The Crown Estate

R3 Sediment Gap Analysis

Date: August 2009

Project Ref: R/3843/2

Report No: R.1538

ABP mer
marine environmental research

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Version	Details of Change	Authorised By	Date
1	Draft	A M Fulford	15.05.09
2	Final	A M Fulford	04.08.09

Document Authorisation		Signature	Date
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Project Overview - R3 Sediment Gap Analysis

Background

The objective of the gap analysis study is to inform The Crown Estate where to focus any enabling marine surveys that can be usefully advanced during 2009 (to obtain additional bathymetric, sedimentological, geophysical or geotechnical evidence) that can be usefully applied by developers in support of R3 zone development and project planning. This study has been carried out by ABP Marine Environmental Research Ltd. (ABPmer), with assistance in data collection and collation from British Geological Survey (BGS).

It is envisaged that the seabed related evidence, when acquired and collated, will support the decisions to confirm suitable project areas within zones and that additional data will be obtained once precise project areas are fully confirmed.

At this stage suggested zones for development have been identified by The Crown Estate based on the application of their MaRS (Marine Resource System) planning tool. Developers interested in Round 3 have already been considering the scale of projects, on a regional level, which they might expect to deliver within any zone. Both exercises have been mainly based on existing broad-scale publications only and, as such, have not considered the detailed data availability that this study is concerned with.

Project Development Risks

To move from a regional scale assessment to confirmation of project scale issues requires an enhanced understanding over a range of interests, not least the sedimentological and geophysical nature of the seabed. It has been recognised that a range of detailed data on these already exists, which needs to be collated and assessed or gaps might be present (i.e. no data coverage or existing data is insufficient) which can only be filled by conducting new surveys.

For offshore wind farm developments, it is important to understand the composition of the seabed to inform an assessment of site location, cable laying options and the suitability for foundations, with different types of foundations posing different issues. In previous rounds of wind farm development a poor understanding of the seabed has led to increased difficulties in project delivery or even withdrawal of a project.

Project areas need to be established within each zone, based on an awareness of potential constraints (of various types including developmental, environmental and engineering). Ideally areas will be relatively flat and featureless, barren of sensitive features and without mobile sediments. The site should also have sub-soils with the geotechnical strength to support heavy gravity base foundations (or that can be piled into for mono-pile foundations) and be easily ploughed through for laying cables. Conditions different to these potentially involve more expensive engineering solutions and may incur more complicated environmental issues, but this should not preclude their consideration as potential sites.

For areas with highly mobile sediments additional risks may occur over the lifetime of the project where the depth to the seabed either increases or decreases over the longer term. This may alter the design loads on the structures, introduce the need for additional scour protection, affect the integrity of cable burial or complicate access conditions. Ongoing detailed monitoring of the seabed would then become essential to help manage these risks.

Data types required for a typical project include:

- Absolute water depths to an agreed datum achieved through use of multibeam surveys;
- Texture of the seabed to resolve morphologies (e.g. height, asymmetry and wave length of sandwaves, megaripples, obstacles, etc) achieved through sidescan or multibeam;
- (Geophysical) sub-bottom profiling to resolve sediment thickness;
- Particle size distributions of the surface sediment achieved through grab sampling and at sufficient locations to resolve major variations over development areas;
- (Geotechnical) boreholes to define loading properties of soils, required at detailed design and based on preferred foundation solution(s). To include particle size distributions of unconsolidated materials below the seabed.

For the identified zones, 100% coverage of relevant, up to date surveys would be most helpful and may assist in avoiding the requirement to repeat surveys at a later date when project areas become confirmed (depending on the timescales involved and the requirement for up to date data). Grab samples may need to be undertaken on completion of the multibeam and sub-bottom profiling to then target discrete areas where seabed textures appear to show variation.

Approach

To address the objectives identified above, the following stages of work have been undertaken, which are further discussed in Sections 1 and 2 of this report.

- Section 1. Compilation of a UK wide outlook on presently available data related to the physical properties of the seabed. The key deliverable from this stage of work is a series of GIS metadata layers to indicate the data availability only. It is important to note that the GIS layers do not include the data itself. This stage of work is described in greater detail in Section 1 of this report, but the primary themes of information include:

  - Seabed soundings;
  - Discrete sediment samples;
  - Shallow geophysical profiles;
  - Shallow cores (e.g. vibrocores and boreholes).

  A further datalayer is also provided which forms an assessment of confidence in the available data, which has been drawn, in part, from the age of the data and survey method employed.

- Section 2. The application and interpretation of Stage 1 data to current strategic areas of interest and to determine any gaps in the context of the available data to the type of interest. The present and immediate interests of this study are the nine R3 zones. The focus of such interpretation offered in Section 2 is related to potential coastal process applications in support of high-level project planning, outline engineering design and broad-scale environmental assessment (e.g. REA level). This interpretation stage links with the previously reported high-level risk review (ABPmer, 2009). For example, if a risk which has been indicated in the high-level review needs to be investigated further can we confirm here that there is sufficient data already available which can be obtained now to enable a more detailed review. Alternatively, is there a clear gap which is important enough to be targeted in any survey work planned for 2009.

  The output from this stage of work is the assessment of gaps in the available data which is contained in Section 3 of this report.

Acknowledgements

The authors would like to thank Rhys Cooper, Paul Henni and Bob Gatliff of British Geological Survey (BGS), Edinburgh for the provision of the metadata layers and their invaluable assistance in the interpretation and analysis stage.

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1. Preparation of UK-Wide Data Holdings

(Further information on the digital outputs from this stage of the study is given in Appendix A).

The aim of this stage of the study was to capture a UK-wide inventory on publicly available seabed geophysical and geotechnical data. The initial part of this study was assisted by British Geological Survey (BGS) in what was essentially a data collection and collation exercise, concerned with identifying the available relevant data for UK waters. In addition to the data holdings of BGS themselves, metadata (data about data) from other organisations, including UKHO SeaZone, JNCC and ALSF funded studies, has also been sourced and included in the UK-wide dataset.

The technical specification was to compile a UK wide outlook on presently available data related to the physical properties of the seabed. The key deliverables of this task were a series of metadata GIS layers (provided in ESRI shapefile format) to indicate the data availability only. The GIS layers do not include the data itself. The primary themes of information include:

- All marine seismic, seabed samples and shallow cores held in the BGS archive;
- A map of digital singlebeam bathymetry data (SeaZone);
- Outlines of all multibeam data that BGS hold (primarily the MCA data plus SEAS, aggregate levy and some small patches of oil industry data);
- Summary of aggregate levy, SEAS data;
- Oil industry site investigation data that BGS hold;
- Any other data that BGS could source in the Round 3 areas (e.g. JNCC surveys; COWRIE data; REC surveys).

Data that is not included in these GIS layers includes non-digital data and any records held privately by commercial companies (for example prospecting surveys conducted by the aggregates industry).

The attribute data attached to each GIS layer primarily aimed to capture the following information as a minimum (although not all of these fields were available for all data):

- Source of the data;
- Type of data;
- Date of collection / creation;
- Survey type / instrumentation used (if applicable);
- Data format;
- Data resolution / sampling frequency; and
- Any other available information.

These GIS layers form part of the project deliverables and are offered as a 2009 edition (to recognize the fact that data availability will continue to expand as new surveys are conducted), with the available UK-wide data being described in six separate ESRI shapefiles. These shapefiles are further described below.

1.1 GIS Shapefiles

1.1.1 'Samples' Shapefile

This file is a *Point* shapefile containing metadata on available sediment samples, from both BGS and non-BGS sources. The nature of these samples varies from borehole data and surface grab samples to gravity cores and vibrocores. In addition to sample location and date, information is also provided on equipment used and total sample depth achieved (i.e. the depth below the seabed to which the sediment core extended).

1.1.2 'Tracks' Shapefile

This is a *Polyline* shapefile containing the track lines of available seabed surveys, from both BGS and non-BGS sources. The 'Tracks' shapefile includes information on bathymetric data from echosounder and sidescan sonar surveys, as well as sub-bottom geophysical surveys carried out using (among others) Boomer, Pinger and Sparker equipment.

1.1.3 'Multibeam' Shapefile

This is a *Polygon* shapefile detailing the extent of the available multibeam seabed surveys. The majority of these surveys have been carried out by MCA although some additional data sources are also included.

1.1.4 'ALSF_EastCoastREC' Shapefile

This is a *Polyline* shapefile containing survey track lines from the ALSF funded surveys of the East Coast region. The tracks show the location of surveys carried out using echosounder, sidescan sonar, magnetometer and Boomer equipment.

1.1.5 'ALSF_HumberREC' Shapefile

This is a *Polyline* shapefile containing survey track lines from the ALSF funded surveys of the Humber region. The tracks show the location of surveys carried out using echosounder, sidescan sonar, magnetometer and Boomer equipment.

1.1.6 'SeaZone_BathyExtents' Shapefile

This is a *Polygon* shapefile detailing the extent of available single beam bathymetry surveys, currently held by UKHO and distributed through SeaZone.

A further datalayer ('Confidence Grid' shapefile) is also provided, giving an assessment of confidence in the available data, drawn in part from the age of the data and the survey method. Additional information on the metadata layers (including details of how the confidence grid was created along with a list of the abbreviations used in the fields of the shapefile attribute tables), is included in Appendix A of this report.

For all data types, exact extent, resolution and post processing information for specific samples / tracks / surveys is available from BGS.

It is to be noted here that the intellectual property rights (IPR) of the GIS metadata layers will remain with BGS. BGS is the designated UK Data Archive Centre for geophysical data and they retain the responsibility to manage data of this type and to maintain an up to date record of available data. To recognise the IPR of the GIS metadata layers, these outputs are offered to The Crown Estate under licence, which also identifies version. The available metadata can then be offered onto developers freely as an extension of The Crown Estate licence.

2. Application of Data Assessment to the Nine R3 OWF Zones

2.1 Introduction

Section 2 of this study has been carried out by ABPmer and forms a report on the interpretation and application of the UK-wide metadata coverage (output from Section 1) to support decisions related to R3 pre-award planning and preparatory studies.

Information from a wide range of enabling works is required throughout the planning, construction, operation and decommissioning of an offshore wind farm (OWF) installation. In order to establish an environmental baseline condition, against which potential impacts can be referenced, and also to assist with site location and structural design of the turbines and foundation structures, data is required on the prevalent physical properties of the seabed.

As discussed in the Project Overview section of this report, consideration of relevant and up to date information on the nature of the seabed is important at a number of stages during the development of an OWF project. Initially, a description of the baseline conditions is required in order that any potential impact of the OWF development can be described. This baseline includes a description of the seabed sediments so that an assessment of possible plume dispersion can be carried out, as well as a description of any seabed features that may be present, to determine their likely ecological importance.

From an engineering perspective, sound knowledge of the geophysical conditions is important not only for initially siting the OWF, but also to inform on an assessment of the suitability of different foundation options and to gauge the potential risk of scour. This includes a need for information on the geotechnical stability of the bed or the ability to pile into the underlying bedrock, as well as the practicality of burying cables.

During the construction and operation stages of development, additional risks are imposed on areas with a highly mobile bed. The sediment type and presence of bedforms are of key importance in determining seabed mobility, which can have implications on scour, undermining of foundations and exposures of cables.

Throughout the assessment stages, increasingly more detailed, localised and up to date data is required when progressing from initial broad-level studies, through regional-level assessments to a site specific project-level appraisal. The increasing need for detail means that the data

requirements to carry out each type of study vary greatly. This report provides a view on data sufficiency for both a 'zone-level' and a 'project-level' assessment.

The assessment of data sufficiency takes the form of a 'gap analysis' whereby the available data of various types, ages and sources (output from Section 1 of the study) is considered on a zone-by-zone basis. Gaps in the available data can then be identified and their significance to regional and site specific studies assessed. The types of data considered are described below in more detail.

2.2 The Data

A summary of the data considered in this report is given in Table 1.

Table 1. Data type and shapefile location

Data Type	Contained in Shapefile(s)	ESRI Shapefile Type
Bathymetry	Multibeam.shp	Polygon
	Tracks.shp	Polyline
	Seazone_BathyExtents.shp	Polygon
	ALSF_EastCoastREC.shp	Polyline
	ALSF_HumberREC.shp	Polyline
Seabed Features	Multibeam.shp	Polygon
	Tracks.shp	Polyline
	ALSF_EastCoastREC.shp	Polyline
	ALSF_HumberREC.shp	Polyline
Surface Sediments	Samples.shp	Point
Sub-Bottom Profiling	Tracks.shp	Polyline
	ALSF_EastCoastREC.shp	Polyline
	ALSF_HumberREC.shp	Polyline

A description of the different types of data considered for each of these classes is described below.

2.2.1 Bathymetry

Sources of bathymetry data include multibeam surveys which cover large areas of the seabed in great detail; and single beam surveys (echosounder or sidescan surveys) which collect data at discrete points along a survey line. Due to the wide coverage, the availability of multibeam data is considered of greater use to an assessment of bathymetry than single beam surveys. For each data type, the resolution of the survey itself will determine how detailed the bathymetry data is.

2.2.2 Seabed Features

In general, these can only be described from multibeam data, although some single beam surveys (such as sidescan) may provide information from narrow survey tracks. For other methods, only the presence of larger bedforms such as sandwaves and dunes may be suggested. Due to the wide coverage, the availability of multibeam data is considered of greater use to an assessment of seabed features than single beam surveys. As with

bathymetry data, the survey data resolution will ultimately determine what type of seabed features can be identified.

2.2.3 Surface Sediments

Data on surface sediments is obtained primarily from grab samples and cores taken at discrete locations (although there are a number of different types of each of these collection methods, as shown in Plot 1). For a description of the surface sediments, grab samples or cores are considered the most useful type of sample since they allow for a range of processing options to determine particle size, dependant on bed type. Other survey techniques, such as video surveys, may allow some estimation to be made of sediment type but this will likely only be of a qualitative nature.

2.2.4 Sub-Bottom Profiles

There are a number of survey techniques for collecting geophysical information from the sub-surface. Pinger surveys typically penetrate up to 30m below the seabed, whilst Boomer and Sparker equipment can record data up to 80m and 120m respectively. For deeper surveys, Airguns can typically collect data up to 2km below the bed. For a typical OWF development, sub-bottom profiles up to approximately 30m depth are usually sufficient since this tends to be the depth to which monopile foundations extend. In general terms, sub-bottom profiling tends to be a trade-off between depth penetration and resolution. For this reason, Pinger and Boomer surveys are likely to be more useful than Sparker and Airgun equipment, since they should provide data at a higher resolution over the relevant depth. In addition, Magnetometer and Gravimeter surveys can determine information of sub-surface rock type.

2.3 Initial Data Analysis

The UK-wide data was first 'clipped' to focus only on the areas of interest, in this case the nine R3 OWF zones. The 'samples' shapefile was then interrogated to determine the number of successful bed samples that existed within each of the nine R3 OWF zones. The number of successful samples was then combined with the area of the zone to determine the 'sample density' to initially determine zones that were limited in the number of bed samples available. An initial review of the BGS sediment maps was also carried out to obtain a measure of the homogeneity of the seabed, since the more the seabed changes across a zone, the higher number of samples are required to adequately describe its character. The number of different sediment types observed over each zone is given in Table 2.

A similar process was carried out on the 'multibeam' data, although since this dataset is in polygon format, the percentage area coverage of multibeam data within each zone was calculated. Areas where multibeam data did not exist were then investigated to determine whether or not other bathymetric data sources were available (e.g. single beam surveys from BGS tracks, ALSF surveys or SeaZone Digital Survey data).

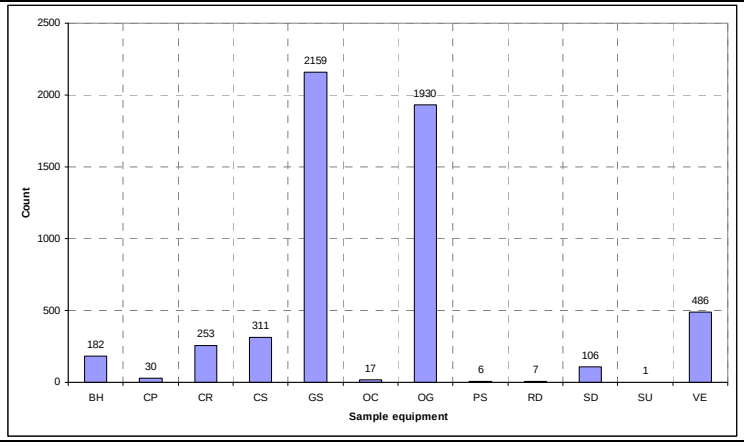
Tables 2 and 3 show the density of successful sediment samples and percentage coverage of bathymetric data for each of the nine OWF sites, whilst Plot 1 shows a breakdown of the successful sediment samples, by type, for all of the nine R3 zones combined.

Table 2. Successful core / grab sample density (samples/km^2)

Zone	Seabed Stability Risk (From ABPmer, 2009)	No of Sediment Types Present (After Folk 1954)	Sample Density (Samples/km^2)	Sample Density (Including Multiples*, Samples/km^2)
Moray Firth	Low	4 (S to sG)	0.12	0.17
Firth of Forth	Low to Medium	6 (S to G)	0.07	0.12
Dogger Bank	Low to Medium	5 (S to G)	0.03	0.04
Holderness	Medium	6 (mS to sG)	0.26	0.3
Norfolk	Medium	6 (mS to sG)	0.37	0.39
Hastings	Low to Medium	4 (S to sG)	0.93	0.96
West Isle of Wight	Low	5 (gS to R)	0.10	0.11
Bristol Channel	Medium	10 (sM to R)	0.35	0.52
Irish Sea	Medium	6 (gmS to G)	0.04	0.07

* Sample density including multiple samples where more than one type of sample was taken at a given site.

Plot 1. Total successful bed samples, by type, for the nine R3 OWF zones



* See Section 2.2.3 for a discussion of the most relevant types of seabed sample for OWF studies.

Table 3. Percentage coverage of Multibeam survey by site and other available bathymetric data

Zone	Multibeam Source	Multibeam Coverage (%)	Other Digital Data Available	Other Digital Data Coverage (%)
Moray Firth	MCA	97.6	BGS Survey Tracks	NA
Firth of Forth	MCA	94.4	SeaZone Digital Survey data	5.6
Dogger Bank	JNCC	2.1	BGS Survey Tracks	NA
Holderness	N/A	0	SeaZone Digital Survey data	78.4
Norfolk	N/A	0	SeaZone Digital Survey data	98.5
Hastings	N/A	0	SeaZone Digital Survey data	100
West Isle of Wight	Natural England	2.0	SeaZone Digital Survey data	82.7
Bristol Channel	MCA	1.6	SeaZone Digital Survey data	69.5
Irish Sea	JNCC / SEA	5.1	SeaZone Digital Survey data	100

Although the attribute table of each data set gives various information on data type, age, source etc, it does not contain information on the post-processing of data (e.g. whether or not a grab sample has subsequently been analysed for particle size etc.). Information on the spatial resolution and quality of surveys is also not given (e.g. what resolution the multibeam data is available at - 1m, 5m, 10m centres etc.). This information can be confirmed by BGS for specific samples / surveys.

2.4 Gap Analysis Rating System

The following sections describe the gap analyses that have been undertaken for each of the nine R3 OWF zones. Each section begins with a summary of the relevant risks identified for the zone during the recently completed R3 Risk Review project (ABPmer, 2009). As explained in the Project Overview section of this report, this study identified potential issues throughout the construction, operation and decommissioning of an OWF sited within the zone. The availability of data considered in this study may assist with determining data type and coverage in areas where a significant risk exists, thus enabling a survey strategy to be developed to target areas where data gaps are evident.

For each data type, within each zone, a scoring system has been put in place to prioritise additional survey requirements. At the end of each zone assessment, a summary table is provided, placing a Low, Medium or High priority for collection of each data type as required for both regional and project-level studies. This is a relative scale whereby an assessment has been made on the need for additional survey data, based on existing survey type and coverage.

For example, a zone where no multibeam surveys have been carried out will generally have a medium to high priority for collection of data on seabed features (since multibeam surveys are considered most useful for assessing such features as they have a greater coverage compared to single beam methods). Likewise, zones that do not have Pinger survey tracks will generally have a higher priority rating for sub-bottom profiling than those that do (since this type of survey is considered more useful for resolving the depth of the sub-surface most relevant to OWF foundation structures).

In addition to the individual scoring assessments within each zone, the Summary of Recommendations section, at the end of the report, picks out the data type(s) with the highest relative priority within each zone. This has been provided based on data sufficiency for a regional level assessment only.

3. Gap Analysis for Zones 1-9

3.1 Zone 1. Moray Firth

Table 4 is a summary of the relevant risks identified for Zone 1 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 4. Summary of relevant identified risks (from R3 Risk Review) for Zone 1 Moray Firth

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Low	Medium
O2	Migration of seabed features	Undermining of foundations	Low to Medium	Medium
O3	Migration of seabed features	Exposure of cables	Low to Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Low to Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Superficial sea bed sediments are predominately coarse, typically composed of sand and gravel populations (with limited fine material, hence the sediment mobility risk is rated as low).

Available literature indicates that Zone 1 is typically devoid of any sea bed features. Further to this, models of maximum tidal bed-stresses, as given in UKSeaMap (Conner *et al*., 2006), show these stresses to be very low. Net sediment transport is directed into the Moray Firth, and due to the benign tidal regime it is suggested that transport is limited in frequency and related to low-frequency, high energy events.

3.1.1 Bathymetry

- Available data type and coverage: For determination of bathymetry across Zone 1, data is available from Multibeam surveys carried out by MCA. This Multibeam dataset covers approximately 98% of Zone 1. The remainder of the Moray Firth, a small area of approximately 13km^2 to the extreme east of the zone, is crossed by a set of three side-scan sonar and echo sounder survey tracks, carried out by BGS in 1970. Available data type and coverage is shown in Figure 1.

- Sufficiency: The available bathymetric data for Zone 1 has near total coverage of the area of interest, almost entirely consisting of multibeam survey data, giving a good coverage for a regional assessment. If R3 OWF sites were to be placed in the small area to the east of Zone 1 (where only single track side-scan and echo sounder data is available) or if the multibeam survey was not considered recent enough (by the time the project development begins), further, more detailed surveys of bathymetry may be required for the project development phase.

- Priority site ranking: Low priority for bathymetric data collection in Zone 1.

3.1.2 Seabed Features

- Available data type and coverage: For characterisation of seabed features across the Zone 1, data is available from Multibeam surveys carried out by MCA. In this case, the same dataset as can be used to determine bathymetry can also be used to investigate the presence, or otherwise, of seabed features. Coverage of this dataset is as described in 1.1 above. The spatial resolution of the multibeam data is the overriding factor in determining what seabed features can be determined. For example, a horizontal resolution of less than 5m would be required to resolve mega ripples.

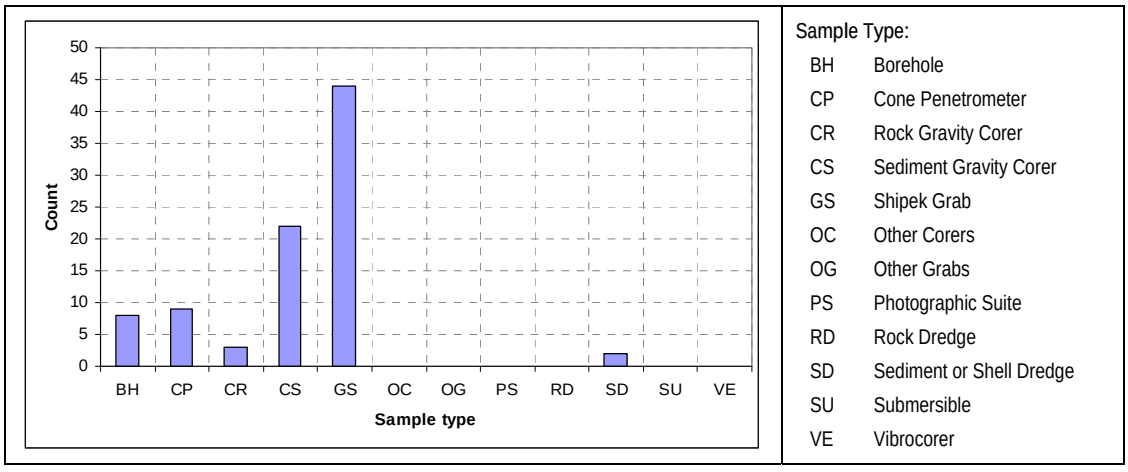
- Sufficiency: Multibeam survey data is available for approximately 98% of Zone 1. Unlike the bathymetry assessment, identification of seabed features from side-scan sonar surveys is limited, due to the narrower (relative to multibeam data) survey footprint. Therefore, data on seabed features for the 13km² area to the east of Zone 1, is likely to be limited in its extent.

- Priority site ranking: Low priority for much of the zone, Low to Medium priority for the eastern part of the zone, with no multibeam coverage.

3.1.3 Surface Sediment

- Available data type and coverage: Zone 1 contains a total of 88 successful samples of seabed surface sediment. This represents a sample density of 0.17 samples/km². The majority of these samples are either Shipek Grab samples (44) or Sediment Gravity Core samples (22). A breakdown of samples, by type, is given in Plot 2, below.

Plot 2. Moray Firth surface sediment samples, by type



- Sufficiency: Although the survey density is relatively low (0.17) compared to that of some of the other zones under consideration, the samples themselves are well spread across the entire Zone 1 area. Previous studies have identified the predominant sediment in the area to be coarse sand and gravel populations. This, coupled with an

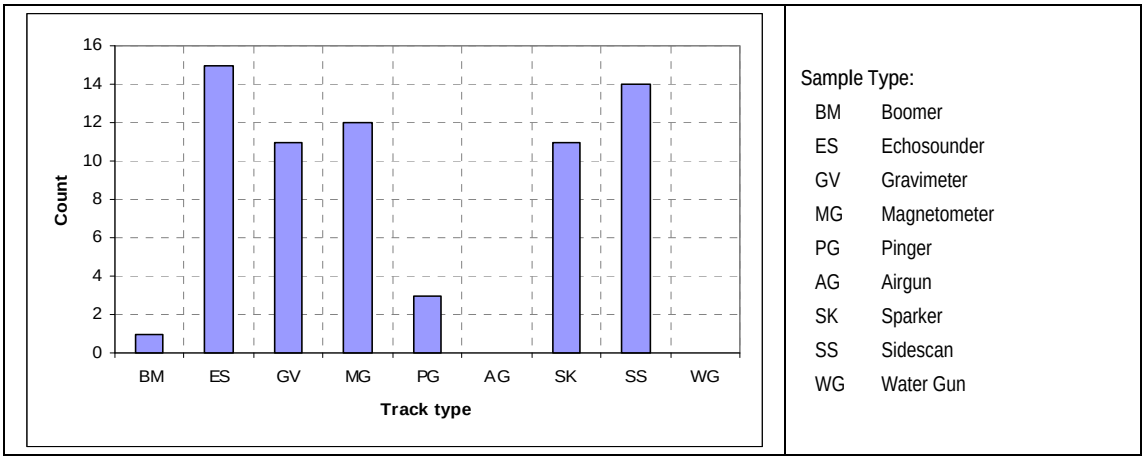
apparent lack of seabed features (ABPmer, 2009), suggests the seabed is likely to be relatively homogenous in nature and the available sample data is likely to give adequate seabed characterisation for a regional assessment. This apparent homogeneity is confirmed from BGS sediment maps, which show the entire zone contains four different sediment classes (after Folk 1954) - Sand, slightly gravelly Sand, gravelly Sand and sandy Gravel. For specific site investigations related to the development phase of an OWF project, additional seabed sampling may be required.

- Priority site ranking: The data spread and likely homogenous nature of the bed suggests a Low priority for sediment sampling of Zone 1.

3.1.4 Sub-Bottom Profiling

- Available data type and coverage: Sub-bottom surveys have been carried out across the full extent of Zone 1. Different types of survey exist in different areas. There is a single Boomer survey towards the western boundary, three Pinger tracks to the west, north and across the middle of the site and a combination of Magnetometer, Gravimeter and Sparker surveys which cross the site in a grid orientation with an approximate spacing of 10km between survey tracks. The locations of the available sub-bottom survey tracks are shown in Figure 2, and a breakdown of survey track, by type, is given in Plot 3, below.

Plot 3. Moray Firth survey tracks, by type



- Sufficiency: The available sub-bottom survey data is limited in coverage of Boomer and Pinger surveys although the Sparker surveys have a better coverage over the majority of the zone. Sparker surveys generally provide sub-bottom profile data to a depth of approximately 120m, although the exact penetration depth is dependent on a number of factors and individual surveys would need to be inspected for actual data extent. The Sparker surveys also have data from magnetometer and gravimeter instruments. These can be used for identifying metallic objects (e.g. wrecks and munitions) on the seabed, as well as determining the presence of ferrous rocks.

For general sub-bottom profiles, the available data is likely to be sufficient for a regional assessment. For any site specific studies, or if data is required from Boomer or Pinger surveys, additional data may be required for some parts of the zone.

- Priority site ranking: Medium priority for sub-bottom profiling of Zone 1.

3.1.5 Summary

Table 5 details a summary of the data gap analysis for Zone 1, for both a regional assessment and a site specific study.

Table 5. Summary of gap analysis for Zone 1 - Moray Firth

Data Type	Priority for 'Regional' Study	Priority for 'Site level' Study
Bathymetry	Low	Low to Medium
Seabed Features	Low to Medium	Medium
Surface Sediment	Low	Medium
Sub-bottom profiling	Medium	Medium to High

3.2 Zone 2. Firth of Forth

Table 6 is a summary of the relevant risks identified for Zone 2 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 6. Summary of relevant identified risks (from R3 Risk Review) for Zone 2 Firth of Forth

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Low to Medium	Low
O2	Migration of seabed features	Undermining of foundations	Low to Medium	Low
O3	Migration of seabed features	Exposure of cables	Low to Medium	Low
O4	Sediment mobility	Scour around foundations and cables	Low to Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Superficial sea bed sediments are predominately coarse, typically composed of sand and gravel populations.

Available literature indicates that the sea bed features within Zone 2 are sand waves and mega ripples, indicative of a mobile regime. Due to the benign nature of the tidal regime and the water depths, it is suggested that the sediment transport within this area is under the predominant control of low-frequency, high energy events.

3.2.1 Bathymetry

- Available data type and coverage: For the majority of Zone 2 (approximately 95% coverage), bathymetry data is available from MCA conducted multibeam surveys. A small area to the extreme south west of Zone 2 is not covered by these surveys but this area is covered by single beam surveys (from 2003) available from the SeaZone Digital Survey dataset. Available data type and coverage is shown in Figure 3.

- Sufficiency: The available bathymetric data for Zone 2 has total coverage of the area of interest with the majority of this information sourced from multibeam surveys. The survey density of the remaining area (covered by the single beam SeaZone data) would need to be inspected before a determination of sufficient data coverage can be made in the south west corner of Zone 2. However, since the data availability shows 'area coverage' (as opposed to single survey tracks) it is likely that the survey coverage is high.

- Priority site ranking: Low priority for bathymetric data collection in Zone 2.

3.2.2 Seabed Features

- Available Data type and coverage: Multibeam survey data is available for nearly the entire site, as carried out by MCA and described in 2.1, above. This survey data can be used to identify the presence, or otherwise, of bedforms across Zone 2, although survey resolution will ultimately determine what type of bedforms can be identified. Previous studies (referenced in ABPmer, 2009) have identified sand waves and mega ripples within this zone.

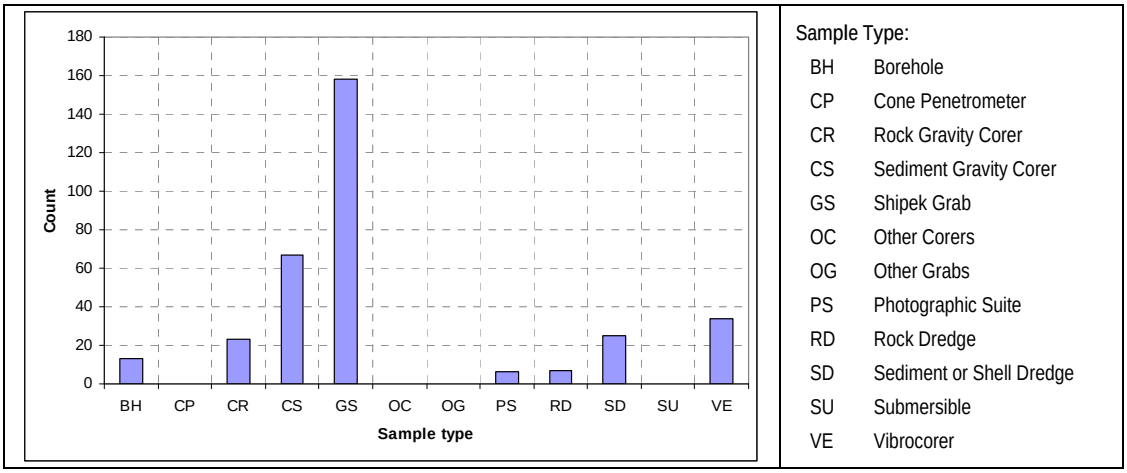
- Sufficiency: For the area of Zone 2 where multibeam survey data is available, seabed features should be identifiable (resolution depending). The same is unlikely to be true for the area to the extreme south west, covered only by SeaZone Digital Survey data, where only larger bedforms (such as sandwaves) are likely to be apparent. The sidescan surveys in this area will likely provide narrow tracks of seabed feature data, but will not obtain the same coverage as the multibeam surveys. This suggests that the available data is likely to be sufficient in the area of Zone 2 covered by multibeam data. For detailed requirements in the area covered by the SeaZone and BGS track data, additional high resolution surveys are likely to be required.

- Priority site ranking: Low to Medium priority for seabed features data collection in Zone 2.

3.2.3 Surface Sediment

- Available data type and coverage: Zone 2 contains a total of 333 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.12 samples/km^2. The majority of these samples are either Shipek Grab samples (158) or Sediment Gravity cores (67). A breakdown of samples, by type, is given in Plot 4.

Plot 4. Firth of Forth surface sediment samples, by type



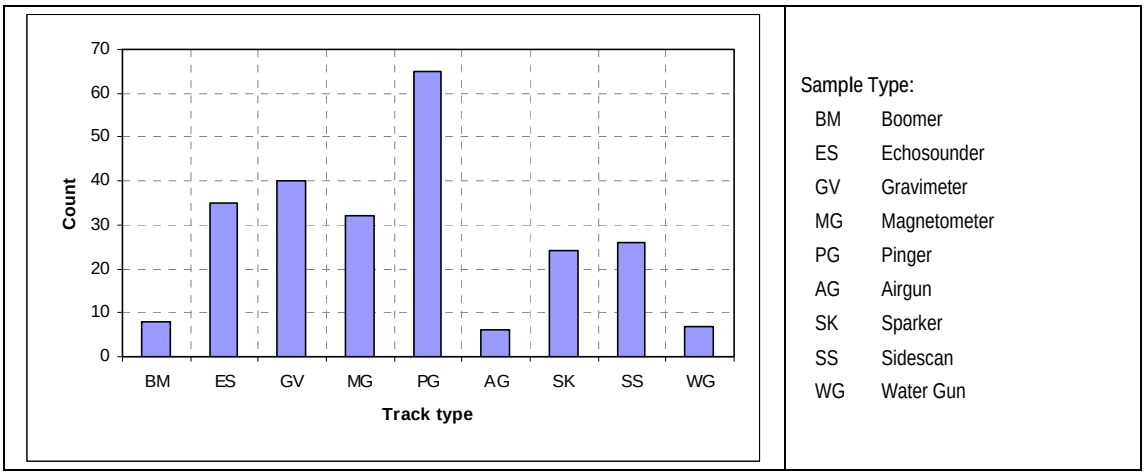
- Sufficiency: Although the sample density is low, compared to some of the other zones assessed, the surface sediment sample locations are well spread across the site with a slightly higher sample density towards the western side. Previous work (ABPmer, 2009) has noted the predominant sediment is coarse, typically containing sand and gravel populations. This apparent homogeneity suggests the available sample data is sufficient for a regional assessment of the sediment composition within Zone 2. This homogeneity is confirmed from BGS sediment maps which show the vast majority of the site is composed of Sand, gravelly Sand, sandy Gravel and Gravel with small pockets of muddy Sand located towards the west of the zone. For detailed project development studies, additional sediment sampling is likely to be required.

- Priority site ranking: Low priority for surface sediment sampling of Zone 2.

3.2.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 76 survey tracks crossing the full extent of Zone 2. Of these, the majority are Pinger surveys (65) with fewer Sparker (24) and Boomer (8) tracks. Approximately half of the surveys also have Magnetometer (32) and Gravimeter (40) data collected. The locations of the available sub-bottom survey tracks are shown in Figure 4, and a breakdown of survey track, by type, is given in Plot 5.

Plot 5. Firth of Forth survey tracks, by type



- Sufficiency: The majority of the site is covered by Pinger and Sparker surveys, typically imaging the sub-bottom profile of the seabed to a depth of between 30m (Pinger) and 120m (Sparker). There are also six Airgun survey tracks, mainly running north-south across the zone, which typically penetrate up to 2km below the seabed. The available data type and coverage should be sufficient for a regional assessment and also for detailed project development studies across much of the zone.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 2.

3.2.5 Summary

Table 7 details a summary of the data gap analysis for Zone 2, for both a regional assessment and a site specific study.

Table 7. Summary of gap analysis for Zone 2 - Firth of Forth

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low	Low to Medium
Seabed Features	Low to Medium	Medium
Surface Sediment	Low	Medium
Sub-bottom profiling	Low	Low to Medium

3.3 Zone 3. Dogger Bank

Table 8 is a summary of the relevant risks identified for Zone 3 during the recently completed R3 Risk Review project (ABPmer 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 8. Summary of relevant identified risks (from R3 Risk Review) for Zone 3 Dogger Bank

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Low to Medium	Low
O2	Migration of seabed features	Undermining of foundations	Low to Medium	Low
O3	Migration of seabed features	Exposure of cables	Low to Medium	Low
O4	Sediment Mobility	Scour around foundations and cables	Low to Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer 2009)

Superficial sea bed sediments are predominately coarse, typically composed of gravelly Sand and slightly gravelly Sand.

Available literature indicates the presence of storm related bedforms, which may extend up to 3m in height and would indicate that sediment transport is episodic. The sea bed transport that does occur would appear to be limited in frequency, related to low-frequency, high energy events. The sediment movement that would occur under these extreme events may most probably result in scour and/or bed level changes.

3.3.1 Bathymetry

- Available data type and coverage: Bathymetric data coverage in Zone 3 is limited (in comparison with zones 1 and 2), with multibeam surveys restricted to 11 survey tracks running approximately north-south across the zone. Each survey track, collected by JNCC, is approximately 200m wide and is spaced at around 9km. Based on zone area, the available multibeam coverage amounts to approximately 2%.

  No SeaZone Digital Survey data exists for this zone so the only additional bathymetry data is available from BGS survey tracks (conducted between 1973 and 1994), which are a combination of sidescan and echosounder surveys. These tracks are orientated in a grid pattern across the whole zone with a closer track spacing over the southern half (approximately 8km compared to 15km for the remainder of the zone). Available data type and coverage is shown in Figure 5.

- Sufficiency: The coverage of the available bathymetric data suggests that there may be enough information for a regional assessment, with good track coverage over the zone. However, the vintage of some of the data (BGS tracks from 1994 and earlier) may not give an up to date reflection of the existing conditions if the area is prone to morphological changes. Furthermore, for a site-level assessment during project development, the available data is unlikely to give adequate coverage.

- Priority site ranking: Medium to High priority for bathymetric data collection in Zone 3.

3.3.2 Seabed Features

- Available data type and coverage: Data on seabed features for Zone 3 is limited in extent to the narrow multibeam tracks collected by the JNCC survey and the sidescan surveys from the BGS tracks (dated between 1980 and 1985). Within these 200m wide JNCC tracks, seabed features are likely to be identified (where present), however, for the vast majority of the site, up to date data on seabed features is limited.

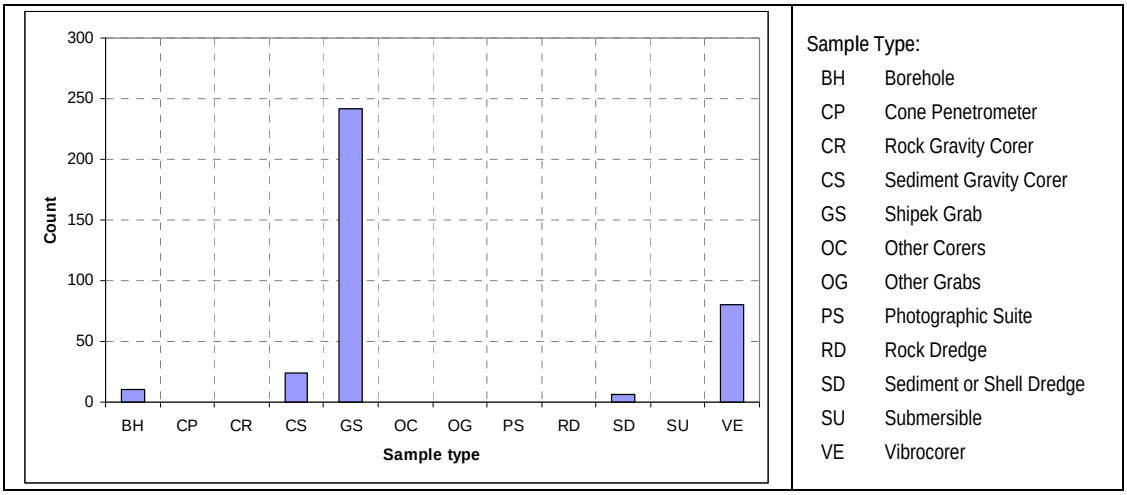
- Sufficiency: The limited extent of multibeam data across Zone 3, coupled with the absence of any SeaZone Digital Survey bathymetry, means that recent survey data on seabed features is mostly unavailable for 98% of the site.

- Priority site ranking: High priority for collection of seabed features data for Zone 3.

3.3.3 Surface Sediment

- Available data type and coverage: Zone 3 contains a total of 362 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.04 samples/km^2. The majority of these samples are either Shipek Grab samples (248) or Vibrocorer (80). A breakdown of samples, by type, is given in Plot 6, below.

Plot 6. Dogger Bank surface sediment samples, by type



- Sufficiency: The large area of Zone 3 results in a very low sample density across the site. The sample locations are, however, well spread across the site and approximately follow the BGS survey track lines. Previous reports (ABPmer, 2009) have noted the predominant surface sediment in this zone is coarse material, made up mainly of gravelly Sand and slightly gravelly Sand. Inspection of the BGS sediment map of the

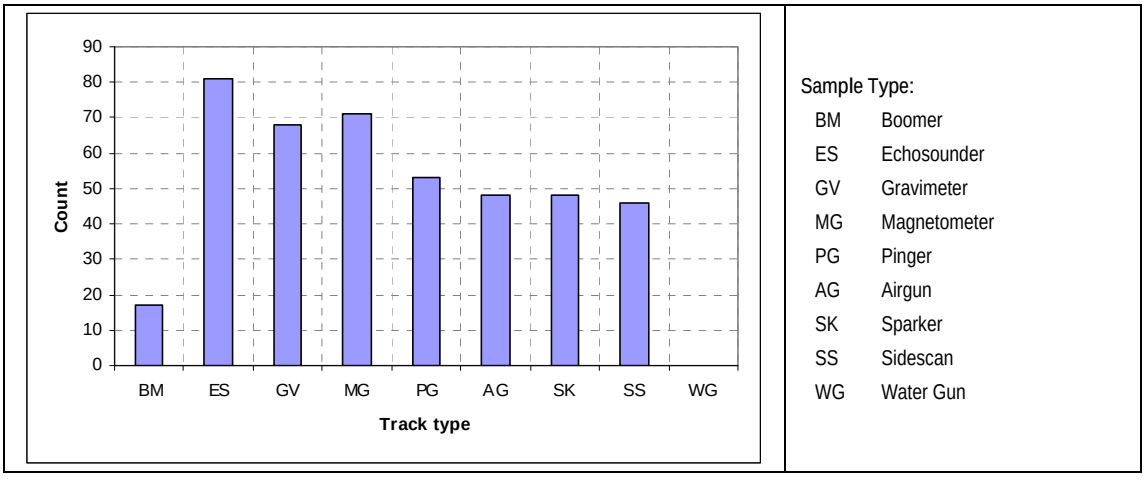
area confirms this, and also points out smaller areas of Sand and Gravel located mainly to the north and west of the zone. This homogenous nature suggests that even with a low sample density, the available data is likely to be sufficient for a regional assessment of surface sediment. However, for detailed project development studies, additional samples are likely to be required.

- Priority site ranking: Low to Medium priority for surface sediment sampling of Zone 3.

3.3.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 81 survey tracks crossing the full extent of Zone 3. Of these, the majority are Pinger (53) and Sparker (48) surveys with fewer Boomer (17) tracks. Almost all of the surveys also have Magnetometer (71) and Gravimeter (68) data collected, whilst just over half of them (48) contain Airgun data too. The track lines are orientated in a grid with good coverage over much of the zone, although the extreme eastern side has a lower track density than the remainder of the site. The locations of the available sub-bottom survey tracks are shown in Figure 6, and a breakdown of survey track, by type, is given in Plot 7, below.

Plot 7. Dogger Bank survey tracks, by type



- Sufficiency: Most of Zone 3 is covered by Pinger surveys with the southern part also containing Sparker tracks and the northern part covered by Boomer surveys. The whole zone is also covered by Airgun tracks, typically giving penetration up to 2km below the seabed. The available data type and survey track coverage of Zone 3 should be sufficient for a regional assessment and, with the possible exception of small areas to eastern side of the zone, also adequate for detailed project development studies.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 3.

3.3.5 Summary

Table 9 details a summary of the data gap analysis for Zone 3, for both a regional assessment and a site specific study.

Table 9. Summary of gap analysis for Zone 3 - Dogger Bank

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Medium to High	High
Seabed Features	High	High
Surface Sediment	Low to Medium	Medium
Sub-bottom profiling	Low	Low to Medium

3.4 Zone 4. Holderness

Table 10 is a summary of the relevant risks identified for Zone 4 during the recently completed R3 Risk Review project (ABPmer 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 10. Summary of relevant identified risks (from R3 Risk Review) for Zone 4 Holderness

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Medium	Low
O2	Migration of seabed features	Undermining of foundations	Medium	Low
O3	Migration of seabed features	Exposure of cables	Medium	Low
O4	Sediment Mobility	Scour around foundations and cables	Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer 2009)

Sands and gravels dominate the superficial sea bed sediment population. It is reported that the sea bed features are indicative of a mobile regime, with sand waves the dominant sea bed feature within the zone. It should however be noted that these features do not extend over the entire zone. The limited available information for Zone 4 prevents the exact location and detailed characteristics of such features to be identified.

The limited strength of the tidal regime, combined with the coarseness of the dominant sediment population, would suggest that there is a limited potential for sediment transport over much of the zone. Whilst the water depths are, over much of the zone, too great to allow sediment transport to occur as a result of wave action, the occurrence of high energy, low

frequency events would suggest there is potential for sediment movement under these extreme events, with potential to result in scour and/or sand wave migration.

3.4.1 Bathymetry

- Available data type and coverage: No multibeam data coverage exists for Zone 4. The available bathymetric data consists mainly of SeaZone Digital Survey data sourced from a series of single beam surveys carried out between 1986 and 1998. This data covers approximately 78% of the site with a single area to the south west of the zone and two small areas to the east containing no such data.

  Additional bathymetric data is available from a series of BGS echosounder and sidescan surveys carried out between 1976 and 1984. The orientation of the BGS tracks form a grid over the entire site with a regular track line spacing of approximately 7km in both the east-west and north-south directions. Available data type and coverage is shown in Figure 7.

- Sufficiency: The availability of the Digital SeaZone data, suggests that sufficient data exists over much of the site for a regional assessment. The vintage of the data (the latest SeaZone survey is dated 1998) means that additional data may need to be collected for an up to date assessment if the area is likely to be subject to morphological change. Additionally, should detailed information be required in the areas to the east and west of Zone 4 (where only BGS survey track data is available) additional bathymetry data is likely to be required, particularly for project developments in these areas.

- Priority site ranking: Low to Medium priority for bathymetric data collection in Zone 4.

3.4.2 Seabed Features

- Available data type and coverage: The lack of multibeam survey data over Zone 4 limits the amount of seabed feature information available. For the area of the zone covered by SeaZone Digital Survey data (78%), large scale bedforms (such as sand waves) may be apparent but smaller scale features such as ripples, will not be. The areas to the extreme east and west of Zone 4, where only BGS survey tracks are available (dating from 1980 to 1984), will only yield narrow tracks of data on seabed features from the sidescan surveys.

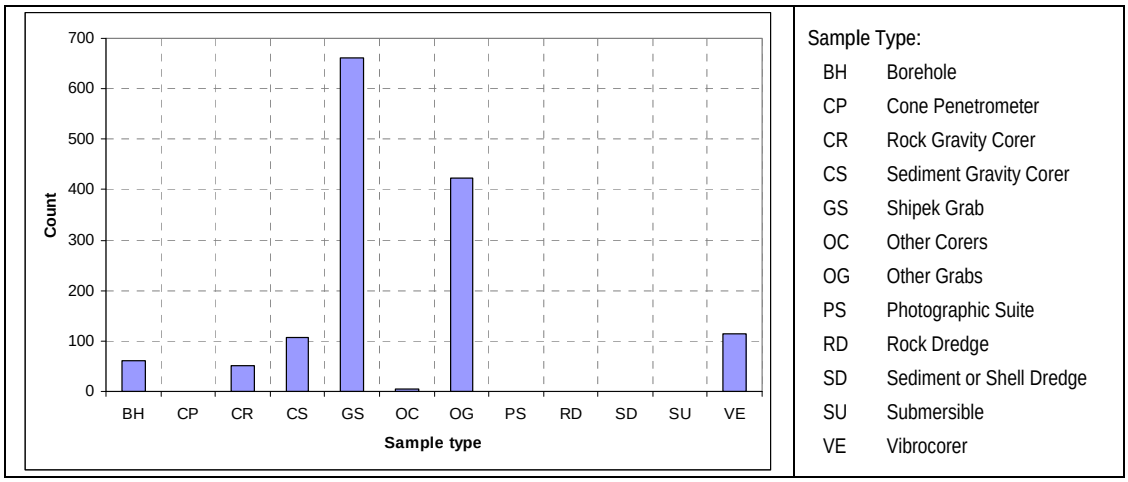
- Sufficiency: For large scale bedforms, the available SeaZone data may be sufficient for a regional assessment over the centre of the zone. However, information on small scale bedforms and detailed assessments for project development are likely to require additional high resolution surveys.

- Priority site ranking: Medium to High priority for collection of seabed feature data for Zone 4.

3.4.3 Surface Sediment

- **Available data type and coverage:** Zone 4 contains a total of 1423 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.3 samples/km^2. The majority of these samples are either Shipek Grab samples (660) or Other Grabs (424), although a significant number of Sediment Gravity Cores (107) and Vibrocores (114) have also been taken. A breakdown of samples, by type, is given in Plot 8, below.

Plot 8. Holderness surface sediment samples, by type



- **Sufficiency:** The available sediment samples are well spread across Zone 4, with a slightly lower density towards the northwest corner and patches of very high density samples on the eastern side. It has been previously reported (ABPmer, 2009) that sediment type in the region is dominated by sands and gravels and inspection of BGS sediment maps show this to be the case, with small pockets of muddy Sand found towards the eastern side of the zone. This typically homogenous nature to the sediments and the high density, well spread samples suggest that the available sediment data will be sufficient for a regional assessment and will also likely contribute a large part to the requirements of a detailed project development study.

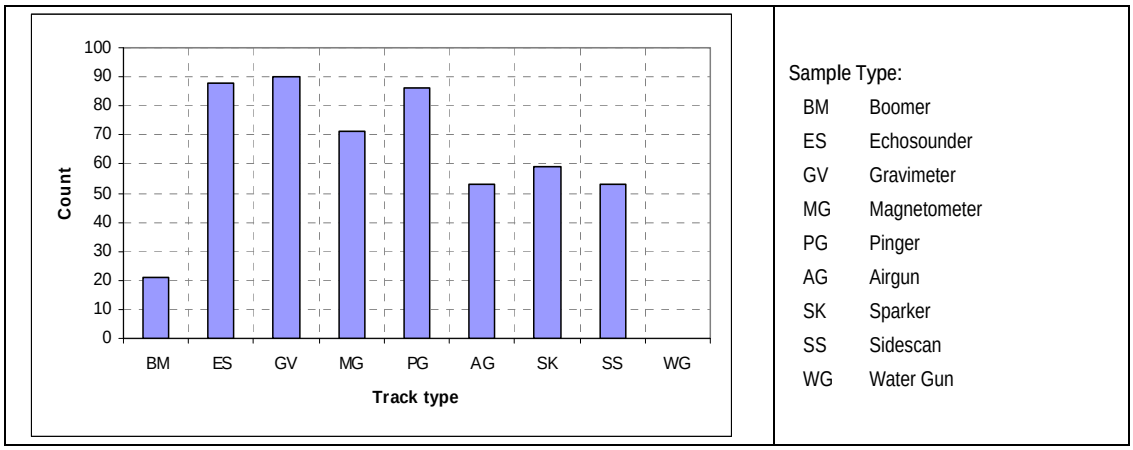
- **Priority site ranking: Low** priority for surface sediment sampling of Zone 4.

3.4.4 Sub-Bottom Profiling

- **Available data type and coverage:** There are a total of 106 BGS survey tracks crossing the full extent of Zone 4. Of these, the majority are Pinger (86) surveys with fewer Sparker (59) and Boomer (21) tracks. Most of the surveys also have Gravimeter (90) and Magnetometer (71) data collected, whilst half of them (53) contain Airgun data too. The track lines are orientated in a grid with full coverage over the entire zone. In addition to the BGS surveys, seven survey tracks from the ALSF Humber REC also cross the southern part of the site. In addition to echosounder measurements, these survey tracks also collected Boomer data. The locations of the available sub-bottom

survey tracks are shown in Figure 8, and a breakdown of the BGS survey tracks, by type, is given in Plot 9, below.

Plot 9. Holderness survey tracks, by type



- Sufficiency: The whole of zone 4 is covered by Pinger and Sparker tracks with the southern half of the site also containing a series of well spread Boomer surveys (from both BGS and ALSF Humber REC). The Airgun tracks also cover the whole zone with all surveys orientated in a grid at a spacing of approximately 5km. The data type and coverage should be sufficient for both regional and detailed project development assessments.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 4.

3.4.5 Summary

Table 11 details a summary of the data gap analysis for Zone 4, for both a regional assessment and a site specific study.

Table 11. Summary of gap analysis for Zone 4 - Holderness

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low to Medium	Medium to High
Seabed Features	Medium to High	High
Surface Sediment	Low	Low to Medium
Sub-bottom profiling	Low	Low to Medium

3.5 Zone 5. Norfolk

Table 12 is a summary of the relevant risks identified for Zone 5 during the recently completed R3 Risk Review project (ABPmer 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 12. Summary of relevant identified risks (from R3 Risk Review) for Zone 5 Norfolk

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Medium	Medium
O2	Migration of seabed features	Undermining of foundations	Medium	Medium
O3	Migration of seabed features	Exposure of cables	Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer 2009)

Coarse sediments, gravels and sands, dominate the superficial sea bed sediments. It is reported that bedforms indicative of a mobile regime are present on the sea bed, with sand waves dominating Zone 5. Sand banks are present but are typically restricted within the nearshore section.

Typically, it is the tidal regime which dominates the sediment mobility and thus sediment transport pathways over the extent of the zone, with the wave regime dominating in water depths less than 20m. Storm surges also play an important, short-term, role in sediment transport within Zone 5.

3.5.1 Bathymetry

- Available data type and coverage: No multibeam data coverage exists for Zone 5. The majority of the zone (approximately 98%) is covered by SeaZone Digital Survey data, sourced from a series of single beam surveys carried out between 1981 and 2000. This data does not cover the area to the extreme north east of the zone.

  Additional bathymetry data is available from a number of BGS survey tracks (a combination of side scan and echosounder surveys) carried out between 1969 and 1993. The orientation of these track lines forms a grid over the whole zone with a finer resolution towards the western side (track spacing of approximately 5km) and coarser resolution for the remainder (track spacing approximately 8km). Available data type and coverage is shown in Figure 9.

- Sufficiency: The available bathymetric data is likely to be sufficient for a regional assessment although, as with other zones, if data vintage is considered important, more up to date surveys may be desirable. For project development in the north east region, where SeaZone Digital Survey data is not available, additional surveys are likely to be required.

- Priority site ranking: Low to Medium priority for bathymetric data collection in Zone 5.

3.5.2 Seabed Features

- Available data type and coverage: The lack of multibeam data for Zone 5 limits the available data on seabed features. As with Zone 4, the area of this site that is covered by SeaZone Digital Survey data may give information on large scale bedforms such as sandwaves and sandbanks, which have been reported to dominate the zone (ABPmer, 2009). The area to the north east of the zone, where only BGS survey track data is available (dating from 1969 to 1993), will only offer narrow tracks of data on seabed features, from sidescan surveys.

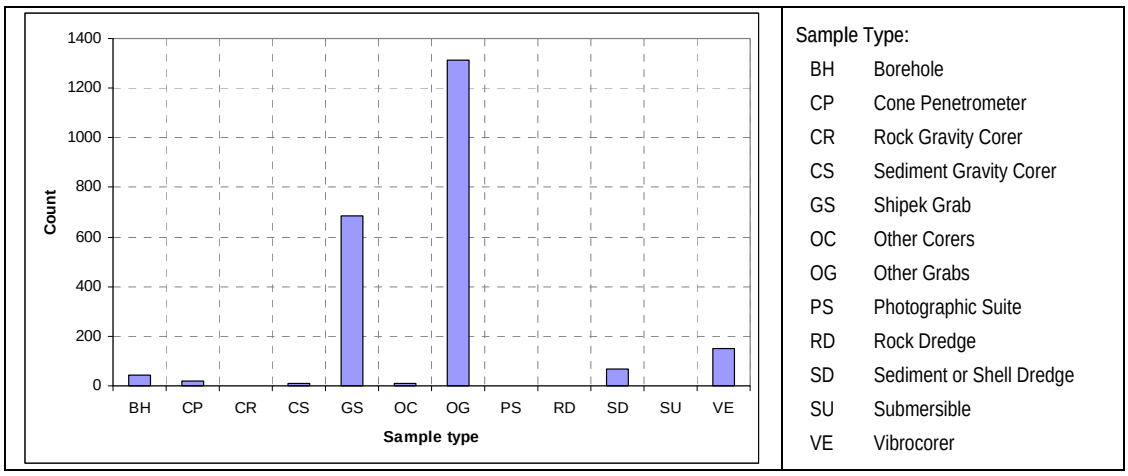
- Sufficiency: For the area of Zone 5 covered by SeaZone data, the available surveys may show the presence of large scale bedforms, sufficient for a regional assessment. For the remainder of the site, and for detailed studies on smaller scale features, additional high resolution surveys are likely to be required.

- Priority site ranking: Medium priority of seabed feature data collection for Zone 5.

3.5.3 Surface Sediment

- Available data type and coverage: Zone 5 contains a total of 2302 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.39 samples/km². The majority of these samples are either Other Grab samples (1312) or Shipek Grab (686), although a significant number of Vibrocores (153) have also been taken. A breakdown of samples, by type, is given in Plot 10, below.

Plot 10. Norfolk surface sediment samples, by type



- Sufficiency: The available sediment sample data is well spread across Zone 5 with very high survey density across much of the northern and western sides (where samples are typically spaced approximately 1km apart). Inspection of the BGS

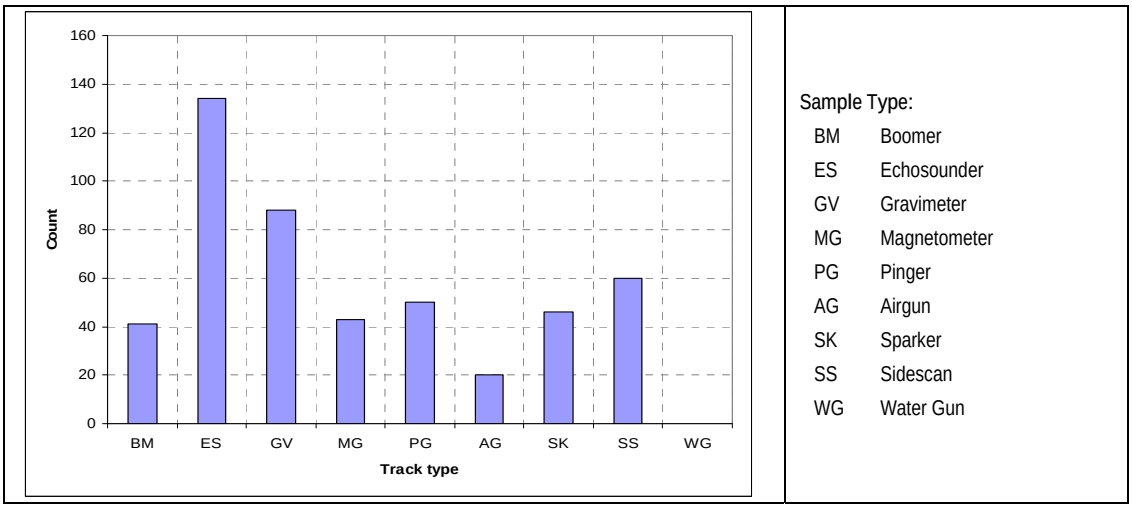
sediment maps reveal the vast majority of the site consists of Sand and Gravel populations, with small pockets of muddy Sand and gravelly muddy Sand found towards the north of the zone. The homogenous nature of much of the bed, coupled with the high survey density and good spread of the samples suggest the available data will be sufficient for a regional assessment and may also prove adequate for detailed project development studies. There are some areas, particularly along the south eastern boundary where additional samples may be desirable for a detailed analysis.

- Priority site ranking: Low priority for surface sediment sampling of Zone 5.

3.5.3 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 144 survey tracks crossing the full extent of Zone 5. The collected data type is well spread with 50 Pinger, 46 Sparker and 41 Boomer surveys. Most of the surveys also have Gravimeter (88) data whilst 43 tracks contain Magnetometer surveys. Meanwhile, 20 tracks contain Airgun data too. The track lines are primarily orientated in a grid with good coverage over the entire zone. In addition to the BGS tracks, 51 survey lines from the ALSF East Coast REC also cover the western part of Zone 5. These surveys form a grid at approximate spacing of 3km by 6km and collected Boomer data. The locations of the available sub-bottom survey tracks are shown in Figure 10, and a breakdown of BGS survey tracks, by type, is given in Plot 11, below.

Plot 11. Norfolk survey tracks, by type



- Sufficiency: Of the available sub-bottom data for Zone 5, the whole zone is covered by Pinger surveys with data from Sparker equipment restricted to the east and west sides and Boomer data limited to the northerly, westerly and southerly extremes. The Pinger tracks are regularly spaced in an 8km by 15km grid across the zone, typically giving ground penetration up to 30m. The available Pinger data is likely to be sufficient for regional and detailed project development assessments of the shallow sub-surface.

However, for investigations of the deeper sub-bottom facies, particularly across the middle of the zone, additional data is likely to be required.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 5.

3.5.4 Summary

Table 13 details a summary of the data gap analysis for Zone 5, for both a regional assessment and a site specific study.

Table 13. Summary of gap analysis for Zone 5 - Norfolk

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low to Medium	Medium
Seabed Features	Medium	High
Surface Sediment	Low	Low to Medium
Sub-bottom profiling	Low	Low to Medium

3.6 Zone 6. Hastings

Table 14 is a summary of the relevant risks identified for Zone 6 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 14. Summary of relevant identified risks (from R3 Risk Review) for Zone 6 Hastings

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Low to Medium	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Low to Medium	Medium
O2	Migration of seabed features	Undermining of foundations	Low to Medium	Medium
O3	Migration of seabed features	Exposure of cables	Low to Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Sands and gravels dominate the superficial sea bed deposits. It is reported that sand streaks, patches and megaripples are present on the sea bed; these are indicative of a mobile sediment regime. Sand waves, which indicate the presence of higher tidal currents than the pre-mentioned features, are not widespread and occur only in localised zones within the study area. Zone 6 is also located over the Northern Paleovalley which (i) forms a relatively steep boundary to the coastal platform; and (ii) is formed of both open and sediment infilled channels.

Within Zone 6, it is typically the tidal regime which dominates sediment mobility and thus sediment transport pathways.

3.6.1 Bathymetry

- Available data type and coverage: No multibeam data coverage exists for Zone 6. SeaZone Digital Survey data covers the entire site, sourced from a series of single beam surveys carried out between 2002 and 2003. Additional bathymetry data is available from a number of BGS survey tracks (dated between 1976 and 1988) running both east-west and north-south, spaced at approximately 5km. Available data type and coverage is shown in Figure 11.

- Sufficiency: The SeaZone data shows good coverage over the zone and is sourced from some of the more recent surveys available. The vintage and coverage of the BGS bathymetry data is of lower importance than in other zones due to the total coverage of the SeaZone Digital Survey data. Providing the SeaZone data is available at a high enough spatial resolution, this should be sufficient for both regional and project development assessments.

- Priority site ranking: Low priority for bathymetric data collection in Zone 6.

3.6.2 Seabed Features

- Available data type and coverage: The absence of multibeam survey data for Zone 6 limits the amount of information available on seabed features. Previous studies (ABPmer, 2009) have identified sand streaks and megaripples within the zone, neither of which will be apparent from the available SeaZone Digital Survey data. Sandwaves occur in localised areas and there is a possibility that these will show up on the SeaZone Digital Survey data which covers the whole site. The BGS sidescan surveys (dating from 1981 to 1988) will likely provide detailed bedform information within narrow tracks.

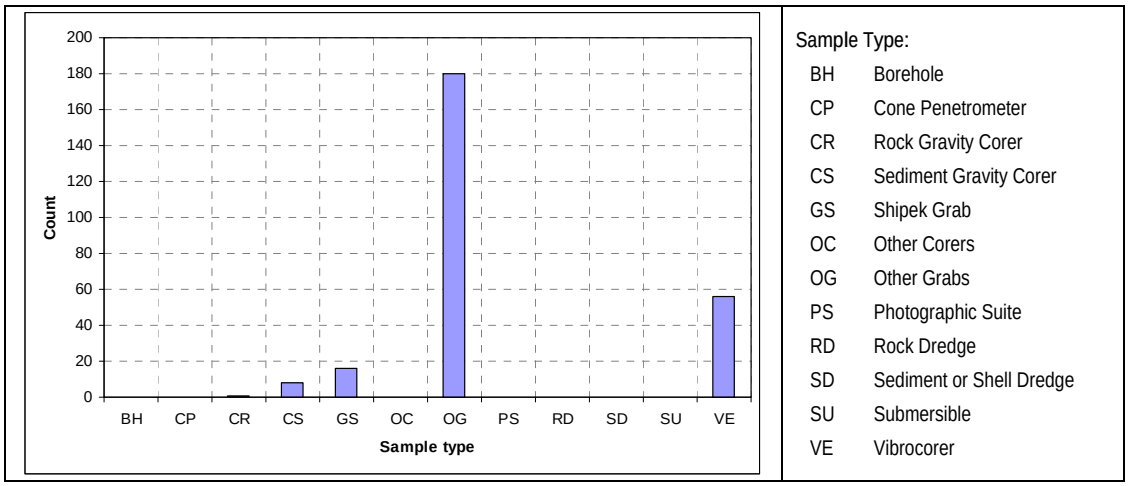
- Sufficiency: The available data is likely to be sufficient for a regional assessment of large scale features. However, detailed investigations of small scale bedforms and project development studies are likely to require additional high resolution surveys.

- Priority site ranking: Medium priority for collection of seabed feature data for Zone 6.

3.6.3 Surface Sediment

- Available data type and coverage: Zone 6 contains a total of 261 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.96 samples/km^2. The majority of these samples are either Other Grab samples (180) or Vibrocores (56). A breakdown of samples, by type, is given in Plot 12, below.

Plot 12. Hastings surface sediment samples, by type



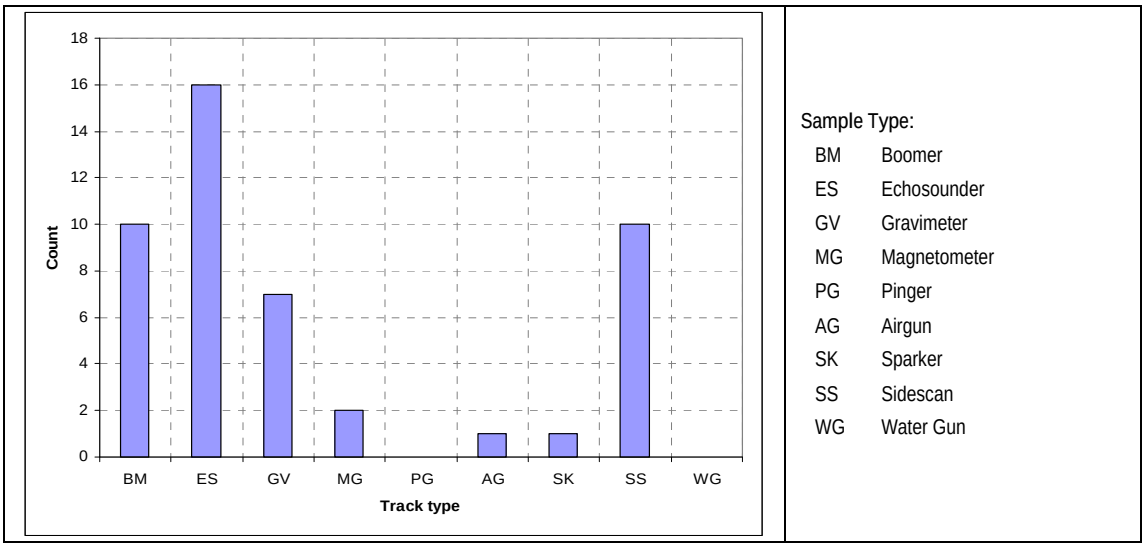
- Sufficiency: The available sediment sample data within Zone 6 has a high survey density, mainly due to the small size of the zone. The samples are relatively well spaced across much of the site, although there exists a band of between 2-3km along the southern boundary where no sediment sample data is available. Inspection of the BGS sediment maps reveal this area to comprise solely of gravelly Sand, with the remainder of the site characterised by Sand and slightly gravelly Sand populations. Although some gaps in sediment sample coverage exist across the zone, the homogenous nature of the bed suggests that these gaps do not present too large an issue from a bed characterisation perspective.

- Priority Site Ranking: Low to Medium priority for surface sediment sampling of Zone 6.

3.6.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 16 survey tracks crossing the full extent of Zone 6. Of these, the majority are Boomer (10) surveys with a single Sparker track and no Pinger data at all. Approximately half of the tracks have Gravimeter surveys (7) and a further 2 also have Magnetometer data collected. The track lines are orientated in a grid with a spacing of approximately 5km over the whole zone. The locations of the available sub-bottom survey tracks are shown in Figure 12, and a breakdown of survey track, by type, is given in Plot 13, below.

Plot 13. Hastings survey tracks, by type



- Sufficiency: Boomer surveys cover the majority of Zone 6 with the exception of a band approximately 1-2km wide across the southern part of the site, where no sub-bottom profile data is available. Spacing between the Boomer survey tracks is approximately 5km. For a regional or project development assessment of the shallow to mid depth (up to approximately 80m) sub-surface, the available data is likely to be sufficient. However, if data is required to greater depths (Sparker / Airgun) or at higher resolutions (Pinger), additional surveys may be required.

- Priority site ranking: Low to Medium priority for sub-bottom profiling of Zone 6.

3.6.5 Summary

Table 15 details a summary of the data gap analysis for Zone 6, for both a regional assessment and a site specific study.

Table 15. Summary of gap analysis for Zone 6 - Hastings

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low	Low to Medium
Seabed Features	Medium	High
Surface Sediment	Low to Medium	Medium
Sub-bottom profiling	Low to Medium	Medium

3.7 Zone 7. West Isle of Wight

Table 16 is a summary of the relevant risks identified for Zone 7 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 16. Summary of relevant identified risks (from R3 Risk Review) for Zone 7 West Isle of Wight

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Medium	Medium
C3	Migration of seabed features	Construction problems due to sea bed stability	Low	Medium
O2	Migration of seabed features	Undermining of foundations	Medium	Medium
O3	Migration of seabed features	Exposure of cables	Low to Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Medium	Low

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Sandy gravels dominate the superficial sea bed deposits, although it is reported that a proportion of fines are also present. Sea bed features are present, depending upon the sea bed material; both gravel furrows and sand ribbons have been reported along with sand waves, which indicate the presence of higher tidal currents than the pre-mentioned features, are not widespread and occur only in localised zones within the study area. Zone 7 is also located over the Northern Paleovalley which (i) forms a relatively steep boundary to the coastal platform; and (ii) is formed of both open and sediment infilled channels.

Within Zone 7, for the sandier sediment fractions, it is typically the tidal regime which dominates sediment mobility and thus sediment transport pathways. Gravel deposits are only reported to be mobile during low frequency, high energy events i.e. storms. Further, in the zone's shallower extents, the wave regime has the greatest control upon sediment transport.

3.7.1 Bathymetry

- Available data type and coverage: Zone 7 contains a small area covered by multibeam survey, towards the north of the area. This survey is part of the Natural England multibeam survey offshore of Swanage, Dorset and covers approximately 2% of Zone 7. Approximately 82% of the site is covered by SeaZone Digital Survey bathymetry (mostly from 2002) with the exception of the western part, for which no such data is available.

Additional data is available from BGS survey tracks of the area, which cover the entire zone with a combination of sidescan and echosounder surveys, dating from between 1973 and 1988. The spacing of the survey tracks ranges from approximately 5km to 7km and includes coverage of the western part of the zone where no multibeam or SeaZone data exists. Available data type and coverage is shown in Figure 13.

- Sufficiency: For the majority of Zone 7, the available multibeam and SeaZone data is likely to give sufficient bathymetric coverage for regional and project development assessments. However, if data is required subsequent to 2002 or within the western part of the zone where only BGS survey track data is available, additional surveys are likely to be required.

- Priority site ranking: Low to Medium priority for bathymetric data collection in Zone 7.

3.7.2 Seabed Features

- Available data type and coverage: The small area of multibeam survey (2% of the zone) is likely to give data on the presence of both large and small scale bedforms (resolution dependant). Of the remainder of the zone, the area covered by the SeaZone Digital Survey data may give information on larger scale bedforms. However, bedform data of any description is unlikely to be available for much of the western part of the zone, where only two short BGS sidescan survey tracks (dating from 1988) are available.

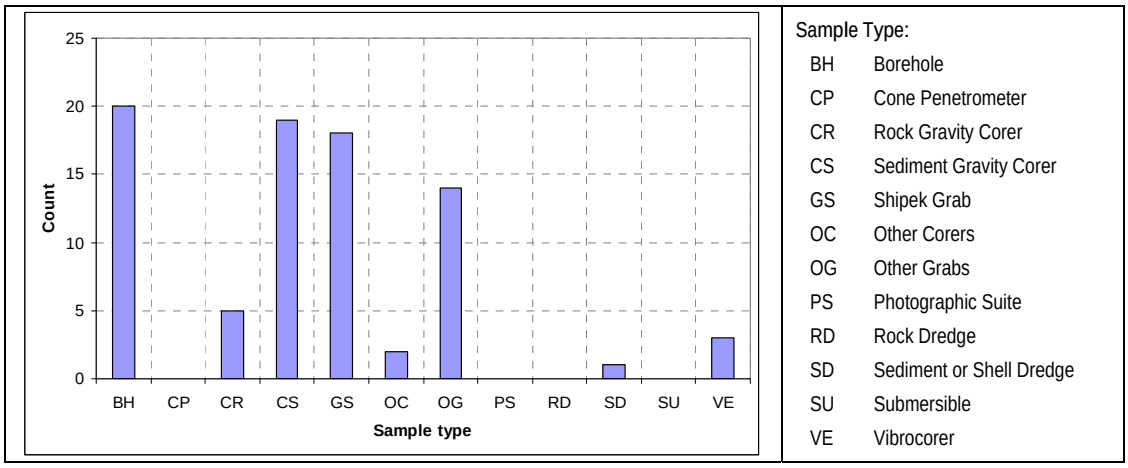
- Sufficiency: Although likely to be detailed enough to define certain small scale features, the coverage of the multibeam data means it is unlikely to be of much use for a detailed site assessment. The SeaZone data is may be sufficient for a regional assessment of larger scale features but a detailed investigation or a study into small scale features is likely to require additional high resolution surveys.

- Priority site ranking: Medium priority for collection of seabed feature data for Zone 7.

3.7.3 Surface Sediment

- Available data type and coverage: Zone 7 contains a total of 82 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.11 samples/km^2. The majority of these samples are either Boreholes (20), Sediment Gravity Cores (19) or Shipek Grab samples (18). A breakdown of samples, by type, is given in Plot 14, below.

Plot 14. West Isle of Wight surface sediment samples, by type



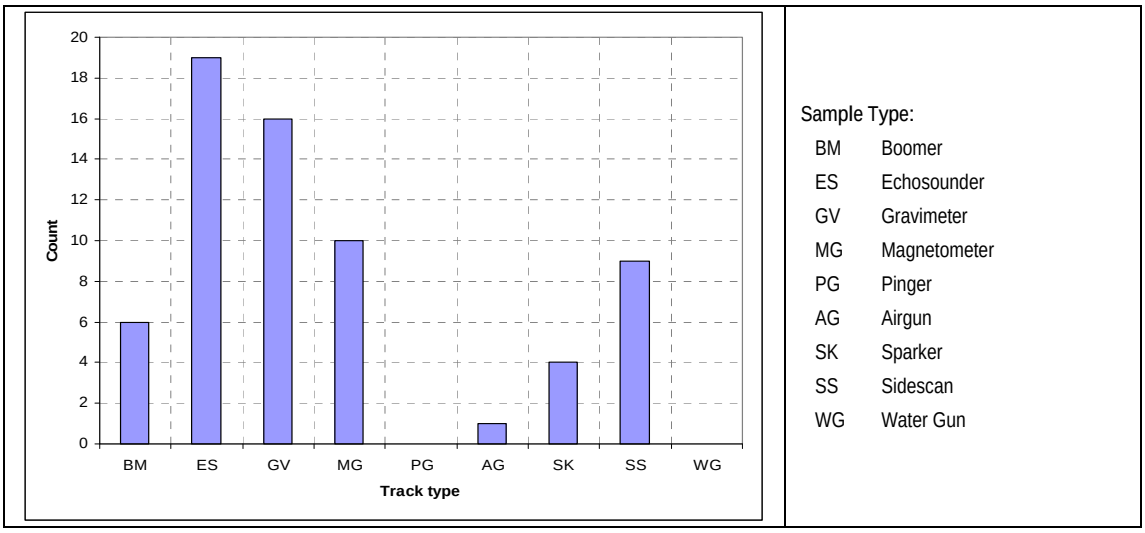
- Sufficiency: The available sediment sample data, while relatively well spread across the site, is not at a very high density, leading to large areas of the zone where no sample data exists. The bed in the region is characterised mainly by sandy Gravel and muddy sandy Gravel but there are also outcrops of Rock as well as localised patches of Sand and Gravel populations. The sediment sample data is likely to be sufficient for a regional assessment, especially in areas of the zone where the sediment type is homogenous. However, in areas where a number of different bed types exist, and for detailed project development studies, additional samples are likely to be required.

- Priority site ranking: Medium priority for surface sediment sampling of Zone 7.

3.7.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 22 survey tracks crossing the full extent of Zone 7. Of these, the sub-bottom profile tracks comprise of 6 Boomer and 4 Sparker surveys, with no Pinger data available. Around half of the surveys also have Gravimeter (16) and Magnetometer (10) data collected. The track lines are orientated in a grid with coverage over the zone at a track spacing of between 5 and 10km. The locations of the available sub-bottom survey tracks are shown in Figure 14, and a breakdown of survey track, by type, is given in Plot 15, below.

Plot 15. West Isle of Wight survey tracks, by type



- Sufficiency: The sub-bottom data available for Zone 7 is limited to a series of Boomer surveys, running east to west across much of the site. Towards the western boundary, a number of Sparker surveys have also been undertaken whilst a single Airgun track runs north to south through the middle of the zone. For mid-depth sub-surface studies, the available data is likely to be sufficient for a regional assessment. However, for data on the deep sub-surface and detailed project development studies at shallow sub-bottom depths, additional data is likely to be required.

- Priority site ranking: Medium priority for sub-bottom profiling of Zone 7.

3.7.5 Summary

Table 17 details a summary of the data gap analysis for Zone 7, for both a regional assessment and a site specific study.

Table 17. Summary of gap analysis for Zone 7 - West Isle of Wight

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low to Medium	Medium
Seabed Features	Medium	High
Surface Sediment	Medium	Medium to High
Sub-bottom profiling	Medium	Medium to High

3.8 Zone 8. Bristol Channel

Table 18 is a summary of the relevant risks identified for Zone 8 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 18. Summary of relevant identified risks (from R3 Risk Review) for Zone 8 Bristol Channel

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Medium to Low	High
C3	Migration of seabed features	Construction problems due to sea bed stability	Medium	Medium
O2	Migration of seabed features	Undermining of foundations	Medium	Medium
O3	Migration of seabed features	Exposure of cables	Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Low to Medium	Medium

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Sea bed sediments are coarse (coarse sands and gravels), with areas of exposed bedrock also present. It is noted that the bedrock has only been observed in localised areas towards the central and east of the zone, with an extensive zone present to the east of Zone 8. Sand waves are also present in the centre of the zone which are indicative of a mobile regime. The sand wave field is commonly referred to as Nobel Sands where feature crest heights are typically in the range 1 - 14m, with a maximum of 16m.

The tidal regime plays the dominant role in sediment transport within the zone. Extreme events are likely to have an infrequent influence upon sediment transport.

3.8.1 Bathymetry

- Available data type and coverage: There is a small area to the south of Zone 8 where multibeam data is available from an MCA survey of Barnstaple Bay, although this survey only covers approximately 1.5% of the total zone area. SeaZone Digital Survey data (from single beam surveys dated between 1977 and 1999) is available for the western half of the zone, covering approximately 70% of the area.

  Additional bathymetric data is available from BGS sidescan and echosounder survey tracks carried out between 1971 and 1992. These tracks cover the extreme eastern part of the zone at a high spatial resolution (2km by 5km spacing) and also cover the remainder of the zone, not covered by other data, but at a reduced resolution (only two track lines within a zone area that measures approximately 8km by 22km). Available data type and coverage is shown in Figure 15.

- Sufficiency: Available bathymetry data for the western part of Zone 8 is likely to be sufficient for a regional assessment. However, for assessments within much of the eastern part, along with any requirements for information subsequent to 1999, additional surveys will likely be required.

- Priority Site Ranking: Medium priority for bathymetric data collection in Zone 8.

3.8.2 Seabed Features

- Available data type and coverage: The small area of multibeam coverage to the south of Zone 8 is likely to give detailed information on seabed features. For the remainder of the zone, the area covered by SeaZone Digital Survey data may give information on larger scale bedforms. However, for the eastern part of the zone, bedform data is only likely to be available from narrow sidescan survey tracks (dating from 1981).

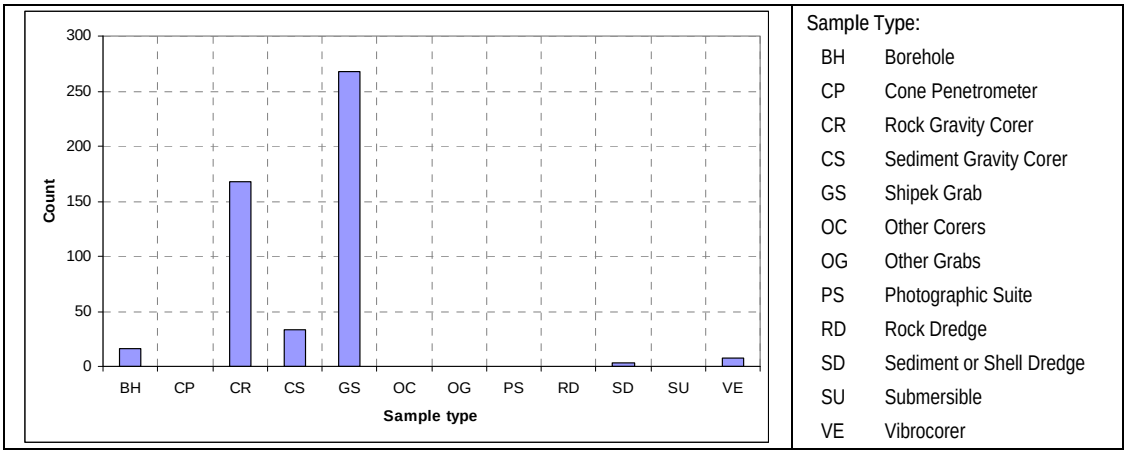
- Sufficiency: For a detailed project development assessment in the southern part of Zone 8, the available multibeam data is likely to be sufficient (resolution depending). The SeaZone data covering the western part of the zone may be adequate to carry out a regional assessment of larger scale features but for detailed studies here, and any up to date data required within the eastern part of the zone, additional surveys are likely to be required.

- Priority site ranking: Medium to High priority for seabed feature data collection in Zone 8.

3.8.3 Surface Sediment

- Available data type and coverage: Zone 8 contains a total of 496 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.52 samples/km^2. The majority of these samples are either Shipek Grab samples (268) or Rock Gravity cores (168). A breakdown of samples, by type, is given in Plot 16, below.

Plot 16. Bristol Channel surface sediment samples, by type



- Sufficiency: Available sediment sample data for Zone 8 has a relatively high survey density (compared to other zones) and the sample locations are well spread across the site. Inspection of the BGS sediment maps for Zone 8 show the bed to be classified by 10 different sediment classes, making it the most heterogeneous of any of the nine

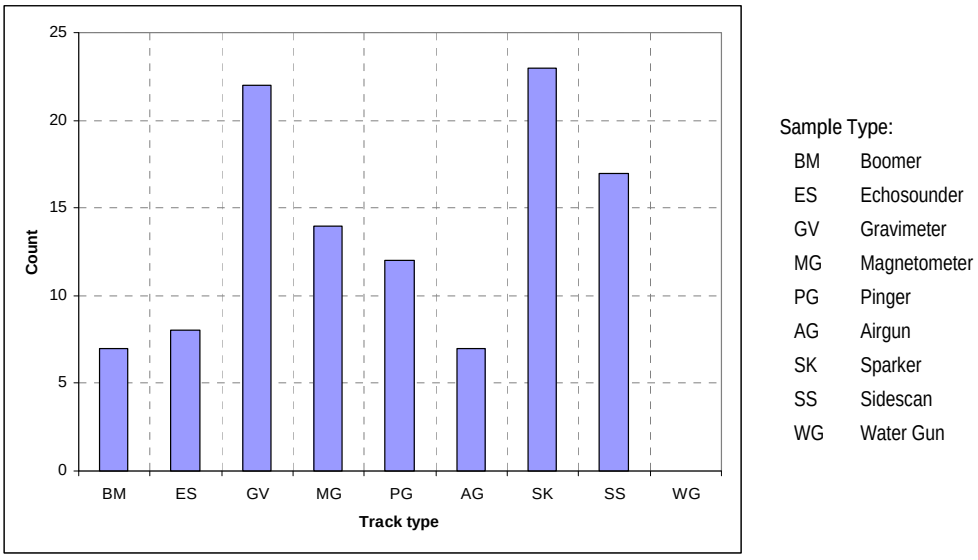
zones. The sediment types range from sandy Mud, through Sand and gravelly Sand to Gravel and Rock outcrops. Whilst the bed is made up of a number of sediment types, the sample density and spread is likely to be sufficient to characterise the zone for a regional assessment and, in most areas, is also likely to be adequate for detailed project development studies. In some areas, mostly towards the western extent, additional samples may be required for a detailed investigation.

- Priority site ranking: Low to Medium priority for surface sediment sampling of Zone 8.

3.8.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 26 survey tracks crossing the full extent of Zone 8. Of these, the majority are Sparker (23) surveys with fewer Pinger (12) and Boomer (7) tracks. Most of the surveys also have Gravimeter (22) and Magnetometer (14) data collected, whilst the eastern region of the zone contains Airgun (7) data too. The track lines are orientated in a grid with good coverage over much of the zone, although the extreme eastern side has a higher track density than the remainder of the site. The locations of the available sub-bottom survey tracks are shown in Figure 16, and a breakdown of survey track, by type, is given in Plot 17, below.

Plot 17. Bristol Channel survey tracks, by type



- Sufficiency: The whole of Zone 8 is covered by both Pinger and Sparker surveys, orientated in a grid with track lines spaced at approximately 6km by 11km. the eastern part of the zone is also covered by Boomer surveys at a closer spacing of approximately 2km by 6km. These same surveys also have data from Airgun equipment. The available data type and coverage for Zone 8 is likely to be sufficient for both regional and project development assessments.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 8.

3.8.5 Summary

Table 19 details a summary of the data gap analysis for Zone 8, for both a regional assessment and a site specific study.

Table 19. Summary of gap analysis for Zone 8 - Bristol Channel

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Medium	Medium to High
Seabed Features	Medium to High	High
Surface Sediment	Low to Medium	Medium
Sub-bottom profiling	Low	Low to Medium

3.9 Zone 9. Irish Sea

Table 20 is a summary of the relevant risks identified for Zone 9 during the recently completed R3 Risk Review project (ABPmer, 2009). A descriptive overview of the existing seabed conditions, within the zone, is given below.

Table 20. Summary of relevant identified risks (from R3 Risk Review) for Zone 9 Irish Sea

Risk ID	Coastal Process Topic	Coastal Process Risk	Risk Rating*	Confidence Rating*
C1	Sediment Mobility	Plumes of high suspended sediment concentration occurring during the construction process	Medium to Low	High
C3	Migration of seabed features	Construction problems due to sea bed stability	Medium	Medium
O2	Migration of seabed features	Undermining of foundations	Medium	Medium
O3	Migration of seabed features	Exposure of cables	Medium	Medium
O4	Sediment Mobility	Scour around foundations and cables	Medium to High	Medium

* Note: ABPmer 2009 should be reviewed to understand the context of these ratings

Existing Zone Conditions (from ABPmer, 2009)

Zone 9 can be characterised by coarser sediments (gravels and sands) and mobile bedforms at those locations where the tidal currents are more energetic. Sediment deposits containing fines are also located within the study area, typically where there is a reduction in tidal stresses.

3.9.1 Bathymetry

- Available data type and coverage: Multibeam data is available from four surveys at various locations across Zone 9, conducted by JNCC and SEA.UKDEAL. Overall the multibeam surveys cover approximately 5% of the total zone area. The remainder of the site is covered completely by SeaZone Digital Survey data, sourced from single beam surveys carried out between 1975 and 1996.

  Additional data is also available from BGS echosounder and sidescan survey tracks, dating between 1968 and 1974. Available data type and coverage is shown in Figure 17.

- Sufficiency: The available combination of multibeam and SeaZone Digital Survey data should provide adequate information of both a regional and project development assessment, although as with other zones, consideration should be given to data vintage and the likelihood of morphological change occurring within the zone. For up to date bathymetry, likely to be required for a site development, additional data is likely to be required.

- Priority site ranking: Low priority for bathymetric data collection in Zone 9.

3.9.2 Seabed Features

- Available data type and coverage: For the four areas covered by multibeam surveys, the available data is likely to give detailed information on the presence of seabed features. The remainder of the site is covered by SeaZone Digital Survey data (which may give information of larger scale features, where present), and a series of BGS sidescan surveys, dated between 1968 and 1974 (which will likely provide bedform information from narrow tracks).

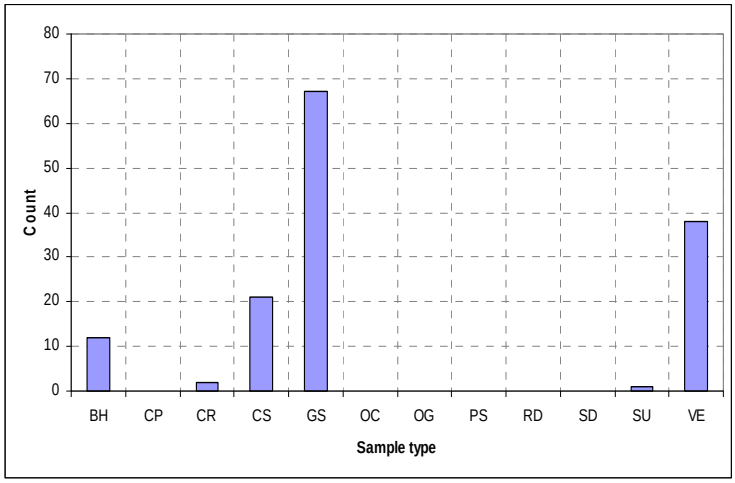
- Sufficiency: The multibeam data is likely to be sufficient for detailed project development assessments in these areas (resolution dependant). For the remainder of Zone 9, the SeaZone data may be adequate to carry out a regional assessment of larger scale features but for more detailed studies in these areas, additional high resolution surveys are likely to be required.

- Priority site ranking: Medium priority for collection of seabed feature data for Zone 9.

3.9.3 Surface Sediment

- Available data type and coverage: Zone 9 contains a total of 141 successful samples of surface sediment. Over the whole zone, this represents a sample density of 0.07 samples/km^2. The majority of these samples are either Shipek Grab samples (67) or Vibrocores (38). A breakdown of samples, by type, is given in Plot 18, below.

Plot 18. Irish Sea surface sediment samples, by type



Sample Type:

BH	Borehole
CP	Cone Penetrometer
CR	Rock Gravity Corer
CS	Sediment Gravity Corer
GS	Shipek Grab
OC	Other Corers
OG	Other Grabs
PS	Photographic Suite
RD	Rock Dredge
SD	Sediment or Shell Dredge
SU	Submersible
VE	Vibrocorer

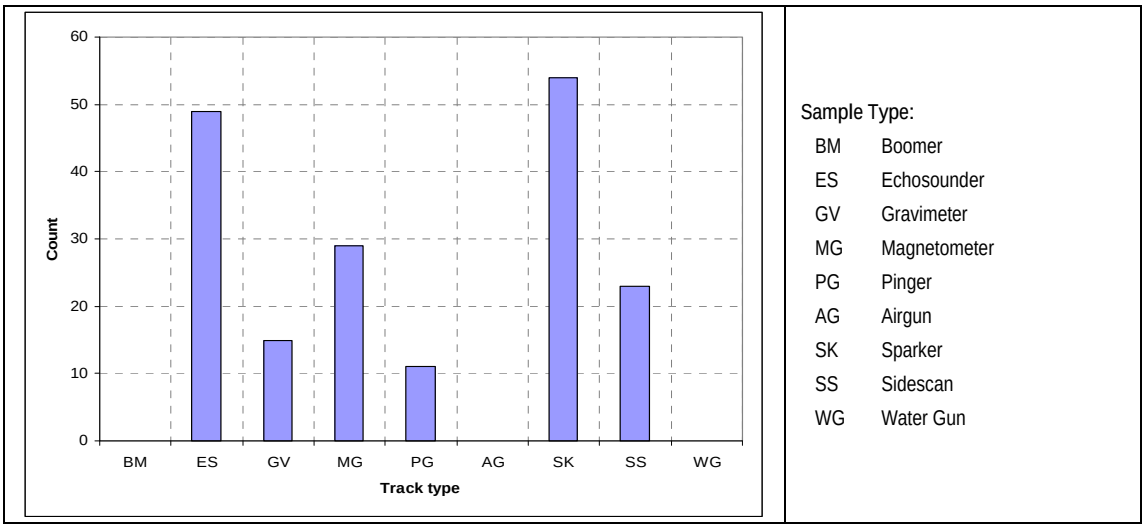
- Sufficiency: Within Zone 9, the available sediment sample data is well spread but the sample density is relatively low (compared to other zones). Inspection of the BGS sediment maps show the nature of the bed to be predominantly Gravel, sandy Gravel and gravelly Sand populations (with localised patches of gravelly muddy Sand and sandy muddy Gravel). The available data is likely to be sufficient for a regional assessment, however in order to properly define the boundaries between the different sediments and for detailed project development studies, additional sampling is likely to be required.

- Priority site ranking: Medium priority for surface sediment sampling of Zone 9.

3.9.4 Sub-Bottom Profiling

- Available data type and coverage: There are a total of 64 survey tracks crossing the full extent of Zone 9. Of these, the majority are Sparker (54) surveys with a few Pinger (11) tracks and no Boomer data available. Almost half of the surveys also have Magnetometer (29) data with a further 15 also containing Gravimeter surveys. The track lines are orientated in a grid with good coverage over much of the zone. Coverage of Sparker surveys is at a higher track density than Pinger surveys. The locations of the available sub-bottom survey tracks are shown in Figure 18, and a breakdown of survey track, by type, is given in Plot 19, below.

Plot 19. Irish Sea survey tracks, by type



- Sufficiency: Sparker survey tracks cover the full extent of Zone 9, orientated in a grid with a spacing of approximately 7km by 15km. Pinger surveys area also available for much of the zone, but these are spaced wider at 11km by 16km. The available Sparker data should give information of the sub-surface up to approximately 120m, with the Pinger data also giving higher resolution data of the shallow sub-surface (up to 30m). The combination of these data should be sufficient for both a regional assessment and detailed project development studies.

- Priority site ranking: Low priority for sub-bottom profiling of Zone 9.

3.9.4.1 Summary

Table 21 details a summary of the data gap analysis for Zone 9, for both a regional assessment and a site specific study.

Table 21. Summary of gap analysis for Zone 9 - Irish Sea

Data Type	Priority for 'Regional' Study	Priority for 'Site Level' Study
Bathymetry	Low	Low to Medium
Seabed Features	Medium	High
Surface Sediment	Medium	Medium to High
Sub-bottom profiling	Low	Low to Medium

4. Summary of Recommendations

Table 23, summarises the data collection priorities for each data type within each zone (as determined from the gap analysis), and ranks each zone depending on their data requirements (discussed below). The summary of data collection priorities highlights that for the majority of the nine zones, data availability on Seabed Features is the most limited. This is especially true in Zone 3 - Dogger Bank, where the limited availability of both multibeam and SeaZone Digital survey data leads to a High priority ranking. From this summary table, a further zone with insufficient data availability is Zone 7 - West Isle of Wight, where the available data on Seabed Features, Surface Sediment and Sub-bottom Profiling all return a Medium priority for additional surveying. Applying a simple numerical score to each priority level (where Low = 1; High = 5), the combined scoring suggests Zone 3 - Dogger Bank has the greatest requirement for additional surveys (scoring 12) closely followed by Zone 7 - West Isle of Wight (scoring 11).

Table 22. Summary of data collection priorities by zone

Zone	Bathymetry	Seabed Features	Surface Sediment	Sub-bottom	Score
3. Dogger Bank	Medium to High	High	Low to Medium	Low	12
7. West IOW	Low to Medium	Medium	Medium	Medium	11
8. Bristol Channel	Medium	Medium to High	Low	Low	9
4. Holderness	Low to Medium	Medium to High	Low	Low	8
9. Irish Sea	Low	Medium	Medium	Low	8
6. Hastings	Low	Medium	Low to Medium	Low to Medium	8
1. Moray Firth	Low	Low to Medium	Low	Medium	7
5. Norfolk	Low to Medium	Medium	Low	Low	7
2. Firth of Forth	Low	Low to Medium	Low	Low	5

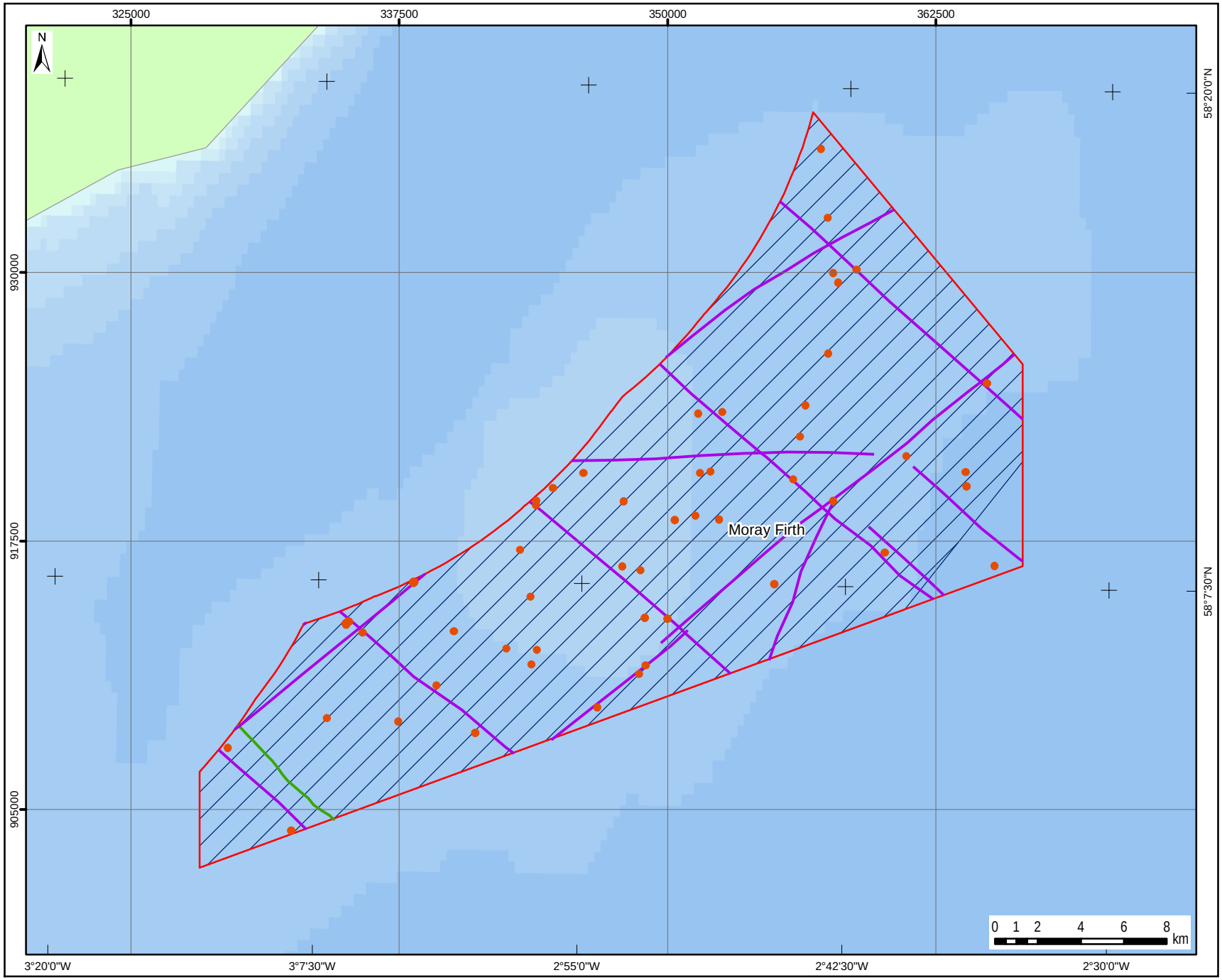
5. References

ABPmer, 2009. Round 3 Zones: High-Level Risk Review of Physical Processes. Report for The Crown Estate. ABP Marine Environmental Research Ltd, Report No. R.1503.

Conner, D.W., Gililand, P.M., Golding, N., Robinson, P., Todd, D. & Verling, E., 2006. UKSeaMap: the mapping of seabed and water column features of UK seas. Joint Nature Conservation Committee, Peterborough.

Folk, R.L., 1954. Journal of Geology, 62, pp 344-359.

Figures



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan + Echosounder
- Multibeam surveys
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:250,000	
QA		RJR	
3843 - Fig1_moray_firth.mxd			
Produced by ABPmer Ltd			

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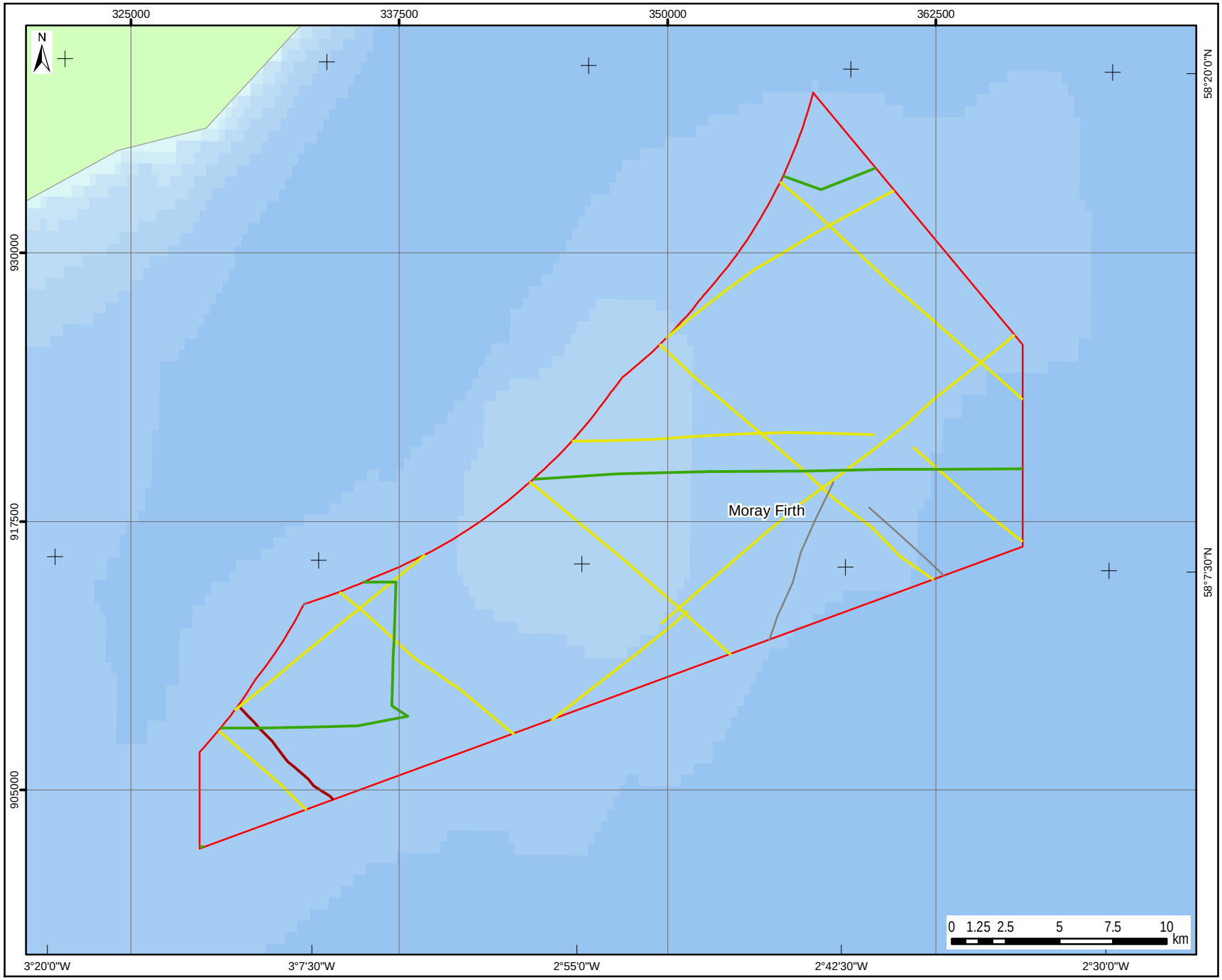
[GIS metadata layers supplied by BGS under licence]
Derived from US Naval DBDB0-V Version 4.2 bathymetry

ABP mer
marine environmental research

Available Bathymetry and seabed sample data for Zone 1. Moray Firth

Figure 1



Survey tracks - sub-bottom

- Other equipment
- Pinger
- Boomer
- Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:250,000	
QA		RJR	
3843 - Fig2_moray_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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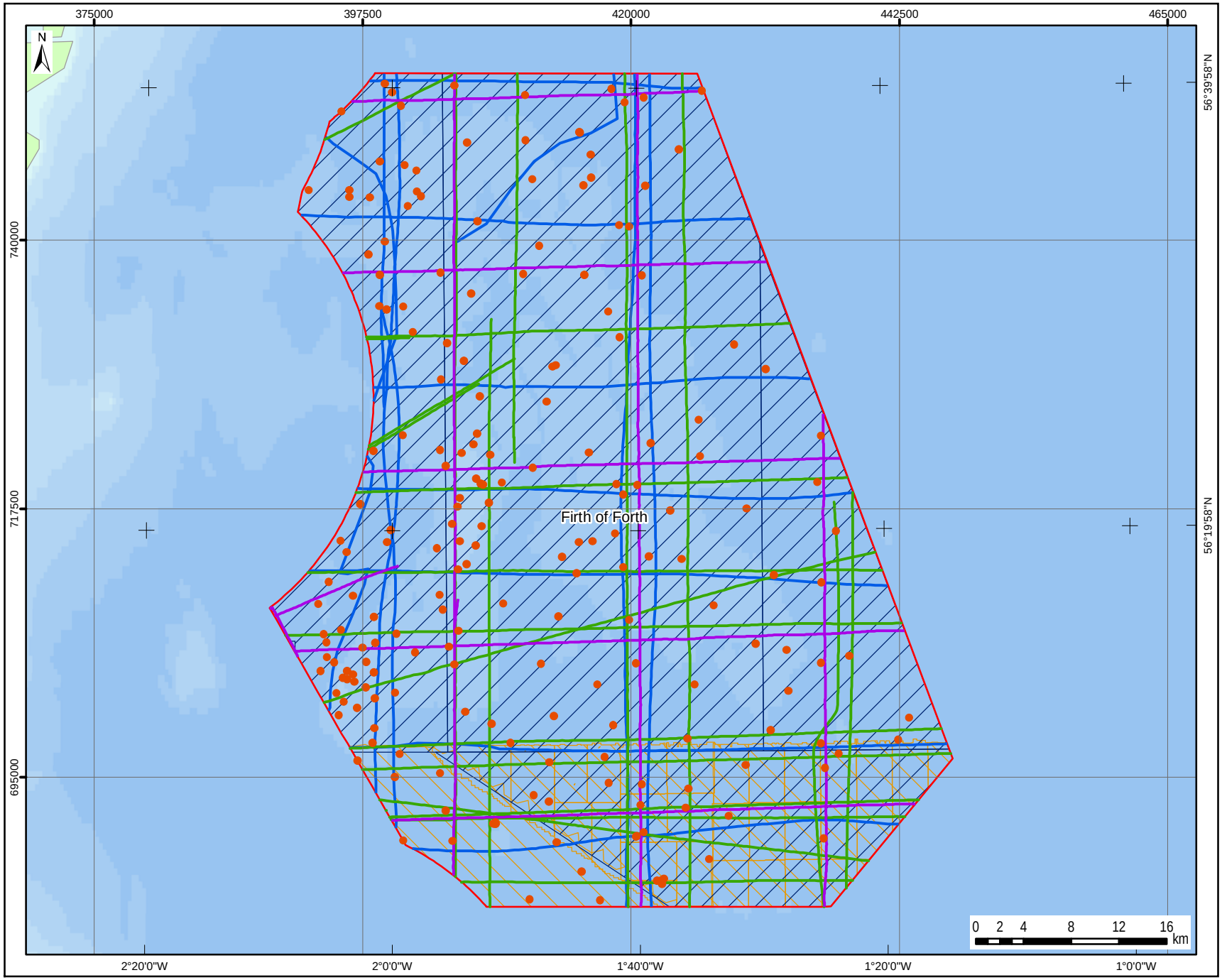
Available sub-bottom survey data for Zone 1. Moray Firth

Figure 2



Bed samples

- Successful sample

Survey tracks

- Sidescan
- Echosounder
- Sidescan + Echosounder
- R3 Zone boundary
- Multibeam surveys
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:450,000	
QA		RJR	
3843 - Fig3_firth_forth.mxd			
Produced by ABPmer Ltd			

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Background from US Naval DBDB0-V Version 4.2 bathymetry

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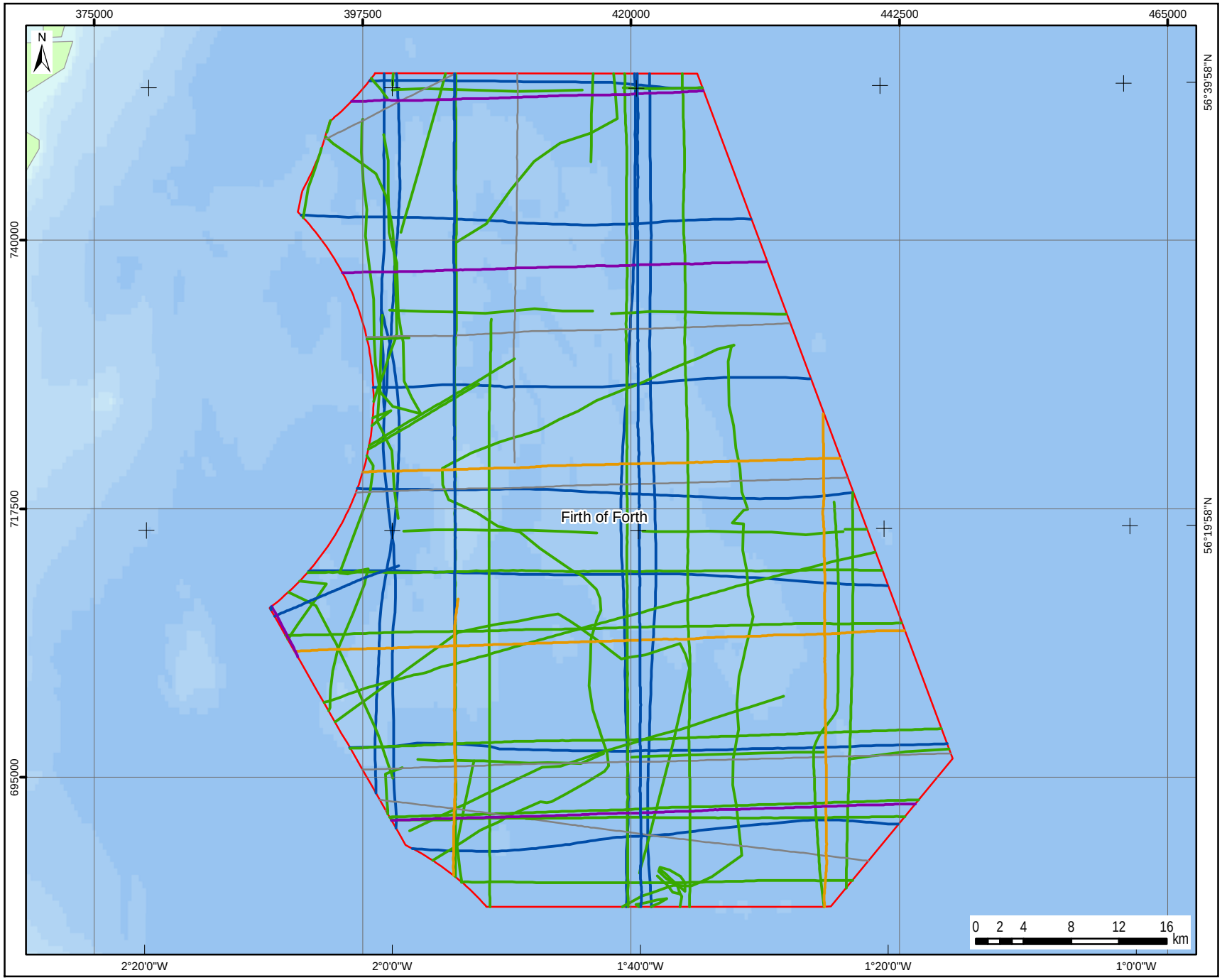
Available Bathymetry and seabed sample data for Zone 2. Firth of Forth

Figure 3



Survey tracks - sub bottom

- Other equipment
- Pinger
- Pinger / Sparker
- Boomer / Pinger / Sparker
- Boomer / Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:450,000	
QA		RJR	
3843 - Fig4_forth_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Background from US Naval DBDB0-V Version 4.2 bathymetry

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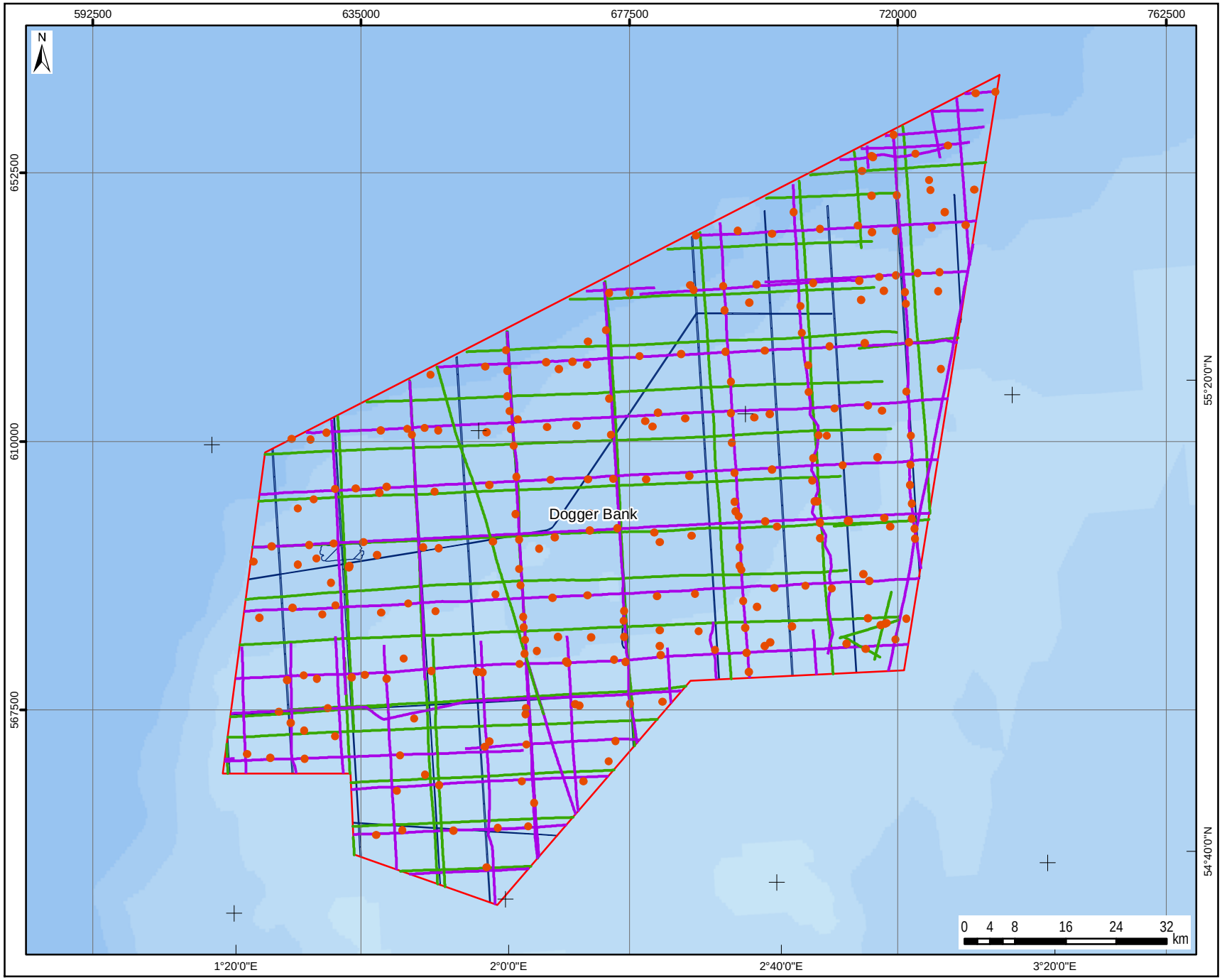
Available sub-bottom data for Zone 2. Firth of Forth

Figure 4



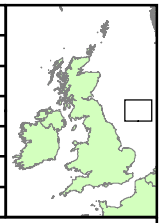
Bed samples

- Successful sample

Survey tracks

- Sidescan
- Sidescan + Echosounder
- R3 Zone boundary
- Multibeam surveys

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:850,000	
QA		RJR	
3843 - Fig5_dogger_bank.mxd			
Produced by ABPmer Ltd			



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Background from US Naval DBDB0-V Version 4.2 bathymetry

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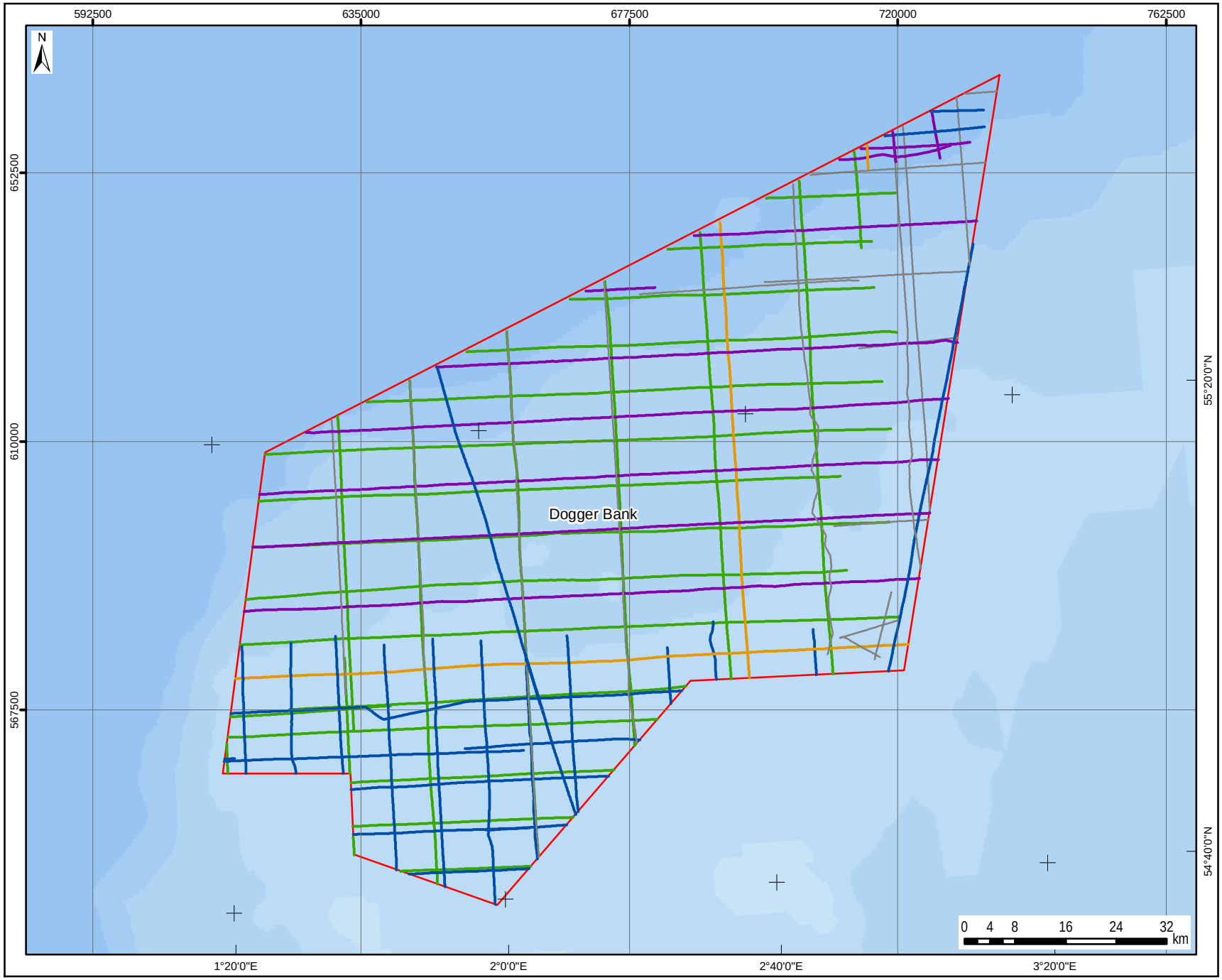
Available Bathymetry and seabed sample data for Zone 3. Dogger Bank

Figure 5



Survey tracks - sub bottom

- Other equipment
- Pinger
- Pinger / Sparker
- Boomer / Pinger / Sparker
- Boomer / Sparker
- R3 Zone boundary

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:850,000	
QA		RJR	
3843 - Fig6_dBank_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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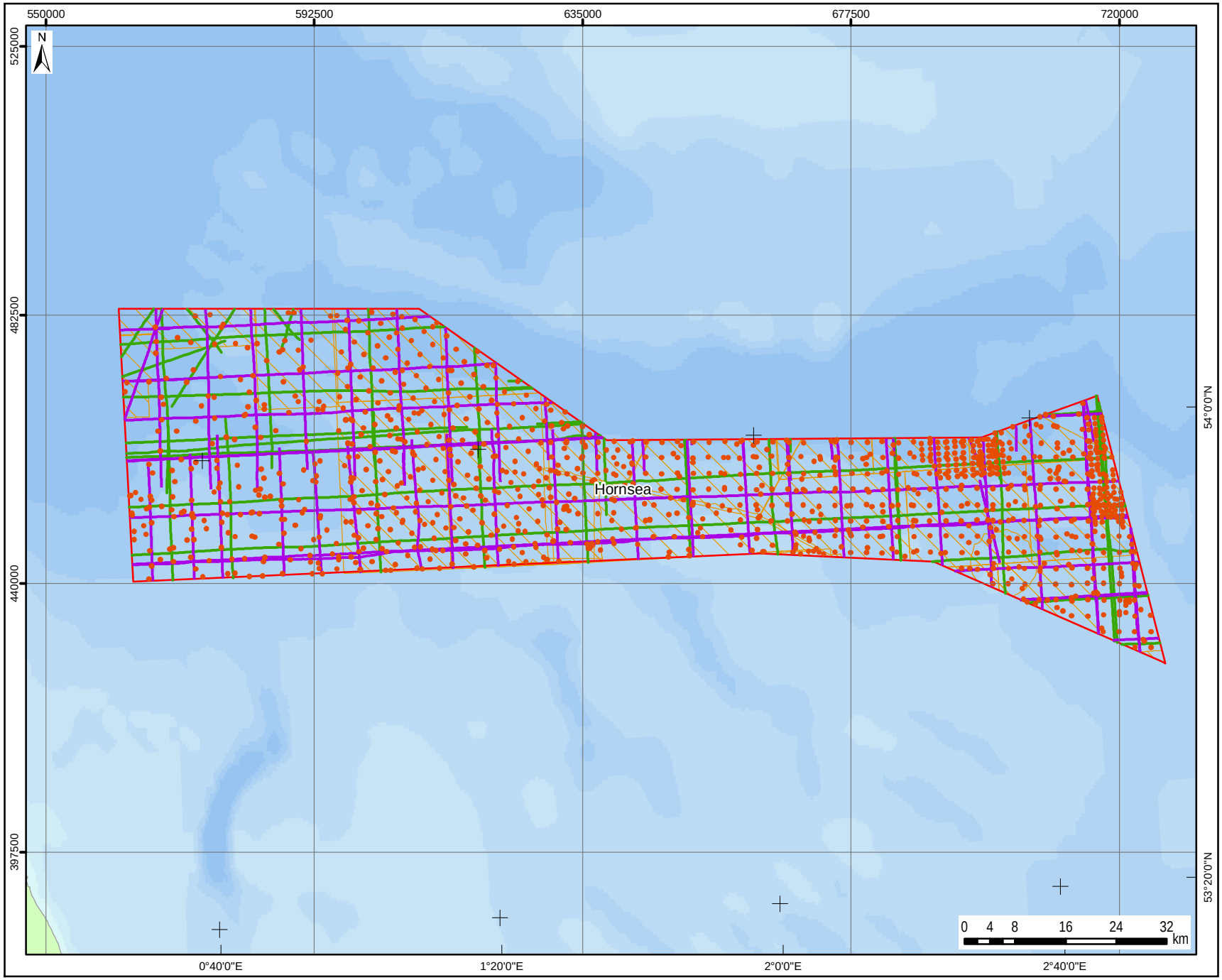
Available sub-bottom survey data for Zone 3. Dogger Bank

Figure 6



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan + Echosounder
- R3 Zone boundary
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:850,000	
QA		RJR	
3843 - Fig7_hornsea.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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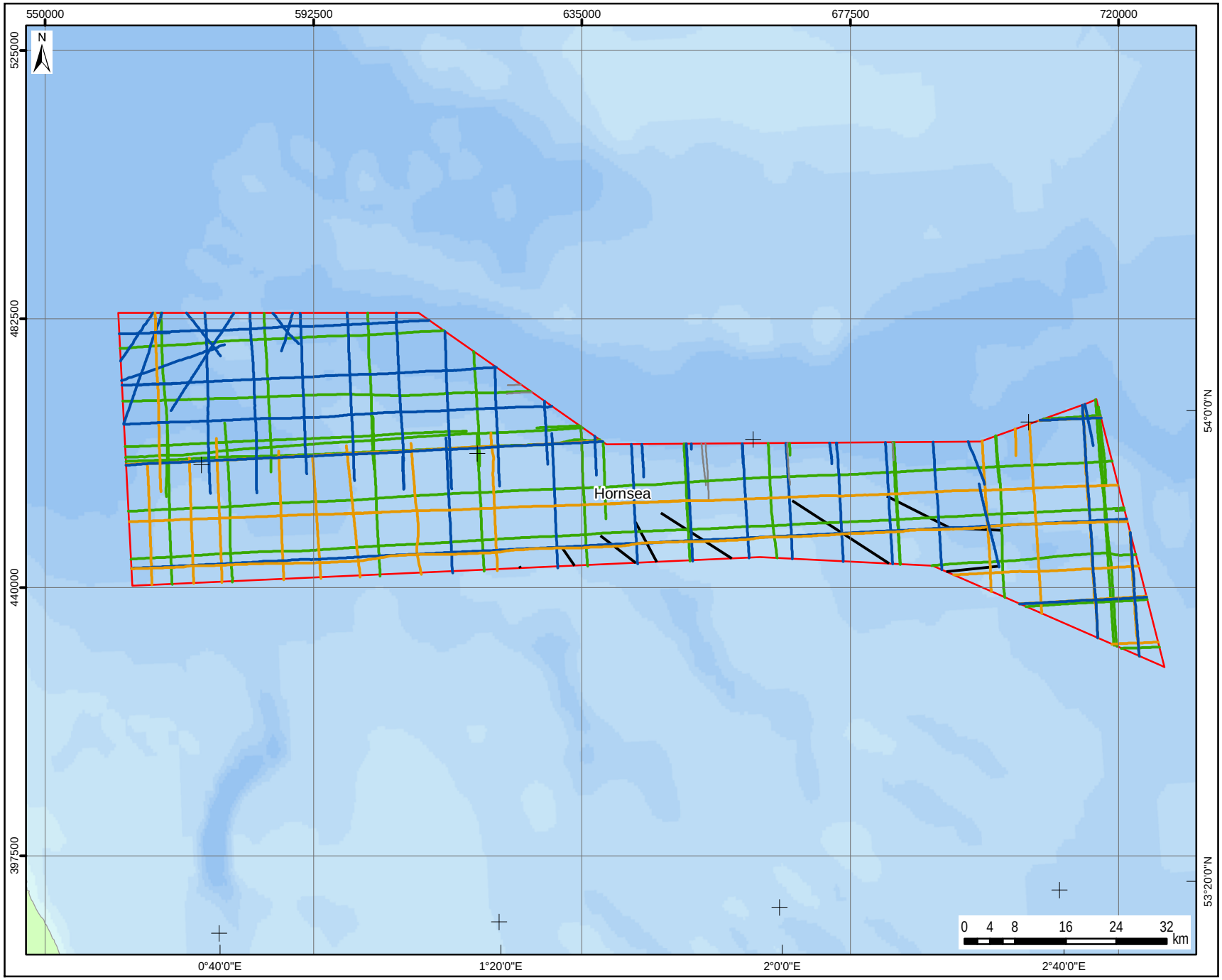
Available Bathymetry and seabed sample data for Zone 4. Hornsea

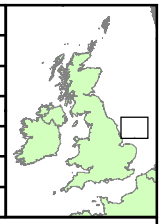
Figure 7



Survey tracks - sub bottom

- Other equipment
- Pinger
- Boomer / Pinger / Sparker
- Pinger / Sparker
- ALSF Humber REC
- R3 Zone boundary

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:850,000	
QA		RJR	
3843 - Fig8_hold_sub_bottom.mxd			
Produced by ABPmer Ltd			



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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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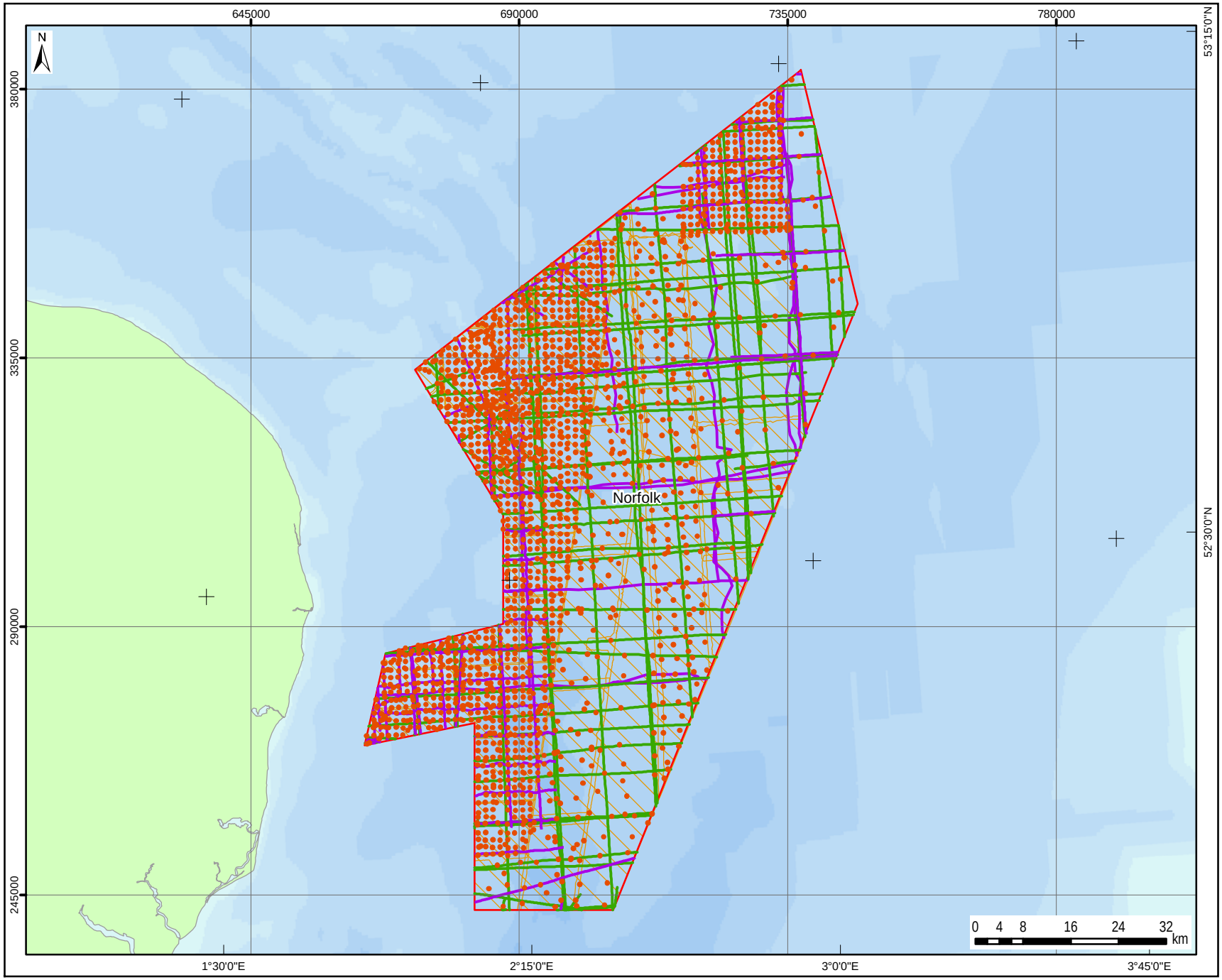
Available sub-bottom survey data for Zone 4. Hornsea

Figure 8



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan + Echosounder
- R3 Zone boundary
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:900,000	
QA		RJR	
3843 - Fig9_norfolk.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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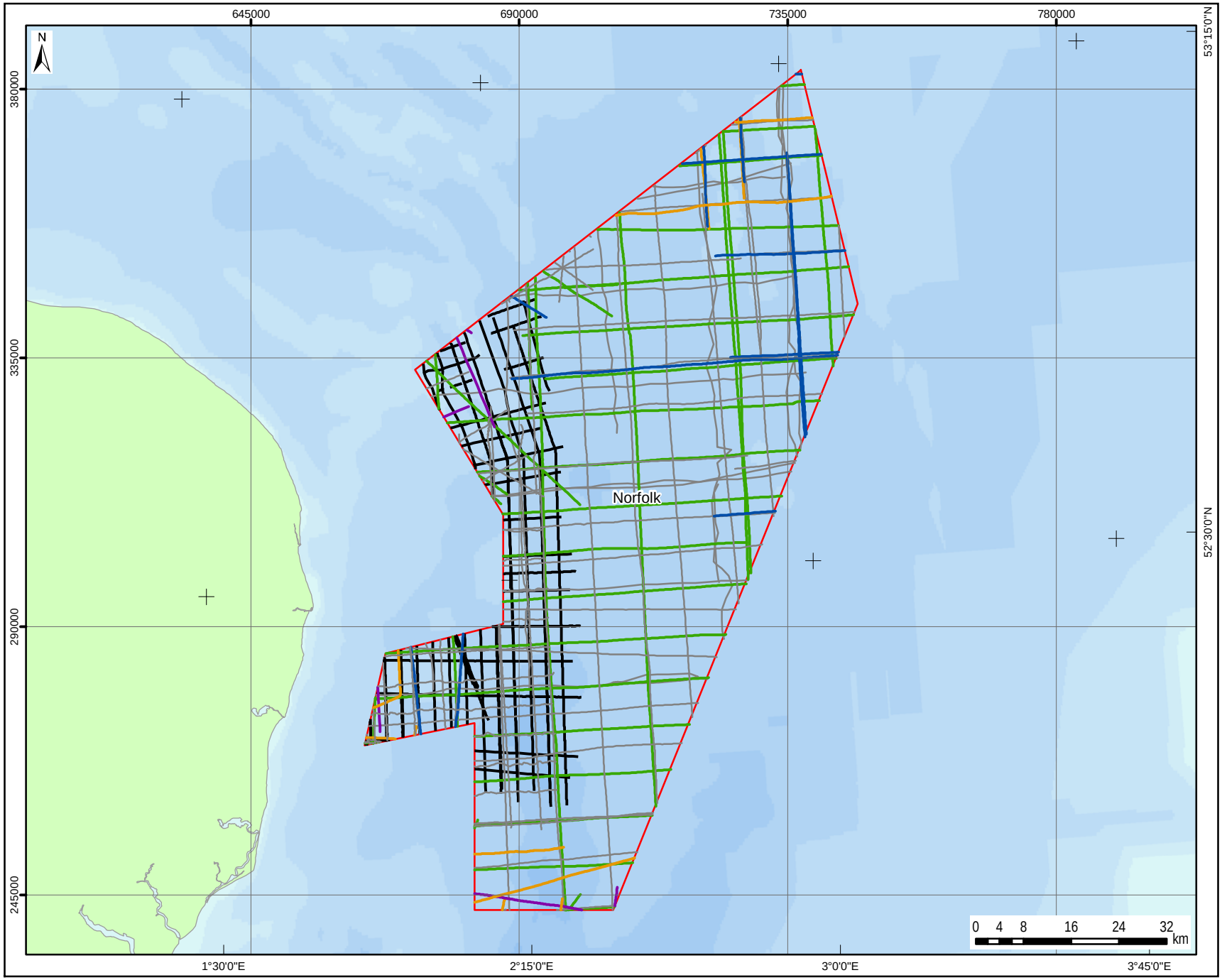
Available Bathymetry and seabed sample data for Zone 5. Norfolk

Figure 9



Survey tracks - sub bottom

- Other equipment
- Pinger
- Pinger / Sparker
- Boomer / Pinger / Sparker
- Boomer / Sparker
- ALSF East coast REC
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:900,000	
QA		RJR	
3843 - Fig10_nrflk_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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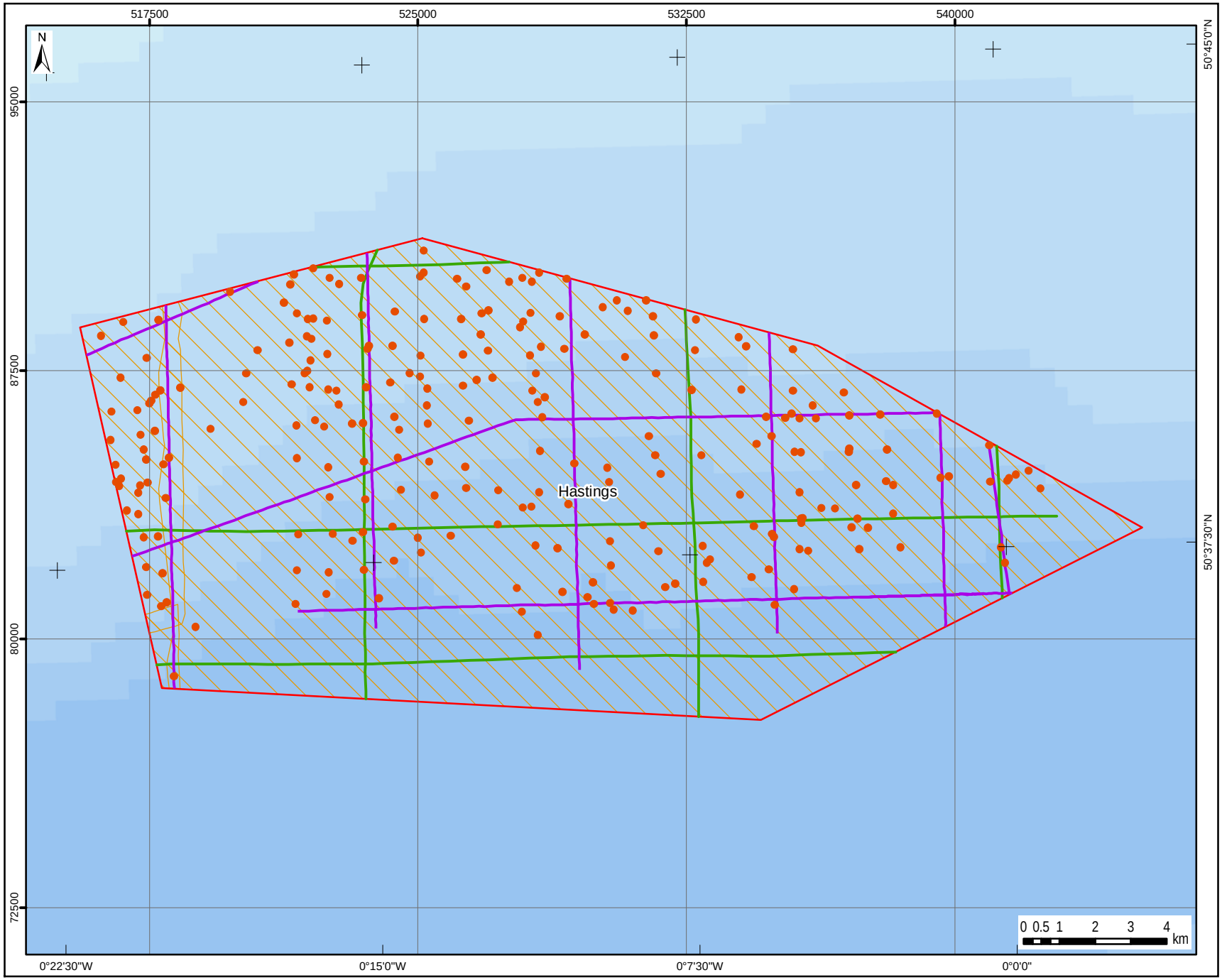
Available sub-bottom survey data for Zone 5. Norfolk

Figure 10



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan + Echosounder
- R3 Zone boundary
- SeaZone Digital Survey data

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:150,000	
QA		RJR	
3843 - Fig11_hastings.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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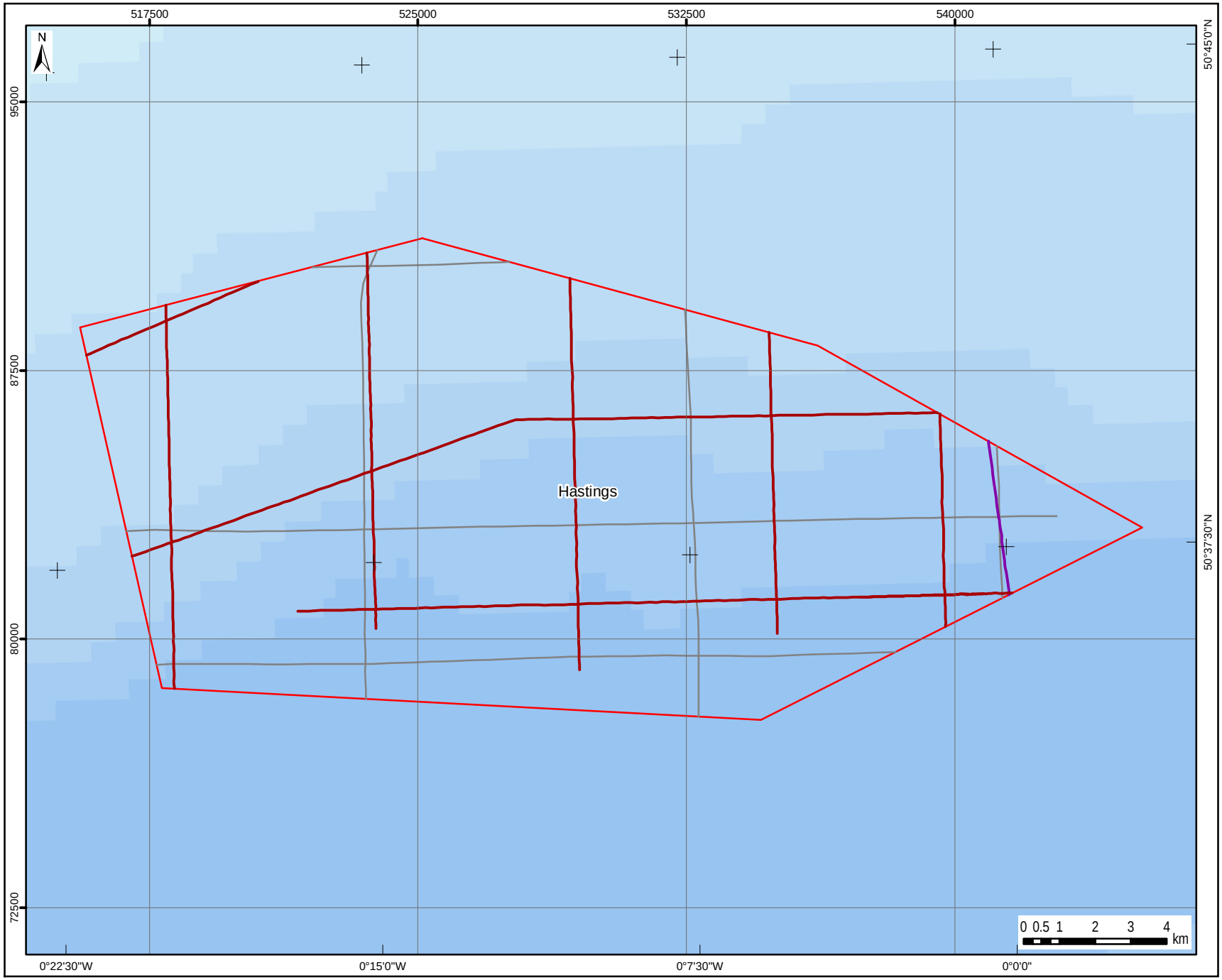
Available Bathymetry and seabed sample data for Zone 6. Hastings

Figure 11



Survey tracks - sub bottom

- Other Equipment
- Boomer
- Boomer / Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:150,000	
QA		RJR	
3843 - Fig12_hast_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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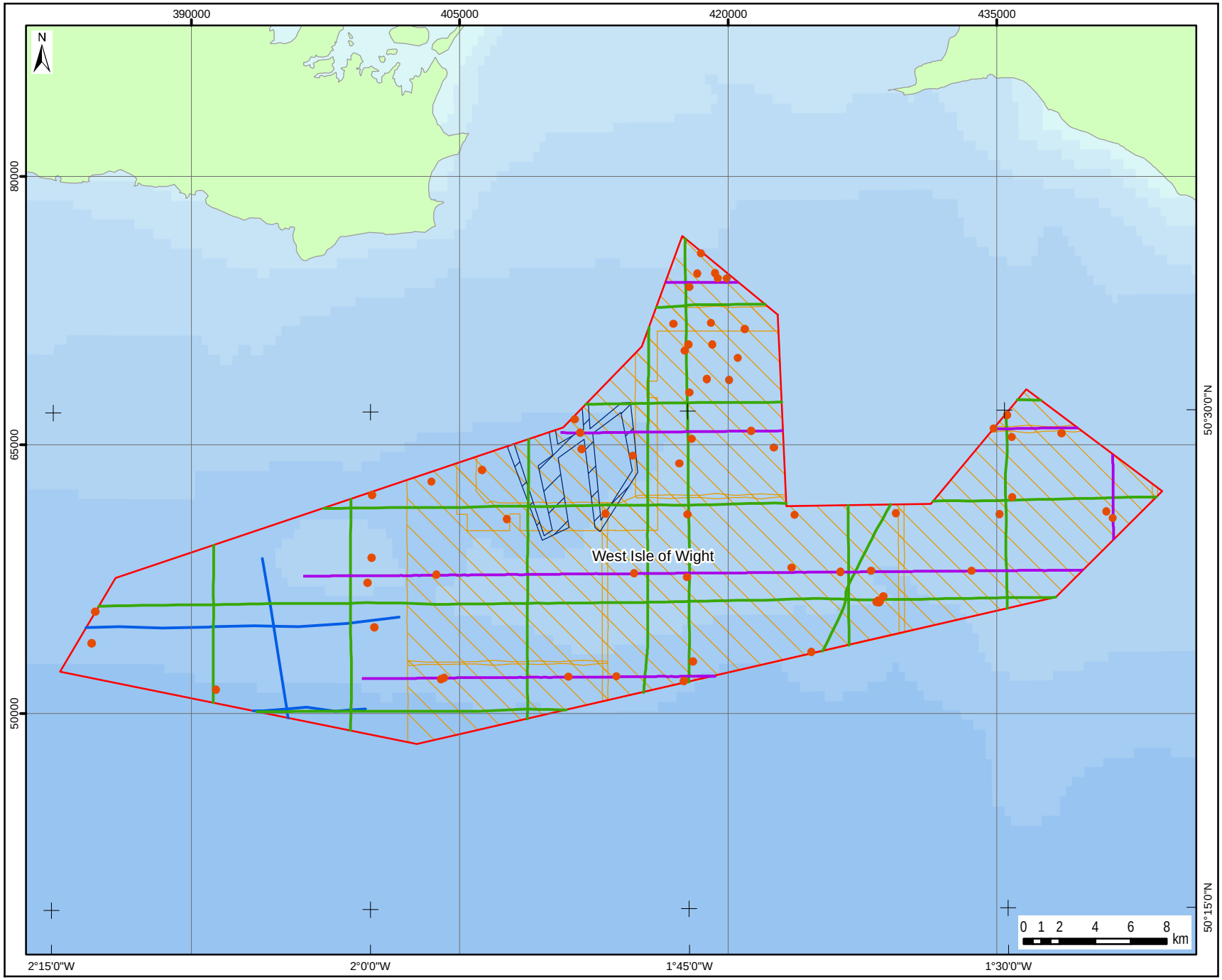
Available sub-bottom survey data for Zone 6. Hastings

Figure 12



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan
- Sidescan + Echosounder
- R3 Zone boundary
- Multibeam surveys
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:300,000	
QA		RJR	
3843 - Fig13_west_iow.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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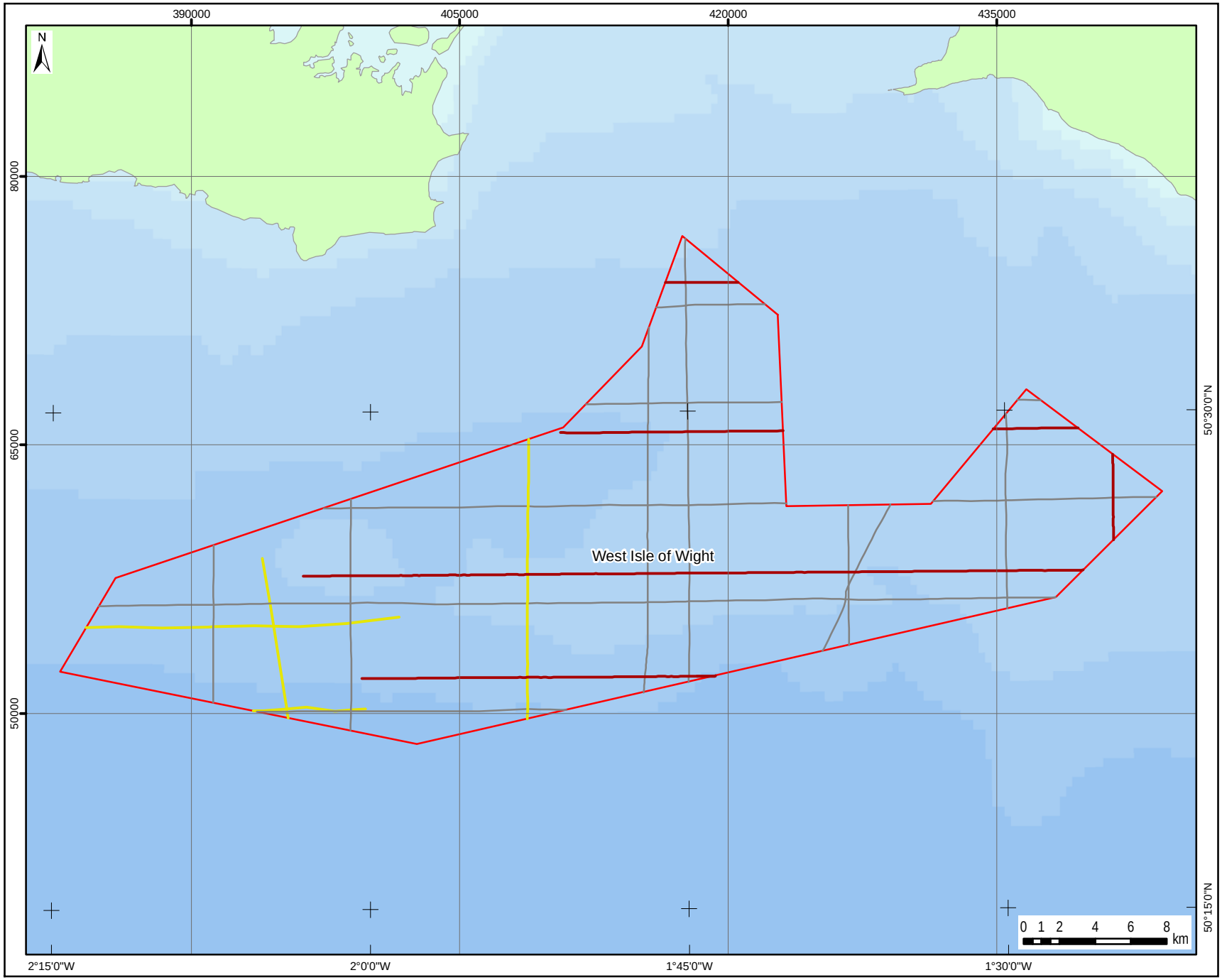
Available Bathymetry and seabed sample data for Zone 7. West IOW

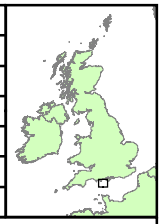
Figure 13



Survey tracks - sub bottom

- Other equipment
- Boomer
- Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:300,000	
QA		RJR	
3843 - Fig14_wiow_sub_bottom.mxd			
Produced by ABPmer Ltd			



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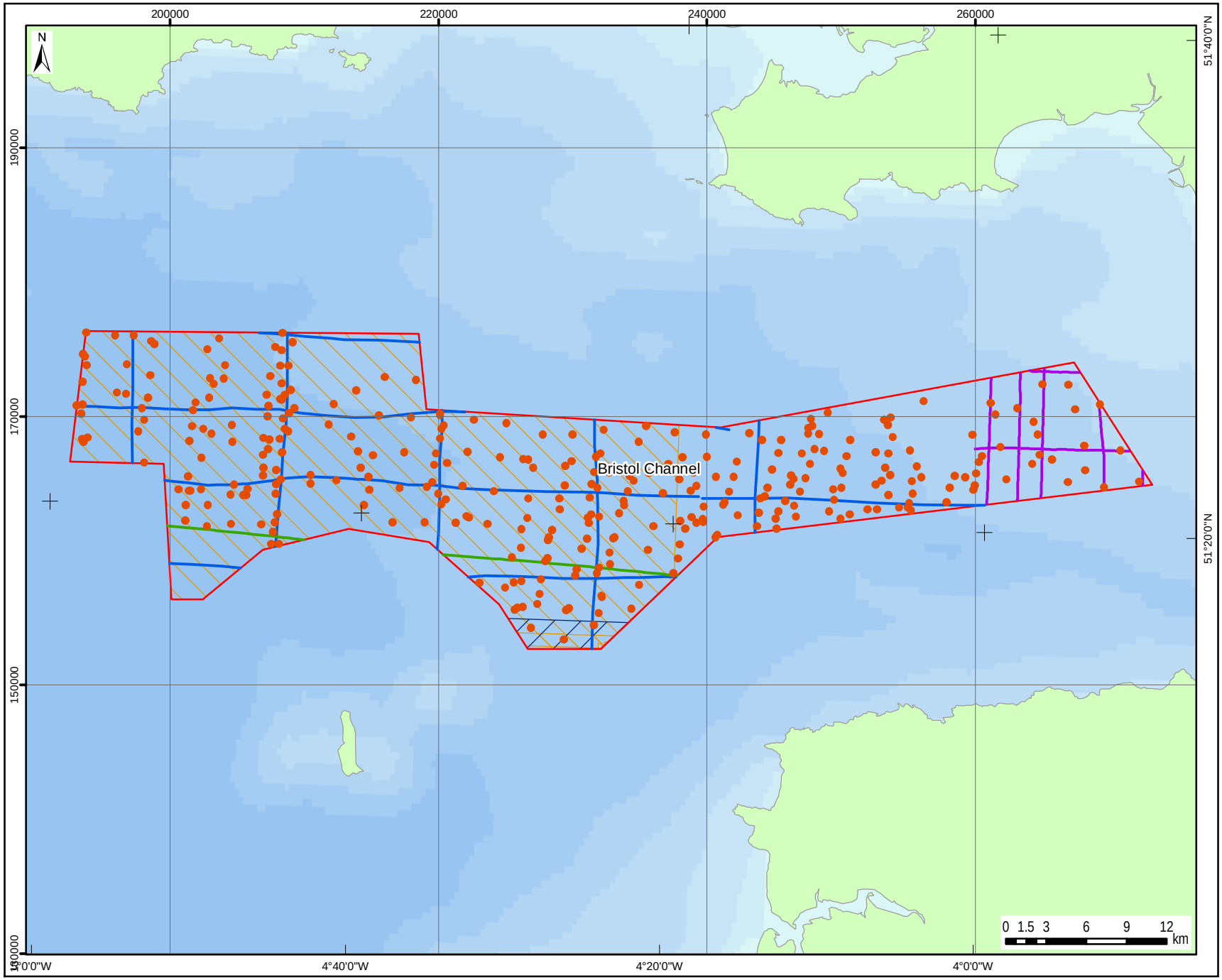
Available sub-bottom survey data for Zone 7. West Isle of Wight

Figure 14



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan
- Sidescan + Echosounder
- R3 Zone boundary
- Multibeam surveys
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:400,000	
QA		RJR	
3843 - Fig15_bristol_channel.mxd			
Produced by ABPmer Ltd			

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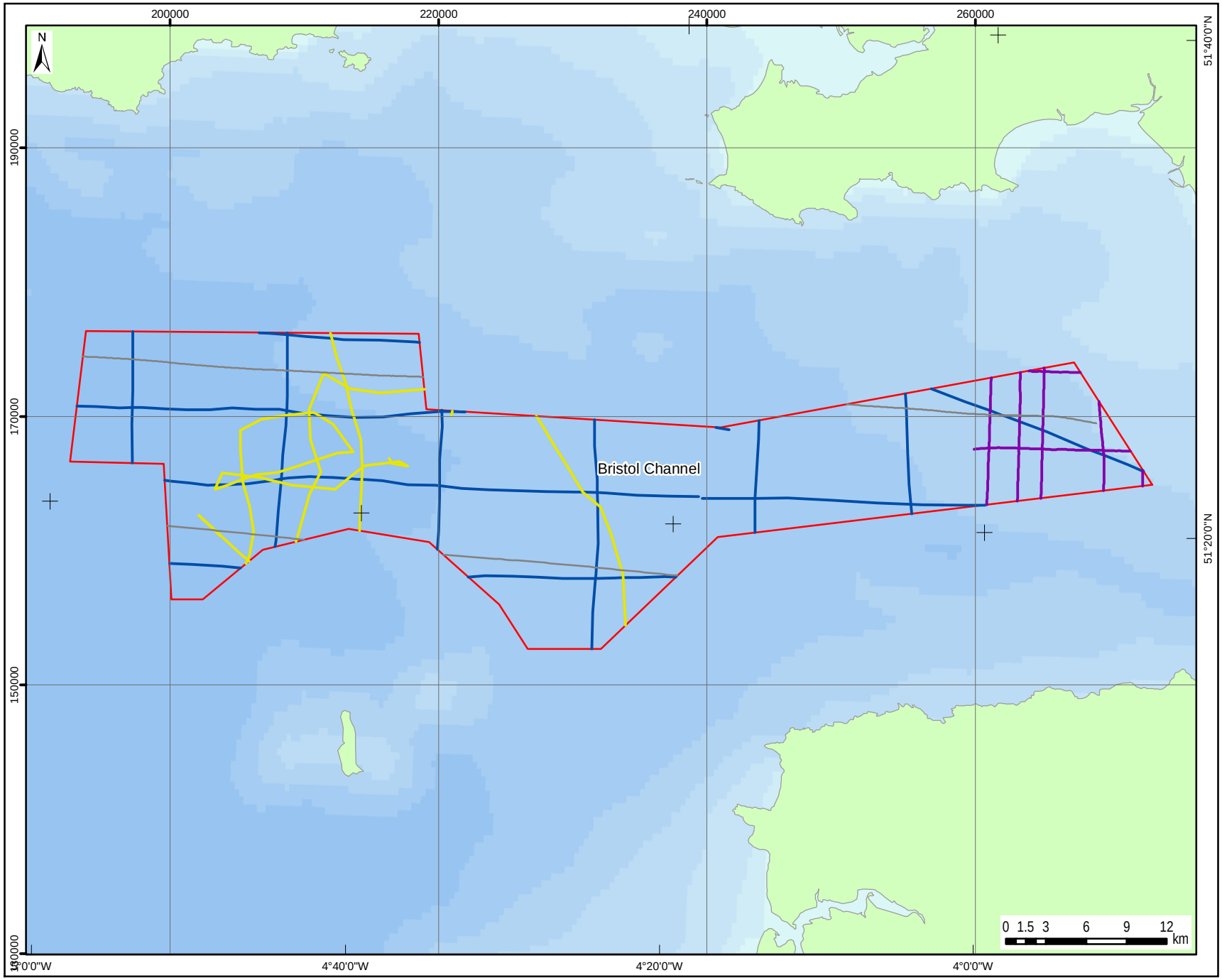
Available Bathymetry and seabed sample data for Zone 8. Bristol Channel

Figure 15



Survey tracks - sub bottom

- Other equipment
- Pinger / Sparker
- Boomer / Sparker
- Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:400,000	
QA		RJR	
3843 - Fig16_bc_sub_bottom.mxd			
Produced by ABPmer Ltd			

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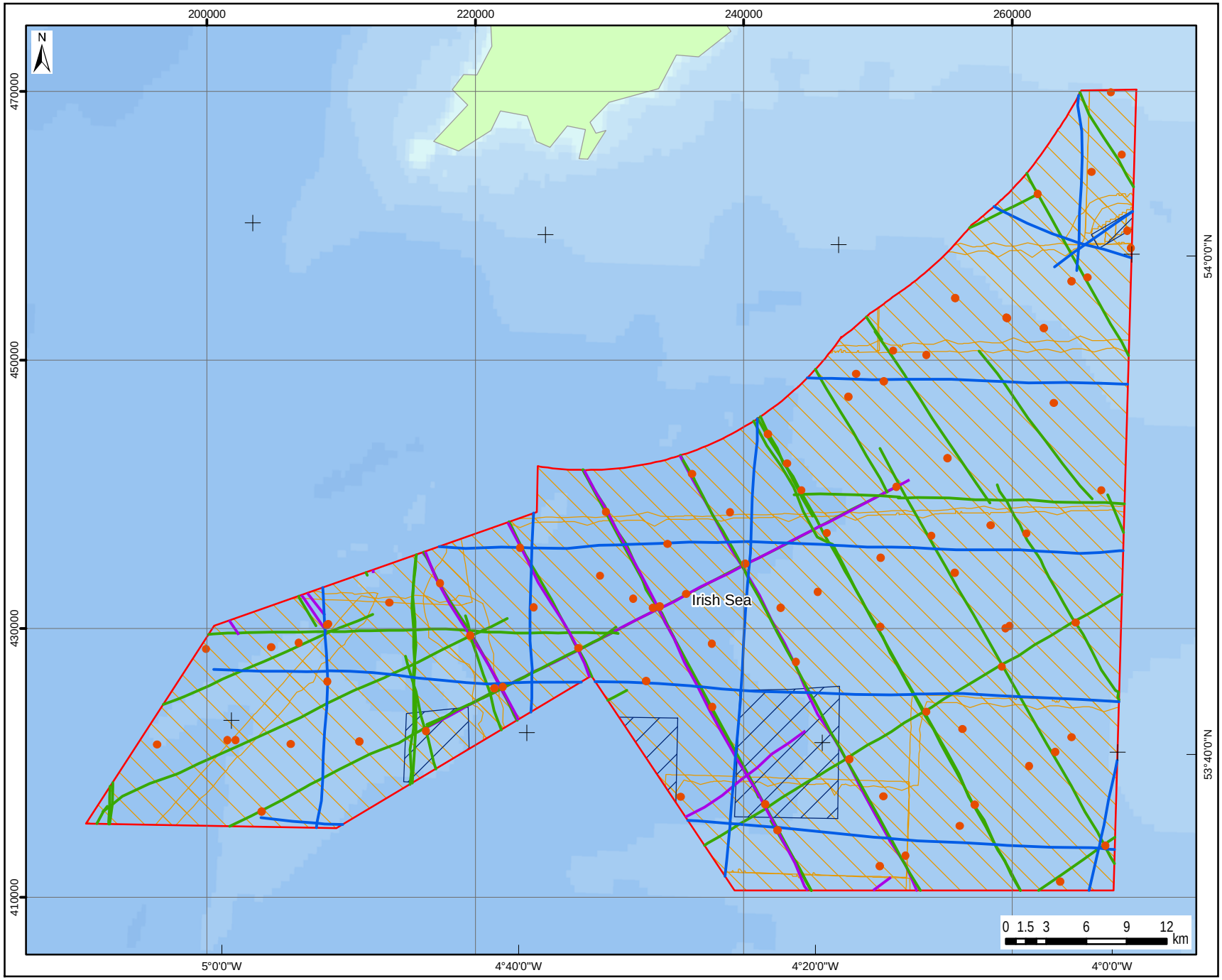
Available sub-bottom survey data for Zone 8. Bristol Channel

Figure 16



Bed samples

- Successful sample

Survey tracks

- Echosounder
- Sidescan
- Sidescan + Echosounder
- R3 Zone boundary
- Multibeam surveys
- SeaZone Digital Survey data
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:400,000	
QA		RJR	
3843 - Fig17_irish_sea.mxd			
Produced by ABPmer Ltd			

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Derived from US Naval DBDB0-V Version 4.2 bathymetry

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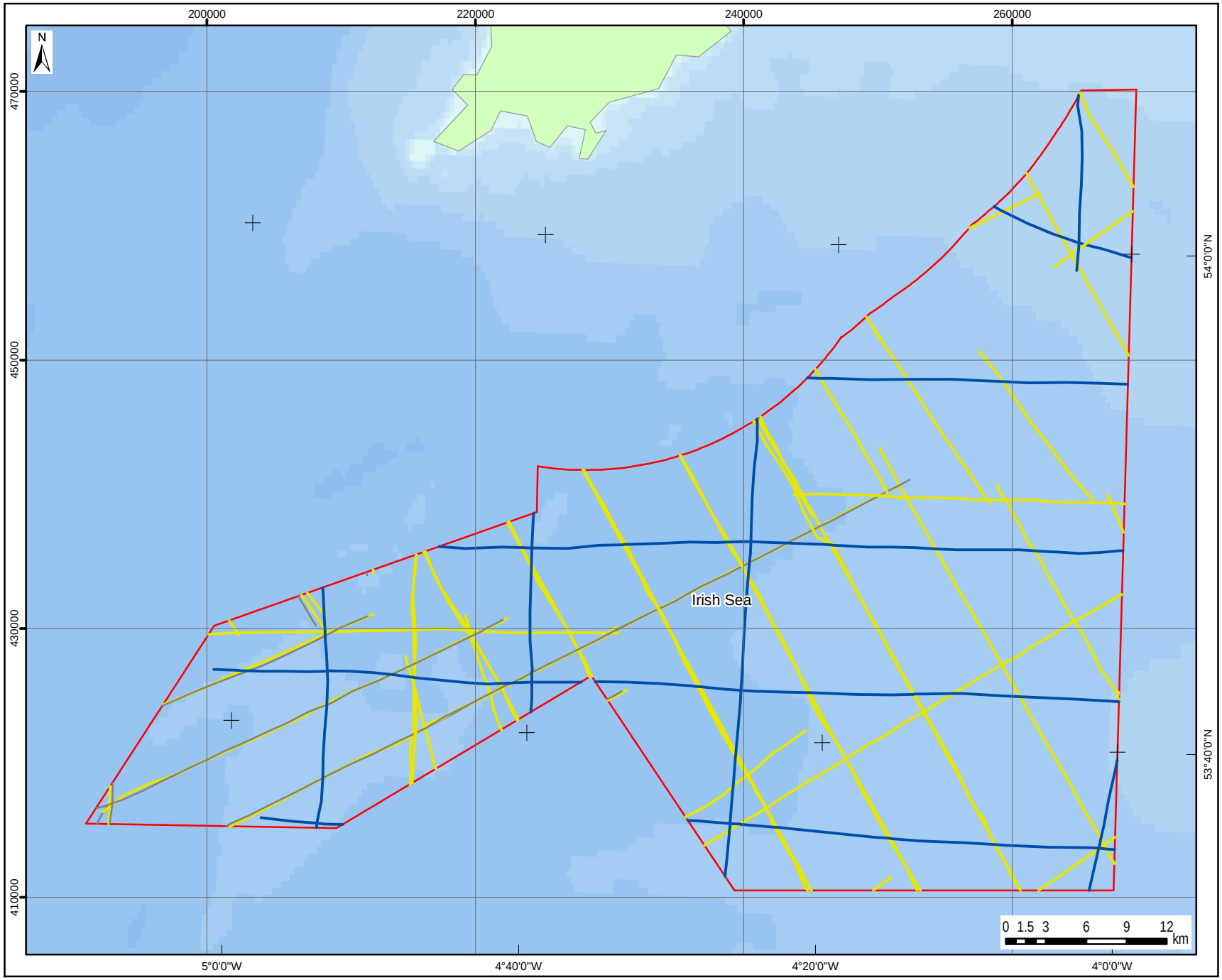
Available Bathymetry and seabed sample data for Zone 9. Irish Sea

Figure 17



Survey tracks - sub bottom

- Other equipment
- Pinger / Sparker
- Sparker
- R3 Zone boundary
- UK Coastline

Date	By	Size	Version
April 09	AMF	A4	1
Projection		OSGB 1936	
Scale		1:400,000	
QA		RJR	
3843 - Fig18_irish_sub_bottom.mxd			
Produced by ABPmer Ltd			

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Available sub-bottom survey data for Zone 9. Irish Sea

Figure 18

Appendix A

Additional Information on
BGS Datalayers and Confidence Grid
(All Information Supplied by
Rhys Cooper, BGS Edinburgh)

Appendix A. Additional Information on BGS Datalayers and Confidence Grid
(All Information Supplied by Rhys Cooper, BGS Edinburgh)

In addition to the ISO metadata, attached to each shapefile, this appendix gives a list of the abbreviations used in the field name codes of the Samples and Tracks shapefiles.

Seabed Sampling Equipment (From Attribute Table of Samples Shapefile)	
AM	Amon or Hammon Grab
BC	Box Corer
BH	Borehole
BS	Beach Sample
CM	Multi-Corer
CP	Cone Penetrometer
CR	Rock Gravity Corer
CS	Sediment Gravity Corer
CT	Conductivity, Temperature and Depth Sample
DI	Collected by a Diver
DM	BGS 1-metre Drill
DR	BGS 5-metre Drill
EB	Epibenthic Sledge
GD	Day Grab
GH	Hydraulic Grab
GS	Shipek Grab
OC	Other Corers
OG	Other Grabs
PS	Photographic Site
RD	Rock Dredge
SD	Sediment or Shell Dredge
SU	Submersible
TA	Agassiz Trawl
VE	Vibrocorer

Sub--Bottom Profiling Equipment (From Attribute Table of Tracks Shapefile)	
AG	Single-Channel Airgun
BM	Boomer (Shallow or undefined)
ES	Echo sounder
GV	Gravimeter
HS	Hydrosweep
MG	Magnetometer
PG	Pinger
PR	Parametric Sound Source
RF	Refraction or Wide-Angle Reflection
SA	Presumed wrong code for combined Sparker-Airgun
SB	Presumed wrong code for combined Sparker-Boomer
SK	Sparker
SP	Wrongly coded Sparker
SS	Sidescan Sonar (or Undefined Sonar)
WA/WG	Water gun

Key to Numerical Value in 'Equipment Type' Column (For Both Samples and Tracks Shapefiles)	
0	No sample attempted
1	SUCCESS - Analogue Data or Sample
2	No sample (geological reasons)
3	No sample (equipment failure)
4	No sample (undifferentiated)

List of Field Name Codes (Used in Tracks Shapefile)		
Field Code	Geophysical Data Attribute Full Name	Comments
CRUISE	CRUISE	This is the "name" by which a cruise is known. It is normally a combination of the older YEAR and PROJ.
LINE	LINE	This is the "name" by which a line is known. Examples: 78 ,SBGS-93/02-A1 , M89-WB-3A
START_POIN	START_POINT_ORDER	The Sequential Point Order value at the start of the line (normally 1)
START_EAST	START_EASTING	The easting coordinate of the line start, it may be lat/long, national grid, UTM, etc.
START_EA_1	START_EASTING_ACCURACY	The accuracy of the start Easting (in the same units as the start Easting)
START_NORT	START_NORTHING	The northing coordinate of the line start, it may be lat/long, national grid, UTM, etc.
START_NO_1	START_NORTHING_ACCURACY	The accuracy of the start Northing (in the same units as the start Northing)
START_EPSG	START_EPSG_CODE	The EPSG (OGP) "name" (usually a number) for the coordinate system used at the start point
END_POINT_	END_POINT_ORDER	The Sequential Point Order value at the end of the line
END_EASTIN	END_EASTING	The easting coordinate of the line end, it may be lat/long, national grid, UTM, etc.
END_EAST_1	END_EASTING_ACCURACY	The accuracy of the end Easting (in the same units as the end Easting)
END_NORTHI	END_NORTHING	The northing coordinate of the line end
END_NORT_1	END_NORTHING_ACCURACY	The accuracy of the end Northing (in the same units as the end Northing)
END_EPSG_C	END_EPSG_CODE	The EPSG (OGP) "name" (usually a number) for the coordinate system used at the start point
BOOMER_SHA	BOOMER_SHALLOW_OR_UNKNOWN	Contains "1" if "Boomer (shallow or unknown)" equipment has been used, otherwise "0".
BOOMER_DEE	BOOMER_DEEP	Contains "1" if "Boomer (Deep)" equipment has been used, otherwise "0".
CHIRP	CHIRP	Contains "1" if "CHIRP" equipment has been used, otherwise "0".
DIGITAL_DE	DIGITAL_DEEP_SEISMIC	Contains "1" if "Digital Deep Seismic" equipment has been used, otherwise "0".
DIGITAL_SH	DIGITAL_SHALLOW_SEISMIC	Contains "1" if "Digital Shallow Seismic" equipment has been used, otherwise "0".
EXPLOSIVE_	EXPLOSIVE_CHARGE	Contains "1" if "Explosive charge" equipment has been used, otherwise "0".
ECHO_SOUND	ECHO_SOUNDER	Contains "1" if "Echo Sounder" equipment has been used, otherwise "0".
GRAVIMETER	GRAVIMETER	Contains "1" if "Gravimeter" equipment has been used, otherwise "0".
MULTI_BEAM	MULTI_BEAM	Contains "1" if "Multi-Beam" equipment has been used, otherwise "0".

List of Field Name Codes (Used in Tracks Shapefile)		
Field Code	Geophysical Data Attribute Full Name	Comments
MAGNETOMET	MAGNETOMETER	Contains "1" if "Magnetometer" equipment has been used, otherwise "0".
PRECISION_	PRECISION_DEPTH_RECORDER	Contains "1" if "Precision Depth Recorder" equipment has been used, otherwise "0".
PINGER	PINGER	Contains "1" if "Pinger" equipment has been used, otherwise "0".
PARAMETRIC	PARAMETRIC_SOUND_SOURCE	Contains "1" if "Parametric Sound Source" equipment has been used, otherwise "0".
AIRGUN	AIRGUN	Contains "1" if "Airgun" equipment has been used, otherwise "0".
REFRACTION	REFRACTION_OR_WIDE_ANGLE_REFLE	Contains "1" if "Refraction or Wide-angle Reflection" equipment has been used, otherwise "0".
SLEEVE_EXP	SLEEVE_EXPLODER	Contains"1" if "Sleeve Exploder" equipment has been used, otherwise "0".
SPARKER	SPARKER	Contains "1" if "Sparker" equipment has been used, otherwise "0".
SIDESCAN_O	SIDESCAN_OR_UNKNOWN_SONAR	Contains "1" if "Sidescan (or Unknown) Sonar" equipment has been used, otherwise "0".
TRANSIT_SO	TRANSIT_SONAR	Contains "1" if "Transit Sonar" equipment has been used, otherwise "0".
WATER_GUN	WATER_GUN	Contains "1" if "Water Gun" equipment has been used, otherwise "0".
CRUISE_LIN	CRUISE_LINE	Concatenated CRUISE and LINE attributes separated by '#', for example 1966/3#1
START_EA_2	START_EASTING_ED50	Easting of the Start Point of this line in the ED50 Coordinate System SRID=4230.
START_NO_2	START_NORTHING_ED50	Northing of the Start Point of this line in the ED50 Coordinate System SRID=4230.
END_EAST_2	END_EASTING_ED50	Easting of the End Point of this line in the ED50 Coordinate System SRID=4230.
END_NORT_2	END_NORTHING_ED50	Northing of the End Point of this line in the ED50 Coordinate System SRID=4230.
START_EA_3	START_EASTING_WGS84	Easting of the Start Point of this line in the WGS84 Coordinate System SRID=4326.
START_NO_3	START_NORTHING_WGS84	Northing of the Start Point of this line in the WGS84 Coordinate System SRID=4326.
END_EAST_3	END_EASTING_WGS84	Easting of the End Point of this line in the WGS84 Coordinate System SRID=4326.
END_NORT_3	END_NORTHING_WGS84	Northing of the End Point of this line in the WGS84 Coordinate System SRID=4326.
START_EA_4	START_EASTING_BNG	Easting of the Start Point of this line in the ED50 Coordinate System SRID=27700.
START_NO_4	START_NORTHING_BNG	Northing of the Start Point of this line in the ED50 Coordinate System SRID=27700.
END_EAST_4	END_EASTING_BNG	Easting of the End Point of this line in the ED50 Coordinate System SRID=27700.
END_NORT_4	END_NORTHING_BNG	Northing of the End Point of this line in the ED50 Coordinate System SRID=27700.
BGS_LINE_L	BGS_LINE_LENGTH	Line length in KM to nearest whole number
CLIENT_ID	CLIENT_ID	Client ID Reference Number
CLIENT_NAM	CLIENT_NAME	Client Name

Information on the Creation of the BGS Confidence Grid

An ESRI grid (1km cell) has been created to represent a level of confidence in assessing the seabed conditions/sediment at a known location. The grid has a numerical score of 0 to 10, from a low to higher level of confidence. Confidence has been assessed only in terms of easily quantifiable parameters. The score is based upon data availability/density and equipment type. No allowance has been made for positional accuracy due to the resolution of final grid cell size.

The following is a brief outline of the six stages used to develop a single confidence level grid with a value of between 0 and 10. Each individual stage below results in an intermediate grid, with an appropriate score, that are summed to produce the final confidence grid.

1. Sample Density
   The sample density was calculated using the Point Density function of ArcGIS Spatial Analyst. The density of samples is calculated for a 4km² square area around the centroid of each individual 1km cell. The number of points falling within the search area is totalled and divided by the search area, in this case 4km². The resulting grid was then reclassified to assign an appropriate score for inclusion in the final confidence grid. For example: <0.24 = 0 (no samples); 0.25-0.5 = 2 (between 1 and 2 samples); >0.5 = 3 (more than 2 samples).

2. Survey Tracks
   Survey track plots were converted into a 1km grid and assigned a score of 1.

3. Multibeam
   Areas covered by swath survey were converted into a 1km grid and assigned a high score of 5.

4. SeaZone Digital Bathymetry
   Charted areas available in a digital format via SeaZone were converted into a 1km grid and assigned a score of 1 (except in areas already covered by multibeam).

5. Side Scan Sonar
   Survey track lines where the equipment used included a side scan sonar were converted into a 1km grid and were given an additional score of 1 (except in areas already covered by multibeam).

6. Sample Equipment Type
   Grab and core samples were assigned an additional score of 1 (except in areas already covered by multibeam). Samples of dredges/trawls are considered of lower value than grabs/cores.

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