School of Geography and Environmental Sciences

EGM502 Seafloor mapping Handbook
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01. Introduction

Module co-ordinator

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Key text


UU Library Shelfmark QC242.2.L87 2010

Aims

1. To examine the principles and methodology of underwater acoustics as applied to seafloor surveying and exploration;
2. To undertake the processing, integration and interpretation of seafloor data;
3. To demonstrate the wide range of industrial and academic applications of underwater acoustics, and
4. To develop a range of key skills including numeracy, problem solving, presentation and communication appropriate to this area.

Learning outcomes

On successful completion of this module you should be able to:

1. Understand the basic theoretical concepts behind underwater acoustics;
2. Understand the techniques for the acquisition, processing and interpretation of seabed and subsurface acoustic data, and
3. Successfully integrate a diverse set of marine geological and geophysical data for the solution of an academic/industrial problem.
# 02. Lectures

Slides are available for download at the dropbox link:

[https://www.dropbox.com/sh/gpfxfImb81bg3bg/AAAA6RQEZWTAW6LZPRR8QgOLa?dl=0](https://www.dropbox.com/sh/gpfxfImb81bg3bg/AAAA6RQEZWTAW6LZPRR8QgOLa?dl=0)

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<td>Development of underwater acoustics</td>
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<td>3.</td>
<td>Wave propagation</td>
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<td>Reflection, backscattering, and target strength</td>
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<td>Transceivers</td>
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<td>Signal and noise</td>
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<td>Navigation and positioning</td>
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<td>Singlebeam echosounders</td>
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<td>Seismic profilers</td>
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<td>Sidescan sonars</td>
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<td>Multibeam echosounders</td>
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<td>Ground-truthing of acoustic data: the seafloor</td>
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<td>15.</td>
<td>Ground-truthing of acoustic data: the subsurface</td>
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<td>16.</td>
<td>Airborne remote sensors</td>
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<td>17.</td>
<td>Water column applications: navigation, military, fisheries and oceanography</td>
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<td>18.</td>
<td>Marine animal acoustics</td>
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<td>19.</td>
<td>Archaeological applications</td>
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<td>Geological applications</td>
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03. Practicals

Practical sessions are in IT Laboratory G049. ArcMap is used each week and you will need a minimum of 6 GB storage on a device with real-time read-write access (OneDrive is unsuitable). Bring the storage device with you each week. The practical sessions are designed to develop your GIS skills, acoustic data interpretation skills, and to aid you in the completion of assignment 3: an abiotic characterization of Belfast Lough. The material covered in these sessions contributes directly to assignment 3 – attendance at all practical sessions is therefore essential.

Relevant data are available for download at the dropbox link:

https://www.dropbox.com/sh/unos99fhojxprue/AABPdZQV2ZLVRqrjVn9mfkVRa?dl=0

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<td>1.</td>
<td>Introduction to module assessment and desktop research</td>
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<td>2.</td>
<td>MBES bathymetry data: ArcMap revision, MXD files, projections, rendering and shading</td>
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<td>3.</td>
<td>MBES bathymetry data: Bedforms, hydro dynamics and sediment dynamics</td>
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<td>4.</td>
<td>Class test 1</td>
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<td>5.</td>
<td>MBES backscatter data: segmentation, sediment samples and substrates</td>
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<td>6.</td>
<td>Shipwreck data, scour and depositional processes</td>
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<td>7.</td>
<td>Seismic stratigraphy</td>
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<td>8.</td>
<td>Class test 2</td>
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<td>9.</td>
<td>Scientific reports: structure and content</td>
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<td>10.</td>
<td>Time-lapse studies and difference-modelling</td>
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<td>11.</td>
<td>Workshop</td>
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<td>12.</td>
<td>Workshop</td>
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Practical 2

In this practical you will:

- Explore how to load raster data in ArcGIS and interrogate the spatial referencing and resolution of data;
- Plot, analyse and derive secondary products (hillsides, slope maps etc.) from MBES bathymetry data, and
- Learn how to output maps from ArcGIS with a view to producing professional quality figures for inclusion in assignment 3.

Practical 3

In this practical you will:

- Explore how to classify bedforms imaged on MBES bathymetric data using established schemes (Stow et al., 2009 and van Landeghem et al., 2009) with a view to producing a bedform classification for Belfast Lough for inclusion in assignment 3;
- Explore hydrodynamic data for Belfast Lough extracted from a numerical model (Callaway et al., 2011);
- Derive information on hydrodynamics and sediment dynamics from the morphology of the bedforms, and
- Begin to digitise the crestlines of the classified bedrooms in ArcGIS with a view to producing bedform maps for inclusion in assignment 3.

Recommended reading


**Practical 5**

In this practical you will:

- Explore subjective and objective methods to segment backscatter data;
- Explore how to classify MBES backscatter data using algorithms in ArcGIS;
- Explore how to derive substrate maps of the study area by combining segmented backscatter data with sediment data, with a view to producing a substrate map for inclusion in assignment 3.

Recommended reading


- Parker, JG, 1982a, Grain-size characteristics of Recent sediments in Belfast Lough, Marine Geology, 50: 143-154. (Hardcopy version in UU Library)


**Practical 6**

In this practical you will:

- Plot a database of UKHO shipwrecks for Belfast Lough and examine their distribution;
- Explore the spatial correlation between the UKHO wreck database and wrecks imaged on the MBES bathymetric data, and
- Derive information on hydrodynamics and sediment dynamics from the morphology of the scour signatures around the wreck sites with a view to including this information in assignment 3.

Recommended reading


Practical 7

In this practical you will:

- Be introduced to the concept of seismic stratigraphy, and
- Apply a seismo-stratigraphic approach to describing and interpreting a pinger seismic line from Belfast Lough, with a view to including this analysis in assignment 3.

Recommended reading

- Eyles, N, Boyce, JI, Halfman, JD, Koseoglu, B (2000) Seismic stratigraphy of Waterton Lake, a sediment-starved glaciated basin in the Rocky Mountains of Alberta, Canada and Montana, USA, Sedimentary Geology, 130: 283-311. (http://dx.doi.org/10.1016/S0037-0738(99)00120-7)

Practical 9

In this practical you will:

- Explore the principles of scientific writing and data presentation;
- Explore the IMRAD structure of scientific reports: where IMRAD is an acronym for introduction, methods, results, and discussion. Original research articles are typically structured in this basic order.
- This session will prepare you for writing assignment 3, and should help with your dissertation.
Practical 10

In this practical you will:

- Be introduced to the concept of difference-modelling, and
- Create a difference model of a wreck site using data from repeat MBES surveys.

Recommended reading


Practicals 11 and 12

These workshops are designed for you to resolve any issues you have with respect to assignment 3. I am there to help and address your questions.
04. Assignment 1

Class test 1

20% of module mark
Week 4 of semester
G049 during practical session
Duration 1.5 hours
The test examines material from lectures 2 to 6
Test comprises 6 questions. Answer 3.
Bring pens, a ruler, and a scientific calculator.

Sample class test questions (for class tests 1 and 2)

The answers will be marked using the qualitative/quantitative assessment criteria for Level 6 modules as described in the Ulster University Assessment Handbook.

1. (a) Draw and label a plot best approximating the variation in the speed of sound with water depth. (b) Discuss the factors influencing the shape of the curve.

2. Discuss the use of acoustic surveys in mapping temporal change in the marine environment. Inform your answer with references to case studies discussed in lectures and the broader scientific literature.

3. MBES are often described by their achievable angular sector (A). (a) Define the term angular sector, (b) discuss three factors that control the useful swath width of a MBES system, and (c) calculate the effective swath width of a MBES system (with respect to water depth) given A=110°. Show all calculations.

4. Discuss the vertical and horizontal resolution of seismic profilers.

5. The very high reflectivity of the air-water interface (+0.99) explains three phenomena that occur on sub-bottom profiles: long-path multiples, short-path multiples and blanking. Discuss the generation of long-path and short-path multiples, supporting your answer with illustrations.

6. Marine acousticians strive to acquire and interpret data characterised by high signal-to-noise ratio (SNR). Outline: (a) noise sources, (b) steps taken during data acquisition to ensure high quality acoustic data is available for post-processing, and (c) steps taken during post-processing to ensure high quality acoustic data is available for interpretation.

7. For hydrographic purposes we want to identify the first arrival (i.e. the seabed) when conducting bathymetric surveys. Discuss two methods for picking the seabed reflector from digital data and outline the positives and negatives of each approach.
05. Assignment 2

Class test 2

20% of module mark
Week 8 of semester
G049 during practical session
Duration 1.5 hours
The test examines material from lectures 7 to 13
Test comprises 6 questions. Answer 3.
Bring pens, a ruler, and a scientific calculator.
06. Assignment 3

Abiotic site characterization of Belfast Lough

60% of module mark
Deadline: 23.59 Sunday 18 December 2016
Submit to Turnitin

I. Background

The Convention for the Protection of the marine Environment of the North-East Atlantic (the 'OSPAR Convention') was open for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. It was adopted together with a Final declaration and an Action Plan. OSPAR is therefore the mechanism by which fifteen Governments of the western coasts and catchments of Europe, together with the European Community, cooperate to protect the marine environment of the North-East Atlantic. It started in 1972 with the Oslo Convention against dumping. It was broadened to cover land-based sources and the offshore industry by the Paris Convention of 1974. These two conventions were unified, up-dated and extended by the 1992 OSPAR Convention. The new annex on biodiversity and ecosystems was adopted in 1998 to cover non-polluting human activities that can adversely affect the sea. The fifteen Governments are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

The 'OSPAR Guidance on Environmental Considerations for Offshore Wind Farm Development' (Reference number: 2008-3) states that the "abiotic properties of a site for the assessment of environmental impacts and for engineering considerations in respect of the prospective location include, but are not limited to:

- the sediment characteristics (structure, topography, mobility, sediment transport) of a prospective location should be established since this is important basic information for characterisation and baseline surveys (e.g. planning of benthos investigations). The sediment characteristics can be ascertained by grab sampling and hydroacoustic methods;

- bathymetry and geomorphology need to be taken into account;

- information on the geological/geophysical structure at the site is important for an assessment of the general suitability of the location in the planning phase. The soil property data should be available well in advance of the beginning of turbine installation. Information on the soil properties is a technical prerequisite for the stable construction of the foundations of offshore wind turbines, thus ensuring the structural integrity and safety of the installation;

- for safety and environmental reasons information on the prevailing wind speeds, hydrographic conditions (e.g. currents, wave heights) and if applicable ice conditions should be assessed, and

- for sites of archaeological interest, planned locations of foundations and cables should be adjusted; hydroacoustic/seismic surveys and evaluation of historical records in the planning phase required.
2. Assignment

Your assignment is to address the abiotic aspects of the Environmental Impact Assessment for a planned offshore renewables site in Belfast Lough by completing an abiotic site characterization report. The renewables site is to be developed by a local engineering firm, traditionally involved in the shipbuilding industry, but now expanding into offshore renewables. The practical sessions in weeks 1-12 are all designed around this assignment, so attendance is essential.

The following data are provided for the assignment and will be processed during the practical sessions in ArcGIS:

- Coincident MBES bathymetry and backscatter data;
- Seismic data;
- Shipwreck database;
- Sediment samples.

You can download the acoustic and GIS data from this dropbox link:

https://www.dropbox.com/sh/unos99fhojxprue/AABPdZQV2ZLVRqrjVn9mfkVRa?dl=0

3. Instructions to authors

Word limit: 3000
Figures: Maximum of 8 (composite figures are allowed)
Tables: Maximum of 3
Referencing: The Harvard referencing system should be used

- Write to inform, not to impress.
- Use simple clear language. Do not use long words where short words will do.
- Ask a colleague to read a draft of the paper and be prepared for constructive criticism.
- If one reader does not understand parts of your text, others will have the same problem.
- Make sure the paper follows a clear logical structure and does not jump around between ideas.
- Use subheadings effectively but not excessively - each subheading should comprise more than one paragraph.
- Make sure paragraphs are not too long (more than a single page) or too short (less than three sentences).

4. Guidelines for writing the scientific report

The report should be divided into the seven parts: Title, Abstract, Introduction, Material and Methods, Results, Discussion, and References. The IMRAD structure is the most prominent norm for the structure of a scientific journal, where IMRAD is an acronym for introduction, methods, results, and discussion. Original research articles are typically structured in this basic order.

Use an outline to organise your ideas before you start writing your paper. Make an outline of the major headings and subheadings. List the key ideas under each heading. Organize your thinking, narrative and arguments at this stage.
Abstract

The abstract is a one paragraph summary (usually 200-300 words) of the entire article. The abstract should be self-contained, capable of being understood without the benefit of the main text. It should contain four elements:

1. the scope and principle objectives of the study (the central question);
2. a brief description of the methods used;
3. a brief summary of the results, and
4. a statement of the principal conclusions.

Do not refer to the paper in the abstract. If uninformative phrases such as 'is discussed' and 'is shown' appear in the abstract, the above criteria are not met.

Introduction

The purpose of the introduction is to tell readers why they should want to read what follows. It should:

1. present the nature and scope of the problem;
2. review the pertinent literature (within reason);
3. briefly outline the method of investigation, and
4. conclude with a clear statement of aims/objectives and/or hypothesis/hypotheses.

Material and Methods

The methodology section should begin with a background to the study site, describing the key physical elements and processes of the landscape taken from the existing literature. The methodology should be written in the past tense and in sufficient detail that a competent scientist could replicate the work. It should focus on the methodology you used to condition, process, and interpret the data.

Results

The results section contains applications of the methodology described above. The results are data and can be presented as tables or figures, and analyses. Whenever possible, include at least one example of recorded data to illustrate the concept being proposed. Selective presentation of results is important. Redundancy should be avoided, and results of minor variations on the principal experiment should be summarized rather than included. Details appearing in figure captions and table heads are not restated in the text. The patterns, trends and outliers in results should always be described in the results section and links to figures and tables provided to ensure internal consistency in the paper.

Discussion and Conclusions

Often scientists hesitate to impose their interpretations and conclusions on the reader, especially those that pertain to the significance of their results. However, without interpretations and conclusions, readers can only wonder why they read the manuscript. Readers are unlikely to ascribe any more significance to a paper than the author gives it.
The Discussion and Conclusions sections should include:

1. the principles, relationships, and generalisations inferred from the results (but not a repetition of the results);
2. any exceptions to, or problems with, these principles, relationships, and generalisations as indicated by the results;
3. agreements or disagreements with previously published work;
4. theoretical implications and possible practical applications of the work, and
5. conclusions drawn (especially regarding significance), with a summary of the evidence for each conclusion.

Figures and tables

- You are limited to 8 figures and 3 tables. Therefore you need to think carefully about the content of every figure and table. Composite (multi-part or multi-element) figures are effective.
- Figures and tables should be numbered in order of appearance.
- A figure/table caption should contain sufficient information so that a reader can understand a table or figure without reference to the text.
- Captions are often most effective when they briefly summarize the main result presented in the table or figure.
- Figure captions are positioned below a figure. Table captions are positioned above a table.

5. Resources

Below are some references to help get you started. This is by no means an exhaustive list of relevant papers, but you should read these at a minimum. The final site report should be informed by both the scientific and the grey literature (there are some excellent examples of site reports for offshore renewables online).


Parker, JG, 1982a, Grain-size characteristics of Recent sediments in Belfast Lough, Marine Geology, 50: 143-154.


6. Software

To produce effective scientific diagrams takes time, thought, effort and a decent drawing package. Download Inkscape and GIMP from the links below:

**Inkscape** is vector graphics software which runs on Windows, Mac OS X and Linux. It is similar to Adobe Illustrator and Corel Draw, but is free.

https://inkscape.org/en/

**GIMP** is a raster graphics editor which runs on Windows, Mac OSX and Linux. It is similar to Adobe Photoshop, but is free.

https://www.gimp.org

**QGIS** is an open source geographic information system which runs on Windows, Android, MacOSX and Linux. It is similar to ESRI ArcGIS, but is free.

http://www.qgis.org/en/site/
**Recommended reading**


Parker, JG, 1982a, Grain-size characteristics of Recent sediments in Belfast Lough, Marine Geology, 50: 143-154. (Hardcopy version in UU Library)


(http://dx.doi.org/10.1111/j.1095-9270.2010.00272.x)
## A1. Assignment 3 marking scheme

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### Abstract (5%)
Abstract is succinct (<300 words) and accurately summarizes the study, methodology, results, and conclusions.

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### Introduction (10%)
The introduction presents the nature and scope of the study, reviews the pertinent literature and presents clear and achievable aims and objectives.

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### Methodology (10%)
Methods for the processing and analysis of the data is detailed, clear, effective and informed by the literature. Methodology is written in the past tense.

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### Results (35%)
Results are clearly and accurately presented and described. Accurate terminology is used. All data sets provided are used to good effect and integrated effectively. Maps and graphs are accurately drafted and presented.

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### Discussion and conclusions (20%)
The principles and relationships inferred from the results are summarised. Agreements or disagreements with previously published work are discussed, and theoretical implications and possible practical applications of the work and conclusions are drawn.

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### Presentation (10%)
Outstanding presentation, logically structured, correct spelling and grammar.

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### Referencing (10%)
Outstanding referencing and bibliography. Extensive evidence of integrating appropriate supplementary sources.

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### Main strengths
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### Main weaknesses
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### Turnitin similarity

### Module attendance

Mark*  

* Marks are provisional until confirmed by the Board of Examiners
Notes