted to limit the size of a resultant coverage by specifying the level of accuracy (reduction in number of points).

MONA mapping was prepared on the 4170 machine using FORTRAN 77 language and Tektronix's Interactive Graphics Library (IGL) routines. (Since two systems - WANG VS/80 and 4170 - were already linked through their communication channels, transferring data between them did not create any problem). The system is vector-based and uses a simple latitude/longitude projection system. The main mapping features of MONA are as following:

- User friendly with interactive use.
- On-screen map drawing, modification, deletion.
- Choice of map features (islands, rivers, lakes).
- Various user selectable options for both data presentation and base-map drawing (size, colour, symbol).
- Choice of detailed/non-detailed data presentation (in point symbols).
- Choice of presenting up to 10 maps on the same screen.
- Choice of presenting up to 50 different data on one or more maps.
- Zoom/pan operations (facility provided by 4107 graphics terminal).

Beyond MONA

Transition to PCs brought new facilities to MEDU. Easy-to-use graphics packages forced us to also review the mapping activities. Besides the existence of better tools, two factors have been crucial: Increased expectations/demands for better outputs, and also the limitations of MONA. The following is a brief summary of needs with comparisons against MONA:

- Thematic mapping, area shading. MONA needs to be improved since it provides only point presentations.
- Flexibility in final product preparation/alteration/storage. Map preparation with MONA is quite time consuming, not to mention the difficulties in final form alterations. On the other hand, final product cannot be stored for later printing.
- Compatibility with PC hardware and software. MONA mapping resides on Tektronix 4170, which is not compatible with PCs. Software development was based on the IGL routines which are solely for the superb capabilities of the 4107 terminal.

by the Institut Géographique National (IGN) under contract to MUMM. Depth values were required at the nodes of a uniform, orthogonal lattice, with a grid spacing equal to 4 km (in UTM coordinates, in geographical coordinates and in the BSEX coordinate system) in both the longitudinal and latitudinal directions.

Digitization of the Coastlines

As for the coastlines, two databases were prepared: the first (642,893 points) is referred to as a "high resolution coastline" and consists of the coordinates of arbitrarily but very closely spaced points located on the water boundary reported on the U.K. Admiralty Charts, whereas the second (4,922 points) is referred to as a "staircase", or "low resolution" boundary with N-S and E-W line segments very close to 4 km. The purpose of the latter database was to provide a "solid boundary" readily usable in a finite difference numerical hydrodynamical model. High quality graphical representations of all digitized coastline information have been provided by IGN.

Digitization of the Bathymetry

The bathymetry has been digitized separately for three distinct zones: the southwest quadrant (from 12°W to 0° and from 48°N to 55°N); the North Sea area (bounded SW by the 2°W meridian, in the north by the 59°N parallel, and including the Skagerrak and Kattegat in the east); and the part of the Norwegian Trench area comprised between 2°E and 6°E and between 59°N and 62°N (figure 2).

The southwest quadrant was digitized by the IGN, based on the most appropriate soundings reported on navigation charts (37,476 soundings digitized). As the spatial distribution of these points is rather inhomogeneous, the IGN has performed the task of interpolating the available data onto a uniform horizontal grid by means of their sophisticated Digital Terrain Model (DTM) system. It must be noted that the square cells defined for the DTM net correspond to the "staircase" representation defined above. The principle for the production of a DTM (IGN, final report) is that a tangential plane is generated in each point of the spread input points being characterized by 3 values x, y, and z. For each input point, the programme seeks out the nearest N points in the x-y plane. The tangential plane is calculated by the least square method according to these neighbouring N points being weighted by the distance between the considered point and a neighbouring point. Hence, the Z coordinate in each node of the DTM net is calculated according to a weighted mean value of the M nearest tangential planes (with M different from N). Morphological correction schemes are applied but not discussed here. Bathymetric lines are generated by isolating DTM surfaces (min. 2 cells) including all points which are higher or equal to those lines. Land

Remarks on the Preparation of a European Digital Marine Atlas

Additions to the above considerations can be made if a broader product, such as a Digital European Marine Atlas, is aimed for. Some thoughts on the subject are presented below:

- Difficulties in acquiring reliable coastal data, since sources are most likely going to be country statistical yearbooks.
- Problem of languages for the employed software, and, more specifically, on the final Atlas product.
- The need for scientific analysis of certain types of data before presenting on a map; existence of various analysis criteria.
- Choice of hardware and software (PC versus Macintosh); need for a strong PC (*e.g.* 386-based PC which is not yet common among average users) for such an application.
- Wide end-user spectrum will likely result in different products.
- Difficulty in choosing an up-to-date technology in a rapidly changing field.
- Employment of the other developing techniques (video/audio/computer interaction, 3-D mapping, clip art, *etc.*).
- Any proposal for giving the user an option of importing and presenting his own data will increase the size of the project, not to mention a possible need to resolve copyright issues.

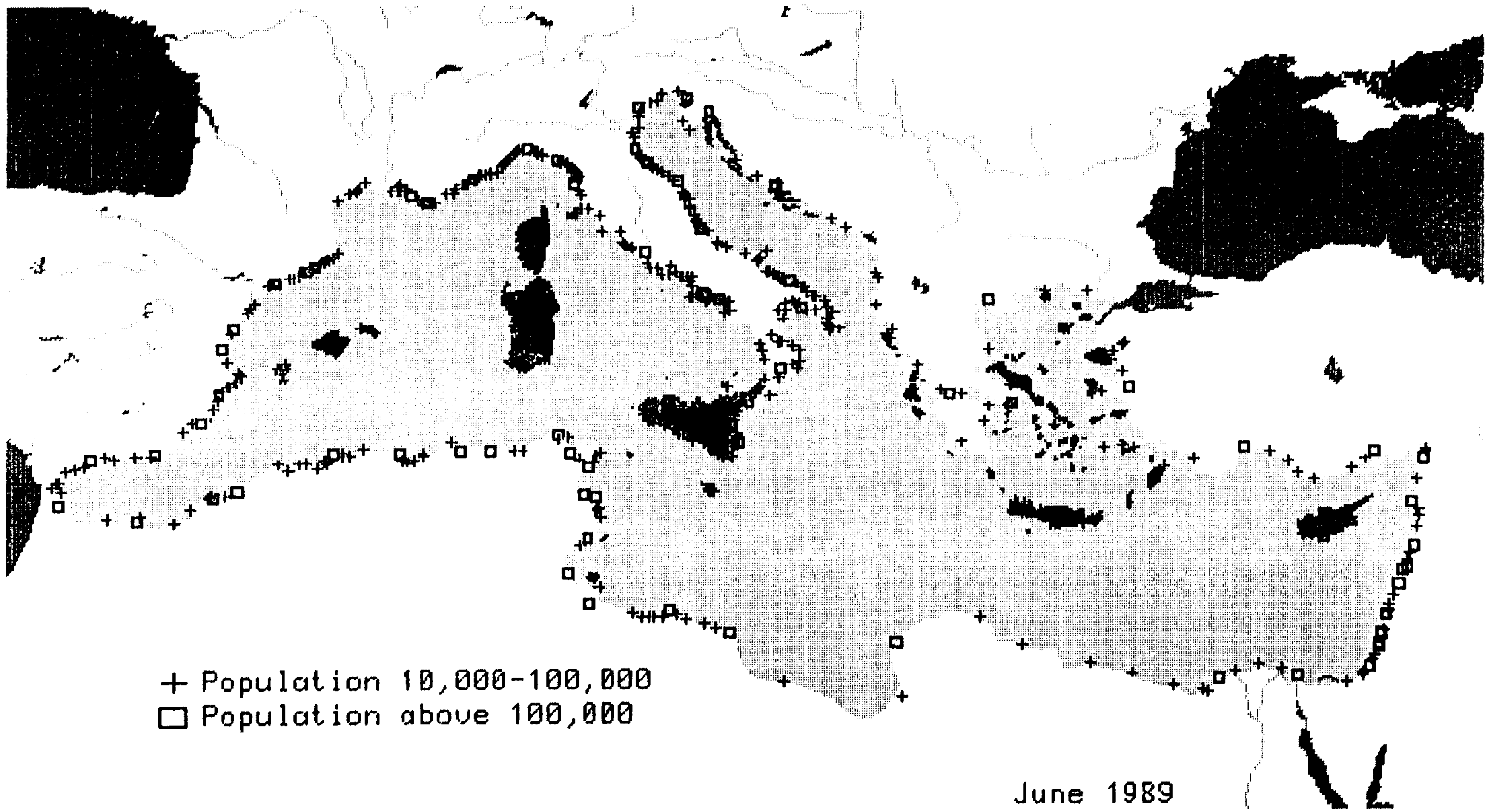

Figure 1. Mediterranean Coastal Cities (Population above 10,000).

PRESENTATION OF MARINE INFORMATION ON MAPS AT THE INSTITUTE OF MARINE RESEARCH

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The Institute of Marine Research (IMR) use mainly one system for presentation of marine information. This system is called ITAKS, and was developed at IMR on a NORSK DATA mainframe computer, running the SINTRAN operating system. ITAKS is a menu-driven fourth generation tool and takes as input an ASCII file with a special format for data, line types and symbols generated from a program or report generator, or input from a terminal or workstation. ITAKS also has an interactive graphical input module. The user can edit plots and generate symbols. Output can be generated on a graphic screen, pen plotter and now also on a Postscript laser printer. But the system is very device dependent, and since the electronic data processing (EDP) strategy at the Institute is based on a open systems networked environment, the system must either be ported to a standardized system, or IMR must evaluate another system.

The EDP-strategy at IMR means that the Institute is investing in standards, for example UNIX workstations connected together by ethernet running TCP/IP and NFS protocols. Development of new systems is done using standards like GKS (GPGS), X-windows, SQL database languages, *etc.* We think that the main language in the future is C or C++, but at the moment we use C, FORTRAN and Pascal. With these considerations we have some thoughts of how we will rewrite our ITAKS system to conform to an open system approach.

The ITAKS system is composed of three main sections: the MAP database, the MAP-LIBRARY based on the graphical library GPGS-F, and the FOCUS screen-handling system from NORSK DATA as the user interface (figure 1). The system is written in FORTRAN. The MAP-LIBRARY is a collection of procedures based on GPGS for plotting data on a map, with isolines, symbols, *etc.* The system can generate plots in horizontal maps or vertical faces with bottom contours. The MAP database and the MAP-LIBRARY have already been ported to UNIX on SUN computers. If we port the ITAKS system to UNIX computers, we probably will use X-windows as user interface, the UNIX version of MAP-LIBRARY and the UNIX version of MAP database.

The Institute of Marine Research have also evaluated the ARC/INFO Geographical Information System (GIS) , which is almost a standard. Other GIS-related systems such as UNIRAS will also be evaluated, so we will probably use a third-party software tool in addition to ITAKS.

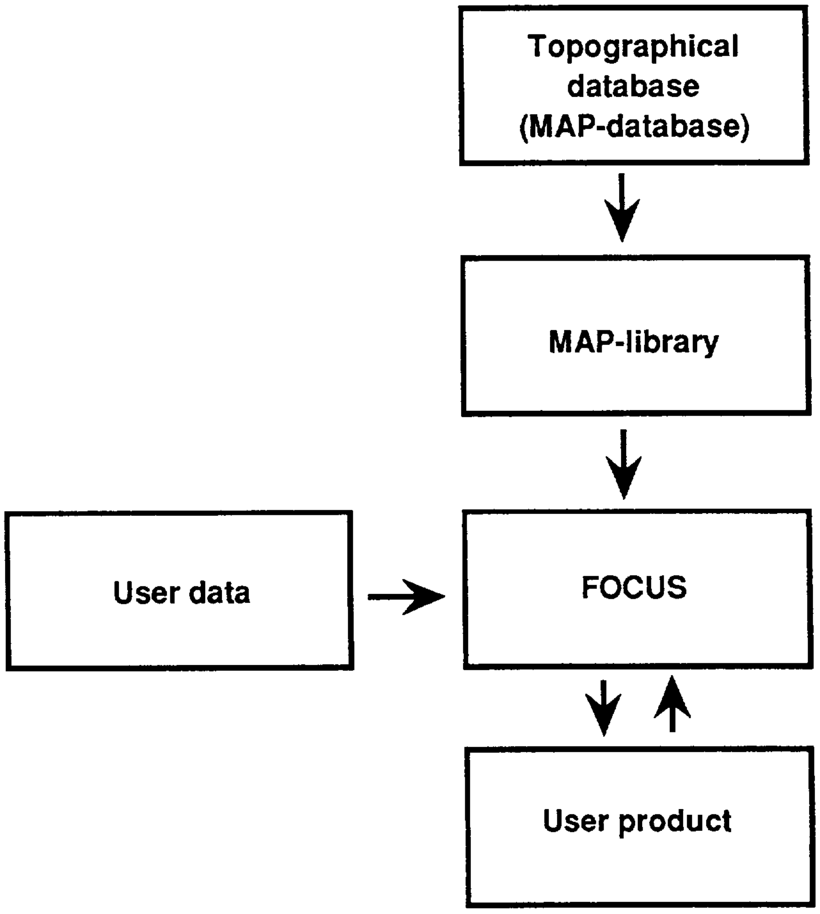

Figure 1. System overview of ITAKS. The different sections of the system can be used seperately, for example with FORTRAN programs.

IMR use a lot of PC and Macintosh tools for different presentations. These are geneally well known proprietary packages.

Examples from ITAKS are shown in the following figures.

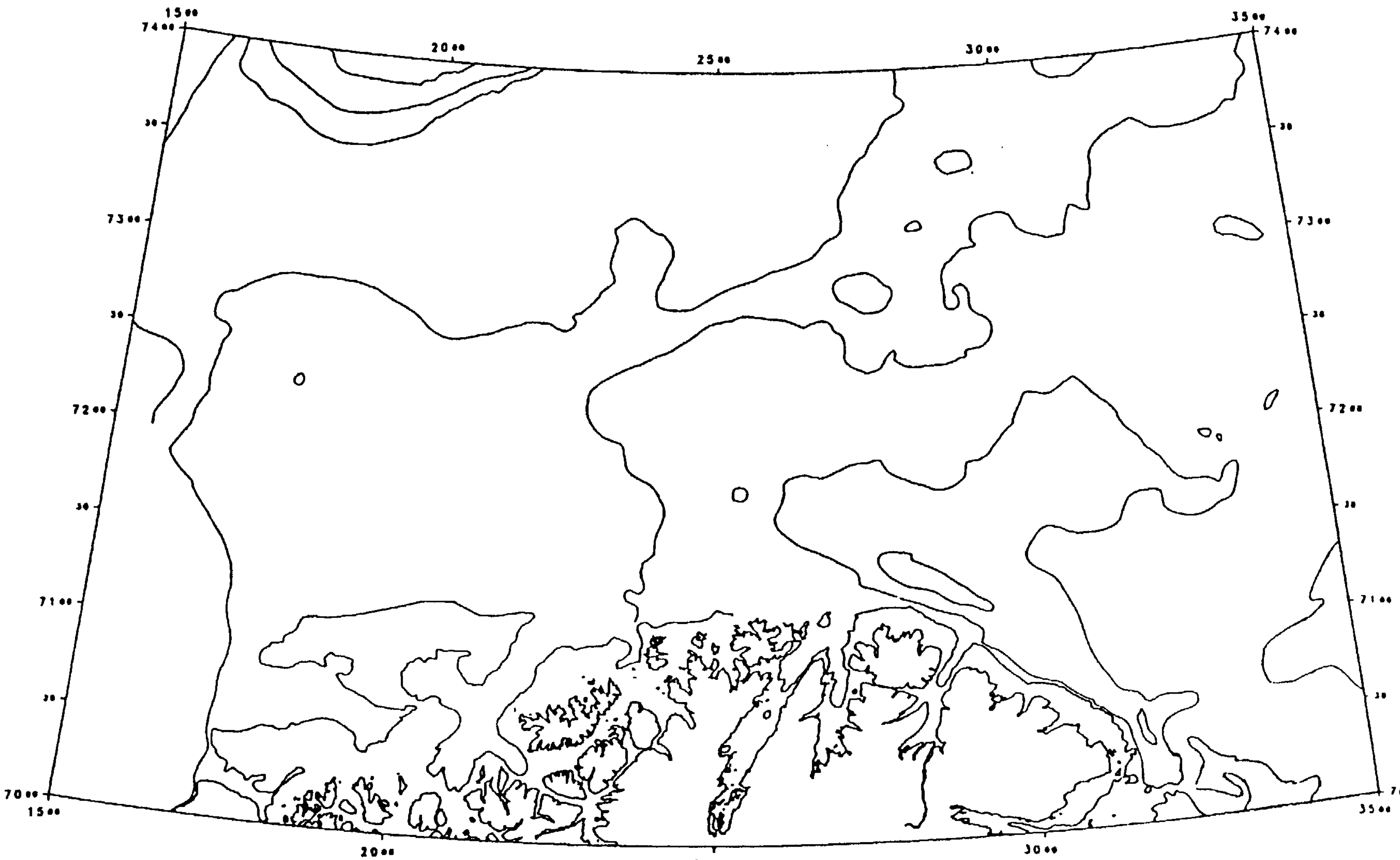

Figure 2. A chart frame with text, coastlines and depth lines.

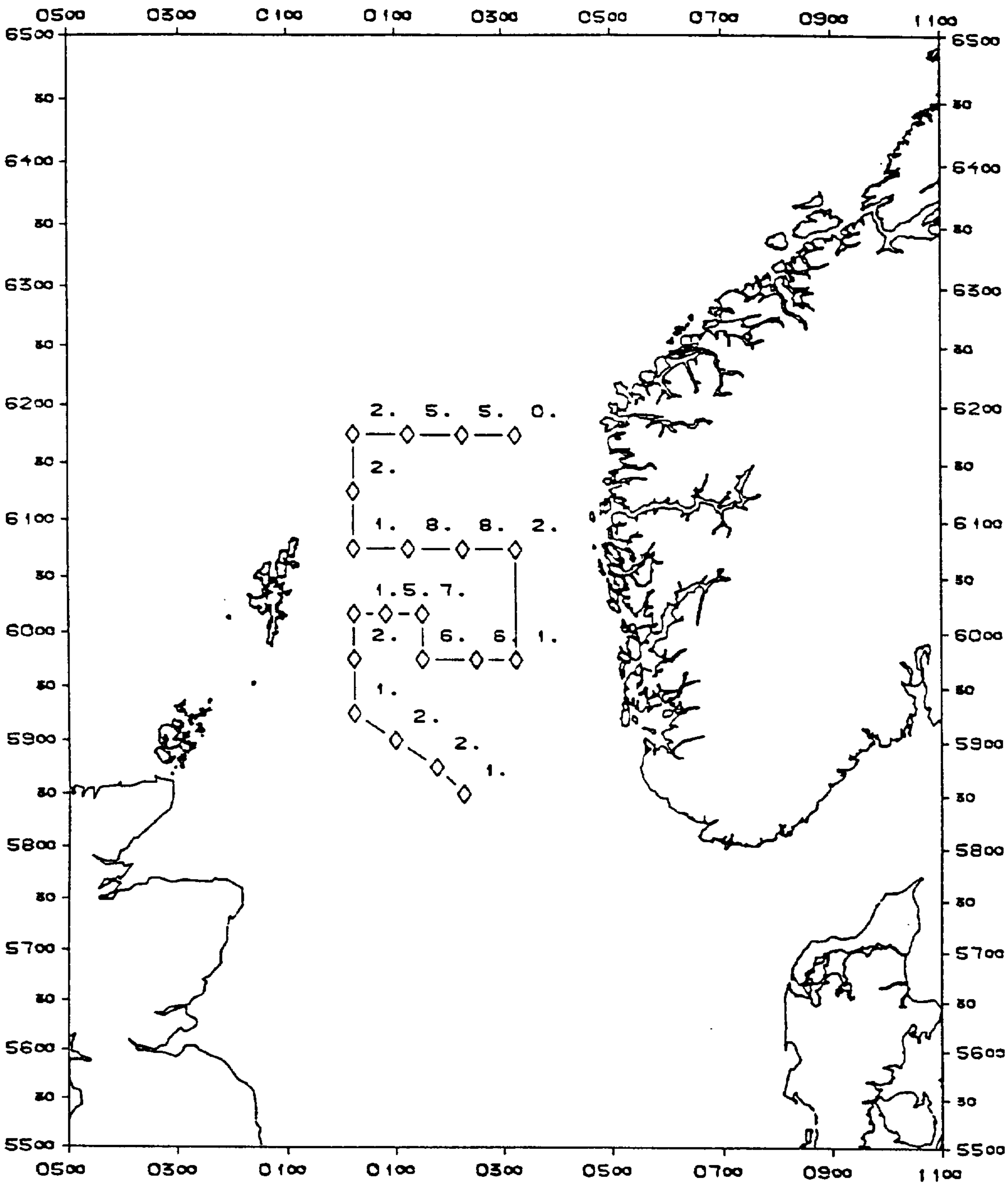

Figure 3. A chart frame with text, coastlines and data points.

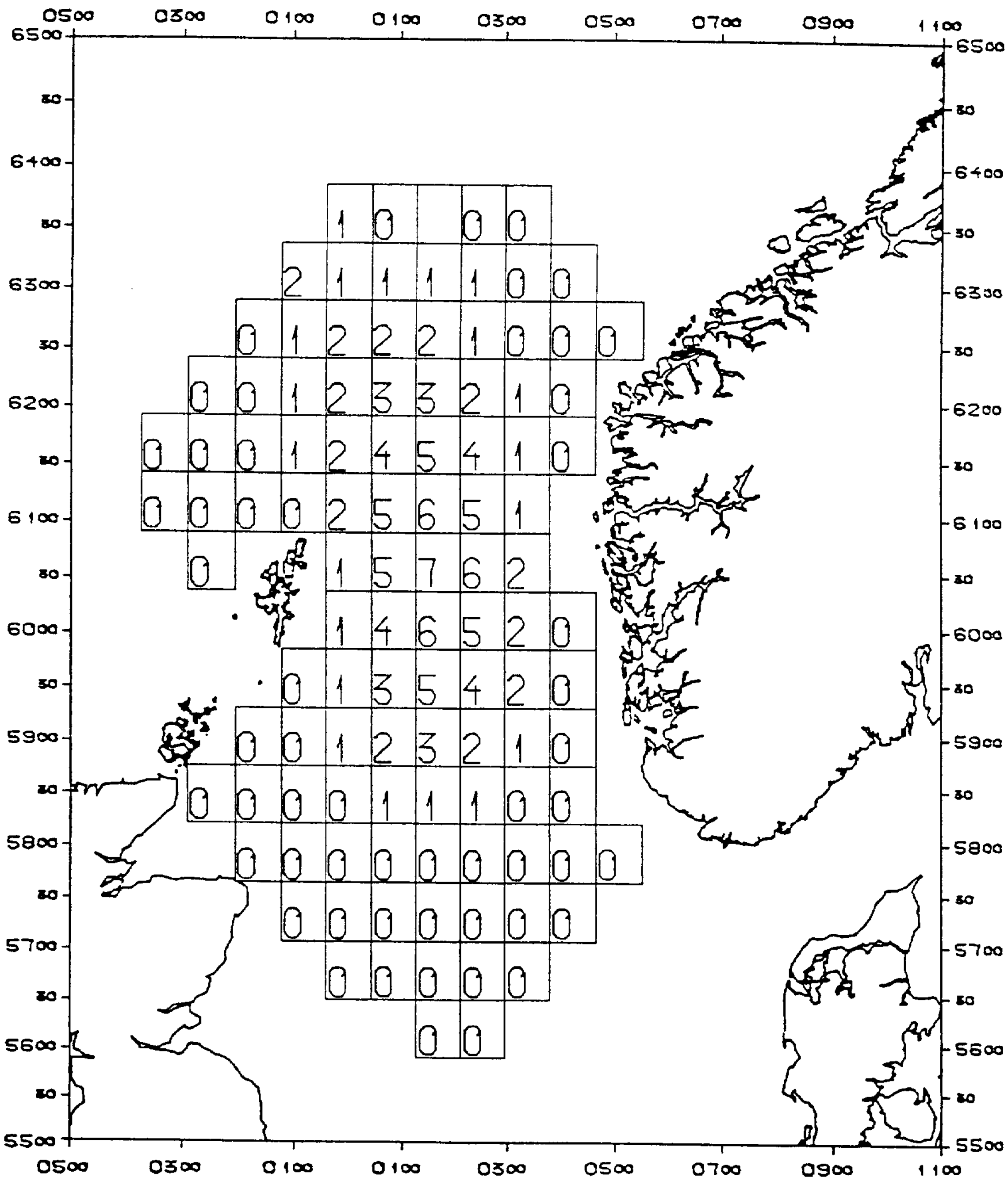

Figure 4. A chart frame with text, grid and coastlines. Grid is blanked near coastlines.

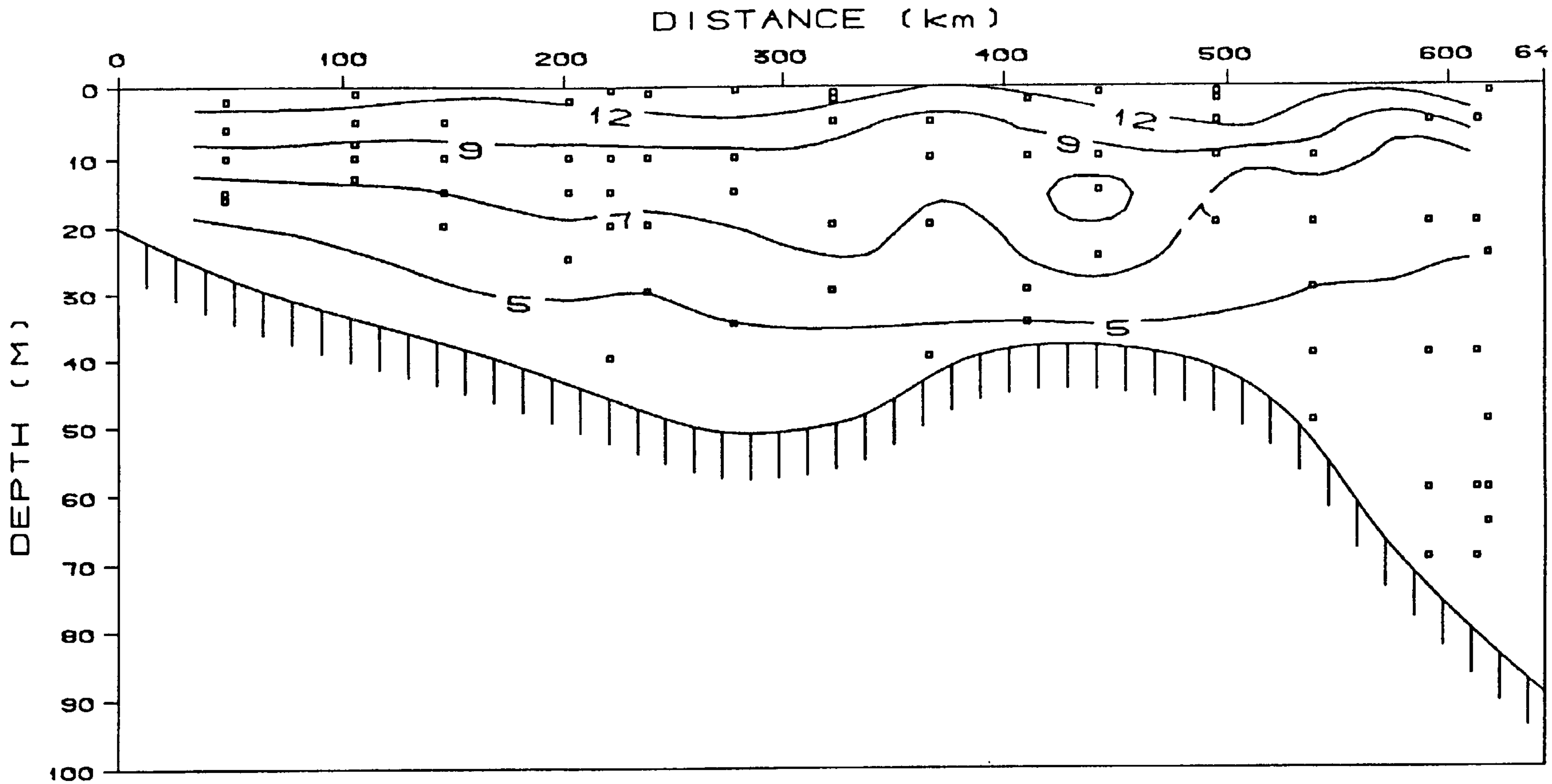

Figure 5. Number of stations = 20. Number of projected stations = 16.
Lat/long$_1$ = (5500, 0000), lat/long$_2$ = (5800, 0900)

CERBOM: "STONE AGE" METHODS - ALL BY HAND!

Pierre Revillon

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Traditional Approach to Data Analysis and Presentation

To analyze the spatial distribution of oceanographical parameters such as salinity, temperature, concentrations of heavy metals or other chemical or biological constituents in a certain area we employ sets of lines of equal values (isopleths) of the parameter in question.

To generate these we use a very traditional data processing method, where everything is done by hand with only an electronic aid: a pocket calculator. Every station point is marked by hand on a chart with a number indicating the value of the parameter and isopleths are drawn in a rather primitive but efficient manner by hand, interpolating by eye through the set of points.

If the individual points are sufficiently close to each other we recourse to a method derived from the Marsden Square technique based on a grid of latitudes and longitudes. The sides represent a number of minutes of degrees which is a sub-multiple of 60, so that an area of one square degree contains a whole number of "squares". This number, which is the "pitch" of the network, is chosen according to the scale of the chart, the denseness of the set of points, and the precision of the location of the points, in order to reach a compromise between the number of points in a square and the precision of the isopleths drawing. In much of our work we have found a pitch of 6' convenient. The fact that at our latitude the "squares" are in reality rectangles with a moderate elongation dependent on latitude is a minor disadvantage compared with the universality of the technique which allows a very simple means of obtaining averaged values.

This method works best when the data in every square is well distributed temporally and when their number is sufficiently great for the mean to be significant. In many cases this does not happen, but the situation improves gradually as new data are collected. On the other hand this method is more flexible than at first sight, since, for example, several squares may be grouped into a bigger one. In areas where the data are spatially well distributed and closer to each other than elsewhere, a more subtle analysis can be carried out by subdividing the initial squares, for example, by replacing locally a contiguous set of 6' squares by a corresponding set of 3' squares.

At any rate the number of data in every square is an indication (at least partly, since it does not account for the temporal distribution) of the confidence that you can concede to the mean value in the square, and the drawing of the isopleths can take this into account.

We give (figure1) an example where is shown, on the scale of a nearly final draft working chart in a limited densely explored area (Coast of Provence, west of Nice):

- The squares themselves with their mean values (mercury concentration in mg/l) the middle of the number marking approximately the position of the mean point and the bracketed numbers indicating the number of measures in every square (blank squares are those where there is no measure).[1]
- The corresponding isopleths.

Advantages and Disadvantages of the Traditional Approach

At every step of this work the draughtsman must make use of his judgement, according to his knowledge of the area, as well as of the constraints of the oceanographic work at sea. In fact he should be preferably an oceanographer and, if possible, an oceanographer who has participated in the collecting of the data he is working on. It is useful to be able to foresee the possible influence of river plumes, of the main industrial, agricultural, geological *etc.* sources of pollution by run-off or emissions, thus anticipating the possible changing of shape of an isopleth he is drawing. In the same spirit the spacing between isopleths may not be standard, but vary in order, by example, to set off, according to the local or regional situation, the values which separate groups of the same parameter; the more or less important degree of uncertainty of such or such isopleth or part of isopleth may be shown graphically (pecked and dotted, for instance, instead of continuous lines), unusual values may be shown by a star or circles of different diameters.

Only the initial phase (drawing of the network of the requested squares) and the final phase of drawing the ultimate product, a map of isopleths for instance of size 21 x 27 mm (A4) are reserved for a professional draughtsman, who may use a photographic reduction of the last draft chart drawn by the draughtsman-oceanographer on a sheet of paper which can be more than 1 m^2 in size.

Moreover, "le mieux est l'ennemi du bien"[2], and lacking the resources to publish coloured maps, we have found that in general, depending on the scale, overloading an already "dense" final map by a "spray" of typical values (with or without the mark of the number of averaged data) as well as by enhancing in black and white the value of the spacing between isopleths by means of

[1] In order to increase legibility of figure 1 the reference number of every square has been omitted.

[2] "leave well (enough) alone"

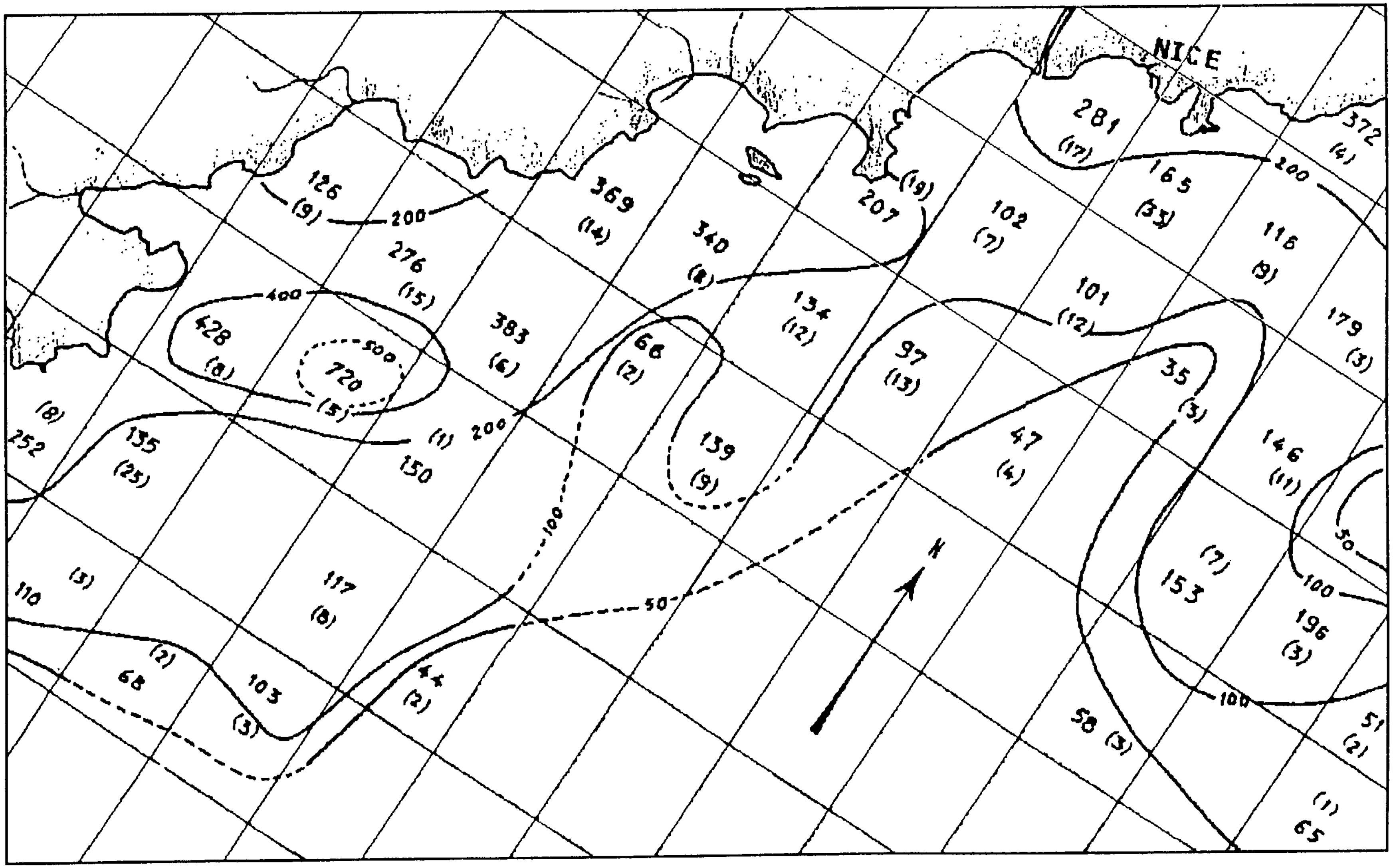

Figure 1. Example of Marsden Squares on draft working map (final stage). Coast of Provence, west of Nice.

hatching, cross-hatching, shading, is very detrimental to legibility and gives poor results (see figure 2). It is better to restrain oneself to indications such as > and < such and such value judiciously arranged here and there (see figure 3). Naturally the utilization of colour would be greatly beneficial.

The foregoing comments on the creation of an isopleth map in CERBOM apply fully only when there is a rather considerable abundance of data in the considered area. If the data are more scarce the work can of course be greatly simplified where all the station points with all the concentrations are marked (figure 4).

I have tried to attract your attention to our good old method of drawing isopleths "by brains and pencil alone" with its reasonably good results. These are obtained at the cost of considerable effort by an experienced oceanographer acting as a draughtsman, and we feel that some, or maybe a considerable, alleviation and even improvement could be obtained by at least a partial "computerization". But this is for our centre a matter of reconversion with all the consequences related to equipment, staff, money *etc.* when publishing atlases of isopleths maps in special issues of our scientific quarterly (Revue Internationale d'Océanographie Médicale) is only a small part of the activity of CERBOM.

An Example of a Computerized Method in a Neighbouring Field

For the part of our activity related to "studies of impact on the natural environment" in the construction or extension of marinas, development of artificial beaches *etc.* we need, very quickly, dense and accurate networks of isobaths in limited areas close to the shore, the depths being measured on board our research vessel. We have recourse to a society of land and naval surveyors acting as a subcontractor, whose maps of isobaths are drawn by computer.

The method, which is the same for isobaths at sea as for contour lines on land, is called MODELISATION NUMERIQUE DU TERRAIN ("Numerical modelling of the ground"). This technique involves an automatic triangulation of the station points, from which the computer can draw isopleths through the patchwork of triangles. Occasionally however, there may arise an ambiguous situation, in which case manual intervention is necessary.

It is clear that, in order to draw isopleth maps of concentrations in sea water (the required absolute precision is much less than for near-shore isobaths but the connections with possible land sources are much more intricate) the foregoing computerized method could be adapted to save steps in the long and sometimes tedious hand work. This is only partly true, since the oceanographer's knowledge is still essential in the mapping process.

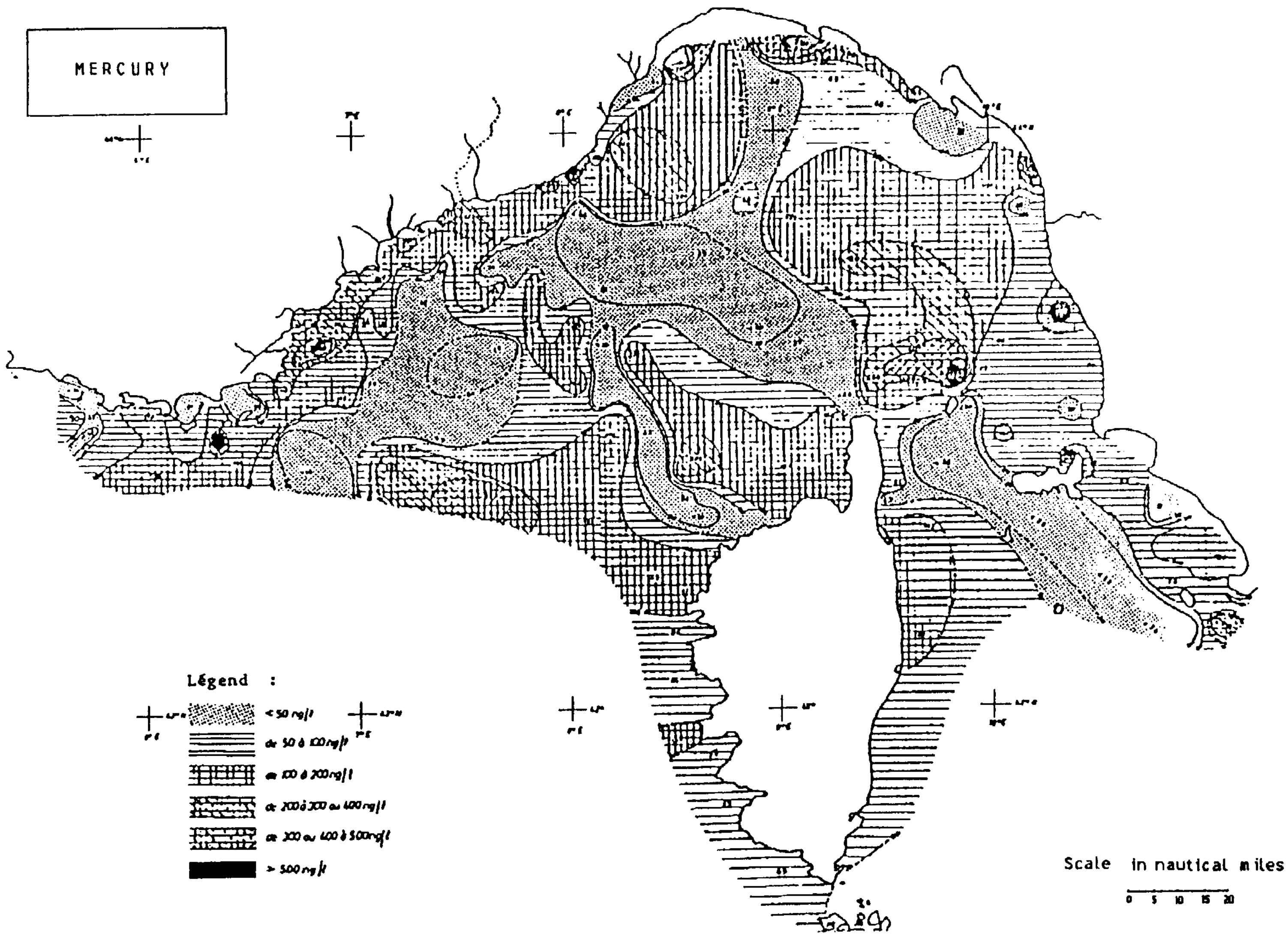

Figure 2. Cruises from May 1976 to August 1982 (Ligurian Sea). Heavy symbology leads to poor legibility.

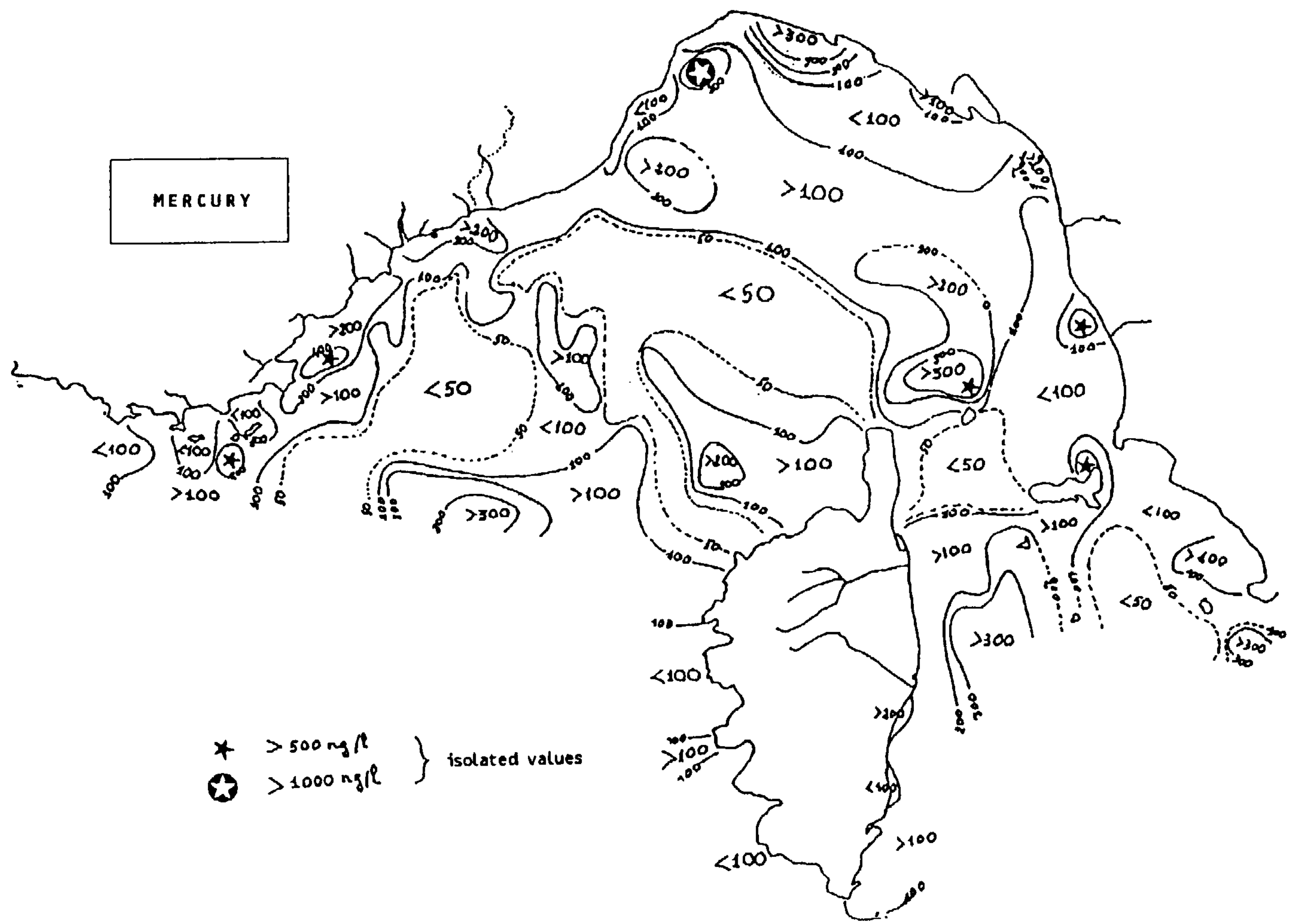

Figure 3. As figure 2 but with no area shading and representative point samples added.

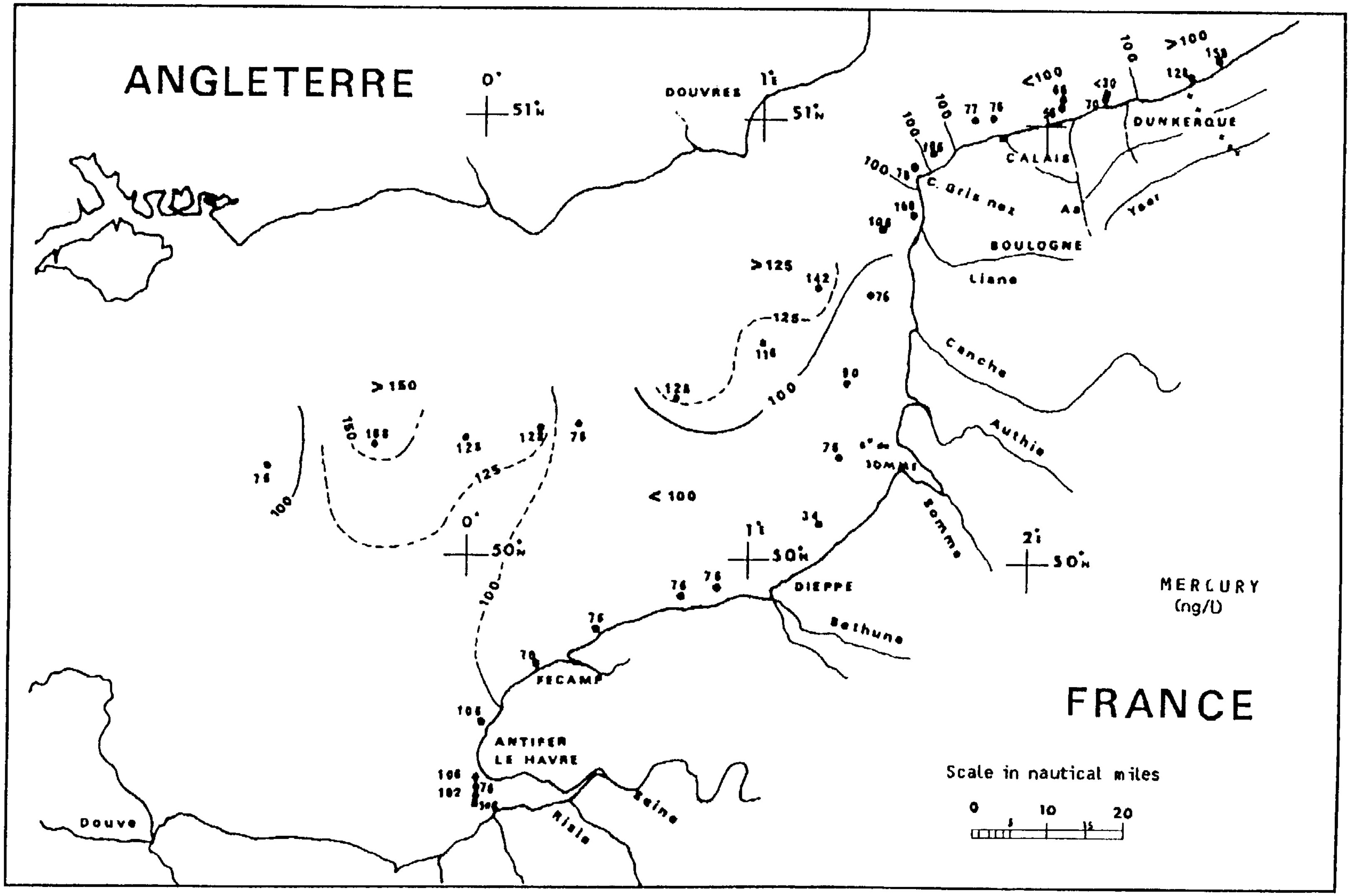

Figure 4. Method used for relatively scarce data distribution.

The computers used by the surveyors are IBM PCs, with a disk capacity of at least 40 megabytes. We have found that our Macintosh computers are unable to do similar work due to the unavailability of suitable commercial mapping software.

Meteorological Techniques

To draw a network of predicted isobars, for example, meteorologists start from a set of met-stations points with the present value of atmospheric pressure. That set is laid out on a grid of equal sides squares and the computer interpolates the present time values of the pressures at the nodes of the grid. Then another computer calculates the future (for example 48 h later) values at the nodes, which are sent back to the previous computer which, interpolating between them, draws the future isopleths.

This is the "full game" which requires gigantically powerful computers (CDC 860 and CRAY 2) as those of Paris-Palaiseau to cover Eastern Atlantic and Western Europe (the grid is 3000 x 3000 km with mesh sides of 35 km) at 15 or 16 levels, or as those in this town of Reading, still more powerful to cover the whole world.

Of course the problem becomes simpler when there is no need to calculate future values and when the area covered is smaller. For instance, to drawn lines of equal heights of rainfall for the whole of France by computer, the central climatological service in Paris uses the same principle as above: first interpolation to obtain the values at the nodes and another interpolation between the nodes to draw the isopleths.

The secondary climatological services do not possess such as equipment however. Instead, for example, lines of equal height of rainfall for the Department of Alpes Maritimes are drawn by hand by the climatologists of Nice.

Note that the gigantically powerful computers of Paris-Palaiseau and Reading themselves have their limits: at present they are unable to draw such simple features as atmospheric cold and warm fronts, which go on being the prerogative of the meteorologist's brain and pencil.

Some Ideas About Marine Atlases

The CERBOM has published 5 or 6 works on the distribution in the European seas from the Scheldt mouth to the Aegean Sea (but chiefly in the western basin of the Mediterranean) of all or part of the following parameters: salinity, temperature, O_2, pH, turbidity, metals, nutrients chlorophyll, plankton, *etc.* The data are chiefly, but not only, relative to surface water. These works are based entirely on the analysis, by our laboratory, of the samples collected (starting in 1962) on our own research ship, the skipper of which is our Director who happens to be not only a scientist but also a highly experienced sailor. They form special issues of our scientific quarterly (Revue Internationale d'Océanographie Medicale: International Magazine of Medical Oceanography). One can find in them many isopleth maps, as well as their interpretation in connection with possible land sources.

We are not aware of similar extensive sets of maps published by other agencies, either in France or in neighbouring countries. The reason could be that, as far as concentrations of heavy metals in the water are concerned, the compilation of data from different laboratories is hardly possible at the present stage: these concentrations being extremely weak. Different methods of collecting the samples and different methods of analysis by different chemists in different laboratories often give very different results.

The concentrations in sea water of heavy metals given by other authors over the last few years have tended to be lower than ours (especially for mercury), but the measures have generally been obtained after particular filtration (in CERBOM we keep to total, and not dissolved, metal which is directly absorbed by biomass and sediment) and on samples collected at a few metres depth (we collect them at 5-10 cm, where the water is generally more contaminated).

These lower concentrations show a weak variety in the "data landscape" which hardly corresponds to the aspect of often very "uneven ground" shown, for example, by the concentrations of the same metal in biomass: observe the similarity of distribution between the concentration of mercury in the biomass and in surface water (measures by CERBOM) in the same area during approximately the same period of time (Figs. 5a, 5b).

Such comparative maps are very useful to illustrate atlases, as are maps of currents which are the main vectors of the transport and dispersal of pollutants, as well as carefully chosen pictures taken from satellites. The "uneven ground" ("variety of landscape") of the concentrations correspond in many cases to the contrast between different masses of water due to the action of currents, and appears on satellite pictures (figs. 6, 7a to 7d, 5b, 2: observe, in particular, the frontal belt between Nice and North-West of Corsica).

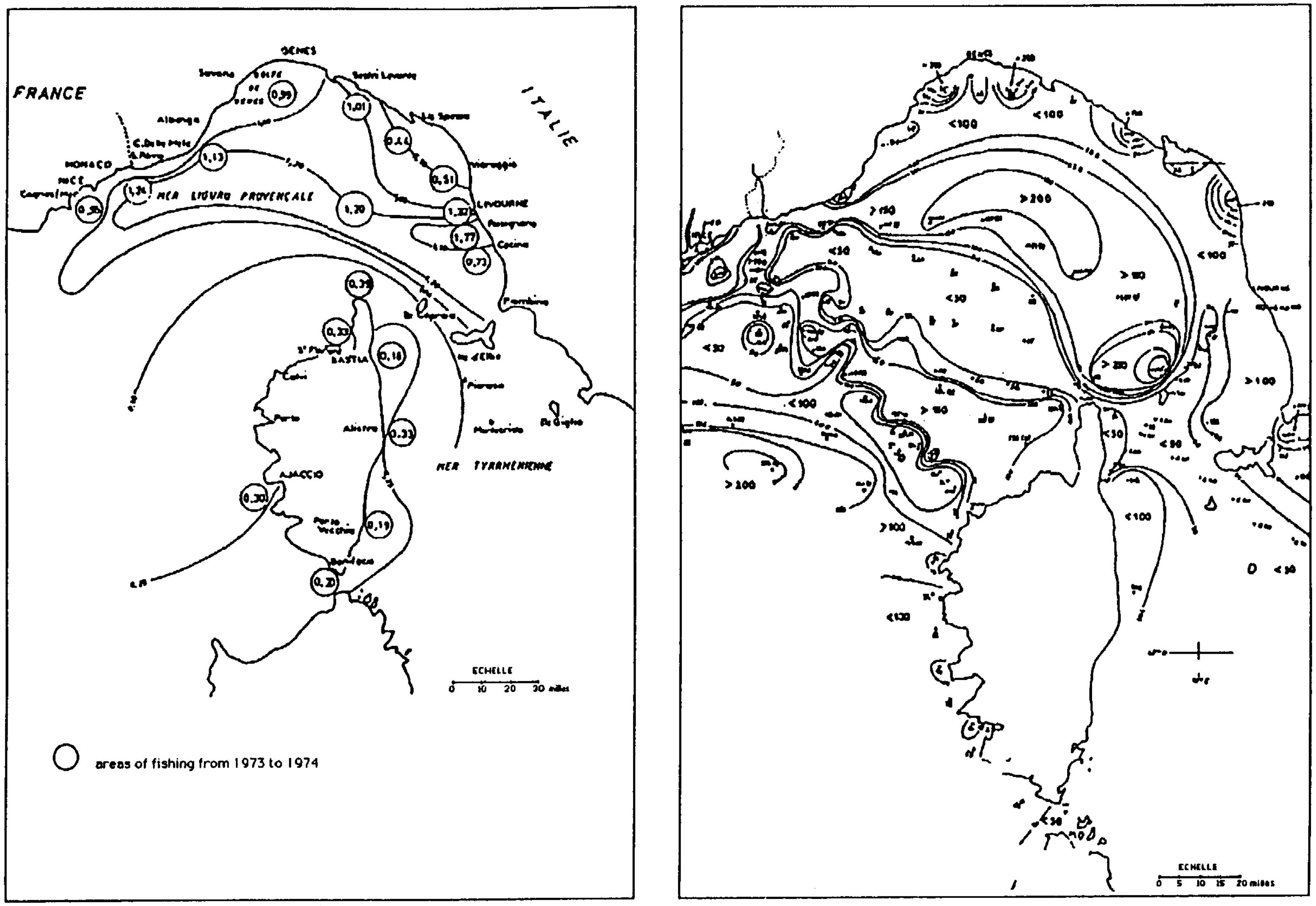

Figure 5. Distribution of heavy metal (mercury) concentration in the biomass (5a) and surface water (5b) .

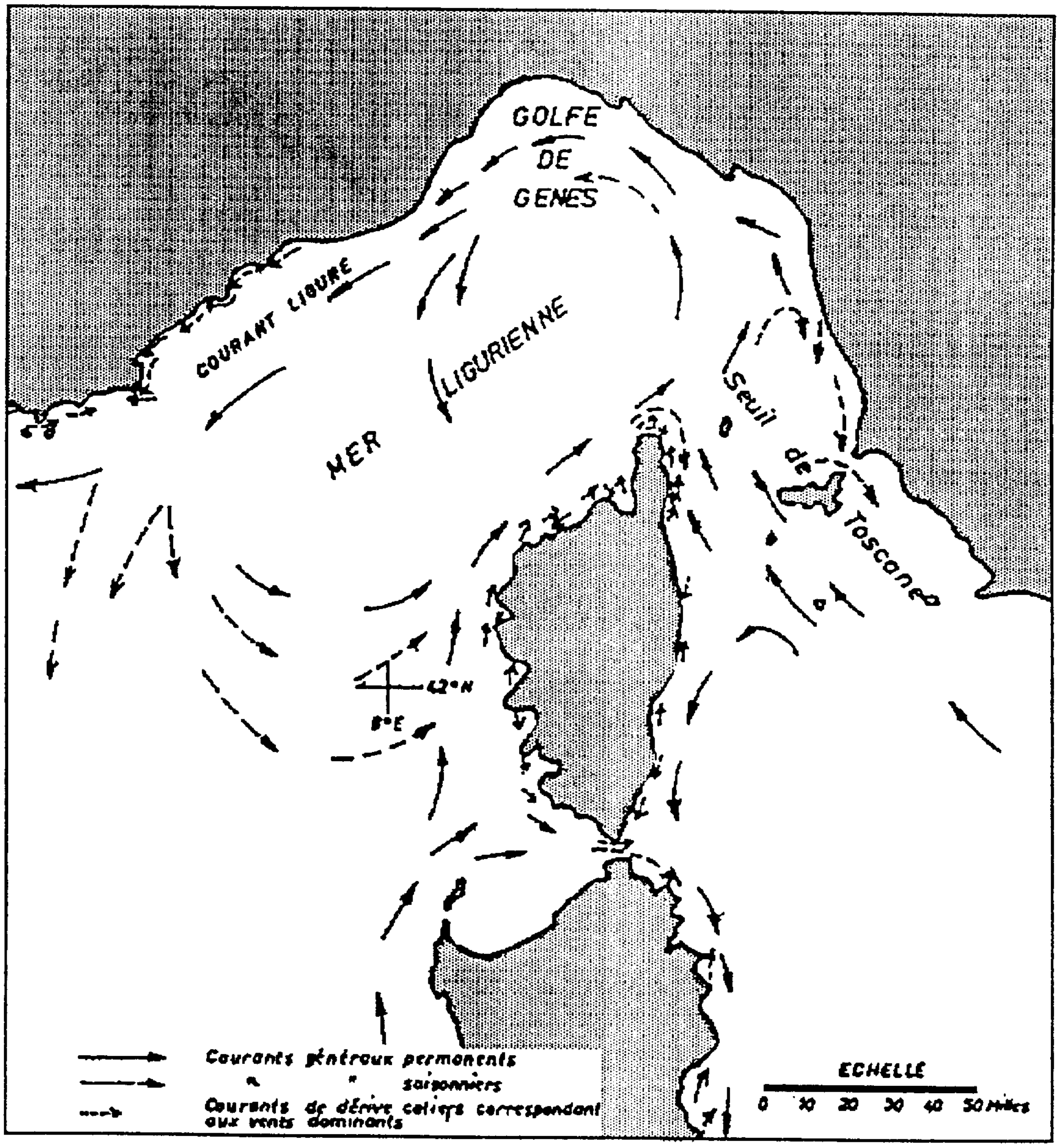

Figure 6. Prevalent current directions in and around the Ligurian Sea.

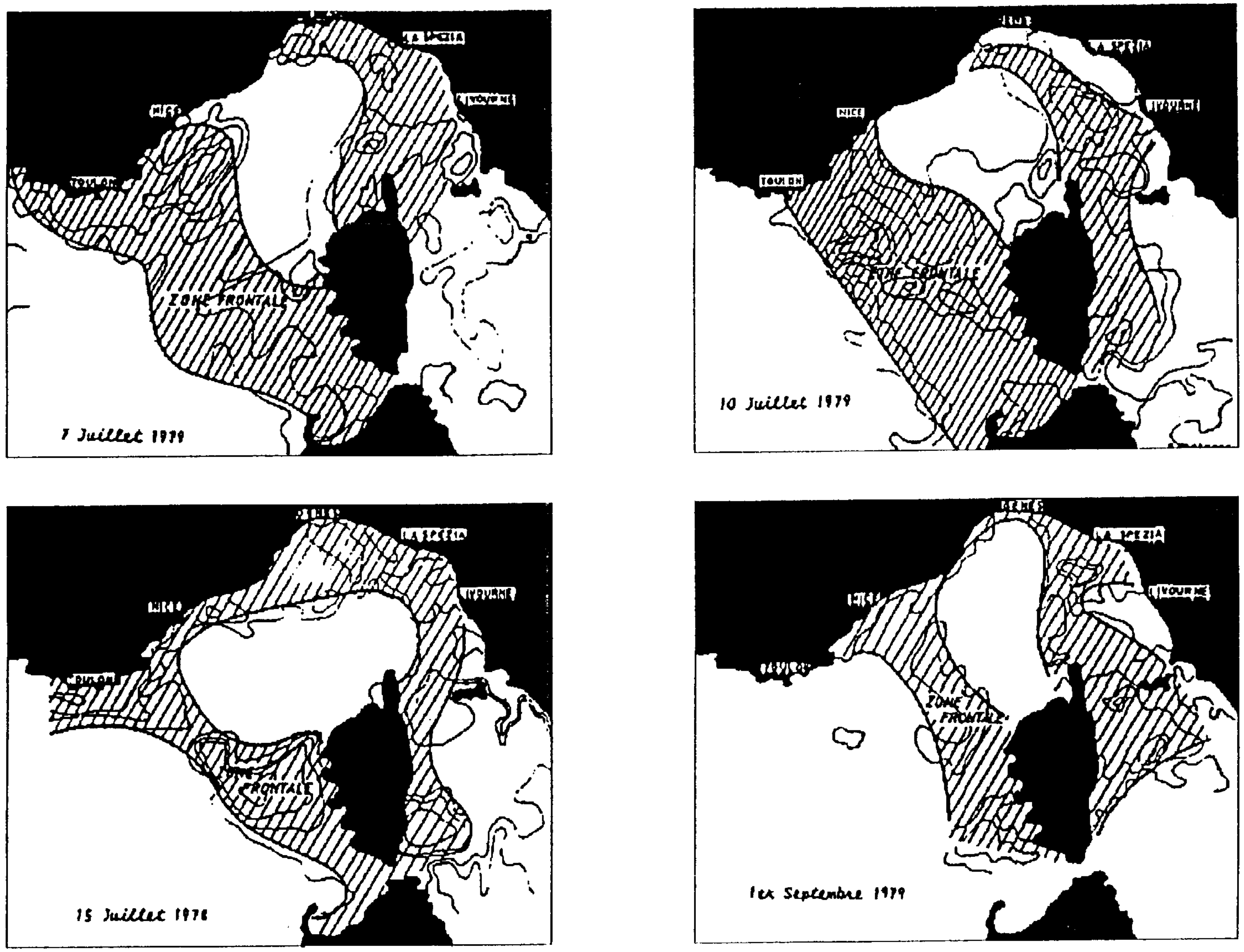

Figure 7. Satellite derived maps showing the influence of currents and winds on the distribution of pollutants. Note the frontal zone between Nice and NW Corsica.

Last but not least, we feel very useful are "compound" maps (hydrological + economical (industrial and agricultural) + geological), suggesting the main possible land (or sea-ground) sources. If possible their scale should be the same as the scale of the isopleths maps. Their compilation from different land atlases is often ticklish, as one must realize a compromise between legibility and abundance of data. Thoughtful considerations are often necessary: for instance, if the run-off from volcanic ground can be responsible for a certain increase of mercury in the coastal sea, the submarine reappearance of freshwater from a karstic calcareous soil can explain some weakened values of salinity near the shore, *etc.*

DIGITAL CATALOGUE OF GEOLOGICAL OCEANOGRAPHY DATA AT THE PORTUGUESE GEOLOGICAL SURVEY

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Large quantities of geological and geophysical data are generated during geological surveying aboard oceanographic vessels. Bottom samples and subsurface samples of the continental shelf collected by surface sampling and drilling operations also produce a vast amount of laboratory data. Normally these data are produced by different research groups and by different exploration companies and require processing to be compatible.

The first Marine Geology Data Catalogue (1973) made by the Survey were based on transparent overlays of base maps consisting of standard GEBCO Plotting sheets at scale 1/1000000 and 1/100000 UTM charts for the coastal regions. Overlays were made for geophysical and sampling data inventories. At any time paper copies of the overlays provided an index of available data.

Later (1980), in order to interpret and publish the data, it was recognized as necessary to store, retrieve, process and compile the data which is both in numeric and text form but mainly in graphic form. The use of relatively small microcomputer systems including plotting and digitizing facilities can provide at reasonable cost, tools for the use of automated cartography to produce maps and illustrations for geological reporting. At the same time these systems allow convenient storage of the data, that can later be retrieved and modified in response to new data or second thoughts of the mapper.

Because most of marine geology data are plotted in navigational charts using Mercator map projection of the geodetic coordinates and land maps are in UTM projection the programs should provide conversion for different systems of coordinates in order to be applicable. Plotting facilities include symbols, line types and polygons used in geological maps.

At the Marine Geology Group of the SGP an "official-scale" system for producing geological maps of the continental shelf and for drafting sections and other illustrations are presently in use with valuable results.

The NERC Marine Atlas Demonstrator Version 1.1 indicated to us that the data already digitized could easily be transported to a similar program and presented directly to the user of a PC in an interactive presentation form.

It is a relatively easy task to convert the data formats and we proceeded in conjunction with the Oceanography Group of the University of Lisbon (GODFUL) with the necessary experiments using already digitized databases. A demonstrator using bathymetry, seismic lines and well logs is presently under preparation.

MUMM'S ACTIVITIES AND SPECIAL INTEREST IN DIGITIZED GEOGRAPHICAL INFORMATION

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MUMM's Missions

The Management Unit of the Mathematical Model of the North Sea and the Scheldt Estuary (MUMM) is a department of the Belgian Ministry of Public Health and Environment affiliated to IHE, a State research institute. The unit's responsibilities lie in the area of marine environmental protection and resource assessment; they include:

- The monitoring of the North Sea environment, since 1977, through surveillance programmes and oceanographic campaigns.
- The study of marine processes, marine resource management and marine pollution, using mathematical modelling as a tool.
- The management of the State environmental protection activities relating to the sea.

MUMM is responsible for implementing national and international legislation pertaining to the protection of the marine environment, *e.g.* the Oslo and Paris Conventions for the prevention of the pollution of the sea, the CEC Guidelines, *etc.* It is the licensing authority for waste dumping and incineration at sea. It serves in an advisory capacity in the national counter-pollution contingency arrangements and coordinates environmental surveillance in case of marine incidents. MUMM does also consultant work for other organizations, public and private, in its particular area of expertise.

All data - i.e. meteorological, hydrographical, ecological and pollution - acquired during the monitoring of the Belgian continental shelf and the Western Scheldt estuary are stored and managed at MUMM which functions thus as a National Oceanographic Data Centre (NODC). This NODC provides the water quality data requested by the Joint Monitoring Program of the Oslo and Paris Conventions, and also communicates Belgian data to the ICES.

The processing of these data and their further display on digitized maps are considered as priorities for the near future.

Means

MUMM runs a 51 m oceanographic vessel, the Belgica, automatic recording stations and a computer and laboratory facility in Ostend on the Belgian coast. MUMM runs a large computer centre (CAMME = Computer Assisted Management of the Marine Environment) in Brussels where its headquarters are located. It owns a Convex 230 supercomputer and operates a network of workstations - one dedicated to image processing - and PC's.

The Models

Since its creation in 1976, MUMM has employed simulation modelling as an essential tool in the prediction of pollutant fate and impacts (see.g. Mommaerts *et al.*, 1987), storm-surges, ecosystem response to different types of impacts, *etc.* It has also been and is still striving towards a rational scheme for the coupling of all existing models (figure 1).

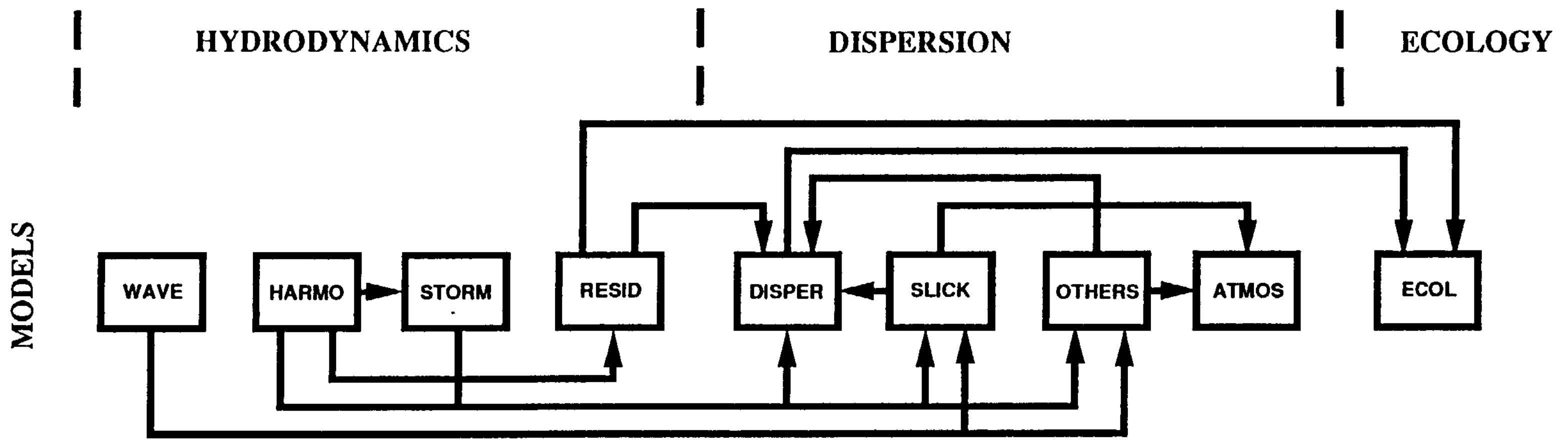
Essential to other models pertaining to the same scheme is the non-stationary, hydrodynamic, numerical model (presently: STORM) that computes the tidal variables in the whole North Sea and part of the English Channel (depth-averaged current and free-surface elevation). In this context, the digitization of the coastlines and bathymetry of the North Sea and surrounding waters is an important issue.

Mapping Experience

The purpose of the digitization task undertaken at MUMM in 1985-1986 was to prepare a data set of geometrical information that could be used by numerical modellers to perform hydrodynamical computations (Jamart *et al.* (1986), thereafter heavily quoted). This task was part of a contract study, named "Bottom Stress EXperiment" (BSEX), with the Det Norsk Veritas organization.

The manner in which geographical information needs to be digitized depends to a large extent on the model(s) to which it is input and, more specifically, on i) the coordinate system in which the governing equations are written, ii) the method and scheme used in the horizontal discretization of the equations and iii) the technique used to implement lateral boundary conditions. The geometrical information required to set up a hydrodynamical model comprises: i) the lateral boundaries of the domain of interest and ii) the topography of the basin.

The task of digitizing the coastlines and the bathymetry in the entire area of interest (from 12°W to 12°E and from 48°N to 63°N (coastlines) or 48°N to 55°N (bathymetry)) has been performed



	HYDRODYNAMICS	DISPERSION	ECOLOGY
PRODUCTS	Wave spectra. Instantaneous velocities and elevations. Average flows. Stress on the sea bottom.	Concentrations of substances in the water column, at the sea surface and in the atmosphere.	Stocks and fluxes in and trough ecological compartments, seasonal cycles.
APPLICATIONS	Atlas of hydrographic information, alarm in case of flooding, minimal water levels on navigation channels. Access to ports and platforms, working conditions for divers and robots. Effects of sand mining, destination of dredged materials. Sizing of pipelines, removal of mines.	Deliberate and accidental dumpings. Dispersion of substances discharged from coastal outfalls. Sedimentation and resuspension. Pollution combating. Fate of oil slicks and dispersants. Dispersion of fish larvae.	Eutrophication, nutrient reduction scenarios. Impact of sand mining. Connection with the cycle of pollutants. Impact of toxicants.

Figure 1. Relationships amongst existing simulation models at MUMM.

by the Institut Géographique National (IGN) under contract to MUMM. Depth values were required at the nodes of a uniform, orthogonal lattice, with a grid spacing equal to 4 km (in UTM coordinates, in geographical coordinates and in the BSEX coordinate system) in both the longitudinal and latitudinal directions.

Digitization of the Coastlines

As for the coastlines, two databases were prepared: the first (642,893 points) is referred to as a "high resolution coastline" and consists of the coordinates of arbitrarily but very closely spaced points located on the water boundary reported on the U.K. Admiralty Charts, whereas the second (4,922 points) is referred to as a "staircase", or "low resolution" boundary with N-S and E-W line segments very close to 4 km. The purpose of the latter database was to provide a "solid boundary" readily usable in a finite difference numerical hydrodynamical model. High quality graphical representations of all digitized coastline information have been provided by IGN.

Digitization of the Bathymetry

The bathymetry has been digitized separately for three distinct zones: the southwest quadrant (from 12°W to 0° and from 48°N to 55°N); the North Sea area (bounded SW by the 2°W meridian, in the north by the 59°N parallel, and including the Skagerrak and Kattegat in the east); and the part of the Norwegian Trench area comprised between 2°E and 6°E and between 59°N and 62°N (figure 2).

The southwest quadrant was digitized by the IGN, based on the most appropriate soundings reported on navigation charts (37,476 soundings digitized). As the spatial distribution of these points is rather inhomogeneous, the IGN has performed the task of interpolating the available data onto a uniform horizontal grid by means of their sophisticated Digital Terrain Model (DTM) system. It must be noted that the square cells defined for the DTM net correspond to the "staircase" representation defined above. The principle for the production of a DTM (IGN, final report) is that a tangential plane is generated in each point of the spread input points being characterized by 3 values x, y, and z. For each input point, the programme seeks out the nearest N points in the x-y plane. The tangential plane is calculated by the least square method according to these neighbouring N points being weighted by the distance between the considered point and a neighbouring point. Hence, the Z coordinate in each node of the DTM net is calculated according to a weighted mean value of the M nearest tangential planes (with M different from N). Morphological correction schemes are applied but not discussed here. Bathymetric lines are generated by isolating DTM surfaces (min. 2 cells) including all points which are higher or equal to those lines. Land

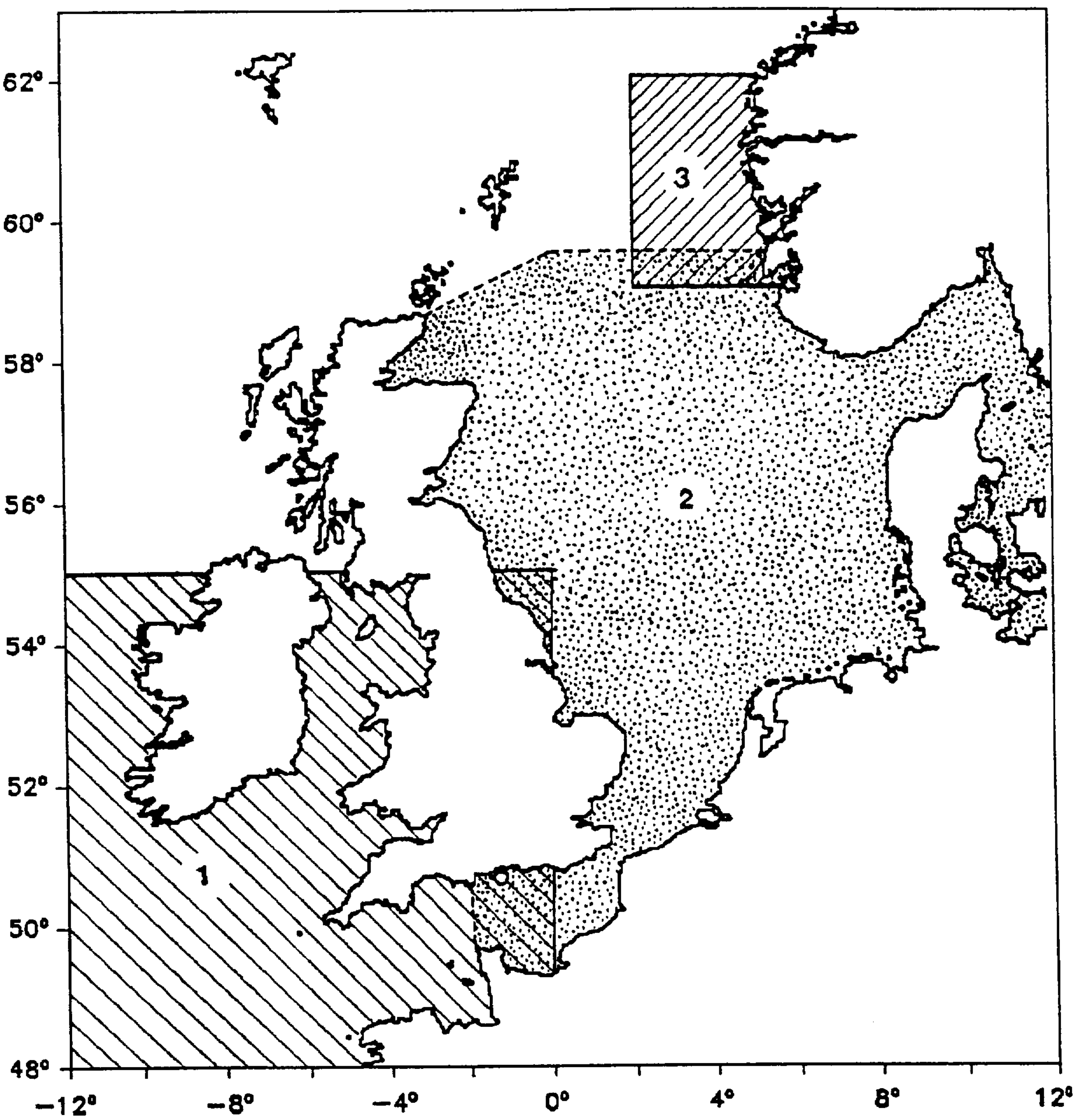


Figure 2. Demarcation of areas for digitisation of bathymetry.

points are flagged so that contour lines are interrupted in their nearest neighbourhood. The final results of IGN's gridding are displayed in a colour map of the marine topography in the southwest quadrant.

The North Sea area was digitized after a pre-existing dataset of digitized information was kindly provided to MUMM by researchers at the Rijkswaterstaat (Netherlands). These data were not actual soundings but corresponded to the bathymetry prepared for use in a numerical model (Voogt, 1984a & 1984b). A transformation procedure (system of projection and interpolation to suit the BSEX grid) was applied. The final results are displayed on a computer terminal. No paper product has been made available so far.

The bathymetry data of **the Norwegian Trench area** were compiled from a variety of maps: in most cases the latest Admiralty Charts from the U.K. Hydrographic Department, but also the bathymetry map of the N-E North Sea prepared by Hovland (1983) whenever the density of soundings reported on the Admiralty Charts was insufficient for our purpose. The final results are displayed on a computer terminal. No paper product has been made available so far.

The Choice of a Coordinate System

Considerable effort has gone into the search of a suitable projection system. Indeed, distortion in maps may be in area, length or angle. Hence, it is impossible to devise a projection system in which each cell of a uniform grid in Cartesian coordinates would correspond exactly to 4 x 4 km2 squares on the surface of the earth. The conformal transverse Mercator projection (cylindrical Gauss-Krüger projection) and, in particular the UTM system, where the Earth is divided into 60 zones 6° wide in longitude, seemed more appropriate for the purposes of the BSEX project. There was however a very serious difficulty as the area of interest extends over 4 different UTM zones and as the proper transformation of the hydrodynamical equations into such a coordinate system appeared rather horrendous. Thus, it was finally decided that the definition of the location on the Earth's surface of the digitized information would remain independent of any particular projection system, and that approximation procedures used to transform hydrodynamical equations (henceforth written in spherical coordinates) into a Cartesian coordinate system such as the f-plane (*e.g.* Pedlosky, 1979) would be used.

Nevertheless, a coordinate transformation system remained necessary to i) allow graphical representation of the results; and ii) to define a rectangular grid in Cartesian coordinates on which some data manipulations (*e.g.* interpolation) could be performed. Thus, a "BSEX coordinate system" was defined wherein the x and y coordinates (respectively functions of longitude and latitude) are expressed in 10-6 radians units, with the longitudinal axis (x) being "stretched" by a factor k such that a square of sides $\Delta x = \Delta y = 626$ units is basically a 4 x 4 km2 square. This type of projection is essentially equivalent to the conventional projection known as "Carte parallélogrammatique" or "die reckteckige plattkarte" (Pearson, 1984).

Conclusions

The experience of MUMM, with respect to digitization of geographical information, is essentially related to its uses in connection with mathematical modelling, i.e. the input of geometrical data and the output of model results. It is felt here that this particular application should certainly not be overlooked when defining basic options for a digitized atlas of the european seas.

The digitization work performed at MUMM on the coastlines and bathymetry of the North Sea, using the best available information and sophisticated interpolation techniques, forms a valuable and coherent database that ought to be taken into consideration when establishing a digitized atlas of the European seas.

As can be seen from the BSEX digitizing task (performed in 1985-1986), the means of displaying and plotting geographical information and data (*e.g.* from the NODC) at MUMM were not yet standardised or customized or even existing, as far as some applications are considered. The computer centre of MUMM (CAMME) has considerable potential today but choices have still to be made. In that respect, any development and standardisation in the EEC frame is awaited with great interest.

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THE IRISH SITUATION

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(on behalf of the Department of the Marine)

Background

The Republic of Ireland has no National Oceanographic Data Centre and indeed no indigenous Hydrographic Survey Office. Until 1987, responsibility for marine activities was dispersed amongst various Government Departments. The establishment of a new Department of the Marine in 1987, with the objective of centralising marine activities under one Departmental umbrella, is a clear indication of the importance placed by the Irish Government on the development of marine resources.

To consolidate and develop Ireland's marine scientific and technical capabilities, the Government is in the process of establishing a national Marine Institute and is currently progressing the necessary legislation through the legislature (Marine Institute Bill, 1989). It is expected that the Marine Institute will establish a national marine database (Marine Data Centre) as a key national facility.

In the interim, a number of Government and University based research groups are investigating the use of computer based GIS and digital atlas systems for data management and retrieval.

Current GIS/Digital Atlas Programmes in Ireland

In the marine area, no group has an operational GIS or PC based marine atlas system though several maintain marine data bases (*e.g.* Department of Oceanography, UCG, Fisheries Research Centre, Irish Science and Technology Agency, *etc.*).

The Petroleum Affairs Division (PAD), of the Department of Energy, which has responsibility for overseeing the exploitation of hydrocarbon resources on the Irish Continental Shelf, maintains a database run on a Digital Micro-Vax and uses digitised coastline and geophysical software supplied by Petroconsultants (Switzerland) and a geological mapping and database package supplied by Terra Sciences (USA). Output is *via* a Calcomp plotter.

Desktop GIS systems available in Ireland run on either IBM compatibles, using ARC/INFO, or on Macintosh's using J-Map.

ARC/INFO is used by the State Forestry Board (An Coilte) and the Environmental Sciences Unit (Trinity College Dublin) for forestry management purposes and by Technomics Ltd., a Dublin based consultancy firm, to produce digitised maps showing the distribution of science and technology infrastructure (*e.g.* Science Parks, Research Institutes, Universities, *etc.*) within the European Community (part of an EC funded project).

Macintosh systems, using J-Map, are used by Crowe Schaffilisky & Associates for geological mapping and by ERA Maptec to produce cartographic overlays on satellite maps. ERA Maptec have developed J-Map further and use it in conjunction with graphics packages like Canvas to produce final film for full colour maps with overlays from satellite maps. Satellite imagery is downloaded directly from a Digital Vax and the road networks are digitised on screen. A sub-routine has been developed which takes these digitised roads and assigns them a line thickness and colour associated with national routes *etc.*

While J-Map is still being developed, its two main disadvantages are:

i) There is no contouring facility.

ii) Whilst there are Pan and Zoom facilities, zooming does not give a new hierarchy of information.

Although neither ARC/INFO nor J-Map are currently used for marine applications, the Department of the Marine's Fisheries Research Centre (FRC) is currently investigating the use of these systems (and others *e.g.*NOAA's CMAS) for the management and retrieval, in map format, of marine environmental data.

Within the context of the proposed national Marine Institute, the Department of the Marine is following developments with respect to the EC funded EODAN and EURO-MARIS Projects, and the current marine digital atlas project, with great interest.

Without doubt the outcome of the above projects will have a major bearing on the direction taken by the Irish Marine Institute with respect to the establishment of a Marine Data Centre. Whatever system is adopted will need to be flexible, networking existing databases in both Ireland and the wider Community. In addition, while most Irish Government agencies use IBM compatible hardware, many of the tertiary and secondary educational establishments use Apple systems. Thus a dual system, which for example provides ROM discs for the distribution of information and education material, would have a distinct advantage.

While there is currently no active national marine GIS or marine digital atlas programme, Ireland does possess an expertise and technical capability in this area and regards, in the short term, the establishment of norms and standards for PC based Community marine atlases and in the longer term the establishment of a European marine GIS system, with the participation of all Member States, as a worthwhile and important Community endeavour.

La Tene Maps, itself, expects to have a PC based marine atlas capability later this year and to use this facility for generating marine maps and atlases.

EAST COAST GLORIA DATA ON CD-ROMS

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Background

On March 10, 1983, President Reagan signed a proclamation establishing an Exclusive Economic Zone (EEZ) extending 200 nautical miles seaward from the coasts of the United States, the Commonwealth of Puerto Rico and the Northern Mariana Islands and US Territories and Possessions.

The reconnaissance-scale mapping tool selected to map the EEZ was the Geological LOng-Range Inclined Asdic (GLORIA). GLORIA maps the ocean floor by a side-scan sonar method. The images of the sea floor are produced by transmitting sound pulses from two sets of transducers in the towed vehicle which look to port and starboard, respectively.

Each transmitted sound signal insonifies a narrow band of sea floor from directly below the towed vehicle out to the side a distance of approximately 22 km. These narrow sea floor bands are sonograph images of the ocean floor, which ultimately make up the data provided on this disc. The data presented on this CD-ROM disc are from the ocean floor off the United States' east coast.

The East Coast CD-ROM

This disc is the second in a series of GLORIA discs (the first being the Gulf of Mexico disc). This disc was structured with four "categories" of computer systems in mind: i) DOS systems with the Orchid VGA display card, ii) DOS Systems with either generic VGA or EGA display cards, iii) Macintosh II systems, and iv) PC and/or minicomputer Geographic Information Systems or image processing systems. DOS system users without the Orchid VGA display card can use the IMDISP program (IMage DISPlay) developed for the National Aeronautics and Space Administration by Jet Propulsion Laboratory's Planetary Data System.

The preferred, and recommended system for scientific inquiry using the data on this disc is an 80386 or 80386SX microprocessor DOS system with a minimum 70Mb hard disk, VGA capable monitor, and an Orchid Designer 800 or Prodesigner series display card.

This disc is divided into sub-directories containing the 21 files representing 2-degree by 2-degree sections of the seafloor off the East Coast, plus north and south area mosaics. The 2-degree map files have a resolution of 50 meters. The north and south mosaics have a resolution of 200 metres. All the files in this sub-directory were formed from processed "6 hour" sonograph images by digital mosaicking. These 2-degree files range in size from approximately 15 to 17 megabytes and contain no header information. The north and south mosaics are approximately 12 and 14 megabytes respectively. Each mosaic and 2-degree file has associated with it a ".LBL" file. These files have been provided in order to conveniently integrate the 23 image files with the IMDISP image display program.

An additional sub-directory contains all of the original bathymetric data files used to create the binary data files used by the IMVIS program. The bathymetry was digitized from NOAA's Bathymetric Map Series of 1:250,000 and 1:1,000,000 scale. The bathymetric contours are in metres, with a 250-m contour interval. These bathymetric files have a minimum resolution of 50 metres.

The TRACK sub-directory contains both the original ASCII format files and the binary files created from them which are used by the IMVIS program to graphically overlay the vessel's track on the corresponding image file. This function will then provide the user a reference to the pertinent six-hour data on the East Coast B disc.

The data are on 2 CD-ROMs in the ISO-9660 format. Accompanying the data are the software programs necessary to select and display the data in image format on an enhanced VGA monitor. Discs are available for evaluation by contacting JOMAR.

COMPUTER PRESENTATION OF INFORMATION AT INSTITUTO ESPAÑOL DE OCEANOGRAFIA

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A new National Atlas of Spain is being assembled by the Instituto Geográfico Nacional (IGN) in collaboration with 120 National Public Institutions. This new atlas will be in traditional (paper) and digital format. The Instituto Español de Oceanografía (IEO) is coordinating the activity of marine science participants. Thematic maps currently in preparation include: bathymetry, coastal characteristics, sediments in marine basins, surface currents (seasonal), temperature and salinity (seasonal), and waves (height and frequency). This information, mainly from IEO, is held at several scales, and sampling densities, *etc.* and has to be processed and integrated to be compatible.

At present, the lines of activity in IEO involve: fisheries stocks evaluation, marine aquaculture, marine ecosystem studies, pollution, coast currents, geological cartography in continental margin and antarctic marine research. A few research groups are using different applications on small microcomputer systems in specific cases or areas. In contrast, the marine geology specialist must to answer day to day questions concerned with other fields and it is necessary to have a database about geological or other studies performed, physical parameters, water chemical conditions and biological characteristics.

With a digital database the specialist can easily and quickly access general information, information about specific areas, derive relationships between parameters (in pollution, bio-geological association, life and bottom evolution, *etc.*), and service the general public.

At the moment, using the mainframe facilities available, marine geologists at IEO are investigating: information about systems; training; selection of system and/or new equipment; and the retrieval, storage, processing and compilation of data in alphanumeric and graphic compatible formats for use on PC's. In this work, several problems have been found:

- There are differences in representation of the same information between geographical charts.
- Information is held in geographic (latitude/longitude) and UTM coordinates, depending on the positioning system.

- Are compatible data acquisition systems necessary ?
- What should be the standards for data presentation ?

In summary, our main problems to resolve in a digital catalogue of marine data are: common geographic reference system, the possibility of conversion for different systems of coordinates, range of scales for different parameters, the addition and modification of data easily (in an active system), reasonable cost and use in PC's. To solve these problems, we must cross the frontier between an live (digital) atlas and a static (paper) atlas.

Finally, it is worth mentioning that we are currently studying the results and applications of ARC/INFO, ERDAS and other systems installed in more than 40 public institutions and private companies of Spain.

SUBMARINE GEOLOGICAL ACTIVITIES OF THE INSTITUTE OF GEOLOGICAL AND MINING EXPLORATION

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Introduction

The submarine Geology Department in IGME has been active since 1976. The importance of the Marine Research in Greece is obvious: more than the half of the Greek area is sea.

The targets of the research activities at IGME are:

- The study of the sea-floor and the geology under it.
- The detection of sedimentary mineral concentrations (placers).
- The construction of sea-floor maps.
- To undertake work for third parties.

Activities

The following activities are undertaken at IGME:

- Mapping in scale 1:200,000: the Greek sea area is divided into approximately 40 sheets of maps in scale 1:200,000. Up until now two sheets have been published: Thassos-Samothraki and Kavala-Ierissos. Two other sheets are under preparation: Pagassitikos and Sporades.
- Survey for sub-bottom sedimentary mineral concentrations (placers) in Aegean Sea.
- Study of the South Aegean arc (Santorini).
- Study of the Greek Continental Shelf.
- Surveys for applied Marine Geological Work (sewage outfalls, construction of ports, site surveying for oil drilling *etc.*).

Field-work

The work which is carried out in the field includes:

Geology

Sampling of the sea-floor, mainly from sediments. The density of sampling for 1:200,000 mapping is approximately 250 samples per sheet of map, and is collected by two types of samplers: Van-Veel and Dietz La Fond. Core samples are classified into two categories:

- Cores collected by gravity corer. The weight of the corer is approximately 250 Kg and the length of this core is up to 6 m.
- Cores collected by vibro-corer system in sea-depth up to 100 m. The length of this core is up to 3 m.

Bathymetry is measured with an echo reflection instrument.

Geophysics

Seismic-deflection data are collected using:

- a 3.5 kHz system and a UNIBOOM system for shallow penetration, up to approximately 50m below the sea bottom.
- a SPARKER system for penetration up to approximately 500 m below the sea bottom.
- Occasionally, magnetic data are collected using a Barringer Magnetometer.

Laboratory Analysis

The collected samples and cores are analysed as follows:

- Grain-size analysis. The sedimentary rocks are classified according the grain-size in a range from 6 to 9 Phi.
- Mineral analysis: Petrography; X-Rays analysis.
- Total Carbonate content.
- Natural Radioactivity measurements.

From the seismic profiles the study of Stratigraphy (Helocen-Pleistocene, Pliocene/Messinium) and Tectonism is carried out.

Maps

Maps illustrating the bathymetry, the sedimentology, the tectonism and the stratigraphy are constructed. Also, general geographical, geological and tectonic maps at smaller scales are constructed in cooperation with other departments of IGME. The coverage of all the Greek sea area with maps at a scale of 1:200,000 is one of the future plans of IGME.

Data Banks: Computerized Analysis

The first computerized work, interpretation and evaluation of the data was carried out in 1985, with the creation of data files and some calculations performed on them. Today the collected data constitutes data files which form a data-bank system.

The main data file is "NAVIG" which contains all navigation data, geographic coordinates *etc.* All information about the samples and the cores are contained in a row-based data file called "SAMP/C".

Four more data files exist: "GEOCHEM" , "CARB", "KOKKO", and "AMMOI", which contain respectively the results of sample geochemical analyses in 15 chemical elements of all the samples and cores, the results of total Carbon analysis, the results of the grain-size analysis and the results of the sand fraction analysis.

Software

There are two packages containing programs with which the data files can be manipulated: the package "MARJKOKO" and "AMIPRA".

The first package "MARJKOKO" has as input the file KOKKO and works out all the results of the grain-size analysis.

The output of this package are: a print-out which contains the results of gravel, sand, silt and clay-size analysis, with tables; the file "SAND" which is used as an input file for the second package "AMIPRA", and the file "GRAPH" with which various diagrams (histograms, *etc.*) are produced.

The second package is "AMIPRA", which has as input the files "AMMOI" and "SAND", elaborates all the results of coarse fraction analysis. The output of this package are: a print-out containing the results of the coarse fraction analysis, with tables and the file "SGRAPH" from which various diagrams are produced.

The programs which constitute the above mentioned package are written in the FORTRAN and BASIC programming languages. Data entry is *via* screen forms and the data files are stored in ASCII format.

Hardware

The available hardware includes a WANG VS/80 system, with a 1600 bpi, 9-track tape unit; a PRIME 9755 system with 8Mb memory, streamer tape drive and 2 X 500 Mbyte disks, a PC COMPAQ 386 with 4Mb memory, and various PCs, a plotter, digitizer, electrostatic plotter and a printer.

Future Plans

At the present stage, work is proceeding on the development of the data-bank and producing digital maps. Specially constructed data files with a simple format, (which incidentally are not derived from real data), are used and manipulated with commercial software packages, *e.g.* ARC/INFO and ERDAS.

The next step should be the production of experimental digital maps followed by the production of digital maps constructed from the real data files.

We believe that cooperation and exchange of experience between people working in the area of digital Marine Atlases will improve these techniques and will ultimately help in the realization of a Digital Marine Atlas.

MARINE DATA MANAGEMENT AT OSSERVATORIO GEOFISICO SPERIMENTALE

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Background

The Osservatorio Geofisico Sperimentale in Trieste (OGS) is involved in oceanographic research concerned with marine environment studies and a data management system has been developed to hold and process large data set of recording current meter data, wave data, hydrographic station data as well as CTD data. In the framework of the Italian-Yugoslav monitoring program for the protection of the Adriatic Sea, new data sets have been considered for data banking in the fields of physical, chemical, biological and geological oceanography, as well as the different methodologies used by the scientists in obtaining the oceanographic data.

Since 1982, when a mainframe computer was installed at OGS, an evaluation of the techniques and the commercial software systems available to assist in the creation of the oceanographic data bank was carried out. In order to speed-up the selection of the system, contact was established with the international institutions acting as National Oceanographic Data Centres (NODC), to gain familiarity with their techniques of data banking and processing.

Presently the computer facilities are based on a mainframe IBM 3090/120E machine with 32 Mbytes of real memory and 20 Gbytes of mass storage. Peripheral devices such as tape drives, terminals, graphic workstations, plotters and printers are connected to the mainframe giving the end-user a complete interactive environment for the design and development of application programmes. Application programmes, coded in FORTRAN and the SQL data base language, take advantage of scientific libraries in the fields of statistical analysis and digital signal processing and from routines developed in applications of the recent research in data analysis and analytical methodologies on marine sciences for the computation of the derived parameters.

The graphical presentation of data is based mainly on the Uniras packages installed on the IBM mainframe and on different workstations (HP, Apollo). The GIS package from ESRI Inc. (ARC/INFO) will be installed on a HP workstation.

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[1] Unable to attend workshop.

At the national level there is interest in connecting two major institutes active in the field of marine data management: OGS, located in Trieste and ENEA/CREA, located in la Spezia, so as to implement the basic idea of a spatially distributed data system.

System Design for Data Bank

A relational approach for data banking was an outcome of the selection process for a DBMS for oceanographic data.

From the user point of view the structure of the Data Bank has been designed as three separate levels:

- Logical view of the banked data (Cruises General Inventory, Actual Data Series, Code Tables).
- Physical Database.
- Application interfaces (Programs, ISWL Language, Database Service Utilities).

The Cruises General Inventory holds the information in application of the Report of Observations Sample Collected by Oceanographic Programme (ROSCOP).

The Actual Data Series is the database that holds the detailed information on the measured parameters and the data values. It has been logically designed in accordance with the BODC basic structure.

The Code Tables database contains the coding system used in the other databases, as the codes elaborated by WC/IODE for platforms, countries, parameters as well as the international coding system of the World Meteorological Organization for the measured air-sea interface parameters.

An implementation plan has been developed to undertake the following tasks:

Data Acquisition

Several computer input forms have been designed to speed-up the transmission of the data to the Bank for bio-geochemical parameters.

The layouts are designed to meet the necessary information and data documentation ideally required to describe the methodologies of data acquisition and their quality. A PC-based application procedure is available for data input.

Data Screening

Full screening is performed for the data collected by means of high-speed data acquisition system, as for current meter data, wave data, CTD data.

The data received by other originators are summarily screened and inter-calibrated with other data sets in order to check if these exhibit reasonable oceanographic characteristics.

Data Storage Structure

Although the oceanographic data are widespread, there are logical links which allow the grouping of data for retrieval purposes. Such groupings have been considered to be important to constitute a general inventory maintained on direct access storage devices, for data retrieval.

In order to keep this information on-line a set of tables (relations) has been arranged to give the opportunity to retrieve the data by means of basic relational database facilities using the SQL language.

The actual data series are requested to be maintained on direct access devices only for the duration of the research. Then these constitute a valuable resource for secondary users.

The data files are indexed in the general inventory where the information on the physical storage are maintained. Only as a consequence of a retrieval process may the data be requested on line for standard elaboration and presentation.

Inventory Report of the Banked Data

Although the portion of the database holding the general inventory could be accessed on-line, detailed technical reports of the banked data are maintained. Such reports may be retrieved by oceanographic disciplines, specific parameters, cruises, fixed station (primary keys) as well as by means of the data values contained in the relations (secondary keys).

Data Exchange

The database structure has been designed for what concerns the attribute definition of the relational tables (type, character length, parameter code, method identifier, *etc.*) to meet the requirements and the recommendations of the WC/IODE in the exchange of the oceanographic data by means of the GF-3 magnetic tape format.

Off-line Data Elaboration

The data processing and products of the Data Bank meet standard requirements in the presentation of the oceanographic parameters such as plotting versus time, scatter diagrams, progressive vector diagrams, depth series representations, contouring of oceanographic variables on geographic basis, statistic analysis, *etc.* non-standard elaborations arise from special enquiries for spectral analysis, computation of deterministic phenomena, filtering, probability of distribution of predicted extreme values, correlations between the measured parameters, thematic maps.

Work in Progress: Methodologies and Projects

The generation of a thematic map or, more generally, a scientific visualization of marine data is subjected to a two-step process which involves an interpolation phase and a representation phase. The interpolation is needed since the in situ measurements are very often irregularly distributed in space; for an evaluation of a field variable on a regular mesh, it is necessary to resort to an algorithm that is able to take into account the relationships among data (i.e. physical, as distance or statistical, as covariance).

Every class of interpolators is based on an hypothesis of the structure of the field variable that has to be reconstructed. If the field variable is representable globally or locally in an analytic form (deterministic model), it is possible to follow the classical approach of interpolation as a special case of constrained approximation (polynomials, splines, *etc.*). If the correlation among measurements depends on distance, a geometric method can be adopted. In the case in which the field can be assimilated to a stationary random variable, a statistical method like objective analysis and Kriging can be used. These last methods give, in addition to interpolated field, an associated estimation error field.

The representation of field variable takes advantage of a set of different output. The thematic areal maps show the variable field distribution on a geographical base, the transect maps represent, on different scales in x and y, the behaviour of water masses in a marine section. Three- and four-dimensional plots (the last ones obtained using colours as the fourth dimension) are interesting for a qualitative point; in this case a tight connection with original data is lost and but the most important features of the phenomenon can be rendered in a very intuitive way.

Some results are obtained adopting these methodologies on the data collected during the POEM (Physical Oceanography of the Eastern Mediterranean) experiments.

The measurements were carried out by six participating countries (Cyprus, Germany, Greece, Israel, Italy and Turkey) in different periods of the year. The map of CTD stations covered during the cruises is given in figure 1.

The pooled data sets are the result of a valuable scientific effort, and will be very useful to constitute a definitive marine atlas of Eastern Mediterranean based on up-to-date measurements.

In the framework of the Italian-Yugoslavian Program for the protection of the Adriatic Sea (ASCOP), multidisciplinary data sets have been collected on the grid of stations given in figure 2. The parameters considered are physical, chemical and biological concerning water and sea bottom. The parameters taken as pollution indicators concern all the most important matrices: water, suspended matter and sediments.

The results obtained from 1983 to 1984 during five seasonal experiments represent one of the most significant sources of high quality data on the pollution and related oceanographic processes in the international waters of the Adriatic Sea.

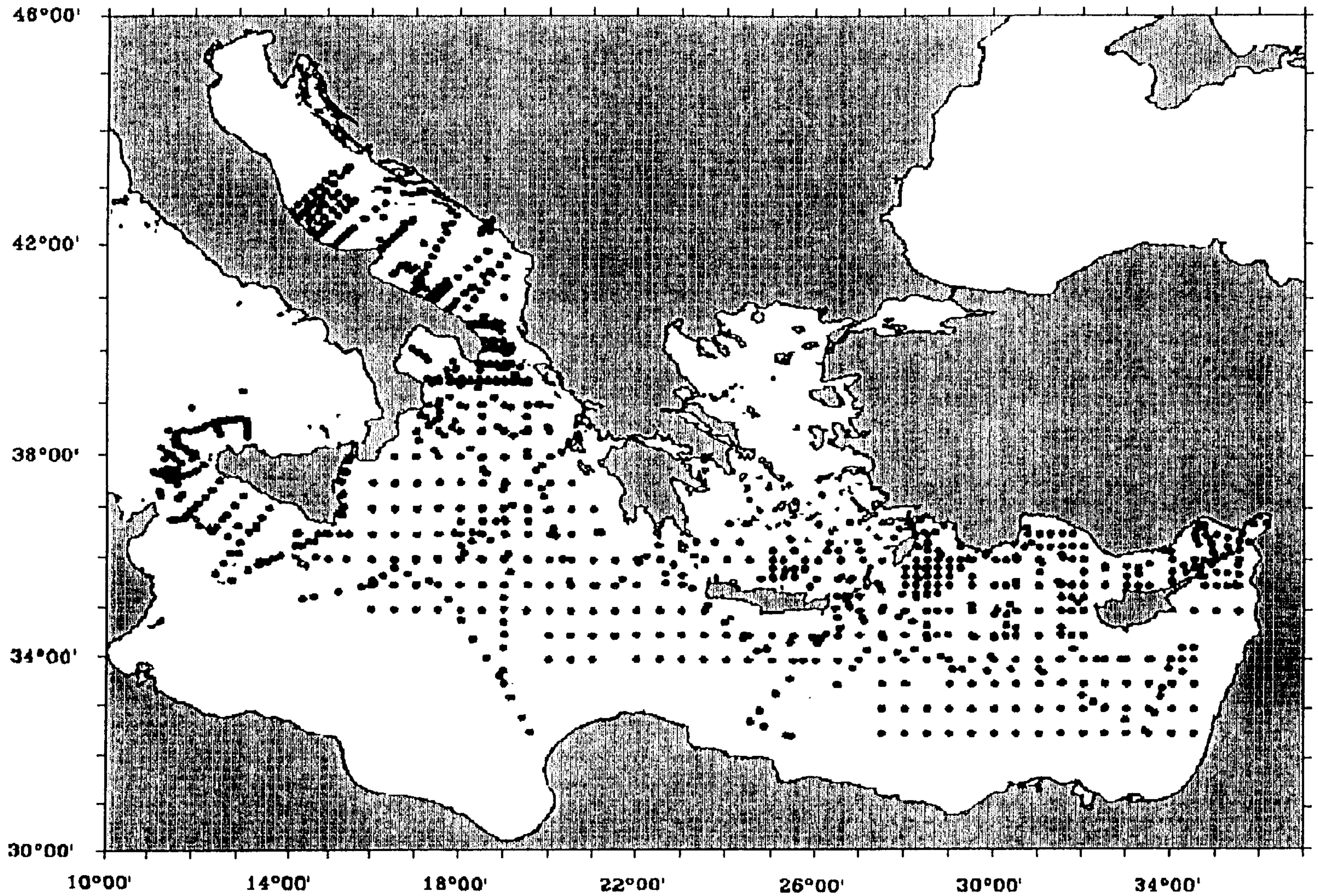

Figure 1. Distribution of CTD stations during POEM cruises.

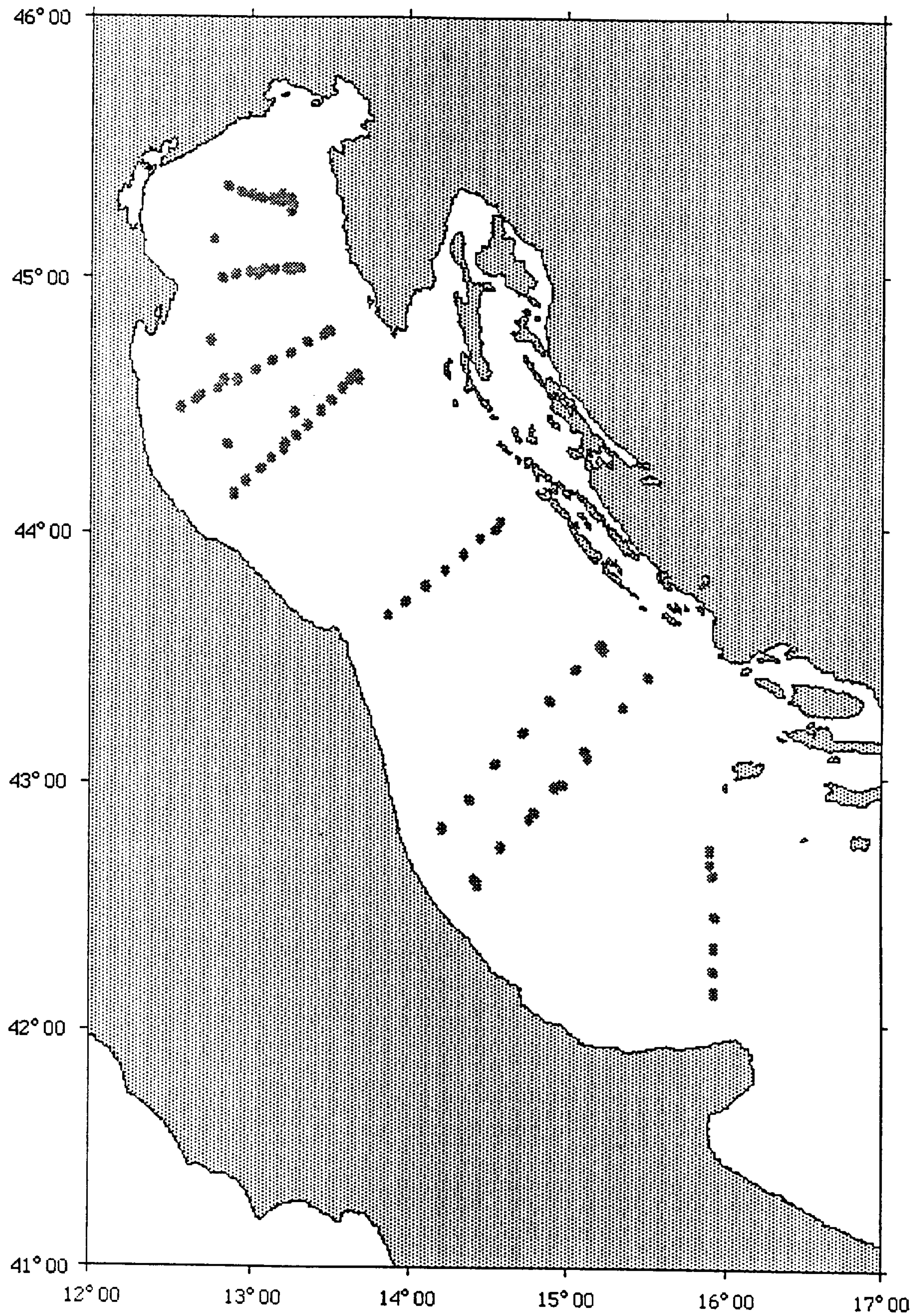

Figure 2 . Distribution of sampling sites during ASCOP programme.

APPENDIX 1: RECOMMENDATIONS AND CONCLUSIONS

Following the workshop presentations delegates split into three working groups to discuss the technical, application and administrative issues involved in implementing a digital marine atlas for European waters. The following sections summarise the conclusions and recommendations reached by these working groups.

Technical Issues

1) Language: multiple languages will be required for those products containing text. The translation of descriptive textual information will be straightforward. However difficulties are envisaged in providing different languages for the user interfaces (e.g. menus and prompt messages) and the variation of lengths of text labels on maps and diagrams etc. with source language. The first can be solved by providing "loadable" multi-lingual text information for the generation of menus etc., whilst the second should be a topic for further research.

2) Portability: the likely platform for the Atlas will be the PC. IBM PCs and compatibles running MSDOS are acknowledged to have a less attractive user interface but a wider user base (within Europe, but not the US) compared to the Apple Macintosh PC. The adoption of portable software, either proprietary or written "in-house", for both platforms is one possible solution. This should be investigated further, along with the possibility of using UNIX in the future for an even wider platform base.

3) Dimensionality: full three dimensional data sets should not be handled (at least initially) due to the complexities of data storage and presentation. However, selected 2.5 data sets, portrayed as special products (e.g. perspective views, or 2D slices) will be feasible. Time should be handled in the same way as in paper atlases, i.e. separate maps of seasonal variation.

4) Projections and Scale: no problems are foreseen with producing maps on different projections, even "on the fly". 1:250,000 scale is thought to be the optimum scale for holding and portraying information generally. Larger scales would be used for more detailed information, for example at the national level.

5) Coastlines: the adoption of a set of common coastlines, such as the World Vector Shoreline (WVS) from the US Defense Mapping Agency, is essential. This would have great benefit in

terms of the effort involved in data capture and standardisation between marine data sets and also with land-based information.

6) Format: raster and vector data formats will be required, as appropriate for each data set. Some data sets will be stored in both, such as bathymetry.

7) Copyright and Security: copyright of the data within the atlas would have to be established at the outset of the project. To prevent, or at least discourage, the unauthorised extraction of information from the digital atlas some form of security may be required. This could take the form of data encryption in which only certain subsets would be extracted into a common CAD or GIS format by means of a (supplied) data conversion routine.

8) Implementation: option number 3, suggested in the Review was considered the most appropriate.

Applications Issues

1) Inter-calibration: to be left to the national data centres, institutes, and expert working groups, who will peer review and in effect "weight" the data from which a map is produced that is forwarded for inclusion into the MIS. All maps will be derived from processed or "good" data in the main. It is recognised that some suitable international mechanisms have already been established.

2) Subjects: subject coverage stemming from the questionnaire is a good starting point (page 50 of Review). It was noted that the ICES current meter inventory is readily available.

3) Areas: to be based on the EC map to be produced by Mr. J. Coleman in June 1990. Given the intrinsic importance of the coastal zone a separate scale should be employed for the 12 mile zone in order to allow better resolution of all parameters.

4) Space and Time Scales, Time Series: where possible histograms, line graphs etc. depicting variation in time should appear in "pop-up" windows over the base map, with the latter being flagged to indicate that this information is available. All aspects of rare and extreme events (e.g. Chernobyl and red tides) should be given special attention, although it is expected that most time series material will originate from specific long-term projects. Where possible links should be established with the spatial and temporal data formats used in the WOCE project.

5) Users: a well-developed menu interface that takes account of the wide range of potential users was felt to be the key to user-friendliness. The individual users, across the spectrum of the intelligent 15 year-old to the senior decision maker, should be able to decide for themselves which features met their needs.

"Ways and Means"

1) The final large-scale project envisaged would be beyond the means of central funds to support; national co-operation, probably under some CEC umbrella, might be appropriate.

2) However, a feasibility study including the development of a demonstrator could be accommodated within CEC funding.

3) Such a demonstrator would be a valuable means of raising support for the project at national level.

4) If, during the feasibility study, prototype software were developed or widely available proprietary systems were used, these would assist countries to participate in the fuller programme.

5) In the pilot study some results should be delivered within a year, for example a CD-ROM with associated software.

6) The pilot study should contain:

a) some software development.

b) establishment of base-line data, including coastlines and bathymetry.

c) an application of GIS.

d) a representation of some basic parameters, perhaps temperature and salinity with their seasonal variations, for the whole area of the "European waters".

e) a much more detailed study of a small area with many parameters.

7) Within 2-3 years it should be clear from the pilot study how to proceed further.

8) There should be a steering committee and a full-time coordinator. The steering committee could consist of the Principal Investigators of the various components of the pilot study.

9) This pilot study will be seen as a potential Central Initiative within MAST-2.

10) A very basic costing of the pilot study should be completed by the end of May 1990, with a break-down for each of three years.

11) Detailed planning of the pilot study should take place via small working groups, based on the Reading workshop participants, (but not all of them) in the Summer or Autumn of 1990. This meeting should generate detailed costs and a work programme.

APPENDIX 2: ATTENDEES

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