

## DTI Strategic Environmental Assessment Area 6 (SEA6) Geological Metadata

Continental Shelf & Margin Programme Report CR/02/287



#### BRITISH GEOLOGICAL SURVEY

#### COMMISSIONED REPORT CR/02/287

## DTI Strategic Environmental Assessment Area 6 (SEA 6) Geological Metadata

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### 1. Introduction

This report describes work carried out under commission to the Department of Trade and Industry to compile an inventory of geological metadata for area SEA6 that may be applied to strategic environmental assessment. The area of SEA6 covers the eastern Irish Sea, Cardigan Bay, and the St George's Channel (Figure 1). In accordance with the contract conditions, the database of publicly available data has been compiled in Endnote© format and produced on a compact disc (Appendix 1). It is based on the contractors' experience of work on geological interpretation of the area together with an extensive on-line literature survey.



Figure 1 Division of sea areas for strategic environmental assessment

The objective of the programme of research is based on the following questions:

- 1. What is the scope of data (published and unpublished references and data archives)?
- 2. Where is the original data stored?
- 3. What is the data quality?
- 4. How do we access data (include issues of costs and licensing)?
- 5. Brief narrative report geology and geological processes.

This report was completed November 2002 and is complemented by a report completed August 2003 for data overlapping from the UK sector of SEA 6 and SEA7 into the Irish sector (Wheeler, A. 2003. UK-Irish border public domain geological survey metadata. (Cork: University College, Department of Geology and Environmental Research )).

### 2. Synopsis

The area SEA6 is an almost completely enclosed sea that lies between Britain and Ireland. In the north the outlet is through the narrow North Channel between the Southern Uplands and Ireland, whereas in the south there is a broad outlet into the Celtic Sea. Water depths are up to 160m. Early sedimentary basin formation took place in the Palaeozoic and during the Mesozoic approximately 10 kilometres of sediments accumulated in a subsiding basin, one of the thickest sedimentary accumulations known on the United Kingdom shelf. There are up to 400m of Quaternary sediments underlying the St George's Channel and seabed sediment grades from gravel to mud.

There is a wealth of geological data for SEA6, although much of this is subsurface information on bedrock geology and structure. There is a considerable database of published articles on recent sediment distribution in the area as well as sedimentary processes now operating. Appendix 1 reviews the seabed morphology and recent sedimentary processes in relation to the modern seabed environment.

Regarding subsurface and sedimentary geology, there has been a comprehensive programme of research undertaken by the British Geological Survey, in association with Universities such as the University of Wales at Aberystwyth, as part of its remit to map the continental shelf during the 25 year Department of Energy contract that ran during the 1970's to 1990's. The objective of this contract was to provide published solid geology, quaternary geology and sediment distribution maps at 1:250,000 scale for the UK shelf. The area SEA6 is fully covered by this programme of research. In addition the culmination of the programme was a series of offshore reports describing the geology of the area SEA6. The relevant reports are referenced as Tappin et al., 1994 (Cardigan Bay and Bristol Channel) and Jackson et al., 1995 (East Irish Sea). The reference lists from both of these publications are included in the Endnote<sup>©</sup> database provided. The mapping scale used by BGS in the offshore programme was at 1:100,000. Therefore each 1:250,000 scale map is composed of four 1:100,000 scale maps. At 1:100,000 scale the maps provide data on seismic traverses, sample locations and interpretations of the seabed sediments and seabed geology. The maps are available from the BGS as noted in the sources of metadata below, subject to Intellectual Property Rights (IPR) and cost of copying. BGS published data (reports and maps) are available at cost and identified as high quality (5) in the review carried out in Endnote<sup>©</sup>.

The BGS hold non-BGS reports submitted or donated by commercial companies and Universities. There are almost 300 items in this collection. Some of this data is held in confidence. If required, the BGS would identify the owner to DTI. Other items are available at cost, subject to IPR constraints. As well as the BGS publications there are numerous peer-reviewed papers published in scientific journals. These papers are also referenced in the Endnote<sup>©</sup> database and carry a (3) or higher category rating.

In the area SEA6 much sub-seabed data has been acquired by oil companies during periods of exploration. As is well known there are producing gas fields in the East Irish Sea. There are (non-commercial) oil finds in Cardigan Bay and the St George's Channel. There are many special publications on the theme of hydrocarbons (e.g. Croker and Shannon, 1995; Meadows et al., 1997 and Shannon et al., 2001) that contain peer-reviewed articles on the geology of the area. There are numerous other articles that have been published in peer-reviewed scientific journal and these carry a quality rating of 5.

Whereas the subsurface data may not be of immediate interest to this report, it should be noted that site-survey data acquired as part of the oil exploration may have a use in environmental assessment. There are a number of site-survey reports held at BGS, but most of these are confidential so that individual companies would have to be approached if access was required. There may be cost involved in this instance.

There are a number of metadata sites included in the report, not all of which have been reviewed in detail. However, it is considered likely that these sites may contain data of relevance to the present DTI project. Notwithstanding, there is a new project, recently set up by the Joint Nature Conservation Committee called 'The Irish Sea Pilot'. The objectives of the project are to trial a proposed new marine nature conservation framework in the Irish Sea, involving English Nature, Scottish Natural Heritage, Countryside Council for Wales and Environment and Heritage Service (N.I.). An essential aspect of the project is the setting up of a GIS. The web site for this initiative is appended.

### 3. Methods

Along with previously accumulated personal bibliographic data sets, five online databases were searched in order to compile the inventory. Although this report deals with the environmental geology of SEA6, the contractors also compiled inventories of contamination for SEA6 as well as contamination and geology for areas SEA7 and SEA8. To avoid duplication of effort, searches were carried out to cover both subjects in all three areas and the retrievals later sorted into separate Endnote© libraries for geology and the contamination of water and sediments in sea areas 6, 7 and 8. Searches were carried out on the basis of geographical and subject matter keywords (see 3.1 below).

Online bibliographic databases searched for journal, thesis and other references were: Web of Science, GeoRef, GeoArchive, Zetoc and Aslib

Each search was repeated with all five databases, because they appear to hold slightly different collections of references.

The **Web of Science** online data set provides web access to ISI Science Citation Index, Social Sciences Citation Index, Arts and Humanities Citation Index, and Index to Scientific and Technical Proceedings.

The **GeoRef** online database, established by the American Geological Institute, has 1.9 million bibliographic references across all geological subject areas. The North American literature has been indexed from 1785 onwards, and other areas from 1933. Journal articles, books, conference volumes, reports, maps etc are all covered. It is particularly good for searches of the geological journal literature.

**GeoArchive** is an online bibliographic database covering all types of information sources in geoscience, hydroscience, and environmental science. The database is produced by Geosystems (UK) and is provided online by Oxmill Publishing.

**Zetoc** provides Z39.50 compliant access to the British Library Electronic Table of Contents. It covers the 20 000 most heavily requested journal titles from the British Library, and 16 000 conference proceedings per year. It contains 15 million items and is updated daily. Items are added within about 3 days of receipt. The database covers from 1993 onwards.

**Aslib** consists of bibliographic records with abstracts, where available, for UK theses of all types and subjects. It covers theses accepted from years 1970 to 1999 and is the online equivalent of the printed index from volume 21 to 48 and parts 1-3 of volume 49.

**Endnote**<sup>©</sup> has inbuilt import filters for Web of Science and GeoRef and, using the import filter manager, completed searches from these databases load easily and straightforwardly into Endnote<sup>©</sup>, after downloading and saving as text or word documents. For GeoArchive it was necessary to create an Endnote<sup>©</sup> import filter, which was then saved within the Endnote<sup>©</sup> program filter collection to enable successful imports of the saved, tagged, word documents downloaded from searches. Zetoc was searched from within the Endnote<sup>©</sup> programme using the 'connect and search' function, enabling references to be loaded straight into the Endnote<sup>©</sup> library ready for manual filtering of relevant material. Individual records retrieved from the Aslib database were copied and pasted into a separate document to enable manual entry into the relevant Endnote<sup>©</sup> library.

An Endnote<sup>©</sup> output style was created to provide output in the same format as that specified in the contract for an Excel spreadsheet. For the Notes section of the output, journal articles are generally considered to be free and the data quality to be high (ranked 3 or higher). Where appropriate, journal articles have specific Notes attached.

#### 3.1 KEYWORDS USED IN SEARCHING THE BIBLIOGRAPHIC DATABASES

Irish Sea Liverpool Bay Solway Firth North Channel Mersey Estuary Ribble Estuary Sellafield Cardigan Bay St George's Channel Tremadoc Bay Menai Straits Morecambe Bay South-West Approaches Celtic Sea Bristol Channel English Channel Malin Sea N.E. Atlantic Ocean North Channel Isle of Man Dundalk Bay Burrow Head Peel Port Erin Deposition Sediments Stratigraphy Geology Petroleum Quaternary Holocene Seismic Tectonics Hydrocarbon Environment Sea floor Metal Processes Continental Shelf Wales

Appendix 2 comprises a list containing references in Endnote© format.

### **3.2 BGS SCOPE OF DATA**

BGS data sets comprise both BGS-acquired data and non-BGS-acquired data. There may be licensing issues for the BGS use of non-BGS data (e.g. Hydrographic Office sonar and bathymetric data) and/or with issue of BGS interpreted data where intellectual property rights is owned by others (e.g. BGS digital bathymetry, seabed sediment, geochemical data).

#### 3.2.1 BGS data

Regional Offshore Reports (bibliography held in Endnote©) available at cost. Non-confidential BGS reports likely to be released at cost of reproduction (grey literature).

Geophysical Survey data (data source from ORACLE database) including:

- Regional surveys sub-seabed
  - Profile/sub seabed/seabed Air gun Sparker
    - Boomer Pinger
- Regional surveys Seabed only Sidescan sonar
  - Swath bathymetry Swath back scatter 3D seabed returns

Sampling surveys

- Regional surveys
  - Sub-seabed (seabed secondary objectives) Gravity core or similar Vibrocore Drill

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Seabed (sub-seabed secondary objective) Grab Seabed photographs Published maps (available at cost) Solid 1:250 000 hard copy Quaternary 1:250 000 hard copy Seabed sediments and bathymetry hard copy Solid 1:1000 000 hard copy Quaternary 1:1000 000 hard copy

Seabed sediments and bathymetry 1:1000 000 hard copy

Digital interpreted data

Seabed sediments texture and mineralogy Bathymetry Geochemistry (principally inorganic) but note the overlap with the contamination of seawater and seabed sediment components of the SEA programme of work

#### 3.2.2 Non-BGS data

Non-confidential non-BGS reports (grey literature) are likely to be released at cost of reproduction, subject to IPR constraints and where permission to copy has been obtained. These include:

Commercial site investigation reports. For well sites these would typically consist of 3x3 or 1x1km area surveyed with single- or multi-channel mini-sleeve/air-gun, sparker, pinger/boomer/echosounder, sidescan sonar, with some interpretation calibrated by core. More problematic sites may have employed seabed photography, some with AUVs.

Aggregate surveys.

University survey reports.

Hydrographic Office Series Sidescan sonar interpretation Single-beam echosounder (close survey) Sea bed samples of various types and qualities of interpretation.

# **3.2.3** University College Cork, Department of Geology and Environmental Research data

Assistance to assessing the amount, whereabouts and quality of data is given in the form of a report on the areas where data overlap from within the UK side of the SEA 6 boundary to approximately 50km within the Irish border (Wheeler, A. 2003. UK-Irish border public domain geological survey metadata. (Cork: University College, Department of Geology and Environmental Research )).

#### 3.2.4 United Kingdom and European metadata (Section 4)

Metadata data sources available on digital networks are compiled from BGS sources (Alan Stevenson). Sources are listed below with HURL sites. There are likely to be huge datasets some of which may be too limited and time consuming (costly) to be of use for environmental surveys.

### 4. Sources of metadata

Much of the assembled metadata is based on collections of reports, papers and other databases held at the British Geological Survey (BGS) and at the Dept. of Geology and Environmental Research, University College, Cork. These holdings have been supplemented by the literature searches outlined above.

Published BGS and University College, Cork reports and grey literature identified in the database will normally be available at BGS and Cork.

There are other metadata databases identified as potentially providing additional material, although there have been no exhaustive searches made of these. These are as follows:

### - PAN-NATIONAL AGENCY/DEPARTMENT/UNIVERSITY

- Joint Nature Conservancy Council: <u>http://www.jncc.gov.uk</u>
  With particular site: <u>http://www.jncc.gov.uk/Marine/irishsea\_pilot/default.htm</u> for the new initiative 'Irish pilot project'
- Countryside Council for Wales:

### http://www.ccw.gov.uk

- Environment and Heritage Service: <u>http://www.ehsni.gov.uk</u>
- NGDF National Geospatial Data Framework (includes 'ask giraffe') <u>www.ngdf.org.uk</u>
- UKMIC UK Marine Information Council <u>www.ukmarine.org</u>
- IACMST . The Inter-Agency Committee on Marine Science and Technology

#### http://www.marine.gov.uk/

IACMST is a UK Government Committee reporting to the Office of Science and Technology. IACMST is responsible for the Marine Environmental Data Action Group (MEDAG), which, together with the Marine Environmental Data Co-ordinator, forms the UK Marine Environmental Data (UKMED) Network. The network has set up the <u>OceanNET</u> (<u>http://www.oceannet.org/</u>) web site as a portal to data and information about the marine environment. OceanNET also contains a new UK Directory of Coastal Data Sets. UKMED is currently funded by the Defence Science and Technology Laboratory (DSTL), Department for Environment, Food and Rural Affairs (DEFRA), the Environment Agency (EA), Fisheries Research Service (FRS), the Met Office, the Natural Environment Research Council (NERC) and the UK Hydrographic Office (UKHO).

 Marine equivalent of MAGIC needed <u>www.magic.gov.uk</u>, with possible start provided by <u>www.cefas.co.uk</u>

### - INTRA-RESEARCH COUNCIL/UNIVERSITY

• <u>www.nerc.ac.uk/data/</u>

### - INTRA-SURVEY/INSTITUTION

- <u>www.bgs.ac.uk</u> BGS Intranet/Geoscience/Metadata
- SOC <u>http://www.soc.soton.ac.uk/cgi-bin/seadog/seadog.pl</u>).
- List of searchable Databases (in addition to SOC SeaDOG) that contain references to cruises within the Area of SEA6

Database	URL
Name	
British	www.bodc.ac.uk
Oceanographic	
Data Centre	
National	www.ngdc.noaa.gov
Geophysical	
Data Centre	
European	http://www.bodc.ac.uk/frames/index4.html?/services/edmed/index.html&2
Directory of	
Marine	
Environmental	
Data	
(EDMED)	

• List of Sampling Databases. There are too many samples of many different type and age outside of BGS to make a sensible list. The SOC boscor site was not functioning October 2002.

Database Name	URL
BGS metadata	http://www.bgs.ac.uk/discoverymetadata/home.html
National Geophysical Data	www.ngdc.noaa.gov
Centre	

### - PAN EUROPEAN

- GEIXS (Geological Information Exchange System) <u>http://geixs.brgm.fr/</u>
- EU-SEASED <u>www.eu-seased.net</u>. The EU-SEASED website consists of metadata from the following EC 4<sup>th</sup> and 5<sup>th</sup> Framework projects
  - EUMARSIN (European Marine Sediment Information Network)
  - EUROSEISMIC (European Marine Seismic Metadata and Information Centre)
  - EUROCORE (A searchable Internet database of seabed samples from the Ocean Basins held at European Institutions)
- SEASEARCH (Gateway to Oceanographic and Marine Data & Information in Europe) <u>www.sea-search.net</u>. Includes:
- EDMED (European Directory of Marine Environmental Datasets)
- PANGAEA <u>http://www.pangaea.de/</u>

PANGAEA is a public data library on the Internet aimed at archiving, publishing and distributing geocoded data with special emphasis on environmental, marine and geological research. It is operated by the Alfred Wegener Institute for Polar and

Marine Research and the Centre for Marine Environmental Sciences at the University of Bremen.

### References

Croker, P.F. and Shannon, .P.M. (Editors), 1995. The petroleum geology of Ireland's offshore Basins. Geological Society Special Publication, 93. Geological Society of London, 498 pp.

Jackson, D.I., Jackson, A. A, Evans, D., Wingfield, R. T. R., Barnes, R. P., Arthur, M. J., 1995. United Kingdom offshore regional report: the geology of the Irish Sea. HMSO for the British Geological Survey, London. 123 pp.

Meadows, N., Trueblood, S., Hardman, M. and Cowan, G., (Editors), 1997. Petroleum geology of the Irish Sea and adjacent Areas. Special Publication 124, Geological Society of London. 447 pp.

Shannon, P.M., Haughton, P.D.W. and Corcoran, D.V. (Editors), 2001. The petroleum exploration of Ireland's offshore basins. Special Publication 188, The Geological Society of London, 469 pp.

Tappin, D.R., Chadwick, R.A., Jackson, A.A., Wingfield, R.T.R. and Smith, N.J.P., 1994. United Kingdom offshore regional report: the geology of Cardigan Bay and the Bristol Channel. HMSO for the British Geological Survey, London, 107 pp.

### APPENDIX 1

# SYNOPSIS OF SEABED MORPHOLOGY AND RECENT SEDIMENTARY PROCESSES

The area SEA6 is an almost completely enclosed sea lying between Britain and Ireland. In the north the outlet is through the narrow North Channel between the Southern Uplands and Ireland, whereas in the south the outlet is into the Celtic Sea. In the north, in the eastern Irish Sea, water depths are mainly less than 100m. However, west and south of the Isle of Man, the Celtic Trough is a deeper water feature that continues southward into the St George's Channel and the Celtic Sea, where water depths reach a maximum of 160m.

The present seabed morphology and sediment distribution is due mainly to glaciogenic processes operating over the past several 100,000 years. Five bathymetric zones are recognised (Tappin et al., 1994; Jackson et al., 1995):

- 1. Coastal embayments: 50% intertidal and up to 10m deep formed during the Holocene sealevel rise (Eyles and McCabe, 1989),
- 2. Inner Shelf platforms: up to 100km in width in the East Irish Sea with gentle gradients of 1:100 to 1:2000. Water depths are mainly up to 60m, except in the south where there are depths of 100m. The platforms formed at times of lowered sealevel during the last (Weichselian) glaciation.
- 3. The Celtic Trough: a linear feature that runs from west of the Isle of Man to the Celtic Sea. Water depths are generally at 110m but are as great as 160m, and seafloor gradient is subdued (1:50). The origin of the trough is problematic, although it is not structural. It is an erosive feature, almost certainly formed at lower sealevels associated with glacial maxima, probably during the mid or early Pleistocene (Eyles and McCabe, 1989).
- 4. Rocky prominences: mainly areas of rough seabed topography, found in: coastal embayments where they are represented by rocky headlands or shoals; on the inner shelf where they are islands and shoals; and where sedimentary rocks are exposed at seabed. Those at less than 25m water depth were formed during the Holocene transgression (Eyles and McCabe, 1989).
- 5. Enclosed deeps: less than 5km wide, up to 30km long and 10 to 50m deeper than the surrounding sea floor. Gradients are less than 1:10. They are found on the inner-shelf platform and within the Celtic Trough. They formed as kettle holes during the early Holocene (Eyles and McCabe, 1989).

Seabed sediments range from gravel to mud, and two units (layers A and B) are recognised as being actively involved in the present-day hydraulic regime (Pantin and Evans, 1984). Layer A is the mobile sediment, with a patchy distribution. It comprises mud, sand and gravel grade and over much of the area is up to 0.3m thick. In the East Irish Sea there is a general transition southeast and east from the Isle of Man and towards the coast from coarser-grained gravel and sand to mud that forms a mud belt, termed the Western Irish Sea Mud Belt (Belderson, 1964). Within the sandy and gravelly areas, there are extensive fields of sand ribbons and sand waves as well as barchan dunes. Sediment in these sand and gravel areas is

up to 40m thick (Wingfield, 1987; James and Wingfield, 1987). In the St Georges Channel and Cardigan Bay areas there is a dominance of coarser sand and gravel that also forms seabed features similar to those in the Irish Sea.

Layer B underlies Layer A and comprises a relict deposit of gravel and sand, often a pebbly (shell) coquina or gravel. It is generally up to 0.2m thick. Where Layer A is absent Layer B is part of the active system and the fine-grained component is being winnowed and removed. Off the Welsh coast there are relict glacial outwash features termed Sarns.

The controls on the present day sedimentation regime include climate, tidal currents, bathymetry, sediment input and distance from source. The climate is temperate with a dominance of westerly winds, with those above Force 8 recorded between 35 and 45 days per year. The exposure of the southern part of the area to the open ocean in the south ensures abundant wave action that is effective mainly along the coast, and leads to active erosion in this zone, which thereby provides a sediment source. There is a semidiurnal tidal regime with maximum surface velocities of  $1.0 \text{m/s}^{-1}$  that results in bed-load partings being located off Pembrokeshire and the Lleyn Peninsula. Thus the dominant bed-load transport direction is southward (into the Celtic Sea) and northward (into the Irish Sea) from the Lleyn/Anglesey area. There is a positive correlation between areas of maximum bed-load stress and maximum erosion. In the area of the bed-load parting off Anglesey the seabed is swept clean of sediment. The floor of the Celtic Trough is composed of coarse sand and gravel. In the east of the Irish Sea, where there is an area of slack tide, the seabed comprises mud.

Underlying the seabed sediment there are a series of sedimentary basins (Tappin et al., 1994; Jackson et al., 1995). North of Anglesey, the rocks are mainly of early and pre-Mesozoic age with a Quaternary cover up to ~100m thick. In this area there are a number of producing gas fields. South of Anglesey there are accumulations of Mesozoic rocks, which in places are over 10km thick. There is an overlying Quaternary cover up to 400m thick. There has been an active hydrocarbon exploration programme here but limited commercial accumulations have as yet been discovered.

### References

Belderson, R.H. 1964. Holocene sedimentation in the western half of the Irish Sea. Marine Geology, 2(1-2): 147-163.

Eyles, N. and McCabe, A. M. 1989. The late Devensian (<22,000 BP) Irish Sea basin; the sedimentary record of a collapsed ice sheet margin. Quaternary Science Reviews **8**(4): 307-351.

Jackson, D.I., Jackson, A. A., Evans, D., Wingfield, R. T. R., Barnes, R. P., Arthur, M. J. 1995. United Kingdom offshore regional report: the geology of the Irish Sea. HMSO for the British Geological Survey, London. 123 pp.

James, J.W.C. and Wingfield, R.T.R. 1987. Aspects of sea bed sediments in the southern Irish Sea. In: M.G. Bassett (Editor), Geology and sediments of offshore Wales and adjacent areas. Proceedings of the Geologists' Association. Geologists' Association, London, United Kingdom, pp. 404-406.

Pantin, H.M. and Evans, C.D.R. 1984. The Quaternary history of the central and southwestern Celtic Sea. Marine Geology, 57: 259-293.

Tappin, D.R., Chadwick, R.A., Jackson, A.A., Wingfield, R.T.R. and Smith, N.J.P. 1994. United Kingdom offshore regional report: the geology of Cardigan Bay and the Bristol Channel. HMSO for the British Geological Survey, London, 107 pp.

### APPENDIX 2

Annotated references in Endnote© format are on compact disc.

The following references are output from the Endnote format files:

Abril, J.M. & Leon, M.G. 1994. Modelling the distribution of suspended matter and the sedimentation process in a marine environment. *Ecological Modelling*, **71**, Pt 4, 197-219.

Adams, T.D. & Haynes, J. 1965. Foraminifera in Holocene marsh cycles at Borth, Cardinganshire (Wales). *Palaeontology*, **8**, 27-38.

Addison, K. & Edge, M.J. 1992. Early Devensian Interstadial and Glaciogenic Sediments in Gwynedd, North-Wales. *Geological Journal*, **27**, Pt 2, 181-190.

Al, S.Z.D. 1970. The geological structure of part of the central Irish Sea. *The Geophysical Journal of the Royal Astronomical Society*, **20**, Pt 2, 233-237.

Aldridge, J.N. 1995. Optimal fitting of a model to observations of sediment concentration in the Irish sea. *In:* Spaulding Malcolm, L. & Cheng Ralph, T. (eds.). *Estuarine and coastal modeling; proceedings of the 4th international conference.* (Estuarine and Coastal Modeling. Proceedings of the ... International Conference). **4**. American Society of Civil Engineers, New York, NY, United States, 416-428.

Allen, J.R.L. 1990. The Severn Estuary in southwest Britain: its retreat under marine transgression, and fine-sediment regime. *Sedimentary Geology*, **66**, 13-28.

Allen, P. & Rees, I. 1999. Irish Sea seabed image archive. 120 in *Marine and land based inputs to sea research seminar*. (Bangor: Detr.)

Anderton, R., Burgess, P.H., Leeder, M.R. & Sellwood, B.W. 1979. *A dynamic stratigraphy of the British Isles*. Allen and Unwin, London.

Anonymous. 1995. *Zur Verbreitung meeresbodennaher gashaltiger Sedimente*. (FWG-Report). Kiel, Federal Republic of Germany,

Ardus, D.A. & Harrison, D.J. 1990. The assessment of aggregate resources from the UK Continental Shelf. *In:* Ardus, D.A. & Champ, M.A. (eds.). *Ocean Resources Vol. 1 Assessment*. Kluver, Dordrecht, 113-128.

Arkell, W.J. 1947. The geology of the country around Weymouth, Swanage, Corfe and Lulworth. *Memoir of the Geological Survey of Britain*, **Sheets 341, 342, 343 with small portions of sheets 327, 328, 329**.

Arthurton, R.S., Johnson, E.W. & Mundy, D.J.C. 1988. Geology of the country around Settle. *Memoir of the Geological Survey of Great Britain, Sheet 60 (England and Wales)*.

Arthurton, R.S. & Wadge, A.J. 1981. Geology of the Country around Penrith. Memoir of the Geological Survey of Great Britain, Sheet 24 (England and Wales).

Atkinson, K. 1971. The relationship of Recent foraminifera to the sedimentary facies in the turbulent zone, Cardigan Bay. *Journal of Natural History*, **5**, Pt 4, 385-439.

Avione, J., Allen, G., Nichols, M., Salomon, J.C. & Larsonneur, C. 1981. Seaward suspended sediment dispersion from the Seine estuary, France. *Marine Geology*, **40**, 119-137.

Bailey, R.J. 1979. The continental margin from 50 degrees N to 57 degrees N; its geology and development. *In:* Banner, F.T., Collins, M.B. & Massie, K.S. (eds.). *The North-west European shelf seas; the sea bed and the sea in motion; I, Geology and sedimentology.* Elsevier Sci. Pub. Co., Amsterdam, Netherlands, 11-24.

Ball, B.J., Fox, G. & Munday, B.W. 2000. Long- and short-term consequences of a Nephrops trawl fishery on the benthos and environment of the Irish Sea. *Ices Journal of Marine Science*, **57**, Pt 5, 1315-1320.

Barr, K.W., Colter, V.S. & Young, R. 1981. The geology of the Cardigan Bay-St George's channel basin. *In:* Illing, L.V. & Hobson, G.D. (eds.). *Petroleum geology of the continental shelf of North-West Europe; Proceedings of the second conference.* Heyden and Son, London, United Kingdom, 432-443.

Barrie, J.V. 1980. Heavy mineral distributions in bottom sediments of the Bristol Channel, UK. *Estuarine and Coastal Marine Science*, **11**, 369-381.

Barrow, G. 1906. The geology of the Isle of Scilly.

Belderson, B.H., Wilson, J.B. & Holme, N.A. 1988. Direct observation of longitudinal furrows in gravel and their transition with sand ribbons of strongly tidal seas. *In:* Boer, P.L.D., Gelder, A.v. & Nio, S.D. (eds.). *Tide-influenced sedimentary environments and facies*. Dordrecht: Reidel, 79-90.

Belderson, R.H. 1964. Holocene sedimentation in the western half of the Irish Sea. *Marine Geology*, **2**, Pt 1-2, 147-163.

Belderson, R.H. & Stride, A.H. 1969. Tidal currents and sand wave profiles in the north-eastern Irish Sea. *Nature (London)*, **222**, Pt 5188, 74-75.

Berry, F.G. 1979. Late Quaternary scour-hollows and related features in central London. *Quarterly Journal of Engineering Geology*, **12**, 9-29.

Black, J.H. & Brightman, M.A. 1996. Conceptual model of the hydrogeology of Sellafield. *The Quarterly Journal of Engineering Geology. 29, Suppl*, **1**, 83-93.

Blundell, D.J., Griffiths, D.H. & King, R.F. 1969. Geophysical investigations of buried river valleys around Cardigan bay. *Geological Journal*, **6 Part 2**, 161-180.

Bowden, D.Q., Rose, J., McCabe, A.M. & Sutherland, D.G. 1986. Correlation of Quaternary glaciations in England, Ireland, Scotland and Wales. *In:* Sibrava, S., Bowden, D.Q. & Richmond, G.M. (eds.). *Quaternary glaciations in the Northern Hemisphere*. **5**. Quaternary Science Reviews, 229-340.

Bowden, D.Q. & Sykes, G.A. 1988. Correlation of marine events and glaciations on the northeast Atlantic margin. *Philosophical Transactions of the Royal Society of London*, **318B**, 619-635.

Bowen, D.Q. 1973. The Pleistocene succession of the Irish Sea; an orthodox view. *Circular - Geologists' Association (London)*, **751**, 1-2.

Bowen, D.Q. 1973. The Pleistocene Succession of the Irish Sea. *Proceedings of the Geologists' Association*, **84 Part 3**, Pt 3, 249-272.

Bowen, D.Q. 1977. The coast of Wales.

Bowers, D.G., Boudjelas, S. & Harker, G.E.L. 1998. The distribution of fine suspended sediments in the surface waters of the Irish Sea and its relation to tidal stirring. *International Journal of Remote Sensing*, **19**, Pt 14, 2789-2805.

Brindley, J.C. 1967. The geology of the Irish Sea area. *Irish Naturalists' Journal*, **15**, Pt 9, 245-249.

British Geological Survey, U.K. 1980. Lake District; sheet 54 degrees N-04 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1978. Liverpool Bay; Sheet 53 degrees N-04 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1982. Anglesey; sheet 53 degrees N-06 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1982. Cardigan Bay; Sheet 52 degrees N-06 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1982. Isle of Man; sheet 54 degrees N-06 degrees W. Solid Geology 1:250 000. Ordnance Survev., Southampton, United Kingdom.

British Geological Survey, U.K. 1983. Lake District; sheet 54 degrees N-04 degrees W. Sea-bed Sediment and Quaternary Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1983. Lundy; sheet 51 degrees N-06 degrees W. Sea-bed Sediments 1:250 000. Ordnance Survey, Southampton; United Kingdom.

British Geological Survey, U.K. 1983. Lundy; sheet 51 degrees N-06 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton; United Kingdom.

British Geological Survey, U.K. 1984. Liverpool Bay; Sheet 53 degrees N-04 degrees W. Sea-bed Sediments and Quaternary Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1985. Isle of Man; sheet 54 degrees N-06 degrees W including part of Ulster 54 degrees N-08 degrees W. Sea-bed Sediments and Quaternary Geology 1:250 000. Ordnance Survev., Southampton, United Kingdom.

British Geological Survey, U.K. 1987. Nymphe Bank; sheet 51 degrees N-08 degrees W, including part of Waterford 52 degrees N-08 degrees W. Solid Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1988. Cardigan Bay; Sheet 52 degrees N-06 degrees W including part of Waterford 52 degrees N-08 degrees W and Mid Wales and Marches 52 degrees N-04 degrees W. Sea-bed Sediments 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1988. Nymphe Bank; sheet 51 degrees N-08 degrees W, including part of Waterford 52 degrees N-08 degrees W. Sea-bed Sediments 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1990. Anglesey; sheet 53 degrees N-06 degrees W including part of Dublin 53 degrees N-08 degrees W. Quaternary Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1990. Anglesey; sheet 53 degrees N-06 degrees W including part of Dublin 53 degrees N-08 degrees W. Sea-bed Sediments 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1990. Cardigan Bay; Sheet 52 degrees N-06 degrees W including part of Waterford 52 degrees N-08 degrees W and Mid Wales and Marches 52 degrees N-04 degrees W. Quaternary Geology 1:250 000. Ordnance Survey, Southampton, United Kingdom.

British Geological Survey, U.K. 1994. East Irish Sea sheet special edition 53.25 degrees N-05 degrees W to 55 degrees N-2.83 degrees W. Ordnance Survey, Southampton, United Kingdom.

Carter, R.W.G., Johnston, T.W., McKenna, J. & Orford, J.D. 1987. Sea-level, sediment supply and coastal changes: examples from the coast of Ireland. *Progress in Oceanography.*, **18**, 79-101.

Cartwright, D. 1959. On submarine sand-waves and tidal lee-waves. *Proceedings of the Royal Society of London*, **253A**, 218-241.

Cartwright, D. & Stride, A.H. 1958. Large sand waves near the edge of the Continental Shelf. *Nature*, **181**, 41.

Caston, G.F. 1975. Igneous dykes and associated scour hollows of the North Channel, Irish Sea [letter]. *Marine Geology*, **18**, Pt 5, M77-M85.

Caston, G.F. 1976. *The floor of the North Channel, Irish Sea; a side-scan sonar survey*. (Report - Natural Environment Research Council, Institute of Geological Sciences). British Geological Survey, London, United Kingdom.

Caston, V.N.D. 1965. Localised sediment transport and submarine erosion in Tremadoc bay, northern Wales. *Marine Geology*, **3**, Pt 6, 401-410.

Caston, V.N.D. 1966. Tremadoc Bay sediments. Unpublished PhD thesis, University of University of Wales.

Caston, V.N.D. 1968. Recent sedimentation in a restricted embayment, Tremadoc Bay. *Proceedings of the Geological Society of London*, **1650**, 158.

Caston, V.N.D. 1995. The Helvick oil accumulation, Block 49/9, North Celtic Sea basin. *In:* Croker, P. & Shannon, P. (eds.). *The petroleum geology of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 93.

Charlesworth, J.K. 1936. Geomorphology of the Irish Sea basin. *Nature (London)*, **138**, Pt 3503, 1040-1041.

Charlesworth, J.K., Greenly, E., Grisswell, R.K., Hollingworth, S.E. & Miller, A.A. 1936. Discussion on the geomorphology of the Irish Sea basin.

Clark, C.D. & Meehan, R.T. 2001. Subglacial bedform geomorphology of the Irish Ice Sheet reveals major configuration changes during growth and decay. *Journal of Quaternary Science*, **16**, Pt 5, 483-496.

Cofaigh, C.O. & Evans, D.J.A. 2001. Sedimentary evidence for deforming bed conditions associated with a grounded Irish Sea glacier, southern Ireland. *Journal of Quaternary Science*, **16**, Pt 5, 435-454.

Collinson, D.J. 1986. Alluvial Sediments. *In:* Reading, H.G. (ed.). *Environments and Facies*. Blackwell Scientific Publications, Oxford, 20-60.

Colter, V.S. 1997. The East Irish Sea Basin - from caterpillar to butterfly, a thirty-year metamorphosis. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas*. (Special Publication-Geological Society of London). **124**. Geological Society, 1-10.

Colter, V.S. & Barr, K.W. 1975. Recent Developments in the Geology of the Irish Sea and Cheshire Basins. *In:* Woodland, A.W. (ed.). *Petroleum and the Continental Shelf of NorthWest Europe*. Applied Sciences Publishers, London, 61-73.

Cope, F.W. 1939. Oil occurrences in south-west Lancashire. *Bulletin of the Geological Survey of Great Britain*, **2**, 18-25.

Cope, J.C.W. 1997. The Mesozoic and Tertiary history of the Irish Sea. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas*. (Special Publication- Geological Society of London). **124**. Geological Society, 47-60.

Craig, G.T. 1983. *Geology of Scotland (2nd edition)*. Geological Society of London, London.

Crawford, I. 1994. The Application of archaeology in dating coastal processes evidence from the Aird a `Bhorrain peninsula, North Uist. 15-17 in *Sea-level change and the coastal environment*. Delaney, C. (editor). The Irish Association for Quaternary Studies.)

Crimes, T.P., Chester, D.K. & Thomas, G.S.P. 1992. Exploration of Sand and Gravel Resources by Geomorphological Analysis in the Glacial Sediments of the Eastern Lleyn- Peninsula, Gwynedd, North Wales. *Engineering Geology*, **32**, Pt 3, 137-156.

Croker, P.F. & Shannon, P.M. 1995. The petroleum geology of Ireland's offshore basins: introduction. *In:* Croker, P. & Shannon, P. (eds.). *The petroleum geology of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 93. Geological Society of London, London.

Croker, P.F.a.S.P.M. (ed.). 1995. *The petroleum geology of Ireland's offshore Basins*. (Geological Society Special Publication). Geological Society of London.

Cronan, D.S. 1969. *Recent sedimentation in the central north-eastern Irish Sea*. (Report - Natural Environment Research Council, Institute of Geological Sciences). British Geological Survey, London, United Kingdom.

Cronan, D.S. 1970. Geochemistry of Recent sediments from the central Northeastern Irish Sea. *Research*, 20.

Cronan, D.S. 1972. Skewness and kurtosis in polymodal sediments from the Irish Sea. *Journal of Sedimentary Petrology*, **42**, Pt 1, 102-106.

Curry, D., Adams, C.G., Boulter, M.C., Dilley, F.C., Eames, F.E., Funnell, B.M. & Wells, M.K. 1978. A correlation of Tertiary rocks in the British Isles. *Special Report - Geological Society, No. 12*.

Deegan, C.E. 1978. Interpretation of the shallow seismic data on sheet 55°N/6°W, with comments on the IGS seaborne magnetic results. *In:* McLean, A.C. & Deegan, C.E. (eds.). *The solid geology of the Clyde Sheet (55°N/6°W)*. Report of the Institute of Geological Sciences, No. 78/9, 49-64.

Deegan, C.E. 1987. The future potential for oil and gas discoveries on the UK continental shelf. *Journal - Camborne School of Mines*, **87**, 36-42.

Deegan, C.E., Kirby, R., Rae, I. & Floyd, R. 1973. The superficial deposits of the Firth of Clyde and its sea lochs.

Delantey, L.J. 1980. The geology of the north Celtic Sea. Unpublished PhD thesis, University of Wales.

Delantey, L.J. & Whittington, R.J. 1977. A re-assessment of the "Neogene" Deposits of the south Irish Sea and Nymphe Bank. *Marine Geology*, **24**, M23-M30.

Department of Trade and Industry. 1992. *Development of the oil and gas resouces of the United Kingdom*. HMSO, London.

Devoy, R.J. 1982. Analysis of the geological evidence for Holocene sea-level movements in southeast England. *Philosophical Transactions of the Royal Society of London*, **279A**, 233-241.

Dobson, M.R., Delanty, L. & Whittington, R.J. 1982. Stratigraphy and inversion tectonics in the St. Georges Channel area off SW Wales, U.K. *Geo-Marine Letters*, **2**, Pt 1-2, 23-30.

Dobson, M.R., Evans, E.E. & Whittingham, R.J. 1973. The geology of the south IrishSea.

Dobson, M.R., Evans, W.E. & James, K.H. 1971. The sediment on the floor of the southern Irish Sea. *Marine Geology*, **11**, Pt 1, 27-68.

Dobson, M.R., Evans, W.E. & Whittington, R. 1973. *The geology of the South Irish Sea.* (Report - Natural Environment Research Council, Institute of Geological Sciences). British Geological Survey, London, United Kingdom.

Dobson, M.R. & Whittington, R.J. 1979. The geology of the Kish Bank Basin. *Journal of the Geological Society of London*, **136**, 243-249.

Dobson, M.R. & Whittington, R.J. 1987. The geology of Cardigan Bay. *In:* Bassett, M.G. (ed.). *Geology and sediments of offshore Wales and adjacent areas.* (Proceedings of the Geologists' Association). **98; 4**. Geologists' Association, London, United Kingdom, 331-353.

Downing, R.A., Edwards, W.M. & Gale, I.M. 1987. Regional groundwater flow in sedimentary basins in the UK. *In:* Goff, J.C. & Williams, B.P. (eds.). *Fluid Flow in Sedimentary Basins and Aquifers*. Geological Society Special Publication, No. 34, London, 105-125.

Draper, L. 1973. Extreme wave conditions in British and adjacent waters. *Proceedings , 13th Coastal Engineering Conference, Vancouver, Canada*, 157-165.

Duff, P.M.D. & Smith, A.J. 1992. *Geology of England and Wales*. The Geological Society of London, London.

Eakins, J.D. & Lally, A.E. 1984. The Transfer to Land of Actinide-Bearing Sediments from the Irish Sea by Spray. *Science of the Total Environment*, **35**, Pt 1, 23-32.

Earp, J.R., Magraw, D., Poole, E.G., Land, D.H. & Whiteman, A.J. 1961. Geology of the Country around Clitheroe and Nelson. Memoir of the Geological Survey of Great Britain, Sheet 68 (England and Wales).

Earp, J.R. & Taylor, B.J. 1986. Geology of the country around Chester and Winsford. Memoir of the British Geological Survey, Sheet 109 (England and Wales).

Eastwood, T. 1930. The geology of the Maryport District. Memoir of the Geological Survey of Great Britain, Sheet 22 (England and Wales).

Eastwood, T., Dixon, E.E.L., Hollingworth, S.E. & Smit, B. 1937. The geology of the Whitehaven and Workington district. Memoir of the Geological Survey of Great Britain, Sheet 28 (England and Wales).

Eastwood, T., Hollingworth, S.E., Rose, W.C.C. & Trotter, F.M. 1968. Geology of the country around Cockermouth and Caldbeck. Memoir of the Geological Survey of Great Britain, Sheet 23 (England and Wales).

Ebbern, J. 1981. The geology of the Morecambe gas field. *In:* Illing, L.V. & Hobson, G.D. (eds.). *Petroleum geology of the continental shelf of North-West Europe; Proceedings of the second conference.* Heyden and Son, London, United Kingdom, 485-493.

Eden, R.A., Deegan, C.E., Rhys, G.H., Wright, J.E. & Dobson, M.R. 1973. Geological investigations with a manned submersible in the Irish Sea and off western Scotland 1971.

Eden, R.A., McQuillin, R. & Ardus, D.A. 1977. U.K. experience of the uses of submersibles in the geological survey of continental shelves. *In:* Geyer, R.A. (ed.). *Submersibles and their use in oceanography and ocean engineering.* Elsevier Sci. Publ. Co., Amsterdam, Netherlands, 235-278.

Edwards, E. 1997. Sedimentology and Dating of Glacigenic Sequences: Eastern Irish Sea Basin. *Quaternary Newsletter*, Pt 82, 58.

Evans, C.D.R. 1982. The geology and superficial sediments of the inner Bristol Channel and Severn Estuary. *In: Severn Barrage: proceedings of a symposium organised by the Institution of Civil Engineers.* Thomas and Telford, London, 35-42.

Evans, C.D.R. 1990. United Kingdom offshore regional report: the geology of the western English Channel and its south-western Approaches. Thomas Telford, London.

Eyles, C.H. & Eyles, N. 1984. Glaciomarine Sediments of the Isle-of-Man as a Key to Late Pleistocene Stratigraphic Investigations in the Irish Sea Basin. *Geology*, **12**, Pt 6, 359-364.

Eyles, N. & McCabe, A.M. 1989. Glaciomarine facies within subglacial tunnel valleys; the sedimentary record of glacio-isostatic downwarping in the Irish Sea basin. *Sedimentology*, **36**, Pt 3, 431-448.

Eyles, N. & McCabe, A.M. 1989. The late Devensian (<22,000 BP) Irish Sea basin; the sedimentary record of a collapsed ice sheet margin. *Quaternary Science Reviews*, **8**, Pt 4, 307-351.

Eyles, N. & McCabe, A.M. 1991. Glaciomarine deposits of the Irish Sea Basin; the role of glacio-isostatic disequilibrium. *In:* Ehlers, J., Gibbard Philip, L. & Rose, J. (eds.). *Glacial deposits in Great Britain and Ireland.* A. A. Balkema, Rotterdam, Netherlands, 311-331.

Floodpage, J., Newman, P. & White, J. 2001. Hydrocarbon prospectivity in the Irish Sea area: insights from recent exploration of the Central Irish Sea, Peel and Solway basins. *In:* Shannon, P.M., Haughton, P.D.W. & Corcoran, D.V. (eds.). *The Petroleum Exploration of Ireland's Offshore Basins*. (Special Publication- Geological Society of London). **188**. Geological Society, 107-134.

Ford, T.D. 1987. Geological excursion guide 4: Isle of Man. *Geology Today*, **3**, 64-69.

Foster, H.D. 1970. Sarn Badrig, a submarine moraine in Cardigan Bay, North Wales. *Zeitschrift fuer Geomorphologie*, **14**, Pt 4, 475-486.

Francis, A., Millwood Hargrave, M., Mulholland, P. & Williams, D. 1997. Real and relict direct hydrocarbon indicators in the East Irish Sea Basin. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas*. (Special Publication- Geological Society of London). **124**. Geological Society, 185-194.

Fyfe, J.A., Long, D. & Evans, D. 1993. *United Kingdom offshore regional report: the geology of the Malin-Hebrides sea aea.* HMSO for the British Geological Survey, London.

Garrard, R.A. 1977. The sediments of the south Irish Sea and Nymphe Bank area of the Celtic Sea. *In:* Kidson, C. & Tooley, M. (eds.). *The Quaternary history of the Irish Sea.* **7**. Special Issue of the Geological Journal, London, 69-92.

Garrard, R.A. & Dobson, M.R. 1974. The nature and maximum extent of glacial sediments off the west coast of Wales. *Marine Geology*, **16**, Pt 1, 31-44.

Geoghegan, M., Gardiner, P. R. R. AND Keary, R. 1989. Possibilities for commercial mineral deposits in Irish offshore area. *Marine Mining, .* **8**, 267-282.

George, M. & Murray, J.W. 1977. Glauconite in Celtic Sea sediments. *Proceedings* of the Ussher Society, **4**, 94-101.

Glasser, N.F., Hambrey, M.J., Huddart, D., Gonzalez, S., Crawford, K.R. & Maltman, A.J. 2001. Terrestrial glacial sedimentation on the eastern margin of the Irish Sea basin: Thurstaston, Wirral. *Proceedings of the Geologists Association*, **112**, 131-146.

Green, M.O. & McCave, I.N. 1995. Seabed drag coefficient under tidal currents in the eastern Irish Sea. *Journal of Geophysical Research*, **100**, Pt C//8, 16,057.

Green, P.F. 2001. The influence of thermal history on hydrocarbon prospectivity in the central Irish Sea basin. *In:* Shannon, P., Haughton, P. & Corcoran, D. (eds.). *The petroleum exploration of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 188. **188**. Geological Society of London, London, 171-188.

Greenley, E. 1919. *The geology of Anglesey. Memoir of the Geological Survey of Great Britain.* Geological Survey of Great Britain,

Greig, D.C. 1971. British regional geology: the south of Scotland (3rd Edition). (London: HMSO for the Institute of Geological Sciences.).

Gresswell, R.K. 1956. Note on pro-glacial lake deposits of the western side of the Isle of Man. *Liverpool and Manchester Geological Journal*, **1 Part 4**, 381-384.

Gresswell, R.K. 1964. The origin of the Mersey and Dee estuaries. *Geol. J., Liverpool*, **4 Part 1**, 77-86.

Guilcher, A. 1969. Pleistocene and Holocene sea level changes. *Earth Science Reviews*, **5**, 69-97.

Hardman, M. & Meadows, N. 1995. Petroleum Geology of the Irish Sea and Adjacent Areas - Burlington-House, March, 1995. *Journal of Petroleum Geology*, **18**, Pt 2, 236-237.

Harland, R. 1978. Modern and Quaternary organic-walled microplankton from the North-east Irish Sea. *In:* Pantin, H.M. (ed.). *Quaternary sediments from the Northeast Irish Sea; Isle of Man to Cumbria.* (Bulletin of the Geological Survey of Great Britain). **64**. H.M.S.O., London, United Kingdom, 41-43.

Harris, C., Williams, G., Brabham, P., Eaton, G. & McCarroll, D. 1997. Glaciotectonized Quaternary Sediments at Dinas Dinlle, Gwynedd, North Wales, and their Bearing on the Style of Deglaciation in the Eastern Irish Sea. *Quaternary Science Reviews*, **16**, Pt 1, 109-127.

Harris, C.R. 1980. Recent sediment distribution in Dublin Bay and its approaches. *Journal of Earth Sciences, Royal Dubin. Society,*, **2**, 41-52.

Harrison, D.J., Laban, C., Leth, J.O. & Larsen, B. 1998. Sources of sand and gravel on the Northern European Continental Shelf. *In:* Latham, J.-P. (ed.). *Advances in* 

aggregates and armourstone evaluation Special Publication. Part 13. Geological Society Engingeering Geology.

Harvey, J.G. 1966. Large sand waves in the Irish sea. *Marine Geology*, **4**, Pt 1, 49-55.

Haughton, P.D.W. & Corcoran, D.V. 2001. The petroleum exploration of Ireland's offshore basins. *Spec Publ Geol Soc Lond*, Pt 188, 1-8.

Haward, N.J.B. 1977. The live and dead shelly fauna and the sediments of outer Cardigan Bay. Unpublished PhD thesis, University of University of Wales.

Haynes, J. & Dobson, M.R. 1969. Physiography, foraminifera and sedimentation in the Dovey Estuary (Wales). *Geological Journal*, **6**, 217-256.

Haynes, J.R. 1973. *Further remarks on Cardigan Bay Foraminifera*. (Publications - University College of Wales, Aberystwyth, Department of Geology). University of Wales, Aberystwyth, Institute of Earth Studies, Aberystwyth, United Kingdom.

Haynes, J.R., Kiteley, R.J., Whatley, R.C. & Wilkes, P.J. 1977. Microfaunas, microfloras and the environmental stratigraphy of the Late Glacial and Holocene in Cardigan Bay. *Geological Journal*, **12 Part 2**, 129-158.

Heathershaw, A.D. & Codd, J.M. 1985. Sandwaves, internal waves and sediment mobility at the shelf-edge in the Celtic Sea. *Oceanologica Acta*, **8**, 391-402.

Heathershaw, A.D., New, A.L. & Edwards, P.D. 1987. Internal tides and sediment transport at the shelf break in the Celtic Sea. *Continental Shelf Research*, **7**, 485-517.

Hensley, R.T. 1996. A preliminary survey of benthos from the Nephrops norvegicus mud grounds in the North-western Irish Sea. *Estuarine Coastal and Shelf Science*, **42**, Pt 4, 457-465.

Hession, M.A. & Whittington, R.J. 1987. Aspects of the Quaternary sediments of the Anglesey Sheet. *In:* Bassett, M.G. (ed.). *Geology and sediments of offshore Wales and adjacent areas.* (Proceedings of the Geologists' Association). **98; 4**. Geologists' Association, London, United Kingdom, 398-400.

Hession, M.A., Whittington, R.J. & Wingfield, R. 1987. The Quaternary sediments of the South Irish Sea and their implications for the Pleistocene geology of western British Shelf. *In:* Anonymous (ed.). *International Union for Quaternary Research, XII (super th) international congress; programme and abstracts--Union internationale pour l'etude du Quaternaire, XII (super e) congres international; programme et resumes.* (Congress of the International Union for Quaternary Research). [International Union for Quaternary Research], International, 186.

Hession, M.A.I. 1988. Quaternary geology of the South Irish Sea. Unpublished PhD thesis, University of Wales.

Hession, M.A.I. & Whittington, R.J. 1987. Aspects of the Quaternary sediments of the Anglesey sheet. *Proceedings of the Geologists' Association*, **98**, 398-400.

Heyworth, A. & Kidson, C. 1982. Sea-level changes in south-west England and Wales. *Proceedings of the Geologists' Association*, **93**, 91-111.

Hickey, K.R. & Szwagrzak, L. 1994. The historical evidence of recent coastal instability in N.W. Europe with special reference to coastal dune movements and sandstorms. 30-31 in *Sea-level change and the coastal environment*. Delaney, C. (editor). The Irish Association for Quaternary Studies.)

Hillis, R.R. 1988. The geology and tectonic evolution of the Western Approaches Trough. Unpublished PhD thesis, University of Edinburgh.

Holland, C.H. 1981. A geology of Ireland. Scottish Academic Press, Edinburgh.

Horn, D.P. & Hardisty, J. 1990. The application of Stokes' wave theory under changing sea levels in the Irish Sea. *Marine Geology*, **94**, Pt 4, 341-351.

Houghton, S.D. 1989. Coccolith sedimentation and transport in the Irish Sea. *Marine Geology*, **86**, Pt 1, 67-74.

Howells, M.F., Reedman, A.J. & Leveridge, B.E. 1985. *Geology of the country around Bangor*. Br. Geol. Surv., Keyworth, United Kingdom.

Huddart, D. 1994. Controversial Irish Sea glacial models; some answers from the Cumbrian lowlands. *Proceedings - Cumberland Geological Society*, **5 Part 4**, 476-480.

Huddart, D., Tooley, M.J. & Carter, P.A. 1977. The coasts of north-west England. *In:* Kidson, C. & Tolley, M.J. (eds.). *The Quaternary history of the Irish Sea.* **7**. Special Issue of the Geological Journal, 119-154.

Huddart, D., Tooley, M.J. & Carter, P.A. 1977. The coasts of north-west England. in The Quaternary history of the Irish Sea. *In:* Kidson, C. & Tooley, M. (eds.). *The Quaternary history of the Irish Sea.* **No. 7**. Special Issue of the Geological Journal, 119-154.

Hughes, M.J. 1978. Foraminifera from vibrocore G5 samples. *In:* Pantin, H.M. (ed.). *Quaternary sediments from the North-east Irish Sea; Isle of Man to Cumbria.* (Bulletin of the Geological Survey of Great Britain). **64**. H.m.s.o., London, United Kingdom, 37-39.

Huntley, D.A. 1980. Tides on the North-West European Continental Shelf. *In:* Banner, F.T., Collins, M.B. & Massie, K.S. (eds.). *The North-West European shelf seas: the sea bed and the sea in motion - II. Physical and chemical oceanography and physical resources.* Elsevier, Amsterdam. Hutchinson, S.M. & Prandle, D. 1994. Siltation in the saltmarsh of the Dee Estuary derived from (super 137) Cs analysis of shallow cores. *Estuarine, Coastal and Shelf Science*, **38**, Pt 5, 471-478.

Hydrographic Department. 1960. West coast of England pilot (10th edition). *In:* Hydrographer of the Navy, Taunton.

Illing, L.V. & Hobson, G.D. 1981. *Petroleum geology of the continental shelf of North-West Europe; Proceedings of the second conference*. Heyden and Son, London, United Kingdom.

Jackson, D.I. 1997. The geology of the Irish Sea. *Geoscientist*, **7**, Pt 1.

Jackson, D.I., Jackson, A.A., Evans, D., Wingfield, R.T.R., Barnes, R.P. & Arthur, M.J. 1995. *The geology of the Irish Sea*. HMSO,

Jackson, D.I. & Mulholland, P. 1993. Tectonic and stratigraphic aspects of the East Irish Sea basin and adjacent areas; contrasts in their post-Carboniferous structural styles. *In:* Parker, J.R. (ed.). *Petroleum geology of Northwest Europe; Proceedings of the 4th conference.* (Petroleum Geology of Northwest Europe: Proceedings of the ... Conference). **4**. The Geological Society of London, London, United Kingdom, 791-808.

Jackson, D.I., Mulholland, P., Jones, S.M. & Warrington, G. 1987. The geological framework of the East Irish Sea Basin. *In:* Brooks, J. & Glennie, K.W. (eds.). *Petroleum geology of North West Europe*. Graham and Trotman, London, 191-203.

James, J.W.C., Harrison, D.J. & Ciavola, P. 1992. Marine Aggregate Survey Phase 4, Irish Sea. 20 pp.

James, J.W.C. & Wingfield, R.T.R. 1987. Aspects of sea bed sediments in the southern Irish Sea. *In:* Bassett, M.G. (ed.). *Geology and sediments of offshore Wales and adjacent areas.* (Proceedings of the Geologists' Association). **98; 4**. Geologists' Association, London, United Kingdom, 404-406.

James, K.H. 1972 - 73. Recent sediments and shelly fauna of the Caernarvon Bay region, Southern Irish Sea. Unpublished PhD thesis, University of University of Wales.

Jardine, W.G. 1976. Some problems in plotting the mean surface level of the North Sea and the Irish Sea during the last 15,000 years. *Geologiska Foereningen i Stockholm Foerhandlingar*, **98 Part 1**, Pt 564, 78-82.

Jasin, B. 1976. Quaternary microfauna in 5 BGS boreholes in Cardigan Bay. Unpublished MSc thesis, University of University of Wales.

Johnson, L.R. 1983. The transport mechanisms of clay and fine silt in the north Irish Sea. *Marine Geology*, **52**, Pt 1-2, M33-M41.

Jones, A.S.G. 1971. A textural study of marine sediments in a portion of Cardigan bay (Wales). *Journal of Sedimentary Petrology*, **41**, Pt 2, 505-516.

Jones, N.S., Kain, J.M. & Stride, A.H. 1965. The movement of sand waves on Warts Bank, Isle of Man. *Marine Geology*, **3**, Pt 5, 329-336.

Keegan, B. 1989. Remote Reconnaissance Survey of Dublin Sewage Sludge and Dredge Spoil Disposal Grounds, July 1988.

Keegan, B.F., Dinneen, P., Costelloe, M. and Cunningham, P. 1983. Benthic Characterisation (1983) of the Dublin Bay Dumping Grounds.

Kenyon, N.H. 1970. Sand ribbons of European tidal seas. Marine Geology, 9, 25-39.

Kenyon, N.H., Belderson, R.H., Stride, A.H. & Jones, M.A. 1981. Offshore tidal sandbanks as indicators of net sand transport and as potential deposits. *Special Publication of the International Association of Sedimentologists*, **55**, 257-268.

Kenyon, N.H. & Stride, A.H. 1970. The tide-swept continental shelf sediments between the Shetland Isles and France. *Sedimentology*, **14**, 159-173.

Kershaw, P.J. 1986. Radiocarbon dating of Irish Sea sediments. *Estuarine, Coastal and Shelf Science*, **23**, Pt 3, 295-303.

Kershaw, P.J., Swift, D.J. & Denoon, D.C. 1988. Evidence of Recent sedimentation in the eastern Irish Sea. *Marine Geology*, **85**, Pt 1, 1-14.

Kidson, C. 1977. Some problems of the Quaternary of the Irish Sea. *Geological Journal, Special Issue. 7, .* 1-12.

Kidson, C. 1977. Bibliography of the Quaternary history of Irish Sea coasts. 81.

Kidson, C. & Tooley, M.J. 1977. *The Quaternary history of the Irish Sea*. (Geological Journal, Special Issue). Seel House Press, Liverpool, United Kingdom.

Kirby, R. 1987. Sediment exchanges across the coastal margins of NW Europe. *Journal of the Geological Society of London*, **144**, Pt 1, 121-126.

Knight, D.J. 1977. Morecambe Bay feasibility study - sub-surface investigations. *Quarterly Journal of Engineering Geology*, **10**, 303-354.

Knight, J. 2001. Glaciomarine deposition around the Irish Sea basin: some problems and solutions. *Journal of Quaternary Science*, **16**, Pt 5, 405-418.

Lambeck, K. 1995. Late Devensian and Holocene Shorelines of the British-Isles and North-Sea from Models of Glacio-Hydro-Isostatic Rebound. *Journal of the Geological Society*, **152**, 437-448.

Lambeck, K. 1996. Glaciation and sea-level change for Ireland and the Irish Sea since Late Devensian/Midlandian time. *Journal of the Geological Society*, **153**, 853-872.

Lambeck, K. & Purcell, A.P. 2001. Sea-level change in the Irish Sea since the last glacial maximum: constraints from isostatic modelling. *Journal of Quaternary Science*, **16**, Pt 5, 497-506.

Larcombe, P. & Jago, C.F. 1994. The Late Devensian and Holocene Evolution of Barmouth-Bay, Wales. *Sedimentary Geology*, **89**, Pt 3-4, 163-180.

Lee, C. 1991. Hydrocarbon exploration in offshore Wales. *Teaching Earth Sciences*, **16**, Pt 2, 55-58.

Lowe, J. 2001. Special issue: The glaciation of the Irish Sea basin. *J Quaternary Sci*, **16**, Pt 5.

Maddox, S.J., Blow, R.A. & O'Brien, S.R. 1997. The geology and hydrocarbon prospectivity of the North Channel basin. *In:* Meadows, N., Trueblood, S., Hardman, M. & COWAN, G. (eds.). *Petroleum geology of the Irish Sea and adjacent areas - Spec Publ Geol Soc Lond*. Part 124.

Maingarm, S., Izatt, C., Whittington, R.J. & Fitches, W.R. 1999. Tectonic evolution of the Southern-Central Irish Sea Basin. *In:* Quirk, D.G. (ed.). *Hydrocarbon potential of the Irish Sea; Journal of Petroleum Geology*. Part 3. **22**. Scientific Press Ltd, 287-304.

Malvarez, G. & McCloskey, J. 1994. Numerical modelling for energy distribution on the nearshore and the importance of input data quality. 23 in *Sea-level change and the coastal environment*. Delaney, C. (editor). The Irish Association for Quaternary Studies.)

Max, M. 1969. The oblique asdic and its use in an investigation of a marine highenergy environment. *SedImentology*, **13**, **105-122**., 13, 105-122.

Max, M., Harris, C. R., Geoghan, M. A., Cathcart, G. S., Ní Conchuir, M. E. and Fahy, C. J. . A Preliminary Report on the Recent Sedimentation on the Sea Floor Immediately to the East of Dublin. Geological Survey of Ireland Report Series, RS 76/1. 1976. A Preliminary Report on the Recent Sedimentation on the Sea Floor Immediately to the East of Dublin.

McCabe, A.M. & Clark, P.U. 1998. Ice-sheet variability around the north Atlantic Ocean during the last deglaciation. *Nature*, **392**, Pt 6674, 373-377.

McCabe, A.M. & Eyles, N. 1990. Late Devensian event stratigraphy of the Irish Sea basin. *In:* Addison, K., Edge Martin, J. & Watkins, R. (eds.). *The Quaternary of North Wales; field guide.* (Field Guide - Quaternary Research Association). **1990**. Quaternary Research Association, Hampshire, United Kingdom, 22-30.

McCabe, A.M., Eyles, N., Haynes, J.R. & Bowen, D.Q. 1990. Biofacies and sediments in an emergent late Pleistocene glaciomarine sequence, Skerries, east central Ireland. *Marine Geology*, **94**, Pt 1-2, 23-36.

McCabe, A.M. & Ocofaigh, C. 1995. Late Pleistocene Morainal Bank Facies at Greystones, Eastern Ireland - an Example of Sedimentation During Ice Marginal Re-Equilibration in an Isostatically Depressed Basin. *Sedimentology*, **42**, Pt 4, 647-663.

McCabe, M., Knight, J. & McCarron, S. 1998. Evidence for Heinrich event 1 in the British Isles. *Journal of Quaternary Science*, **13**, Pt 6, 549-568.

McCabe, M.A. 1997. Geological constraints on geophysical models of relative sealevel change during deglaciation of the western Irish Sea Basin. *Journal- Geological Society London*, **154**, Pt 4, 601-604.

McCarroll, D. 1995. Geomorphological Evidence from the Lleyn-Peninsula Constraining Models of the Magnitude and Rate of Isostatic Rebound During Deglaciation of the Irish-Sea Basin. *Geological Journal*, **30**, Pt 2, 157-163.

McCarroll, D. 2001. Deglaciation of the Irish Sea basin: a critique of the glaciomarine hypothesis. *Journal of Quaternary Science*, **16**, Pt 5, 393-404.

McCarroll, D., Knight, J. & Rijsdijk, K. 2001. The Glaciation of the Irish Sea basin. *Journal of Quaternary Science*, **16**, Pt 5, 391-392.

McGovern-Traa, C., Leu, J.Y., Hamilton, W.A., Spark, I.S.C. & Patey, I.T.M. 1997. The presence of sulphate-reducing bacteria in live drilling muds, core materials and reservoir formation brine from new oil fields. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas.* (Special Publication- Geological Society of London). **124**. Geological Society, 229-236.

McKerrow, W.S. & Soper, N.J. 1989. The lapetus suture in the British Isles. *Geological Magazine*, **126**, 1-8.

McLean, A.C. & Deegan, C.E. 1978. The solid geology of the Clyde Sheet (55°N/6°W).

McMahon, N.A. & Underhill, J.R. 1995. The regional stratigraphy of the southwest United Kingdom and adjacent offshore areas with particular reference to the major intra-Cretaceous unconformity. *In:* Croker, P. & Shannon, P. (eds.). *The petroleum geology of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 93. Geological Society of London, London.

McMillan, A.A., Heathcote, J.A., Klinck, B.A., Shepley, M.G., Jackson, C.P. & Degnan, P.J. 2000. Hydrogeological characterization of the onshore Quaternary sediments at Sellafield using the concept of domains. *Quarterly Journal of Engineering Geology and Hydrogeology*, **33**, 301-323.

Meadows, N., Trueblood, S., Hardman, M. & Cowan, G. 1997. *Petroleum geology of the Irish Sea and adjacent Areas*. (Special Publication Geological Society London). Geological society of London, London.

Menpes, R.J. & Hillis, R.R. 1995. Quantification of Tertiary exhumation from sonic velocity data, Celtic Sea/South-Western Approaches. *In:* Buchanan, J. & Buchanan, P. (eds.). *Basin Inversion - Special Publication Geolocial Society of London*. Part 88. Geological Society of London, London.

Merritt, J.W. & Auton, C.A. 2000. An outline of the lithostratigraphy and depositional history of Quaternary deposits in the Sellafield district, west Cumbria. *Proceedings of the Yorkshire Geological Society*, **53**, 129-154.

Michie, U. 1996. The geological framework of the Sellafield area and its relationship to hydrogeology. *Quarterly Journal of Engineering Geology*, **29**, S13-S27.

Michie, U.M. 1994. The Geology and Hydrogeology of Sellafield. *Nuclear Energy Journal of the British Nuclear Energy Society*, **33**, Pt 1, 25-39.

Miller, A.A. 1939. *Preglacial erosion surfaces round the Irish sea basin*. (Proceedings of the Yorkshire Geological Society). Yorkshire Geological Society, Leeds, United Kingdom.

Mitchell, G.F. 1972. The Pleistocene history of the Irish Sea; second approximation. *The Scientific Proceedings of the Royal Dublin Society. Series A.*, **4**, Pt 13, 181-199.

Mitchell, G.F., Penny, L.F., Shotton, F.W. & West, R.G. 1973. A correlation of Quaternary deposits in the British Isles. *Special Report of the Geological Society of London*, **4**.

Montag, E. 1945. The origin of the Menai straits. *Proceedings of the Liverpool Geological Society*, **19 Part 2**, 69-71.

Moore, J.R. 1968. Recent sedimentation in northern Cardigan bay, Wales. *Bulletin of the British Museum, Natural History. Mineralogy*, **2**, Pt 2, 19-130.

Morton, A.C. 1989. Heavy minerals in seabed sediments on the southern part of the UK continental shelf.

Murdoch, L.M., Musgrove, F.W. & Perry, J.S. 1995. Tertiary uplift and inversion history in the North Celtic Sea basin and its influence on source rock maturity. *In:* Croker, P. & Shannon, P. (eds.). *The petroleum geology of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 93. Geological Society of London, London, 297-319.

Naylor, D. & Shannon, P.M. 1982. *The Geology of offshore Ireland and West Britain*. Graham and Trotman, London, United Kingdom.

Naylor, D. & Shannon, P.M. 1999. The Irish Sea region: why the general lack of exploration success? *Journal of Petroleum Geology*, **22**, Pt 3, 363-370.

Naylor, D. 1965. Pleistocene and post-Pleistocene sediments in Dublin Bay. *Scientific Proceedings of the Royal Dublin Society,*, **A2**, 175-188.

Needham, T. & Morgan, R. 1997. The East Irish Sea and adjacent basins: new faults or old? *Journal Geological Society London*, **154**, Pt 1, 145-150.

Newman, P.J. 1999. The geology and hydrocarbon potential of the Peel and Solway Basins, East Irish Sea. *Journal of Petroleum Geology*, **22**, Pt 3, 305-324.

Norton, M.G. & Rowlatt, S.M. 1982. A review of the results of sediment survey in Liverpool Bay 1973-81. 65.

O' Cofaigh, C. & Evans, D.J.A. 2001. Sedimentary evidence for deforming bed conditions associated with a grounded Irish Sea glacier, southern Ireland. *Journal of Quaternary Science*, **16**, Pt 5, 435-454.

Oldfield, F. & Yu, L.H. 1994. The Influence of Particle Size Variations on the Magnetic Properties of Sediments from the North-Eastern Irish Sea. *Sedimentology*, **41**, Pt 6, 1093-1108.

Pantin, H.M. 1977. Quaternary sediments from the northern Irish Sea. *In:* Kidson, C. & Tooley, M.J. (eds.). *The Quaternary history of the Irish Sea.* **No. 7**. Special Issue of the Geological Journal, 27-54.

Pantin, H.M. 1978. *Quaternary sediments from the North-east Irish Sea; Isle of Man to Cumbria.* (Bulletin of the Geological Survey of Great Britain). H.M.S.O., London, United Kingdom.

Pantin, H.M. 1991. Seabed sediments around the United Kingdom: their bathymetric and physical environment, grain size, mineral composition and associated bedforms. *Marine Geology Series research report*, 47.

Pantin, H.M. & Evans, C.D.R. 1984. The Quaternary history of the central and southwestern Celtic Sea. *Marine Geology*, **57**, 259-293.

Parkin, M. & Crosby, A. 1982. Geological results of boreholes drilled on the southern United Kingdom shelf 1969-1981.

Parnell, J. 1997. Fluid migration history in the North Irish Sea-North Channel region. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas.* (Special Publication- Geological Society of London). **124**. Geological Society, 213-228.

Parrish, J.G. 1971-72. Recent sediments and shelly fauna of the western Irish Sea - St. John's Point to Cahore Point. Unpublished PhD thesis, University of University of Wales.

Paulsen, S.C. & Owen, R.M. 1996. Quantative Model of Sediment Dispersal and Heavy Mineral Distribution in North Cardigan Bay, Irish Sea. *Marine Georesources and Geotechnology*, **14**, Pt 2, 143-160.

Perkins, E.J. 1966. Silt movements in the north-east Irish Sea and Solway Firth. *In:* Arnold, P.W. (ed.). *Estuarine soils.* (Proceedings of the North of England Soils Discussion Group). **3**. North of England Soils Discussion Group, United Kingdom, 27-31.

Perry, J. & Bond, A.J. 1996. Offshore oil and gas development: impact on the environment round Cardigan Bay. *Project Appraisal*, **11**, Pt 2, 117-127.

Phillips, A.W. 1974. The geomorphology and geology of Morecambe Bay. *Proc Westmorl Geol Soc*, **1**, Pt 2.

Pingree, R.D. & Griffith, D.K. 1979. Sand transport paths around the British Isles resulting from M2 and M4 tidal interactions. *Journal of the Marine Biological Association of the United Kingdom,*, **58**, 211-226.

Price, C.A., Dailly, P.A. & Dewey, J.F. 1988. Structure and evolution of the East Irish Sea Basin System. A100 in *Geological Association of Canada, Mineralogical Association of Canada, Canadian Society of Petroleum Geologists, 1988 joint annual meeting; program with abstracts--Association Geologique du Canada, Association Mineralogique du Canada, Societe Canadienne des Geologues Petroliers, 1988 reunion annuelle conjointe; programme et resumes.* Program with Abstracts -Geological Association of Canada; Mineralogical Association of Canada; Canadian Geophysical Union, Joint Annual Meeting. Anonymous (editor). (Waterloo, ON, Canada: Geological Association of Canada.)

Pye, K. & Neal, A. 1994. Coastal dune erosion at Formby Point, North Merseyside, England; causes and mechanisms. *Marine Geology*, **119**, Pt 1-2, 39-56.

Quirk, D.G. & Kimbell, G.S. 1997. Structural evolution of the Isle of Man and central part of the Irish Sea. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas*. (Special Publication-Geological Society of London). **124**. Geological Society, 135-160.

Quirk, D.G., Roy, S., Knott, I., Redfern, J. & Hill, L. 1999. Petroleum geology and future hydrocarbon potential of the Irish Sea. *Journal of Petroleum Geology*, **22**, Pt 3, 243-260.

Reynaud, J.Y., Tessier, B., Proust, J.N., Dalrymple, R., Marsset, T., De Batist, M., Bourillet, J.F. & Lericolais, G. 1999. Eustatic and hydrodynamic controls on the architecture of a deep shelf sand bank (Celtic Sea). *Sedimentology*, **46**, Pt 4, 703-721.

Rhys, G.H. & Ardus, D.A. 1981. The geology of the British Isles and the adjacent continental shelf; the offshore post-Hercynian basins. *In:* Kerr, J.W., Fergusson, A.J.

& Machan, L.C. (eds.). *Geology of the North Atlantic borderlands.* (Memoir - Canadian Society of Petroleum Geologists). **7**. Canadian Society of Petroleum Geologists, Calgary, AB, Canada, 665-682.

Rijsdijk, K. 2001. Reconstructing the late Devensian glaciation history of the southern Irish Sea basin: testing of competing hypotheses. *Quaternary Newsletter*, Pt 93, 62-63.

Rose, C.L., McKay, W.A. & Toole, J. 1994. The Use of the <sup>234</sup>Th/<sup>238</sup>U Disequilibrium in Studying Surf-Zone Sediment Processes in the Eastern Irish Sea. *Marine Environmental Research*, **37**, Pt 4, 393-416.

Rowe, J., Chadwick, R.A., Bailey, R.J. & Kirby, G.A. 1996. Discussion of `The post-Triassic structural evolution of north-west England and adjacent parts of the East Irish Sea'. Proceedings, Vol. 50, part 1, pp. 91-102, 1994. *Proceedings-Yorkshire Geological Society*, **51**, Pt 2, 173-175.

Rowe, J., Chadwick, R.A., Baily, H.E. & Kirby, G.A. 1996. The post-Triassic structural evolution of North-West England and adjacent part of the East Irish Sea; discussion and reply. *Proceedings of the Yorkshire Geological Society*, **51 Part 2**, 173-175.

Rowell, P. 1995. Tectono-stratigraphy of the North Celtic Sea basin. *In:* Croker, P. & Shannon, P. (eds.). *The petroleum geology of Ireland's offshore basins - Spec Publ Geol Soc Lond*. Part 93. Geological Society of London, London, 101-137.

Rowlatt, S.M., Rees, H.L. & Rees, E.I.S. 1986. Changes in sediments following the dumping of dredged materials in Liverpool Bay. *Unpublished report*, 1-7 plus figures.

Rowley, E. & White, N. 1998. Inverse modelling of extension and denudation in the East Irish Sea and surrounding areas. *Earth and Planetary Science Letters*, **161**, Pt 1-4, 57-71.

Shafig, u.R.S. 1990. The development of high-frequency acoustics for the measurement of suspended sediment in the eastern Irish Sea. Unpublished Doctoral thesis, University of University of East Anglia. Norwich, United Kingdom.

Shannon, P.M. 1986. Irish offshore geology and petroleum prospectivity. *In:* Duffy, N.B. (ed.). *Oil and gas prospects in Ireland.* Inst. Chem. Eng., Rugby, United Kingdom, 21-37.

Shannon, P.M. 1991. The development of Irish offshore sedimentary basins. *Journal of the Geological Society of London*, **148**, 181-190.

Shannon, P.M. 1993. Oil and gas in Ireland; exploration, production and research. *First Break*, **11**, Pt 10, 429-433.
Shannon, P.M. 1996. Current and future potential of oil and gas exploration in Ireland. *In:* Glennie, K. & Hurst, A. (eds.). *AD1995: NW Europe's hydrocarbon industry*.

Shannon, P.M. & Croker, P.F. 1994. Conference report: The petroleum geology of Ireland's offshore basins [Dublin, 21-22 April 1994]. *First Break*. (Dublin:

Shannon, P.M., Haughton, P.D.W. & Corcoran, D.V. 2001. The petroleum exploration of Ireland's offshore basins [introduction]. *In: Spec Publ Geol Soc Lond*. (Spec Publ Geol Soc Lond). Part 188. **188**. p. 1-8.

Shannon, P.M. & Mactiernan, B. 1993. Triassic prospectivity in the Celtic Sea, Ireland: a case history. *First Break*, **11**, Pt 2, 47-57.

Shannon, P.M. & Naylor, D. 1998. An assessment of Irish offshore basins and petroleum plays. *Journal of Petroleum Geology*, **21**, Pt 2, 125-152.

Shelton, R. 1997. Tectonic evolution of the Larne Basin. *In:* Meadows, N.S., Trueblood, S.P., Hardman, M. & Cowan, G. (eds.). *Petroleum Geology of the Irish Sea and Adjacent Areas*. (Special Publication- Geological Society of London). **124**. Geological Society, 113-134.

Shi, Z. 1993. Recent Salt-Marsh Accretion and Sea-Level Fluctuations in the Dyfi Estuary, Central Cardigan Bay, Wales, UK. *Geo-Marine Letters*, **13**, Pt 3, 182-188.

Shi, Z. & Lamb, H.F. 1991. Postglacial Sedimentary Evolution of a Microtidal Estuary, Dyfi Estuary, West Wales, Uk. *Sedimentary Geology*, **73**, Pt 3-4, 227-246.

Smith, A.J. 1992. Offshore geology. *In:* Duff, P. & Smith, A. (eds.). *Geology of England and Wales*. Geological Society of London, London, 445-487.

Smith, B. 1931. Borings through the glacial drifts of the northern plain of the Isle of Man. *Summary of Progress of the Geological Survey of Great Britain (for 1930)*, **3**, 14-23.

Steers, J.A. 1939. Sand and shingle formations in Cardigan Bay [Wales]. *Geographical Journal*, **94**, Pt 3, 209-277.

Stride, A.H. 1963. Current-swept sea floors near the southern half of Great Britain. *Quarterly Journal of the Geological Society of London*, **119, Part 2**, Pt 474, 175-199.

Stride, A.H. 1982. *Offshore tidal sands; processes and deposits*. Chapman and Hall, London.

Sutton, G.W., A.J. 1999. Reconnaissance Assessment of Coastal Seabed Sand & Gravel Resources in the Form of Seabed Mapping & Quantification. *3rd International Conference on Shellfish Restoration ICSR Europe '99: 28:9:99-2:10:99,.* (Jury's Hotel, Cork. Eire:

Swift, D.J.P., Stanley, D.J. & Curray, J.R. 1971. Relict sediments on continental shelves, a reconsideration. *Journal of Geology*, **79**, 322-46.

Synge, F.M. 1985. Coastal evolution. *In:* Edwards, K.J. & Warren, W.P. (eds.). *The Quaternary geology of Ireland*. Academic Press, London, 115-131.

Tappin, D.R., Chadwick, R.A., Jackson, A.A., Wingfield, R.T.R. & Smith, N.J.P. 1994. *United Kingdom offshore regional report: the geology of Cardigan Bay and the Bristol Channel.* HMSO for the British Geological Survey, London.

Taylor, D.I. 1992. Nearshore shallow gas around the U.K. coast. *In:* Davis Angela, M. (ed.). *Methane in marine sediments conference.* (Continental Shelf Research). **12**; **10**. Pergamon, Oxford, United Kingdom, 1135-1144.

Taylor-Smith, D. 1987. Geotechnical studies in Tremadoc Bay. *Proceedings of the Geologists' Association*, **98**, 385-396.

The Natural Environment Research Council. 1971. A review of recent investigations of the sea bed on the continental margin around the British Isles. (Publications - Natural Environment Research Council, Series C). Natural Environment Research Council, London, United Kingdom.

Thomas, G.S.P. 1975. A possible late Devensian marine episode in the Isle of Man and its implications for the limit of the last glaciation in the Irish Sea. unpaginated in *Europe, from crust to core; abstracts of keynote addresses and short communications.* (Reading, United Kingdom: Geol. Soc. Lond.-Univ.)

Thomas, G.S.P. 1977. The Quaternary of the Isle of Man. *Geological Journal, Special Issue*, Pt 7, 155-178.

Thomas, G.S.P. 1985. The Quaternary of the northern Irish Sea basin. *In:* Johnson, R.H. (ed.). *The geomorphology of north-west England.* Manchester Univ. Press, Manchester, United Kingdom, 143-158.

Thomas, G.S.P. & Dackombe, R.V. 1985. Glaciomarine Sediments of the Isle-of-Man as a Key to Late Pleistocene Stratigraphic Investigations in the Irish Sea Basin -Comment. *Geology*, **13**, Pt 6, 445-447.

Todd, S.P., Murphy, F.C. & Kennan, P.S. 1991. On the trace of the lapetus suture in Ireland and Britain. *Scottish Journal of Geology*, **23**, 215-220.

Tooley, M. 1994. Sea-level changes: Past, Present and Future. 9 in *Sea-level change and the coastal environment*. Delaney, C. (editor). The Irish Association for Quaternary Studies.)

Tooley, M.J. 1985. Sea-level changes and coastal morphology in north-west England. *In:* Johnson, R.H. (ed.). *The geomorphology of North-West England*. University Press, Manchester, 94-121.

Trimmer, M., Gowen, R.J., Stewart, B.M. & Nedwell, D.B. 1999. The spring bloom and its impact on benthic mineralisation rates in western Irish Sea sediments. *Marine Ecology-Progress Series*, **185**, 37-46.

Turner, J.P. 1997. Strike-slip fault reactivation in the Cardigan Bay basin. *Journal of the Geological Society*, **154**, 5-8.

Turner, J.P. & Corbin, S.G. 1995. Tertiary uplift of a deep rift-sag basin, Cardigan Bay, offshore Wales, UK. *In:* Buchanan, J.G. & Buchanan, P.G. (eds.). *Basin Inversion - Special Publication- Geological Society of London*. (Special Publication-Geological Society of London, London, 587.

Walden, J. 1994. Late Devensian sedimentary environments in the Irish Sea basin; glacioterrestrial or glaciomarine? *In:* Boardman, J. & Walden, J. (eds.). *The Quaternary of Cumbria; field guide.* (Field Guide - Quaternary Research Association). **1994**. Quaternary Research Association, Hampshire, United Kingdom, 15-18.

Wall, D.R. & Whatley, R.C. 1971. The Ostracoda of the Subrecent deposits of Tremadoc Bay, southern Irish Sea. *In: Paleoecology of ostracods.* (Centre de Recherches de Pau (Societe Nationale des Petroles d'Aquitaine), Bulletin.). **5**; **5**. Societe Nationale Elf-Aquitaine (Production), France, 295-309.

Ware, P.D. 1999. Application of sonic velocity analysis to quantify Tertiary Exhumation, East Irish Sea and Kish Bank. Unpublished MPhil thesis, University of University of Birmingham.

Warren, P.T., Price, D., Nutt, M.J.C. & Smith, E.G. 1984. *Geology of the country around Rhyl and Denbigh. Memoir of the British Geological Survey, Sheets 95 and 107 and parts of 94 and 106 (England and Wales)*. HMSO, London.

Warren, W.P. & Keary, R. 1988. The sand and gravel resources of the Irish Sea Basin. *In:* Sweeney, J.C. (ed.). *The Irish Sea: a resource at risk*. **No. 3**. Geographic Society of Ireland Special Edition, No. 3, 66-79.

Warren, W.P.A.K., R. (ed.). 1989. *The sand and gravel resources of the Irish Sea Basin.* (The Irish Sea Basin: A Resource At Risk. edition). Geographical Society of Ireland,.

Watson, E. 1970. The Cardigan bay area. *In: The glaciations of Wales and adjoining regions.* Longman, London, 125-145.

Welch, M.J. 1996. Mechanisms of extension and their influence on basin geometry: the St. George's Channel Basin, Offshore UK. 121-148 in *Structural geology and geomechanics*. Zheng, Y., Davis, G.A. & Yin, A. (editors). (Beijing: Vsp.)

Welch, M.J. 1996. Influence of basement structure on the evolution of the St. George's Channel basin, offshore UK. 312 in *30th international geological congress; abstracts.* International Geological Congress, Abstracts--Congres Geologique

Internationale, Resumes. 30, Vol. Anonymous (editor). ([location varies], International: [International Geological Congress].)

Welch, M.J. 1997. The structural evolution of the St George's Channel Basin. Unpublished Doctoral thesis, University of Birmingham.

Whatley, R.C. & Wall, D.R. 1969. A preliminary account of the ecology and distribution of Recent Ostracoda in the southern Irish Sea. *In:* Neale John, W. (ed.). *The taxonomy, morphology and ecology of Recent Ostracoda.* Oliver & Boyd, Edinburgh, United Kingdom, 268-298.

Wheeler, A.J., Walshe, J. & Sutton, G. (1999). 1999. Geological Appraisal of the Kish, Burford, Bray and Fraser Banks, Outer Dublin Bay Area., 63.

Wheeler, A.J., J. Walshe, J. & Sutton, G. D. (2000). . 2000. Geological Appraisal of the Kish, Burford, Bray and Fraser Banks, Outer Dublin Bay., 35.

Wheeler, A.J., Walshe, J. & Sutton, G.D. 2001. Seabed Mapping and Seafloor Processes in the Kish, Burford, Bray and Fraser Banks Area, Southwestern Irish Sea. *Irish Geography*, **34**, Pt 2, 194-211.

Wheeler, A.J.S., G. 1999. Literature and Data Review for the Arklow Banks within the Context of Offshore Wind-Energy Generation. Final Report to Future Wind Partnership, Naas., 48.

Whittington, R.J. (ed.). 1977. A late-glacial drainage pattern in the Kish Bank area and postglacial sediments in the Central Irish Sea. (The Quaternary History of the Irish Sea.). Seel House Press, Liverpool,.

Whittington, R.J. 1982. The geology of Cardigan Bay. *Geophys J R Astron Soc*, **69**, Pt 1.

Whittow, J.B. 1970. Shoreline evolution on the eastern coast of the Irish Sea. *In: Symposium on the evolution of shorelines and continental shelves in their mutual relations during the Quaternary.* (Quaternaria). **12**. [publisher unknown], Rome, Italy, 185-196.

Wilkinson, I.P. & Halliwell, G.P. 1979. Offshore micro- palaeontological biostratigraphy of southern and western Britain. *Report of the Institute of Geological Sciences*.

Wilks, P.J. 1979. Mid-Holocene sea-level and sedimentation interactions in the Dovey Estuary area, Wales. *Palaeogeography, Palaeoclimatology, Palaeoecology*, **26**, Pt 1-2, 17-36.

Wilson, H.E. 1968. Geology of the Irish Sea area. *Irish Naturalists' Journal*, **16**, Pt 4, 102-105.

Wilson, H.E. 1981. Permian and Mesozoic. *In:* Holland, C.H. (ed.). *A geology of Ireland*. Scottish Academic Press, Edinburgh, 201-212.

Wilson, J.B. 1967. Palaeoecological studies on shell-beds and associated sediments in the Solway Firth. *Scottish Journal of Geology*, **3 Part 2**, 329-371.

Wilson, J.B. 1978. Macrofauna species (shells). *In:* Pantin, H.M. (ed.). *Quaternary sediments from the North-east Irish Sea; Isle of Man to Cumbria.* (Bulletin of the Geological Survey of Great Britain). **64**. H.M.S.O., London, United Kingdom, 40-41.

Wilson, J.B. 1984. *RRS Frederick Russell cruise 7/83; 21 April - 13 May 1983; Sediment and faunal investigations on the continental shelf and upper continental slope west and north of Scotland and in the Irish Sea.* (Cruise Report - Institute of Oceanographic Sciences). Institute of Oceanographic Sciences, Surrey, United Kingdom.

Wilson, J.G. 1984. Benthic Studies on the east Coast. . p. 60-67 in *Lough Beltra - 1984. Proceedings of the 1984 Lough Beltra Workshop,*. O'Sullivan, G. (editor). (Galway, March 2nd, 1984.: National Board of Science and Technology, Dublin.)

Wingfield, R. 1992. Modelling Holocene sea levels in the Irish and Celtic Seas. 760-772 in *International coastal congress*. Sterr, H., Hofstede, J. & Plag, H.P. (editors). (Kiel; Germany: Frankfurt am Main.)

Wingfield, R.T.R. 1987. Giant sand waves and relict periglacial features on the sea bed west of Anglesey. *Proceedings of the Geologists' Association*, **98**, 400-404.

Wingfield, R.T.R. 1990. The origin of major incisions within the Pleistocene deposits of the North Sea. *Marine Geology*, **91**, 31-52.

Wingfield, R.T.R. 1990. Glacial incisions indicating Middle and Upper Pleistocene ice limits off Britain. *Terra Nova*, **1**, 538-548.

Wingfield, R.T.R. 1992. The late Devensian (<22,000 BP) Irish Sea basin; the sedimentary record of a collapsed ice sheet margin; discussion and reply. *Quaternary Science Reviews*, **11**, Pt 3, 377-379.

Wingfield, R.T.R. 1995. A model of sea-levels in the Irish and Celtic seas during the end-Pleistocene to Holocene transition. *In:* Preece, R.C. (ed.). *Island Britain: a Quaternary perspective*. (Special Publication- Geological Society of London). **96**. Geological Society, 209-242.

Wingfield, R.T.R. In press. Modelling Holocene sea levels in the Irish and Celtic seas. *Proceedings of the International Coastal Congress, Kiel 1992.* (Kiel: Christian-Albrechts-Universitat Press.)

Wray, D.A. & Cope, F.W. 1948. Geology of Southport and Formby. Memoir of the Geological Survey of Great Britain, Sheets 74 and 83 (England and Wales).

Yuan, F., Bennell, J.D. & Davis, A.M. 1992. Acoustic and Physical Characteristics of Gassy Sediments in the Western Irish Sea. *Continental Shelf Research*, **12**, Pt 10, 1121-1134.

Ziegler, P.A. 1982. *Geological Atlas of western and central Europe*. Elsevier for Shell Internationale Petroleum Maatschappij BV., Amsterdam.

# UK-Irish Border Public Domain Geological Survey MetaData

# **Final Report**



**Compiled by: Dr. Andy Wheeler** 

#### 1 August 2003

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# **1. INTRODUCTION**

A significant number of research cruises concerned with determining seabed attributes (both biological and geological) have been undertaken especially since the 1970s. The survey areas of these research cruises often cross national boundaries at sea reflecting the contiguity of seabed features across borders. Correspondingly, survey results on features that straddling the border are of relevance to both countries irrespective of which side of the border the surveys were conducted.

The UK Department of Trade and Industry are performing an environmental appraisal of all UK seabed (SEA). This report is a contribution to this process and represents a review of the seabed survey and sampling metadata available from Irish waters adjacent to the UK-Irish marine border.

The metadata that is presented in this report includes details of station lists and survey lines both in tabular and map format as well as associated bibliographic references. Commercial and confidential data is not included in this report. In this context, this report mainly documents the results national and international scientific programmes.

With the bibliographic database, although every effort has been made to make this list as inclusive as possible it is likely that some reference may have been overlooked. This inevitable given the nature of the study area that defines a narrow zone often fringing main geographical areas severely limiting the usefulness of geographic search terms in bibliographic databases. It was therefore necessary to adopt an approach whereby publications were traces by association with the metadata data.

#### **1.1. GEOGRAPHICAL EXTENT OF THE STUDY AREA**

The study area for which data is presented is defined by a zone extending 50km inside Irish waters from the UK-Irish border. 50km was chosen as a generous distance that would encompass all significant geological features that straddled the border whilst maintaining a feasible data gathering exercise within the constraints of the project. Geological features straddling the border and extending more than 50km inside Irish waters are deemed to be regional in significance. Data within the Irish 12 nautical mile limit are excluded for reasons of jurisdiction. The study area includes: part of western Irish-Scottish shelf, Rockall Trough, Rockall Bank, Hatton Basin and Hatton Bank; the western Irish Sea and parts of the Celtic Sea (see Figure 1).

As the study area defines a buffer around a national boundary, it was noticed during data collection that this zone was avoided in many research programmes with Irish study focussing mainly on more central areas. On the U.K. side, a considerable number of surveys where identified as occurring on the general area but closer examination revealed that they stopped at the U.K. border and did not cross into Irish water presumably as permission for operations had not been sort. This scenario was especially true of deep water setting and particularly so for the Rockall Trough. In the Irish Sea, cross border surveys were common.



Figure 1. Area of interest representing a 50km zone within the Irish waters (stippled blue area) adjacent to the UK-Irish marine border (red line) and outside of the 12 nautical mile limit. Bathymetry from GEBCO.

# 3 2. DATA SOURCES

Considerable effort has been put into identifying the major cruises of the past 25 years. Dr. Andrew Wheeler has been actively involved in a number of recent cruises in the area as well as comparable data compilation exercise for Irish clients with the result that significant data was available in-house. These includes metadata holdings for the Irish Sea and Rockall Trough collected as part of various former and on-going project activity in these areas.

Nevertheless, it was prudent to widen the search. The World Wide Web also has a number of searchable databases relating to marine research activity that cover the area of interest. Those sits which proved useful for the present study are briefly described below:

The French SISMER site (see *http://www.ifremer.fr/sismer/*) provides concise cruise details from French cruises worldwide including coverage in the study area. Relevant details were extracted include cruise summaries and survey maps when available. Limited details are available specific sample sites and bibliographic references.

The NGDC GEODAS database documents trackline for geophysics data including side-scan sonar, refraction and reflection seismics, bathymetry etc. collected by survey vessels of a number of nationalities. The data is freely available on-line for downloading from the site ( see *http://www.ngdc.noaa.gov/mgg*). There is also a separate NGDC database for geological core data.

The Irish Sea Pilot study undertaken by the Joint Nature and Conservancy Council (JNCC) (see *http://www.jncc.gov.uk/marine/irishsea\_pilot/reports\_comments.htm*) contains a data review of Irish Sea metadata for the purposes of developing a set of nature conservation objectives for the Irish Sea. The purpose of the conservation objectives is to define that state of the marine environment in which the characteristic biodiversity of the Irish Sea can be sustained. The overview maps presented by this study are also included here.

Sea-Search (see <u>http://www.sea-search.net/roscop</u>) provides online access to cruise reports and has superceded the ROSCOP cruise report facility with a digital database.

TheBritishGeologicalSurveyGeoscienceDataIndex(see<a href="http://www.bgs.ac.uk/geoindex/index.htm">http://www.bgs.ac.uk/geoindex/index.htm</a>) shows map covering and metadata holding for UKwaters but also includes limited coverage into Irish waters that is relevant to this study.

The EU-Seased database (see <u>http://www.eu-seased.net</u>) contains a comprehensive database of core locations and geophysical datasets in EU waters that can be searched by map. The site covers input from EU Fifth Framework programmes collating metadata (EUROCORE, EUMARSIN and EUROSEISMIC).

Furthermore, metadata was also collated through contacts in OMARC (EU 5<sup>th</sup> Framework Programme Ocean Margin Research Cluster) and the Irish Geological Survey.

# 4 3. THE NATURE OF THE DATA

# 5 3.1. LINE DATA

Various types of line data are presented. This data type potentially covers seismic reflection and refraction (deep, intermediate and shallow), gravity, magnetics, side-scan sonar (various types including GLORIA and TOBI), swath bathymetry (SIMRAD EM 300 or similar) and echo-sounding. Other imagery systems such as sea-bottom video line are also line data.

When available, the vessels cruise track is presented. It should be noted that for parts of these tracks the vessel may be in-transit and therefore not actively collecting data. Those cruises where only transit lines cross the area of interest have been omitted. Where data is collected when the data is moving, e.g. most geophysical datasets, the metadata is available as line data.

#### 3.2. COVERAGE DATA

For seabed mapping surveys (e.g. side scan sonar and multibeam mapping), data is presented as coverages when available. In some cases, only areas of operation are available, this is particularly true to old cruises.

# 6 3.3. POINT DATA

Point data includes cores and short dredge samples for geological, geotechnical and biological purposes. Samples may penetrate the seabed from a few centimetres to several metres depending on the nature of the sampling gear and the purpose for which the samples was taken. Also included in point data are camera stills.

# 7 4. DATA PRESENTATION

Metadata has been compiled within a GIS facilitating map productions and data processing. An overview of all the data collected is presented in both map and tabular formats. Tabulated data is compiled on Excel spreadsheets.

Data was available both as details for existing data compilations (e.g. data holding for the British Geological Survey).and as individual cruises. Due to this duality in data compilation, metadata is presented both data compilations and cruise data separately.

For existing data compilations, details of the nature of database are presented as well as a overmap showing the locations of samples/geophysical coverages held in the database and finally a spreadsheet documenting the contents of the database which is included in the accompanying CD-ROM.

A similar presentation is given for individual cruise data with information concerning he nature of the cruise, a map showing the cruise track, sample stations or survey area as available and then a listing of the sample or geophysical survey metadata.

In addition a summary cruise spreadsheet is also presented which lists, where known, the programme name, ship, source of funding, cruise dates, descriptive location, coordinates, chief scientist, contact address, data types and comments.

A bibliography is presented at the end of this report.

All data presented in this report are also available on the accompanying CD-ROM.

# 8 5. DATA QUALITY

Data compiled for this report has been completed to the high standards possible with the budgetary and time constrains of the project. Whilst every effort has been made to make sure that no relevant data has been overlooked, it is appreciated that the possibility exists for dataset to be overlooked due to the disparate nature of the databases. Any omissions are therefore unintentional. Every effort has been made to transcribe data faithfully, however, issues of the quality of the original datasets have not been addressed. There are several aspects to this data quality issue.

Firstly, the quality of the original data acquired at the time of the survey may be variable especially for older surveys where advances in technology may make some datasets of poor quality, obsolete or surpassed by newer acquisitions. Some of the older datasets may not be digitally available or may have been poorly archived.

Secondly, older surveys based on pre satellite navigation, may have poor navigational accuracy. This may not be a problem in a general sense, but can become one when attempting to repeat sampling or line surveys in the same place some years later.

Thirdly, the collected data may have deteriorated over time. Tapes of seismic or imagery data may be unusable after 20 years and, depending on the nature of storage, physical sedimentary or biological samples may also have deteriorated or altered during storage or may have been used for analysis with no sample remaining.

Finally, purposely contains a degree of data duplicity e.g. between cruise entries and data compilation entries. Furthermore, some duplicity may also exist between different data compilation entries. No attempt has been made to rectify this as the details of the databases are presented in their entireties.

# **6. DATA COMPILATION RESULTS**

The following are metadata search results of existing databases and data compilation exercises

## British Geology Survey Seabed Samples Database

Cruise: Dates: Chief Scientist: Responsible Institute: Various 10/01/1953 – 10/01/1996 Various BGS, Edinburgh



#### Details:

Data presented is from the either the BGS's own sampling programs, or have been supplied by other and commercial organisations and are catalogued with the BGS. Listings of locations of numbered samples from the BGS archive, with details of BGS and commercially collected material. Each entry contains a position, degree square,water depth, terminal depth and type of sampling equipment e.g. Vibrocore, grab etc. The dataset is used to archive, cross reference and facilitate access to seabed samples collected for mainly geological and other reasons. Full details of any sample are available on request at a charge. Reference by BGS No and degree sq. Note, the latter is important as numbers cycle.

(see CD-ROM:/Spreadsheets/bgs and com bedsamples wgs 84a.xls)

### BGS Geoscience Database

Dates:	to present
Responsible Institute:	British Geological Survey

Includes seabed samples and geophysical survey lines

The British Geological Survey Geoscience Database holds details of all offshore sample and geophysical data collected and collated by the British Geological Survey that is relevant to UK offshore geology. This database also includes data that extends across the UK border into Irish waters. Note: the some of the data presented here is also reproduced elsewhere under specific cruises and also under the Geological Survey of Ireland dataholdings).

# 9 Seabed Samples







(see CD-ROM:/Spreadsheets/bgs geoscience samples.xls)

# 10Geophysical lines

DTI Strategic Environmental Assessment Area 6 Geology





DTI Strategic Environmental Assessment Area 6 Geology

(see CD-ROM:/Spreadsheets/bgs geoscience geophysics.xls)

## EU SeaSed Database

Dates:	to present
Responsible Institute:	EU

Includes seabed samples and geophysical survey lines

The EU Seased database contains a comprehensive listing of seabed sediment sample locations collected in EU waters as a results of data gathering in 3 EU 5FP projects (EUMARSIN, EUROCORE and EUROSEISMIC) involving the main marine geology institutes in Europe.

11 Seabed Samples



(see CD-ROM:/Spreadsheets/eu seased.xls)

## <u>Geological Survey of Ireland – National Seabed Survey</u>

Cruise: Dates:	Various to present
CHIEF SCIENTIST:	M. GEOGHEGAN
Responsible Institute:	GSI, Dublin

The Geological Survey of Ireland has completed multibeam surveying of Ireland Deep-water territories up to including areas adjacent to the UK border (3A, 3G, 3B and 3F). Datasets collected include:

Multibeam bathymetry and backscatter Sub-bottom profiler Magnetics Gravity



## Geological Survey of Ireland – Seabed samples



#### Details:

Set of records for systematic geological seabed sampling program. Original data collected during many research cruises. Data combined into Geoman archive management product by Irish Marine Data Centre. Total of 611 samples, with verbal field descriptions of sample characteristics. Locational data in Decca, subsequently plotted to latticed Admiralty Charts, and derived Geographic Co-ordinates manually entered to database (IMDC).

(see CD-ROM:/Spreadsheets/gsi bedsamples wgs 84.xls)

### Irish Sea Pilot Study

Dates:	August 2003
Responsible Institute:	JNCC

Overview map of the Irish Sea based on metadata collections for the Irish Sea Pilot Study.





Regional Side-scan Sonar surveys

Dates:	to present
Responsible Institute:	Various

The following regional side-scan sonar coverages were collected in the ECOMOUND project (EU Fifth Framework) and include TTR surveys (Training Through Research – Moscow State University/UNESCO) and SOC TOBI and GLORIA Surveys.



### SWISS sediment samples

Cruise: Dates: Chief Scientist: Responsible Institute: RVs Celtic Voyager and Prince Madoc 01/06/1997 – 10/11/1999 J. Wilson? (Trinity College Dublin) Trinity College Dublin



#### Details:

A baseline study of the sediments of the Southern Irish Sea. Location and description of van veen grab seabed samples. Carried out as part of an extensive survey of the benthic environments of the Irish and Celtic Seas. To be combined with faunal data to aid the definition of habitat boundaries.

# 7. RESULTS BY CRUISE

The following metadata details refer to individual cruises that fall within the study area.

## Benthos Mer Celtique

Cruise: Dates: Chief Scientist: Responsible Institute: Thalassa I - Benthos Mer Celtique 16/06/1977–06/07/1977 Louis Cabioch IFREMER



#### Details:

Study of the Celtic Sea in relation to ecological and grain size parameters. Data collected includes:

- Zoobenthos: identification, special and termporal distribution, community descriptions
- Physical sediment analysis

## Cartopep



#### Details:

Hydrographic mapping of the zone between %&oN and 54.5oN in preparation for future survey (Prospec1 of the Thalassa). Datsets collected include:

• EM12 Multibeam bathymetry

# Challenger 3-85

Cruise:	Challenger 3-85
Dates:	14-27.04.85
Chief Scientist:	?
Responsible Institute:	SAMS



#### Details:

Station Number	Date	Lat Start	Long Start	Water depth start	Sample type	Comments
Chall' 3/85	14.04.1985	55.10000	-11.36667	2760	Agassiz Trawl	Depth approx
Chall' 3/85	15.04.1985	54.65000	-12.25000	2946	Epibenthic Sledge	250um fraction
Chall' 3/85	15.04.1985	54.66667	-12.20000	2906	Agassiz Trawl	
Chall' 3/85	15.04.1985	54.65000	-12.23333	2906	Epibenthic Sledge	0.5mm net. 250um
Chall' 3/85	16.04.1985	54.73333	-12.28333	2896	Agassiz Trawl	
Chall' 3/85	18.04.1985	56.71667	-9.35000	1383	Agassiz Trawl	
Chall' 3/85	20.04.1985	57.30000	-10.36667	2190	Agassiz Trawl	
Chall' 3/85	21.04.1985	57.31667	-10.41667	2190	Epibenthic Sledge	250um fraction
Chall' 3/85	26.04.1985	56.46667	-9.26667	970	Agassiz Trawl	
Chall' 3/85	27.04.1985	56.36667	-9.20000	775	Agassiz Trawl	
Chall' 3/85	27.04.1985	56.38333	-9.13333	525	Agassiz Trawl	

DTI Strategic Environmental Assessment Area 6 Geology

# Challenger 10-83

Cruise:	Challenger 10-83
Dates:	24/07/83-06/08/83
Chief Scientist:	?
Responsible Institute:	SAMS



#### Details:

sample type	date	latitude	longitude	depth	comments
Box core	24.07.83	57 06N	09 22W	992	<0.25m*2, unsorted
Bed Hop Camera	24.07.83	57 06N	09 22W	1042	
Box core	24.07.83	57 06N	09 22W	1172	Weighed & 'speciated'
Box core	24.07.83	57 05N	09 21W	1028	Weiched & 'speciated'
Agassiz Trawl	24.07.83	57 07N	09 23W	1047	Huge muddy sample
Bed Hop Camera	24.07.83	57 07N	09 22W	1007	
Box core	25.07.83	57 22N	10 19W	2165	Subdivided box, Unsorted
Box core	25.07.83	57 22N	10 19W	2160	<0.25m*2, Unsorted
Bed Hop Camera	25.07.83	57 22N	10 17W	2155	
Epibenthic Sledge	25.07.83	57 23N	10 20W	2150	Megafauna, 4mm
Agassiz Trawl	26.07.83	57 21N	10 21W	2165	
Agassiz Trawl	27.07.83	59 02N	10 55W	2084	
Agassiz Trawl	27.07.83	59 59N	10 33W	1150	Phormosoma measured
Agassiz Trawl	28.07.83	59 44N	12 36W	1265	

## DTI Strategic Environmental Assessment Area 6 Geology

Epibenthic Sledge	28.07.83	59 43N	12 33W	1270 Some megafauna
sample type	date	latitude	longitude	depth comments
Agassiz Trawl	30.07.83	58 52N	12 56W	1530
Epibenthic Sledge	30.07.83	58 52N	12 53W	1510 Megafauna
Bed Hop Camera	30.07.83	58 52N	13 09W	1485
Agassiz Trawl	31.07.83	58 26N	12 35W	1595
Epibenthic Sledge	31.07.83	58 26N	12 42W	1595 Megafauna
Agassiz Trawl	31.07.83	57 56N	12 21W	1705
Epibenthic Sledge	31.07.83	57 55N	12 18W	1700 Megafauna
Rock Dredge	01.08.83	57 56N	13 24W	135
Agassiz Trawl	01.08.83	57 27N	12 52W	1041
Bed Hop Camera	01.08.83	57 21N	12 00W	1844
Epibenthic Sledge	01.08.83	57 24N	12 05W	1824 Tiny sample, Megafauna & all Echinods
Box core	02.08.83	56 30N	13 30W	2074 Chalk seabed
Box core	02.08.83	56 30N	13 30W	2049 Chalk seabed
Epibenthic Sledge	02.08.83	56 26N	13 31W	2144 Some megafauna & 4mm echinods
Agassiz Trawl	02.08.83	56 29N	13 26W	2235 Gear lost
Epibenthic Sledge	03.08.83	56 24N	11 59W	2591 Megafauna &4mm echinods
Agassiz Trawl	03.08.83	56 24N	11 58W	2605
Bed Hop Camera	04.08.83	56 24N	11 60W	2591
Box core	04.08.83	56 41N	10 28W	2211 <0.25m*2, Unsorted
Agassiz Trawl	04.08.83	56 39N	10 35W	2255
Box core	05.08.83	56 40N	10 30W	2250 Good core
Agassiz Trawl	05.08.83	56 05N	10 28W	2185
Box core	05.08.83	56 10N	10 29W	2160 Subdivided box, Speciated
Box core	06.08.83	56 13N	10 06W	1961 <0.25m*2
Box core	06.08.83	56 14N	09 51W	1792 <0.25m*2
Box core	06.08.83	56 15N	09 44W	1593 <0.25m*2
Box core	06.08.83	56 15N	09 46W	1631 Good
Box core	06.08.83	56 17N	09 32W	1378<0.25m*2
Box core	06.08.83	56 18N	09 25W	1188<0.25m*2
Box core	06.08.83	56 20N	09 16W	1005 Small & washed core
## Challenger 20-87

Cruise:	Challenger 20-87
Dates:	20-31/10/87
Chief Scientist:	?
Responsible Institute:	SAMS



#### Details:

sample type	date	latitude	longitude	depth	comments
Agassiz Trawl	20.10.87	54 41N	12 11W	2896	
Epibenthic Sledge	20.10.87	54 42N	12 19W	2880	1mm main net, most molluscs & echinoderms
Epibenthic Sledge	21.10.87	54 41N	12 18W	2885	1mm main net, most molluscs & echinoderms
Agassiz Trawl	24.10.87	57 18N	10 24W	2190	
Epibenthic Sledge	24.10.87	57 20N	10 22W	2170	Poor sample, most molluscs & echinoderms
Epibenthic Sledge	27.10.87	57 21N	10 30W	2205	>4mm part sorted,most mollusc & echin'
Agassiz Trawl	29.10.87	56 35N	13 29W	1837	Trawl fast
Agassiz Trawl	30.10.87	56 33N	13 37W	1595	Trawl fast; wrecked, Lophelia
Agassiz Trawl	30.10.87	57 21N	12 41W	1710	Net badly torn
Box core	31.10.87	57 21N	10 21W	2170	Good core
Box core	31.10.87	57 22N	10 26W	2175	Subdivided box
Box core	31.10.87	57 22N	10 27W	2180	Good core

## Challenger 86

Cruise:	Challenger 86
Dates:	
Chief Scientist:	?
Responsible Institute:	SAMS



#### Details:

sample type	date	latitude	longitude	depth	comments
Epibenthic Sledge	16.11.91	54 40 N	12 16 W	2900	1mm net. Good sample
Epibenthic Sledge	17.11.91	54 40 N	12 16 W	2900	0.5 mm net. good sample
Agassiz Trawl	17.11.91	54 43 N	12 07 W	2890	Good sample
Epibenthic Sledge	17.11.91	54 40 N	12 16 W	2905	0.3 mm net. Small sample
Epibenthic Sledge	18.11.91	54 49 N	12 39 W	2900	1 mm net. Tiny sample
Agassiz Trawl	19.11.91	57 18 N	10 24 W	2220	Good sample
Epibenthic Sledge	19.11.91	57 20 N	10 21 W	2200	1mm net. Small sample
Agassiz Trawl	21.11.91	56 21 N	09 48 W	1640	Good sample
Agassiz Trawl	21.11.91	56 34 N	09 31 W	1370	Good sample + wood
Agassiz Trawl	22.11.91	56 36 N	09 17 W	960	Trawl fast. Small sample

## Charles Darwin 91a

Cruise: Dates: Chief Scientist: Responsible Institute: Charles Darwin 91a 02/03/95-22/03/95 B.S.McCartney Proudman



## Charles Darwin 93

Cruise:	Charles Darwin 93
Dates:	18-27.05.95
Chief Scientist:	?
Responsible Institute:	SAMS



#### Details:

Station Number	Date	Lat	Long	Water depth	Sample type	Comments
Darwin 93B	18.05.1995	56.473	-09.156	700	Multi core	Depth approx.
Darwin 93B	18.05.1995	56.48	-09.158	700	Multi core	Depth approx.
Darwin 93B	18.05.1995	56.478	-09.162	700	Multi core	Depth approx.
Darwin 93B	22.05.1995	56.517	-09.289	989	Multi core	
Darwin 93B	23.05.1995	56.517	-09.285	979	Multi core	
Darwin 93B	23.05.1995	56.515	-09.292	995	Multi core	
Darwin 93B	23.05.1995	56.514	-09.288	981	Multi core	
Darwin 93B	24.05.1995	56.01	-10.004	2072	Gravity core	
Darwin 93B	25.05.1995	56.734	-09.393	1497	Multi core	
Darwin 93B	26.05.1995	56.735	-09.385	1485	Multi core	
Darwin 93B	26.05.1995	56.733	-09.405	1490	Multi core	
Darwin 93B	26.05.1995	56.736	-09.405	1513	Multi core	

Darwin 93B	27.0519.95	56.737	-09.390	1501	Gravity core	

## Diaplu2



#### Details:

Surface sampling of the seabed to measure plutonium concentrations and its relationships to chemical changes and processing occurring in the sediments.

## Discovery 123

Cruise: Dates: Chief Scientist: Responsible Institute: Discovery 123 05/08/81-10/09/81 J.B.Wilson Royal Holloway University



#### Discovery 216

Cruise:	Discovery 216
Dates:	26/08/05 - 12/09/95
Chief Scientist:	P.J.Stretham
Responsible Institute:	IOS, Wormley



Figure 2 Discovery Cruise 216, cruise tracks

#### Details:

46 CTD casts (dissolved oxygen, nitrate, silicate, phosphate, salinity, HPLC chlorophyll-a, microzooplankton biomass, aluminium, HPLC pigments, dissolved trace metals, dissolved copper)

1 box core (sediment/chemical analyses)

10 multicores (sediment analyses, chemical analyses, pore water chemistry)

9 radionuclide samples (amino acids)

3 SAPS (stand alone pumping system – trace metals)

#### DTI Survey 1987

Cruise:DTI Survey 1987Dates:1987Chief Scientist:DTIResponsible Institute:DTI



## Faegas 1 Leg 1 - CH39

Cruise: Dates: Chief Scientist: Responsible Institute: Faegas 1 Leg 1 - CH39 (Jean Charcot) 25/06/1973–06/07/1973 Jean-Pierre Peypouquet IFREMER



#### Details:

Geological study of core material including planktonic assemblages of microfossils. Data sets collected include:

- Bathymetry
- Sediment cores
- Dredges

(see CD-ROM:/Spreadsheets/gsi cr 2-89 wgs 84.xls)

## Geological Survey of Ireland – Geoman Cruise 30

Cruise:GSI Geoman Cruise 30Dates:05/09/78 - 13/09/78Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was pinger subbottom profiler and echosounder. Part of fix plot record has been omitted due to ambiguous positional data.

(see CD-ROM:/Spreadsheets/gsi cr dub to wicklow dec deg.xls)

## Geological Survey of Ireland – Cruise 1/83

Cruise:GSI Cruise 1/83Dates:24/04/1983 - 29/04/1983Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was sparker, sub-bottom profiler and echosounder. NB part of the complete vessel track has been excluded owing to presence of poor or ambiguous positional data.

(see CD-ROM:/Spreadsheets/gsi cr 1-83 wgs 84.xls)

## Geological Survey of Ireland –Cruise 2/84

Cruise:GSI Cruise 2/84Dates:28/05/1984 - 02/06/1984Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was sparker, and boomer sub-bottom profilers and echosounder. Shallow seismic coverage to investigate probable presence of extensive coal deposits off the Dublin and Wicklow coasts.

(see CD-ROM:/Spreadsheets/gsi cr 2-84 wgs 84.xls)

### Geological Survey of Ireland – Cruise Lough Beltra 4/84

Cruise:Lough Beltra 4/84Dates:27/08/1984 - 08/09/1984Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was sparker seismics echosounder, and magnetometer . To carry out magnetic and sparker transects in the Carnsore area on behalf of Prof. Tom Murphy (DIAS) and (b) to carry outs sparker transects between Carnsore and the Scilly Isles. Only tracks for the Carnsore area have been made available here.

(see CD-ROM:/Spreadsheets/gsi cr 4-84 wgs 84.xls)

## Geological Survey of Ireland –Lough Beltra 3/85

Cruise:Lough Beltra 3/85Dates:01/11/1985 - 11/11/1985Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was seismics and echosounder . Examination of offshore continuation of host base metal deposits of Navan and midlands. Geological reconnaissance cruise to continue mapping of the near surface geology of Irish waters.

(see CD-ROM:/Spreadsheets/gsi cr 3-85 wgs 84.xls)

### Geological Survey of Ireland -2/89

Cruise:GSI cruise 2/89Dates:02/10/1989 - 13/10/1989Chief Scientist:R. KearyResponsible Institute:GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was single channel seismics (sparker) and echo sounder. Reconnaissance geological investigations.

## Geological Survey of Ireland -2/93

Cruise:	GSI cruise 2/93
Dates:	23/09/1993-02/10/1993
Chief Scientist:	R. Keary
Responsible Institute:	GSI, Dublin



#### Details:

Record of vessel track and fix plot for geological cruise. Equipment used was EG&G boomer, Simrad MS 922 Sidescan Sonar, RoxAnn, and echosounder. Detailed investigation of potentially economic gravel areas on south coast.

(see CD-ROM:/Spreadsheets/gsi cr 2-93 wgs 84.xls)

#### Prospec

Cruise: Dates: Chief Scientist: Responsible Institute: Prospec (Thalassa) 27/06/1996–21/07/1996 Jean-Claude Brabant IFREMER



#### Details:

- -28 chalutages de fond entre 900 et 2000 metres avec greement a 2 entremises jusqu'a 1800 metres puis essai autre greement jusqu'a 2000 metres sans flotteur.
- -3 chalutages pelagiques entre 1100 et 1400 metres, chalut a tres grandes mailles (76 sur 70 m), captures insignifiantes.
- -Observations du fond et du benthos a l'aide du Scampi (7) de 1000 a 2000 metres.
- -5 mouillages de nasses appates a fermeture automatique et chronometage du temps de capture.
- -2 mouillages du systeme MAEVA d'observation des poissons autour d'un appat.
- -Mise au point des sondeurs Micrel grand fond, observations des detections.
- -Reglage des chaluts, observations et mesure de leur geometrie.

• -Mensurations biologiques des captures, etude des otolithes, determination d'especes et catalogue photographique.

# 12

Westline 1993

Cruise: Dates: Chief Scientist: Responsible Institute:

Arcadian Searcher 1993 R.W.Hobbs BIRPS



# 13 **Deep**

# seismic

# profiles

## 8. BIBLOGRAPHY

The following is a list of references that are relevant to the above study. Although every effort has been made to make this list as inclusive as possible it is likely that some reference may have been overlooked.

Armishaw, J.E., Holmes, R. and Stow, D.A.V. 1998. Sedimentation on the Hebridean Slope Apron and Barra Fan, NW U.K. Continental Margin. In: Stoker, M.S., Evans, D. and Cramp, A. (eds.) Geological processes on continental margins: sedimentation, mass-wasting and stability. Geological Society London Special Publication, No. 129.

British Geological Survey and Geological Survey of Ireland (1990). Anglesey Sheet  $53^{\circ}N - 06^{\circ}W$  including Dublin  $53^{\circ}N - 08^{\circ}W$ . Sea Bed Sediments Map, 1:250,000. Ordnance Survey: Southampton.

Buckley, J.S. and Bailey, R.J. 1975. Geophysical evidence on the nature of the Hebrides Terrace Seamount. Scottish Journal of Geology, **111**, 37-45.

Carter, R.W.G., Johnson, T.W., McKenna, J. & Orford, J.D. (1987). Sea-level, sediment supply and coastal changes: examples from the coast of Ireland. *Progress in Oceanography*, 18, 79-101.

Geoghegan, M. (1986). Geological and geophysical surveys on the east and south coasts of Ireland. *In:* G. O'Sullivan (ed) *Lough Beltra - 1984 Proceeding of the 1984 Lough Beltra Workshop Galway March 2nd 1985*. National Board for Science and Technology: Dublin p.95-106.

Geoghegan, M., Gardiner, P. R. R. and Keary, R. (1989). Possibilities for commercial mineral deposits in Irish offshore area. *Marine Mining*, 8, 267-282.

Harris, C. R. (1980). Recent sediment distribution in Dublin Bay and its approaches. *Journal of Earth Sciences, Royal Dubin. Society*, 2, 41-52.

Irish Shell Petroleum Development Company (1979). *Site Survey, Kish Bank, Ireland*. Irish Shell Petroleum Development Company: Dublin.

Jacob, A.W.B., Neilson, G. and Ward, V., 1983. A seismic event near the Hebrides Terrace Seamount. Scottish Journal of Geology, 1983.

Jenner, J. K. (1981). The structure and stratigraphy of the Kish Bank Basin. *In:* L. V. Illing and G. D. Hobson (eds) *Petroleum Geology of the Continental Shelf of Northwest Europe*. Heyden: London. p.425-431.

Keegan, B. (1989). *Remots Reconnaissance Survey of Dublin Sewage Sludge and Dredge Spoil Disposal Grounds, July 1988.* Report for the Dept. of Marine: Dublin.

Keegan, B. F., Dinneen, P., Costelloe, M. and Cunningham, P. (1983). *Benthic Characterisation (1983) of the Dublin Bay Dumping Grounds*. University College Galway: Galway

Max, M. (1969). The oblique asdic and its use in an investigation of a marine high-energy environment. *SedImentology*, **13**, 105-122.

Max, M., Harris, C. R., Geoghan, M. A., Cathcart, G. S., Ní Conchuir, M. E. and Fahy, C. J. (1976). *A Preliminary Report on the Recent Sedimentation on the Sea Floor Immediately to the East of Dublin*. Geological Survey of Ireland Report Series, RS 76/1.

McArdle, P. and Keary, R. (1986). Offshore Coal in the Kish Bank Basin: Its Potential for Commercial Exploitation. Geological Survey of Ireland Report Series RS 86/3

McKenna, P. (1984). *Shallow Seismic Interpretation of the Kish Bank Basin*. Unpub. M.Sc. Thesis, Dept. of Applied Geophysics, University College Galway.

Naylor, D. (1965). Pleistocene and post-Pleistocene sediments in Dublin Bay. *Scientific Proceedings of the Royal Dublin Society*, A2, 175-188.

Omran, M.A. 1990. Geophysical studies in the Hebrides Terrace Seamount area. PhD thesis. University College of Wales, Aberystwyth.

Sutton, G. & Wheeler, A.J. (1999). Reconnaissance Assessment of Coastal Seabed Sand & Gravel Resources in the Form of Seabed Mapping & Quantification. 3<sup>rd</sup> International Conference on Shellfish Restoration ICSR Europe '99: 28:9:99-2:10:99, Jury's Hotel, Cork.

Sutton, G.D. & Wheeler, A.J. (2002). Geophysics, GIS and Gravel!. Abstract: *Geophysical Association of Ireland seminar "Marine Geophysical Investigations in Ireland Today"*, *Dublin 22nd May 2002* 

Warren, W. P. and Keary, R. (1989). The sand and gravel resources of the Irish Sea Basin. *In:* J. C. Sweeney (ed) *The Irish Sea Basin: A Resource At Risk*. Geographical Society of Ireland, Special Publication No. 3, pp.65-79.

Wheeler, A. J. (2002). Environmental controls on shipwreck preservation: the Irish context. *Journal of Archaeological Science*, **29**, 1149-1159.

Wheeler, A. J., Walshe, J. & Sutton, G.D. (2001). Seabed Mapping and Seafloor Processes in the Kish, Burford, Bray and Fraser Banks Area, Southwestern Irish Sea. *Irish Geography*, **34(2)**, 194-211.

Wheeler, A.J. & Sutton, G. (1999). *Literature and Data Review for the Arklow Banks within the Context of Offshore Wind-Energy Generation*. Final Report to Future Wind Partnership, Naas. 48pp.

Wheeler, A.J., J. Walshe, J. & Sutton, G. D. (2000). *Geological Appraisal of the Kish, Burford, Bray and Fraser Banks, Outer Dublin Bay.* Marine Research Series No. 13, Marine Institute, Dublin, 35pp.

Wheeler, A.J., Sutton, G., Keary, R., Walshe, J. & Hanlon, M. (1999). Reconnaissance Assessment of Coastal Seabed Sand & Gravel Resources in the Form of Seabed Mapping & Quantification. *Marine Research Measures Seminar 19<sup>th</sup> May 1999, Marine Institute, Dublin,* 

Wheeler, A.J., Walshe, J. & Sutton, G. (1999). *Geological Appraisal of the Kish, Burford, Bray and Fraser Banks, Outer Dublin Bay Area*. Final Report to the Marine Institute, Dublin. 63pp.

Whittington, R. J. (1977). A late-glacial drainage pattern in the Kish Bank area and postglacial sediments in the Central Irish Sea. *In:* C. Kitson and M. J. Tooley (eds) *The Quaternary History of the Irish Sea.* Seel House Press, Liverpool, p.55-58.

Wilson, J. G. (1984). Benthic Studies on the east Coast. In: (Ed. by G. O'Sullivan) Lough Beltra – 1984. Proceedings of the 1984 Lough Beltra Workshop, Galway, March 2<sup>nd</sup>, 1985. National Board of Science and Technology, Dublin. p. 60-67.

Wingfield, R. T. R. (1990). Glacial incisions indicating Middle and Upper Pleistocene ice limits off Britain. *Terra Nova*, 1, 538-548.

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