CEFAS

The Centre for Environment, Fisheries & Aquaculture Science

Further identification and acquisition of bathymetric data for Irish Sea modelling

for

The Department of the Environment, Transport and the Regions

Contract Ref: CW0753

Further Identification And Acquisition Of Bathymetric Data For Irish Sea Modelling

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DETR contract CW0753:
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EXECUTIVE SUMMARY

The 1995 *Irish Sea Science Co-ordinator's Report*, jointly commissioned by the UK and Republic of Ireland, identified a particular need for data to improve hydrographic models. This was also flagged in a subsequent study commissioned by DETR (EPG 1/9/61). In part, this refers to a requirement for good quality high resolution observational data against which models can be validated. However, it also recognises the need for accurate high resolution values of depth for models, the next generations of which are being developed at resolutions of order 1 km in order to accurately replicate and understand the interaction of persistent density features with bathymetry.

Existing fair sheet and Admiralty chart data, were used to increase the resolution of a previous data set (DETR contract EPG 1/9/61) from 2 x 2 km to 1 x 1 km over the Irish Sea region. Additional data was identified, which enabled areas of the western Irish Sea, previously covered by Admiralty charts, to be replaced by higher resolution data from fair sheets. The resulting bathymetric data set was then corrected from chart datum to values relative to MSL (mean sea level), as required for computer models.

Sources of Celtic Sea and Bristol Channel bathymetric data (within the region south of 52° 08′N; east of 8°W; north of 50°N; the UK coast) were identified. The most comprehensive and accessible data were held by the Hydrographic Office in the form of Admiralty fair sheets. This, combined with data from Admiralty charts where fair sheets were absent, was digitised to form a bathymetry of the Celtic Sea and Bristol Channel component grids of 1/120° latitude by 1/60° longitude. The data were corrected to values relative to MSL. Data extends from the North Channel to the Celtic Sea, bounded in the north and west by 56° 00′N and 6° 31′W, respectively, and in the south and west by 50°N and 10°W, respectively. The Celtic Sea western limit extends beyond the specification of the contract, but is included as it was compiled under parallel MAFF funded work. For ease of interpretation, the dataset has the form of a rectangular grid, with regions outside the range of the source charts appropriately masked. ***Copyright provision for the dissemination of the data was gained from the Hydrographic Office and Irish Government. To facilitate wider use the data set has been lodged with The British Oceanographic Data Centre on the understanding that data is used for research purposes only and that users abide by the copyright conditions (Annex 2 & 3) and acknowledge the source of data*** [*].

Sources of meteorological data necessary for forcing hyrdrodynamic models have been identified. However, the conditions for its scientific use are partially clouded by concerns over funding and copyright. Many of the issues are being discussed by the inter-agency Marine Environmental Data Advisory Group, under the auspices of the Inter-Agency Committee on Marine Science and Technology (IACMST) where it is intended that questions concerning access are clarified.

The next generation of high resolution models currently under development will require bathymetric data at 1 km resolution for the entire European Shelf. Future work should identifying the sources of and constraints on obtaining the necessary data in order to inform the strategy for its compilation.

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[*] The bathymetry used for this work was funded by the Department of Transport and the Regions and the Ministry of Agriculture Fisheries and Food (Brown *et al.*, 1999) ; Brown, J., Joyce, A.E., Aldridge, J.N., Young, E.F., Fernand, L. and P.A. Gurbutt, 1999. Further Identification And Acquisition Of Bathymetric Data For Irish Sea Modelling. DETR research contract CW0753.

BACKGROUND

A pre-requisite for marine environmental management is the ability to understand and predict the physical mechanisms that control chemical and biological processes in the sea. The assessment and forecasting of environmental change, contaminant transport and fisheries recruitment are critically dependent on the application of high resolution hydrodynamic models. Good quality tidal models form the necessary basis for such work and in part their success depends on the quality of the available bathymetry.

Modelling of physical and biological processes in the Irish Sea has been hampered by incomplete and inhomogeneous data sets for bathymetry and meteorology. This was identified as being of the highest priority in the 1995 *Irish Sea Science Co-ordinator's Report*, jointly commissioned by the UK and the Republic of Ireland.

Bathymetry

With regard to the above, CEFAS prepared a coherent and unified bathymetry for the Irish Sea under a recent DETR contract EPG 1/9/61. An innovative approach was adopted, deriving a large part of the bathymetry from Admiralty fair sheets, which give an accurate high resolution measure of depth direct from survey data. In this, it was recognised that previous bathymetries were derived from standard Admiralty navigation charts, offering comparatively poor resolution and reflecting the shallowest point in a particular model grid box, as required for navigation purposes, rather than one representative of the depth throughout the box. Consequently, the variety of diverse bathymetries that existed offered a range of disparate resolutions in different areas, many of which had the disadvantage of having been prepared on comparatively coarse resolution. Additionally, some of the existing 'higher resolution' bathymetries were derived by interpolation from those of coarser resolution, compounding this error.

The next generation of shelf seas models, now beginning development, will be designed to accurately represent the baroclinic (density) forcing. For this, it is necessary to understand the interaction of persistent density features with bathymetry and it should be noted that the natural length scale for deformation of frontal features is of the order 3-5 km. Recently, direct observations in the Irish Sea, North Sea, Celtic Sea and The Minch have demonstrated the existence of strong and persistent jet-like flows whose location and strength is closely linked to the nature of bathymetry which necessarily must be accurately represented in model simulations (e.g. Hill *et al.*, 1996; Hill *et al.*, 1997a; Hill *et al.*, 1997b; Horsburgh, *et al.*, 1998; Brown *et al.*, 1999). In this respect, the requirement for high resolution bathymetry has been demonstrated in the North Sea (Proctor & James, 1996), whilst Young *et al.* (2000) have demonstrated the importance of accurate representation in determining fluxes through the complicated topography of the North Channel of the Irish Sea. Accurate representation of dynamics can only be achieved by considering horizontal scales of order 1 km.

Far field processes have a strong influence on the dynamics of the Irish Sea, in particular, at the southern end by those acting over the Celtic Sea. Presently, the Celtic Seas QSR is focusing on the region. Also, there is significant effort, which is planned

to continue, being expended to understand the factors controlling flow through the region. Modelling forms an important element of the work and requires a coherent and accurate bathymetry which was not available.

This document refers to grid sizes of 2 km and 1 km. Strictly, the dimensions of the former are 1/60° latitude by 1/30° longitude, where each grid element represents a depth in a box of approximate horizontal resolution 2 x 2 km. Similarly, the 1 km grid refers to a grid of dimension 1/120° latitude by 1/60° longitude, where each element represents a depth in a box of approximately 1 x 1 km.

Meteorology

Adequate characterisation of wind fields is necessary for modelling of water transport and associated contaminant pathways as the wind is the principal forcing agent at time scales up to 10 days. Established practice has been to blow a uniform wind field over a region to examine the response. However, recent work at CEFAS and The Unit For Coastal and Estuarine Studies (Menai Bridge) has shown this approach to be inappropriate. Wind fields have considerable temporal and spatial variation (e.g. the passage of typical Atlantic depressions) and the correct representation results in significant differences between the pattern of response as compared to fixed fields. There are a number of potential sources of data (UK, Irish and European), however, the copyright implications and cost are unclear. In addition, to provide a suitable database requires wind fields generated at typically 3 hourly intervals so there are storage and access implications. Often data need to be accessed in near real-time. With attendant inter-agency concerns it is difficult to provide anything more than a feasibility study in this area.

In addition, for biological modelling (e.g. the simulation of phytoplankton blooms) other parameters are required such as insolation, cloud cover, relative humidity, air temperature etc.. Suitable sources for this are sparse and diffuse, but as yet no readily accessible database exists to identify these sources.

Overall Contract objectives

1. Enhance an existing bathymetric data set (produced under DETR contract EPG 1/9/61) to a resolution of 1 km and adjust depths to be relative to Mean Sea Level (MSL).
2. Extend the area covered by the bathymetric data set to include the Bristol Channel and Celtic Sea regions at 1 km resolution.
3. Identify sources of meteorological data for the Irish Sea.
4. Recommendations for future work.

PROGRAMME OF WORK

Adjust existing bathymetry to 1-km resolution and correct to MSL

Existing fair sheet and Admiralty chart data, were used to increase the resolution of a previous data set (DETR contract EPG 1/9/61) from a 2 km grid to a 1 km grid over the Irish Sea region (denoted WIS in Figure 1). Further data was identified (see Annex 1; Table A1.1), which enabled areas of the western Irish Sea previously covered by Admiralty charts to be replaced by higher resolution data from fair sheets. The resulting bathymetric data set was then corrected from chart datum, which corresponds to Lowest Astronomical Tide (LAT), so that depths are relative to mean sea level (MSL) as required for computer models.

Correction from chart datum was undertaken by use of a numerical model (Davies and Aldridge, 1993). A tidal model is run over the LAT depths and a prediction of the mean Spring tidal range is made at every depth point. The difference between the mean Spring range and the extreme Spring range (the Lowest Astronomical Tide) is given by an empirical relation that can be readily calculated for any particular region. This provides a first approximation to the required correction. The model is then run over the newly corrected depths to produce an improved estimate of the mean Spring range and again the derived lowest astronomical prediction is applied. This process is repeated until only small changes in the correction factor occur at all points.

In offshore regions, models can typically reproduce tidal elevations to within 0.1 m. However, errors can be expected to be considerably higher in inter-tidal areas where complex patterns of wetting and drying due to the flood and ebb of tides are difficult to model and validate. Significant inter-tidal regions exist in the Solway, Morecambe, Ribble, Dee and Bristol Channel. Corrections for these regions were based on the tidal range at adjacent sub-tidal locations (i.e. where water exists at LAT). In these regions errors of order 0.5 m might be expected. It is recommended that those particularly interested in the near-shore region check in detail the depths in inter-tidal regions.

Extend the Irish Sea data set to cover the Bristol Channel and Celtic Sea regions at 1 km resolution

A number of data sets containing depth data covering the Celtic Sea and Bristol Channel regions (bounded by south of 52° 08′N; east of 8°W; north of 50°N; Figure 1) exist. In general they were compiled for use in comparatively low-resolution hydrodynamic models.

- The Proudman Oceanographic Laboratory (POL) have 12 km and 8 km data covering this region (e.g. Davies and Jones, 1992; Flather *et al.*, 1991).
- An 8 km grid of depths covering the whole European shelf was distributed widely in the UK during the NERC funded North Sea project.
- POL have an enhanced resolution Bristol channel data set of 4 km in the outer reaches and going down to ~1 km past Hinckley point and Avonmouth (Amin and Flather, 1996).
- Plymouth Marine Laboratory have a 5 km data set (Sinha and Pingree, 1997).

All depth values for the above grids were ultimately obtained from Admiralty charts, the source data for which is held at the Hydrographic Office. However, these are generated for navigation purposes at comparatively poor resolution and reflect the shallowest point in a particular model grid box, rather than one representative of the depth throughout the box. Consequently, the variety of bathymetries that existed offered a range of disparate resolutions in different areas, many of which had the disadvantage of having been prepared on comparatively coarse resolution. Additionally, some of the existing 'higher resolution' bathymetries were derived by interpolation from those of coarser resolution, compounding this error. When compared to high resolution surveys, errors in depth can be of the order of 10 m, in water of up to 150 m.

The Hydrographic Office at Taunton was identified as possessing the most comprehensive set of high-resolution bathymetric data covering the UK continental shelf. This takes the form of fair sheets obtained by surveys undertaken over many years by the Royal Navy or sub-contractors. The fair sheets of original surveys contain depths of water corrected to a chart datum, whilst the datum for the more modern is the Lowest Astronomical Tide. Fair sheets are indexed at the Hydrographic Office by date of survey and by sheet number. They are held as three periods, pre – 1930, 1930 – 1979 and 1980 – present and each sheet may comprise a number of sub-sections. Those used in this project are listed in the Table A1.2 in Annex 1 and shown in Figure 3. In the case of duplication or overlap of regions, the most recent survey data were used.

High resolution surveys cover the majority of the region, with the notable exception of the south-west. Where fair sheets are not available, Admiralty Charts were used. Fortunately, this part of the region is comparatively deep and the topography relatively gentle, consequently the lack of high resolution data could be considered less important.

Preparation and synthesis of data sets

For shelf models, bathymetry is generally defined on a regular rectangular grid in terms of latitude, longitude and depth. In order to transfer data from the fair sheets to electronic format a number of graticules were produced, appropriate to the scale of the fair sheets, with component grids of 1/120° latitude by 1/60° longitude (approximately 1 km x 1 km). These were overlaid on the fair sheets and the mean depth within each grid calculated and input to a database. Here, the latitude and longitude refer to the centre of grid boxes. Thus, while the northwest corner of the data grid is at 56°N 10°W, the associated depth point is half a grid spacing to the south and east at 55.9958°N 9.99167°W. Where fair sheets were not available, data was taken from the highest resolution Admiralty charts. In some locations fair sheets overlapped, in which case the sheets were digitised separately and the depths of the overlaps compared. If the standard error between the different values was less than 0.1 m then the geometric mean was used. Where the depths differed more widely, reference was made back to the original data sources and a judgement made on the 'best' depth. In part, this acted to provide a degree of quality control.

The size of the data set (approximately 126000 estimates of bathymetry including North Channel and Irish Sea; see Figure 1) precludes checking of individual data points. In order to provide quality control the data was viewed as 2-D and 3-D projections (e.g. Figure 4), which when compared with Admiralty charts highlighted anomalies for subsequent correction. The procedure provided the most rational means by which to eliminate anomalies.

Depths, in metres, were corrected from a chart datum corresponding to Lowest Astronomical Tide (LAT), to mean sea level (MSL) by the use of a numerical model as described previously in the section concerning the adjustment of existing bathymetry to 1 km resolution and subsequent correction to MSL.

The procedure was carried out for the Irish and Celtic Sea (Figures 1 & 2). This data was combined with 1 km data sets for the North Channel (NC; Figure 1), constructed under MAFF funding and an existing 1 km data set for the Eastern Irish Sea (EIS; Figure 1). In the overall data set, areas of sand bank which are above MSL, but covered at high water are stored as negative numbers whilst land and areas outside the range of the source charts are stored as –99.

DATA SUBMISSION, WIDER ACCESS AND COPYRIGHT

During construction of the bathymetry CEFAS has publicised the work at a series of meetings. From this, a number of UK and Irish institutes have expressed interest in utilising the data. To encourage wider access, it is intended that the data be lodged with BODC[2] and CEFAS hold a copy. Included with the data will be this report which will incorporate the copyright conditions under which the data are to be used. Its use will require that this report be cited[3] in order to acknowledge the funding of DETR. Wider usage will also be promoted via the forthcoming DETR seminar programme and the Inter-Agency Committee on Marine Science and Technology (IACMST) and in particular the Marine Environmental Data Advisory Group (MEDAG), in which Dr Emmerson (DETR) and Dr Brown (CEFAS) are participants.

A copy of the copyright conditions applying to the bathymetry derived from the charts and fair sheets outlined in Annex 1 is included at Annex 2. For completeness, a copy of the data licence for BODC is included at Annex 3.

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[2] British Oceanographic Data Centre, Proudman Oceanographic Laboratory, Bidston Observatory, Prenton, Merseyside, CH43 7RA, UK.

[3] The bathymetry used for this work was funded by the Department of Transport and the Regions and the Ministry of Agriculture Fisheries and Food (Brown *et al.*, 1999); Brown, J., Joyce, A.E., Aldridge, J.N., Young, E.F., Fernand, L. and P.A. Gurbutt, 1999. Further Identification And Acquisition Of Bathymetric Data For Irish Sea Modelling. DETR research contract CW0753.

SOURCES OF METEOROLOGICAL DATA

Wind data for the Irish and Celtic Seas can be obtained through the UK Meteorological Office (UKMO)[4], The European Centre for Medium-Range Weather Forecasting (ECMWF)[5], The Irish Meteorological Office (IMO)[6] and The British Atmospheric Data Centre (BADC)[7]. All but ECMWF provide data for coastal monitoring stations, but with differences in temporal resolution, ease of access and copyright considerations. All but BADC run forecast models, the output of which includes a grid of points giving the spatial variation in forecast wind speed and direction.

Fixed Stations

A. UKMO provide hourly data of speed and direction for a series of UK stations bordering the Irish Sea, including the Isle of Man. Whilst data is readily available for research purposes there are frequent changes in pricing policy and often considerable delays in obtaining the data. Licence conditions dictate that data may only be used for the purposes specified at the time of purchase, must not be passed onto a third party and that the UKMO must be acknowledged in any publications. Also, there are no checks performed on data quality.
B. IMO provide hourly data of speed and direction for a series of Irish stations bordering the Irish Sea. To date, data is readily available for research purposes at very modest prices in comparison to the UKMO and generally the data is delivered within a week of the request. Data can only be used for the purposes specified at the time of purchase, must not be passed onto a third party and the UKMO must be acknowledged in any publications. Also, there are no checks performed on data quality.
C. BADC provide access to daily data of speed and direction for sites in the UK and Ireland and hourly values for a more limited data set. Much of this data is also held by the UKMO. Access is via the internet following registration with BADC. On registration users are required to specify intended use.

Forecast wind fields

A. UKMO run a numerical weather prediction model operationally at a grid resolution of order 0.5° latitude x 0.5° longitude (Curren, 1993). In addition, a higher resolution model is available of grid resolution 0.15° x 0.15° covering the north east Atlantic, UK continental shelf and north western Europe. Both models are run in continuous data assimilation mode with analysis performed every 3 hours, providing for the purposes of hydrodynamical models wind speed and direction at 10 m above the surface. Archived data can be supplied by post and it is possible to receive the data via e-mail in real-time with forecasts 36 hours ahead. Data can only be used for the purposes specified at the time of purchase,

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[4] The Met. Office, London Road, Bracknell, Berkshire, RG12 2SY, UK.
[5] European Centre for Medium-Range Forecasts, Shinfield Park, Reading, RG2 9AX, UK.
[6] Met Éireann, Glasnevin Hill, Dublin 9, Ireland.
[7] BADC, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire, OX11 0QX, UK

must not be passed onto a third party and the UKMO must be acknowledged in any publications. Analyses are archived and available on request, although the pricing policy is variable and there are often considerable delays in obtaining the data.

B. IMO run a model providing forecast fields of wind speed and direction at 10 m for 48 hours ahead. The horizontal grid resolution is of the order 33 km. At present the data is not readily available whilst resources are committed to changes in the IT area.

C. ECMWF provide a global forecast model at a resolution of 1.125° latitude by 1.125° longitude. Wind speed and direction at 10 m are available at six hourly intervals from 6 to 120 hours ahead. Data are archived and available through BADC for the period from 1979 to present.

Whilst the necessary sources of wind speed and direction exist for modelling purposes, the issue of access is partially impeded by concerns over funding and copyright. For research purposes data supplied via BADC is essentially freely available. However, the temporal and horizontal (spatial) resolution is often not sufficient to meet all needs. The UKMO is the custodian of the higher resolution data, but the policy for dissemination is under development. Many of the issues are being discussed by the inter-agency Marine Environmental Data Advisory Group, under the auspices of the Inter-Agency Committee on Marine Science and Technology (IACMST), where it is intended that questions concerning access are clarified. This is against a background where government is urging that public funded work is made more accessible.

In the case of data for biological modelling (e.g. the simulation of phytoplankton blooms) or simulation of the seasonal heating of the water column, data required are parameters such as insolation, cloud cover, relative humidity, air temperature etc.. For the Irish Sea the most readily accessible source of data is available via the IMO for a station in Dublin. Other stations are held by the UKMO, but payment is by parameter and can be expensive. The UKMO and ECMWF can supply the majority of the parameters from forecast models. In the case of the former the pricing policy and access to historical data remains to be resolved. For the EMCWF, data are available via BADC, essentially free of charge.

RECOMMENDATIONS FOR FURTHER WORK

A unified high resolution bathymetry of the Celtic Sea, Irish Sea and North Channel now exists. The need for such data is most acute in areas of complicated topography. In this regard, the Malin Shelf is the area most in need of updating. However, inter-governmental concerns aired in fora such as OSPAR tend to focus more toward the North Sea and English Channel. Available bathymetries in the UK for these regions are derived from Admiralty charts and are generally at resolutions of order 4 km or worse. To construct a bathymetry of these regions would require significant effort. If it were to be contemplated, the first steps should be to explore existing European data sets, explore copyright considerations and to seek an international consensus on the most appropriate way to proceed.

The data described in this report are intended to provide the needs of large scale shelf models. However, there are numerous models developed by consultancies, which deal with near shore regions, especially in the vicinity of harbours and estuaries. The bathymetric data for these is generally 'commercial-in-confidence' between the consultant and client and not generally available to the wider scientific community. Access may be improved through the creation of an appropriate database of existing bathymetries.

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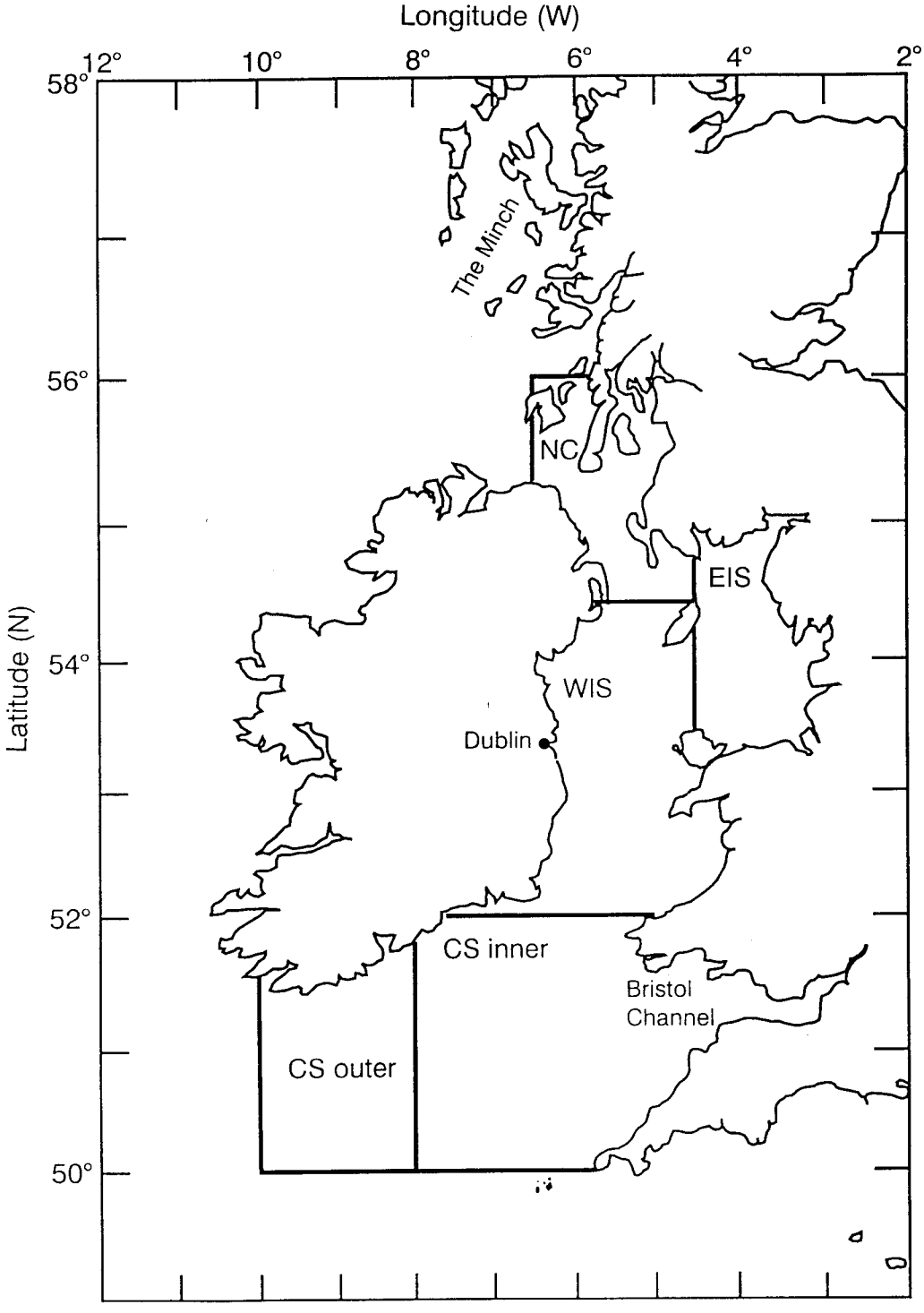

Figure 1. Region for which bathymetry was constructed under this and a previous DETR contract (EPG 1/9/61). The North Channel (NC) bathymetry was constructed under MAFF funding (contract AE1203). The eastern Irish Sea (EIS) bathymetry is based on a high resolution bathymetry compiled originally at the Proudman Oceanographic Laboratory and modified by CEFAS. The western Irish Sea (WIS) bathymetry is that described at page 6. The Celtic Sea (CS) inner was that compiled under this contract, whilst the Celtic Sea (CS) outer was compiled under MAFF funding (project AE1214). In the south–west sector there are no fair sheets available and the data is constructed from appropriate Admiralty charts (see Figure 3b).

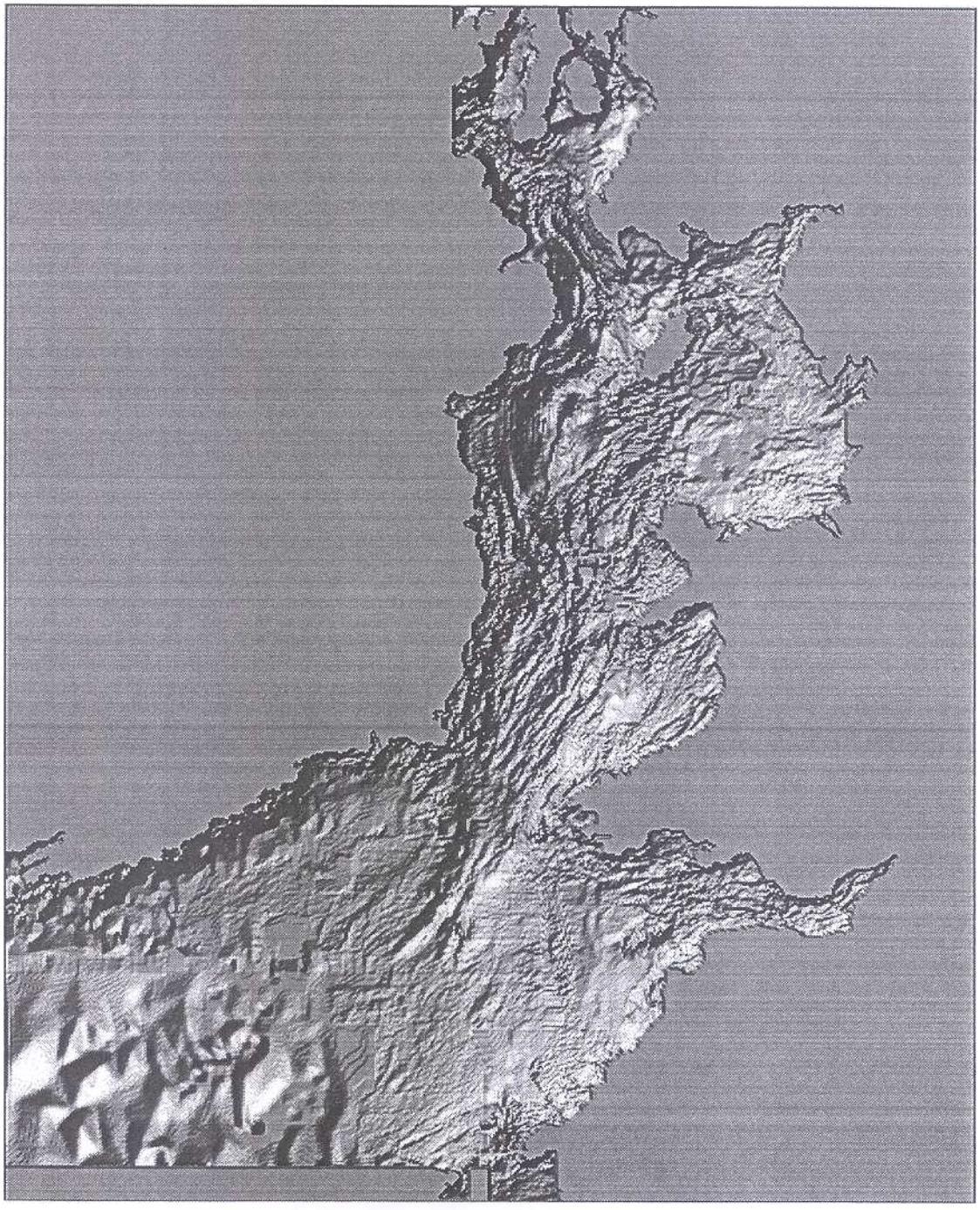

Figure 2. 2-D representation of bathymetry for the Celtic and Irish Seas. Note, the data forming the western Celtic Sea is of lower resolution as no fair sheets are available (see Figure 3b).

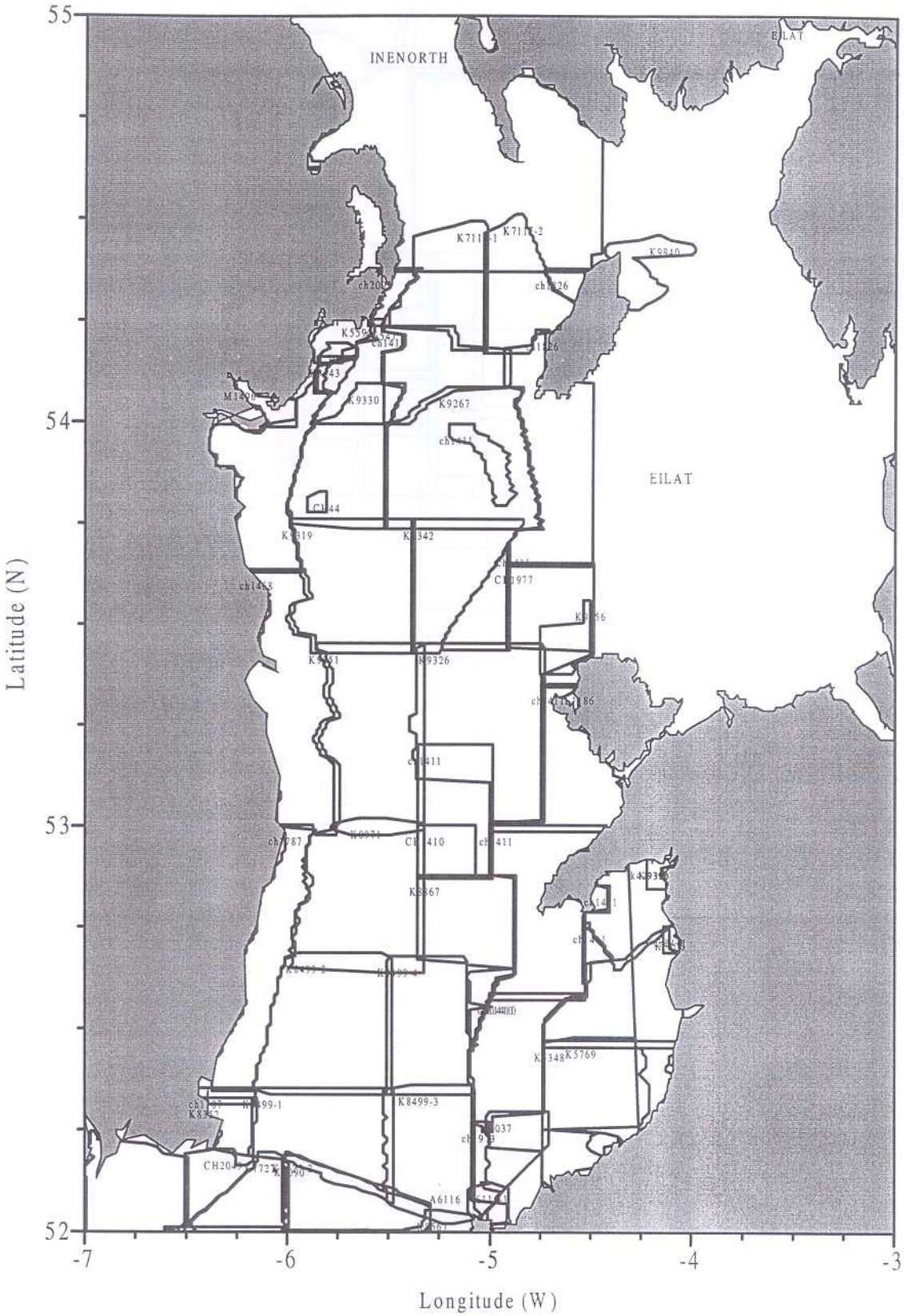

Figure 3(a). Admiralty fair sheets and charts used in the construction of bathymetry. - The western Irish Sea and St. George's Channel bathymetry (numbers relate to those given in Table 1 in Annex 1).

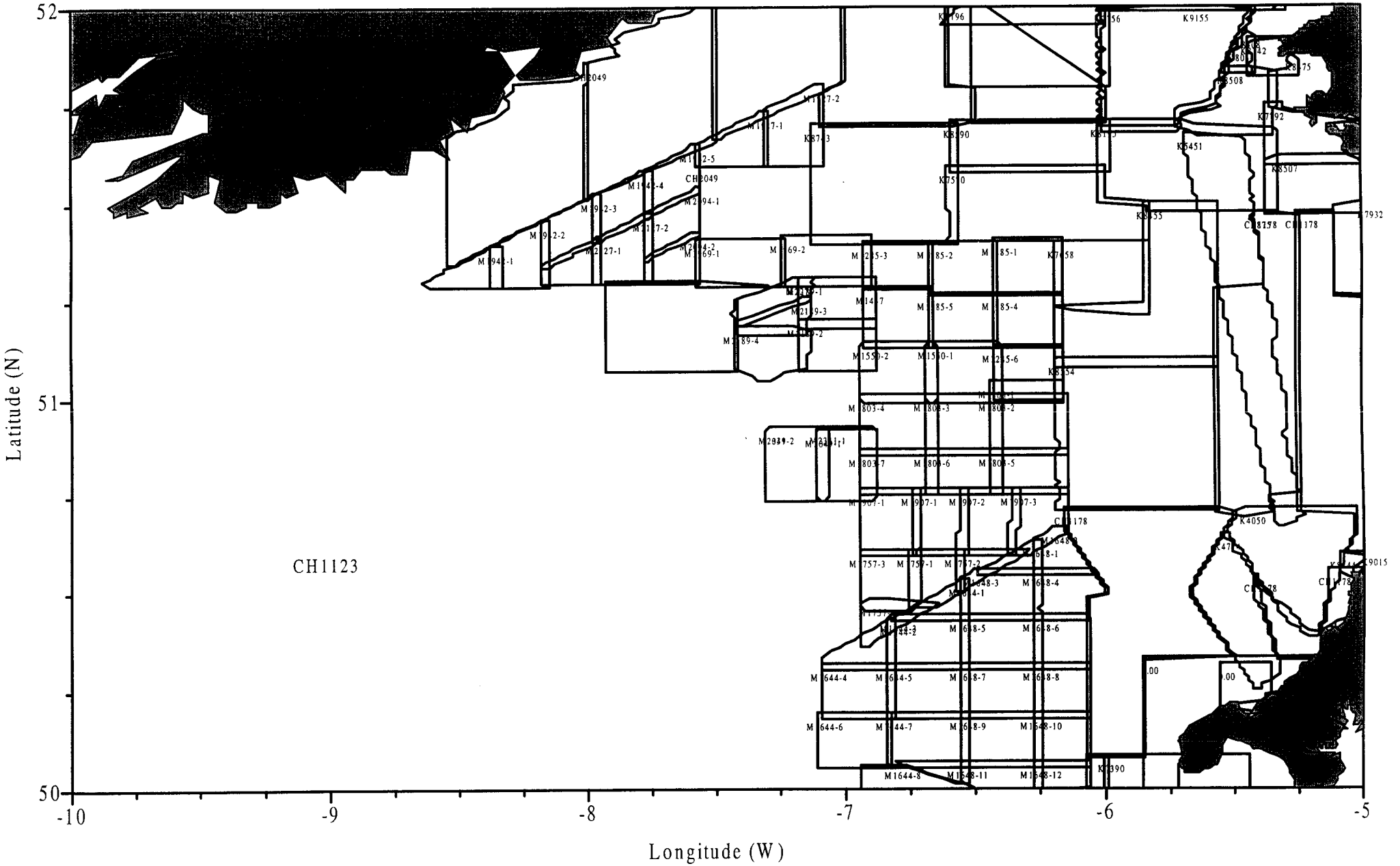

Figure 3(b). The western Celtic Sea (numbers relate to those given in Table 2 in Annex 1).

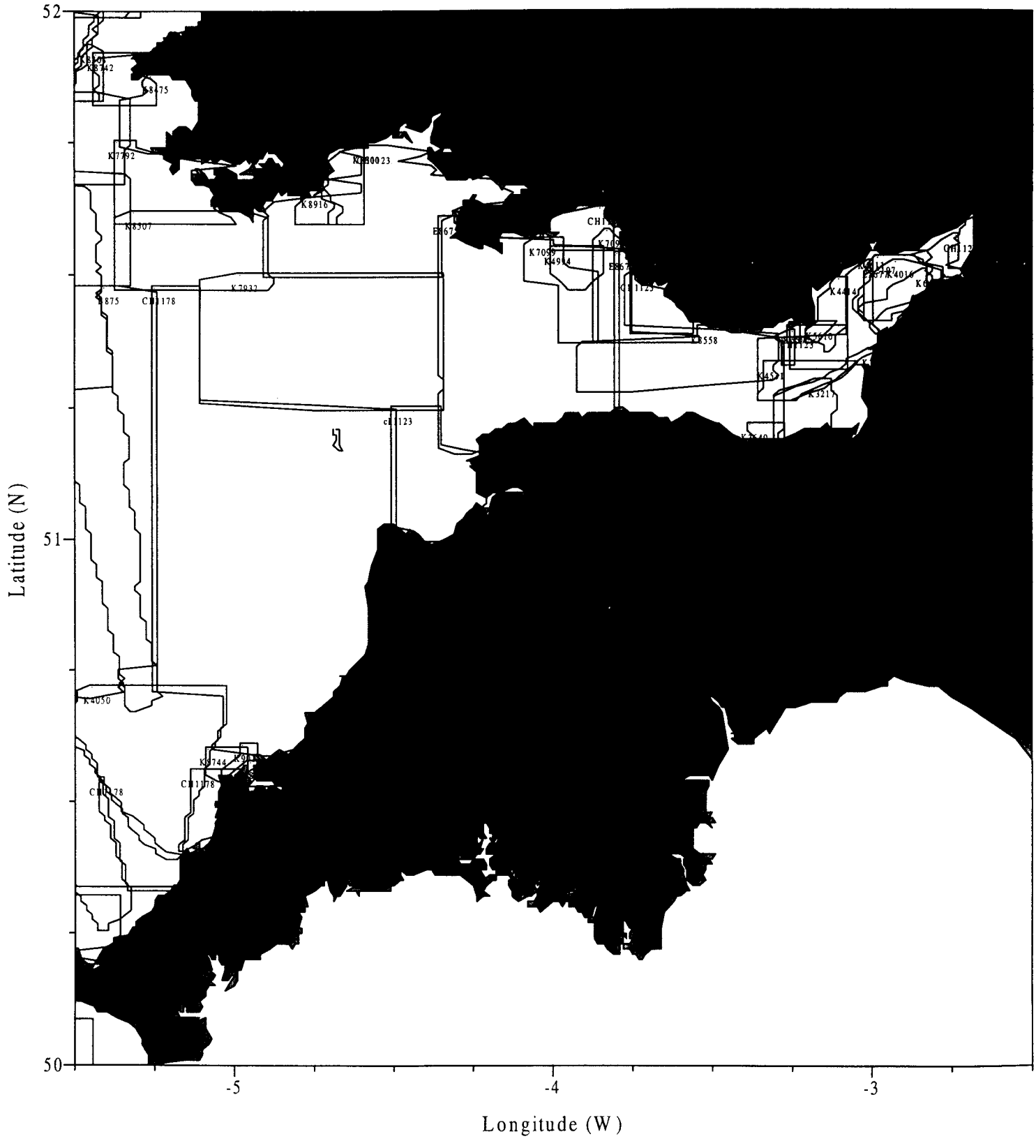

Figure 3(c). The eastern Celtic Sea and Bristol Channel (numbers relate to those given in Table 2 in Annex 1).

Figure 4a : 3D representation at 1 km resolution of the bathymetry of the Celtic and Irish Seas viewed from the south west corner of the region in Figure 1

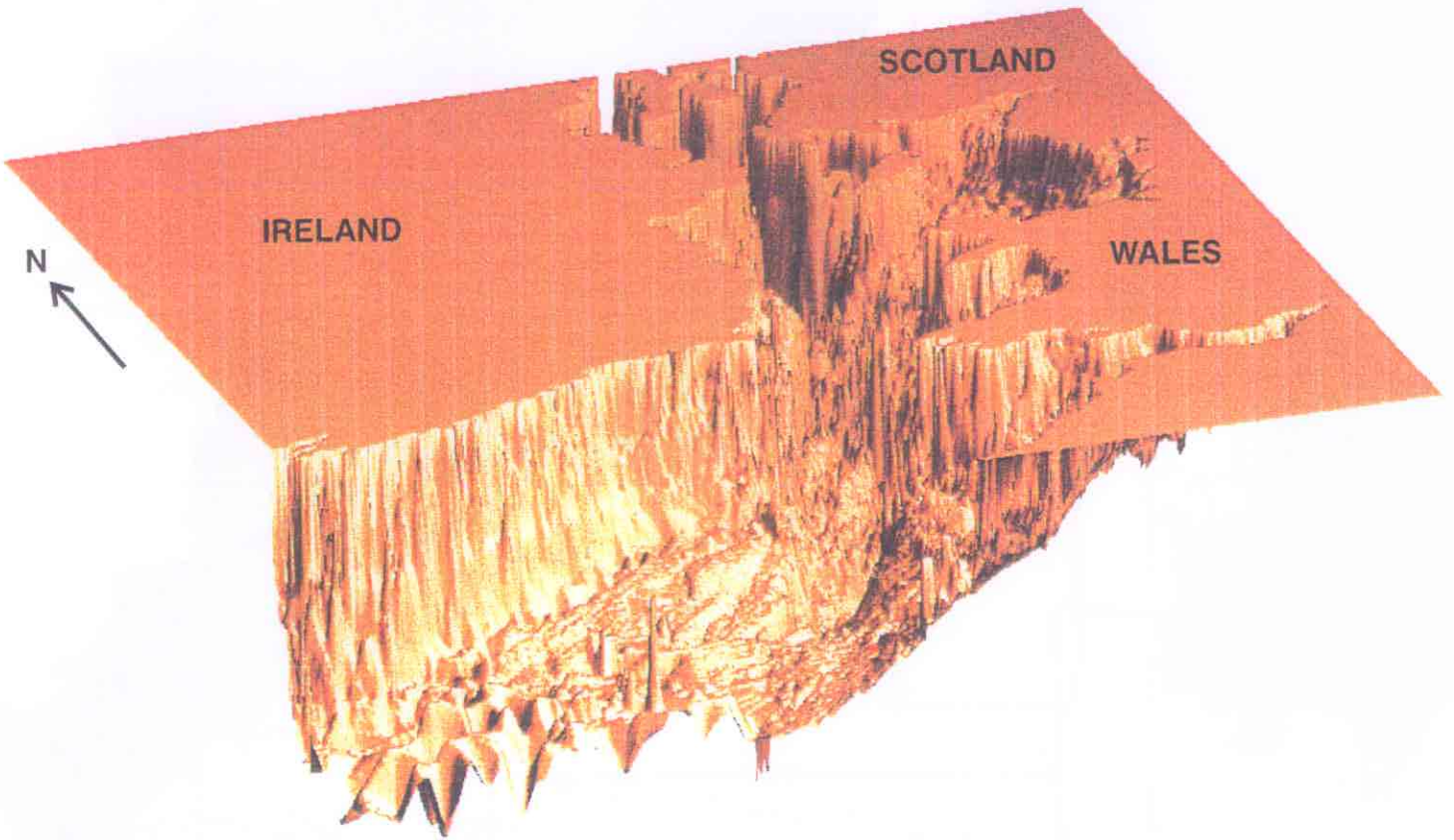

Figure 4(a). 3-D representation of 1 km resolution bathymetry of the Celtic and Irish Seas.

Figure 4b : 3D representation at 1 km resolution of the bathymetry of the Celtic Deep and Bristol Channel

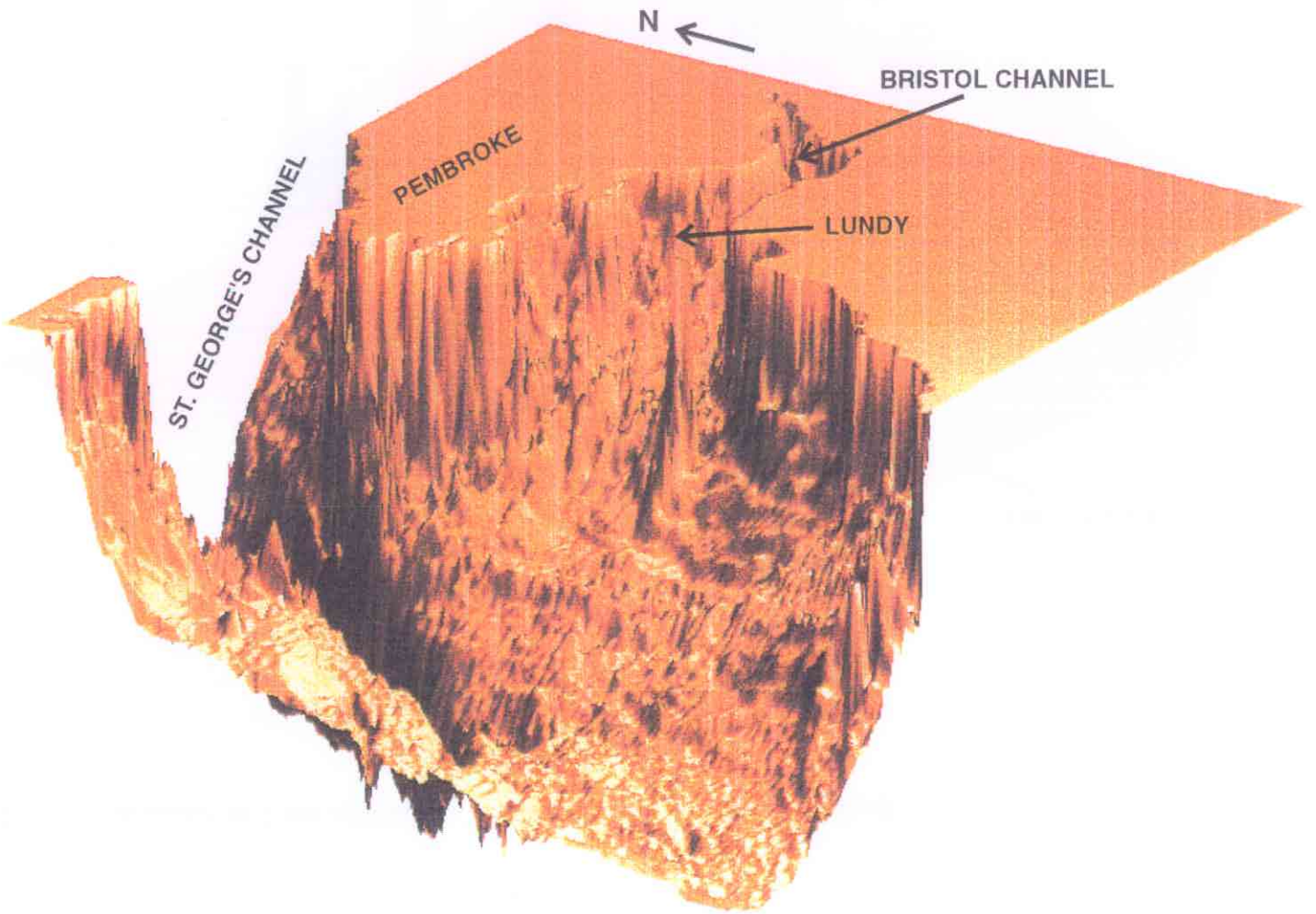

Figure 4(b). 3-D representation of 1 km resolution bathymetry of the Celtic deep and Bristol Channel.

Figure 4c : 3D representation at 1 km resolution of the bathymetry looking through St. George's Channel into the Irish Sea

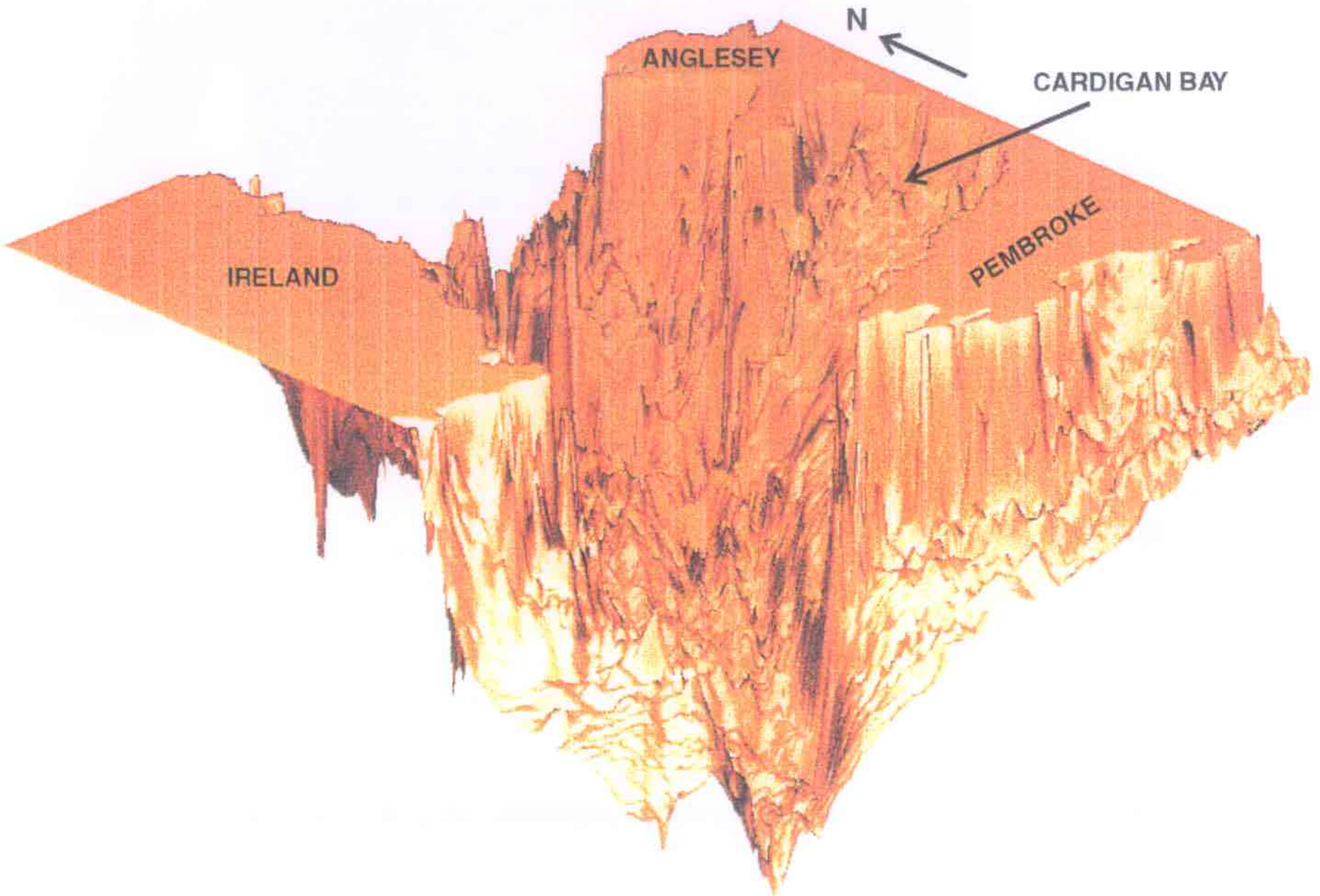

Figure 4(c). 3-D representation of 1 km resolution bathymetry of St. George's Channel and southern Irish Sea.

Figure 4d : 3D representation of bathymetry at 1 km resolution of the Irish Sea

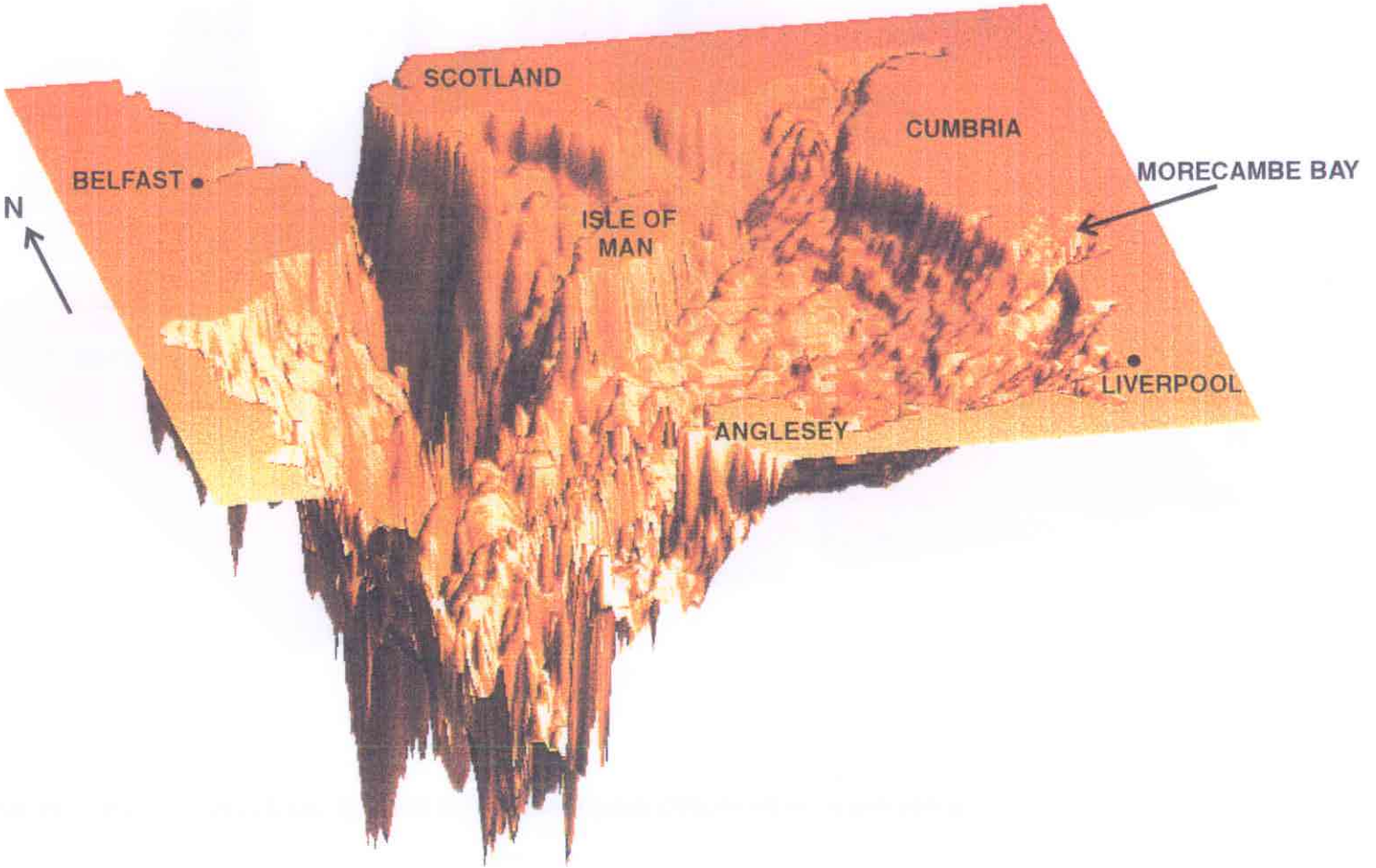

Figure 4(d). 3-D representation of 1 km resolution bathymetry of the Irish Sea.

Figure 4e : 3D representation at 1 km resolution of the bathymetry of the North Channel and Clyde Sea

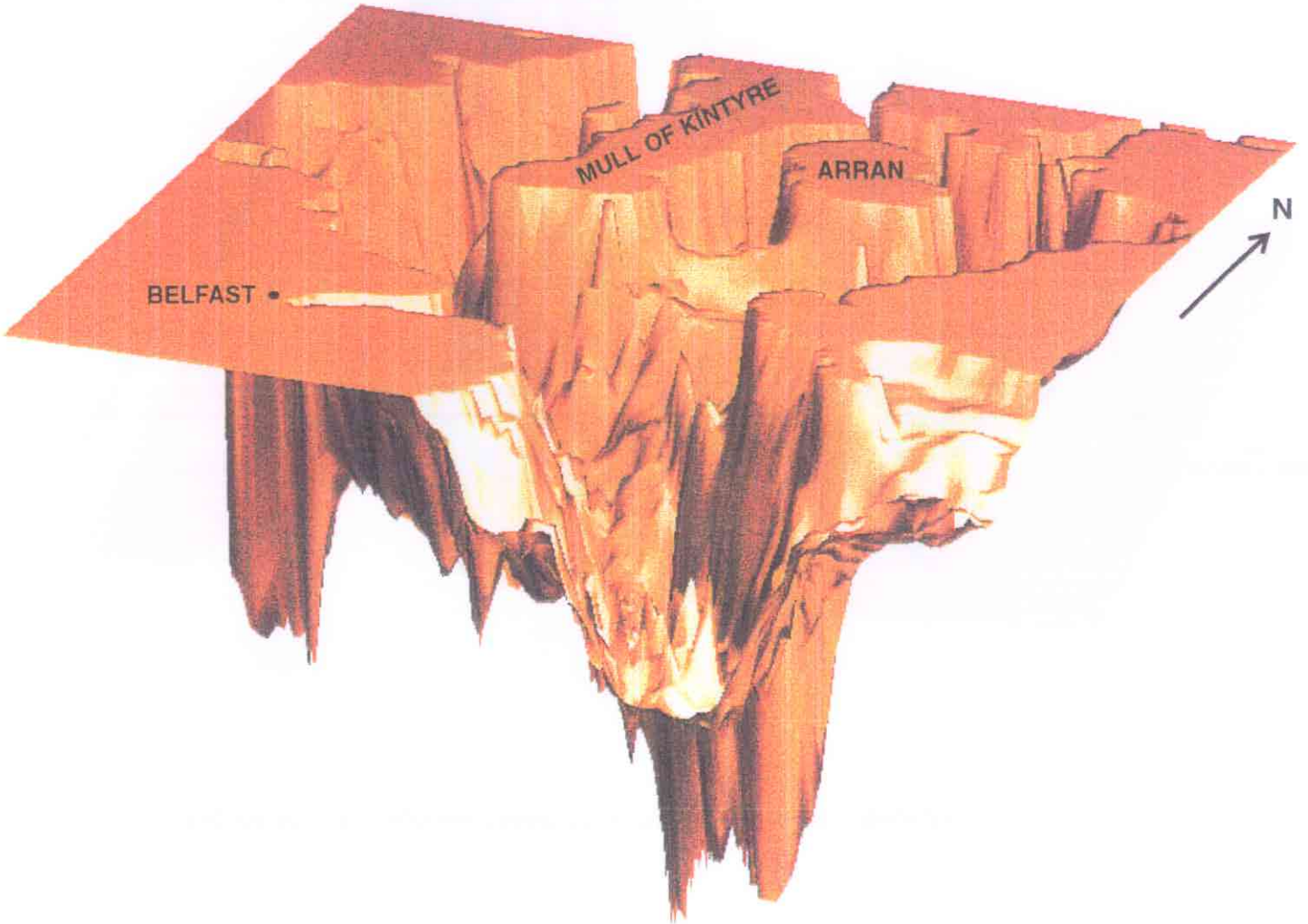

Figure 4(e). 3-D representation of 1 km resolution bathymetry of the North Channel and Clyde Sea.

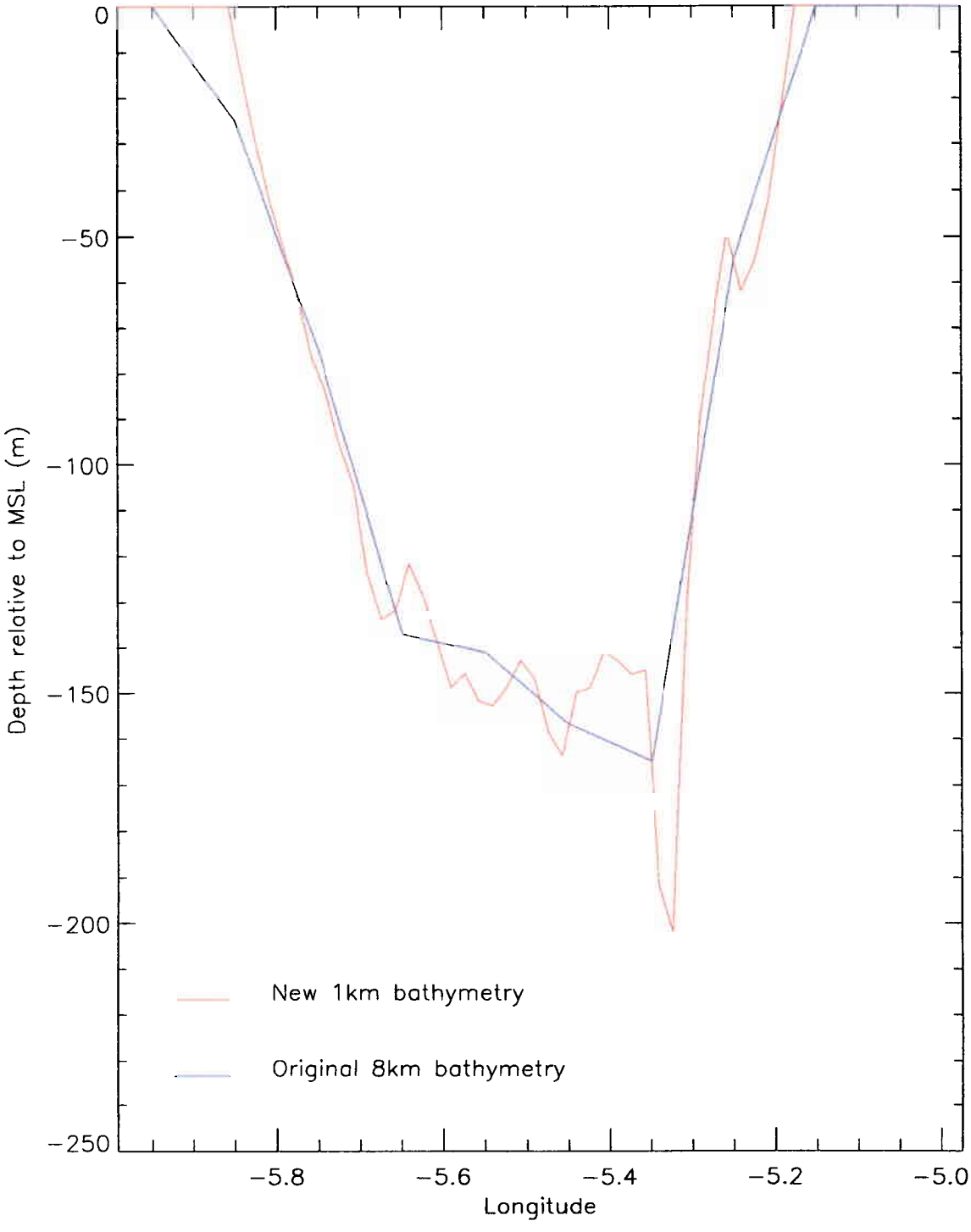

Figure 5(a). Cross section illustrating the differences in bathymetry between the new 1 km bathymetry and an 8 km bathymetry derived from Admiralty charts - North Channel at latitude 54° 54′N.

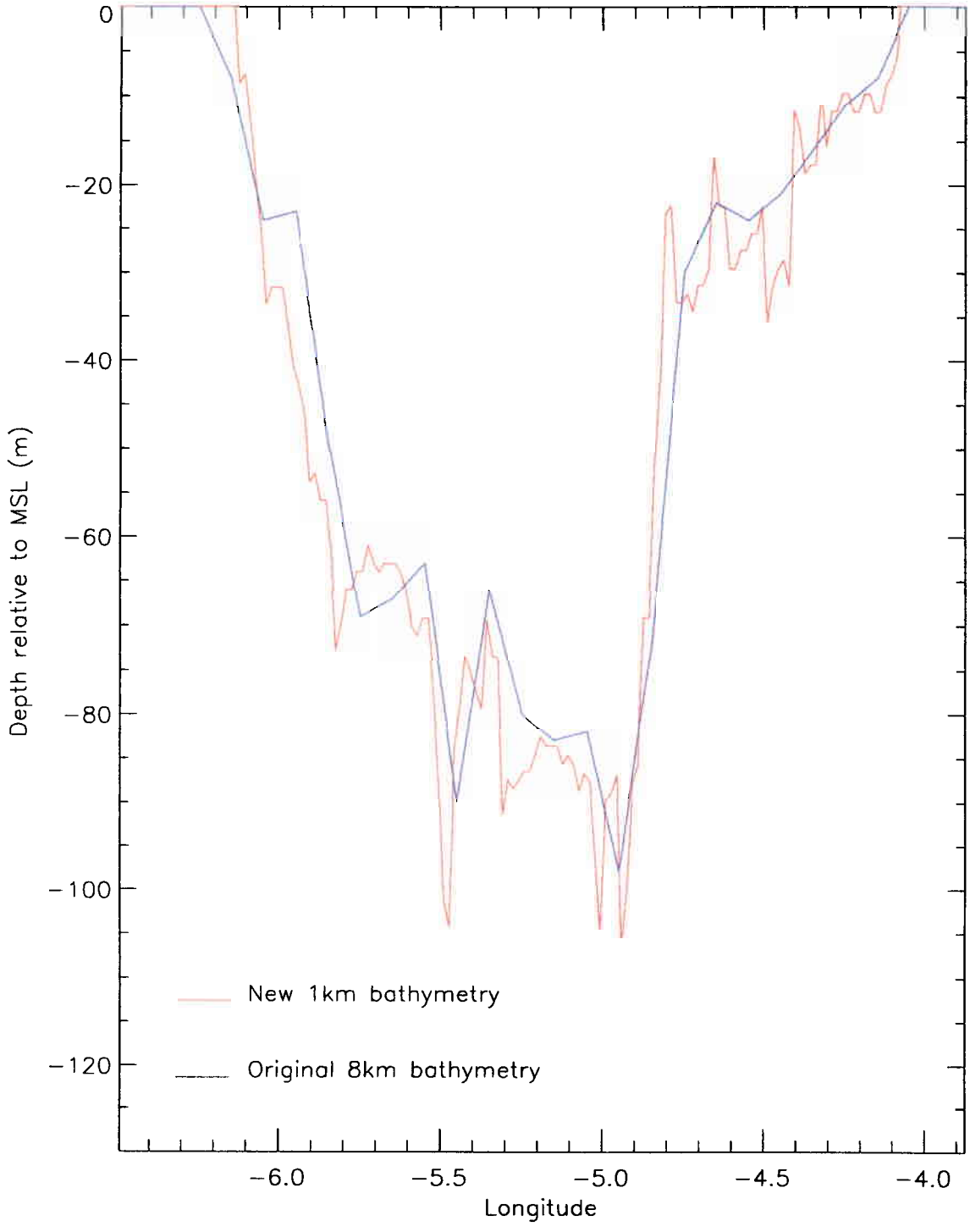

Figure 5(b). Cross section illustrating the differences in bathymetry between the new 1 km bathymetry and an 8 km bathymetry derived from Admiralty charts - St. George's Channel at latitude 52° 44′N.

ANNEX 1

Table 1. Admiralty charts and fair sheets used for the construction of the 1 km bathymetry of the western Irish Sea (WIS; Figure 1).

(a) Post 1980 fair sheets used:

K8499/1	K9051	K9326
K8499/2	K9056/1	K9330/1
K8499/3	K9090	K9342
K8499/4	K9267	K9343
K8867	K9319	K9940
K8971	K9320	M1496

(b) Pre 1980 (1930-1979) fair sheets used:

K4493	K6547
K5348	K7117/1
K5595	K7117/2
K5769	K7727/1
K5806	K7727/2
K6037	K8352

(c) Pre 1930 fair sheets used:

A6116
L1186

(d) Admiralty Charts used:

44	1787	1977
1410	1826	
1411	1973	

Table 2. Admiralty charts and fair sheets used for the construction of the 1 km bathymetry of the Celtic Sea and Bristol Channel (CS inner & outer; Figure 1).

(a) Post 1980 fair sheets used:

K8455	K8744	M1550/1-2	M1927/1-2	M2189/1-4
K8500	K8916/1	M1644/1-8	M1942/1-5	M2273/1
K8554	K9015/1	M1648/1-13	M1969/1-2	M2331/1-2
K8558	K9155	M1757/1-4	M2049/1-2	
K8742	M1285/1	M1803/1-7	M2094/1-2	
K8743	M1437/1	M1907/1-4	M2127/1-2	

(b) Pre 1980 (1930-1979) fair sheets used:

E3388	K3647	K5451	K7658	K8475
E4517	K4016	K5572	K7756	K8507
E5677	K4050	K5610/1	K7792	K8508
E8675	K4414	K5804	K7932/1	K8567
K2197/1	K4531	K6455	K8035	K8590
K3217	K4611	K7099	K8195	
K3640	K4774/1	K7390	K8196	
K3641	K4994	K7570	K8308	

(d) Admiralty Charts used:

1123	1178
1156	2049

ANNEX 2

Copyright conditions for use of the bathymetric data contained within Table A1.2.

PERMISSION HO 510/990308/03

Section 1
Definitions

The following words and expressions will have the following meanings except where the context otherwise requires:

'THE GRANTEE' The Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, Parkfield Road, Lowestoft, Suffolk, NR33 OHT
'COMMENCEMENT DATE' 8 April 1999;
'COPYRIGHT MATERIAL' the material described in section 2 excluding any updates, enhancements, additions and improvements and new releases;
'REPRODUCED MATERIAL' the material produced by the Grantee as a result of the operation of this Arrangement;
'PERMISSION PERIOD' a fixed term of three years from the Commencement Date continuing thereafter unless terminated by the UKHO or the Grantee giving more than three months notice;
'PERMISSION FEE' is set out in section 4.

Section 2
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The Copyright Material described below is limited to those portions of the material that are the sole copyright of the Crown, or the copyright of the Port of London Authority or the hydrographic offices of Belgium, Denmark, Estonia, Finland, France, Germany, Greece, Hong Kong (Hong Kong port authority data gathered prior to 30 July 1997) Iceland, the Netherlands, Oman, Poland, Portugal, South Africa, Spain, Sweden and Uruguay.

The permission of other hydrographic offices and organisations not listed above may be required where their material has been incorporated into the Copyright Material. The source data diagrams or source notes show those areas of the Copyright Material derived from such material.

Also, if the Copyright Material described below was not originally published by the UKHO then the permission of the publisher may also be required.

No	Product	Date	Permission Status
1	Admiralty Chart 1123	27 Mar 1997	Granted
2	Admiralty Chart 1156	23 Jul 1982	Granted
3	Admiralty Chart 1178	9 Sep 1994	Granted
4	Admiralty Chart 2049	10 Feb 1995	Granted
5	E3388	Apr/Jun 1930	Granted
6	E4517	Apr/May 1935	Granted
7	E5677	1939	Granted
8	E8675	Apr/Nov 1949	Granted
9	K2197	Oct Nov 1958	Granted
10	K3217	Sep/Oct 1961	Granted
11	K3640	May/Jun 1962	Granted
12	K3641	May/Jun 1962	Granted
13	K3647	Mar/Jun 1962	Granted
14	K4016	Apr/Jun 1963	Granted
15	K4050	Sep/Oct 1963	Granted
16	K4414	Oct/Nov 1964	Granted
17	K4531	Apr 1965	Granted
18	K4611	Apr/Jun 1965	Granted
19	K4774	Aug/Sep 1965	Granted
20	K4994	Aug/Oct 1966	Granted
21	K5451	Apr 1968	Granted

22	K5572	Sep/Oct 1968	Granted
23	K5610	Apr 1969	Granted
24	K5804	Aug/Sep 1969	Granted
25	K6455	Jul/Nov 1971	Granted
26	K7099	May/Oct 1974	Granted
27	K7390	Jul/Dec 1975	Granted
28	K7570	Jun/Jul 1976	Referred
29	K7658	Nov/Dec 1976	Granted
30	K7756	Jan/Apr 1977	Granted
31	K7792	Jun/Oct 1976	Granted
32	K7932	Apr/Sep 1977	Granted
33	K8035	Jun/Jul 1978	Granted
34	K8195	Sep/Dec 1978	Granted
35	K8196	Aug/Dec 1978	Granted
36	K8308	1979	Granted
37	K8455	Jun 1979/Apr 1980	Granted
38	K8475	Oct 1976/Jun 1979	Granted
39	K8500	Mar/Jun 1980	Granted
40	K8507	Apr 1977/May 1978	Granted
41	K8508	Apr/Oct 1978	Granted
42	K8554	Apr/Nov 1980	Granted
43	K8558	1979-1980	Granted
44	K8567	Jun/Sep 1979	Granted
45	K8590	1979-1980	Referred
46	K8742	May/Jul 1981	Granted
47	K8743	Sep/Oct 1981	Referred
48	K8744	Jan/Apr 1981	Granted
49	K8916	May/Jun 1981	Granted
50	K9015	Jul 1982	Granted
51	K9155	Jan/Apr 1983	Referred
52	M1285	Feb/Dec 1988	Referred
53	M1437	May/Jun 1989	Referred
54	M1550	Oct 89/Jan 90	Referred
55	M1644	Apr/Oct 1990	Granted
56	M1648	Apr/Oct 1990	Granted
57	M1757	Apr/Jun 1991	Granted
58	M1803	Feb/Sep 1991	Referred
59	M1907	Dec 1991/Feb 1992	Granted
60	M1927	Jan/Jun 1992	Referred
61	M1942	Oct 1992	Referred
62	M1969	Jun/Dec 1992	Referred
63	M2049	Feb/Nov 1993	Referred
64	M2094	Feb/Jun 1993	Referred
65	M2127	Feb/Jul 1993	Referred
66	M2189	May/Oct 1993	Referred
67	M2273	Feb/Mar 1994	Referred
68	M2331	Nov 1993/May 1994	Referred

Note:

1. Permission is granted for the use of the sounding information only from the above surveys.
2. Where "Referred" appears in the Permission Status column the United Kingdom Hydrographic Office is unable to grant permission for the use of the survey as all or part relate to the area controlled by the Republic of Ireland. Before the survey is used you must obtain permission from :-

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   Leeson Lane

Dublin 2
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Telephone: 001 353 1 662 0022
Fax: 001 353 1 662 0795

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   1.2. Analogue extracts, not exceeding A3 in size, from the GIS above for distribution to third parties for the purpose of research.;
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   "Bathymetric data reproduced from Admiralty Charts and surveys by permission of the UK Hydrographic Office."

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10. Delete the Copyright Material from any electronic storage media at or before the end of the Permission Period.
11. Pay the UKHO the Licence Fee specified in section 4;

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- a digitising fee of £40.00 per edition of chart for the right to digitise the chart.

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Charge per copy	10p	20p

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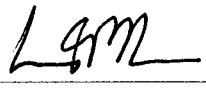
On behalf of: The UKHO

Signatures: 

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Copyright Manager

Date: 11.06.01

ANNEX 3

A sample copy of the BODC data licences for academic users.

ACADEMIC LICENCE FOR THE USE OF DATA SUPPLIED BY BODC

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It is BODC's policy to encourage the use of its data holdings for the advancement of science and to supply data to *bona fide* scientific researchers at a charge not exceeding the marginal costs involved.

Oceanographic data are expensive to collect and, in particular, resources are required to maintain them and to make them available. It is essential that scientists receiving data from BODC do not compromise BODC's ability to recover costs from other users. It is therefore BODC policy to make data available through the mechanism of a licence agreement that formally lays down the conditions under which the data may be used.

The licence agreement also provides a mechanism to restrict the usage of data lodged at BODC on the specific understanding that they will only be made available for scientific research.

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CONDITIONS OF USE

1. The data may be used only for *bona fide* research i.e. academic research conducted solely to advance the state of knowledge with the results made freely available and published in the public domain and not used for any commercial gain.
2. The data may be used only for the research specified in the Data Schedule.
3. The data are supplied for the sole use of the person(s) listed in the Data Schedule. The licensed user(s) will take reasonable care of the data to prevent them being accessed by others. **The data, in whole or in part, may not be passed on or made available in any form to third parties in any circumstances without prior written permission from BODC.**
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1km x 1km gridded bathymetry for Irish Sea, Celtic Sea and North Channel.

The data set is made available under the terms and conditions set out in UK Hydrographic Office Copyright Permission HO 510/990308/03.

Data supplied to BODC by:

Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory.

Publication acknowledgement and reference:

Compilation of the 1km x 1km gridded bathymetry for the Irish Sea, Celtic Sea and North Channel was funded by the Department of Transport and the Regions (DETR), and the Ministry of Agriculture Fisheries and Food (MAFF). Bathymetric data are reproduced from Admiralty Charts and surveys by permission of the UK Hydrographic Office.

Brown, J., Joyce, A.E., Aldridge, J.N., Young, E.F., Fernand, L. and P.A. Gurbutt, 1999. "Further Identification and Acquisition of Bathymetric Data for Irish Sea Modelling." DETR research contract CW0753.

Specific research for which the data are required:

Specific source of funding for the intended research:

Person(s) entitled to use the data:

Organisation:

Marginal costs to be charged by BODC: £

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